FHWA-RD-80-159A

Contract No. DOT-FH-11-9503

Sutron Report No. SCR-342-79-016

APPENDIX A

CASE HISTORIES

STREAM CHANNEL DEGRADATION AND AGGRADATION: CAUSES AND CONSEQUENCES TO HIGHWAYS

7 September 1979

DRAFT

SUTRON

DRAFT

THE SUTRON CORPORATION

1925 North Lynn Street Arlington, Virginia 22209

SUTRON

Contract No. DOT-FH-11-9503
Sutron Report No. SCR-342-79-016

APPENDIX A

CASE HISTORIES
STREAM CHANNEL DEGRADATION AND AGGRADATION: CAUSES AND CONSEQUENCES TO HIGHWAYS

7 September 1979

THE SUTRON CORPORATION
1925 North Lynn Street, Suite 700
Arlington, Virginia 22209

CASE HISTORIES

Case History	Location
1	Rattlesnake Wash at I-40 near Kingman, Arizona
2	Oraibi Wash at SR-264 near Old Oraibi, Arizona
3	Little Colorado River at US-666 near St. Johns, Arizona
4	Little Colorado River at SR-77 near Holbrook, Arizona
5	Fries Wash at I-40 near Kingman, Arizona
6	Quartzite Canyon at US-60 Arizona
7	Santa Cruz River at I-19 near Sahuarita, Arizona
8	Rillito Creek at I-10 near Tucson, Arizona
9	Rillito Creek at US-89 near Tucson, Arizona
10	Avondale Wash at SR-85 near Phoenix, Arizona
11	Holy Moses Wash at US-66 near Kingman, Arizona
12	Walker Creek at US-160 near Mexican Water, Arizona
13	St. Francis River Floodway (ditches 60 & 61) at US-63 near Marked Tree, Arizona
14	Red River at SH-41 between Forman and Fulton, Arkansas
15	Burnt Cane Lake at SH-38-50 near Widener, Arkansas
16	Crow Creek at I-30 near Forest City, Arkansas
17	Sulphur River at US-71 near Fort Lynn, Arkansas
18	Boeuf River at SH-144 near Lake Village, Arkansas
19	Stillwater Creek at SR-299 near Redding, California
20	Smith River at US-101 near Crescent City, California
21	San Diego River at SR-67 near Lakeside, California
22	Cuyama River at SR-166 near Santa Maria, California
23	Kelsey Creek at SR-89 near Kelseyvill, California
24	Mad River at SR-299 near Blue Lake, California
25	Hosler Creek at SR-96 near Hoopa, California
26	Broaddus Creek at SR-20 near Willits, California
27	Wildcat Creek near Ft. Morgan in Morgan County, Colorado
28	15th Street Bridge over the South Platte River, Denver, Colorado
29	Cruz Gulch at US-24 near Colorado Springs, Colorado

Case History	Location
30	Little Missouri River at US-22 north of Killdeer, North Dakota
31	Small Stream at SR-24 south of Fort Yates, North Dakota
32	Tributary to East Fork of the Nishnabotna River at SH-37 near Defiance, Iowa
33	Culver Creek, Tributary to Boyer River at SH-37 near Dunlap, Iowa
34	Mosquito Creek at SH-191 near Portsmouth, Iowa
35	Silver Creek at I-80 near Shelby, Iowa
36	Big Whiskey Creek at US-20 near Lawton, Iowa
37	Iowa River at SH-14 near Marshalltown, Iowa
38	Allen Creek at SH-127 near Magnolia, Iowa
39	Graybill Creek at SH-92 near Carson, Iowa
40	One Hundred and Two River near Gravity, Iowa
41	Floyd River near James, Iowa
42	Kansas River near Bonner Springs, Kansas
43	Stone House Creek, US-24 and US-59 at Williamstown, Kansas
44	Middle Fork of Beargrass Creek at I-64, Jefferson County, Kentucky
45	Poor Fork of the Cumberland River at US-119, Harlan County, Kentucky
46	Chadwick Creek at I-64, Boyd County, Kentucky
47	Taylor Creek, I-471, Campbell County, Kentucky
48	Pond Creek at US-119, Pike County, Kentucky
49	Amite River at SH-37 near Grangeville, Louisiana
50	Cool Creek at I-55 near Kentwood, Louisiana
51	Whitten Creek at SR-37 at Baywood, Louisiana
52	Lawrence Creek at SR-16 near Franklinton, Louisiana
53	Comite River at SH-64, East Baton Rouge Parish, Louisiana
54	West Pearl River at I-59, St. Tammany Parish, Louisiana
55	East Pearl River at I-10, St. Tammany Parish, Louisiana
56	Mississippi River at I-494, South St. Paul, Minnesota
57	Yalobusha River at SH-9 near Calhoun City, Mississippi
58	Perry Creek at I-55 near Grenada, Mississippi
59	Batupan Bogue at SH-8 at Grenada, Mississippi

Case History	Location
60	Black Creek at SR-7 near Avalon, Mississippi
61	Pigeon Roost Creek at SR-305 near Lewisburg, Mississippi
62	Homochitto River at SR-33 at Rosetta, Mississippi
63	Tillatoba Creek at SH-35 at Charleston, Mississippi
64	Kimsey Creek at I-29 near Mound City, Missouri
65	Middle Fork Grand River, SH-46 near Grant City, Missouri
66	Davis Creek at I-70 near Sweet Springs, Missouri
67	West Gallatin River at I-9 near Bozeman, Montana
68	Niobrara River at SR-12 near Niobrara, Nebraska
69	Muddy Creek at SR-50 in Otoe County, Nebraska
70	South Fork Little Nemaha River at SR-50 near Cook, Nebraska
71	Logan Creek at SR-9 near Pender, Nebraska
72	Elk Creek at SR-15 near Jackson, Nebraska
73	Little Nemaha River, County Road near Unadilla, Nebraska
74	Small Creek at US-73 south of Decatur, Nebraska
75	Papillion Creek at SR-64, US-6, SR-92, I-50, SR-370 near Omaha, Nebraska
76	East Branch Pemigewasset River near Lincoln, New Hampshire
77	Arroyo Seco at US-84 near Espanola, New Mexico
78	Chupaderos Arroyo at SR-30 near Espanola, New Mexico
79	Washes at SR-68 near Velarde, New Mexico
80	White Water Creek at US-180 near Glenwood, New Mexico
81	Caddo Creek at SH-53 west of Milo, Oklahoma
82	North Fork of Walnut Creek at US-62 near Blanchard, Oklahoma
83	Wallowa Lake Bridge over Grande Ronde River near Island City, Oregon
84	Pacific Highway West Bridge over the Willamette River near Harrisburg, Oregon
85	Mt. Hood Highway Bridge over White River, Oregon
86	South Fork Forded Deer River at US-51 near Halls, Tennessee
87	Cane Creek at US-51, SR-19, CR-8044, near Ripley, Lauderdale County, Tennessee
88	North Sulphur River at FM-68 near Paris, Texas

Case History	Location
89	Rowdy Creek at FM-38 near Paris, Texas
90	Merrill Creek at SR-34 near Ladonia, Texas
91	Merrill Creek at FM-1550 near Ladonia, Texas
92	Baker Creek at FM-1550 near Ladonia, Texas
93	Mallory Creek at FM-137 near Howland, Texas
94	Cherry Creek at FM-1184 near Howland, Texas
95	Weber River at I-80N between Echo and Riverdale, Utah
96	Salina Creek at I-70 near Salina, Utah
97	Virgin River at I-15 near Bloomington, Utah
98	East Fork of the Virgin River at US-89 near Mt. Carmel, Utah
99	Boxelder Creek at I-25 near Glenrock, Wyoming
100	Carpenter Creek at SR-192 near Sussex, Wyoming
101	Cole Creek at SR-192 near Sussex, Wyoming
102	Unnamed Draw on Kaycee-Mayoworth Road near Kaycee, Wyoming
103	Elk Creek at SR-789 near Basin, Wyoming
104	Alkali Creek at Ralston-Badger Basin Road near Powell, Wyoming
105	Old Badwater Bridge over Badwater Creek near Shoshone, Wyoming
106	Tenmile Draw Creek at I-80 near Point of Rocks, Wyoming
107	Cheyenne River at SR-63 south of Eagle Butte, South Dakota
108	Big Elk Creek Bridge, #47-080-535 at I-90, South Dakota
109	Polo Creek Bridge, #41-162-082 at I-90, South Dakota
110	Bear Butte River Bridge, #47-015-427 at I-90, South Dakota

Case History 1

RATTLESNAKE WASH AT I-40 NEAR KINGMAN, ARIZONA

Description

The channel is 22.86 to 45.72M wide, sinuous locally braided, with low sidecut banks. The stream is ephemeral and the ground cover adjacent to the channel is mesquite brush. Bed material is sand, gravel and cobbles.

The bridges are continuous CIP reinforced concrete slabs supported by 4 concrete wall piers with spread footings. Overall length is 49.99M with a clear span of 10.67M. The west upstream bank is protected with 91.44M of 1.83M high railbank. A rock-lined interceptor enters the channel from the east, just upstream of the EB bridge.

Gradation Problem

In 1972 a borrow pit was located downstream. This activity led to a 6.10M headcut which endangered the piers. However, from 1974 to 1978 the channel had aggraded an additional 0.64M. As of this writing, the bed is 1.52 to 1.83M below the top of the piers.

Countermeasures

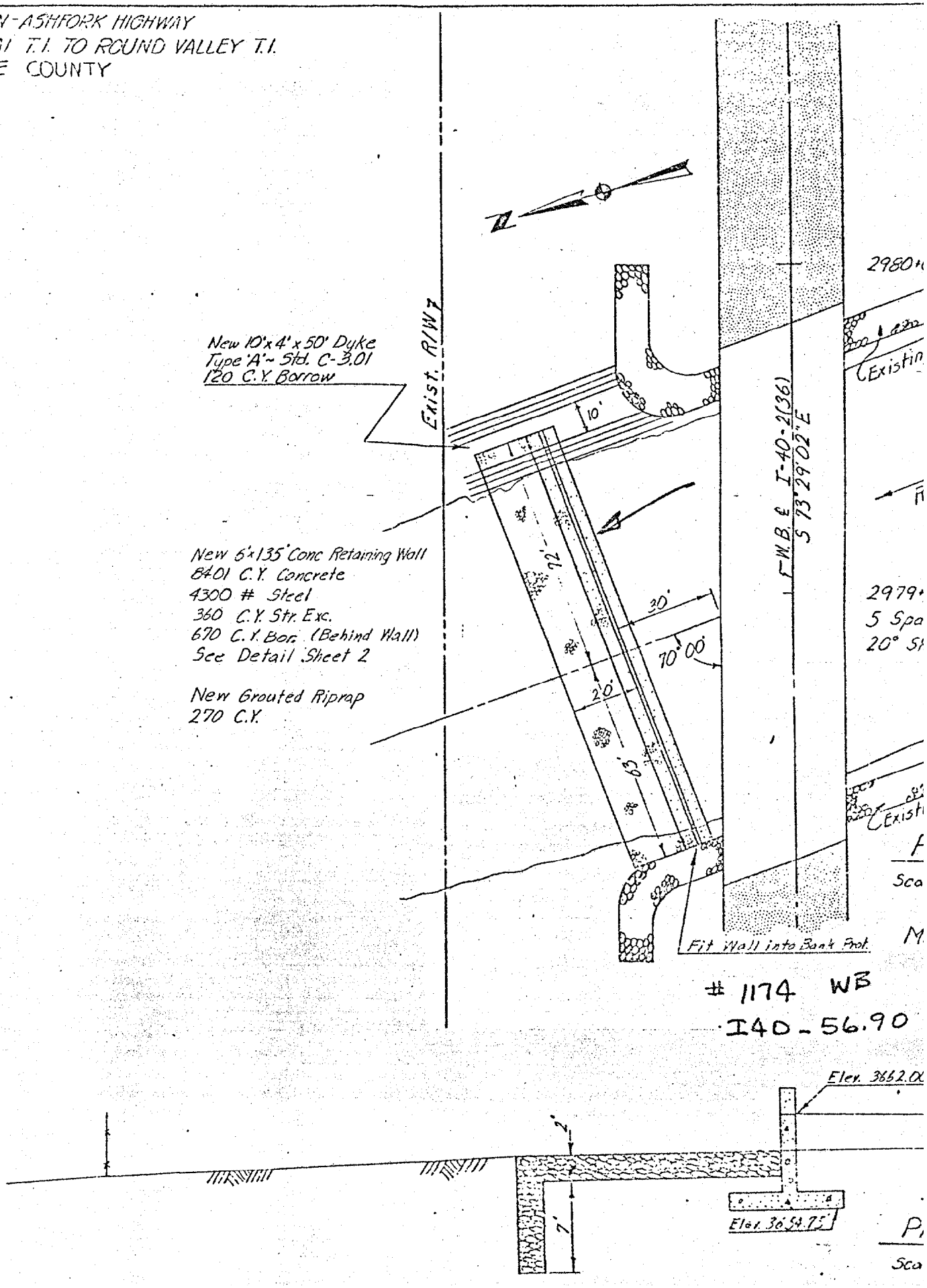
In 1974 plans were initiated to construct a drop structure downstream of the bridge, which was effective in stabilizing the bed level at the site.

Discussion

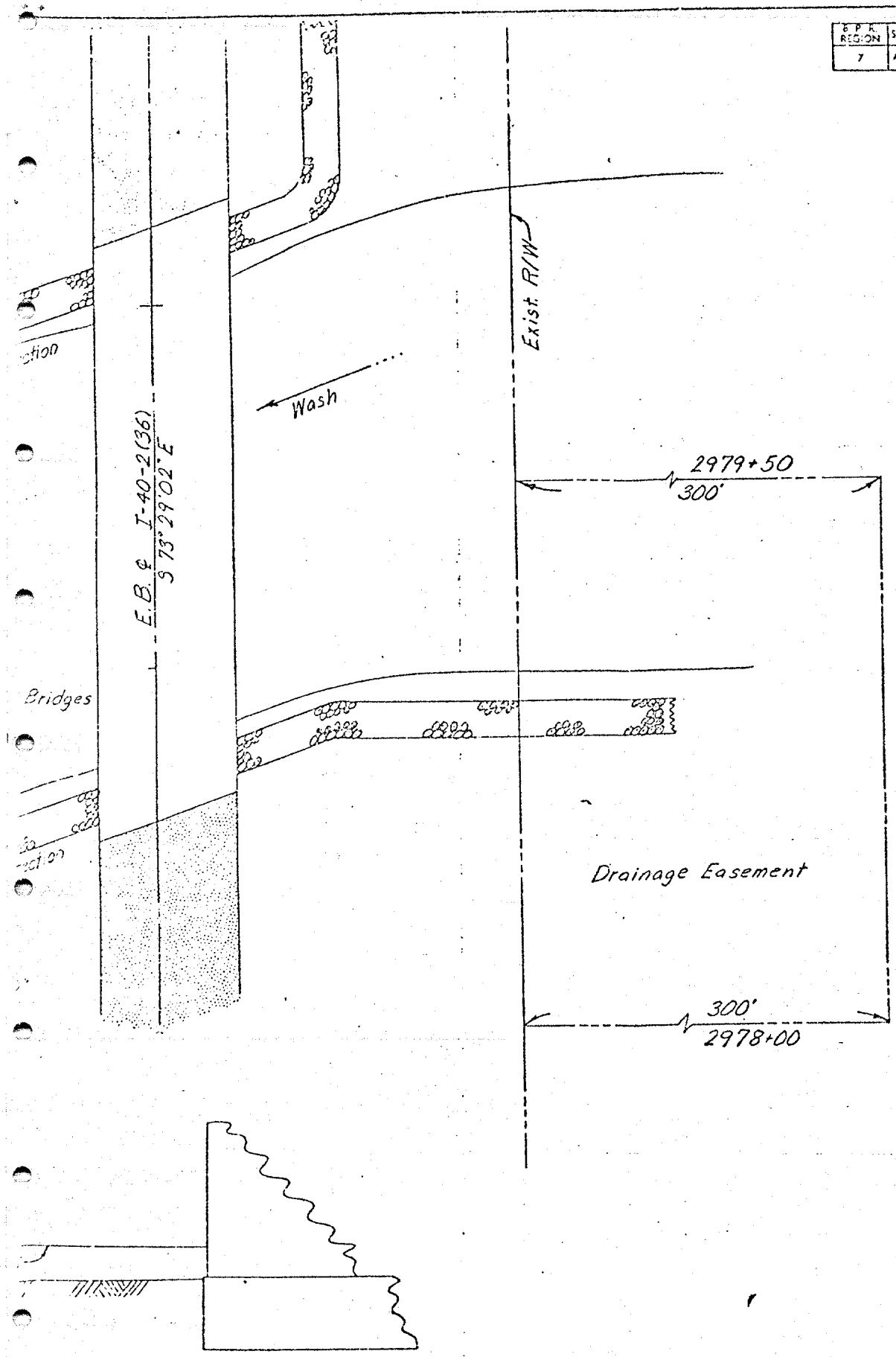
The drop structure effectively controlled a deep headcut which could have reached the piers and stabilized the channel at .61 to .91M above the original construction level.

Available documentation includes recent slides, original plans, drop structure plans, inspection reports, and cross sections.

KINGMAN-ASHFORK HIGHWAY
HUALAPAI T.I. TO ROUND VALLEY T.I.
MOHAVE COUNTY



B.P.R. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
7	ARIZ.	I-40-2-907	8	8	



RATTLESNAKE WASH

SCOUR PROTECTION

Case History 2

Oraibi Wash at SR 264 near Old Oraibi, Arizona

Description:

The site is located in rugged terrain above an alluvial desert plain. Soil in the area is primarily sand, with some gravel and sandstone formations. The drainage area is 1196.58km^2, Q_{50} = 450 cms and Q_{100} = 560 cms. The main channel is 3.05 to 6.10M wide, and the overbank channel is 15.24 to 30.48M wide, with 3.05 to 15.24M steeply sloping banks.

The bridge at this site is a prestressed beam simple span supported by 9 pile bents, with a total length of 106.99M The piles are CIP concrete with steel casing.

Gradation Problem:

In 1969, a routine inspection indicated some erosion of abutment protection. By 1972, routine inspection indicated considerable channel degradation and settlement of abutments was noted. Inspections conducted in 1975 showed continued degradation which left the bents with inadequate sway bracing.

Countermeasures:

In 1960, the original construction replaced a timber pile bridge located approximately 91.44M downstream. The abutments were protected by a woven wire fence with rock rip-rap. In 1975, lateral X-bracing was installed by a contractor and the pile depths were carefully evaluated by state personnel. In 1977, the bridge was restricted to legal loads only (no overloads), and in 1978, a 10-ton load limit was imposed on the bridge in response to continued concern over inadequate sway bracing and bearing capacity.

Currently, a low-flow culvert detour is being constructed just downstream from the bridge. The existing bridge is schedule for replacement, and will be closed when the detour is completed

Discussion:

State personnel believe that the over-all degradation trend was aggravated at the bridge site by a natural meander loop cut-off just downstream. There is no current plan to attempt control of the channel.

Accompanying documentation includes recent slides, original plans, inspection history, progressive channel cross-sections at the crossing, and plans for the detour.

Additional information on Oraibi is available in Phoenix through the Chief Drainage Design Engineer. This information includes stereo photogrammetric coverage and an extensive photographic file.

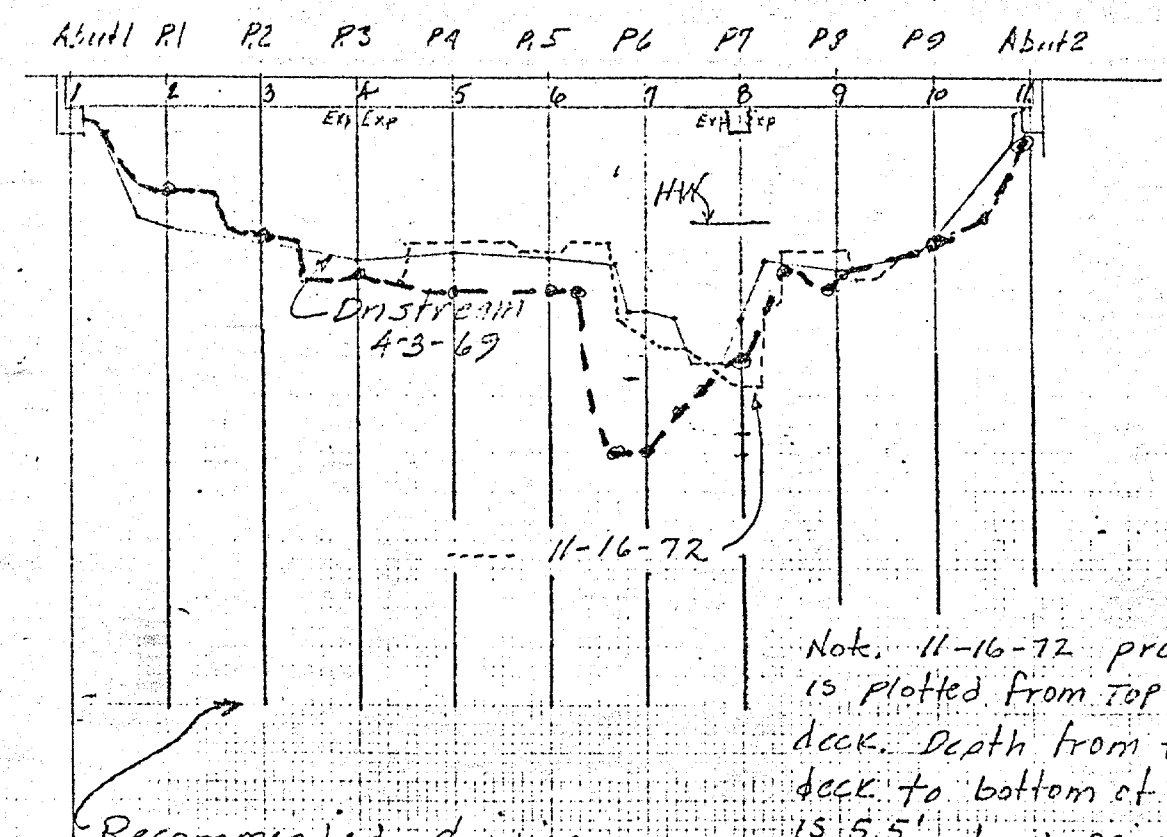
The culvert bypass will remain in service until a new bridge is completed. The existing bridge will be placed back into temporary service during interim repair work on the detour, as the culverts will probably not survive annual peak flows.

1-3-69
264
373.70
Oraibi Wash

1. 2

DOWNSTREAM PROFILE, INSP #3, 8-13-74, GWM
No change 10-23-74 FDD

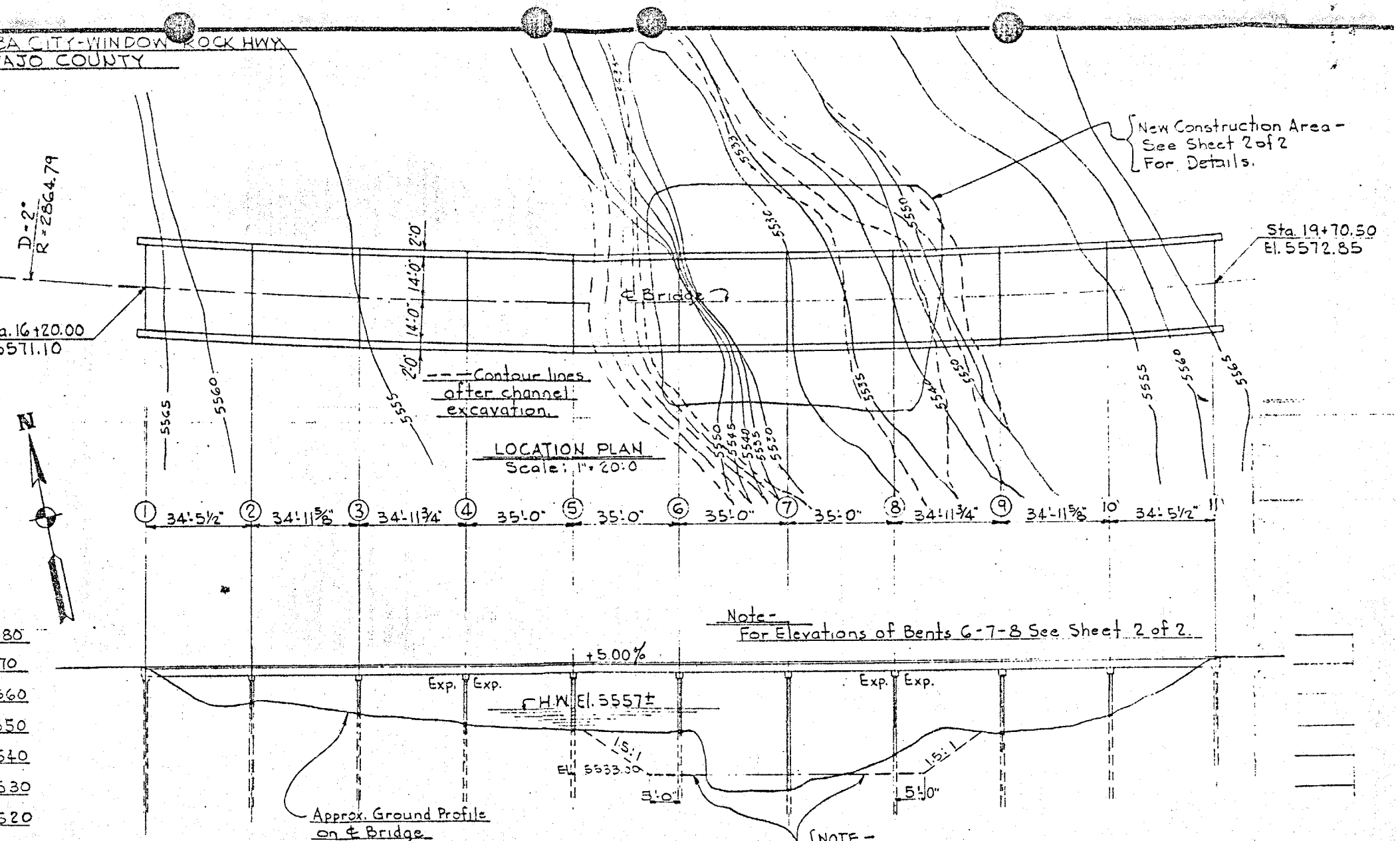
OF SECOND MESA



Note. 11-16-72 profile is plotted from top of deck. Depth from top of deck to bottom of pier cap is 5.5'. Low point in channel is at Pier 7 with a depth of 32' or 26.5' of pile is now exposed. HW is observed High water line on piling, 11-16-72.

Recommended driving length of 62' was stated on constr. Plans. No as-built data available.

BA CITY-WINDOW ROCK HWY
AJO COUNTY



ELEVATION
Scale: 1" = 20'-0
New Bracing at Piers #6-#7 & #8

Note

APPROXIMATE QUANTITIES

	Bent 6	Bent 7	Bent 8	Totals
Channel Excav.	850 CY.	—	650 CY.	1500 CuY
Struct. Steel	992 lbs.	1008 lbs	992 lbs.	2992 Lbs

NOTE -

Case History 3

LITTLE COLORADO RIVER AT US-666 NEAR ST. JOHNS, ARIZONA

Description

The bridge site is located in an alluvial plain, on the east edge of St. Johns, Arizona. The west bank is somewhat protected, and there are houses within 3.05M of the bank. There is a small drop structure 137.16M upstream from the bridge. The overbank flow channel is 45.72 to 91.44M across, with a 1.83 to 2.74M main channel. The bed is sand, silt and gravel, and the wash is overgrown with shrubs.

Spans are wide-flange girders with floor beams. Pilings are CIP concrete. Total bridge length is 42.98M with a clear span of 10.67M. The bridge was erected at this site in 1936.

Gradation Problem

Following the original construction in 1936, the site experienced frequent flooding, possibly aggravated by the constriction at the bridge site. By 1970, the channel had aggraded to the bottom of the girders. Aggradation has continued, further decreasing the freeboard. The area has continued to experience flooding, and the site is still experiencing aggradation problems.

Countermeasures

The channel had aggraded to such an extent that it had to be excavated in order to perform maintenance on girders and rockers. With the continued aggradation, it was recommended that a new bridge be constructed in 1972. In 1977, the 1936 bridge was removed and a new bridge constructed 91.44M downstream. Although the new bridge is longer and higher than the old, it still experiences aggradation problems. The new bridge deck is actually above the adjacent road elevation. The channel is .91 to 1.22M below the girders of the new bridge.

Discussion

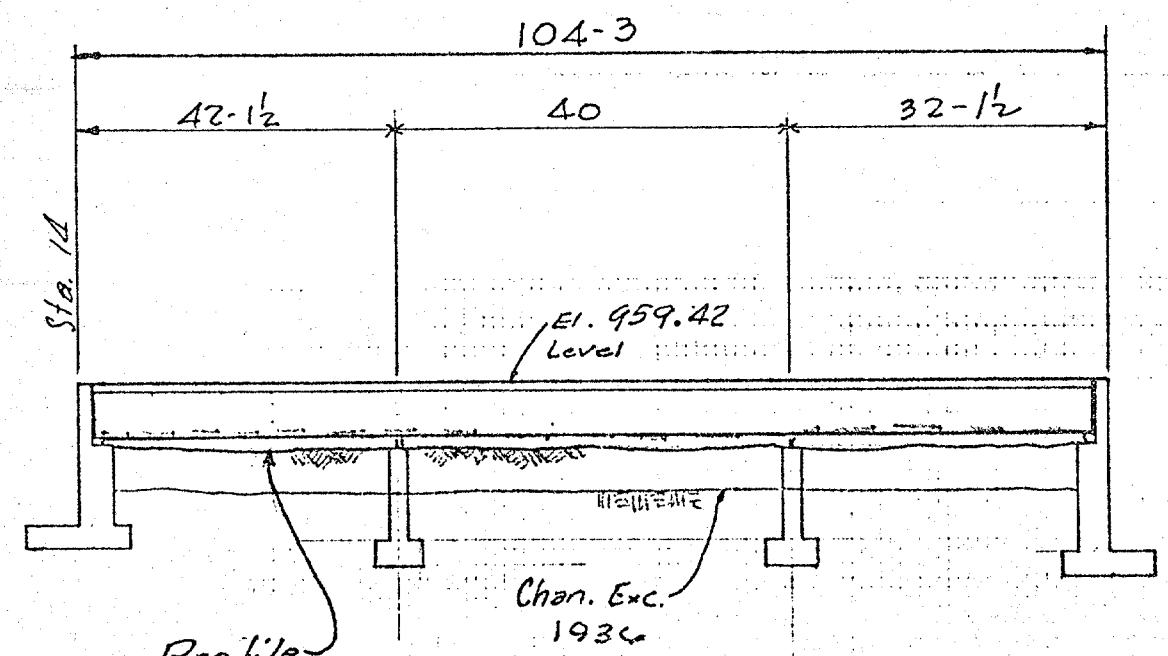
The aggradation of this stream is representative of many streams within this area. The new longer bridge should partly alleviate the damming effect, but will continue to experience the same problem as the old. The channel should be expected to aggrade during low flows to the extent that the clearance at the bridge is insufficient to pass peak flows.

Available documentation includes plans for the old and new bridges, inspection reports, progressive cross sections, assorted correspondence related to flooding in the area, and recent slides.

158
8-4-70
666
666-315.69

2 2

To St. Johns



About 10" to 12" of freeboard remain 9-26-72

— — PROFILE, UPSTREAM, INSP #3, 7-18-74, GWM
NO CHANGE IN PROFILE 4th INSP. 7-7-76 PJM

Case History 4

LITTLE COLORADO RIVER AT SR-77 NEAR HOLBROOK, ARIZONA

Description

The bridge site is located on the south edge of Holbrook, Arizona. The main channel is 68.58 to 91.44M wide with .91 to 1.83M banks. The channel is meandering, and the banks are side-cut. There is an overbank channel which extends 91.44 to 137.16M beyond the main channel with .61 to .91M banks. The bank material appears to be silt from previous overbank flow. The upstream reach has been extensively reworked, with the addition of sand dikes and probably some dredging. During moderate flow, the water surface indicates an antidune bed formation. A short distance (8.05 to 16.09km) upstream, as the terrain changes from flat plain to rolling hills, the river breaks into several narrower (4.57 to 9.14M) channels with 3.05 to 4.57M banks.

The bridge is a steel pony truss supported by 3 wall piers. The total length is 108.20M.

Gradation Problem

Between 1929 and 1948, the freeborad decreased from 3.05M to 1.83M across the entire span, and by 1969 there was insufficient clearance under the exterior spans. Continued aggradation has brought the freeboard from 1.22 to 0.00M and flows continue to overtop the adjacent roadway. The two end spans are badly silted.

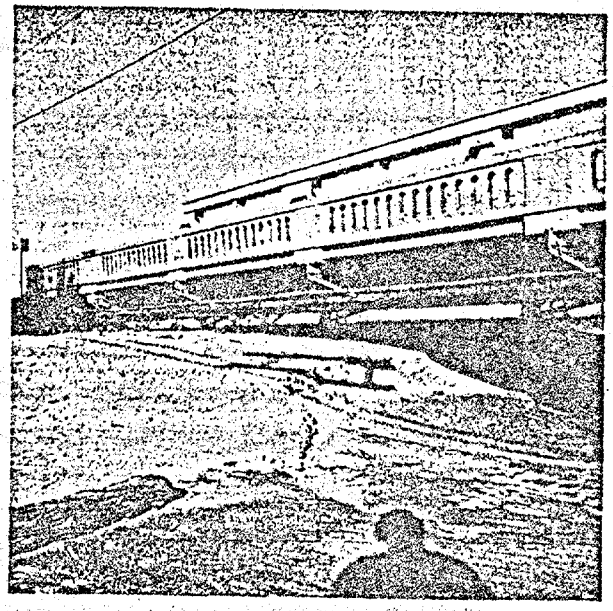
Countermeasures

Very little was done to remedy the aggradation problem until 1975. State personnel deemed the bridge inadequate and the FHWA was requested to replace the bridge under the Special Bridge Replacement Program. In 1977 the bridge was scheduled for replacement.

Discussion

The aggradation trend will probably continue after construction of the new bridge. Reduced encroachment should help alleviate some of the local problems at the bridge site.

Available documentation includes bridge plans with superimposed progressive cross sections, inspection reports since 1973, extracts from a technical inspection in 1969, and recent slides.



Photograph No. 2
North Span Looking Upstream and North
Note that the streambed has silted up to the point that there is less than one foot of clearance under this span.

P

Case History 5

FRIES WASH AT I-40 NEAR KINGMAN, ARIZONA

Description

The stream is ephemeral. Channel is 22.86 to 45.72M across, meandering and locally braided. Banks are .91 to 1.52M sidecut and sloping. Bank material is composed of sand, gravel and cobbles. Sparsely vegetated desert surrounds the channel.

Bridges are continuous CIP reinforced concrete slab supported by 4 wall piers which bear on steel H-piles. Overall length is 42.98M with a 9.14M clear span. Skew is 15°. Abutments are protected with 45.72M of railbank. The channel is controlled by two drop structures, one upstream and the other downstream.

Gradation Problem

A routine inspection in 1972 noted that considerable degradation due to downstream borrow pits had occurred since the original construction in 1965. By 1974 the channel had stabilized to within .61M of the original level. Some undermining of the NE abutment of the WB bridge was noted in 1976. Presently, the channel is stable and there is approximately 3.05M between the bed and the top of the piers. There is, however, a noticeable .61M drop in the bed level upstream from the site.

Countermeasures

Following the inspection in 1972, plans were initiated for channel control. Two drop structures were installed: a 1.22M wall upstream and a 1.83M wall downstream.

Discussion

Available supporting documentation includes recent slides, original plans, drop structure plans, inspection reports and cross sections for both bridges.

909

W 15

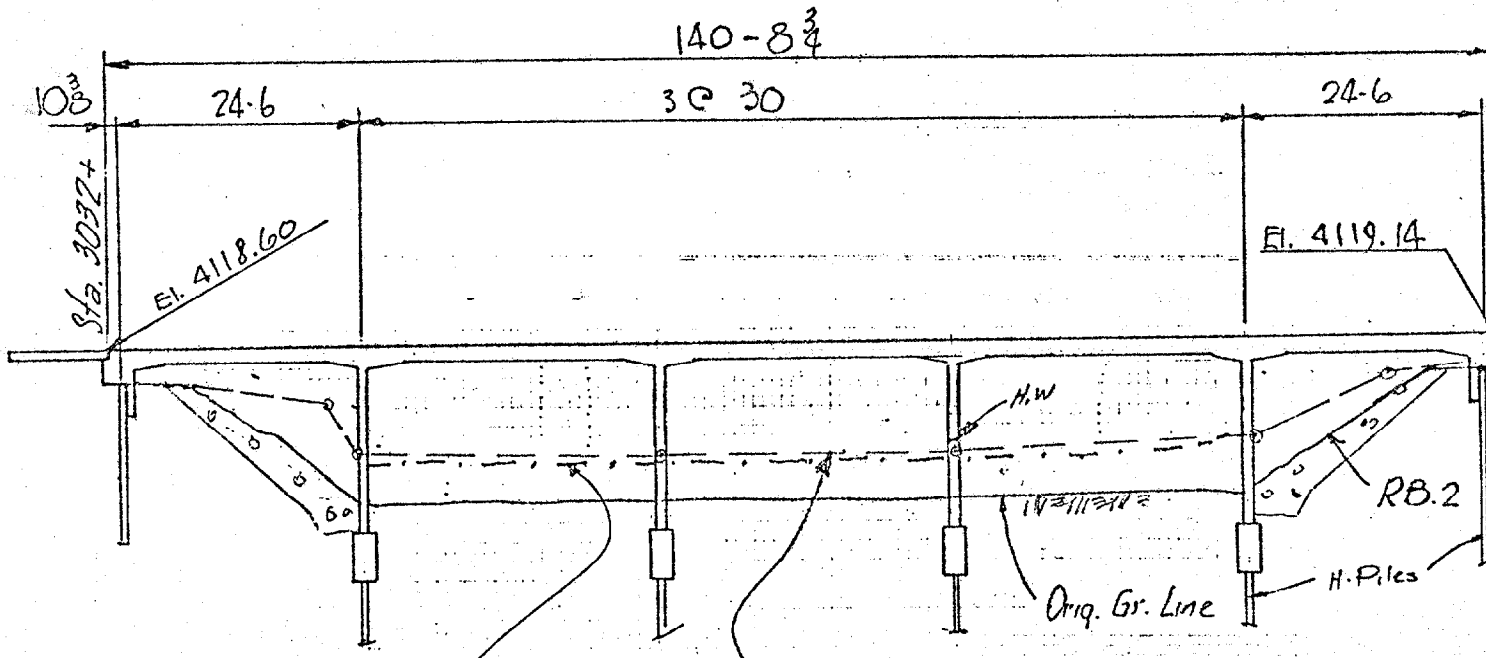
2 2

I 40

I 40 - ~~[illegible]~~ 60.1

E.B.

INSP. NO.	4	5					
DATE	12-76	11/15/78					
INITIAL	GRS	GDH					
SYMBOL	— · —	N.C.				To Ashford	
UPSTREAM	✓	✓					
D'STREAM							



Upstream Profile
2-27-69

No change in profile GRS, AGD, RP
8-28-74

(4) 12-16-76 GRS
Insp. # 4

W13

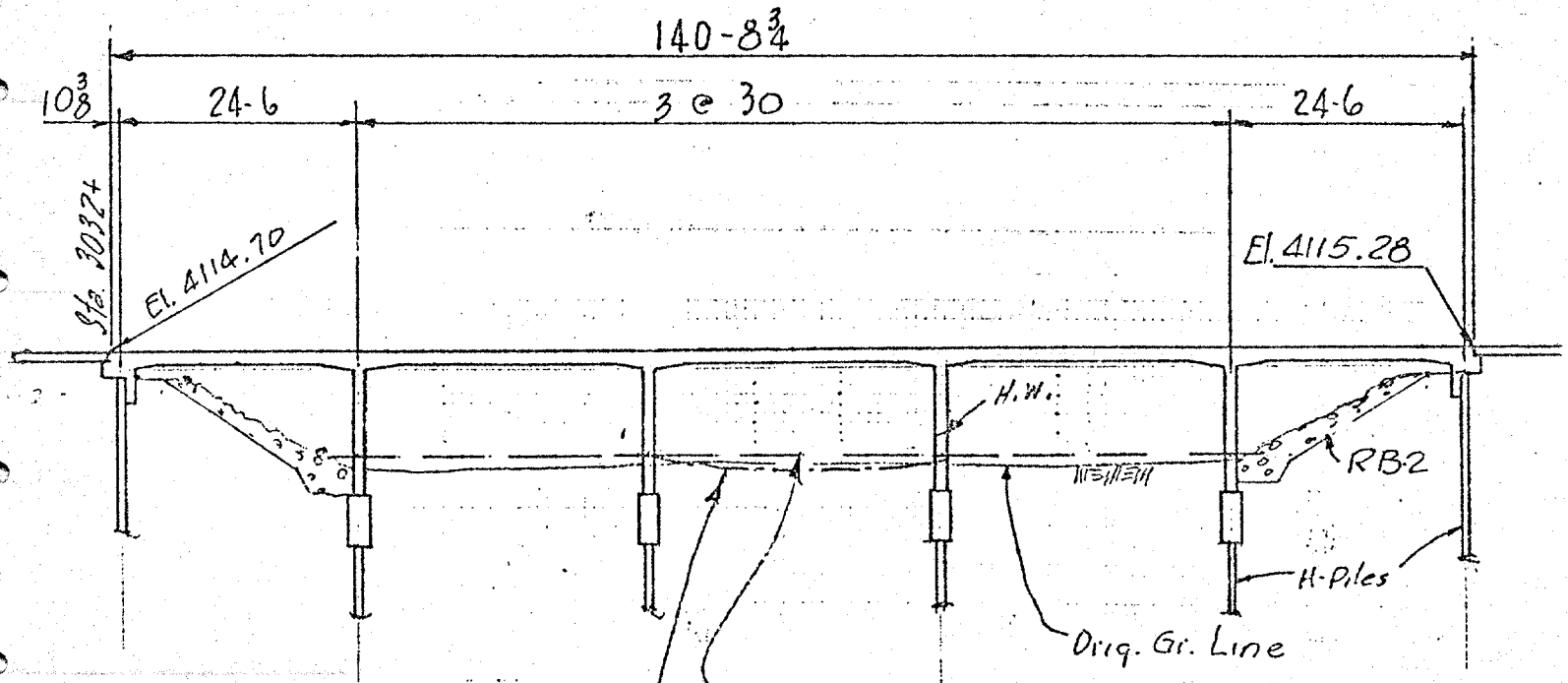
~~909~~ 910 2 2

I40

I40 - [redacted] 60.1 Fries

W.B.

INSP. NO.	4	5					
DATE	12-76	11/15/78					To Ashfork
INITIAL	GRS	GDH					
SYMBOL	—·—	N.C.					
UPSTREAM	✓	✓					
D'STREAM							



Upstream Profile
2-27-69
8-28-74 AGD, GRS, RP

No change 12-16-76
Insp. #4 GRS

Case History 6

Quartzite Canyon at US60 . Arizona

Description:

Located in Gila County, Arizona, this bridge was constructed of simple span concrete T beams across an alluvial valley that appears to have been degrading over many years. The bed of the river is composed of sand and gravel and there is no bed rock in the area. The bridge is skewed approximately 30° to the channel.

Gradation Problem:

Between 1931 and 1969, extensive degradation occured around pier footings. By 1972, the stream bed was dangerously close to the pier footing bottoms (.15M). By 1973, the channel at the bridge site had aggraded to the level of a downstream cutoff wall. Only minor erosion has occured under the bridge since then.

Countermeasures:

Following the inspection in 1969 that noted extensive degradation around pier footings, a cutoff wall was suggested downstream to serve as a control measure.

In 1972, the cutoff wall was constructed downstream with hopes the bridge site bed level would aggrade to the level of yhe cutoff wall. As of 1977, only minor channel work had been necessary to ensure the integrity of the cutoff wall.

Discussion:

Pier footings bear on alluvial material making them vulnerable during peak discharges. The current drop structure has been effective, but would also be vulnerable to peak flows.

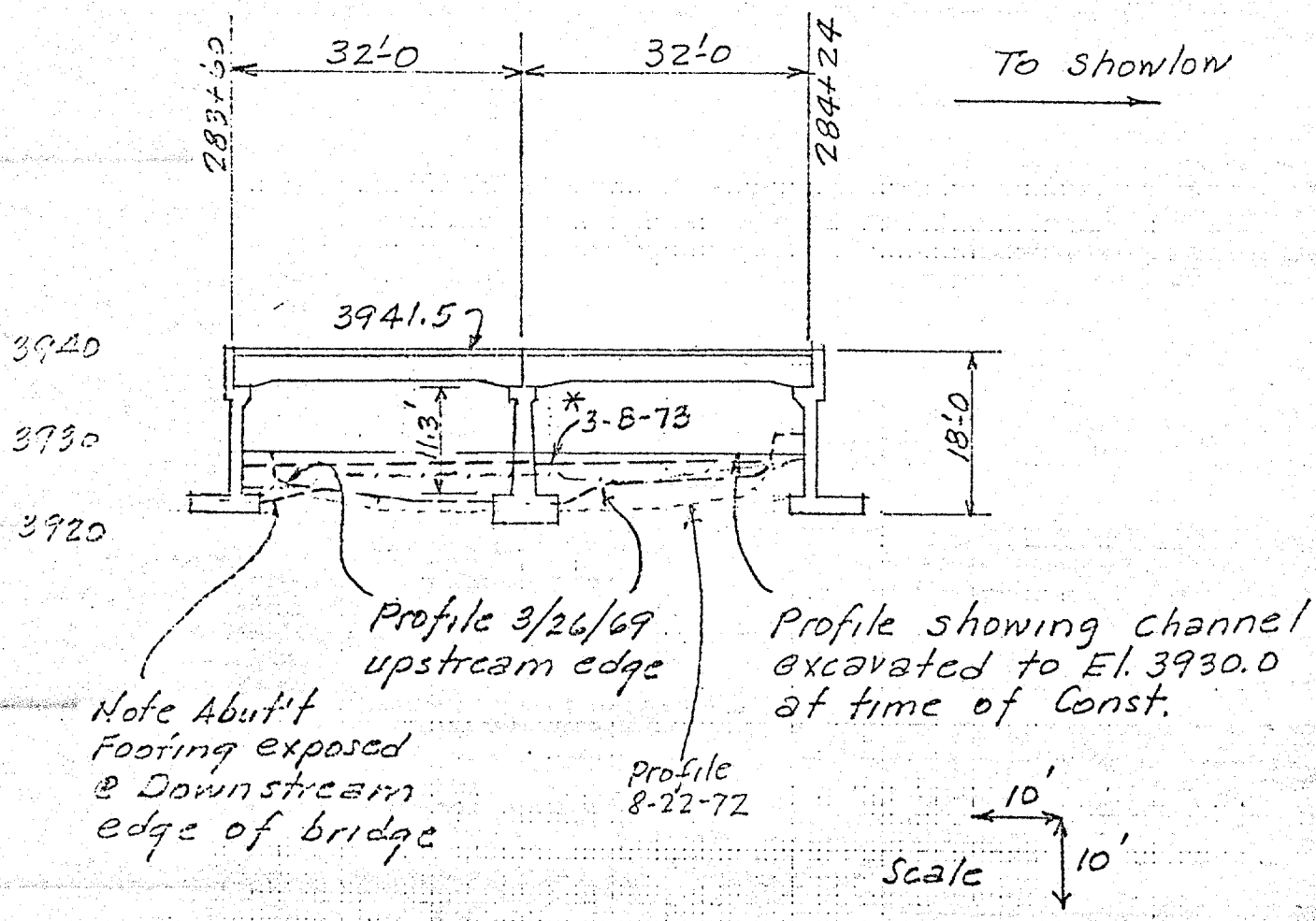
Available documentation includes original plans, 1960 modificati plans, inspection reports and cross sections since 1969, drop structure plans, and a series of photos before and after drop structure construction. There are no current slides of this site

W14

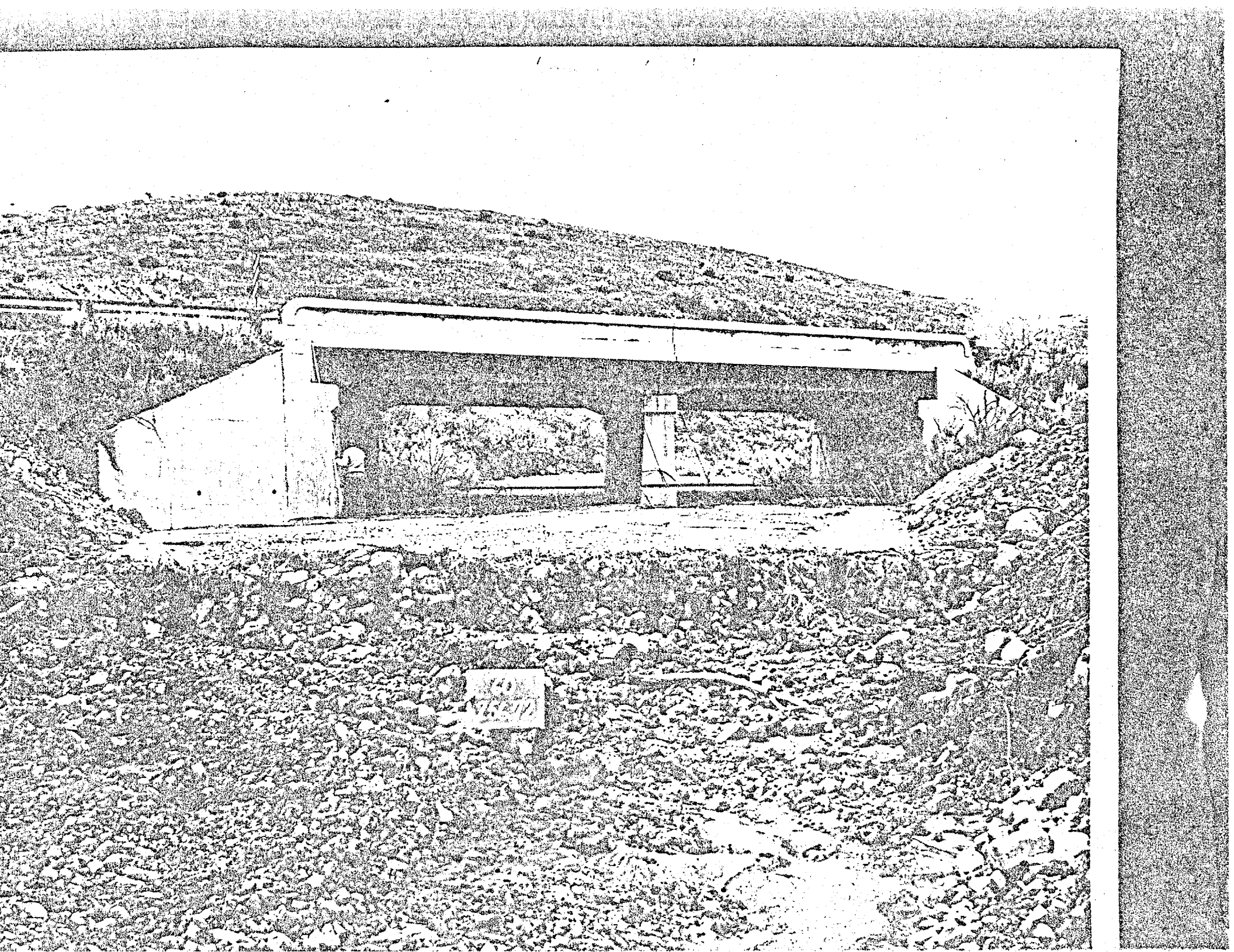
2 2

91
3/26/69
60
60-256.72

Quartzite Bridge.



*After channel repairs
PROFILE UNCHANGED SINCE 3-8-73
INSP#3, 10-30-73, GWM.
No change 8-7-75 GRS #4
Upstream Profile 9-27-77 PJM #5



Case History 7

Santa Cruz River at I19 near Sahuarita, Arizona

Description:

There are three bridges at this site. Two are I-19 northbound and southbound and the other is a bridge to the San Xavier Mission, which is also incorporated into the I-19 southbound on-ramp. The Mission bridge is most affected by river activity, and is the subject of this report. The I-19 bridges are steel girders supported by CIP concrete piers. Total length of the I-19 bridges is 125.27M and the length of the Mission bridge is 77.72M . The Mission bridge is located approximately 274.32M downstream from the interstate bridges. There is extensive bank protection, especially on the south bank.

All three bridges form constrictions in the channel. The natural channel is approximately 274.32M wide with 6.10 to 12.19M banks. Bed material is sand and silt, and bank material is fine sand and silt, with some clay. There is a large meander loop (154.2M across) just upstream from the site.

Gradation Problem:

At the time of original construction, 1956, the Mission bridge abutments were protected by railbank and sheet pile cofferdams. Following the 1969 construction of the interstate bridges, a 1971 inspection noted apparent shifting of the SW abutment and the channel had degraded .91 to 1.22M In 1973, sand and gravel excavation was noted downstream. The cross section however was unchanged from 1971.

Early in 1977, the channel had degraded .91M

which exposed the pile at the SW end of the bridge and weakened t sheet pile support. Extensive flooding in October of that year caused damage to the banks and abutments as well as the final failure of the sheet pile on the SW abutment.

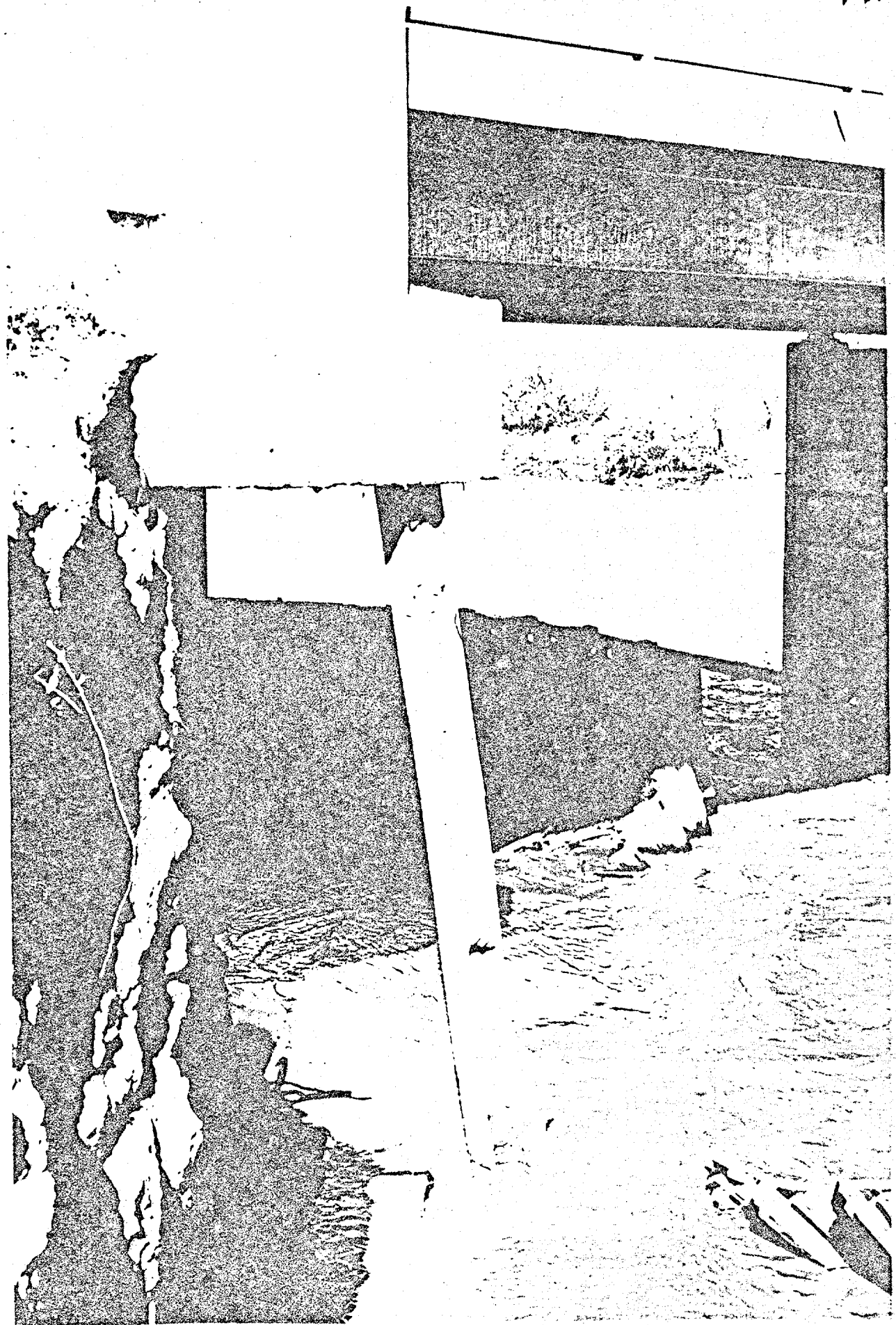
Countermeasures:

Banks and abutments have been revetted wtih sheet piling anc wire-enclosed railbank. No attempt has been made to control bed level.

Discussion:

The main channel has degraded about 1.53M since constructic of the I-19 bridges, and has migrated about 37.2M west at the Mission bridge. These developments make abutments and bank protection vulnerable to peak flows. Gradation problems have been primarily caused by channel constriction. Available documentatio includes recent slides, plans for the Mission bridge and I-19 bridges, inspeciton reports and cross section, photographs, a state 1979 aerial photo, and a memorandum describing flood damage in 1977.

1718



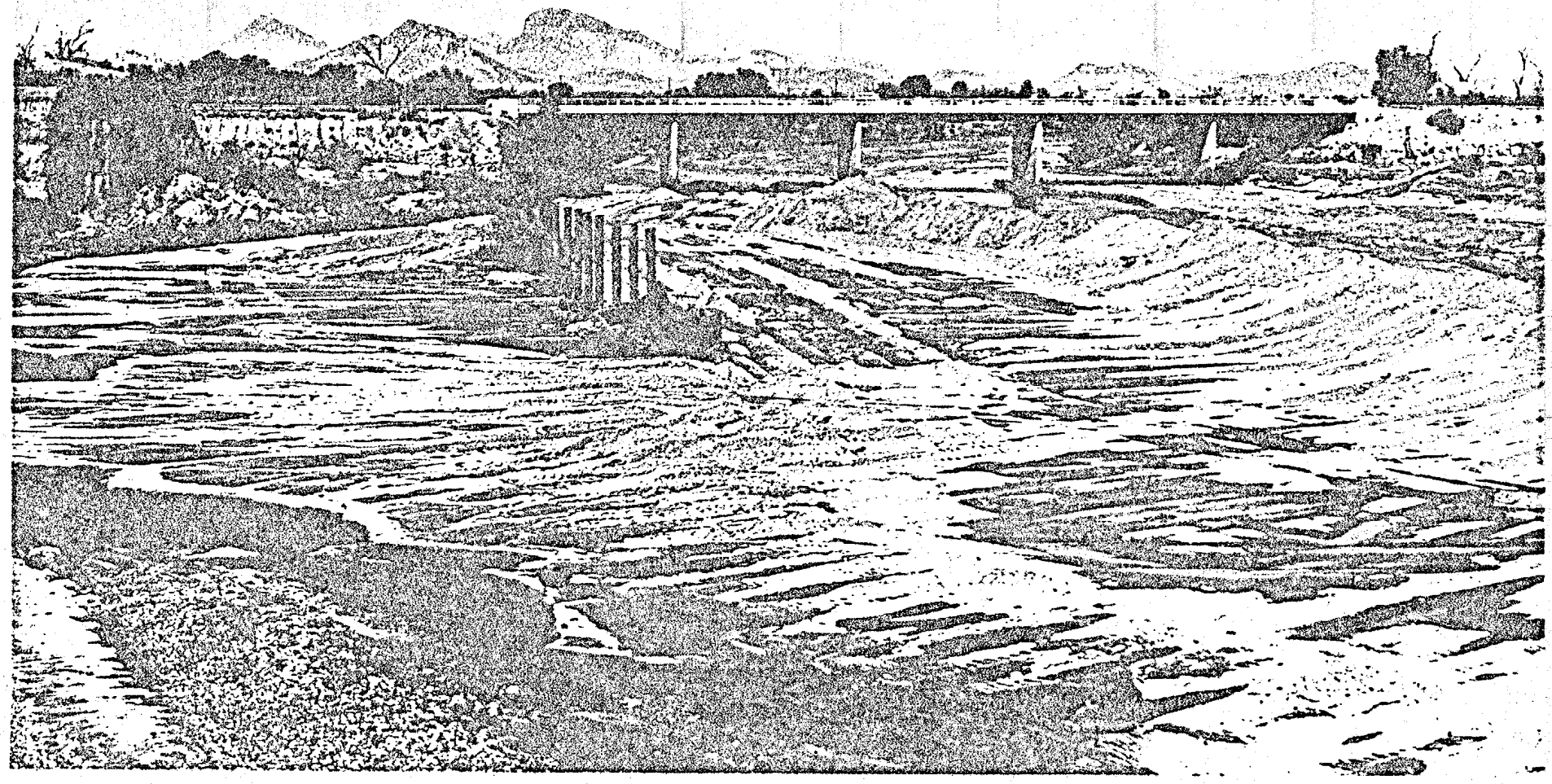
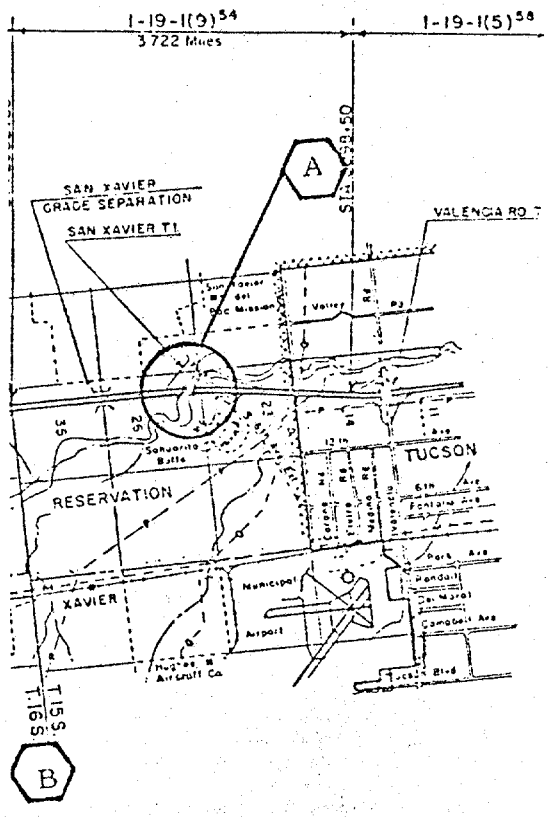


Plate 1


1-19-1(9)54
3722 Miles
1-19-1(5)58
A
SAN XAVIER
GRADE SEPARATION
SAN XAVIER TI
VALENCIA RD
TUCSON
RESERVATION
XAVIER
Municipal
Airport
Hughes Aircraft Co
T15S
T16S
B

Case History 8

Rillito Creek at I-10 near Tucson, Arizona

Description:

This bridge of prestressed concrete beams is supported by 10 CIP concrete piers with a total length of 104.24M and a clear span of 9.75M.

The bridge spans the westbound lanes of I-10 north of Tucson, Arizona. Channel width at the crossing is 91.44 ro 137.16M, and the bed material is fine gravel, sand and silt. The banks are 3.05 to 4.57M high and are generally sidecut. The banks are stratified with well-defined layers of gravel, clay and sand. There are .61 to 1.22M sand islands in the meander loop. Extensive channel reworking activity has been conducted in an effort to contain a large (274.32 to 365.76M across) meander loop which has formed downstream of the east Frontage Road bridge.

Gradation Problem:

The original bridge was built approximately 91.44M downstream from an existing 2 lane highway bridge and railroad bridge. Railbank was emplaced between the two highway bridges. By 1972, the channel had aggraded 1.52 to 1.83M in the northwest part of the channel, and by 1975, the channel had degraded to .61M in the southeast part of the channel. In 1979, a flood washed out 10.67M of railbank and completely washed out the north approach to the Frontage Road bridge.

Countermeasures:

The washed out section of bank is currently being repaired. The north bank between the two bridges is being backfilled and railbank emplaced.

Discussion:

The apparent tendency of the channel at this stie is to migrate north. Cross sections at both the westbound I-10 bridge and the east Frontage Road bridge show a recent trend of aggradation in the south part of the channel, and degradation in the north part. Aerial photographs also support this conclusion. There is gravel mining activity upstream of this site, which may have contributed toward formation of the meander pattern. Also, the SE approach to the railroad bridge tends to deflect the flow northward into the north abutment of the east Frontage Road bridge.

Available documentation includes recent slides, bridge plans, inspection records and progressive cross sections for both the WB I-10 bridge and the Frontage Road bridge, and aerial photographs.

W16

ARIZONA HIGHWAY DEPARTMENT
SUPPLEMENTAL PAGE TO BRIDGE INSPECTION REPORT

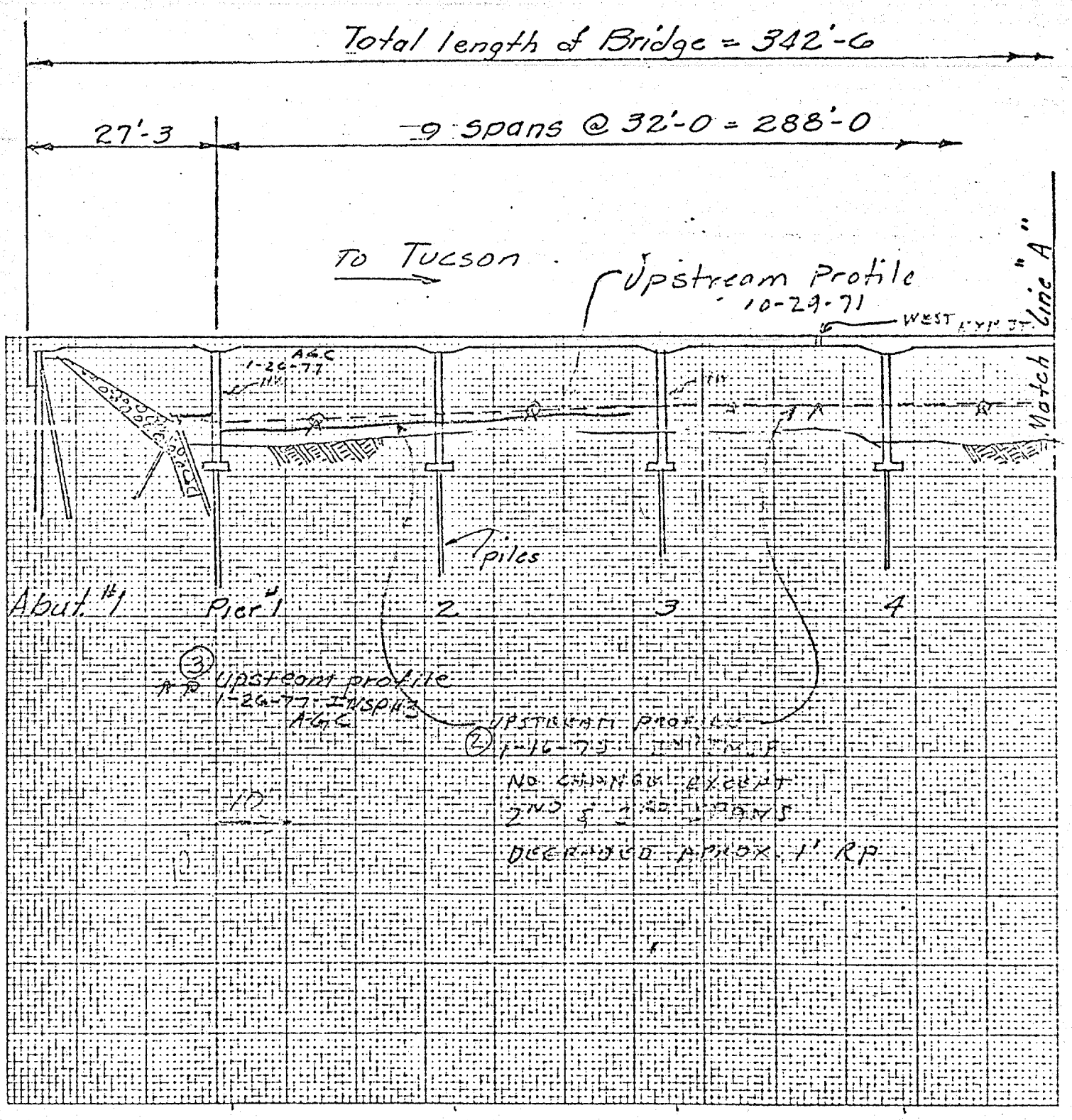
FILE NO. 854 PAGE 2 OF 3

DATE

HWY NO. I-10-250.66W.13

STRUCT. NO. I-10-249.56

Rillito Creek Br.



W16

ARIZONA HIGHWAY DEPARTMENT
SUPPLEMENTAL PAGE TO BRIDGE INSPECTION REPORT

FILE NO. 854 PAGE 3 OF

DATE

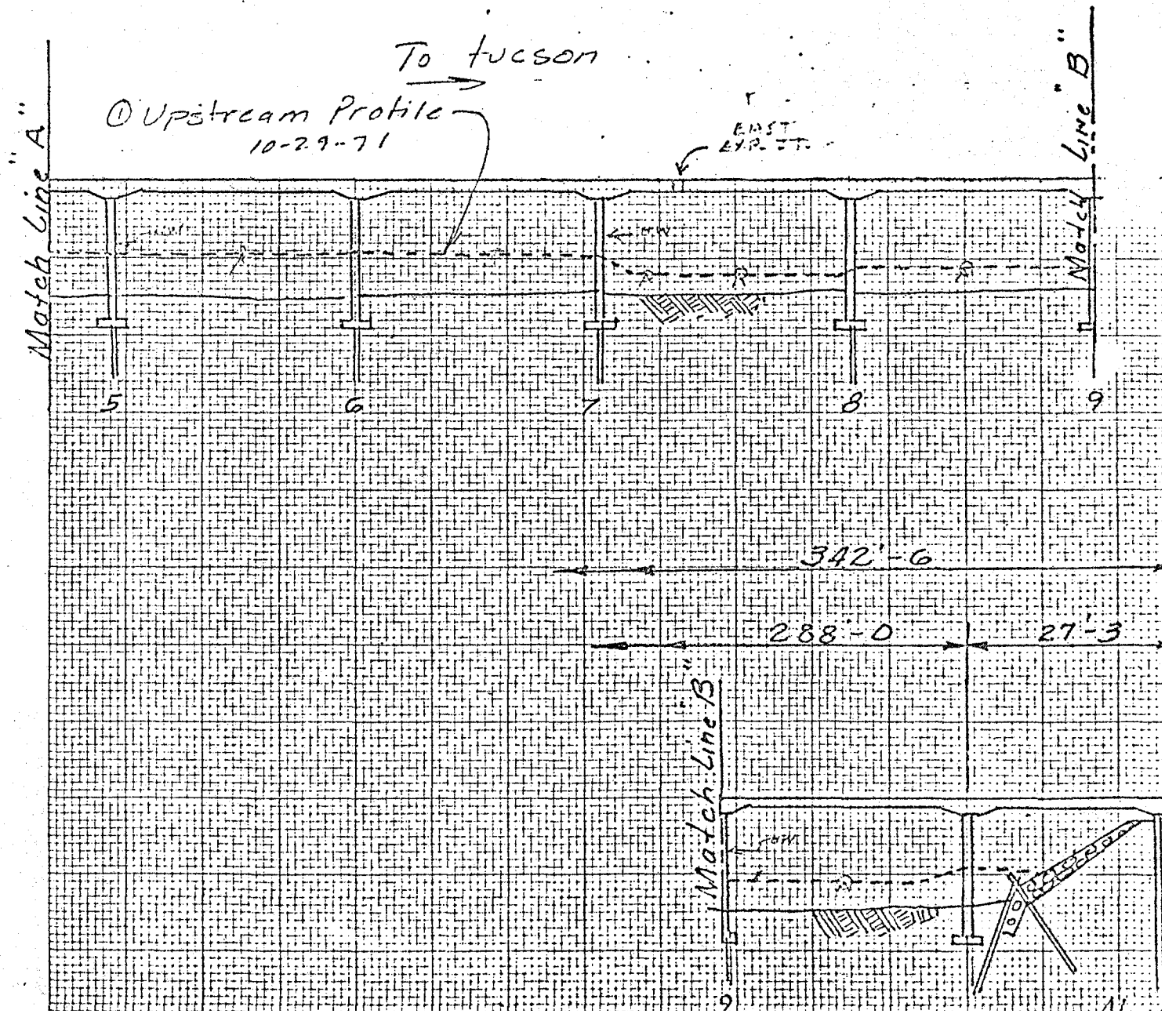
HWY NO. I-10 - 250.66 W.B.

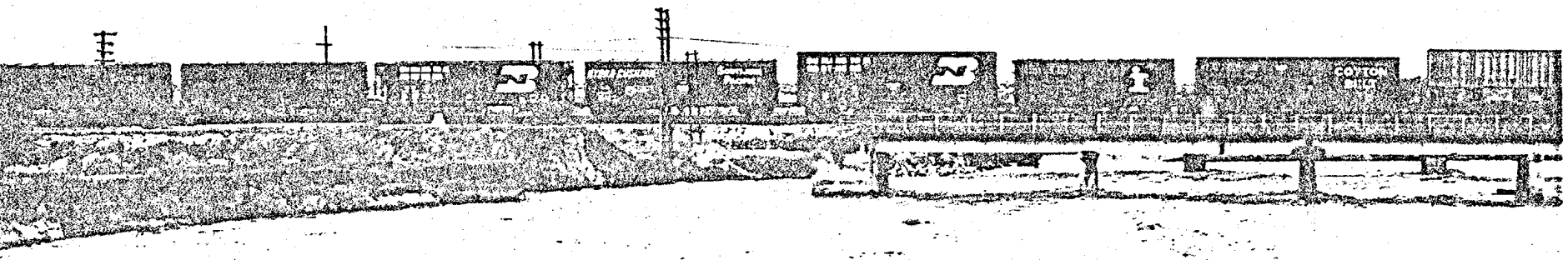
STRUCT. NO. I-10 - ~~849.56~~

Rillito Creek Br.

INSP. NO.	1	2	3			
DATE	10/29/71	1/16/75	1/26/77			
INITIAL	WRB	RP	AGC			
SYMBOL	----	——	⊗ ⊗			
UPSTREAM	✓	✓	✓			
D'STREAM						

7' to E.S.
12' from pier




COVION

Case History 9

Rillito Creek at US 89 near Tucson, Arizona

Description:

These bridges are prestressed concrete girders supported by 4 CIP 4-pier concrete bents. Over-all length is 96.32M with a skew angle of 10°. The clear span is 18.90M .

The double bridge spans a 4-lane primary highway north of Tucson, Arizona. Channel width is 91.44 to 137.16M The bed material is fine gravel, sand and silt, and the banks are 3.05 to 4.57M high and are generally sidecut. Banks are stratified with layers of gravel, sand and clay, and the channel is meandering with large sand bars. The surrounding area is desert with sparse vegetation.

Gradation Problem:

Between 1968 and 1973, borrow pits developed downstream, creating a potential hazard to the footings and bank protection from scour during peak flows. By 1974, cross sections indicated that the channel had degraded 2.13 to 2.44M in the vicinity of the bridge. In 1977, the channel became misaligned with the bridge, although it was stabilized at the 1974 level. Heavy runoff in 1978 damaged the railbank to the NE of the bridge and scour along the SE bank helped to improve the approach angle. The borrow pits were completely filled by natural sedimentation. Presently, the channel has stabilized at 2.13 to 2.44M below the original construction elevation.

Countermeasures:

With the original construction in 1968, the upstream and downstream banks were protected with railbank.

Due to the degradation, downstream excavation was stopped in 1977. This stabilized the channel. The railbank damaged by the heavy runoff of 1978 was repaired.

Discussion:

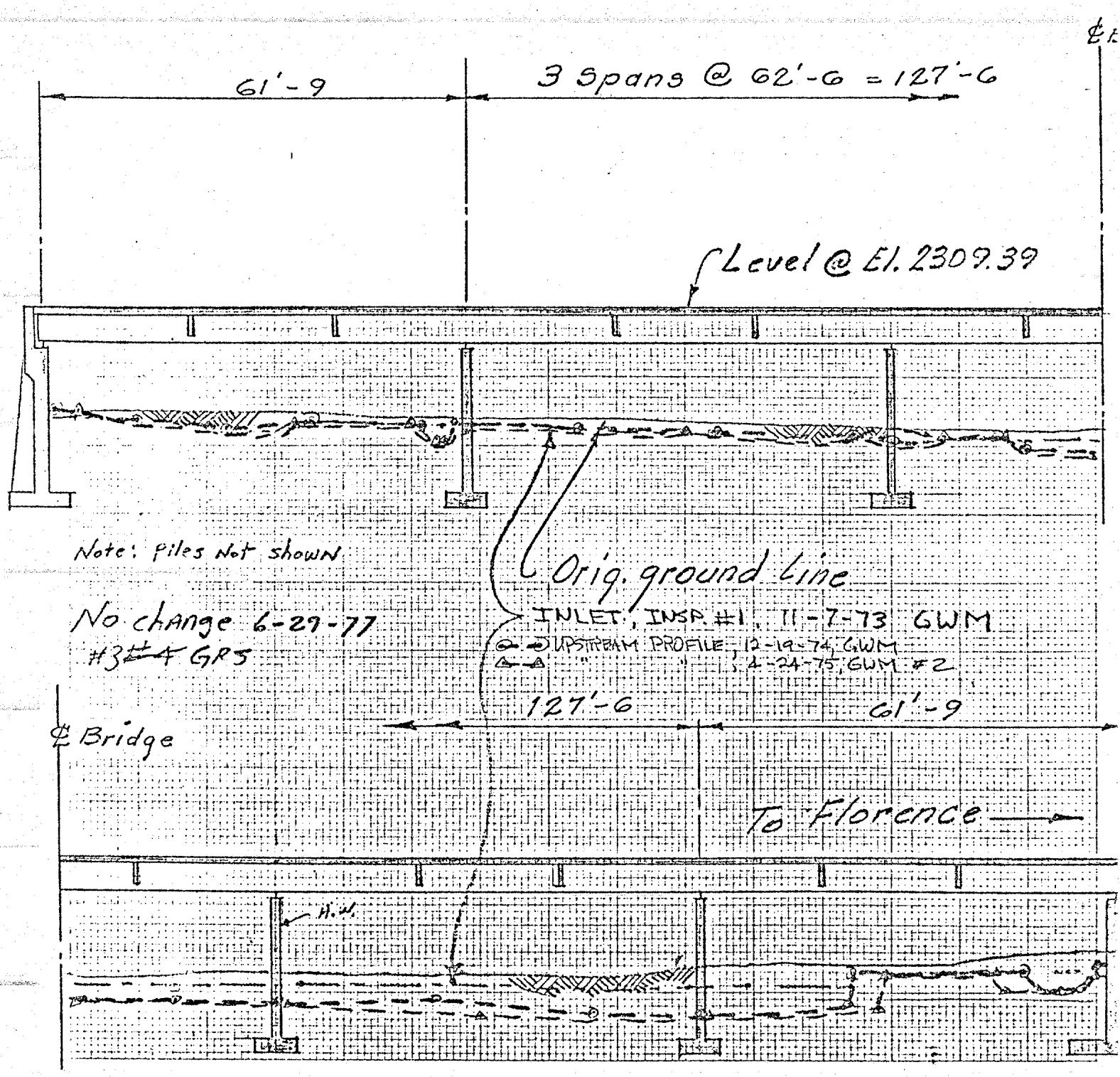
Downstream escavation has evidently caused long-term degradation in bed level at the site. It is anticipated that this site will stabilize since gravel mining has ceased downstream of the site. Available documentation includes bridge plans, inspection reports and cross-sections, photos, and an aerial photo.

No current slides of this site are available.

1550

ARIZONA HIGHWAY DEPARTMENT
SUPPLEMENTAL PAGE TO BRIDGE INSPECTION REPORT

89
89-71.79 (N.B.)



W17

1549

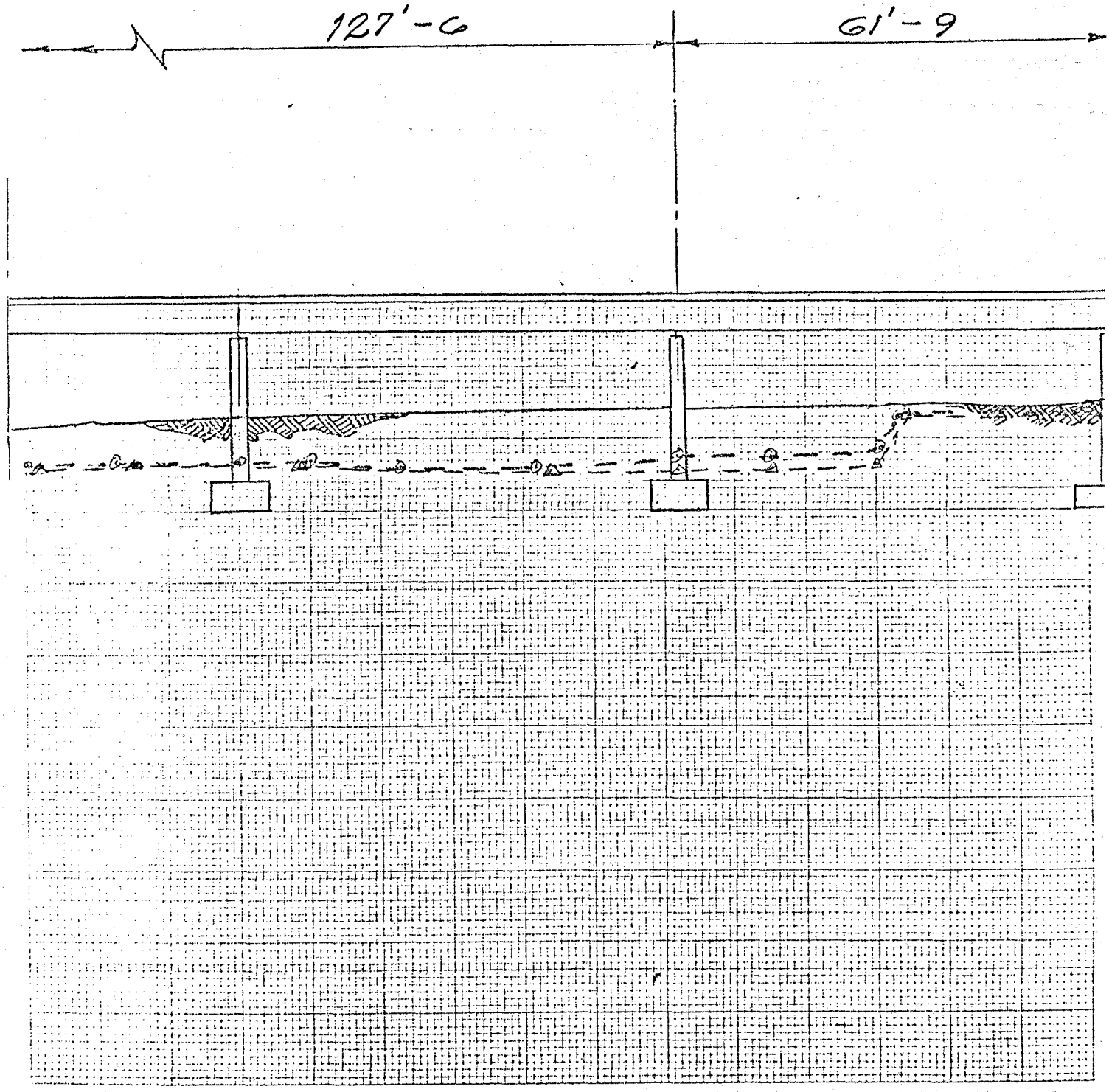
ARIZONA HIGHWAY DEPARTMENT

SUPPLEMENTAL PAGE TO BRIDGE INSPECTION REPORT

PAGE 3 OF 3

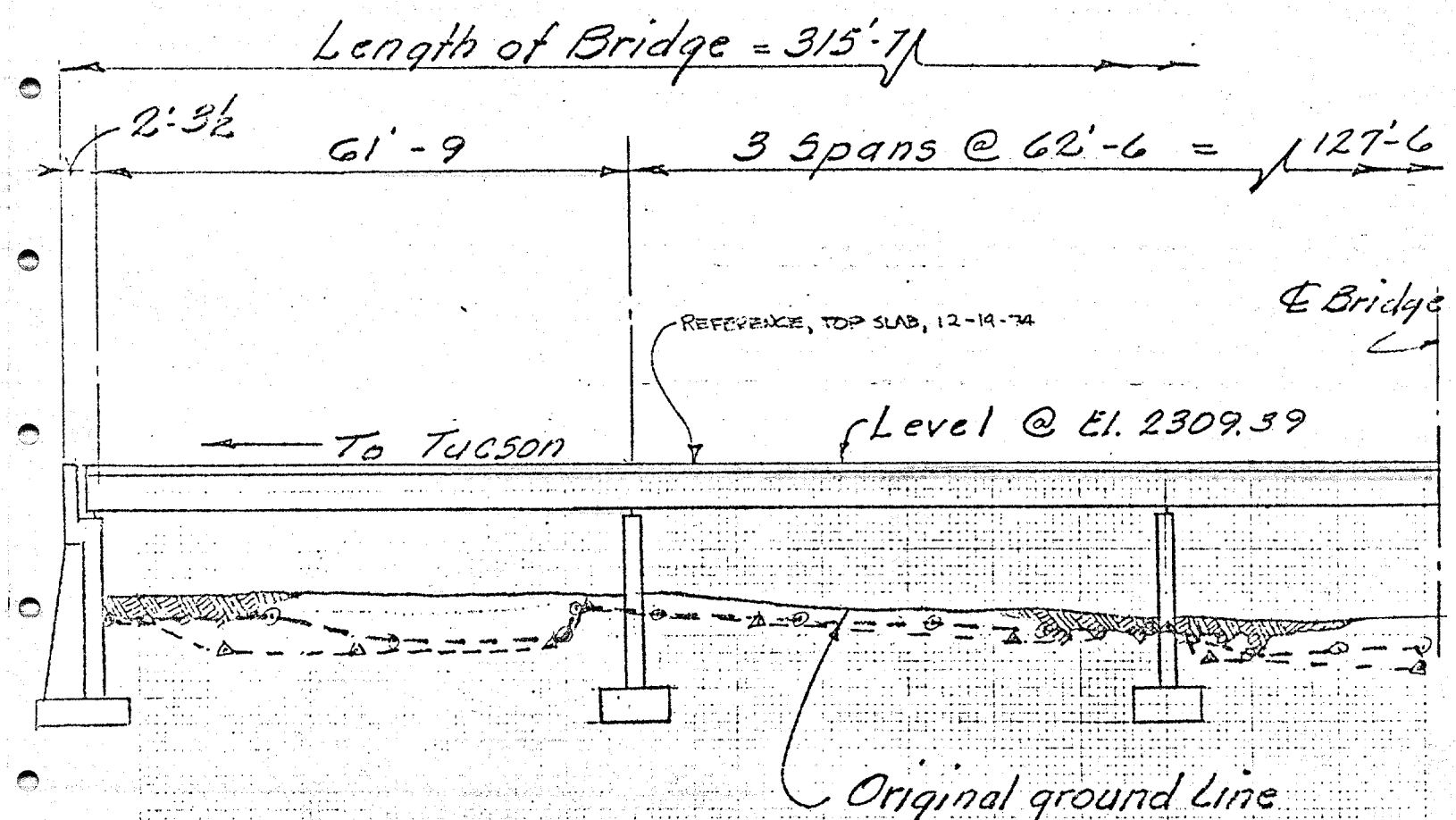
89

89-71.79(SB)



1549

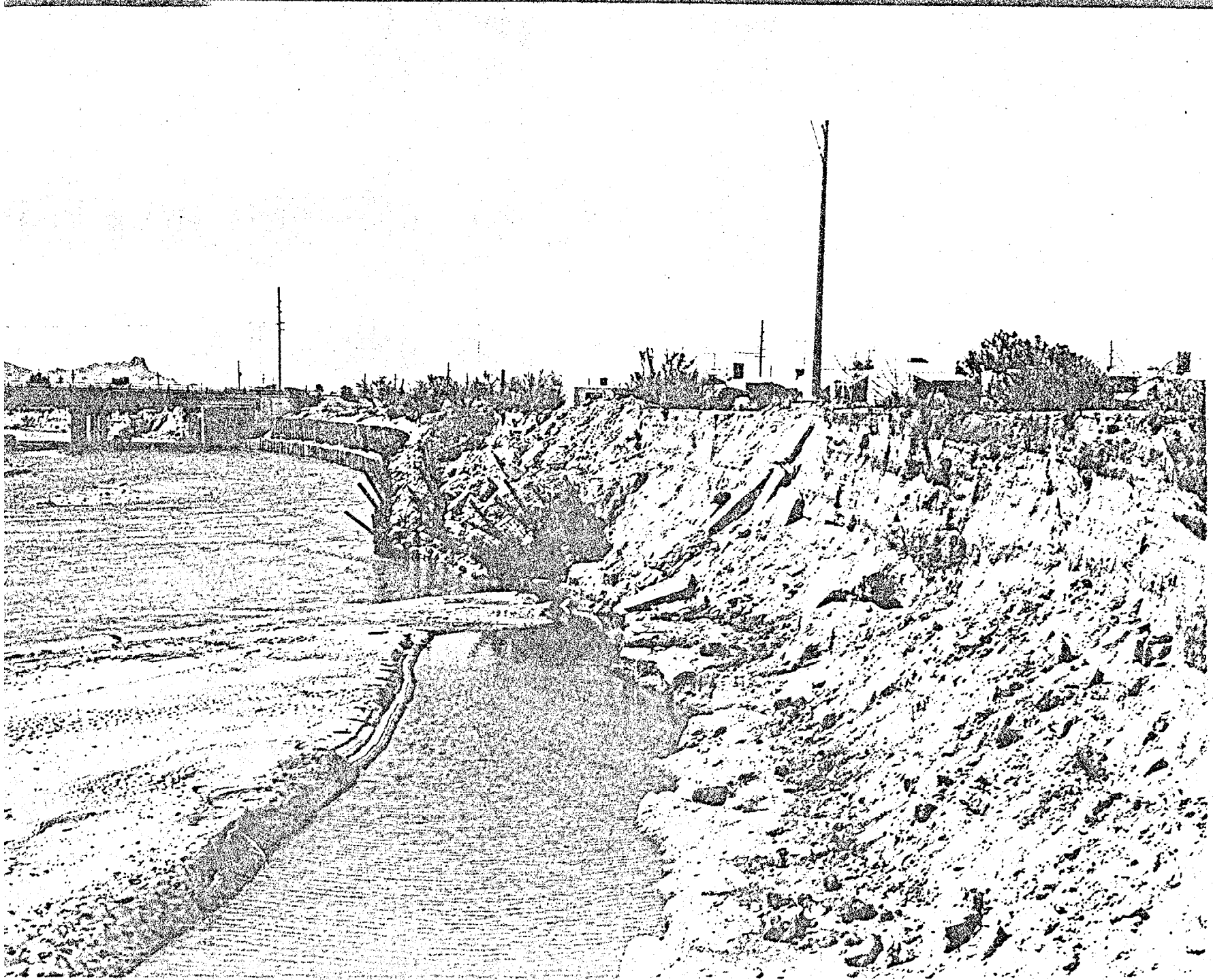
89 89-71.79(S.B.)



Note: piles not shown

No change 6-29-77
#3 GRS

10'
10'



-9305
152.62

Case History 10

Avondale Wash at SR85 near Phoenix, Arizona

Description:

This bridge is a continuous steel wide-flange girder, supported by two concrete piers. There is 12.19M of clear span.

The site is located on a small 9.14 to 18.29M wide wash approximately 45.72M downstream from five 121.92cm culverts which collect runoff from a major airport. The main channel is 1.83 to 2.74M wide and is sinuous. Banks are sloping, 1.52 to 2.44M high and the bed material is fine silt. The surrounding terrain is irrigated farmland, except for the airport. The channel has a tendency to silt in completely during periods of low flow, which is flushed out during peak flows.

Gradation Problem:

In 1937, the bridge was constructed 9.14M downstream from an existing railroad bridge, which was 1.52M higher than the road. Originally the bed was 3.05M below the girders, but by 1957, the bed was only 1.22M below the girders.

An inspection in 1969, revealed aggradation to the girder level, except for a shallow 3.05M wide channel. The bridge was causing local flooding during moderate flows. By 1973, the channel had filled to the bottom flanges of the girders, and by 1977, the upstream channel had overgrown with brush and still continued to block the waterway.

Presently, there is no change in the bed level. Some of the

overbank deposits at the railroad bridge are at the same elevati as the highway, which is creating a high potential for damage to the bridge during peak runoff.

Countermeasures:

In 1957, the bridge was widened on the original piers. Due to local flooding, the railroad company asked the state to clea a channel under the bridge.

Discussion:

There is a long-term aggradation problem at this site, possibly influenced by the culvert configuration upstream. Available supporting documentation includes recent slides, plans for 1936 and 1957, inspection reports and correspondence since 1968, progressive cross-sections, and a 1976 state photo showing upstream reach.

W18

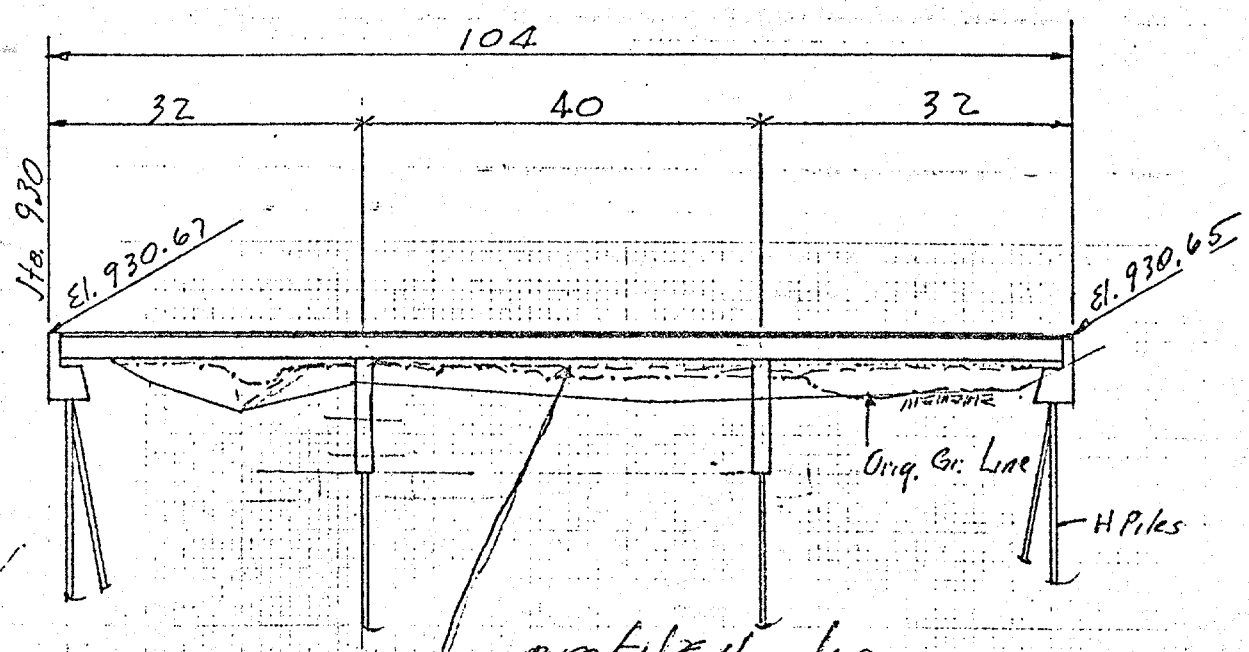
190

80

80 - 176.18

2 2

To Phoenix →



profile 1/28/69
north edge deck
UPSTREAM PROFILE 12-16-75 PJM
NO change 10-6-77 GES

Case History 11

Holy Moses Wash at US66 near Kingman, Arizona

Description:

The channel at this site is ephermal, sinuous, 22.86 to 45.72M wide, with 1.83 to 3.05 M banks which are generally side-cut. The bed material is sand and gravel, with 10.16 to 15.24cm cobbles. Bank material is sand and silt. Mesquite brush grows along the banks upstream.

This bridge is a continuous steel wide-flange girder structure supported by 6 concrete piers with spread footings. Over-all length is 76.50M with a 11.28M clear span. A railbank retaining wall protects the west abutment and the skew angle is 45°.

Gradation Problem:

The original construction was performed in 1939, and the bed level was approximately 2.44M below girders (3.05M above the pier footings). In 1969, the excavation downstream from the bridge caused the channel to degrade, exposing the footings of piers 1 and 2.

The channel then aggraded to approximately .61M above the footings at the bridge by 1972. By 1974, the channel had aggraded under end spans to within 1.52M of girders and the center part of the channel had stabilized at the level of a downstream drop structure.

Countermeasures:

Cut-off walls were installed across the channel in 1972. This caused the channel to aggrade to a satisfactory level and the cutoff walls are still effective.

Discussion:

Downstream excavation evidently caused a long-term drop in bed level at the site. After emplacement of downstream drop structures, channel aggraded and stabilized at a level about 1.52M below original construction elevation.

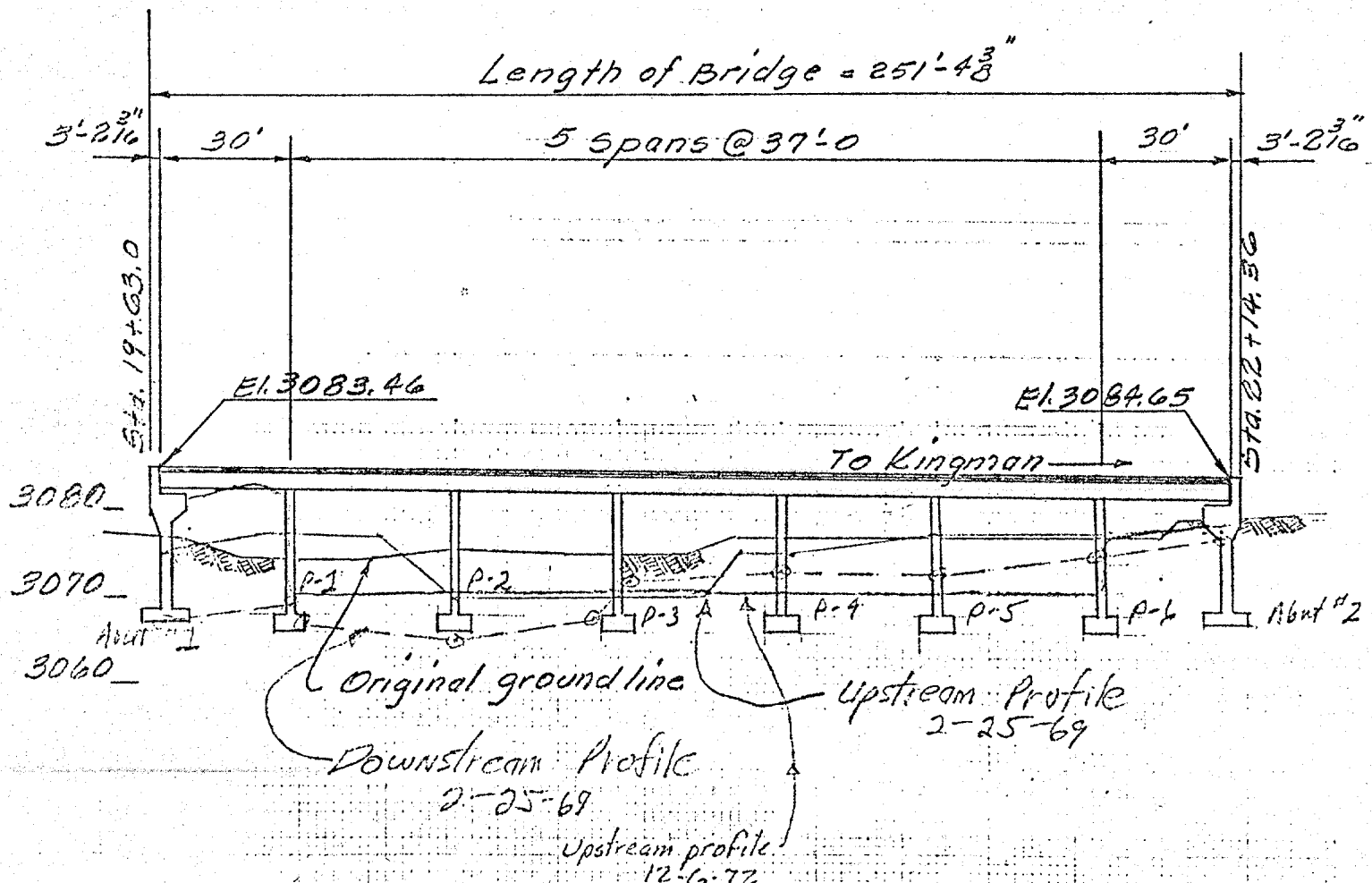
Supporting documentation includes recent slides, original plans, inspection reports and cross-sections since 1969, and pla for the cutoff wall.

247

66

66-50.30

2 3



No major changes in profile
8-8-74 AGD, GRS, RP

W19

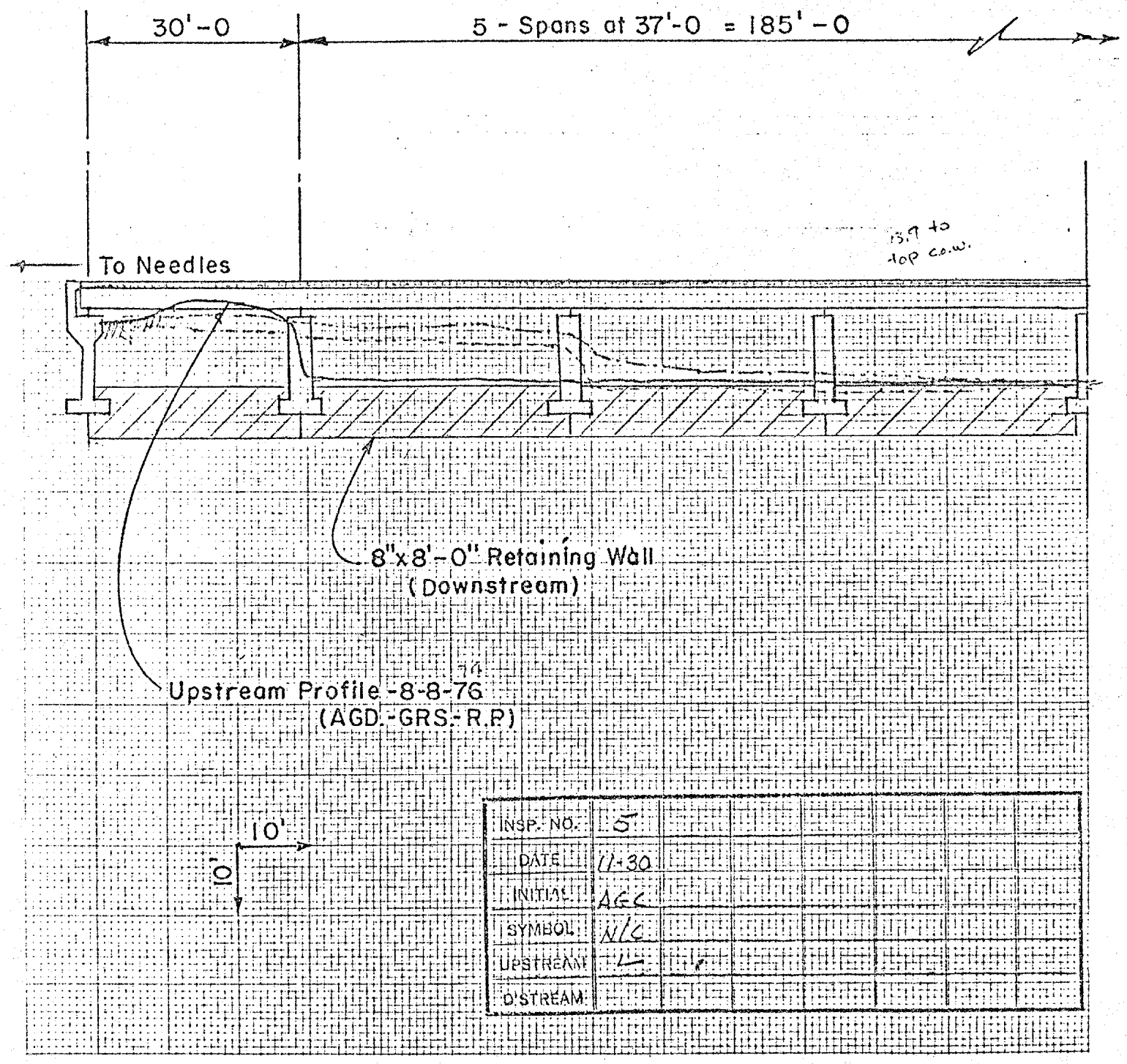
ARIZONA DEPARTMENT OF TRANSPORTATION
STRUCTURES SECTION
SUPPLEMENTAL PAGE TO BRIDGE INSPECTION REPORT

STRUCT NO. 247

DATE

LOCATION NO. 66 (ROUTE) 50.30 (MILEPOST)

NAME OF STRUCTURE HOLY MOSES WASH



INSP. NO.	5
DATE	11-30
INITIAL	AEC
SYMBOL	N/C
UPSTREAM	L
D'STREAM	

W14

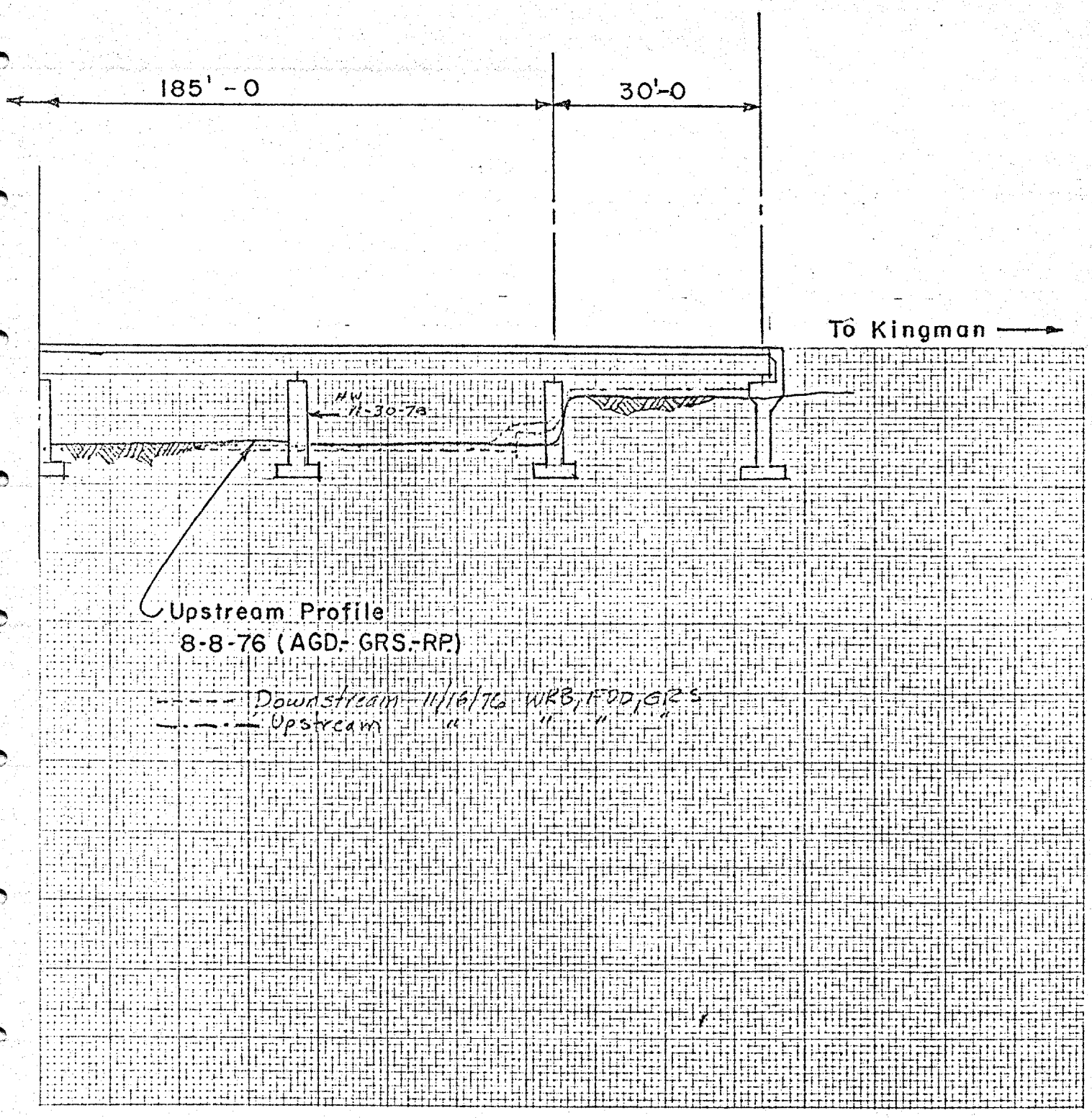
ARIZONA DEPARTMENT OF TRANSPORTATION
STRUCTURES SECTION
SUPPLEMENTAL PAGE TO BRIDGE INSPECTION REPORT

STRUCT NO. 247

DATE

LOCATION NO. 66 (ROUTE) 50.30 (MILEPOST)

NAME OF STRUCTURE Holy Moses Wash



Case History 12

Walker Creek at US160 near Mexican Water, Arizona

Description

This channel is meandering, locally braided, and has 1.52 to 3.05 M sidecut banks. During high water in Walker Creek Reservoir downstream, the backwater extends well upstream of the bridge filling the overbank channel. There is evidence of mass wasting on the banks. The overbank channel is 45.72 to 152.40M wide, and during moderate flows, the stream appears to transport large sediment loads.

The bridge is a wide flange steel girder type supported by 2 concrete piers which bear on treated timber piles. Overall length is 72.85M with a 28.35M clear span.

Gradation Problem:

The channel has experienced severe aggradation since its construction in 1961. Originally the channel was 12.19 to 15.24M below the bridge, and it is now up to within 1.52M of the bridge. The aggradation began in 1963 when Walker Creek reservoir was constructed downstream of the bridge site.

Countermeasures:

No countermeasures to date have been undertaken at this site.

Discussion:

Backwater effects from the reservoir have decreased the freeboard at the bridge to a marginal value. The aggradation can be expected to continue, depending on the reservoir pool level.

W20

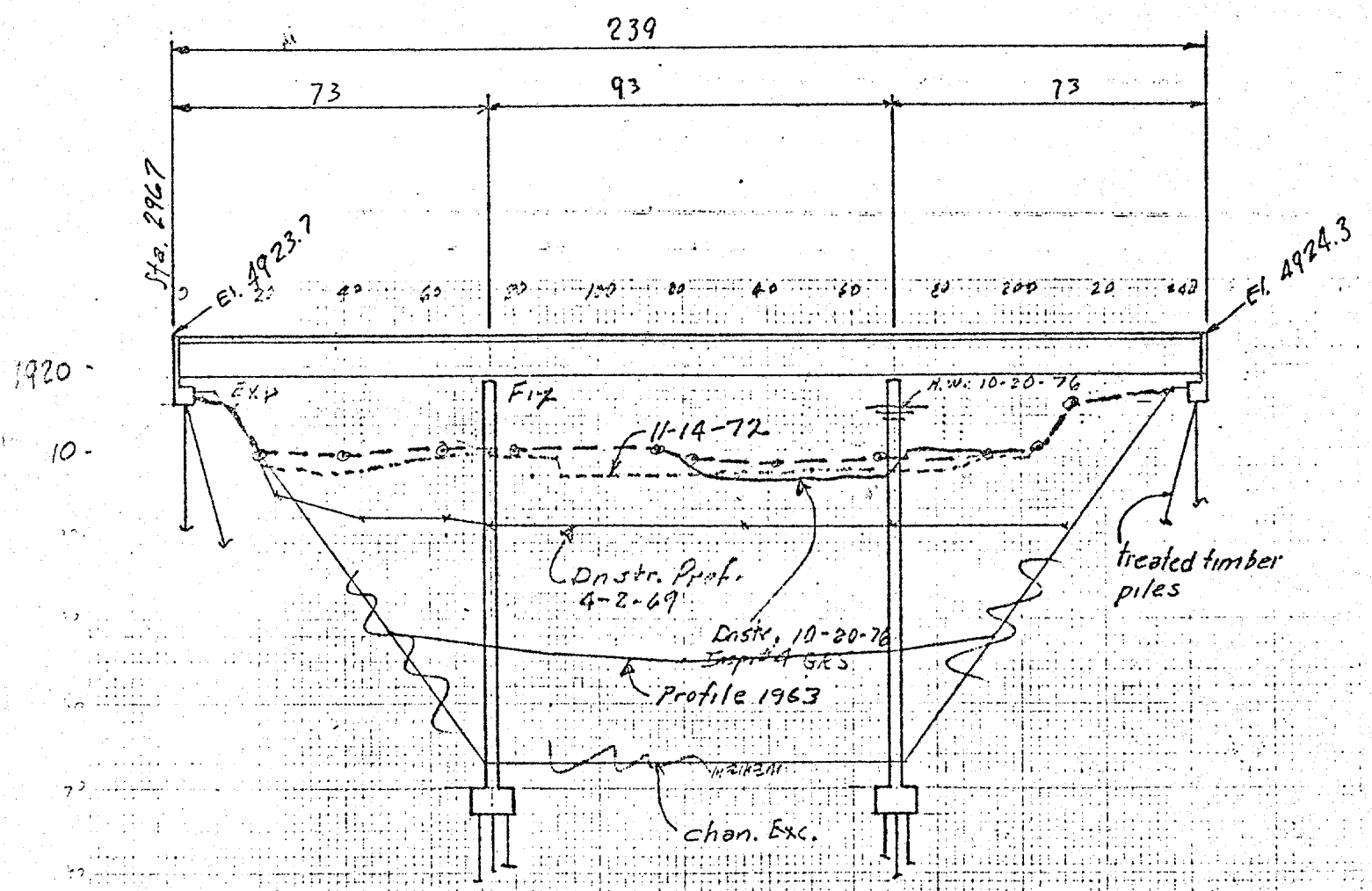
748 BRIDGE INSPECTION REPORT Page 2 2

164
164 — 435.33
W[illegible] Br.

To Tubo City →

Front of Ft. 220/9 220/19 200/22 180/22 Pier 23 100/23 Pier 23 34/22 3/6

294



DOWNSTREAM PROFILE, 8-14-74, INSP #3, GWM

10'
20'

ST. FRANCIS RIVER FLOODWAY (DITCHES 60 & 61) AT US-63 NEAR MARKED TREE, ARKANSAS

Description

Lat. 35°32', long. 90°29'. The flow in the St. Francis River is controlled by an earth fill dam, about 11.3km upstream from Marked Tree, AR. Most of the normal and flood flow from the river is then diverted through the St. Francis River Floodway (fig. 21). Ditches No. 60 and 61, flowing southwesterly, contain this diverted flow and are straight for long reaches.

Gradation Problem

A combination of sustained flows higher than design, straight channels and clear water from the diversion dam have caused general degradation to occur in Ditches No. 60 and 61.

U.S. Highway 63 crosses Ditch No. 61 and Ditch No. 60 near Masked Tree, with two bridges at each crossing. A controlled interconnection between the ditches exists upstream from the Highway crossing.

Serious degradation has been occurring on Ditch No. 61 (fig. 22) causing the Corps of Engineers to divert a larger percentage of the flow into Ditch No. 60. This increased flow has caused degradation, with resulting bank erosion and slumping, to occur in Ditch No. 60.

Countermeasures

All the U.S. Highway bridges crossing the floodway

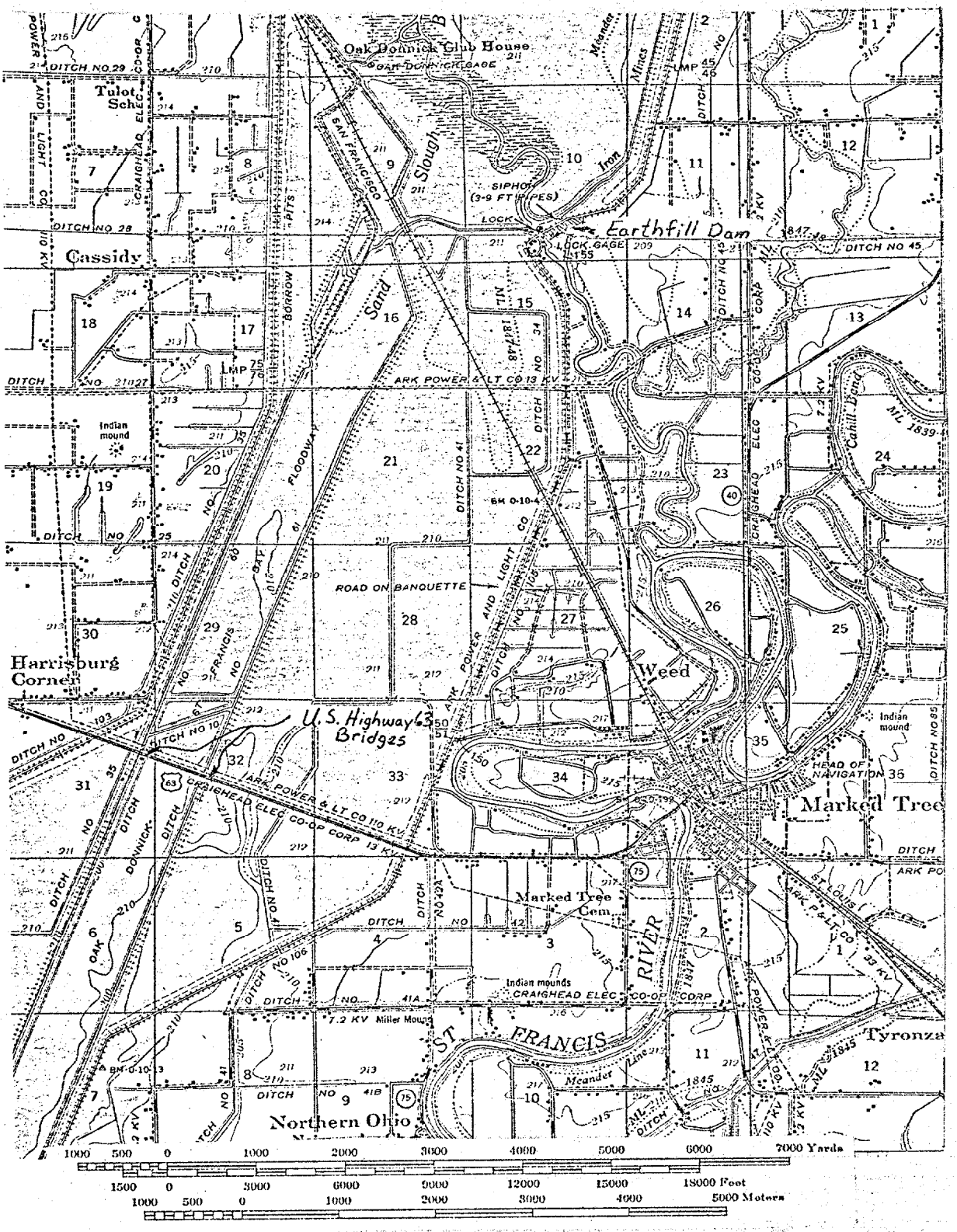


Figure 21 - St. Francis River Floodway
(Ditches 60 and 61)
Location Map Showing Highway
63 Bridges and Diversion Dam
(From M.R.C. Marked Tree, AR

FIGURE 22 NOT AVAILABLE AT THIS TIME

ditches were designed to minimize the effects of channel degradation and resultant bank erosion. It has proven necessary, however, to provide other protection such as riprap in order to protect the integrity of the bridges.

Discussion

Besides the streambed lowering directly associated with degradation, very often bank erosion and slumping will become a serious problem as a streambed lowers.

Case History 14

RED RIVER AT SH-41 BETWEEN FORMAN AND FULTON, ARKANSAS

Description

Lat. 33°35', long. 93°49' to 94°25'. The Red River in Little River County, Arkansas flows in an easterly direction until it turns southerly and flows towards Louisiana. The drainage area at Fulton is 120,433 sq km and the channel width is 275M. The river has a sand bed and has a history of rapid lateral migration as shown by fig. 19.

Gradation Problem

Large reservoirs, such as Denison Dam, have been built on the Red River and have caused channel degradation and accellerated lateral movement due to increased sediment carrying capacity resulting from clear water discharges and increased sustained flows.

Both the I-30 and the Highway 41 bridges over the Red River have experienced lateral movement and degradation of the river channel which has endangered the bridge structures. The extent of lateral migration and degradation at the Highway 41 bridge can be seen in fig. 20.

Countermeasures

Measures used to protect the banks from continued lateral erosion have included: riprap, revetment and timber pile retards. The timber retards have seemed to be the most effective with riprap being least effective.

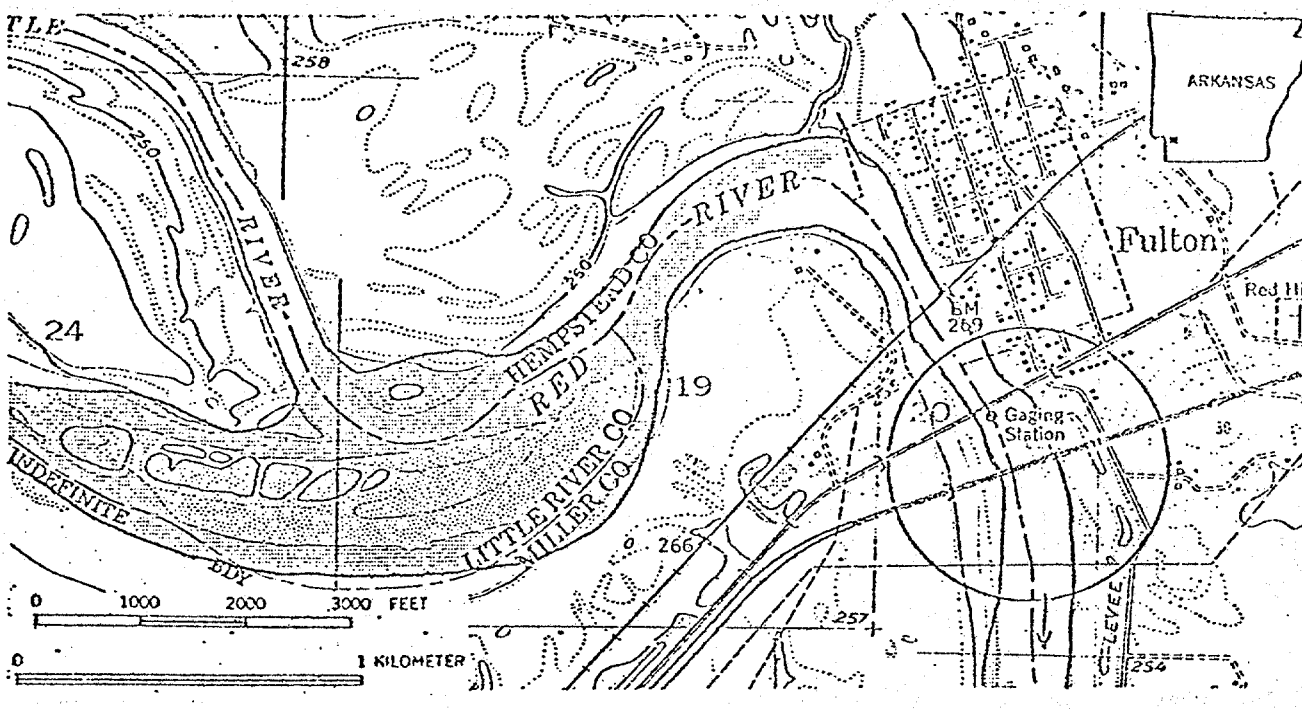


Figure 19 - Red River at Fulton, AR.
Dotted pattern indicates areas of channel change during the period 1951-1975. (From U.S.G.S. Fulton, AR. 7.5' Quad).

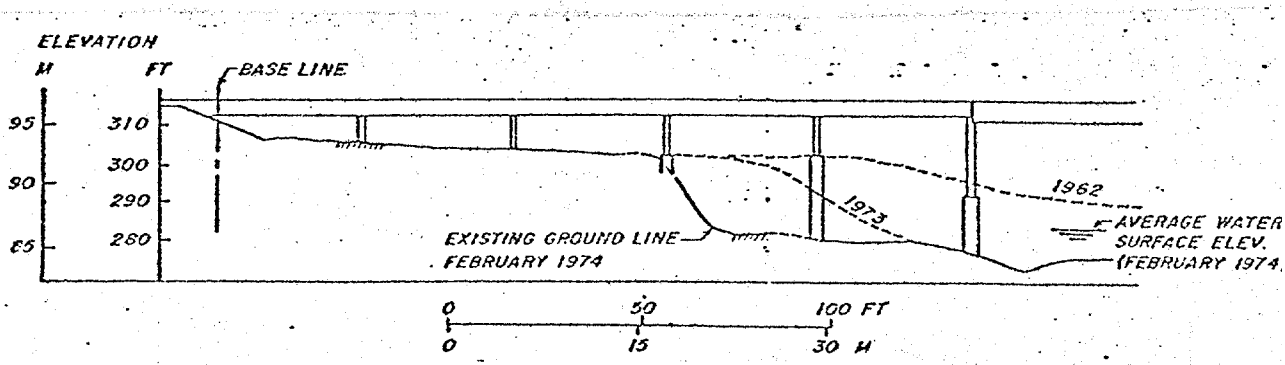


Figure 20 - Red River near Fulton, AR.
Steambed migration and degradation at Highway 41 bridge.

Discussion

In a river characterized by swift lateral movement and degradation, clear water discharges and higher sustained flows from reservoirs should be taken into careful consideration during design of structures to be placed on the river.

Case History 15

BURNT CANE LAKE AT SH-38-50 NEAR WIDENER, ARKANSAS

Description

Lat. 35°01', long. 90°38'. Burnt Cane Lake occupies an old meander scar of the Mississippi River in St. Francis County, AR.

Gradation Problem

The Highway 38-50 bridge over Burnt Cane Lake was built in the 1960's. After the building of the bridge, Round Pond Cut-off was constructed and diverted St. Francis River Floodwaters through Burnt Cane Lake (fig. 24). This diversion and channelization resulted in increased magnitude and duration of flows. Degradation of the channel occurred (fig. 25), along with the associated bank slumping, and two pile bents were seriously exposed.

Countermeasures

Nothing has been done to prevent or control the degradation. The two exposed pile bents have been "jacked down" 2.44 to 3.05M to prevent settlement of the bridge.

Discussion

Degradation of a stream channel should be suspected anytime the duration and magnitude of flow is increased over that present in the stable channel.

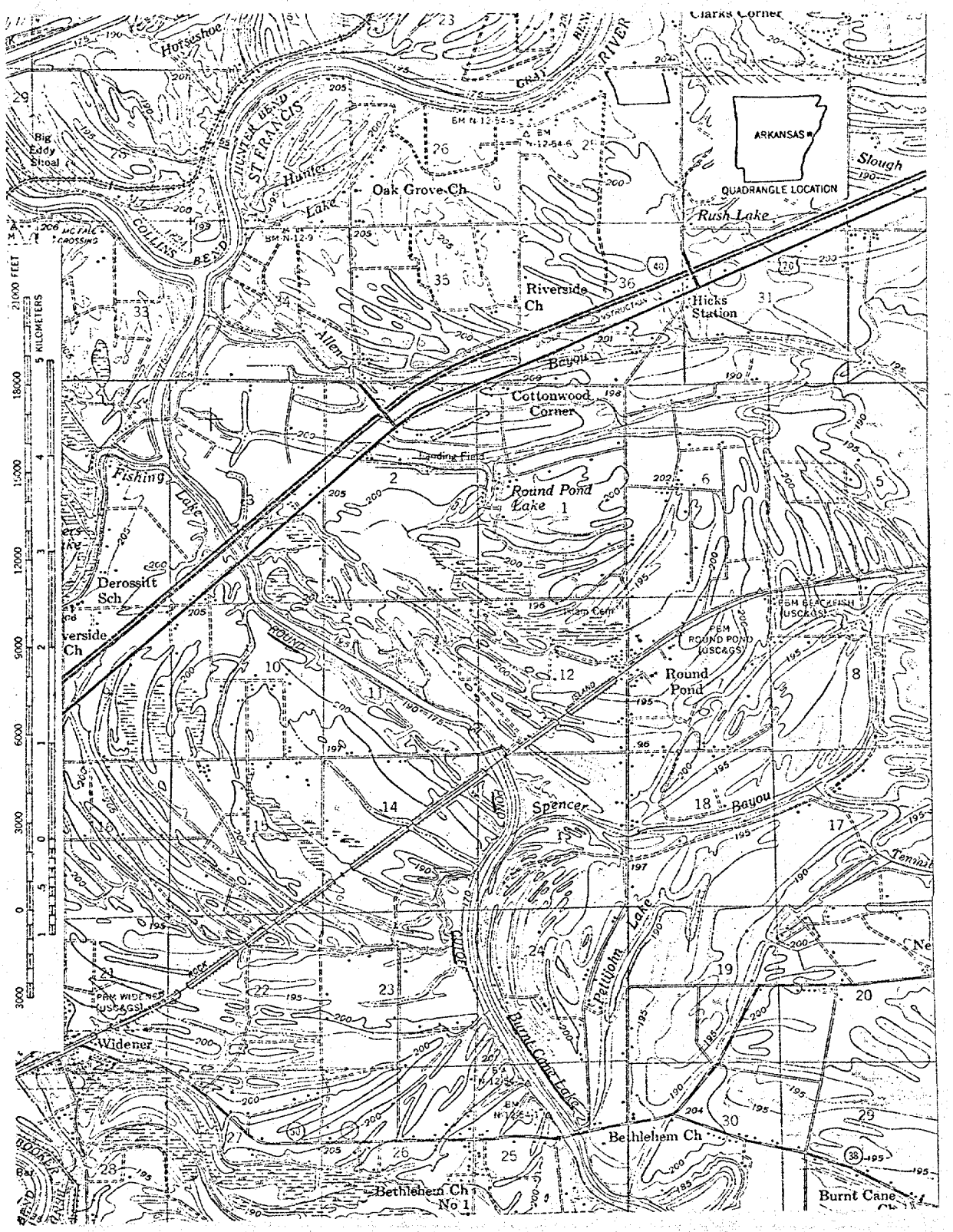


Figure 24 - Burnt Cane Lake and Round Pond Cutoff
near Widener, AR
(From U.S.G.S. Whitmore, AR 15' Quad)

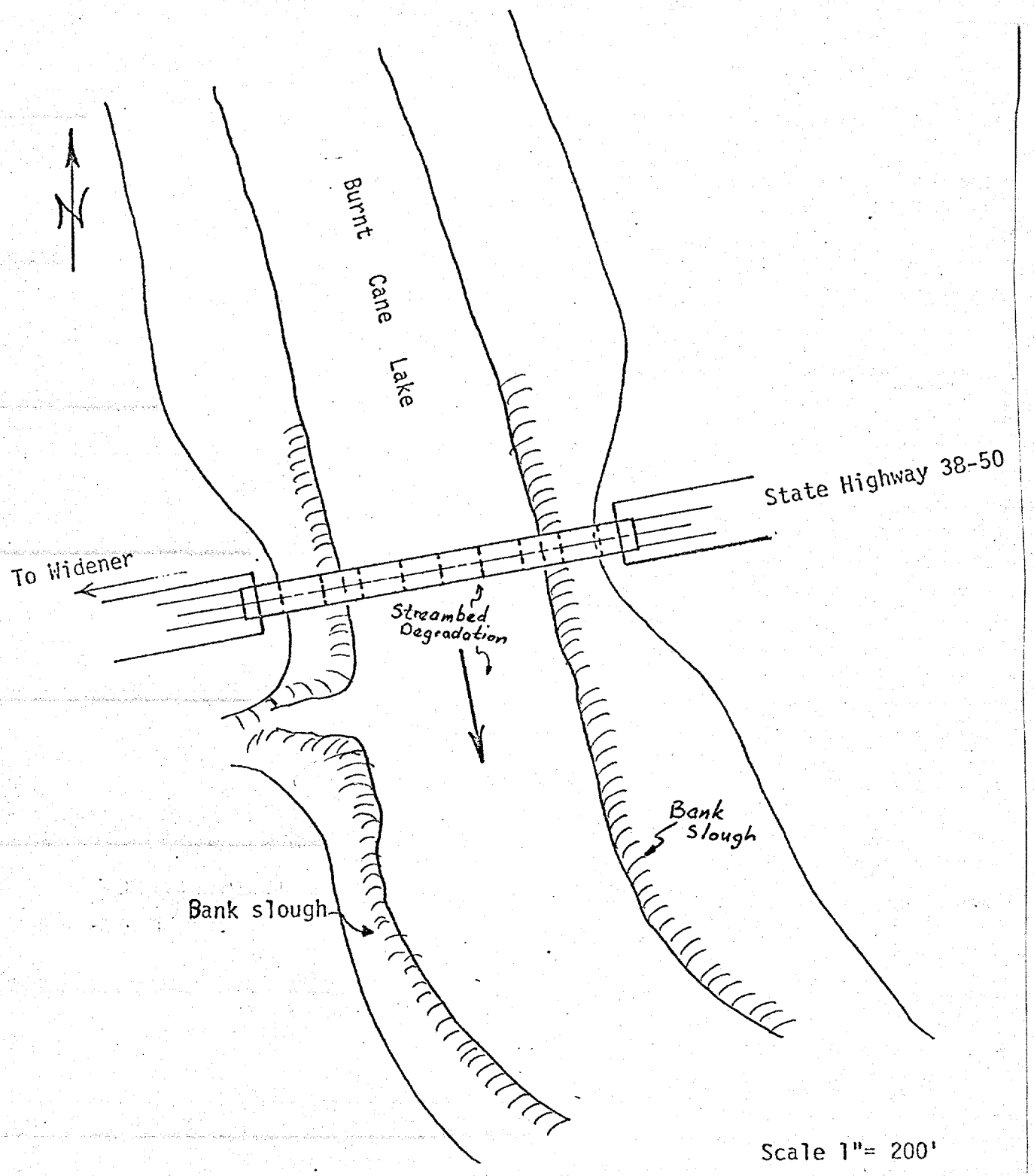


Figure 25 - Burnt Cane Lake near Widener, AR
Areas of Bank Slough and Streambed Degradation at Highway 38-50 Bridge

Case History 16

CROW CREEK AT I-30 NEAR FOREST CITY, ARKANSAS

Description

Lat. 35°02', long. 90°45'. Crow Creek in St. Francis County, AR flows in a southeasterly direction and joins the St. Francis River near Madison, AR. Loessial soils are predominant in the approximately 41.4 sq km drainage area. Bank and bed materials are composed of fine loessial silt intermixed with sand and small amounts of clay.

Gradation Problem

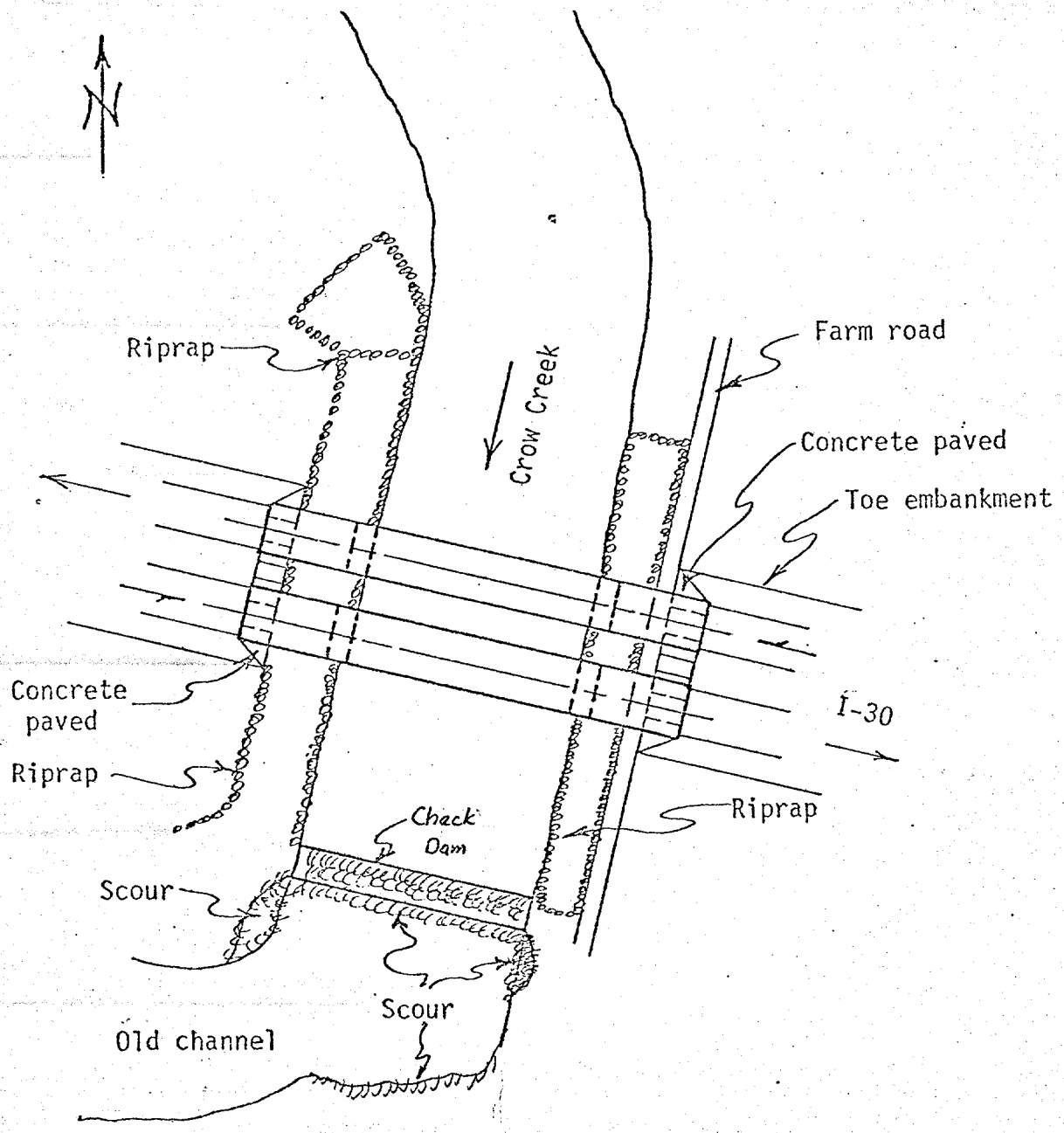
The Crow Creek channel was realigned at the time of construction of the I-40 bridges. Although not an immediate threat to the integrity of the I-40 bridges, considerable channel erosion is apparent in the stream reach.

Countermeasures

Considerable amounts of riprap were installed under the bridges and for a hundred feet or so downstream. Some of the riprap washed out and the degradation became a serious problem at which time a check dam was installed about 150 feet below the downstream bridge (fig. 23). A scour hole has developed near the center and partly underneath the check dam. The banks at the end of the dam have eroded and a scour hole is developing below the dam also. Repairs to the dam will be needed to keep it functioning.

Discussion

Care needs to be taken in the design and construction of structures in loessial soils due to their erodibility.



Scale 1"= 100'

Figure 23 - Crow Creek near Forrest City, AR.
Check dam structure at I-30 bridge.

Case History 17

SULPHUR RIVER AT US-71 NEAR FORT LYNN, ARKANSAS

Description

Lat. 33°09', long. 93°54'. The Sulphur River in Miller County, Arkansas flows southeasterly out of Texarkana reservoir until it joins the Red River near Doddridge, AR. The river is perennial, alluvial, has a silt-clay bed and is in a valley of moderate relief with a slope less than .0001. The drainage area is nearly 10,360 sq km and the channel is meandering.

Gradation Problem

The U.S. Highway 71 bridge over the Sulphur River was built in 1931 and no significant problems existed until 1953. It was in 1953 that the Texarkana Reservoir began operation, causing the normal sediment loads to be stored in the reservoir with clear water releases downstream. The clear water release coupled with sustained flows near average have greatly increased the sediment carrying capacity of the Sulphur River.

Due to the increased sediment carrying capacity, the channel has degraded and lateral erosion endangering the bridge has occurred (fig. 18).

Countermeasures

Huge quantities of riprap have been placed to attempt to stabilize the bank with little success. Timber-pile bulkheads have been installed along the bank and seem to

be holding temporarily with plans under consideration for lengthening the bridge.

Discussion

Riprap is an ineffective method of bank stabilization when care is not taken in sizing and placing. Banks must be cut back to prevent slumping or the riprap will not remain in the proper position to prevent lateral erosion. Surface fissures in the soil along streambanks can be used to indicate a susceptibility to slumping which can then be allowed for in the design process.

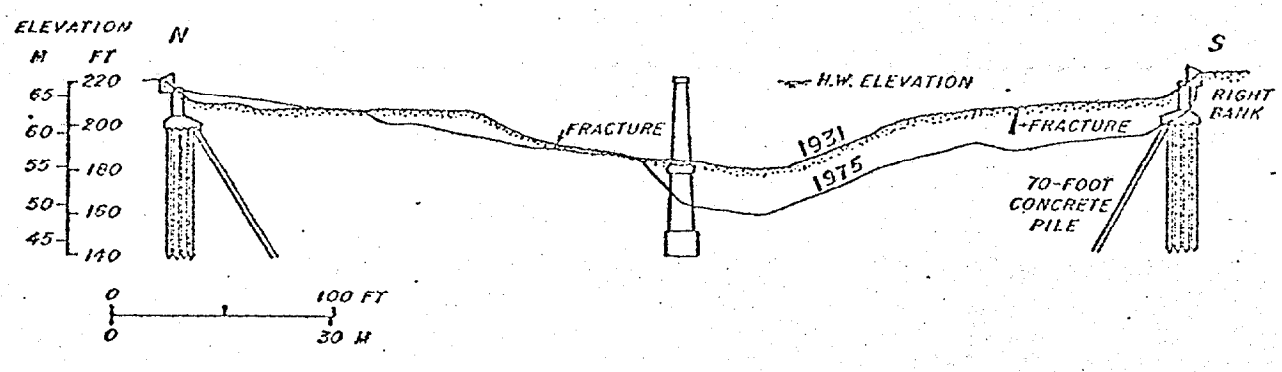


Figure 18 - Sulphur River near Ft. Lynn, AR. Streambed degradation at U.S. Highway 71.

Case History 18

BOEUF RIVER AT SH-144 NEAR LAKE VILLAGE, ARKANSAS

Description

Lat. 33°20', long. 91°22'. The Boeuf River in Chicot County, Arkansas flows in a southwesterly direction into Louisiana where it eventually joins the Red River. The drainage area is 919.5 sq km with a valley slope of .0004. The stream is perennial, alluvial, in a valley of low relief with a wide flood plain. The banks are tree covered on 50-90 percent of the bankline with a sand-silt streambed.

Gradation Problem

The Boeuf River has been straightened and channelized in the reach near Lake Village which created a degradation problem in the reach.

The U.S. Highway 82 bridge over the Boeuf River was built in 1944. The streambed began degrading, necessitating countermeasures in the form of a sheet pile check dam.

The Highway 144 bridge over the Boeuf River, near McMillan Corner, has much the same history as the U.S. Highway 82 bridge.

Countermeasures

At some time after the construction of the bridges, a sheet pile check dam was built just downstream from each bridge to slow down the degradation of the river. Soon afterwards, erosion of the channel bed and banks began downstream from the check dams. Large pools have formed

into which the banks are slumping and receding towards the bridge (fig. 17). Rock riprap placed on the channel banks at the pool has not controlled the bank erosion problem because it is probably too small and on too steep a slope.

Discussion

The check dams have protected the two bridges from the streambed degradation but have caused a bank recession problem downstream that may endanger the bridge abutments. This points out the necessity of careful study and design before measures are taken to control degradation if problems caused by the countermeasures are to be reduced.

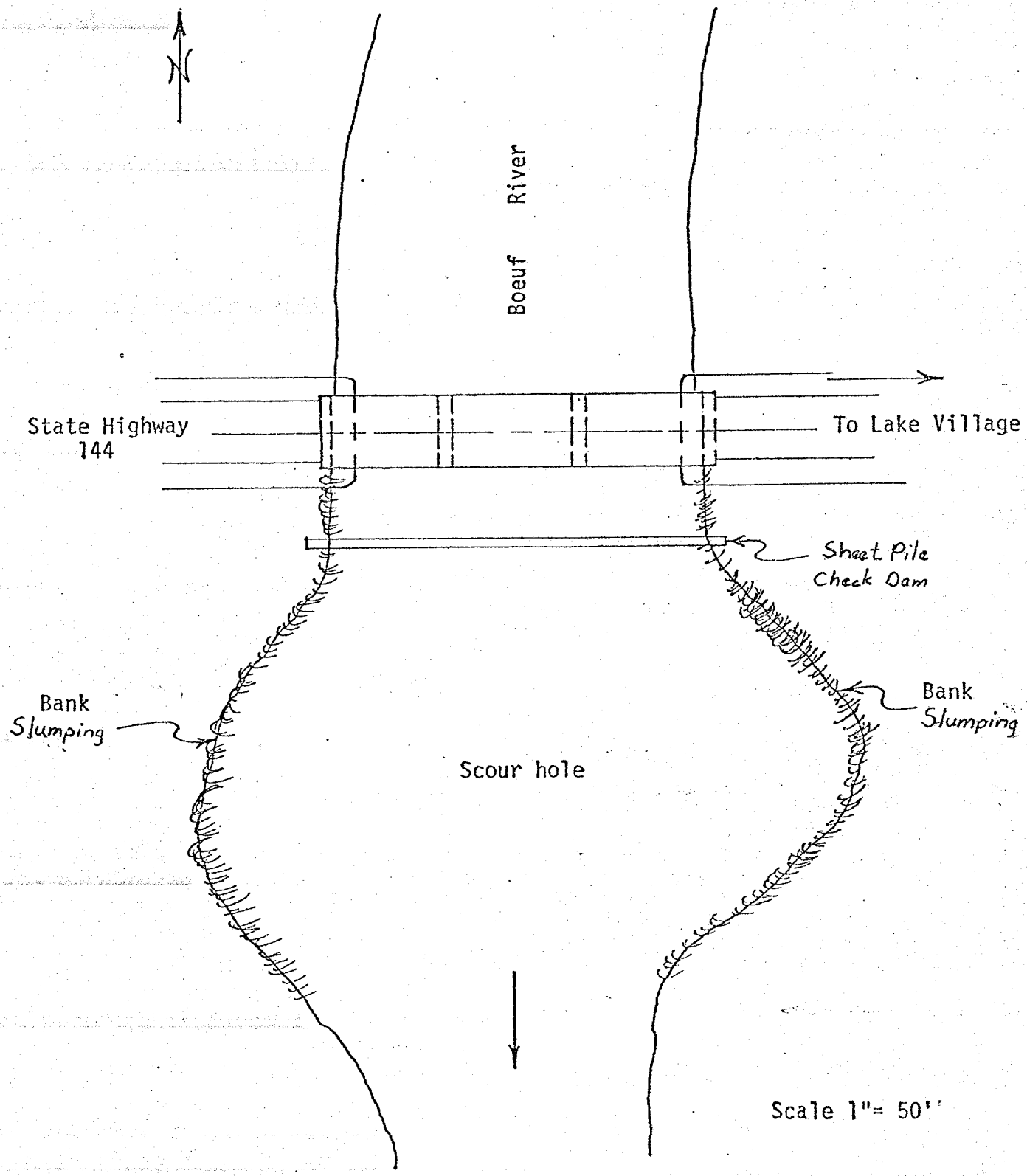


Figure 17 - Boeuf River near Lake Village, AR.
Typical scour hole below Check Dam.

Case History 19

Stillwater Creek at SR299 near Redding, California

Description:

This bridge is a continuous RC slab on wall piers with concrete piles. The over-all length is 45.42M with a 12.80M clear span.

The channel bed is made up of coarse aggragate with some exposed bedrock.

Gradation Problem:

Between the data of construction (1955) and 1964, no significant problems were encountered. However, in 1964, a flood exposed the footings and washed away sacked concrte. The bed level dropped to the bottom of one footing.

1969 photos show the bottoms of the footings exposed, and the slope protection undermined.

1974 brought continued scour problems around footings, expecially on the western end of the bridge.

Countermeasures:

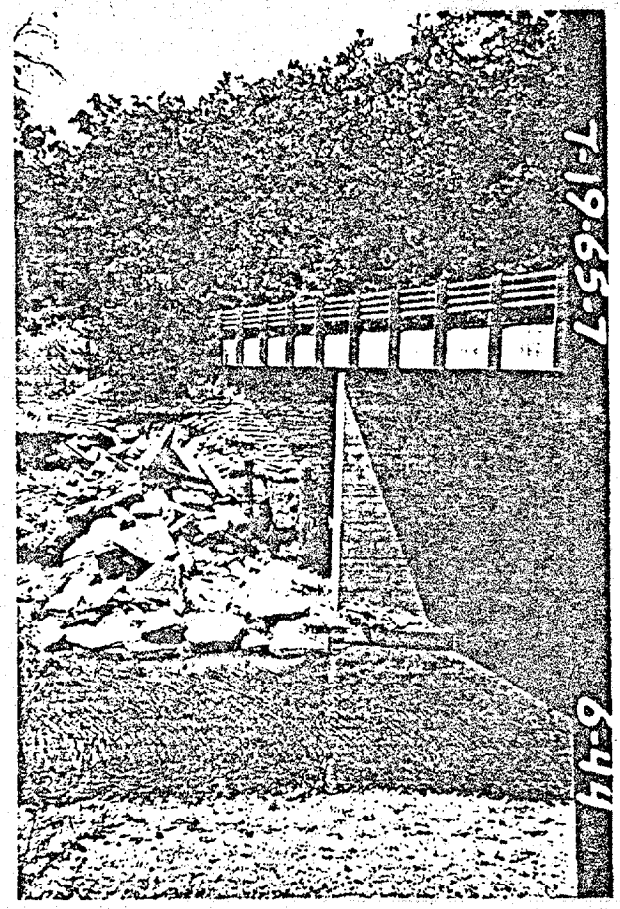
Only minor repair work was done up until 1974. After the flooding of 1974, the abutment scour and bed degradation on the western bridge end endangered the structures integrity. Large rock riprap was placed along the toe of the concrete slope pavement and into the cut channel between the abutment and first pier. In 1976, there was still .61 to .91M of scour around the above pier, and degradation appeared to be mitigating downstream. However, no additional corrective measures have been taken to date.

Discussion:

This site is considered to be typical of maintenance problems

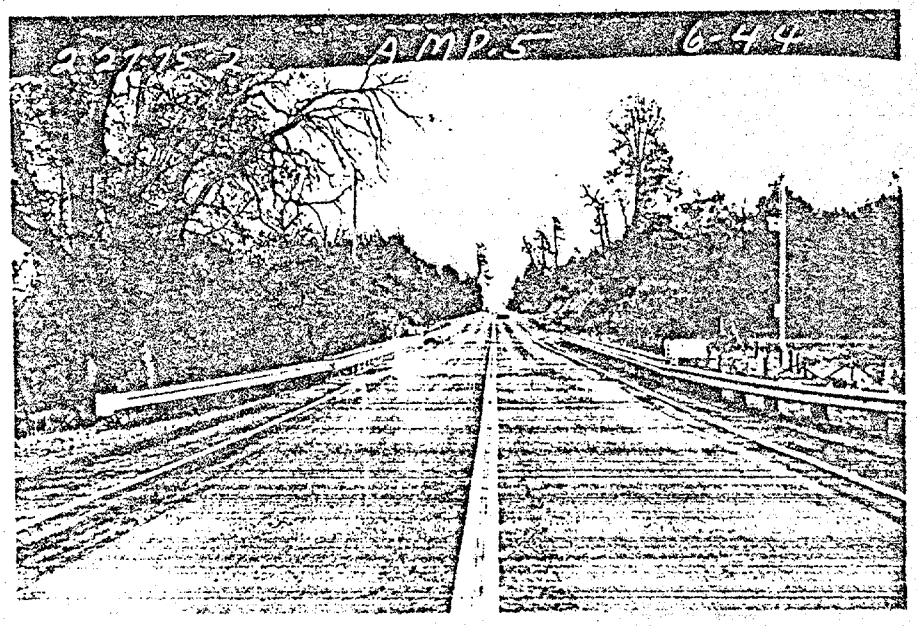
encountered in the Redding area. State personnel attribute the degradation to increased velocity due to highway encroachment and to continual aggregate mining. Also, the 1974 flood seems to have triggered a general degradation trend in the area. Since that time, no form of bank or pier protection has been truly effective. Replacement of riprap has become a continuous activity in the district. The channels in the Redding area are characterized as unstable and degrading, with a potnetial for serious bridge problems in the future.

STILLWATER CREEK

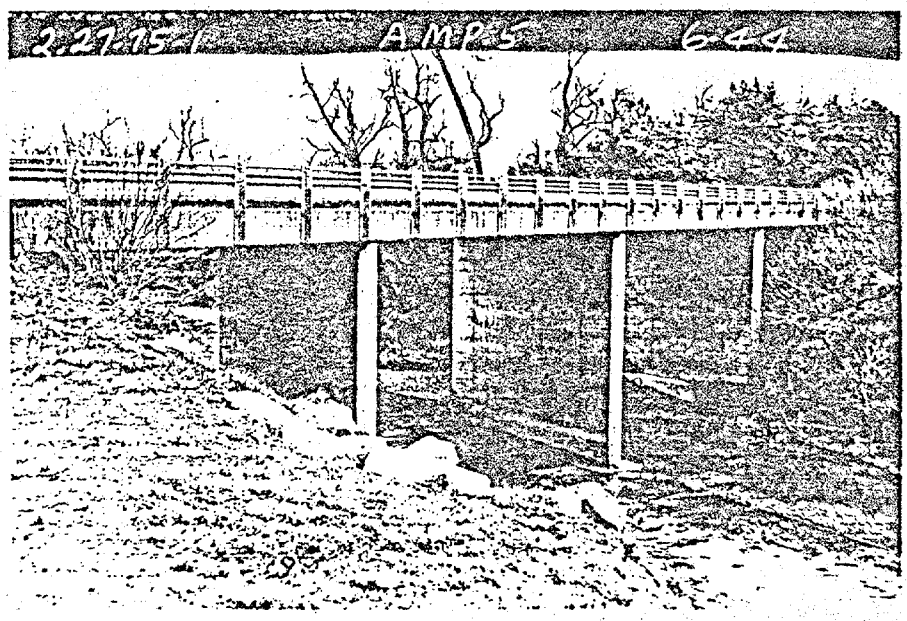


Riprap on right side of abutment-1

STILLWATER CREEK



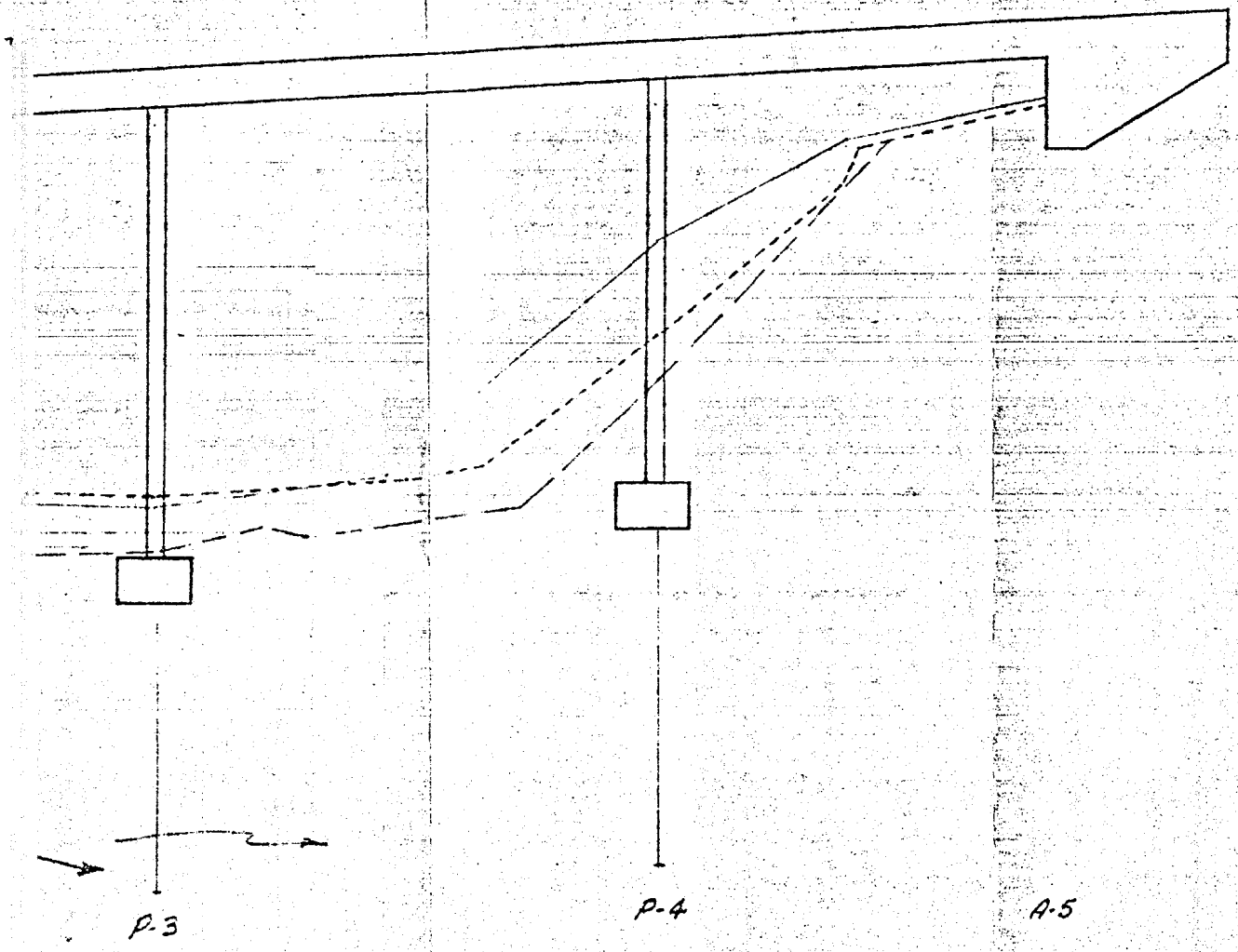
Roadway view looking ahead



6-44 6-44

DIST.	COUNTY	ROUTE	POST MI
02	Sha	299	27.9

Channel Profile @ Upstream Side



Case History 20

SMITH RIVER AT US-101 NEAR CRESCENT CITY, CALIFORNIA

Description

The bridge is constructed of RC continuous slab approach spans, and welded steel plate girder center spans. Some piers are on piles, while others are on spread footings. The clear span is 54.86M.

The channel is alluvial, with sand, gravel and large cobbles. The site is considered to be in the tidal zone.

Gradation Problem

Original construction was completed in 1940, and a 1966 report noted erosion under the southwest corner post and the cantilevered end sections.

By 1972, the bed had degraded 2.74M to the level of at least one footing. Both banks had also been eroded.

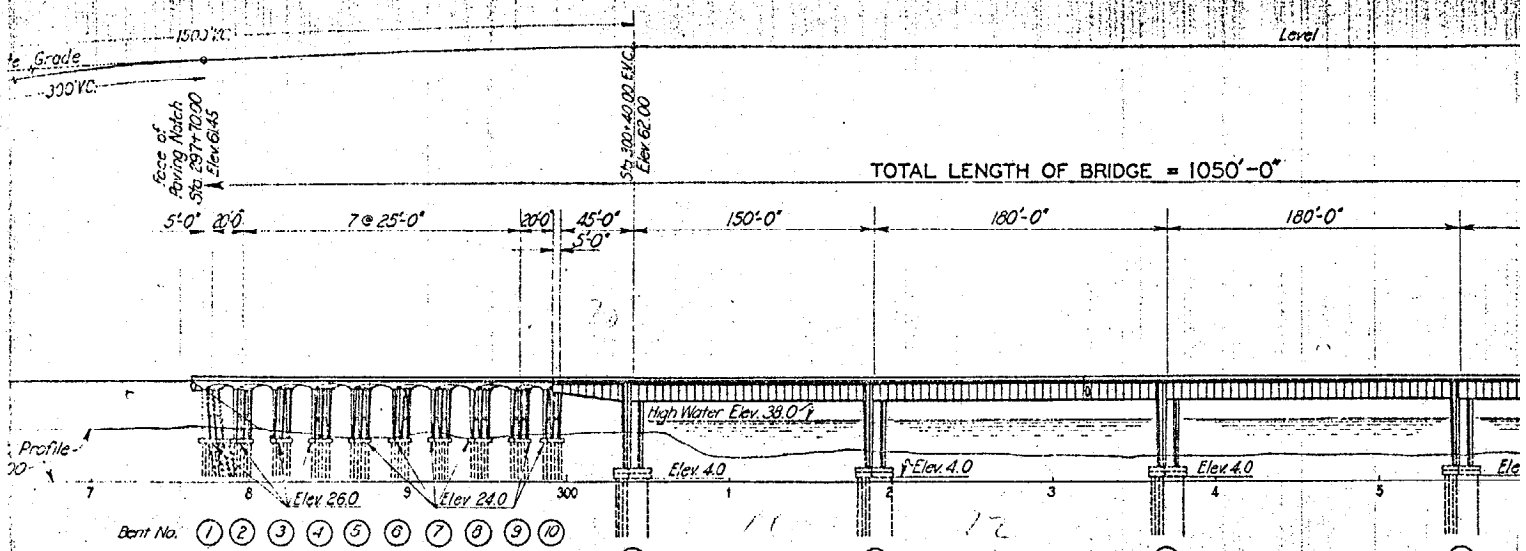
Subsequent inspection in 1972 indicates that the channel had degraded 4.88M in some places. However, inspections in 1974 noted that the bed of the river had partially stabilized and further scour at the footings had ceased.

Countermeasures

Sheet piling and concrete were emplaced around the footing in 1972. These measures were only partly successful.

Discussion

The maintenance efforts in 1974 seem to have controlled the degradation problem at the spread footings. Also, the channel bed appears to be stabilizing. State maintenance personnel attribute this to the termination of the upstream gravel mining.



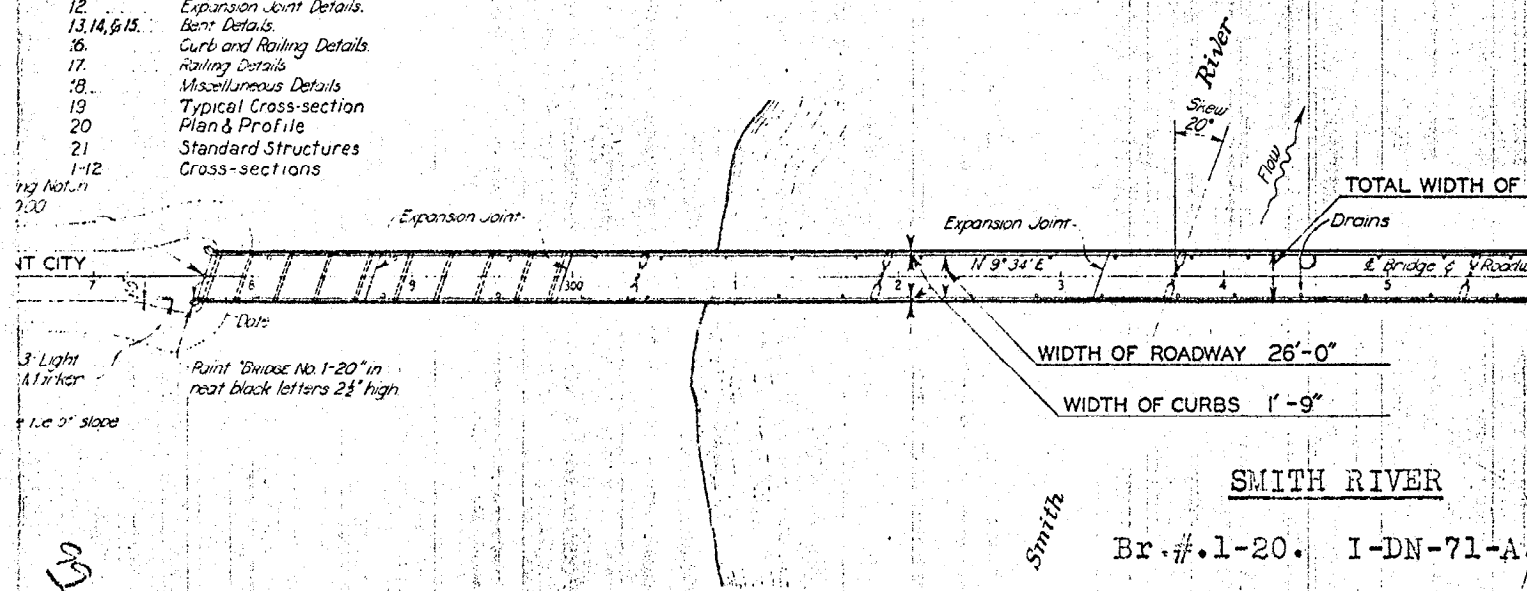
Note:-
Cast-in-place concrete piles in Bents No. 1 to 10 inclusive. Estimated length = 30'.

Note:-
Length of Steel "H" Pile estimating purposes = 4
Piers No. 11 to 15 inclusive.

ELEVATION

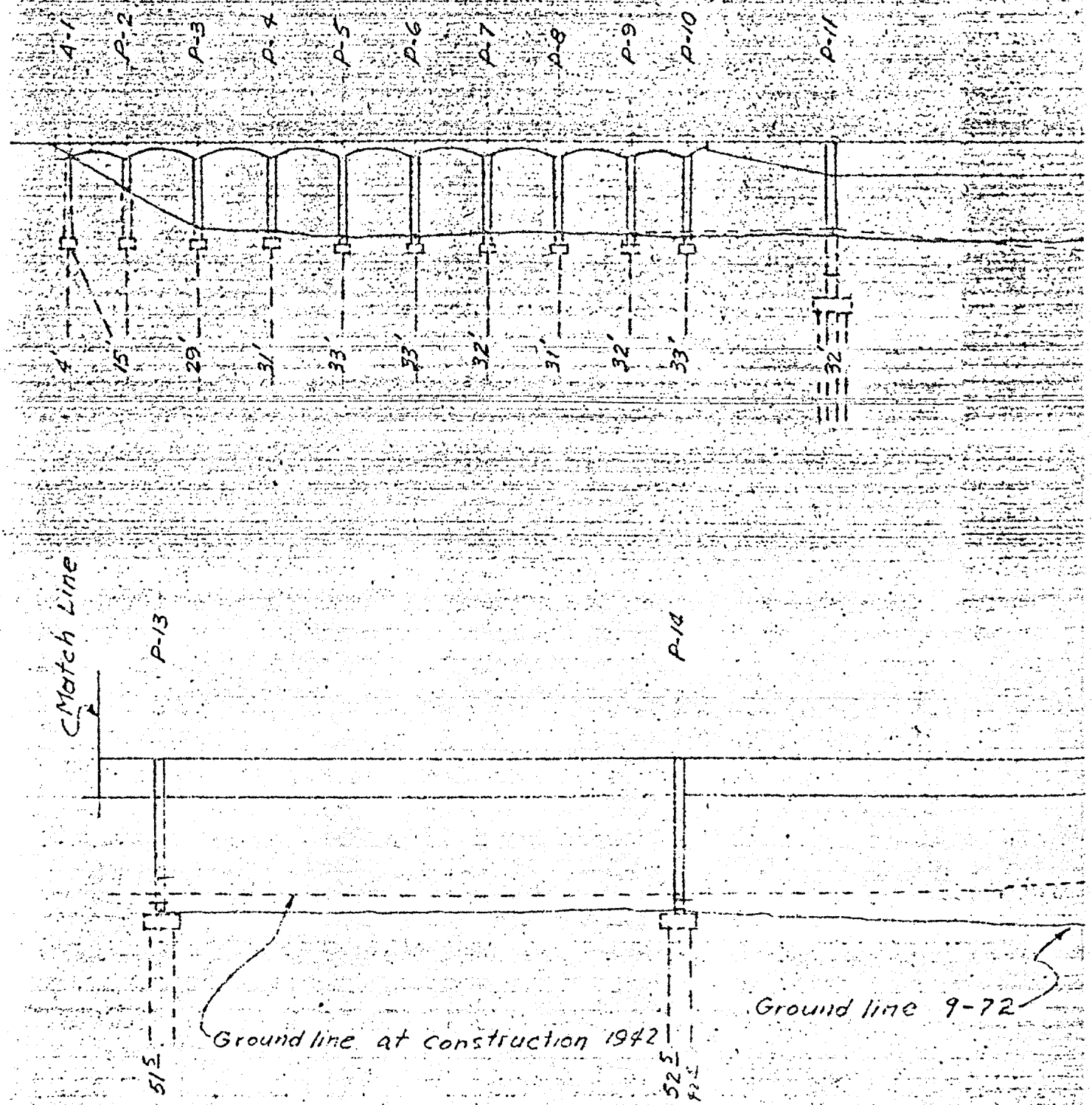
INDEX TO PLANS

SHEET NO.	TITLE
1	General Plan.
2	Foundation Plan.
3	Typical Section, Steel Spans.
4 and 5	Deck Slab- Approach Spans
6	Pier Details.
7	End Diaphragm Details.
8	Girder Layout.
9	Girder Layout Continued.
10	Girder Splice and Hinge Details.
11	Anchorage and Other Details.
12	Expansion Joint Details.
13, 14, & 15	Bent Details.
16	Curb and Railing Details.
17	Railing Details
18	Miscellaneous Details
19	Typical Cross-section
20	Plan & Profile
21	Standard Structures
1-12	Cross-sections



SMITH RIVER

Br. #. 1-20. I-DN-71-A



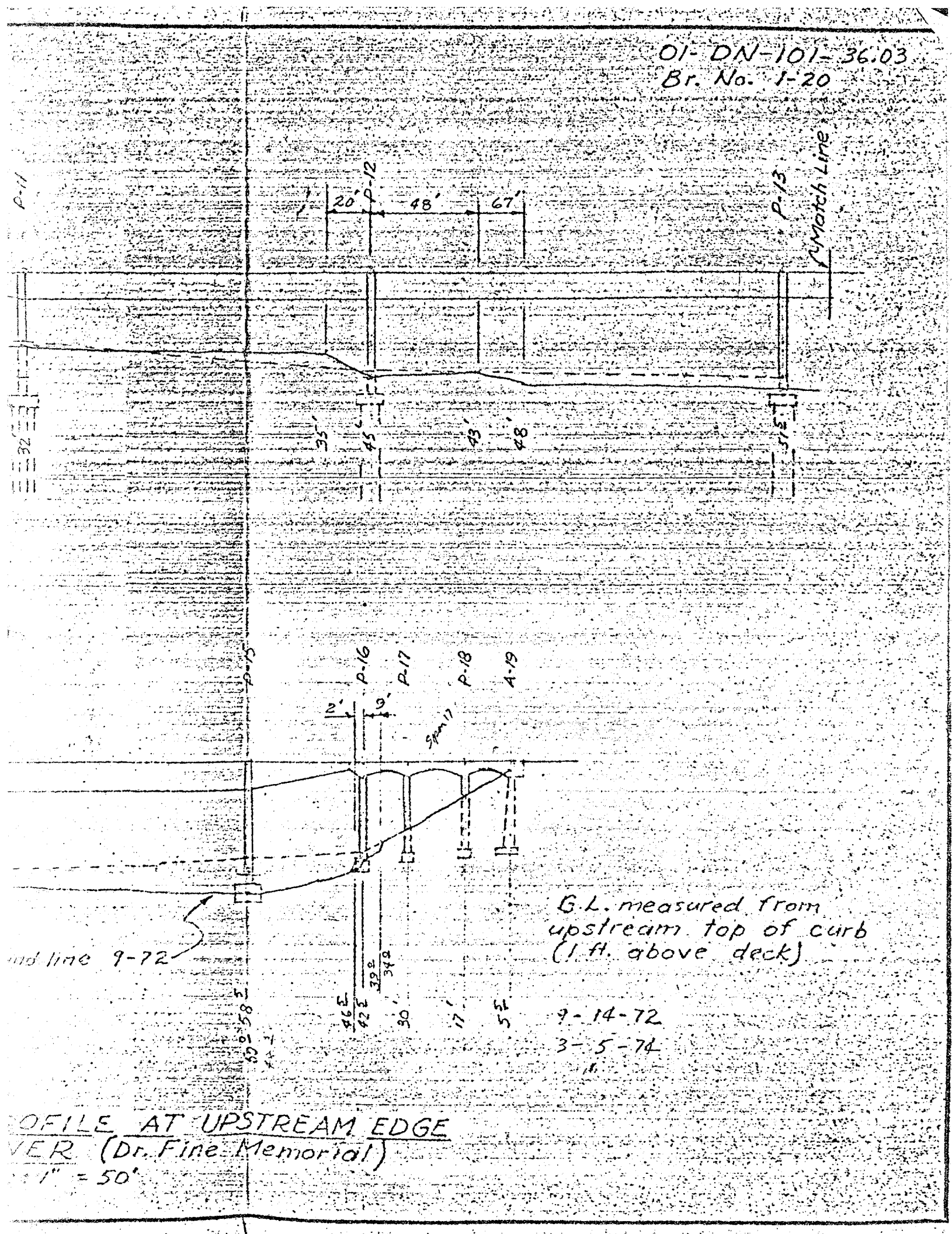
CHANNEL PROFILE AT U
SMITH RIVER (Dr. Fine

Scale: 1" = 50'

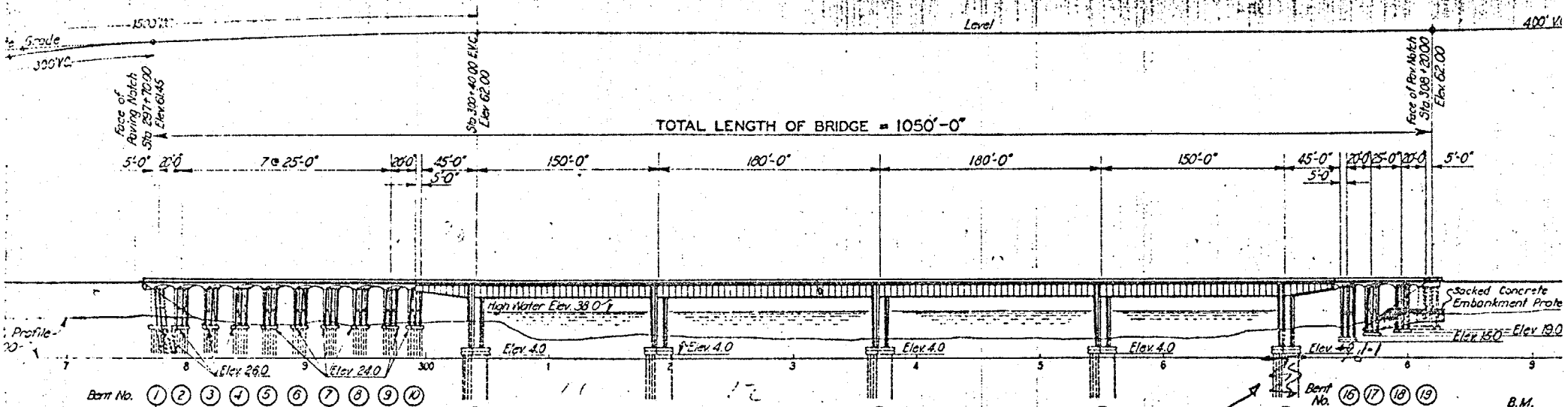
D. J. 9-25-72

BD 108

01-DN-101-36.03
Br. No. 1-20



OFILE AT UPSTREAM EDGE
VER (Dr. Fine Memorial)
1" = 50'



INDEX TO PLANS

SHEET NO.	TITLE
1.	General Plan.
2.	Foundation Plan
3.	Typical Section, Steel Spans.
4 and 5	Deck Slab - Approach Spans
6	Pier Details.
7	End Diaphragm Details.
8.	Girder Layout.
9	Girder Layout Continued.
10.	Girder Splice and Hinge Details.
11.	Anchorage and Other Details.
12.	Expansion Joint Details.
13, 14, & 15.	Bent Details.
16.	Curb and Railing Details
17.	Railing Details
18.	Miscellaneous Details
19	Typical Cross-section
20	Plan & Profile
21	Standard Structures
1-12	Cross-sections

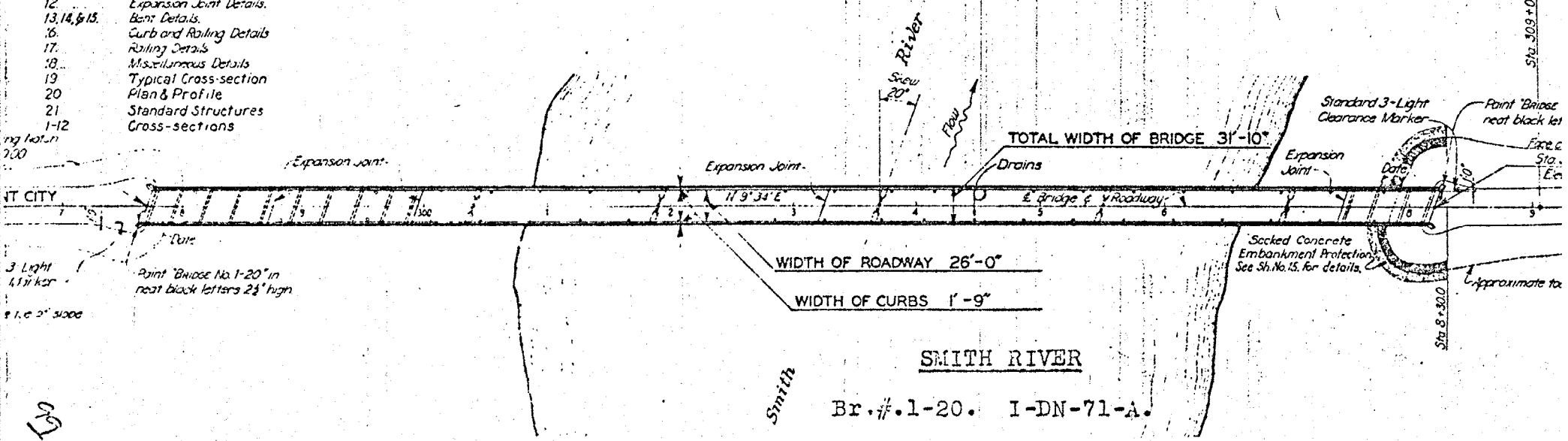
Note:- Cast-in-place concrete piles in Bents No. 1 to 10 inclusive. Estimated length = 30'.

Note:- Length of Steel "H" Piles for estimating purposes = 40'., Piers No. 11 to 15 inclusive.

Piles eliminated during constr. & footing lowered

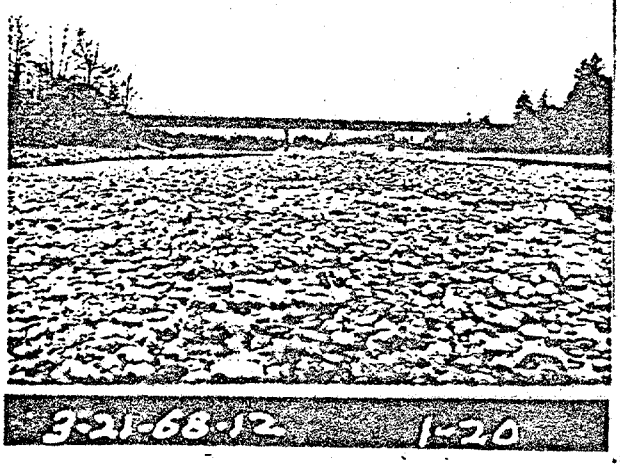
B.M. Elev. 31.49 on 18" sh 25' Rt. of Sta. 297 Elev. 53.68 on 18" o of Sta. 311+30.00

ELEVATION

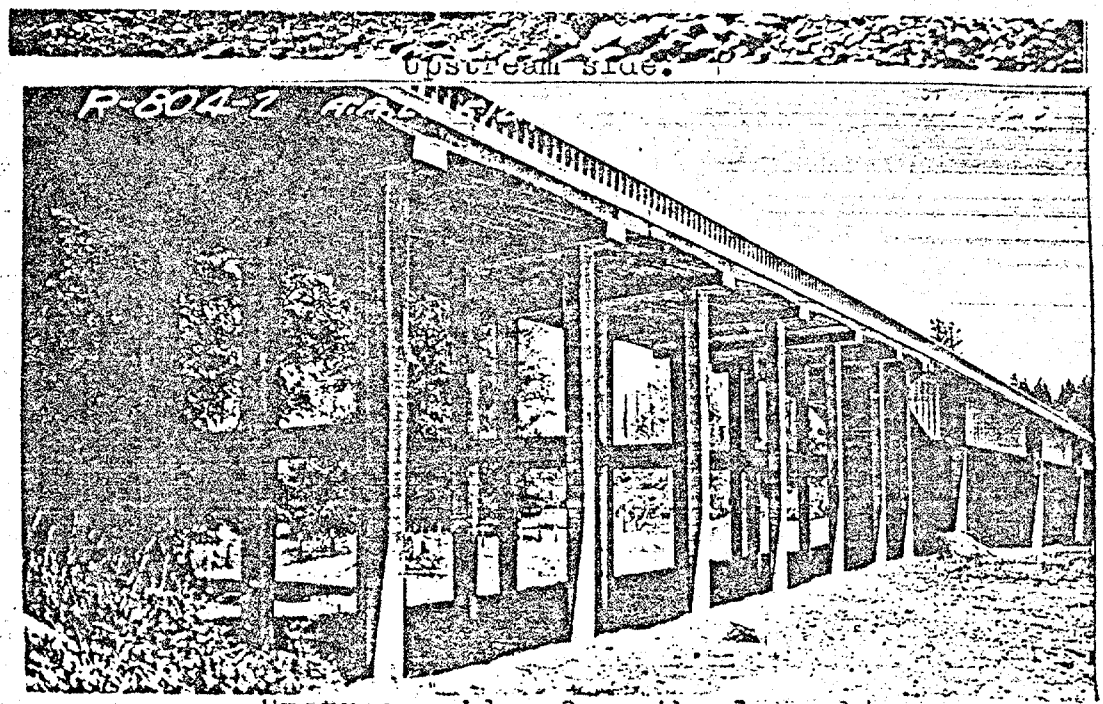


SMITH RIVER

Br. #. 1-20. I-DN-71-A.



Sideview looking
west-downstream

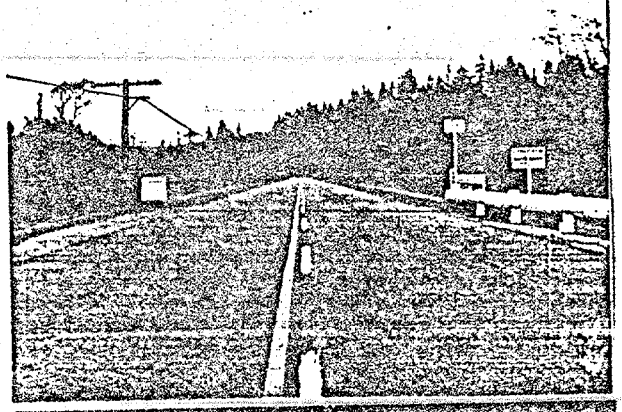


Upstream side.

Upstream side of southerly end.

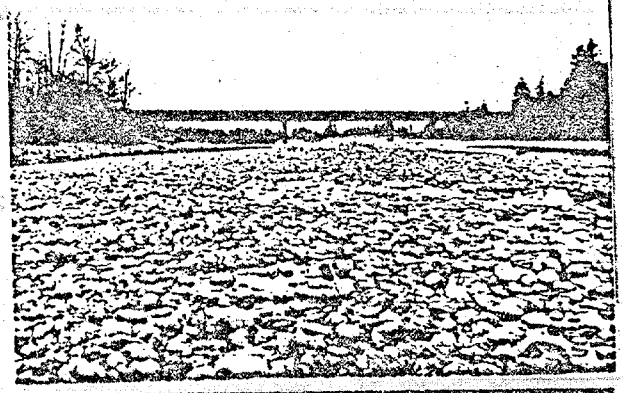
SMITH RIVER

3-21-68-1 1-20



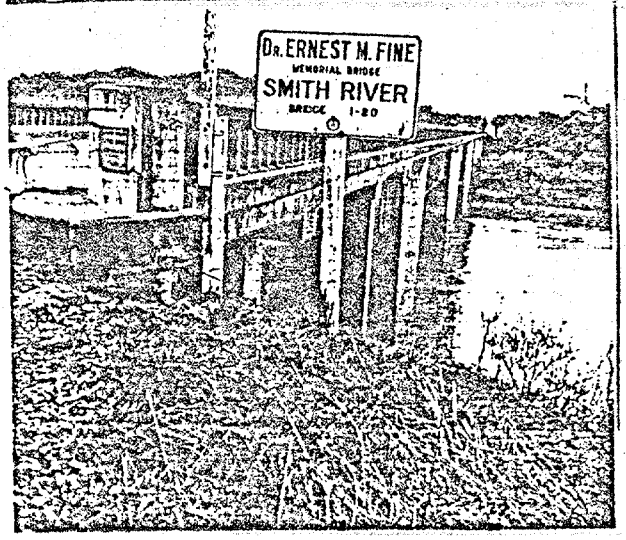
Roadway view looking North-ahead

3-21-68-2 1-20



Sideview looking west-downstream

3-21-68-3 1-20



Downstream side looking South

Case History 21

San Diego River at SR67 near Lakeside, California

Description:

The bridge is a continuous RC slab with cantilevered open-end diaphragm spans on concrete pile bents. The over-all length is 307.85M with a 10.06M clear span.

The channel is approximately 304.80M wide and the flow is controlled by the El Capitan reservoir located about 16.09km upstream.

Gradation Problem:

From the data of construction (1940) through 1965, the bed level was considered generally stable. In 1969, excavation was noted upstream and downstream of the bridge site. This was done under a permit issued by the San Diego County in 1964. By 1978 extensive degradation was noted through many of the spans, and a 3M deep channel had been cut naturally between two of the bents.

Countermeasures:

With the stable situation that existed between 1940 and 1965, only minor scour protection was required. After the excavation was begun and 3M of driven pile was exposed due to heavy runoff in 1978, the structure was closed. At this point, the bed levels were estimated to be from 2.59 to 3.96M below the original construction elevation.

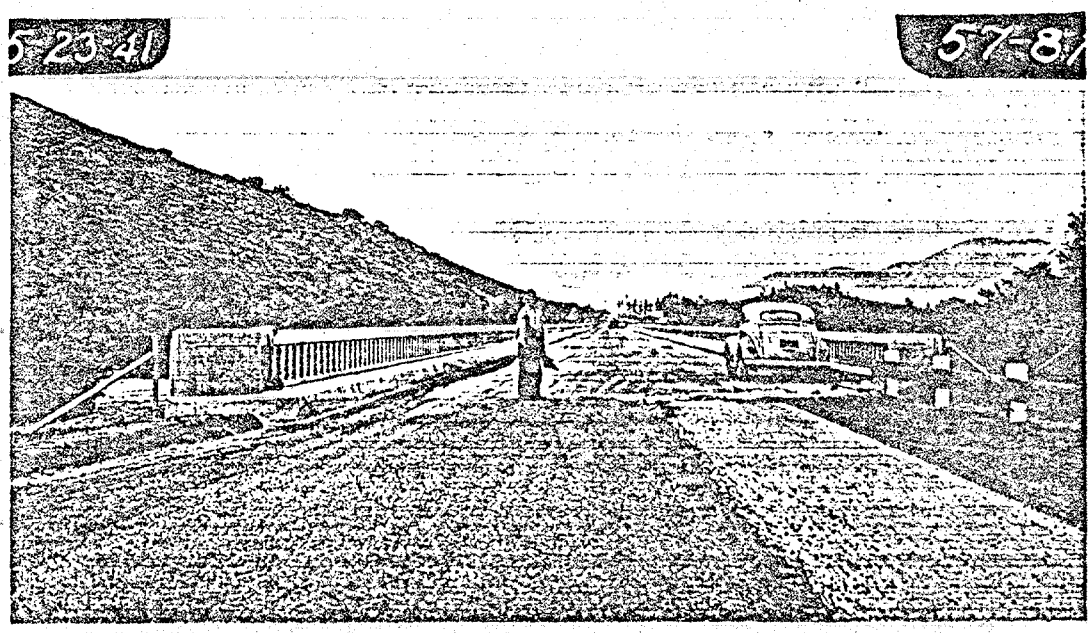
Discussion:

By comparing 1978 and 1941 photographs, the bed level change is obvious. The channel appears to have stabilized at the 1978 degraded level, which provides marginal stability for the pile bents. State maintenance personnel consider this case to be a typical example of unregulated gravel mining. The original permit

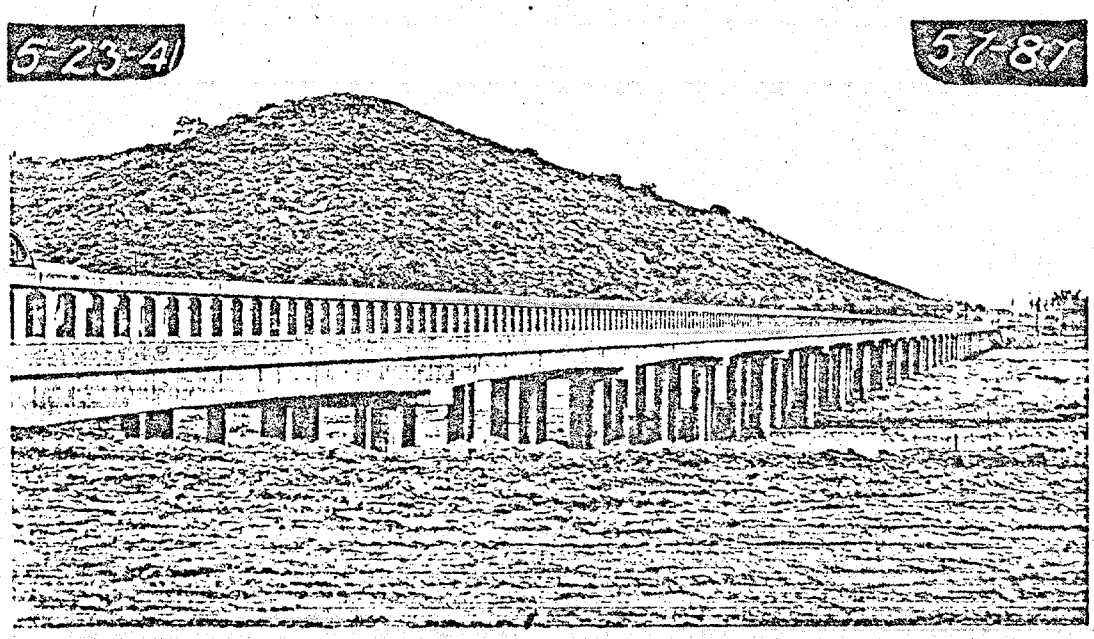
was violated by the contractor, and the bridge was consequently endangered.

State personnel have noted that in cases of degradation caused by gravel mining, the channel usually stabilizes at the degraded level after excavation has ceased.

SAN DIEGO RIVER (LAKESIDE)

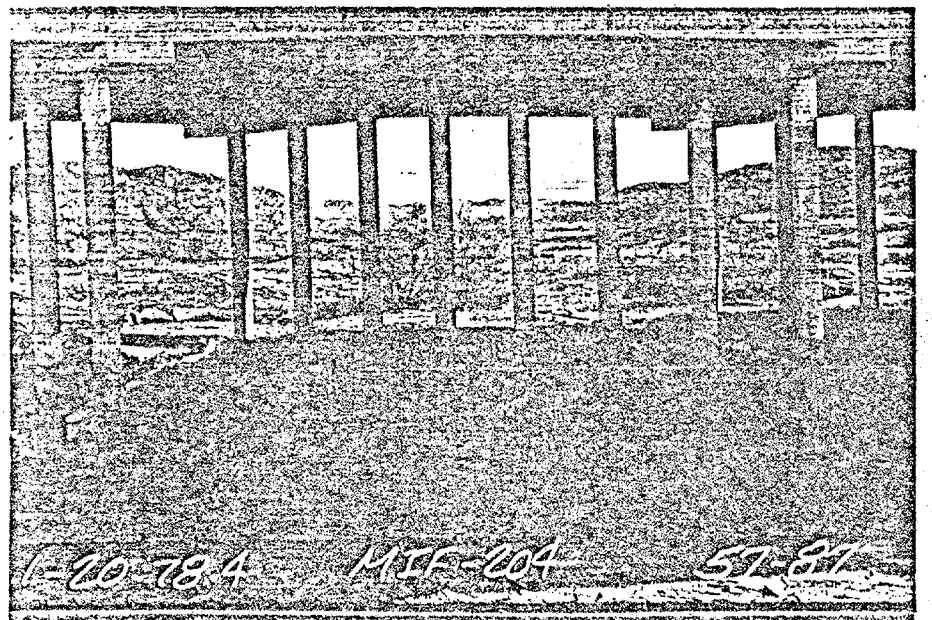


North roadway view

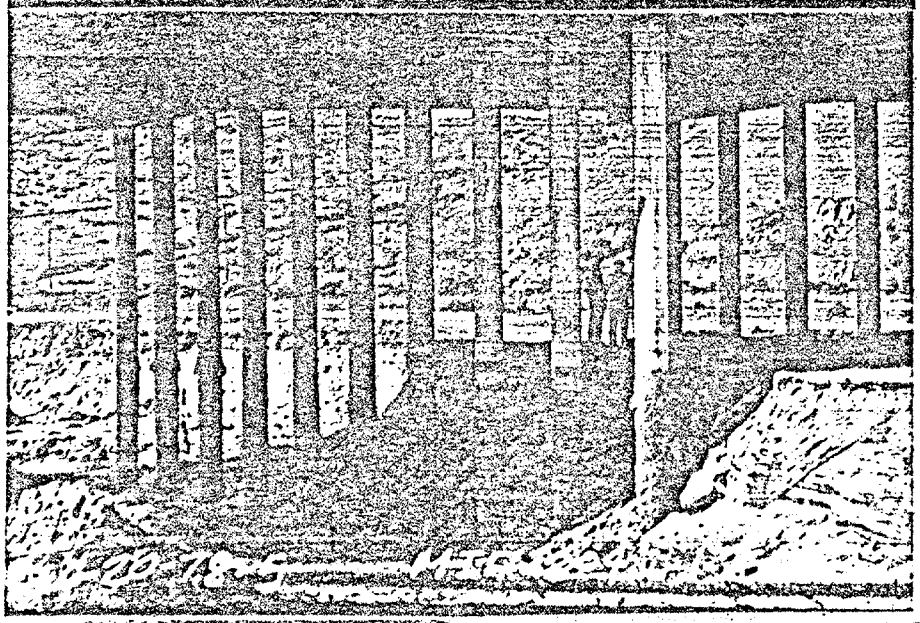


North west side view

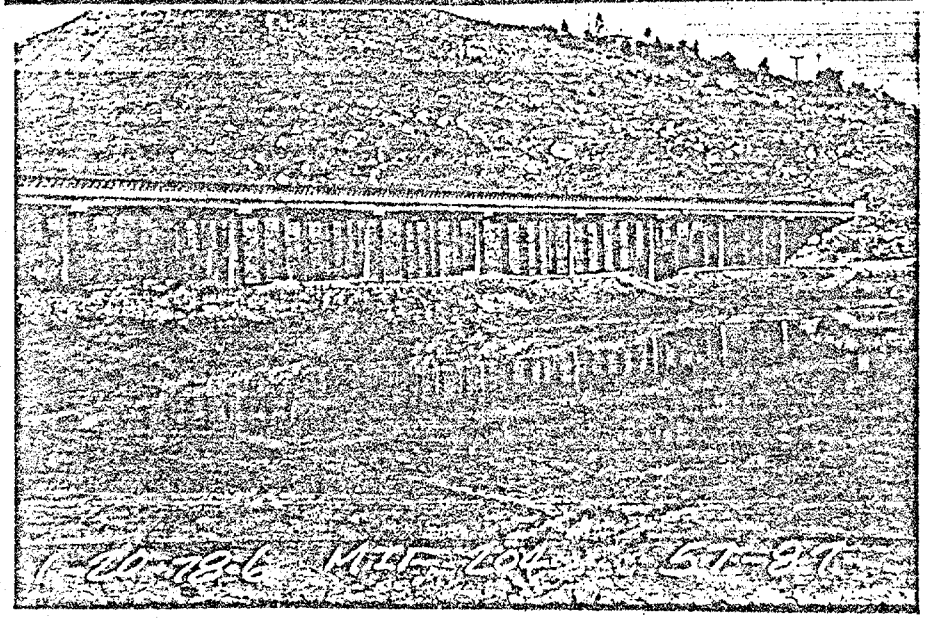
SAN DIEGO RIVER (LAKESIDE)



BENT 23 SCOUR LOOKING EAST



BENT 24 SCOUR LOOKING WEST



SIDEVIEW LOOKING (NORTH-END) FROM SAND PIT LOOKING WEST

Attachment "A"

SUMMARY

Name	San Diego River		Santa Ysabel Creek	
Bridge No	57-87		57-240	
Downstream Borrow Pit Depth	30 ft		10 ft	
Design Discharge	Reservoir Full Q_{100} = 33,500 cfs	Res Half-Full Q_{100} = 7,000 cfs	Reservoir Full Q_{100} = 39,500 cfs Q_{100}, main flow = 25,300 cfs	Res Half-Ful Q_{100} = 16,100 Q_{100}, main flo = 10,300
Scour Depth Due to Dnstr Borrow Pit	26 ft	13.5 ft	9.9 ft.	9.6 ft
Local Scour Due to Pier Obstruction	3.1 ft	2.2 ft	3.7 ft.	3.1
Total Scour Depth	29.1 ft	15.7 ft	13.6 ft.	12.7 ft
Bedload Movement Rate per ft Channel Width	1055 lbs/sec/ft	83 lbs/sec/ft	10,775 lb/sec/ft	8375 lb/sec/ft
Time Req'd To Scour	14 min.	2.5 hrs	10 sec.	12 sec.

Case History 22

Cuyama River at SR166 near Santa Maria, California

Description:

This bridge has a reinforced concrete deck with timber stringers on treated timber pile bents and R.C. abutments. There are 13 spans of 6.10M each, and the overall length is 80.16M

The channel bed is sand and silt. This crossing has a history of rapid changes in channel cross sections during periods of heavy runoff. The watershed area encompasses 1186.22km^2

Gradation Problem:

17 years after its original construction in 1941, a 1958 inspection report after a storm noted a 2.44M bed level drop in some sections of the channel, and slight settlement of one bent. (see cross-section in report)

In 1969, further flooding caused serious damage to the substructure. This was possibly aggravated by previous degradation from the original level.

During February of 1978, a significant flood overtopped the bridge deck by 0.3 to 0.6M and changed the river alignment. Seven of the thirteen spans were completely silted in, and only four of the remaining spans had effective waterway area due to debris deposits. Approximately 33,600M^3 of silt were deposited during this event.

Following the February 1978event, the damaged timber bridge sections were repaired and/or replace. However, before the silt could be removed, another flood occured four weeks later which washed out one of the spans and deposited an additional 16,100M^3 of silt 152M either side of the bridge.

Countermeasures:

Other than continual maintenance of the bridge, no corrective measures have been made to alleviate the channel problem to date.

Discussion:

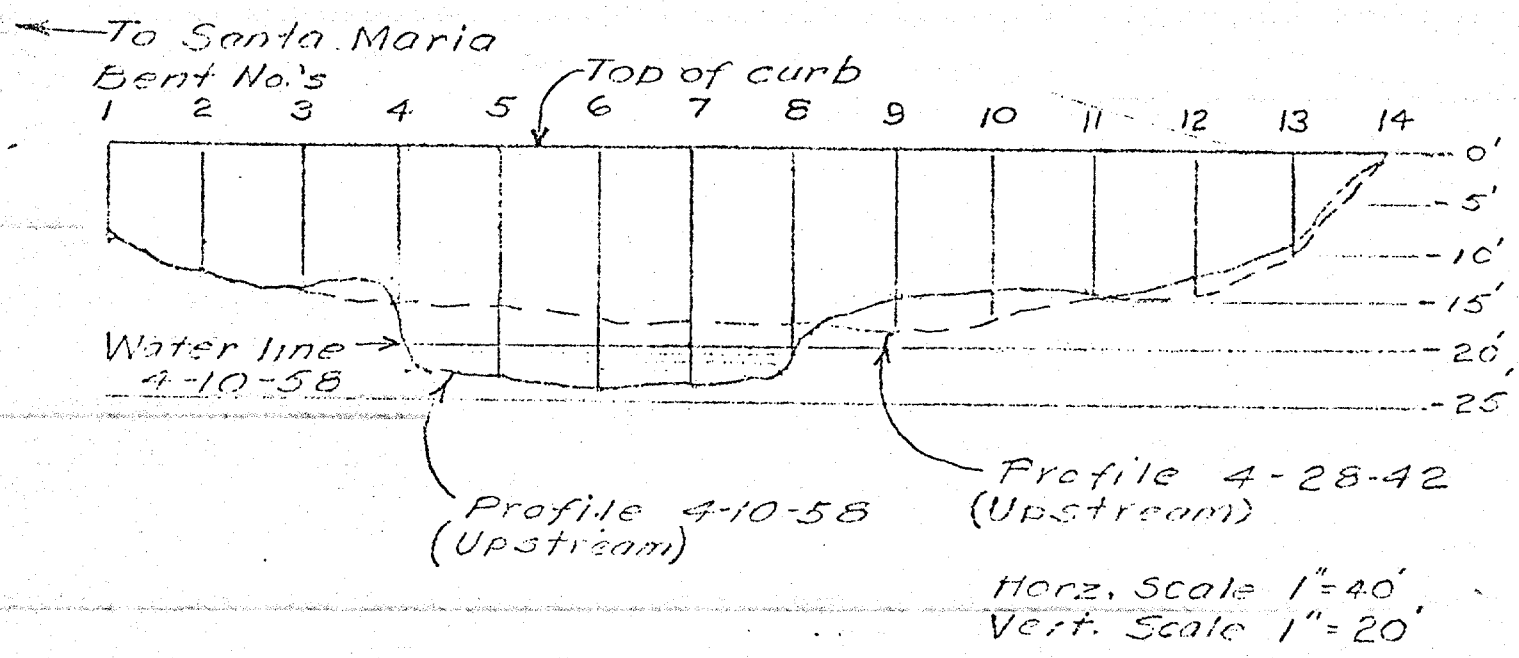
The grade line of this bridge is probably too low to pass a reasonable design discharge. In additon, the mobile nature of the channel bed caused a variety of problems for the timber bents. The bridge has experienced settlement due to degradation, and loss of piles and spans during high waters due to aggradation.

A report packet on bridge 51-66, which is located about 32.18km east of 49-43, has been included in the supportin documents. This packet contains a fairly complete hydraulic description of the site as it existed in 1941. The two bridges are similar in configuration, and appear to have experienced similar problems.

FORM BD-24

BRIDGE NO. 49-43
SHEET
DATE April 16, 1958

CUYAMA RIVER



UPSTREAM PROFILE

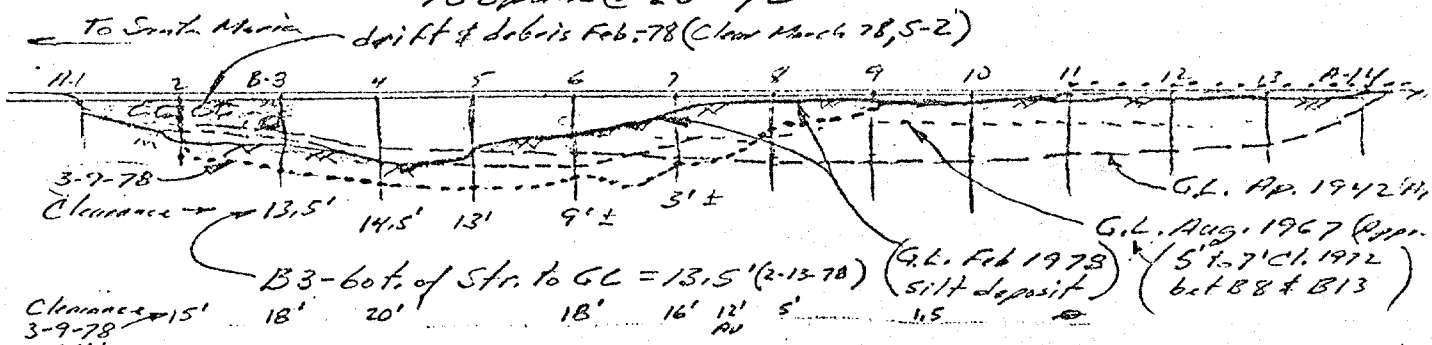
SEE SUPPLEMENTARY REPORT OF

PK Cayman Rio 4-9-43 1 of 1

3-9-78 all profile
2-16-78 Channel

05-SLO-166-51.10

13 spans @ 20' c/c



Clearance between bottom of stringers & silt deposit is about 1' to 2.5' from B-8 & A-14; & this space has much drift. Span 7 has slightly more clearance but drift has much of this plugged. Hence, the east 7 spans are very restricted to flow.

Span 1 & 2 is nearly completely filled with debris, drift & silt. (About 20% of waterway available. Effective waterway only in spans 3, 4, 5 & 6.

Flow overtopped bridge deck, curb & top of rail. Estimated High water 1' to 2' above deck; considering drift & silt on top of rail from spillet.

Over the years the river has meandered towards the outside of the bend (right bank on A-1 side). & has deposited large quantities of silt on the inside of bend. This silt deposit extends about 600' upstream & 500' downstream on line with bent-7. These distances increases substantially at bent 8 & continues to increase to A-14.

Rough quantities to remove silt for 8' clearance and extended to U.S. & D.S. limits.

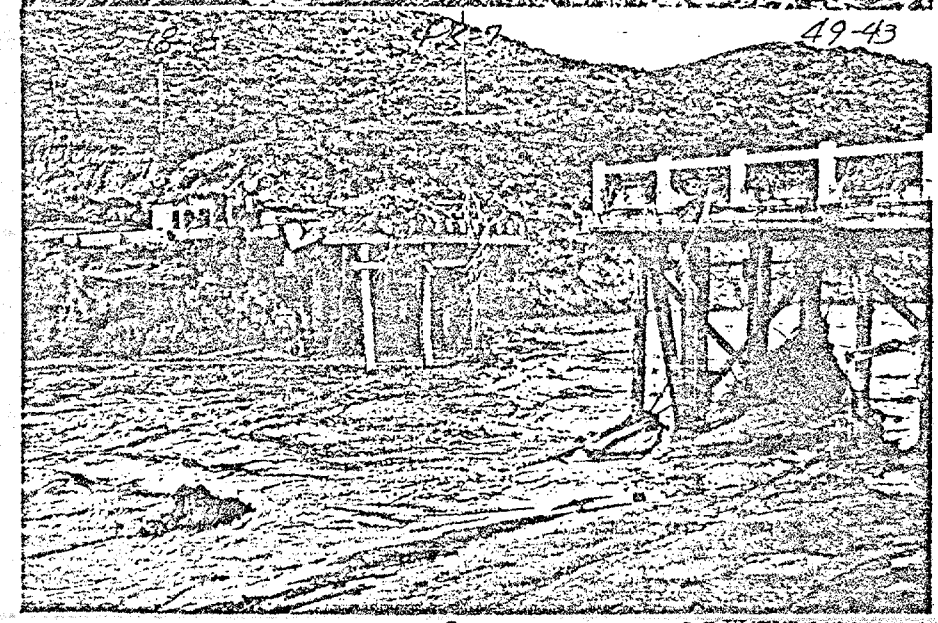
		Sub.Tot.	
Span 7	7000 cy	7000 cy	span 6 ± 2000 cy
✓ 8	8000 cy	15,000 ✓	Clear out at least 3 spans (#7, 8 & 9)
✓ 9	9,000 cy	24,000 ✓	
✓ 10	10,000 cy	34,000 ✓	
✓ 11	11,000 cy	45,000 ✓	
✓ 12	13,000 cy	58,000 ✓	
✓ 13	7,000 cy	65,000 ✓	

CUYAMA RIVER

3-5-78-6 Pk-7 49-43

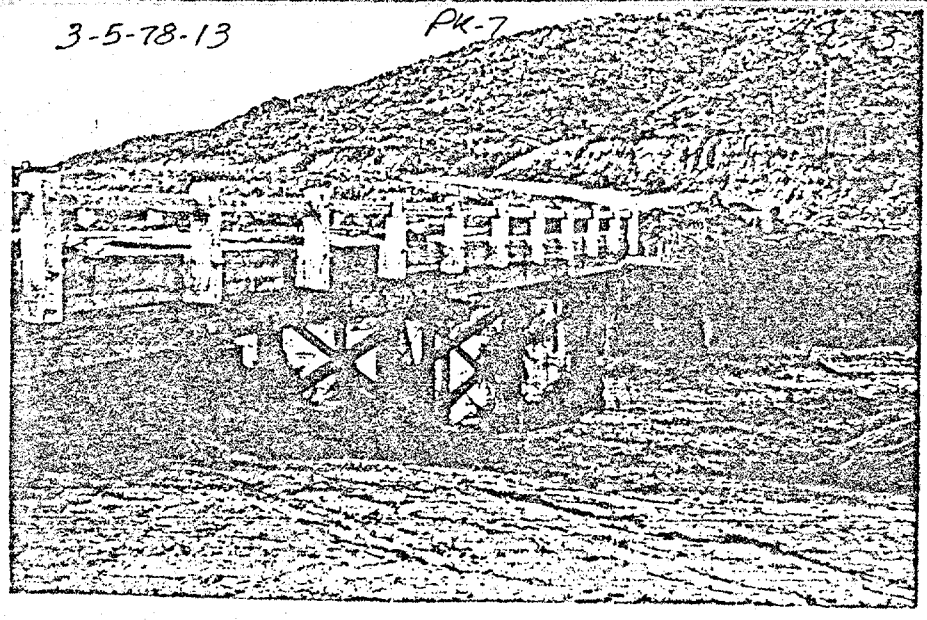
SPAN 4 & 5 OUT
DEBRIS ON SPAN 3

Pk-7 49-43



SPAN 4 & 5 OUT
DEBRIS ON SPAN 3

3-5-78-13 Pk-7



DRIFT AND SILT ON
EASTREN SPANS

Case History 23

Kelsey Creek at SR89 near Kelseyvill, California

Description:

This bridge is constructed of R.C. continuous box girders supported by CIP wall piers on concrete piles. The clear span is 25.30M with an overall length of 64.01M The channel bed material is coarse gravel and cobbles.

Gradation Problem:

In 1968, gravel excavation was noted 91.44M downstream of the site. By 1969, the channel bed had dropped about 1.83M from the original 1966 construction elevation (see 1969 report). Gravel excavation still continued 152.4M downstream.

In 1973, pier 3's footing was completely exposed and the gravel contractor ceased excavation in 1974. The channel had degraded about 2.13M from the construction elevation by 1978.

Countermeasures:

Originally, rock and sacked concrete bank protection were used. When the footing of Pier #3 was exposed, rock riprap was placed around it. As of 1978, the channel was fairly uniform in cross section and had stabilized at the degraded level.

Discussion:

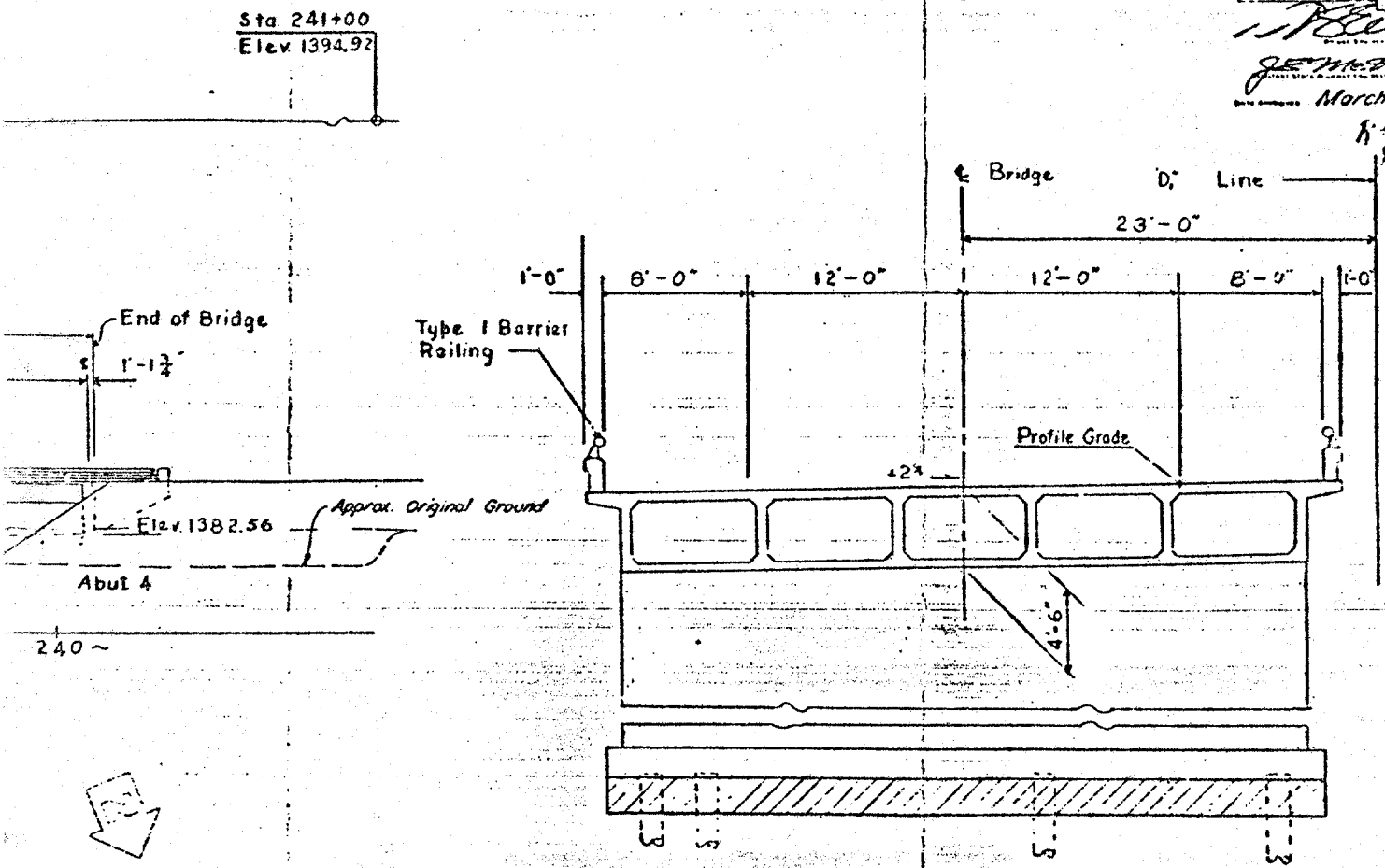
State personnel believe that the downstream excavation was directly responsible for degradation at the bridge site. The contractor possibly violated the terms of his permit. The degradation did not pose an immediate threat to the bridge as the piers bear on concrete piles.

14-64

FED. ROAD DIST. NO.	STATE	F. A. PROJECT NO.	SHEET
7	CALIF		

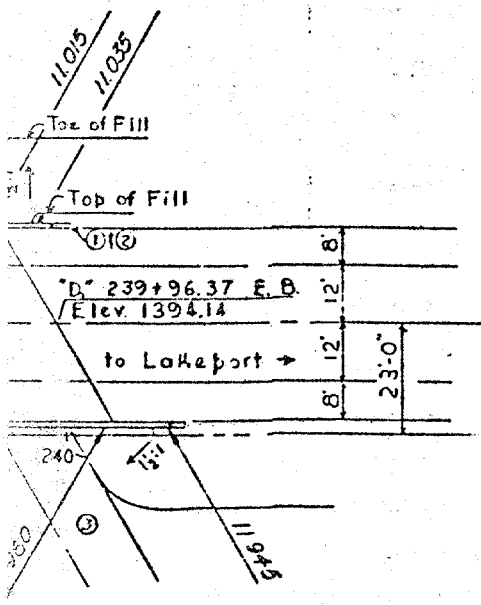
DIST.	COUNTY	ROUTE	POST MILE	SHEET	TOTAL SHEETS
01	Lak	29	14.4/14.8	65	9

March 22, 1965



TYPICAL SECTION

Scale: 1" = 5'-0"



APPROXIMATE QUANTITIES

*STRUCTURE EXCAVATION (BRIDGE)	235 CY
STRUCTURE EXCAVATION (TYPE "A")	160 CY
*STRUCTURE BACKFILL (BRIDGE)	85 CY
FURNISHING CONCRETE PILING (CLASS 1)	2,180 LF
DRIVING CONCRETE PILES	44 EA
*CLASS "A" CONCRETE (BRIDGE)	650 CY
CLASS "A" CONCRETE (FOOTING BLOCK)	52 CY
*BAR REINFORCING STEEL (BRIDGE)	168,000 LBS
CONTRAST TREATMENT	372 SY
BARRIER RAILING (TYPE 1)	486 LF

*FINAL QUANTITIES

INDEX TO PLANS

SHEET No	TITLE
1	General Plan
2	Foundation Plan
3	Abutment Details
4	Pier Details
5	Typical Section
6	Girder Layout
7	Girder Reinforcement
8	Barrier Railing Sheet 1
9	Barrier Railing Sheet 2
10	Box Girder Details No. 1
11	Concrete Pile Details
12	Log of Test Borings

THIS SET OF PLANS HAS BEEN CORRECTED TO CORRESPOND TO THE "AS BUILT" CONDITIONS AS SUBMITTED BY RESIDENT ENGINEER 1-27-66
TRACINGS CORRECTED BY

SHEET	OF
1	12

NOTES

nt bridge number and year
ompleted.
nt Kelsey Creek Bridge.
pe protection, see Road Plans
ntrast treatment.

ROADWAY SEE Foundation Plan

LIVE LOADING H20-S16-44 AND ALTERNATIVE

BRIDGE DEPARTMENT
··· DESIGN SECTION ···
5

Section Supervisor
Project Designer

DESIGN	E. Hamilton	
DETAILS	E. Hamilton	
LAYOUT	E. Hamilton	
QUANTITIES	E. Hamilton	
SPECIFICATIONS		

Approved & Recommended for

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

01-C44514

KELSEY CREEK BRIDGE

LOCATED AT THE SOUTH EDGE OF KELSEYVILLE ABOUT 1/2 MILE UPSTREAM FROM EXISTING KELSEY CREEK BRIDGE IN LAKE COUNTY

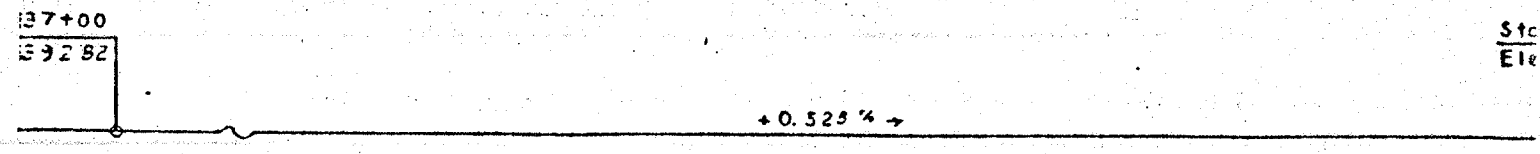
5-2-73

014064

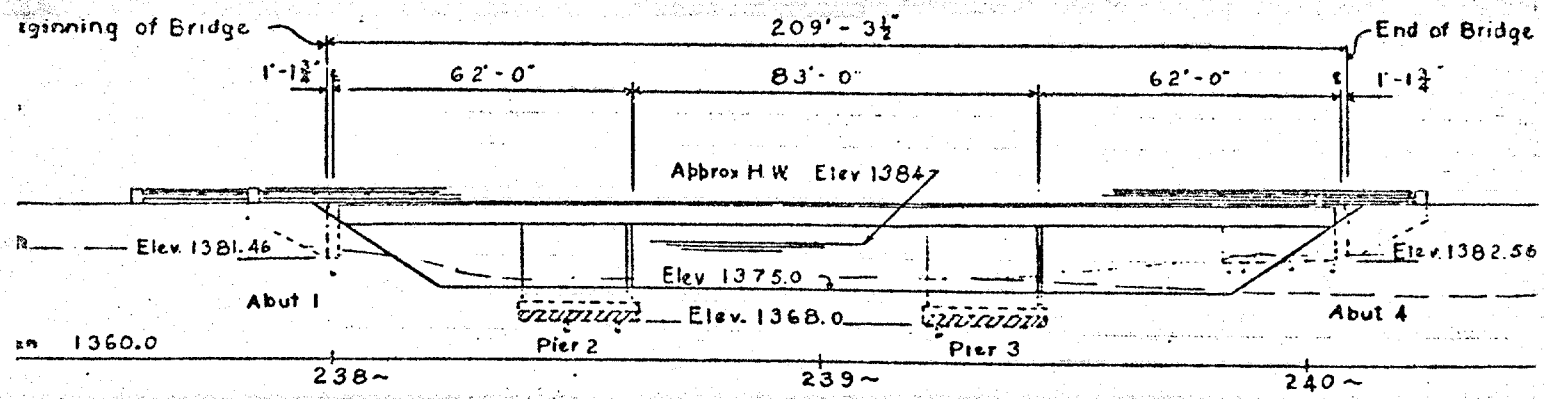
GENERAL PLAN

DAVE

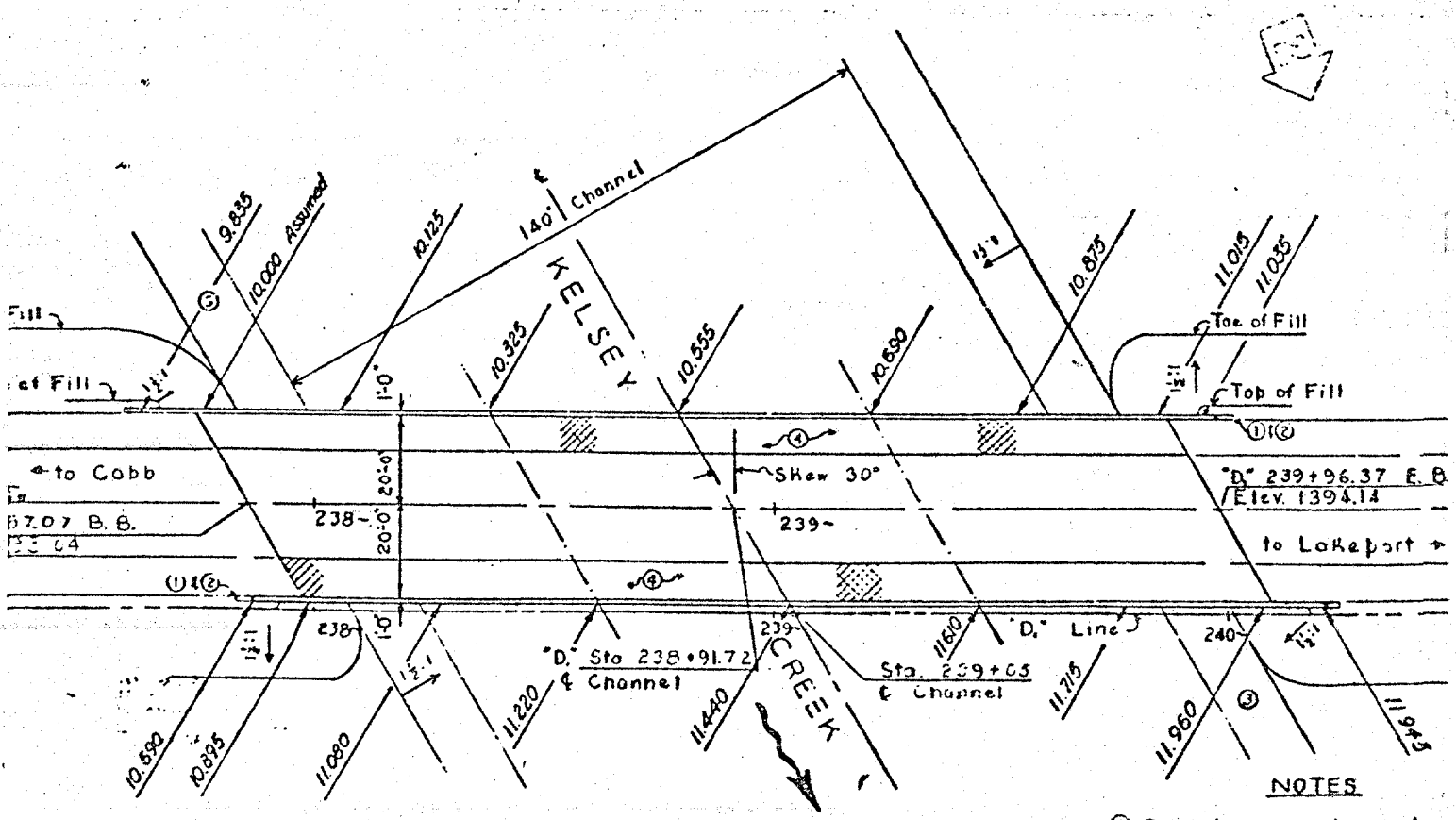
Except as noted SCALE 1" = 20'	BRIDGE 14-64	FINAL FILE	DRAWING 14-64-1



PROFILE GRADE



ELEVATION



PLAN

NOTES

① Point bridge number and y completed.
② Point Kelsey Creek Brid
③ Slope protection, see Roa
④ Contrast treatment.

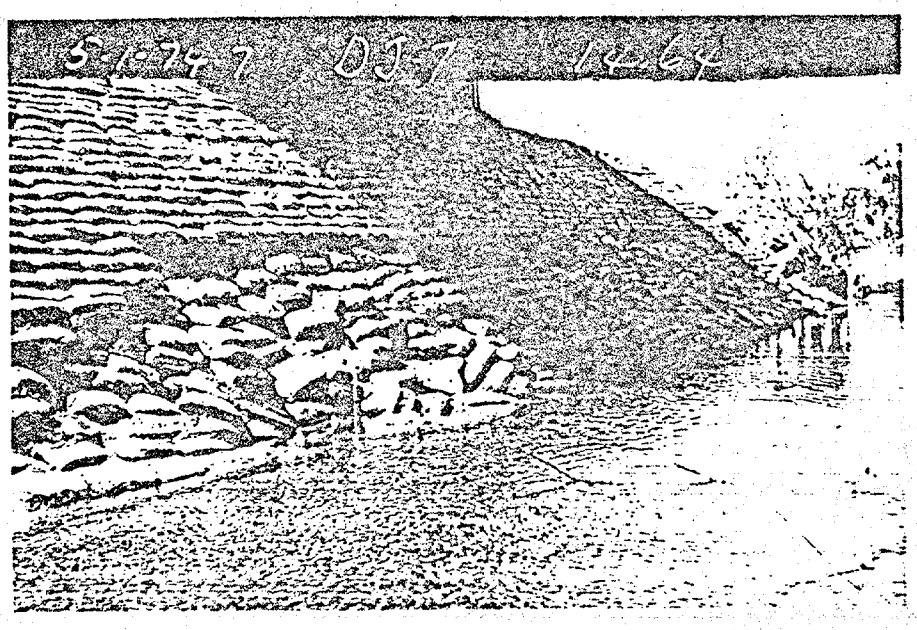
AS BUILT PLANS
Contract No. 01-044514
Date Completed
Document No. 10001106

FOR GENERAL NOTES SEE Foundation Plan

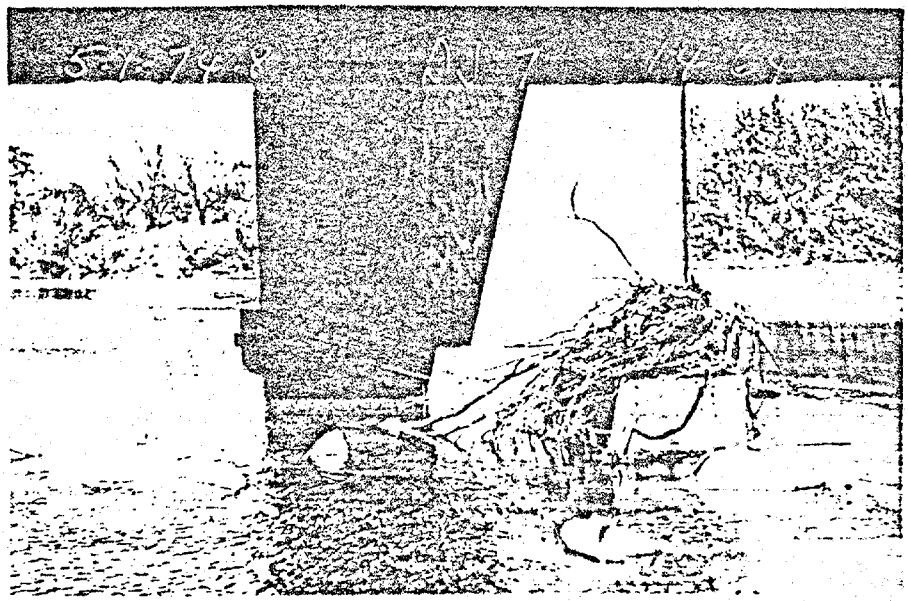
LIVE LOADING H20-S16-44 AND

01-Lak-29 #14-64

KELSEY CREEK



Undermined sacked concrete slope protection in sp 4



Exposed ftg. at pier 3

Case History 24

Mad River at SR299 near Blue Lake, California

Description:

This bridge is a continuous steel plate girder with RC T-girder end spans. Three piers are on spread footings, and the others are on concrete piles. The over-all length is 157.89M with a 45.75M clear span.

The channel bed is coastal alluvial with a coarse sand and gravel bed load. New Ruth reservoir is located 80.45km upstream and controls discharge to an extent, but the interceding reach is long enough to produce heavy winter peak flows.

Gradation Problems:

Original construction was completed in 1948, and in 1956, inspection reports indicated problems with abutment settlement due to embankment washout, scour around footings, and general degradation in the vicinity of the bridge.

The 1962, reports noted additional scour around the footings but no immediate hazard to the structure existed.

The 1973 channel cross sections indicated a 3.05 to 3.66M drop in the bed level from the original construction elevation. This did not seem to threaten the structure as the footings are 4.27M thick and bear on rock. There was some damage to the bank protection, however.

By 1974, gravel excavation was noted 304.8M downstream and the channel had degraded about 6.10M from the 1948 elevation. Degradation has continued to the present.

Countermeasures:

Extensive use of rock riprap has been made since 1955 to protect the piers and channel bed. However, no long term solutions

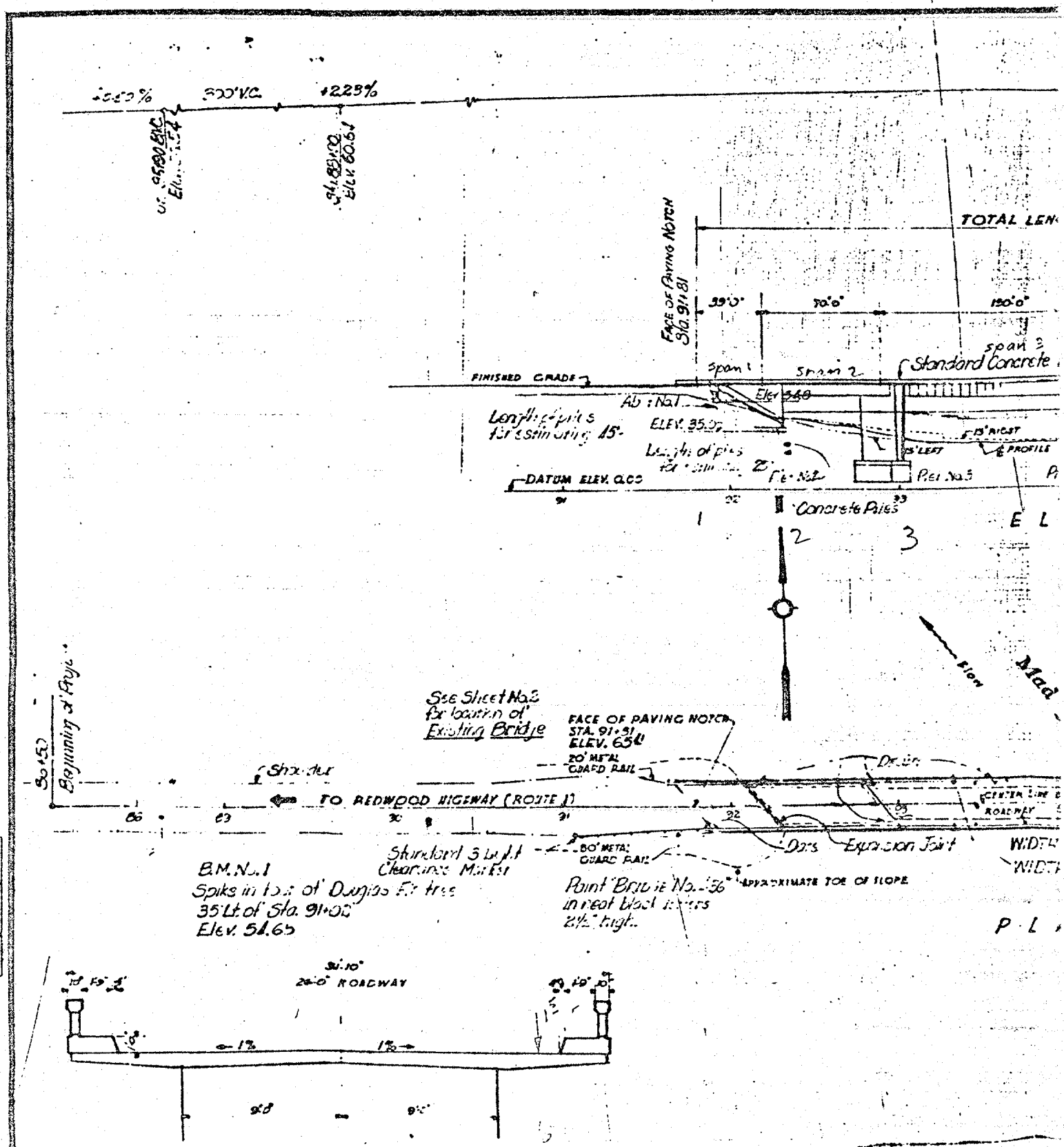
have been undertaken.

Discussion:

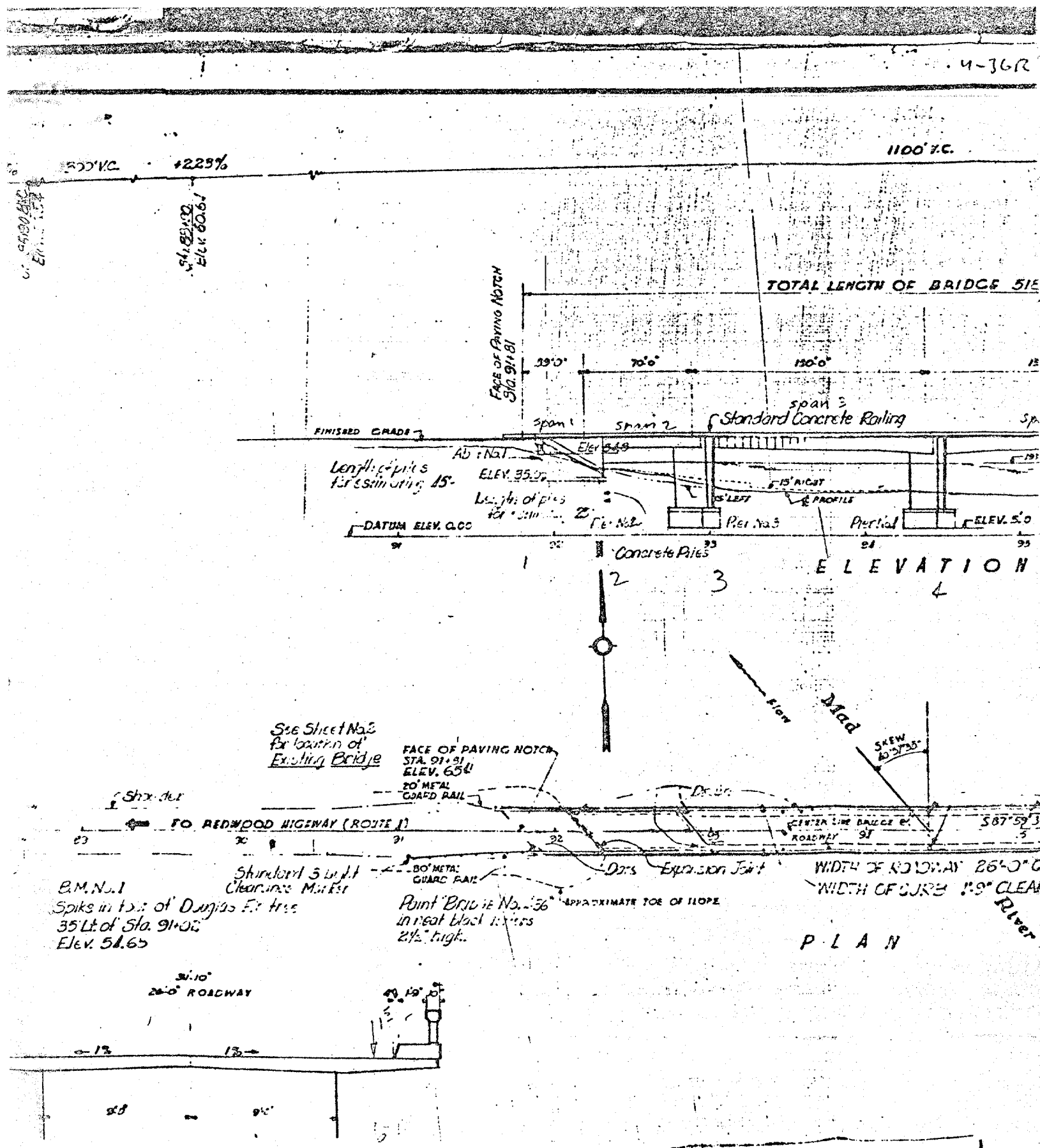
At present, total degradation since 1948, has been about 6.10M. The bridge is in no immediate danger, due to the original overdesign of footings and sound bearing material. Potential for damage exists, however, and scour around the footings is being closely monitored by the district.

State highway personnel attribute the degradation to gravel mining upstream and downstream by various aggregate contractors. This is evidently a recurring problem for most alluvial streams in the area.

Attached reports and correspondence provide further details about cross sections and footing dimensions.


+223%
300' V.C.
TOTAL LEN
FACE OF PAVING NOTCH Sta. 91+81
39'0"
70'0"
130'0"
span 1
span 2
span 3
Standard Concrete
FINISHED GRADE
Elev. 54.0
ELEV. 35.0
Length of piles for estimating 15'
Length of piles for estimating 2'
DATUM ELEV. 0.00
Pier No. 3
Concrete Piles
PROFILE
See Sheet No. 2 for location of Existing Bridge
FACE OF PAVING NOTCH STA. 91+81 ELEV. 65.0
20' METAL GUARD RAIL
Shoulder
TO REDWOOD HIGHWAY (ROUTE 1)
Beginning of Project
Shoulder 3 to 1 Clearance Matrix
80' METAL GUARD RAIL
Dam
Expansion Joint
APPROXIMATE TOE OF SLOPE
B.M.N.1
Spike in base of Douglas Fir tree
35' Lt. of Sta. 91+00
Elev. 54.65
Point Bridge No. 36 in neat wood posts 2½' high.
31'-10"
20'-0" ROADWAY
1%
1%
9'-0"
9'-0"
SCALE ¼" = 1'-0"
AS BUILT P
Contract No.
Date Completed
Document No.

4-36R



AS BUILT PLANS
Contract No. 14 WLC 28
Date Completed
Document No. 10000 845

4-36R

4-36R

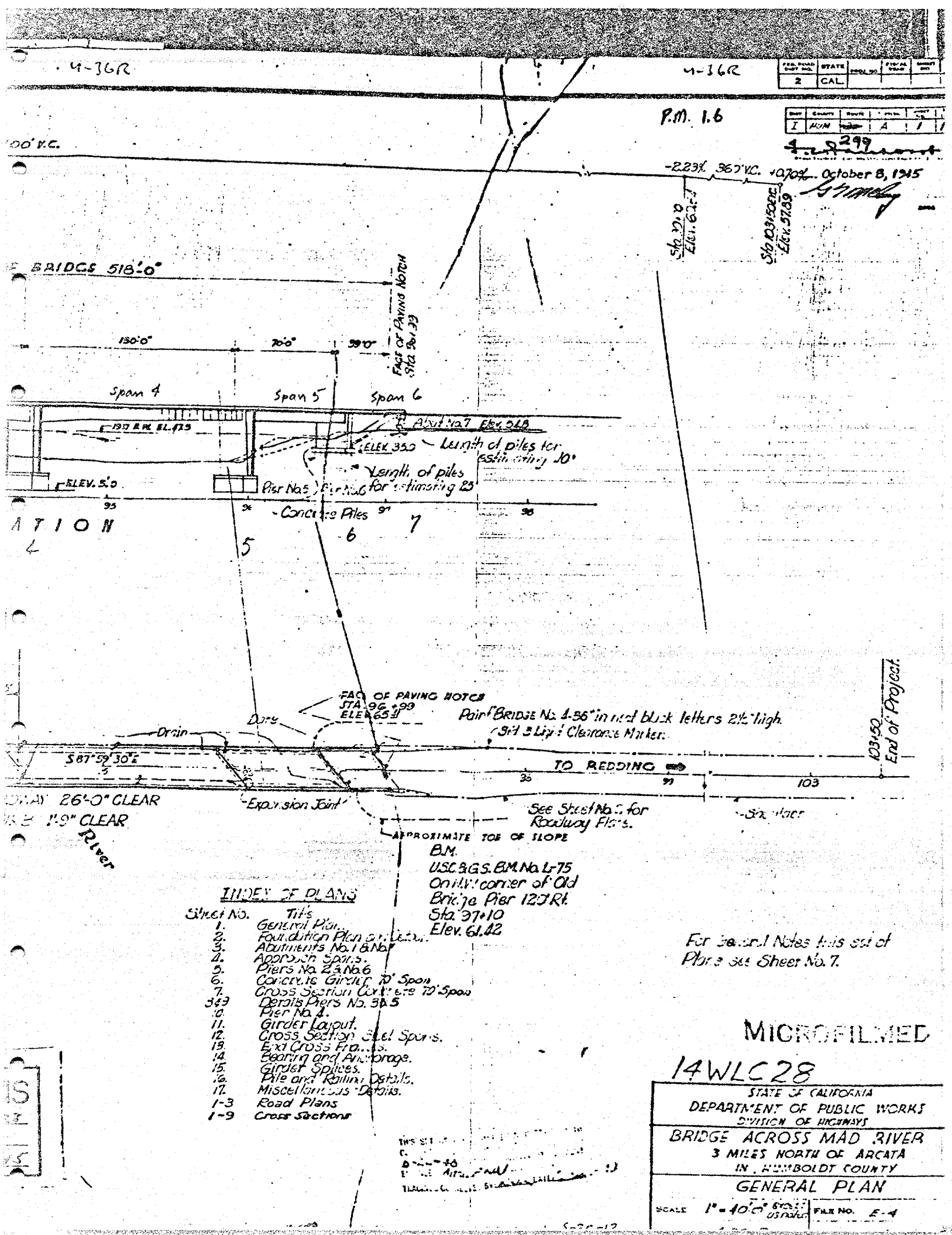
FED. ROAD DIST. NO.	STATE	FISCAL NO.	STATE AID ROUTE	SHEET NO.
2	CAL.			

P.M. 1.6

SHEET	COUNTY	ROUTE	SECTION	SHEET	
I	HUM		A	1	

299

October 8, 1945



INDEX OF PLANS

Sheet No.	Title
1.	General Plan.
2.	Foundation Plan and Details.
3.	Abutments No. 1 & No. 7
4.	Approach Spans.
5.	Piers No. 2 & No. 6
6.	Concrete Girder 70' Span
7.	Cross Section Concrete 70' Span
3 & 8	Details Piers No. 3 & 5
10.	Pier No. 4.
11.	Girder Layout.
12.	Cross Section Steel Spans.
13.	End Cross Frames.
14.	Bearing and Anchorage.
15.	Girder Splices.
16.	Pile and Railing Details.
17.	Miscellaneous Details.
1-3	Road Plans
1-9	Cross Sections

For General Notes this set of Plans see Sheet No. 7.

MICROFILMED

14WLC28

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

BRIDGE ACROSS MAD RIVER
3 MILES NORTH OF ARCATA
IN HUMBOLDT COUNTY

GENERAL PLAN

SCALE 1" = 40'-0" Gross US Datum | FILE NO. E-4

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
BRIDGE REPORT
DS-M58 (REV. 1/75)

Bridge No. 4-36R

Other No.

P.U.C. No.

Location 01-Hum-299-R1.56
Dist - Co - Rte - PM - City

Date of Investigation Feb. 20, 1975

REVISED ORIGINAL REPORT

Name MAD RIVER ~~(Devore Memorial)~~

Lat. 40°-54.6' Long. 124°-03.6'

STRUCTURAL DATA AND HISTORY

Year Built 1948 By Division of Highways Contract No. 14WLC28-F

Date of Revisions

Designed by: B.D. [X] Plans Avail. @ D.S.

Description: Spans 1 & 6 are cellular abutments with T-girder (3) superstructure. Spans 2 & 5 are RC T-girders (3). Spans 3 & 4 are continuous steel plate girders(2). Solid RC piers 3, 4, & 5 are on spread footings. RC piles at all other supports.

Spans 39'-70'-2@150'-70'-39'

Length 518' Skew 41° Lt. Design LL S20-12

Ratings: Inventory Operating Permit

DESCRIPTION – ON STRUCTURE

Bridge Width 2.1'cu-26'-2.1'cu.

Total Width 31.5' Lanes 2 Tracks None

Median None Rail Type Concrete (0111)

Vert. Clearance over deck Unimpaired Appr. Rdwy. Width 34'

Wearing Surface None Deck Seal None

Alignment Tangent

DESCRIPTION – UNDER STRUCTURE

Roadway Section 4'ea-14'AC

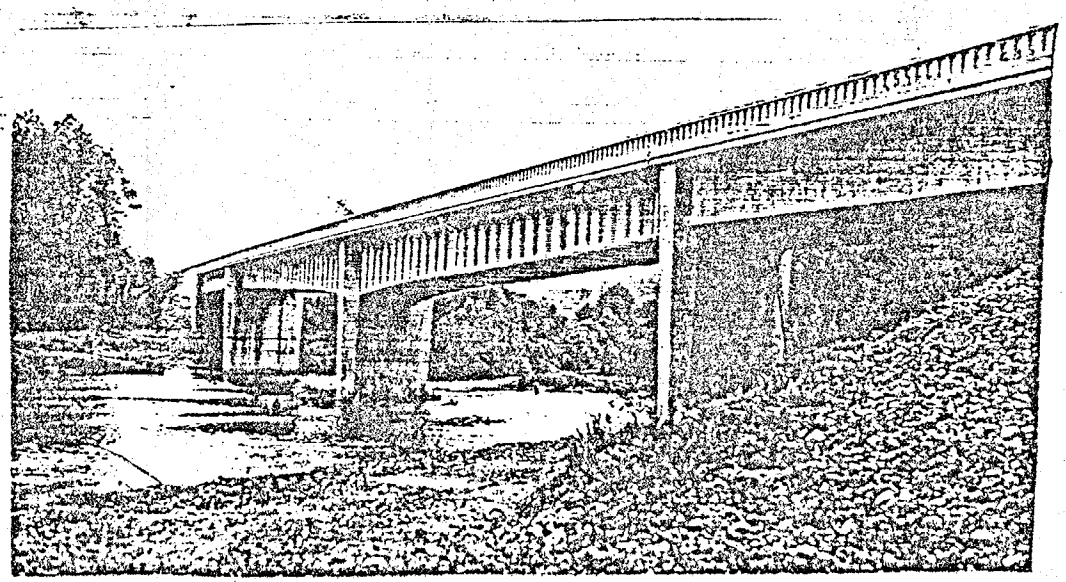
Clearances: Vert. 14'-0" Horiz.; Lt. 6' to Pier 6 Rt.

Lanes one Tracks None Pumpplant: None [X] See Br. No.

Facilities Crossed Ranch road

cc: Dist. 01(4) DJ/nlk

(1) CON'T



Downstream side.

This only.

Case History 25

Hosler Creek at SR96 near Hoopa, California

Description:

The bridge is a reinforced concrete T-girder on 3-column bents with web walls and colymn abutments, all on spread footings. The clear span is 12.19M with an overall length of 27.43M

Gradation Problem:

Original construction of this bridge was completed in 1933. A 1941 report indicates that a flood in February of this year reached an elevation of 1.43M above the bridge deck. This report also states that the vertical clearance under the bridge was unimpaired. A storm in January 1965 again took water over the bridge deck, though this time the sediment load was extremely high, and both the waterway area and bridge deck were completed obstructed with debris and silt. (see accompanying photo #1-20-65-8).

In February 1966, the maximum clearance under the structure was reported as 2.44M compared to 3.5M in 1958.

Countermeasures:

No countermeasures have been undertaken to alleviate obstruction to the bridge during high flows.

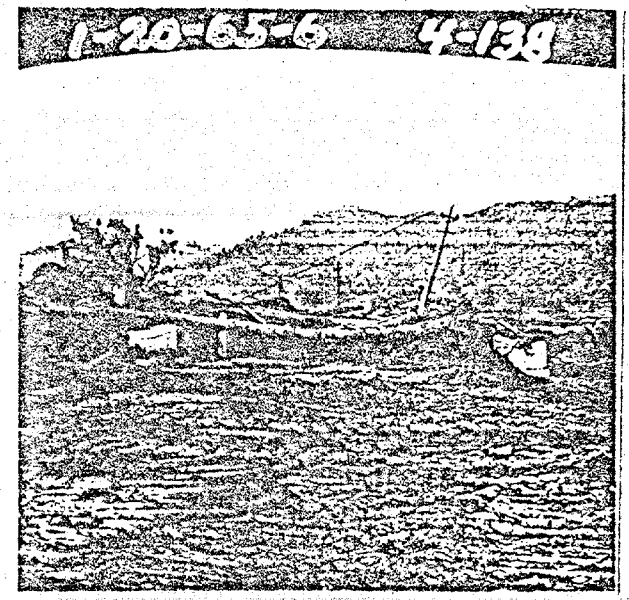
Discussion:

Subsequent to 1970, bridge reports and associated correspondence indicated an annual cycle of aggradation and subsequent channel reworking. There are evidently several bridges in the area which share this problem.

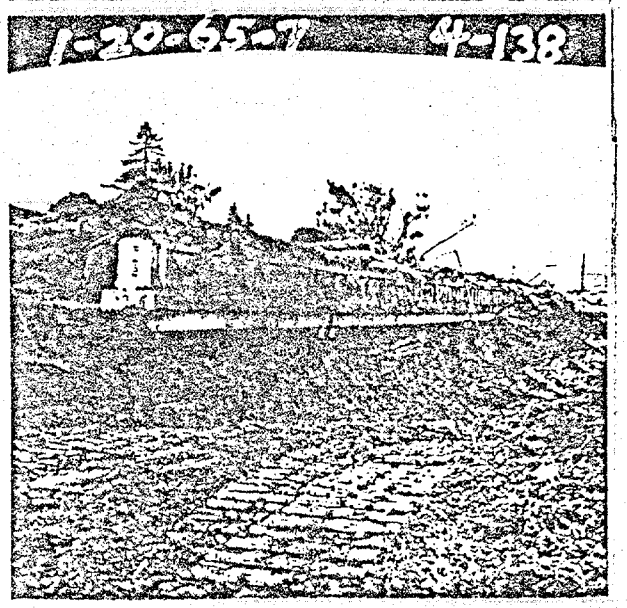
The bridges evidently restrict the channel during the winter

runoff, causing deposition of alluvial material. State maintenance personnel believe that this condition has been aggravated by upstream logging activity. As this state road is classified as a low intensity use route, the state considers that it is more economical to clean out the channel and bridge surface following each flood event than to replace the bridge. However, the basic problem of insufficient vertical clearance remains.

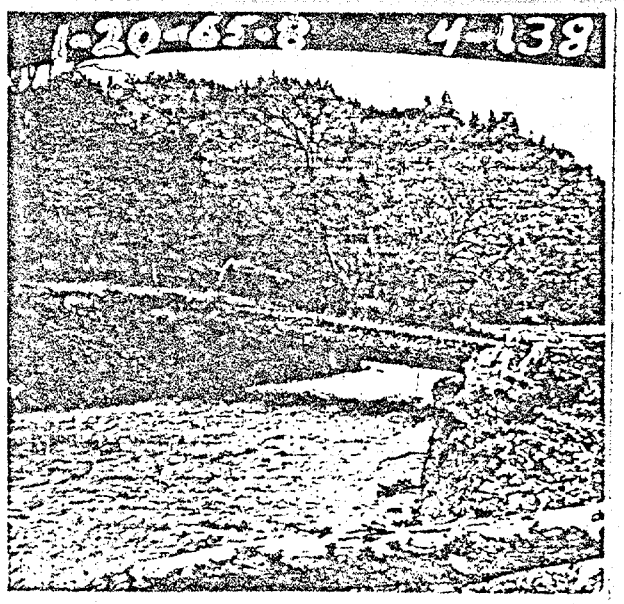
HOSLER CREEK



View toward Hoopa

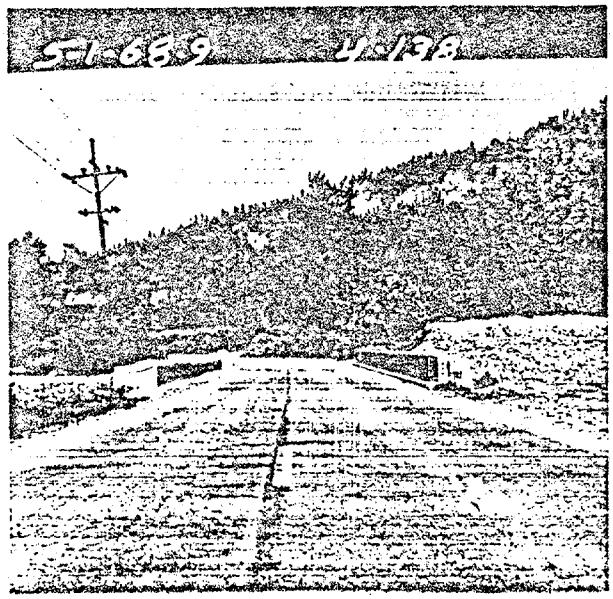


Downstream side toward Hoopa

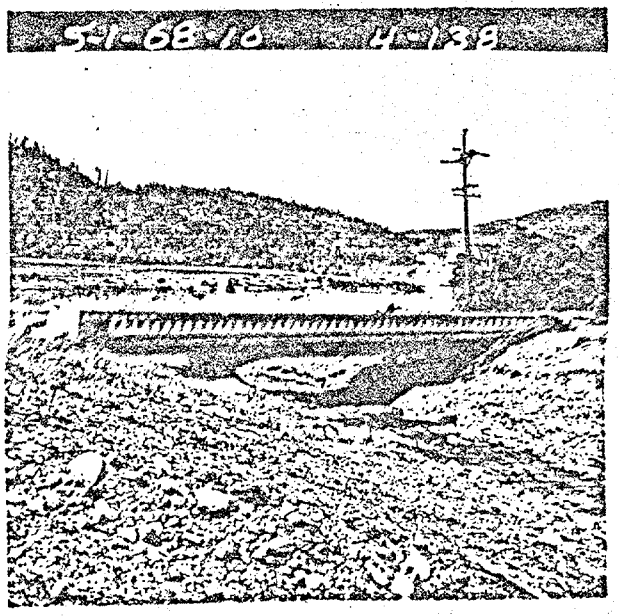


Temporary bridge-
Looking upstream

HOSLER CREEK



Roadway view looking North-ahead



Sideview looking West-downstream

Case History 26

Broaddus Creek at SR20 near Willits, California

Description:

This bridge is and R.C. girder with R.C. straight wall abutments, angles, sloping-top wingwalls, and spread footings. The overall length is 13.87M with a 12.95M clear span.

The creek banks are gravelly sand (Holocene Terrace deposits), and the channel bed consists of gray silt. The channel is significantly restricted by the bridge.

Gradation Problem:

Original construction by Mendocino County, occured in 1956, replacing a timber trestle bridge built in 1940.

A maintenance report issued in 1957 indicated an exposed top of the abutment footing. By 1971, the channel had further degraded around footing, and across the entire width of the channel.

As of 1978, the channel was continuing to scour around abutment No.2. It was also noted that the channel bed and abutemnt foundations might not be of solid rock as previously thought.

Countermeasures:

Rock protection was emplaced whenthe abutment footing became exposed. When the channel was inspected in 1978, a downstream cut-offwall was prescribed to remedy the continuous scouring around abutment No.2 and general degradation at the site.

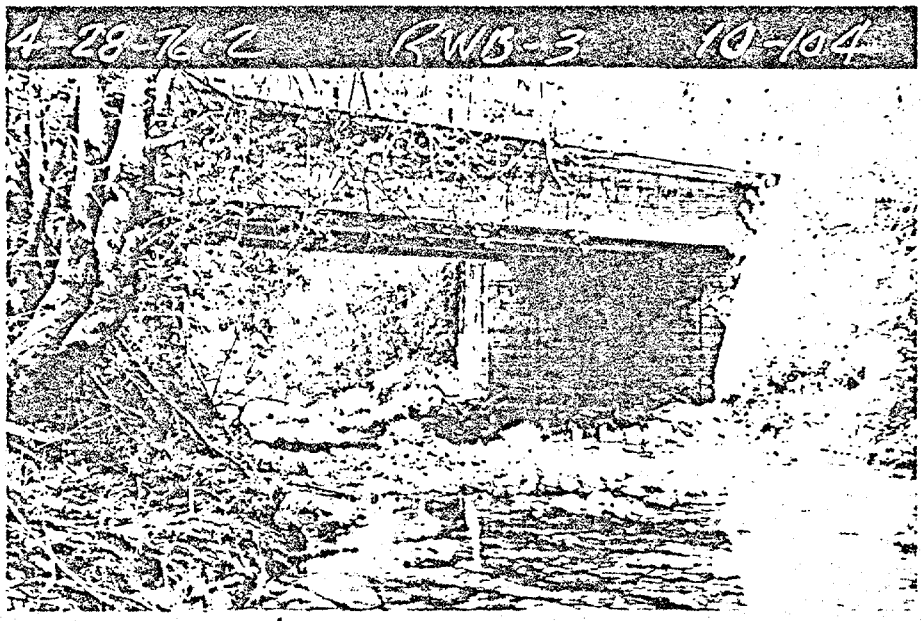
Discussion:

The cut-off wall has not been in service long enough to be evaluated. State personnel suspect that the bed level changes may

be due to gravel mining and also in part to the bridge constriction effect.

The accompanying doeumentation includes maintenace reports and photos for bridge 10-104, and also a similar packet for bridge 10-107. The second bridge is located (.8km) east of the first, is similar in construction, and has experienced similar problems. Records for both bridges indicate that the channel has degraded about 1.52M since 1956.

ROADWAY LOOKING EAST



SIDE LOOKING NORTH ~~UPSTREAM~~
DOWNSTREAM

Case History 27

Wildcat Creek near Ft. Morgan in Morgan County, Colorado

Description:

The most recent 24.38M, 3 span bridge has been washed out. This was the second bridge to stand on this particular site. The first was washed out in 1947, and construction was completed in 1948 on the present bridge.

Wildcat Creek is an intermittent stream in flat terrain, and is sinuous. The channel was straightened by the County Maintenance forces several years ago. The straightening resulted in rapid channel degrddation. A narrow steep-sided channel has eroded 2.44 to 3.05M below the previous streambed elevation. The bed and bank materials are fine grained silts. The banks are of medium height (1.52 to 3.05M) and are sparsely vegetated. The watershed is 295.26km^2.

Gradation Problem:

Rapid channel degradation has occured since the channel was straightened in the mid-1950's. Since then, successive flood events have caused scouring and left holes which led to the toppling of piers and eventually the bridge itself.

In 1963, heavy floods flowed over the road, nearly washing away the abutments. Log debris was noted on the flood plain during the field investigation confirming high-water observations. The estimated discharge was 368 cms.

In 1964 and 1965, degradation continued in the channel and flood damage required additional stabilization of the abutments.

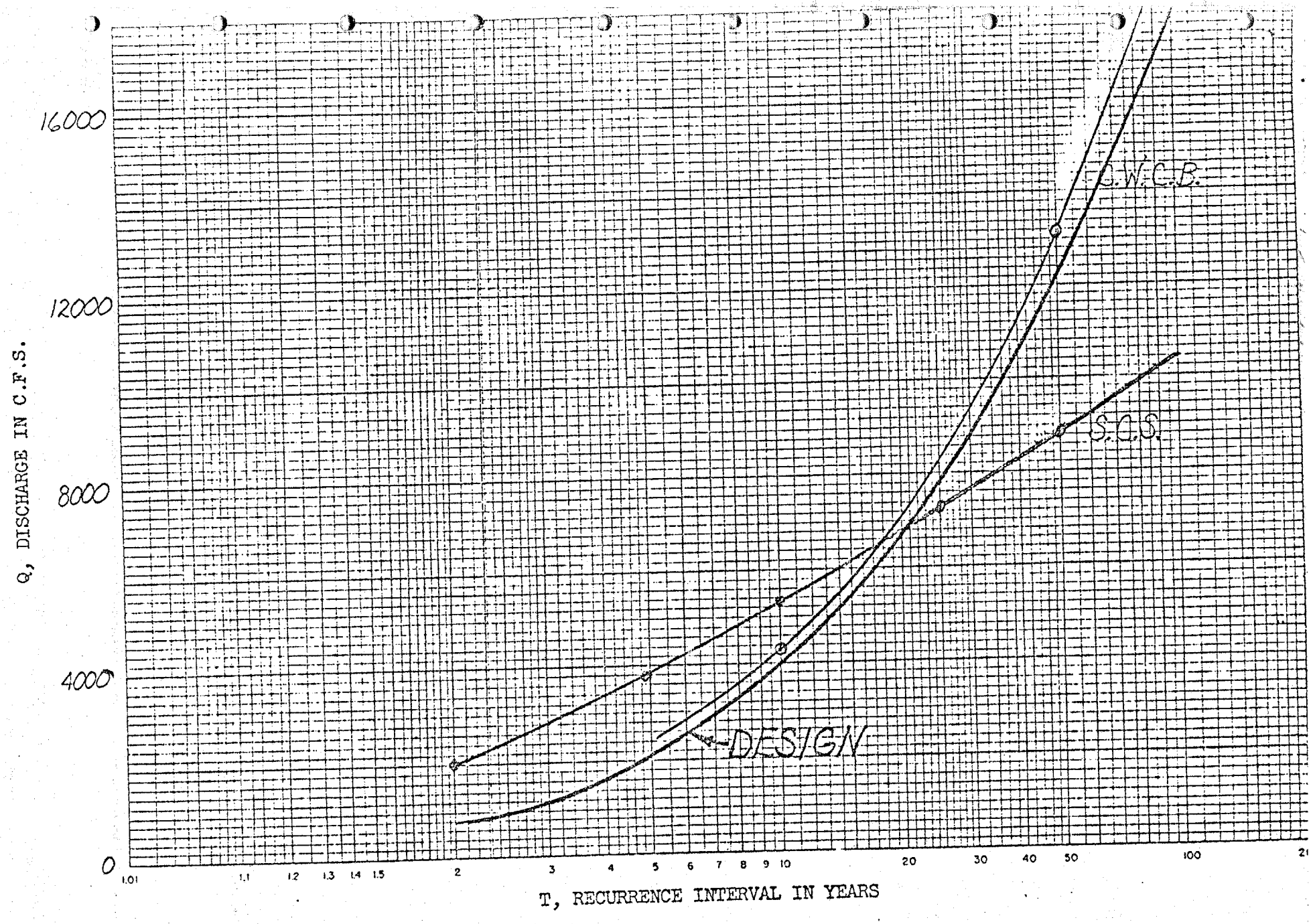
On July 2, 1976, heavy rains fell on the upper basin. The stage was approximately .91M below the bridge girders. When scour was coupled with the debris, the impact toppled the bridge

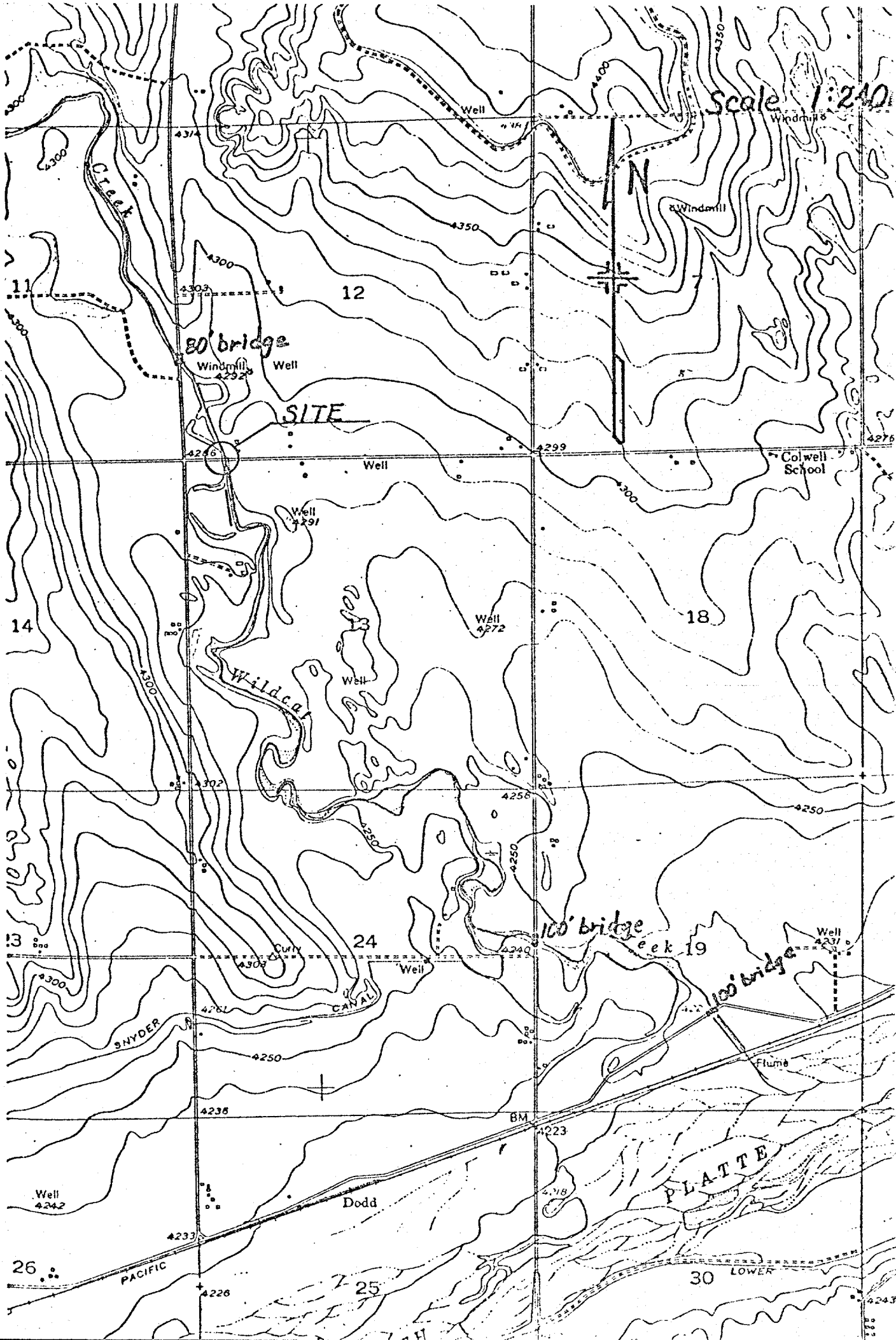
piers, the bridge itself followed moments later. Approximately 2.4 to 3.0M of degradation has occured at this site in recent years.

Discussion:

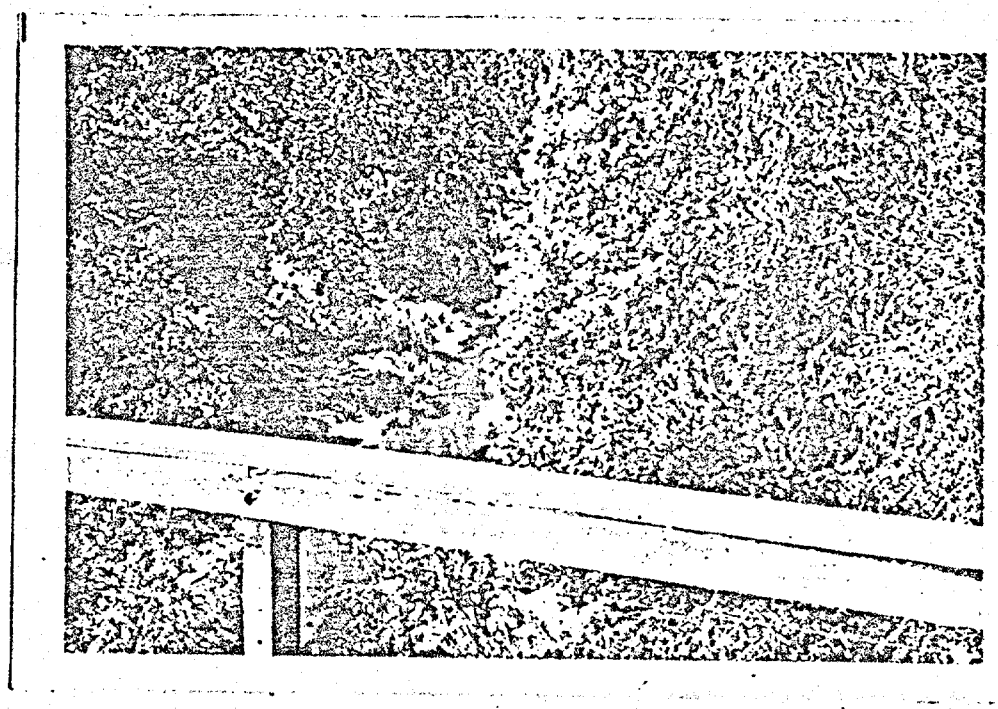
The original channel work has evidently resulted in long term problems for this drainage, however precise measurements are unavailable. There are current plans to rebuild at this site.

Documentation includes topographical maps, hydrologic analysis and pictures.

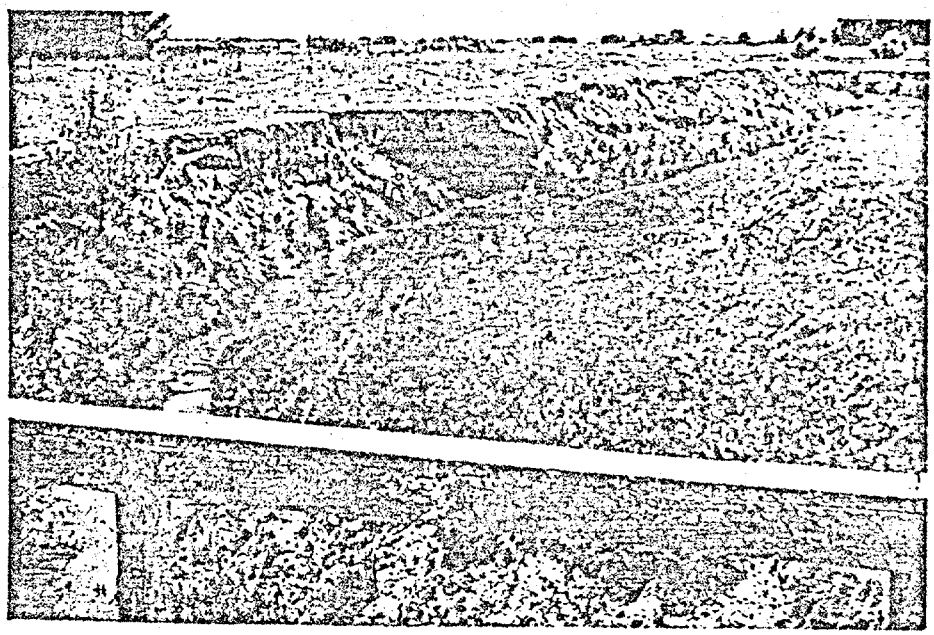

16000
12000
8000
4000
0
Q, DISCHARGE IN C.F.S.
1.01
1.1
1.2
1.3
1.4
1.5
2
3
4
5
6
7
8
9
10
20
30
40
50
100
T, RECURRENCE INTERVAL IN YEARS
D.W.C.B.
S.C.S.
DESIGN


Scale 1:240
N
Creek
Well
Windmill
4314
4350
4400
4300
4303
11
12
80' bridge
Windmill
Well
4292
SITE
4246
4299
Well
Colwell School
4276
Well
4291
14
13
Well
4272
18
Wildcat
Well
4302
4256
4250
100' bridge
Creek
19
Well
4231
13
Curry
24
4303
Well
4240
100' bridge
CANAL
SNYDER
4261
Flume
4238
BM
4223
PLATTE
Well
4242
Dodd
4233
26
PACIFIC
4226
25
30
LOWER

PHOTOS OF SITE



Looking upstream from bridge



Looking downstream from bridge

Taken 6-24-76

Case History 28

15th Street Bridge over the South Platte River, Denver, Colorado

Description:

The original bridge was constructed in 1885 with stone abutments and a single stone pier. The superstructure consisted of two simple span trusses using eye-bar type tension members. In 1963, the steel trusses were removed and replaced by two simple spans using pre-stressed concrete girders with a clear span of 15.24M .

The channel is sinuous and has been subject to heavy channelization. The banks are of medium height (3.05 to 4.57M), and have been armored with railbank throughout the channels' Denver traverse. The bed material is fine sand and silt.

Gradation Problems:

Though the bridge withstood a number of floods, from its date of construction (1963) to 1973, there was long-term degradation which caused the eventual failure of a bridge pier during light flooding in 1973.

Countermeasures:

The bridge was replaced in 1975, and the new pier and abutment now rest on steel "H" piles driven to bedrock.

Discussion:

Long-term degradation caused the eventual failure of the bridge pier. The 1975 replacement bridge is similar to the previous bridge except that its new pier and abutment rest on steel "H" piles driven to bedrock. Details of the failure are given in, "Bridge Foundation Investigation and Scour Study," by URS/Ken R. White Co., 1975, an extract of which has been included in the documentation folder.

Documentation includes the referenced report.

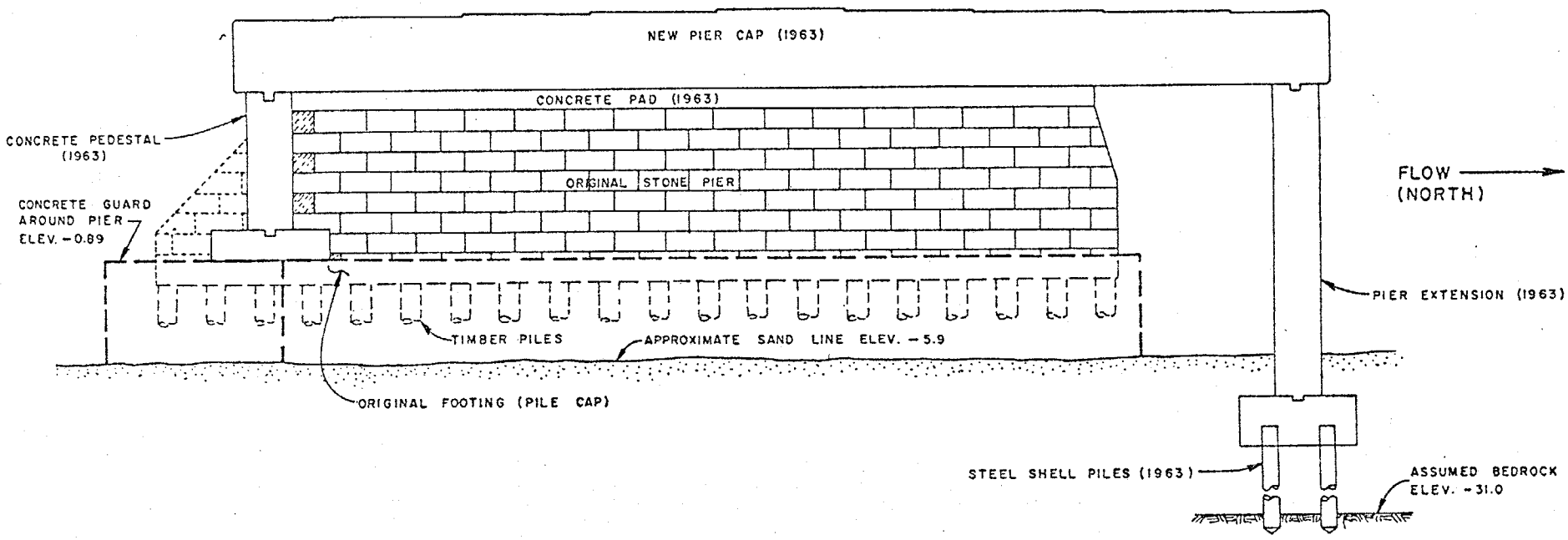


FIGURE 1. Center Pier of Fifteenth Street Bridge

The 1963 pier revision involved:

(1) removing a few layers of stone and placing a concrete pad on the top of the remaining masonry;
(2) placing a reinforced concrete pier cap on the pad;
(3) providing a concrete pedestal and footing at the south end to carry the pier cap load to the original pier footing; and
(4) providing an independent concrete column and footing, supported on concrete filled steel shell piles with driving points, to carry the pier cap load at the downstream (north) extension of the bridge.

Similar extensions were made for the east and west abutments.

The revised bridge withstood the floods of 1965 and 1969 without showing any signs of foundation instability. In fact, many bridges were lost throughout the State of Colorado during the 1965 flood, including six within the City of Denver.

Case History 29

Cruz Gulch at US24 near Colorado Springs, Colorado

Description:

The crossing is a triple CBC: 4.57 x 2.44M, 5.49 x 2.44M, and 4.57 x 2.44M . The length is 65.84M including an inlet and outlet.

The channel is 15.24 to 22.86M wide, straight upstream and sinuous downstream. The upstream banks are 1.22 to 1.52M , sloping, and grass-covered. The downstream bed at present is 3.05 to 4.57M below the outlet, with the channel having sidecut 4.57 to 6.10M near vertical banks. Both the bed and the bank materials are sand, clay and loam. The downstream channel continues to degrade with each heavy runoff. There is an interceptor outlet approximately 91.44M east of this crossing which experiences similar problems on a smaller scale.

Gradation Problem:

The original culvert (built in the mid-1960's) was 1.83 x 1.22 x 35.36M CBC. This crossing was adequate at the time, as upstream pastureland tended to attentuate peaks. The mid-1960's brought suburban development upstream of the site. By 1968, the increased runoff from the housing development caused the single CBC to be inadequate. It was replaced by a double CBC with CSP inlets.

As building continued upstream, the double CBC became inadequate. The present structure was installed in 1970.

The downstream channel started to headcut in the late 1960's and degradation has continued since that time. The present triple box is adequate to pass an annual spring runoff, and sometimes flows within .61M of the top. The outlet protection is

is undermined and is considered marginal at present. There are no current plans to repair the outlet, or to stabilize the downstream channel.

Countermeasures:

The single CBC was replaced with 1st a double and then a triple CBC which exists at present. However, no headcutting countermeasures have been conducted.

Discussion:

Upstream development activity has caused overloading of the two successive installations at this site. The present crossing, while hydraulically adequate, has created downstream degradation. This site is considered typical of Colorado culverts where the channel is grass-covered and stable upstream of the crossing.

Documentation includes recent slides, plans for 1968 and plans for 1970.

LITTLE MISSOURI RIVER AT US-22 NORTH OF KILLDEER, NORTH DAKOTA

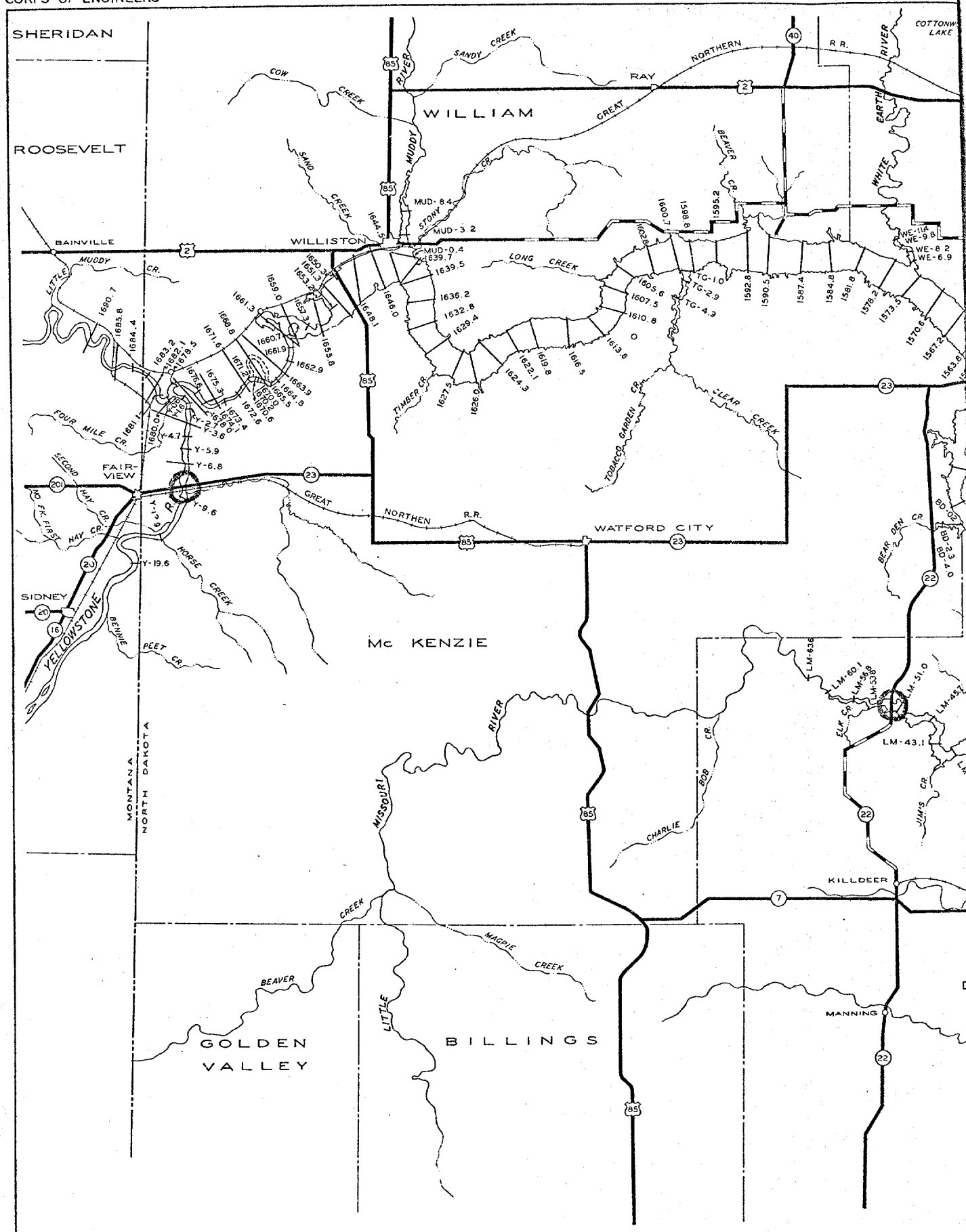
Description

The reach of the Little Missouri River of interest is in Dunn County. The highway crossing is about 24.1 km north of Killdeer on U.S. Highway 22 and is known as Lost Bridge. The highway crossing is in the backwater of Garrison Reservoir on the Missouri River. The drainage area near Watford City, North Dakota is 21,520 km^2 where there is a gaging station. The flow water and sediment discharge have been recorded at this site for 45 years. The bridge has concrete piers, steel pile foundations, spillthrough abutments and concrete wingwalls. The stream is perennial, alluvial, sand bed (d_{50}=0.25 mm), and on a fairly narrow flood plain. The channel is sinuous and the banks are sand. The Corps of Engineers have collected sufficient data to document this site in detail.

Gradation Problem

There has been about 3 m of aggradation at the highway crossing between 1955 and 1969. Garrison Dam was closed in 1953 and over the next few years the backwater condition from Garrison Reservoir had begun to impact Lost Bridge. Figure 1 shows the aggradation ranges where cross-section data is collected approximately every five years by the Corps of Engineers. Figure 2 is a summary of the sediment data collected at Watfort City. Figure 3

CORPS OF ENGINEERS



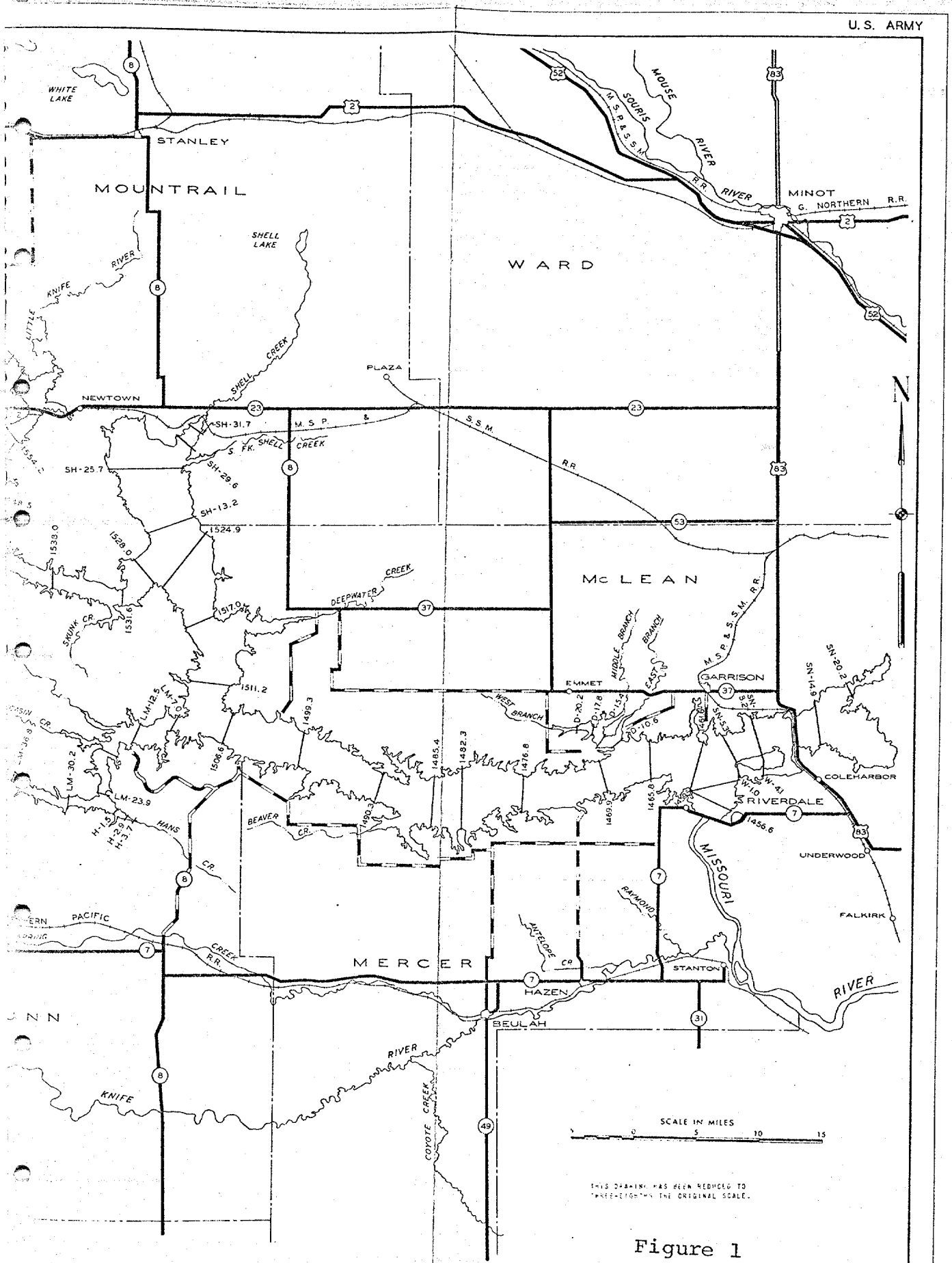


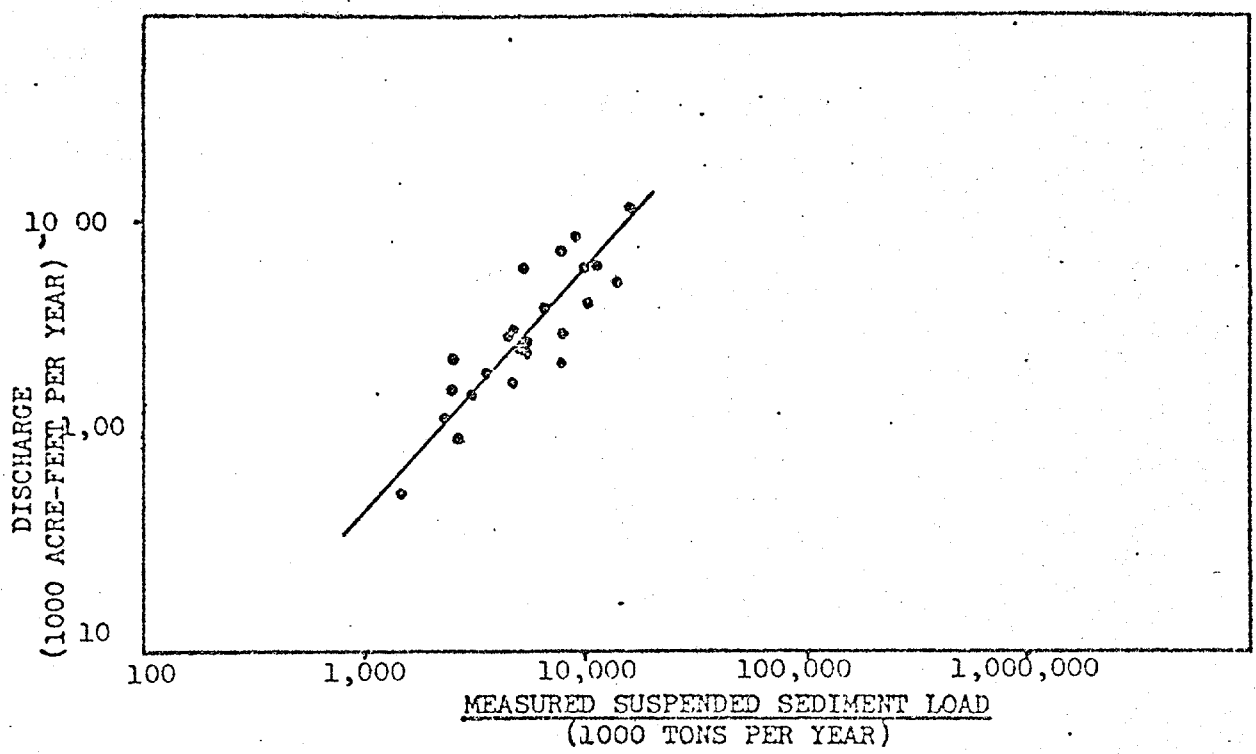
Figure 1

MISSOURI RIVER BASIN

GARRISON DAM AND RESERVOIR

LOCATION OF AGGRADATION RANGES

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA



WATER DISCHARGE AND SEDIMENT LOAD RECORD

YEAR	DISCHARGE (AC-FT)	SEDIMENT (TONS/YR)	YEAR	DISCHARGE (AC-FT)	SEDIMENT (TONS/YR)
1949	616,500	5,627,635	1964	233,200	8,236,300
1950	727,200	9,174,209	1965	532,700	14,706,100
1951	249,500	2,608,200	1966	212,200	3,758,800
1952	849,100	9,518,416	1967	617,100	10,516,400
1953	271,700	5,281,848	1968	181,800	2,578,000
1954	259,900	5,725,982	1969	628,800	11,770,500
1955	290,100	5,784,566	1970	321,000	7,527,561
1956	131,500	2,427,567	1971	1,185,000	16,785,586
1957	195,200	4,853,743	1972	108,850	2,847,695
1958	169,300	3,243,689			
1959	319,400	4,838,805			
1960	337,400	5,019,700			
1961	58,960	1,567,500			
1962	429,800	10,828,700			
1963	415,900	6,795,900			

LOCATION -- U.S.G.S. OFFICE OF WATER DATA COORDINATION STATION NO. 54739

WATER DISCHARGE RECORDS AVAILABLE -- October 1934 through September 1972

Figure 2

MISSOURI RIVER
LAKE SAKAKAWEA
SUSPENDED SEDIMENT RECORD AND RATING CURVE
LITTLE MISSOURI RIVER AT
WATFORD CITY, NORTH DAKOTA
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS, OMAHA, NEBRASKA
JULY 1975

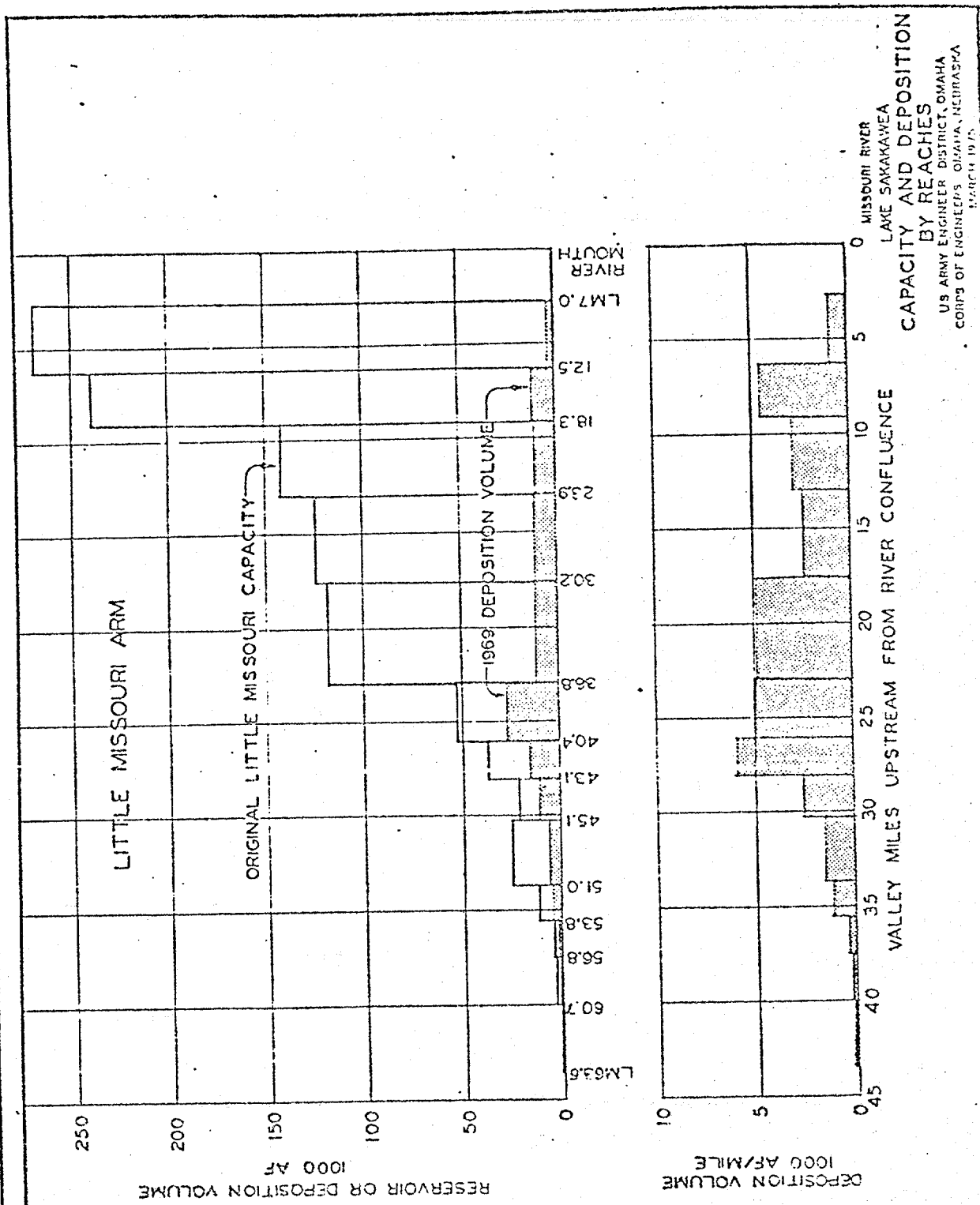

LAKE SAKAKAWEA
CAPACITY AND DEPOSITION
BY REACHES
US ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
MISSOURI RIVER
LITTLE MISSOURI ARM
ORIGINAL LITTLE MISSOURI CAPACITY
1969 DEPOSITION VOLUME
RIVER MOUTH
LM7.0
12.5
18.3
23.9
30.2
36.8
40.4
43.1
45.1
51.0
53.8
56.8
60.7
LM63.6
250
200
150
100
50
0
RESERVOIR OR DEPOSITION VOLUME
1000 AF
10
5
0
DEPOSITION VOLUME
1000 AF/MILE
0
5
10
15
20
25
30
35
40
45
VALLEY MILES UPSTREAM FROM RIVER CONFLUENCE

Figure 3

summarizes the capacity and deposition by reaches of the Little Missouri River upstream of Lost Bridge down to the natural confluence of the Missouri River. The capacity of the river has been reduced considerable and there exists a visual delta at aggradation range LM-36.8. The growth of the delta is fairly predictable and the conditions at the bridge are presently fairly stable.

Countermeasures

The only countermeasure applied at this bridge crossing has been some riprap to protect the abutments. At this point in time most damage and concern has been ice flows. The State Hydraulic Bridge Engineer anticipates that the bridge will have to be extended or raised within the next few years to pass the high flows.

Discussion

Although there is significant aggradation at this highway crossing, during high flows a large amount of sediment is scoured out and transported on downstream. During low flows the sediment fills back in the channel. There is some evidence that the sediment is getting coarser with depth and as a result less material is being scoured out with the high flows.

Case History 31

SMALL STREAM AT SR-24 SOUTH OF FORT YATES, NORTH DAKOTA

Description

The small stream of interest is in Sioux County and is a tributary of Lake Oahe. The stream is intermittent, the bed is sand, the slope is 0.0035, and the banks are steep with sparse grass cover. The drainage area above the bridge is about 50 km^2. The highway crossing is a double 2.4 x 3.0 m RC box that was built in 1962. The design discharge is 48.75 m^3, which is the estimated 25-year flood.

Gradation Problem

An inspection of the highway crossing in 1972 revealed a 3-m degradation at the downstream end of the RC box. The degradation was primarily due to channel modifications and land use changes. A low design discharge may also be partially responsible for some of the degradation after it started. Agricultural demands on adjacent land resulted in realignment and shortening of the channel. The adjacent land was also taken out of grassland and is now cultivated.

The stream banks downstream are very steep and unstable. Some prime agricultural land has been eroded away and transported into Oahe Lake.

Countermeasures

In 1975, a 3-m drop structure and energy dissipator was attached to the downstream end of the two RC boxes. The banks for several hundred meters downstream were reshaped, graded, and stabilized with riprap close to the bed and grass above the riprap. The drop structure and energy dissipator have been tested for 4 years. The design seems to be adequate, and there have been no signs of additional degradation or related problems.

Discussion

Degradation below box bridges is common in North Dakota. It is necessary after about 2 m of degradation to attach a drop structure and energy dissipator to protect the highway crossing. This mitigative measure is adequate to protect the structure and stop additional degradation

TRIBUTARY TO EAST FORK OF THE NISHNABOTNA RIVER AT SH-37 NEAR DEFIANCE, IOWA

Description

Lat. 41° 49', Long. 95° 20'. The East Fork of the Nishnabotna River in Shelby County, Iowa flows in a southerly direction and joins the West Nishnabotna River near Harlan, Iowa. The drainage area for this tributary is approximately 8.94 sq km of hilly and very hilly ground that is extensively farmed with brush and trees covering the remaining areas. The entire area is founded on loess type soils with d_{89} passing the 200 sieve. The banks are vertical except where sloughing has occured and are covered with grasses and some brush to the edge of the vertical drop off.

Gradation Problem

The Nishnabotna River was extensively straightened and channelized in the 1930's and 40's thereby greatly increasing the sediment carrying capacity of the River. A bridge on Highway 37 was built over the tributary to the East Fork of the Nishnabotna River in 1937. In 1965 the tributary had degraded 8.6 feet at the bridge (fig. 1) and was endangering the pier footings shown in fig. 2. Further study indicated that an additional 20 feet of degradation was likely.

Countermeasures

In 1965 and 1966 the Highway Maintenance department attempted to protect the pier footings and the top of piles as shown in fig. 3 but the attempt was abandoned when

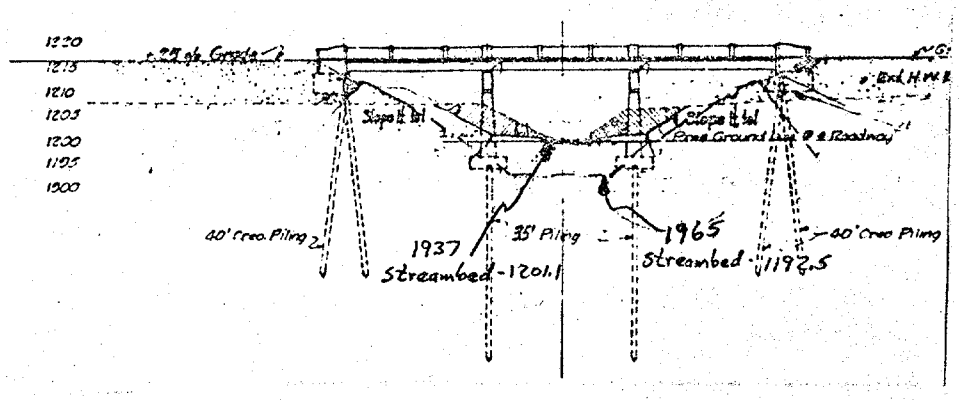


Figure 1. E. Fork at Nishnabotna River near Defiance, IA
Streambed degradation at Highway 37 bridge

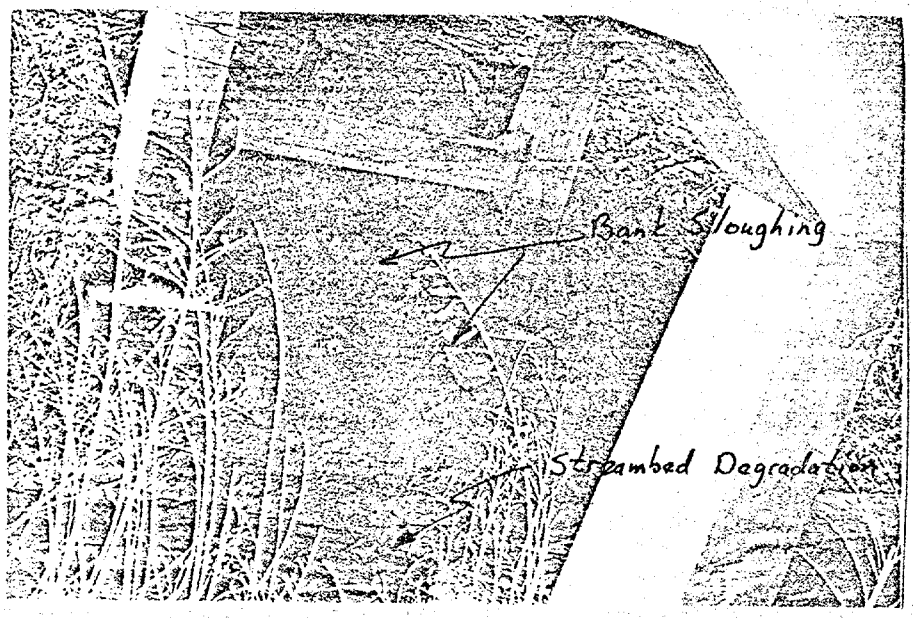


Figure 2 - E. Fork of the Nishnabotna River near Defiance, IA
Streambed Degradation and Bank Sloughing at
Highway 37 Bridge.

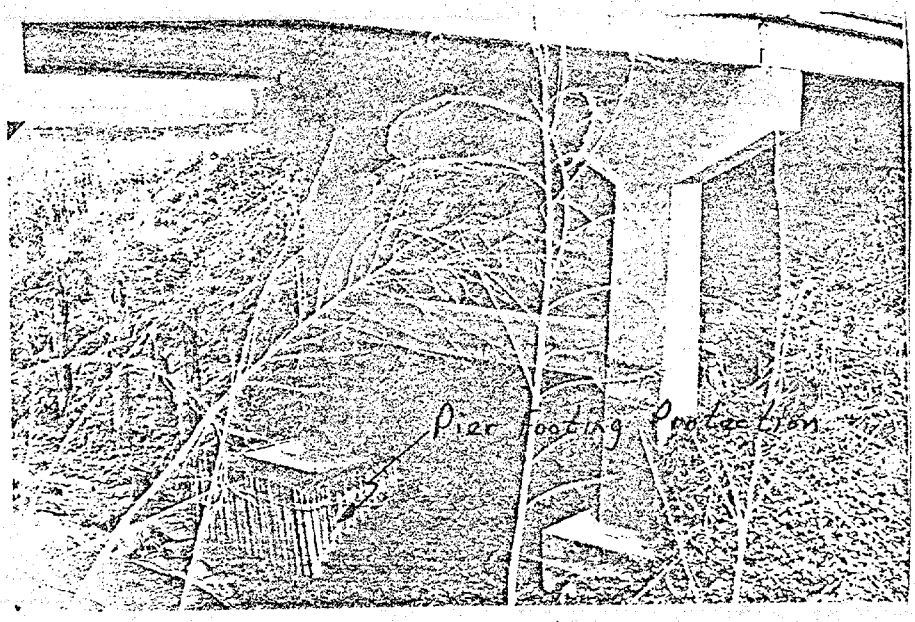


Figure 3 - E. Fork of the Nishnabotna River near Defiance, IA
Pier Footing Protection at Highway 37 Bridge

further study indicated the likelihood of further degradation in the reach. As a solution to the problem, the Highway Department replaced the bridge with a culvert and drop flume in 1968. The upstream end of the flume was set at the original streambed elevation with a drop flume and stilling basin to drop the flow to the existing streambed downstream from the culvert.

Discussion

The Iowa DOT has found culverts and drop structures to be effective in countering degradation if they are designed and constructed properly. County road departments have attempted to use the same idea but with mediocre results due to improper design and construction.

Case History 33

CULVER CREEK, TRIBUTARY TO BOYER RIVER AT SH-37 NEAR DUNLAP, IOWA

Description

Lat. 41° 50', Long. 95° 34'. Culver Creek is a small tributary of the Boyer River with a drainage area of approximately 7.77 sq km. The Boyer River in Harrison and Shelby Counties flows in a southwesterly direction where it eventually joins into the Missouri River. The watershed contributing to Culver Creek is hilly to rolling land that is very nearly 100 percent under cultivation.

The channel is in loess type soils that are characteristic of the entire western region of Iowa. Banks are vertical but show much sloghing and have grasses and brush growing in undisturbed areas.

Gradation Problem

The Boyer River underwent extensive straightening in the late 1930's and early 1940's. Highway 37 crossed Culver Creek with a bridge that was constructed in 1934. By 1948 the streambed under the bridge had degraded 3.04M as shown in figure 4 and strutting was placed between the piles to prevent buckling.

Countermeasures

In 1961 a 5.18M x 3.04M box culvert and flume drop with stilling basin - shown in figure 5 - were constructed to replace the Highway 37 bridge over Culver Creek. The culvert inlet was placed approximately 6.71M above the

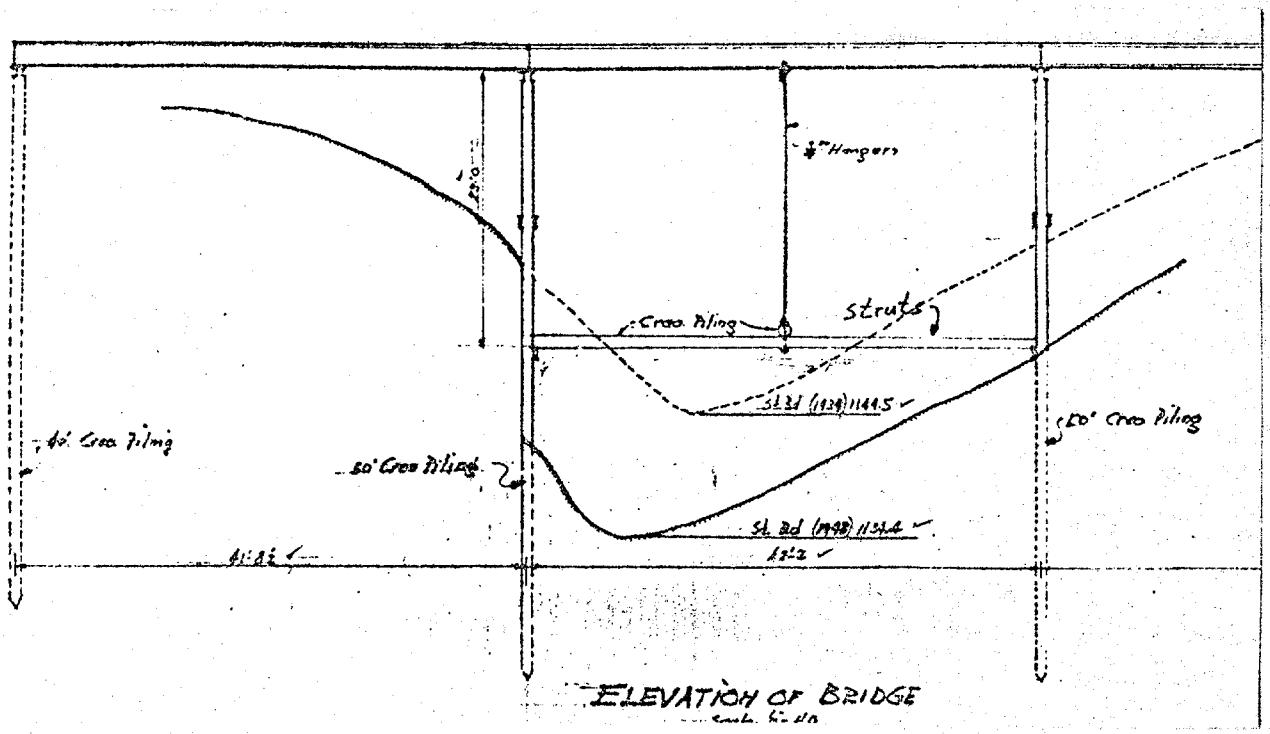


Figure 4 - Culver Creek near Dunlap, IA
Streambed Degradation and
Repair Struts at Highway 37
Bridge

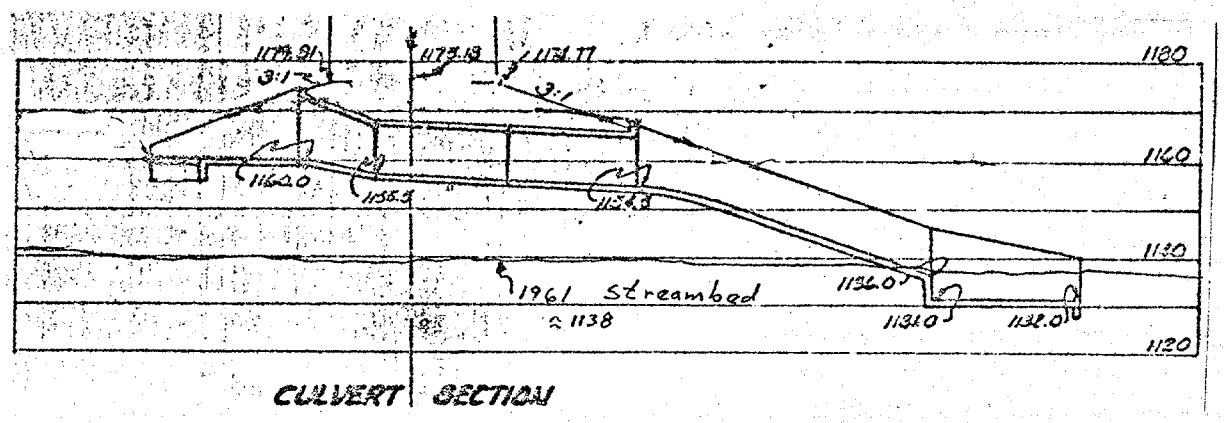


Figure 5 - Culver Creek near Dunlap, IA
Box Culvert and Flume Drop at
Highway 37

existing streambed. By the fall of 1964 the gully upstream from the box culvert had been completely filled with silt to the elevation of the culvert inlet. The amount of silt deposited has been conservatively estimated at 45,500 metric tons. The area upstream from the culvert is presently being used as grazing land and is totally reclaimed.

Discussion

Highway structures can play an important role in stabilization of river reaches if properly designed and constructed. The amount of sediment deposited upstream form the culvert would indicate an average loss of between seven and eight metric tons of soil per acre per year in the watershed before the structure was constructed. Color slides, taken in March 1979, of the culvert and Culver Creek are available.

Case History 34

MOSQUITO CREEK AT SH-191 NEAR PORTSMOUTH, IOWA

Description

Lat. 41° 39', Long. 95° 31'. Mosquito Creek in Shelby, Harrison, and Pottawattamie Counties flows in a southwesterly direction and joins the Missouri River near Council Bluffs, Iowa. Mosquito Creek in the study reach has a drainage area of approximately 83 square km and is situated in an area of rolling hills of loess type soils (d_{89} = #200). The area is farmed extensively with only small areas of homes and trees not under cultivation.

Gradation Problem

Mosquito Creek was involved in a channel straightening project in the late 1930's and channel degradation began at that time. Iowa Highway 191 parallels Mosquito Creek for over 80 km and many of the degradation problems are occurring at crossings of tributaries to Mosquito Creek. The Highway 191 bridge over a small tributary (drainage area = 11.4km^2) to Mosquito Creek in Shelby County near Panama was built in 1939 and the stream gradient was 0.96M per km. In 1956 the stream had degraded nearly 1.82M and the gradient was 4.62M per km. By 1971 the streambed had dropped another 2.44M, shown in figure 5, requiring underpinning of the south pier to maintain the integrity of the bridges. Another Highway 191 bridge, over a tributary to Mosquito Creek (drainage area =

10.36 km^2) in Shelby County near Portsmouth experienced 5.49M of degradation between 1934 and 1971 as illustrated in figure 6. This degradation necessitated replacement of the bridge with a culvert in 1971.

A bridge for Highway 191 was built over Spring Creek in 1934. Spring Creek is a 33.7 sq km watershed tributary to Mosquito Creek in Harrison County near Persia. By 1976 the streambed at the bridge had dropped over 3.09M and after a big storm the water saturated back under the bridge sloughed into the stream and moved one of the piers over 0.30M horizontally, necessitating emergency repairs to the bridge as shown in figure 7.

Countermeasures

In 1965 the Iowa Highway Department decided to undertake measures to prevent further degradation to a reach of the Creek that is crossed by two highways, a railroad, and a county bridge. The structure decided upon was a sheetpile dam embedded in earth and riprap and paved with derick stones in the crest, spillways, and stilling basin. (See figure 8). The top of the sheet piling was set 4.3M above the streambed. Prior to construction of the stabilization structure the streambed had degraded 4.6M or to a highway bridge 0.8 km upstream from the structure, severely undermining the pier footings. At the present time, the stabilization structure is functioning well, has raised the streambed nearly 0.3M at the bridge and the pier footings are nearly covered back over with silt.

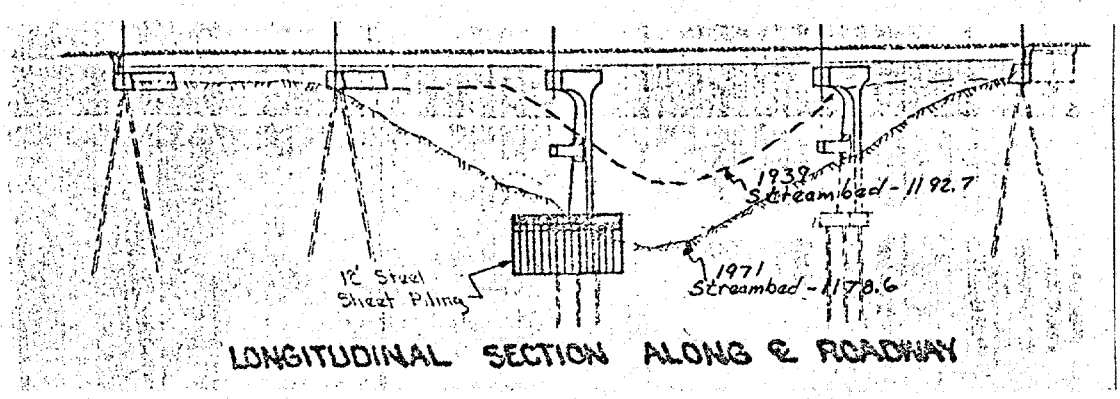


Figure 5 - Mosquito Creek near Portsmouth, IA Streambed Degradation and Pier Underpinning at Highway 191 Bridge over Tributary to Mosquito Creek near Panama, IA

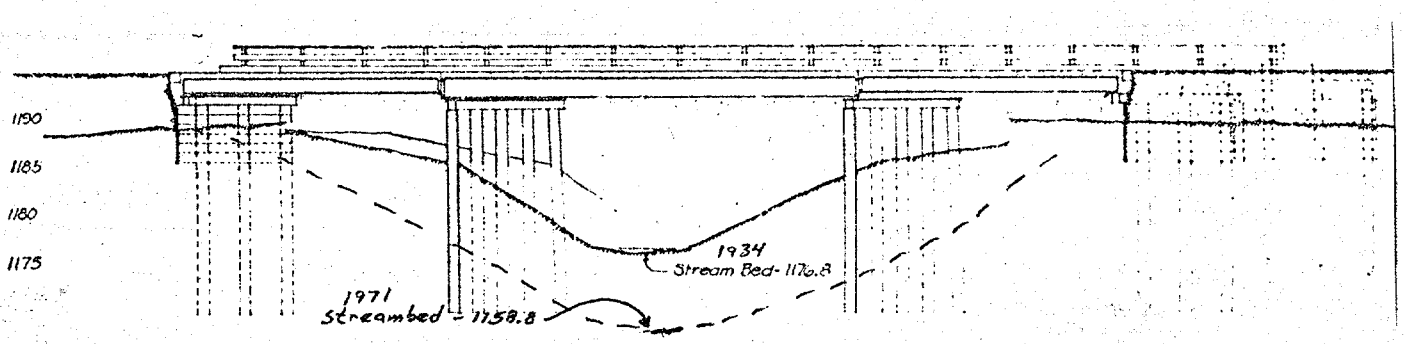


Figure 6 - Mosquito Creek near Portsmouth, IA Streambed Degradation at Highway 191 Bridge over Tributary to Mosquito Creek

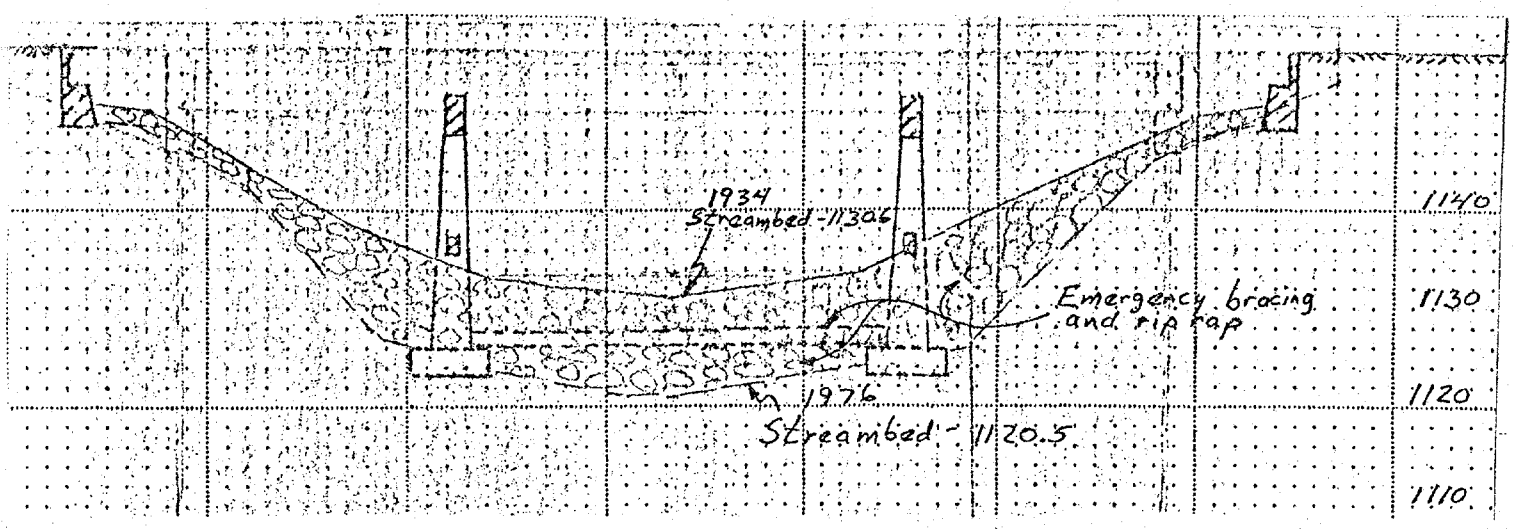


Figure 7 - Spring Creek near Persia, IA
Streambed Degradation and
Emergency Repairs at Highway 191

FIGURE NOT AVAILABLE AT THIS TIME

Figure 8 - Mosquito Creek near Portsmouth, IA
Stream Stabilization Structure

The Highway 191 bridge over Spring Creek was another bridge that was scheduled for replacement with a box culvert and flume drop due to the severe degradation noted previously. However, just before the project was to be awarded it was brought to the attention of the Highway Department that Shelby County had built a dam and flume drop about 0.23 km downstream, on Mosquito Creek, from the Highway 191 bridge. This structure has successfully stopped the degradation previously occurring in the reach and the Highway Department no longer plans to replace the bridge at Spring Creek.

Discussion

Mosquito Creek and it's tributaries contain good examples both of problem degradation and possible solutions. The solutions have been approached in three ways:

(a) Channel stabilization structure (figure 8)

(b) Box culvert and flume drop; and

(c) a flume drop under a bridge as done by Shelby County.

All of the structures adhere to the same principle, that being to raise the streambed at a point such that the slope of the stream is less than that required to cause degradation in the reach. Then, provide a drop structure and energy dissipation so as not to worsen the degradation problem downstream.

Extreme care must be taken during design and construction to insure that the structure will function properly and is not in danger of failure due to soil piping, erosion or continued downstream degradation.

Soil piping can be best controlled by increasing the length the water has to travel before it can short-circuit through or around the structure. This can be done by using cut-off walls of concrete or sheetpiling and with clay cores in the center of earth filled structures.

Erosion is countered through the use of properly sized and placed riprap. Riprap is most useful when used in conjunction with a stabilization structure rather than all alone.

Failure of a structure due to continued downstream degradation is a common problem. If the downstream end of a structure is not built low enough it can be severely undermined if degradation continues in the reach downstream from the structure. Thus, the lowest elevation on a structure should be placed below the point to which the stream will degrade in the future. This coupled with effective energy dissipation in the structure will help prevent structure failure due to continued downstream degradation.

Case History 35

SILVER CREEK AT I-80 NEAR SHELBY, IOWA

Description

Lat. 41° 31', Long. 95° 27'. Silver Creek in Shelby and Pottawattamie Counties, Iowa, flows in a southwesterly direction and joins the West Nishnabotna River near Malvern, Iowa. The drainage area as the river passes Shelby is approximately 114 sq km of which 75% is under cultivation and 25% is in pasture, brush and other uses. The area is composed of rolling loess hills typical of the region. The river banks are nearly vertical but experience sloughing if they become too water-saturated. The slope of the streambed near Shelby is 5.3M per km.

Gradation Problem

Many rivers in the western third of Iowa were extensively straightened in the 1930's but Silver Creek was one that was missed. However, the West Nishnabotna River to which Silver Creek is tributary was straightened in the 1930's and Silver Creek experienced a certain amount of straightening in a piecemeal fashion as individual farmers and areas removed bends and straightened reaches between 1930 and 1960.

I-80 was extended across Silver Creek with two bridges side by side in 1964. At this time the Highway Commission, realizing that there was a degradation problem in Silver Creek, allowed for continued degradation in the design of the bridges as shown in figure 9. At this time (1979), the stream has already degraded over 1.5M where it passes under the bridge.

Countermeasures

The countermeasure involved at the I-80 crossing of Silver Creek is that the Highway Commission allowed for a certain amount of degradation to occur before the bridges will be hurt in any way. This is an effective and inexpensive method of solving the problems resulting from degradation at least for a period of years. It requires knowledge of the attributes of the stream being crossed and possible future changes.

Discussion

As stated above, knowledge of a stream's present physical characteristics and what they may be in the future plays an important part in proper planning and design of highway bridges. Proper planning and design may prevent costly repairs and even replacement of bridges endangered by gradation problems.

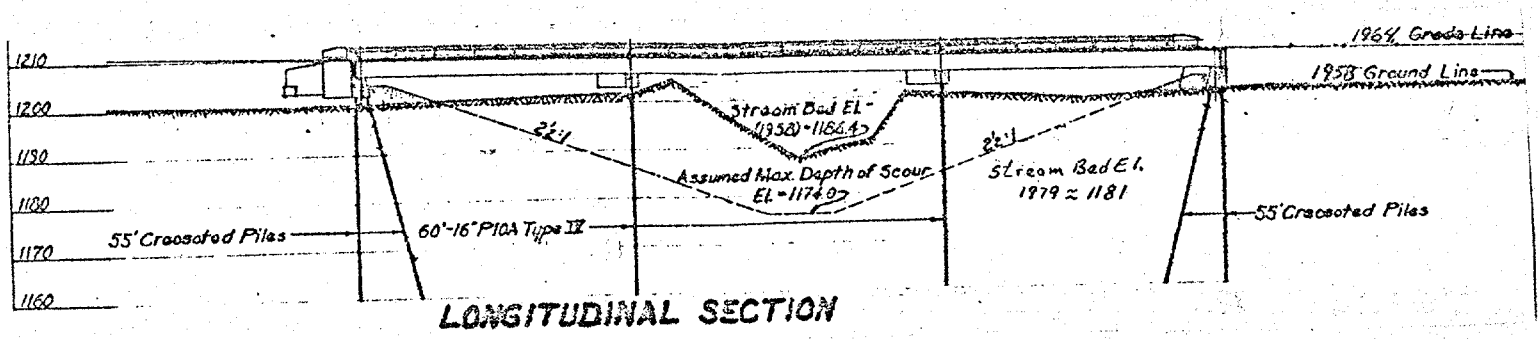


Figure 9 - Silver Creek near Shelby, IA
I-80 Bridge Design Showing
Allowance for Streambed
Degradation

BIG WHISKEY CREEK AT US-20 NEAR LAWTON, IOWA

Description

Lat. 42° 28', Long. 96° 14'. Big Whiskey Creek in Woodbury County runs in a southerly direction and joins Farmers Ditch, near Luton, which then joins the West Little Sioux River. Big Whiskey Creek drains a watershed of approximately 34 sq km much of which is under cultivation.

Gradation Problem

The Little Sioux River was straightened along much of its length in the late 1940's and that, along with the very straight nature of Farmers Ditch into which Big Whiskey Creek flows, caused general streambed slope steepening and degradation in Big Whiskey Creek.

The first U.S. Highway 20 bridge over Big Whiskey Creek was built in 1952 with a second bridge being completed in 1958. At the time of construction some degradation of the streambed was evident, (see figure 10), but it was apparently ignored. By 1977 the streambed had degraded 2.75M and repairs had to be undertaken to prevent bank sloughing and underpin the pier footings.

Countermeasures

Only bridge protection maintenance has been undertaken as a result of the degradation.

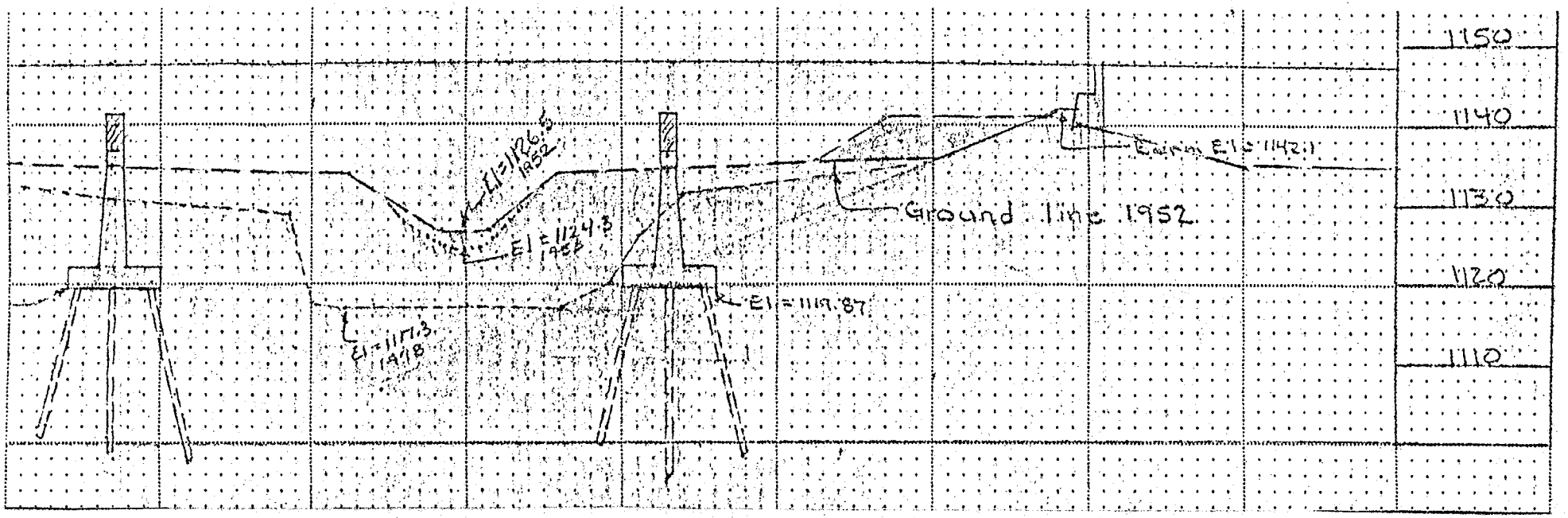


Figure 10 - Big Whiskey Creek near Canton, IA
Streambed Degradation at U.S.
Highway 20

Discussion

In 1950, when the second U.S. 20 bridge over Big Whiskey Creek was built, degradation was already evident and preventive steps could have been taken. Because the Highway Commission did not apply any preventive measures, progressively more major bridge rehabilitation will be needed in order to keep the bridge in service as the degradation continues.

Case History 37

IOWA RIVER AT SH-14 NEAR MARSHALLTOWN, IOWA

Description

Lat. 42° 3', Long. 92° 53'. The Iowa River in Marshall County flows in a southeasterly direction and has a drainage area of 4050 square km.

Gradation Problem

The Iowa River was straightened for 80-160 km upstream of Marshalltown, Iowa in the 1930's (figure 11). The streambed elevation at the Highway 14 bridge over the Iowa River at Marshalltown has agraded over 1.8M since the bridge was built in the 1930's.

Figure 12 shows rating curves for the gaging station at the above mentioned bridge over the Iowa River at Marshalltown, Iowa. As shown in the figure the rating curve has changed dramatically as the aggradation in the river has progressed. Due to the aggradation, Marshalltown is subjected to frequent flooding.

Countermeasures

The Army Corps of Engineers has build levees on both sides of the Iowa River at Marshalltown in control flooding, however, the levees were built using the criteria given by old rating discharge curves and may be too low to be totally effective.

Figure 11 - Iowa River at Marshalltown, IA Channel Straightening (From U.S.G.S. Marshalltown, IA 15' Quad)

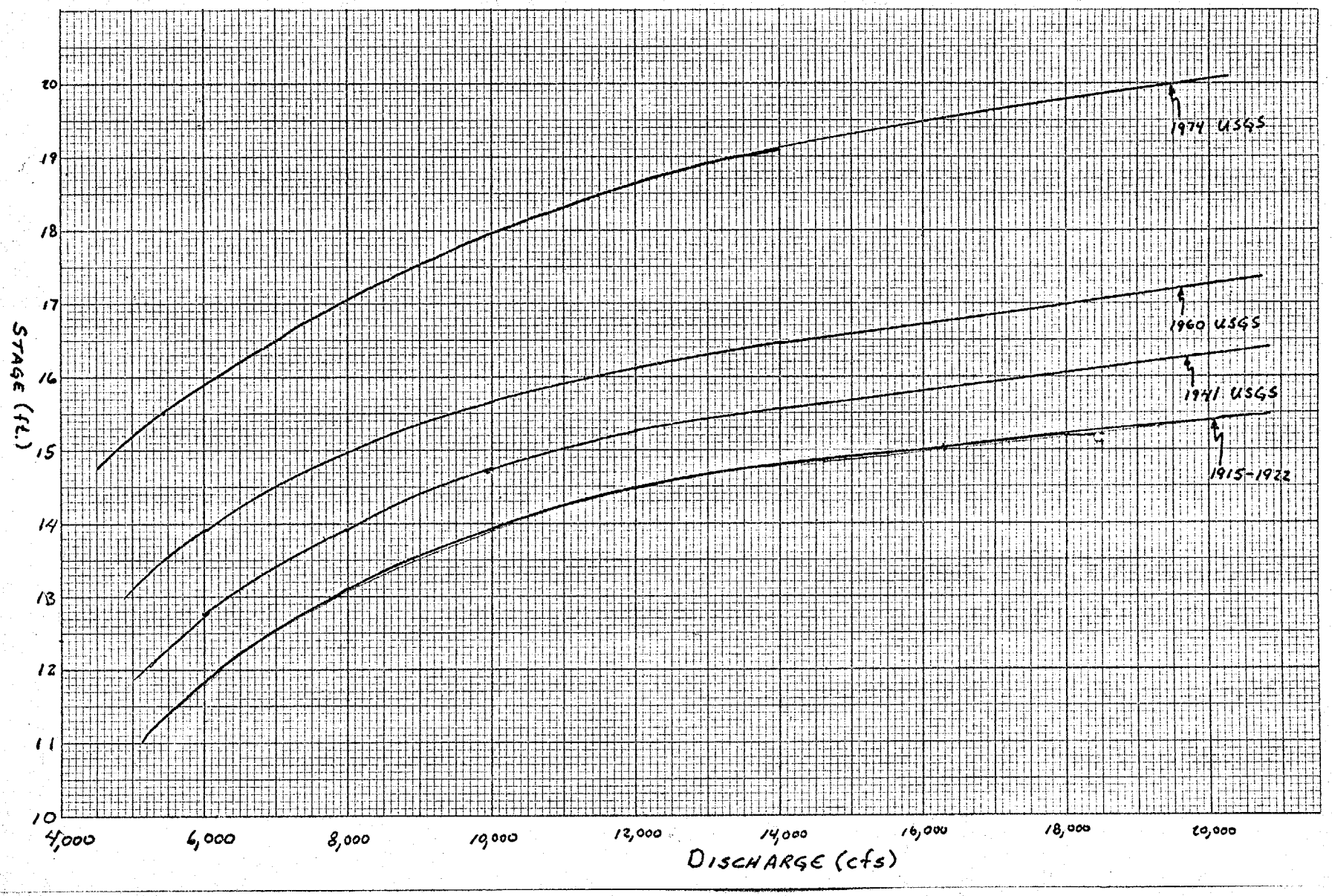


Figure 12 - Iowa River at Marshalltown, IA
Stage-Discharge Graph

Discussion

The straightening of the Iowa River increased the slope and thus the sediment carrying capacity of the river upstream of Marshalltown but did nothing to vary the sediment carrying capacity of the river downstream from Marshalltown. Thus, the added sediments are depositing at the end of the river straightening and the river is aggrading and the flood plain deteriorating at Marshalltown.

Case History 38

ALLEN CREEK AT SH-127 NEAR MAGNOLIA, IOWA

Description

Lat. 41° 41', long 95° 52'. Allen Creek in Harrison and Pottawattamie Counties, flows in a southerly direction. The drainage area is 41.5 square km of hilly to very hilly land which is mostly in cultivation and pasture with some areas of trees. The soil is loess-type with d_{89} passing a 200 sieve.

Gradation Problem

The first bridge for Highway 127 over Allen Creek was built in 1939, and at that time the slope of the creek was 6.06M per km and the streambed had already degraded 1.0 to 1.5M in the preceding 5 years. By 1968, the streambed had degraded an additional 2.5 to 3.0M, as shown in Figure 13; thus necessitating replacement of the existing bridge.

It should be noted that Allen Creek was straightened over almost its entire length in the early 1930's and that is the reason for the extreme river slope noted in 1939 at the time of construction of the first bridge.

Countermeasures

No countermeasures, except that of building a new bridge, were undertaken.

Discussion

More attention should have been given to the slope of the river and its tendency toward degradation at the time of construction of the first bridge. The increased sediment carrying capacity due to straightening can be anticipated when the river slope at the time of construction (6.06M per km) and the slope of stable rivers in loess type soils (0.95-1.12M per km) are compared.

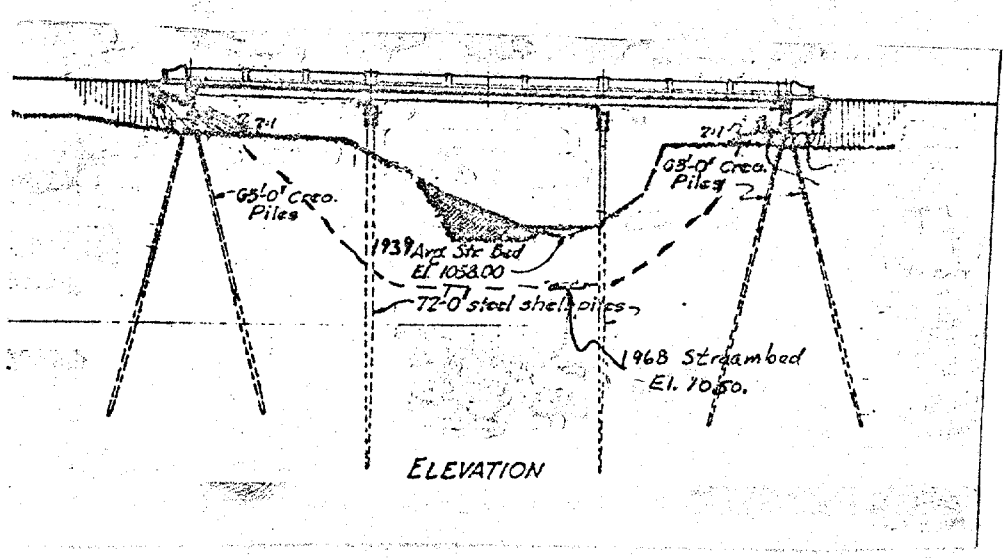


Figure 13 - Allen Creek near Magnolia, IA
Streambed Degradation at
Highway 127 Bridge

Case History 39

GRAYBILL CREEK AT SH-92 NEAR CARSON, IOWA

Description

Lat. 41° 14', Long. 95° 21'. Graybill Creek in Pottawattamie County flows in a southwesterly direction and joins the West Nishnabotna River near Henderson, Iowa. The drainage area of approximately 114 square km is in rolling to very hilly terrain composed chiefly of loess type soils 10-15M deep over sand and gravel underlain by shale. The creek has vertical banks that are heavily vegetated with grasses, brush and trees as shown in figure 14.

Gradation Problem

The Nishnabotna River was extensively straightened and channelized in the 1930's and 1940's. A bridge on Highway 92 over Graybill Creek was constructed in 1954 and at that time no abnormal degradation was apparent. By 1977 the streambed had degraded more than 3.3M as shown in figure 15, and the steel pilings have been exposed 1.8-2.4M below their concrete encasement. The degradation occurred at a very rapid rate evidenced by figure 14. At the time of the photograph in April 1976, in addition to the headcut visible in the photo, there was a headcut underneath the bridge and one 90M downstream of the bridge.

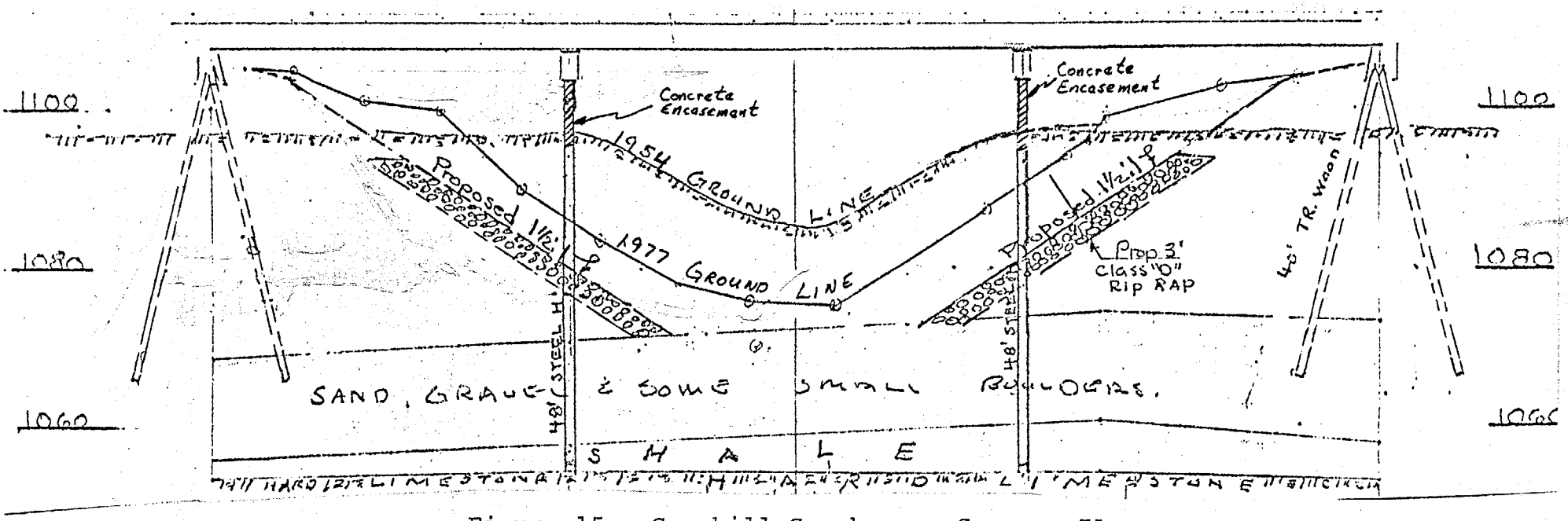


Figure 15 - Graybill Creek near Carson, IA
Streambed Degradation at
Highway 92 Bridge

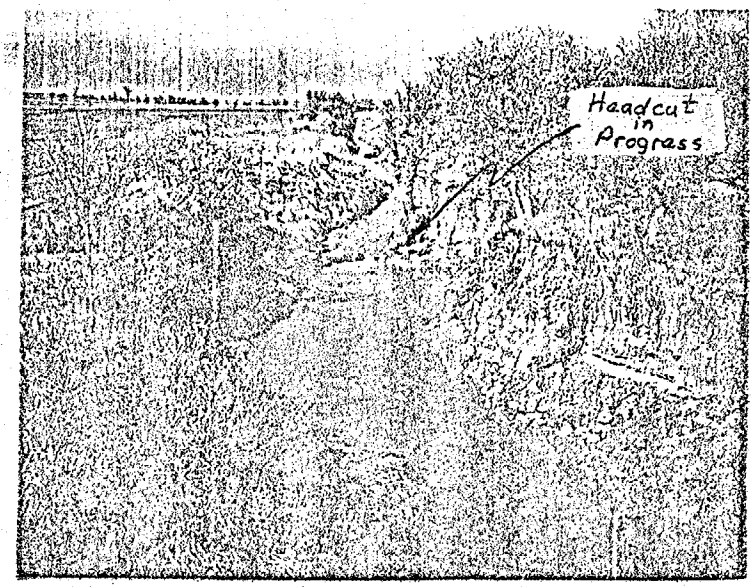


Figure 14 - Graybill Creek near Carson, IA
View Upstream from Highway 92
Bridge, Shwoing Banks and Headcut

Countermeasures

The Highway Maintenance Department is attempting to prevent buckling of the piles and to control the slope erosion by using bracing and riprap. A layer of sand and coarse gravel and cobbles lies just beneath the present streambed. This layer should be effective in slowing down if not arresting totally the degradation in this reach of Graybill Creek.

Discussion

It is easy to overlook the consequences to river tributaries that are caused by work done in the main channel. Such a case is Graybill Creek where the head-cuts did not travel upstream until 20-30 years after the channel straightening occurred in the West Nishnabotna River. When the degradation happened though, it progressed very rapidly and without a good program of inspection may not have been caught until too late to save the bridge. Color slides taken in March 1979 are available.

Case History 40

ONE HUNDRED AND TWO RIVER NEAR GRAVITY, IOWA

Description

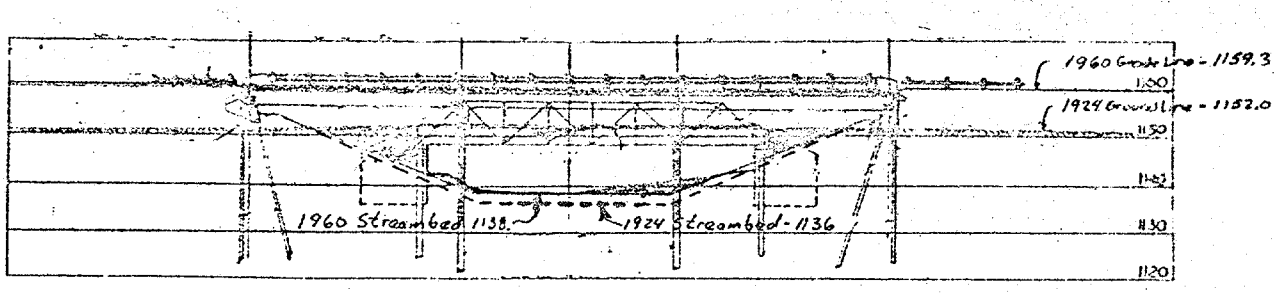
Lat. 40° 15', Long. 94° 45'. The 102 River and its' forks and branches in Taylor County flow in a south westerly direction into Missouri where they all consolidate into one channel. At the Missouri-Iowa border the drainage area is approximately 780 square km of rolling to very hilly terrain. The upper ends of the 102 River are characterized by very low flows except for occasional stormflows during the summer and winter months.

Gradation Problem

In 1960 the State Highway Commission made plans to replace some old bridges in the described reach of the 102 River. At that time it was discovered that the streambed was aggrading an average of 0.76M at the four sites (Figure 26). The bridge grade at each site was raised an average of 2.6M at the time of construction.

Countermeasures

The bridge elevations were raised an average of 2.6M above the existing grades to provide ample room for aggradation to occur before flow constriction will become a problem.



LONGITUDINAL SECTION

Figure 26 - 102 River near Granity, IA
Bridge Replacement Showing
Typical Aggradation and
Countermeasure

Discussion

Persons familiar with the problem were unable to determine the cause of the aggradation in this reach of the 102 River. A possible explanation relates to the impact of farming practices on the sediment load in the 102 River.

The 102 River in the reach described above has just come out of very hilly terrain into flatter terrain where the channel slope is approximately .0004. This change in slope and resultant lower flow velocities results in a lower sediment carrying capacity.

As the value of land has greatly increased in the last 30 years, more and more of the land in this region has been converted from pasture to cultivation. The standard practice in the area is plow the gound in the fall and let it lie dormant through the winter. A dry winter coupled with winds can cause blowing and drifting of the very fine loess silts. This blowing and drifting along with erosion of farmland during storms can greatly add to the sediment load in the rivers. The added sediment load coupled with the low flows often experienced in the 102 River may be entirely responsible for the degradation now happening in the 102 River.

Case History 41

FLOYD RIVER NEAR JAMES, IOWA

Description

Lat. 42° 35', Long. 96° 19'. The Floyd River in Plymouth and Woodbury Counties, Iowa flows in a southwesterly direction into the Missouri River and drains an area of approximately 2280 square km. The area is characterized by loess bluffs which drop off into the Missouri River flood plain.

Gradation Problem

Two factors have caused degradation to occur in the Floyd River. First, around 1958 the dams on the Missouri River, upstream from Sioux City, were completed and storage, with the resultant clear water releases, began. Second, in 1961 the Floyd River channel was straightened through Sioux City.

The combination of the above two factors has led to degradation in the Floyd River as evidenced by the change in the stage-discharge graph at the county bridge near James Iowa (Figure 34). The stage-discharge graph, along with measured elevations indicate a drop of nearly 3M in the bottom of the channel.

Countermeasures

As yet, none of the State Highway bridges in the area have been endangered, and no countermeasures have been taken. The continued degradation of the Floyd River will be taken into consideration during the design of any new or replacement bridges over the river.

Discussion

Clear water discharges from dams along with channel straightening have proven to be two of the major causes of channel degradation

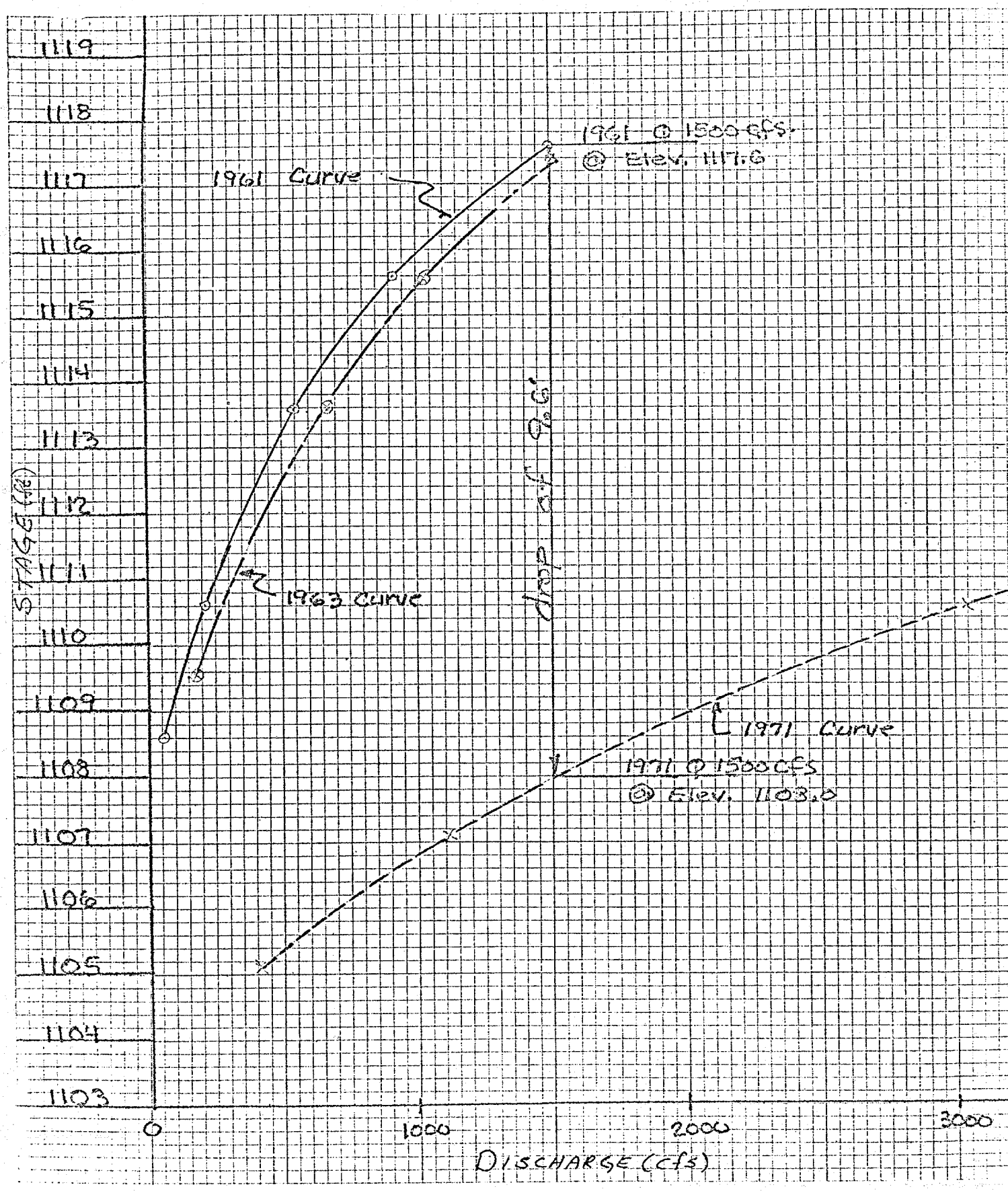


Figure 34 - Floyd River near James, Iowa.
Stage-Discharge Graph
indicating degradation.

Case History 42

KANSAS RIVER NEAR BONNER SPRINGS, KANSAS

Description

The reach of the Kansas River of interest is in Leavenworth County and extends from the county line on the east to the county line on the west. There is no specific highway crossing that will be discussed in detail. There is presently a gaging station at DeSoto. Prior to October 1973 the data was published as "At Bonner Springs". This gaging station is one of the National stream-quality accounting network and pesticide stations. The drainage area at the gage is 154,768 km^2, of which a large area is noncontributing. The stream is perennial, alluvial, sand bed and in a fairly confined flood plain. The channel is sinuous, banks are incised by degradation and has cut banks of silt and sand. The Kansas River flows are controlled by several flood control resevoirs on many of the large tributaries. As a result, sustained flows are generally released throughout the year.

Gradation Problems

There is about 2.1M of degradation reported in this reach of the Kansas River. This is documented at the gaging site at DeSoto, at the various highway crossings where the stream bed elevation is about 2.1M lower than when constructed, and several water intakes are

becoming a serious problem to the communities that depend on diverting water from the Kansas River. The degradation is causing serious lateral erosion and bank caving. Just upstream of DeSoto farm land adjacent to the river is being eroded away as the river is adjusting to an increase in slope. The river in many places is becoming wider, and as banks cave in debris loads are increased.

Countermeasures

Bank protection has been the main issue thus far. Riprap has been placed to control lateral erosion. This has not been very successful, because of additional degradation.

Discussion

A discussion with the local Corps of Engineers and the U.S. Geological Survey indicated that the degradation is primarily due to sand and gravel mining over a rather long reach of the river. The volume of sand and gravel mined on an annual basis could account for most of the degradation. Another contributing factor could be the high sustained flows being released over the year from numerous flood control reservoirs on the tributaries. A small amount of degradation could be attributed to the fact that the Missouri River at Kansas City has degraded about 0.61 meters.

Because most of the bridges are founded on bed rock, degradation has not resulted in any bridge failures. The lateral erosion is the main concern to some of the older bridges, and to saving productive farm land.

Case History 43

STONE HOUSE CREEK, US-24 AND US-59 AT WILLIAMSTOWN, KANSAS

Description

Stone House Creek is located in Jefferson County. There are two highway crossings of interest; one on U.S. Highway 24, 0.2 km north of Williamstown (Lat. 39° 04', Long. 95° 20') and the other on U.S. Highway 59 just north of Williamstown. Stone House Creek is a tributary to the Kansas River. At U.S. Highway 24, the drainage area is 33 square km and the gaging records at the bridge site indicate an average discharge of 9 cubic meters per second. The stream is perennial, alluvial, sand and gravel bed and in a wide flood plain. The channel is sinuous, some channel modifications, incised by degradation and has cut banks of sand. The bridge at U.S.-24 has concrete piers in the channel, wood pile foundations, spillthrough abutments and concrete wingwalls. The bridge at U.S.-59 is a box bridge.

Gradation Problem

There has been about 1.8M of degradation at the U.S.-24 bridge. The degradation has exposed the pier footings and the foundation piles. There is about 1.2M of degradation at the U.S.-59 bridge. The degradation has undermined the box bridge and there is considerable damage to the concrete structure. The banks degradation has caused considerable bank caving and as a result debris has been a problem.

Only minor channel modifications have been made to the channel. The degradation is mainly attributed to headcutting. The Kansas River has degraded due to extensive gravel mining and sustained uniform flow releases from the many flood control reservoirs. This adjustment in bed elevation in the Kansas River has resulted in an adjustment and lowering of the bed elevation in Stone House Creek up to the box bridge, which has acted as a grade control structure.

Countermeasures

Concrete has been poured around the pier footings and the exposed piles at U.S.-24 bridge several times over the years to protect them from exposure to the atmosphere. The State Highway Department has plans to replace this bridge. Below the U.S.-59 bridge riprap stabilized with concrete has been placed below the box bridge and on the banks. The concrete stabilized the riprap but addition degradation has undermined the bank protection and no riprap exists now below the bridge. The State Road Department has plans to replace this bridge soon.

Discussion

Tributary channel degradation, resulting from degradation or adjustment in bed elevation of the Kansas River is to be expected. Lateral erosion, bank caving and debris problems accompanying the degradation has been a serious problem. The bridges were not designed for any bed elevation changes.

Case History 44

MIDDLE FORK OF BEARGRASS CREEK, AT I-64, JEFFERSON COUNTY, KENTUCKY

Description

Lat. 38° 20', Long. 85° 40'. The Middle Fork of Beargrass Creek drains 6.0 square km of Louisville. The channel is meandering with low but fairly stable banks. Bed material is sand, gravel and cobbles. The creek flows under I-64 and the design capacity is 127 cms .

Gradation Problem

In order to eliminate the necessity of constructing 8 box culverts to allow the stream to continue in its natural course under I-64, the Middle Fork of Beargrass Creek was straightened. Although the slope was increased by these cut-offs of bends, the channel is aggrading due to constricted flow under I-64 and increased sediment supply due to urban development and construction.

Countermeasures

None

Discussion

The Middle Fork of Beargrass Creek was straightened to avoid construction of 8 box culverts. Despite this, due to a flow constriction and abnormal amounts of sediment nearby, the channel is aggrading which has decreased flow capacity and increased flood potential.

LYNNVIEW DITCH, JEFFERSON COUNTY, KENTUCKY

Description

Lat. 38° 10', Long. 85° 42'. Lynnview Ditch was constructed to drain a residential and commercial section of Louisville. The ditch passes under many residential streets, Cane Run Road (4-lane) and I-264. The watershed area is approximately 380 hectares of which over 90 percent is urban. Channel slope is .0013 with widths ranging from 1 to 5M and depths from 2 to 3M. The design flood is about 8.5 cms at the downstream end near I-264. Banks are mostly stable and grass covered. The bed consists of sand and silt.

Gradation Problem

Urban development and road construction contribute silt during rainfall events that is aggrading in the channel and aggravates flooding of the ditch.

Countermeasures

None

Discussion

Aggradation is being caused by urban development and inadequate sediment transport capacity of the flow. Constructions under some roads further decrease sediment carrying capacity.

POOR FORK OF THE CUMBERLAND RIVER AT US-119, HARLAN COUNTY, KENTUCKY

Description

Lat. 36° 53', Long. 83° 12'. The Poor Fork flows into the Cumberland River in the southeastern part of Kentucky near the Virginia Border. The stream flows through a fairly rugged mountainous region. Bed material consists of sand, gravel and cobbles while bank material in many places is rock rip-rap from construction of US 119 which parallels the river. The watershed area near Putney, Kentucky is 341 square km. Channel change sections are 30M wide trapezoid designed to carry the flood of record, 475 cms.

Gradation Problem

Projects along this section of 119 required several extensive channel changes. Trapezoidal channels 30 meters wide were used. A decision was made to use habitat improvement deflectors and riffle pool structures to retard the flow since the channel was shortened and straightened in some places. The channel carries an extra amount of sediment due to coal mining and construction and the bed is aggrading and some flow capacity is being lost. The habitat improvement deflectors extend 1/3 channel width while riffle pool structures are mid-channel and both are causing sediment to fill in the channel. Bridges across the channel and the highway by the side of the channel are exposed to increased flood damage due to the aggradation.

Discussion

The habitat improvement deflectors in conjunction with an above normal sediment load combined to cause channel aggradation in many sections of the Poor Fork. Citizens in the area are upset and are trying to force improvements to be made.

Case History 46

CHADWICK CREEK AT I-64, BOYD COUNTY, KENTUCKY

Description

Lat. 38° 25', Long. 82° 40'. Chadwick Creek flows in an easterly direction into the Big Sandy River on the border of Kentucky and West Virginia. Land use in the 1800 hectares drainage basin is primarily grazing land and agricultural. The stream meanders with the bed and bank material mostly sand. The design flood is 53 cms.

Gradation Problem

I-64 was constructed along a portion of Chadwick Creek and encroaches to a degree into the floodplain. Parts of Chadwick Creek were straightened to accommodate the highway. Because of the straightening the channel slope was increased which caused degradation. The degradation of the bed also widens the channel since in many sections, especially where straightening occurred, the banks are unstable.

Countermeasures

The maintenance section of the highway department has placed ditch checks made of rock gabions and sheet piling material which has helped the degradation problem. However, the unstable banks remain and continue to widen but to a lesser degree.

Discussion

Construction of I-64 required straightening of Chadwick Creek thus increasing its slope and ability to transport sediment causing degradation. Ditch checks have slowed the degradation but some additional work should be done to alleviate further bank erosion.

Case History 47

TAYLOR CREEK I-471, CAMPBELL COUNTY, KENTUCKY

Description

Lat. 39° 6', Long. 84° 28'. Taylor Creek drains 8.57 square km of suburban Cincinatti on the Kentucky side of the Ohio River. The basin contains residential area, a school, some commercial property, and I-471 under construction. Bank material is fine and cohesive, bed material consists of sand, gravel, cobbles and a certain amount of trash. The culvert under I-471 is designed to handle a Q100 of 72 cms . The channel is straight with medium height, stable banks with sparse vegetation.

Gradation Problem

Taylor Creek is aggrading. The area between 6th Street and Kentucky was filled by a developer for a commercial parking lot, decreasing the channel slope by a significant amount. Also due to construction of I-471 a detour was built using 6th Street but the culverts used for drainage were placed from 0.5 to 1.0M higher than design. These factors caused sediment due to urbanization and highway construction to aggrade in the channel. Some sediment also partially clogged the culverts. The school athletic fields have been flooded and also received silt damage for which a law suit is pending.

Countermeasures

The channel capacity has been improved by placing a larger culvert under 6th Street and lowering the bottom profile in this area. A concrete flume was built to provide more capacity near the athletic field.

Discussion

Urban development changed the downstream slope of Taylor Creek lessening the sediment transport capacity of the flow. In addition misplaced culverts caused additional constrictions. Sediment availability increased due to road construction and land development. These factors combined to cause aggradation in the creek.

Case History 48

POND CREEK AT US-119, PIKE COUNTY, KENTUCKY

Description

Lat. 37° 37', Long. 82° 16'. Pond Creek flows in a northeasterly direction in Pike County, Kentucky close to the West Virginia border. Pond Creek drains a fairly rugged mountainous area, and near Belfry the drainage area is 55 square km . The bank material is cohesive and the bed material consists of sands, gravel, and cobbles. The banks are low (-1.5M) and are stable with significant vegetation. The watershed was described as 95% mountainous and 5% flat with 50% heavy forest, 20% scrub fores, 15% pasture, 10% cover crops, 3% row crops and 2% built up area. Among these land uses one finds significant surface and subsurface coal mining operations. Highway 119 is being improved from two lanes to four lanes along Pond Creek. Some channel changes were required to fit the road into the Valley. The Valley floor is very narrow with houses and other buildings very close to the stream. Buildings are flooded several times a year.

Gradation Problem

The bed of Pond Creek is aggrading and has aggraded approximately 0.5 to 1.0M over the past 5 years. Aggradation is caused by the numerous coal strip mining operations in the area. Little sediment control has been done by the miners. Improvement of US 119 and its associated channel changes have contributed to the aggradation problem to a small degree. Many culverts have been filled with sediment and the channel itself is losing flow capacity thus worsening an already dangerous flood hazard.

Countermeasures

Contractors in building US 119 have dug out some of the material under bridges and have cleaned out some culverts along the stream.

Discussion

The valley that Pond Creek drains is very narrow. Buildings are built as close as 3M from the streambanks on one side and the road is usually right on the streambanks on the other side. In its natural state, the streambed was only about 1.5 vertical M below the narrow floodplain where the buildings are. With the aggradation problem, the streambed in many areas is only 0.6 to 0.9M below the floodplain; thus, flooding is frequent and continues to worsen. Even without the aggradation problem, the area is a potential disaster area due to flooding. The supply of loose soil is enormous and the aggradation problem is essentially hopeless until the mine spoil and construction areas are reclaimed. Flood hazards will always be high in the Pond Creek Valley due to the development on the floodplain being so close to the stream.

AMITE RIVER AT SH-37 NEAR GRANGEVILLE, LOUISIANA

Description

The Amite River begins in Mississippi and flows into Louisiana. The river forms the boundary between east Feliciana and Helena Parishes, and East Baton Rouge and Livingston Parishes. The reach of interest is just west of Grangeville, Louisiana.

The drainage area is 1,920 km^2, the valley slope is 0.001 and the channel width is 60 m. The stream is perennial, alluvial, gravel bed and in a valley of low relief with a wide flood plain. The channel is meandering, generally anabranched, with sand and gravel banks.

The bridge is 120 m in length, pile bents with square concrete piles in channel and spillthrough abutments (Lat. 30°44', long. 91°51'). The crossing is at a bend in the stream.

Figure 1 is an aerial photograph of the bridge taken in 1976.

Gradation Problem

During the middle 1950's the timber trestle bridges on LA 37 at the Amite River were replaced with concrete structures. The existing bridges consist of the main bridge and four relief structures, one east and three west of the main channel.

The two bridges in question are the main bridge and the first relief bridge to the west. Both structures

are 116 M in length, consisting of ten 6-M slab spans and three 18-M steel I-beam spans.

Before and after construction of the existing bridges, a small stream flowed from the main channel of the river (slightly upstream of the main bridge) through the relief structure and back to the main stream. This created a small island between the two bridges in question.

At the time of construction of these two bridges there were extensive gravel mining operations immediately upstream of LA 37. At present the mining operations continue but are located several miles upstream of the bridges. The mined area west of the main channel consists of large sand desposits and ponds. The sand deposits are very unstable and the main channel of the river can meander at will. This area also has a very low "n" factor which increases the water velocity on the approach to the bridges.

During the 1960's the small stream flowing beneath the relief structure remained relatively stable until the middle and late 1960's. Because of increased gravel mining operations upstream of the bridges and several large floods which occurred in the late 1960's, the embankment between the main bridge and relief bridges became endangered. To prevent the main channel of the river from diverting to the relief bridge, District 61 maintenance forces constructed an earthen dam across this relief stream. This had the effect of preventing any flow through the relief bridge except during times of extreme flooding.

As previously stated the gravel mining upstream of the bridge was contributing to the problem of bank erosion and degradation all along this reach of the Amite River, both upstream and downstream.

With the closure of the relief opening to all but overbank floods, the bank erosion and degradation downstream of

of the main bridge was accelerated. There were some gravel mining operations immediately downstream of LA 37 during this period but on a relatively small scale. After the closure of the relief opening the property owner on the east bank downstream of LA 37 began a gravel mining operation. Recently both property owners downstream of LA 37 have begun more extensive gravel mining operations. These operations have led to continuous maintenance problems of bank erosion and scour. Also the mining operations up and down the Amite River have led to a large amount of degradation in the main channel.

In 1973 the area of concern on the main channel was the east abutment and the upstream side of the west abutment. During March, 1973, a flood occurred which was the highest recorded at the Darlington gage on LA 10. There was extensive bank erosion on the west bank on the upstream side of the bridge and on the east abutment. By using all the broken concrete and asphalt available the District Forces were able to make some repairs on the bankline.

During the summer of 1976, the property owner on the west bank of LA 37 constructed an earthen dike approximately 150 feet downstream along the highway embankment. This had the effect of partially blocking the two western most relief bridges. As the area between the levee and roadway embankment was insufficient to pass the flow of the two relief bridges, this forces more flow to the main bridge.

In December, 1976, the problem of degradation and local scour at the main bridge became critical as there were several inches of settlement at one bent. Emergency repairs were made on this structure at a cost of over $200,000.00.

On April 22, and 23, 1977, the largest flood of record occurred on the Amite River watershed. The U.S. Geological Survey estimates that a discharge of 7650 cms passed through

the Amite River bridges on LA 37. This discharge for this flood was approximately 30% greater than the flood of 1973 but the stage was only 0.1M higher. With the restrictions at the west relief bridges and low stage there were extremely high velocities within the main channel of the river. With the high velocities and large amount of debris which collected on the bents, the amount of degradation and local scour which occurred is not unusual.

The problem of degradation and local scour at the main bridge is created by insufficient opening to convey the flow which is forced to this bridge by restrictions at the west relief openings. As the degradation of the main channel continues from the gravel operations the flood stages will be lower and the relief bridges will become less effective.

Countermeasures

As a countermeasure, pile of pile bents are being driven to greater depth.

Discussion

Gravel mining is being continued, and further degradation of streambed may occur.

Channel degradation is attributed to gravel mining upstream and downstream from bridge. Pile tips of some bents were found at streambed elevation, with no penetration into ground. Relief bridges were rendered ineffective because of levees at gravel mining operations.

Case History 50

COOL CREEK AT I-55 NEAR KENTWOOD, LOUISIANA

Description

The Interstate crossing location of Cool Creek is located at (Lat. 30°27', Long. 90°32'), which is in Tangipahoa Parish. The bridge was built in 1965. It is a concrete girder bridge, 30 m long, supported by 5 square concrete columns per bent and is founded on piles. The abutments are spillthrough type.

The valley slope is 0.0032. The stream is perennial but flashy, alluvial, sand bed and in a valley of low relief. The natural stream is meandering with sand banks and trees cover more than 90 percent of the bankline. Cool Creek is a tributary of the Tangipahoa River.

Gradation Problem

At the time of construction several channel changes were made:

1) The channel was realigned and widened as illustrated in Figure 1.
2) The channel slope was increased from 0.0013 for the old alignment to 0.0028 for the new channel alignment.
3) The bridge abutments were protected with sacked concrete on clay fill on the right bank and sloped concrete paving on the left bank as illustrated in Figure 2.

A 1974 flood almost overtopped the highway. The sacked concrete revetment settled and the lower part of the bank

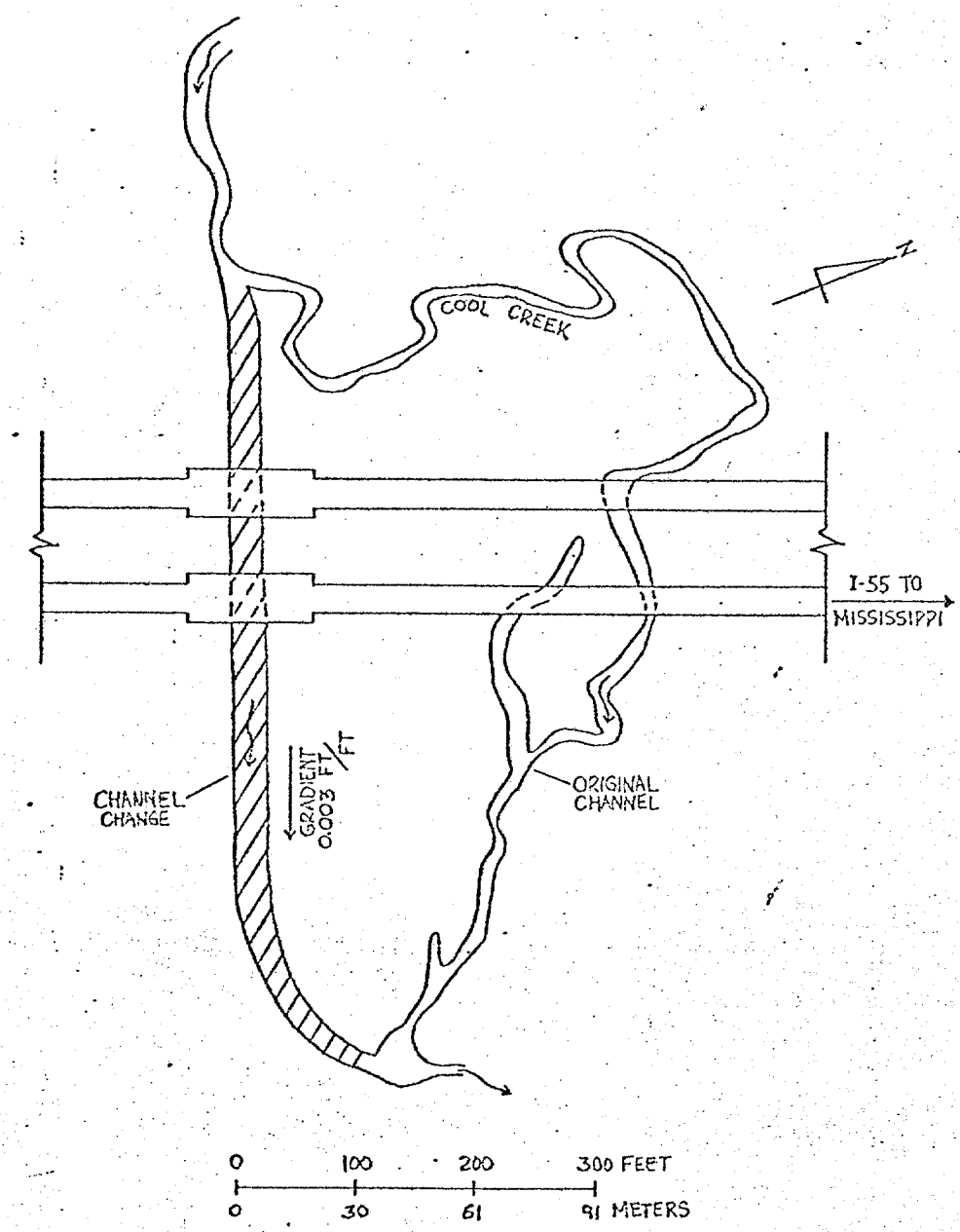


FIGURE 1 —CHANNEL ALIGNMENT CHANGES MADE AT TIME OF BRIDGE CONSTRUCTION.

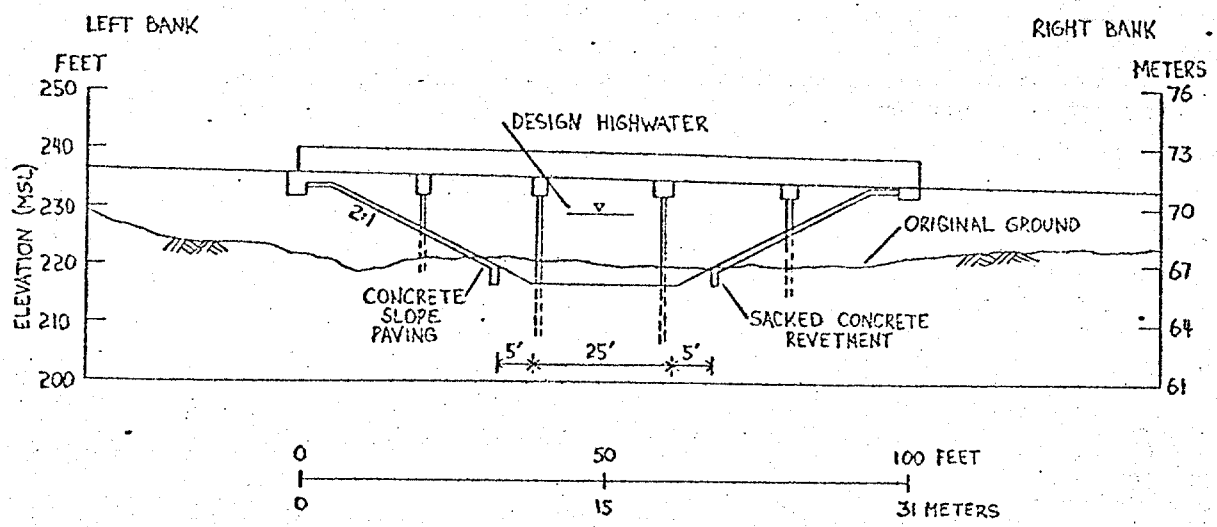


FIGURE 2 —CROSS SECTION OF CHANNEL AT BRIDGE SITE.

slid into the creek. The sloped concrete paving also failed due to undermining. Damage to the abutment protection was probably mainly due to channel degradation and associated local scour and lateral erosion.

Countermeasures

Repair of the abutment protection with riprap has not been tested at this point in time.

Discussion

1) At this site, the changes in alinement and gradient of the former stream apparently contributed to an unstable channel.

2) Streambed degradation continued for about 15 years before the channel approached stability.

3) The cut-off wall built at the toe of the existing concrete slope paving was insufficient to prevent undermining of the embankment protection and eventual failure.

WHITTEN CREEK AT SR-37 AT BAYWOOD, LOUISIANA

Description

The reach of the Whitten Creek of interest is located in East Baton Rouge Parish. The bridge affected (Lat. 30° 41', long. 90°53') was built in 1956 and is 33 m in length. The bridge is supported on timber pile bents driven into the sand and has spillthrough abutments.

The drainage area of Whitten Creek above SR-37 is 32 km^2 and the channel slope is 0.0002. The stream is perennial, alluvial, the bed is sand and fine gravel and is in a valley of low relief within a wide flood plain. The natural channel is meandering, not incised and cut banks are rare.

Whitten Creek is a tributary to the Amite River a few miles below Baywood.

Gradation Problem

Severe channel degradation is attributed to the three reasons as follows:

1. gravel mining downstream of the SR-17 bridge (Figure 1)
2. channel dredging upstream of the SR-17 bridge
3. extensive degradation in the Amite River which could result in some head cutting up Whitten Creek.

The channel bed has been lowered about 3 m at the bridge. The timber pile bents are exposed to a hazardous depth and the abutment fill slopes have been eroded as indicated in Figure 2.

Countermeasures

As a countermeasure, dumped riprap of broken concrete slabs has been placed on abutment fill slopes, in an estimated amount of 152 m^3 and a span 5 m in length has been added to left end of bridge.

Discussion

Dumped riprap has reduced but not halted erosion at abutments, and little riprap remained at abutments in early 1979. The area of bridge opening has increased by a factor of two since gravel mining began, and there were no hydraulic problems at the bridge before gravel mining. Despite addition of span, erosion has continued at the left abutment. Partial failure of riprap is attributed to sand banks, steepness of banks, and probably to lack of filter blanket and toe protection.

It should also be emphasized that the placement of riprap or bank protection in a degrading stream should be placed at a depth below the channel bed.

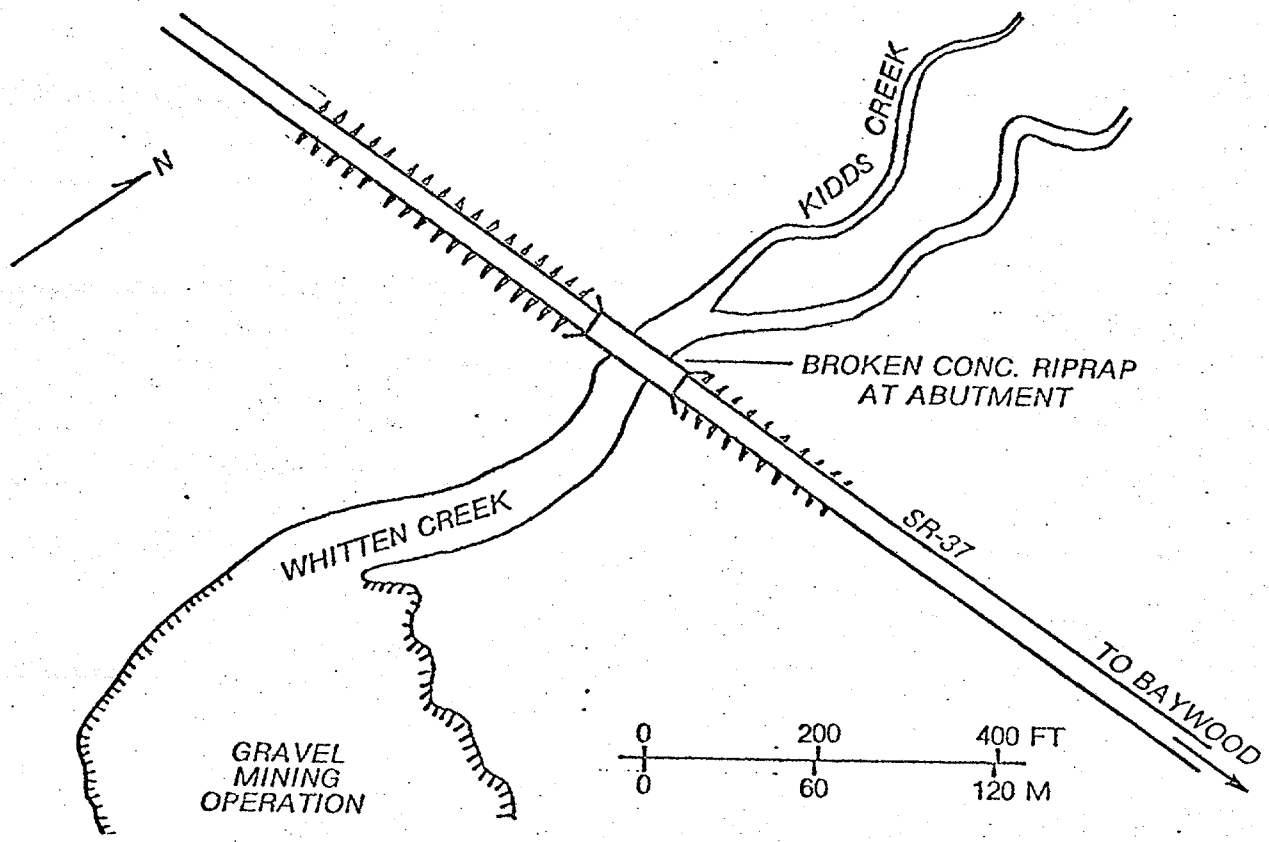


FIGURE 1 PLAN SKETCH OF WHITTEN CREEK AT SR-37. (FROM AERIAL PHOTOGRAPH TAKEN AUGUST 31, 1973).

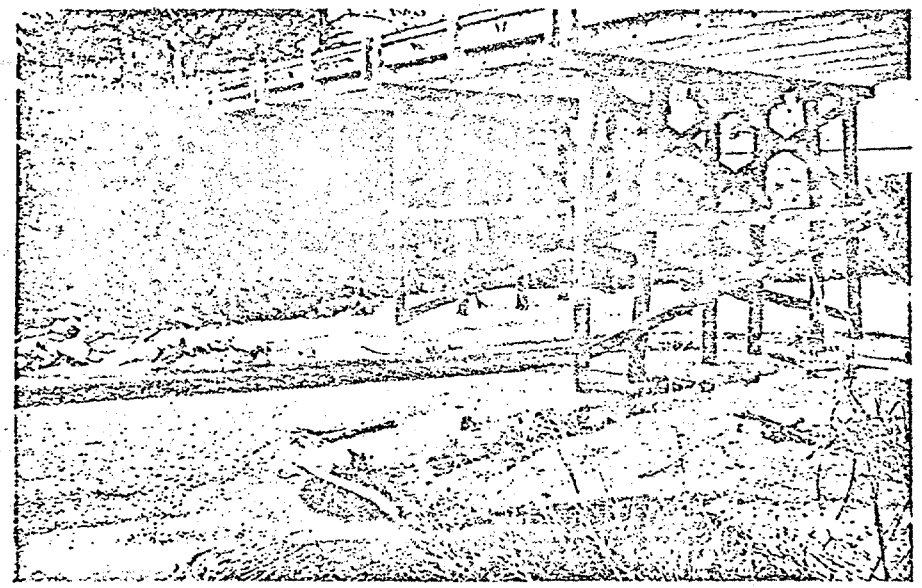


FIGURE 2 VIEW OF STREAMBED AND LEFT ABUTMENT OF SR-37 BRIDGE AT WHITTEN CREEK, ON FEBRUARY 18, 1977.

Case History 52

LAWRENCE CREEK AT SR-16 NEAR FRANKLINTON, LOUISIANA

Description

Lawrence Creek is located in Washington Parish. The river reach of interest is near Franklinton, Louisiana where State Road 16 crosses Lawrence Creek (Lat. 30°19', long. 90° 19'). The bridge is 135 m in length, pile bents with square concrete piles and spillthrough abutments revetted with sacked concrete. The drainage area above SR-16 is 130 km^2 and the channel slope is 0.003. The stream is perennial, alluvial, sand bed, in a valley of low relief and has a wide flood plain. The channel is sinuous, not incised and has sand banks.

Gradation Problem

Sand and gravel mining downstream from the bridge has caused serious channel degradation downstream and upstream. Headcutting moved upstream causing banks to cave in along with large trees and debris. The trees partially blocked the main channel upstream of the bridge, such that at high flows the main flow was diverted to an old channel which flows almost parallel to SR-16 and then makes a 90° bend in order to flow under the bridge.

The channel has been lowered by an estimated 3 m at the bridge.

The degradation, bank caving and debris problems resulted into extensive lateral erosion of banks upstream and downstream of the bridge.

Countermeasures

As a countermeasure, the bridge was lengthened by the addition of span to the right end in 1967. In 1973, the approach embankment was raised and a curved spur dike of earth, revetted with broken concrete riprap, was built at the right abutment to protect the embankment (Figure 1). Timber cleared during construction of the spur dike was to be placed along the embankment but was placed too far from embankment. During a flood in 1974, flow was diverted against the spur dike, eroding the tip and upstream side of the dike and impinging against the approach embankment.

Discussion

Lateral instability of the channel is directly attributed to sand and gravel mining. Although the spur dike serves to direct flow through the bridge waterway, it does not seem to be an effective measure for protection of the approach embankment, which is subject to erosion or breaching during major floods. The main channel of Lawrence Creek is apparently too nearly parallel to the right approach embankment for the spur dike to function properly.

1-21-74
SP 03 00
4 4 6

Case History 53

COMITE RIVER AT SH-64, EAST BATON ROUGE PARISH, LOUISIANA

Description

The Comite River is located in East Baton Rouge and East Feliciana Parishes. The river reach of interest is from the mouth of the river (junction of the Amite River) to State Highway 64. The SH-64 bridge is 6.0 km east of Zachary, Louisiana (Lat. 30°38', long. 91°05'). The drainage area above the SH-64 bridge is 596 square km. The channel slope is 0.00064. The design discharge of the bridge (Q_{50}) is 864 cubic M per second. The river is perennial, alluvial, fine sand bed and in a valley of low relief with a wide flood plain. The channel below SH-64 bridge is fairly straight due to dredging and channel straightening and the banks are a fine sand.

Gradation Problem

In the 1960's the Comite River was dredged and the channel straightened from its mouth where it runs into the Amite River to just below the SH-64 bridge east of Zachary. As a result of these channel modifications, there has been about 3 m of degradation at the SH-64 bridge. A headcutting has been progressing upstream causing bank caving, a serious debris problem and increased lateral movement of the channel. The degradation of the Amite River may also be attributing to the Comite River's degradation and instability problems. The State Highway Department makes hydrographic surveys of the bridge every 3 to 6 months to determine the changes in cross section characteristics.

Countermeasures

Riprap has been placed upstream and downstream to protect the bridge abutments and to reduce lateral erosion. The riprap has not been effective due to additional degradation and the undermining of the bank protection.

Discussion

Sand and gravel mining is directly responsible for the degradation along with the lowering of the channel bed elevation in the Amite River at the confluence. Bank protection must be placed with a knowledge and understanding of annual bed elevation changes due to flooding and a continued degradation.

Case History 54

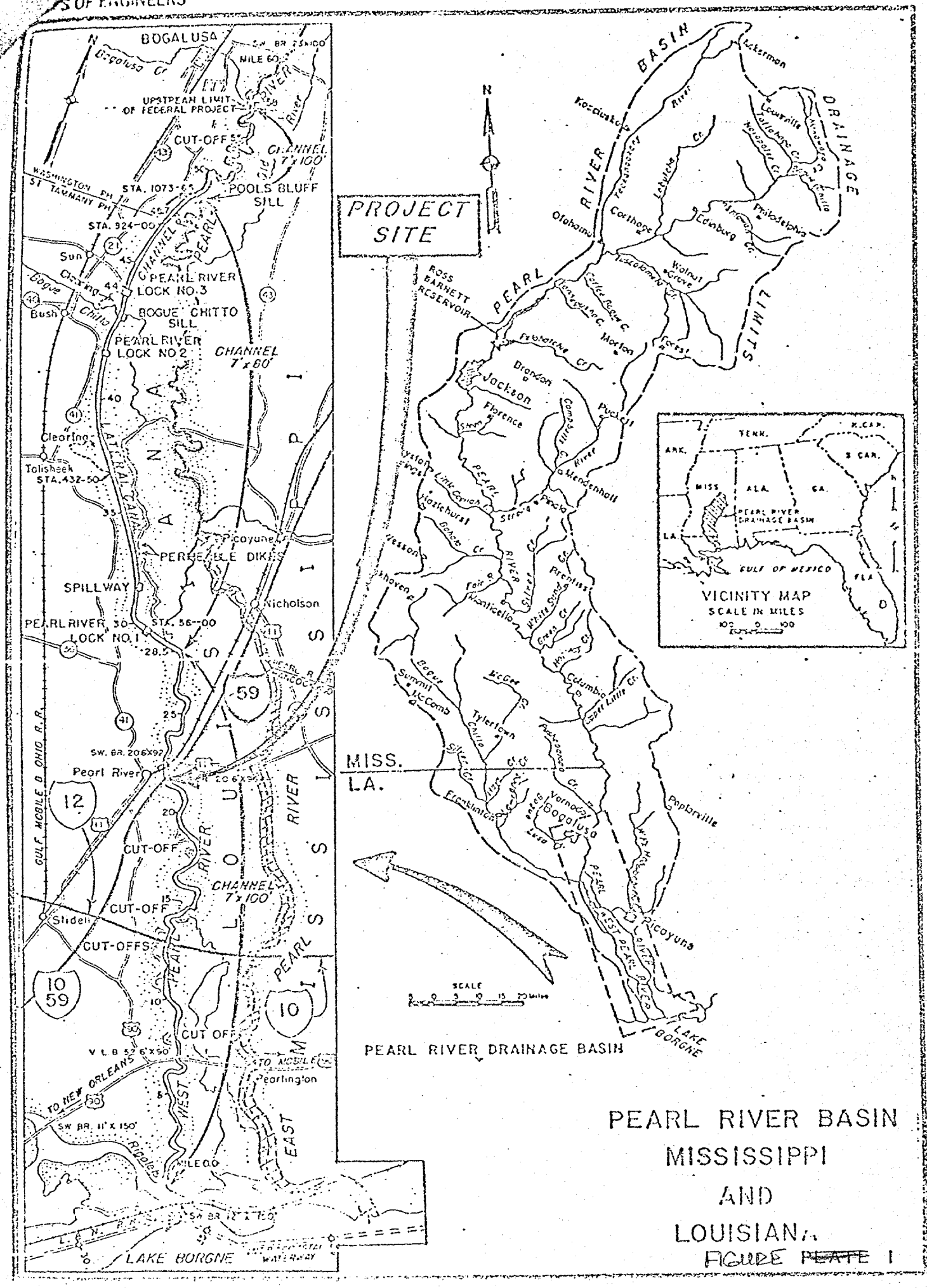
WEST PEARL RIVER AT I-59, ST. TAMMANY PARISH, LOUISIANA

Description

The Pearl River is formed in Neshoba County, Mississippi, by the confluence of Nanawaya and Tallahaga Creeks and flows southwesterly for 209 km to the vicinity of Jackson, then southeasterly 375 km to the head of its outless channels, the East Pearl and West Pearl Rivers. These channels continue in a generally southerly direction for 77 and 79 km, respectively, to empty into Lake Borgne and the Rigolets. The area is shown in Figure 1.

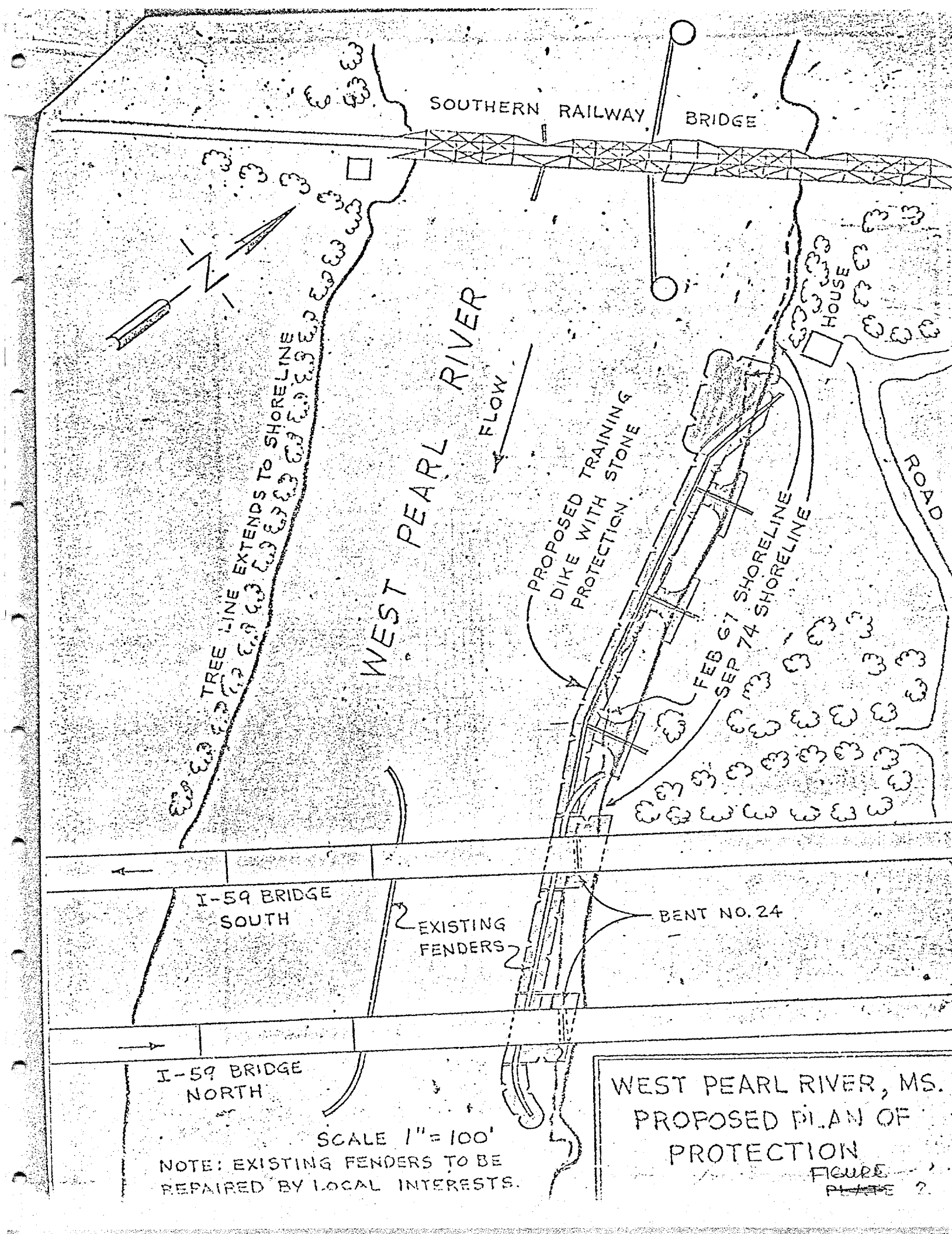
Two bridges, one for southbound and one for northbound traffic, are provided for the I-59 Highway crossing of the West Pearl River at about River Km 35. At this location the river has a top of bank elevation of about 4.6 M above m.s.l., a bottom of channel elevation of about 7.9 M below m.s.l., and a width of about 107 meters.

The I-59 Highway bridges, shown on Figure 2, were constructed in 1963 at a cost of about $3,500,000. The bridges have an overall length of about 792 meters, a maximum elevation of about 18 M above m.s.l. near the center, and a clear center span of 49 M. The bridges' bents supporting the main span are protected by a timber fender system. A horizontal clearance of 40 meters is provided between the two fenders. The low steel elevation across the navigation channel is 15.3 M above m.s.l. The bridges span the existing Federal navigation



PEARL RIVER BASIN
MISSISSIPPI
AND
LOUISIANA

FIGURE ~~PLATE~~ 1


SOUTHERN RAILWAY BRIDGE
N
WEST PEARL RIVER
FLOW
TREE LINE EXTENDS TO SHORELINE
PROPOSED TRAINING DIKE WITH STONE PROTECTION
FEB 67 SHORELINE
SEP 74 SHORELINE
HOUSE
ROAD
I-59 BRIDGE SOUTH
EXISTING FENDERS
BENT NO. 24
I-59 BRIDGE NORTH
SCALE 1" = 100'
NOTE: EXISTING FENDERS TO BE REPAIRED BY LOCAL INTERESTS.
WEST PEARL RIVER, MS.
PROPOSED PLAN OF PROTECTION
FIGURE
PLATE 2

channel for the Pearl River which provides for a 2.1 M -deep by 30- M -wide channel.

Streamflow characteristics.- Based on stream gage records near the project site at Pearl River, Louisiana, the maximum flood of record with a stage of about 6.0 meters above m.s.l. occurred in 1874. The discharge and current associated with this flood are estimated to be about 5665 cms and about 2.6 M per second, respectively. Recurrence interval of this discharge is estimated at about once every 125 years. Data of floods of record are shown in Table 1.

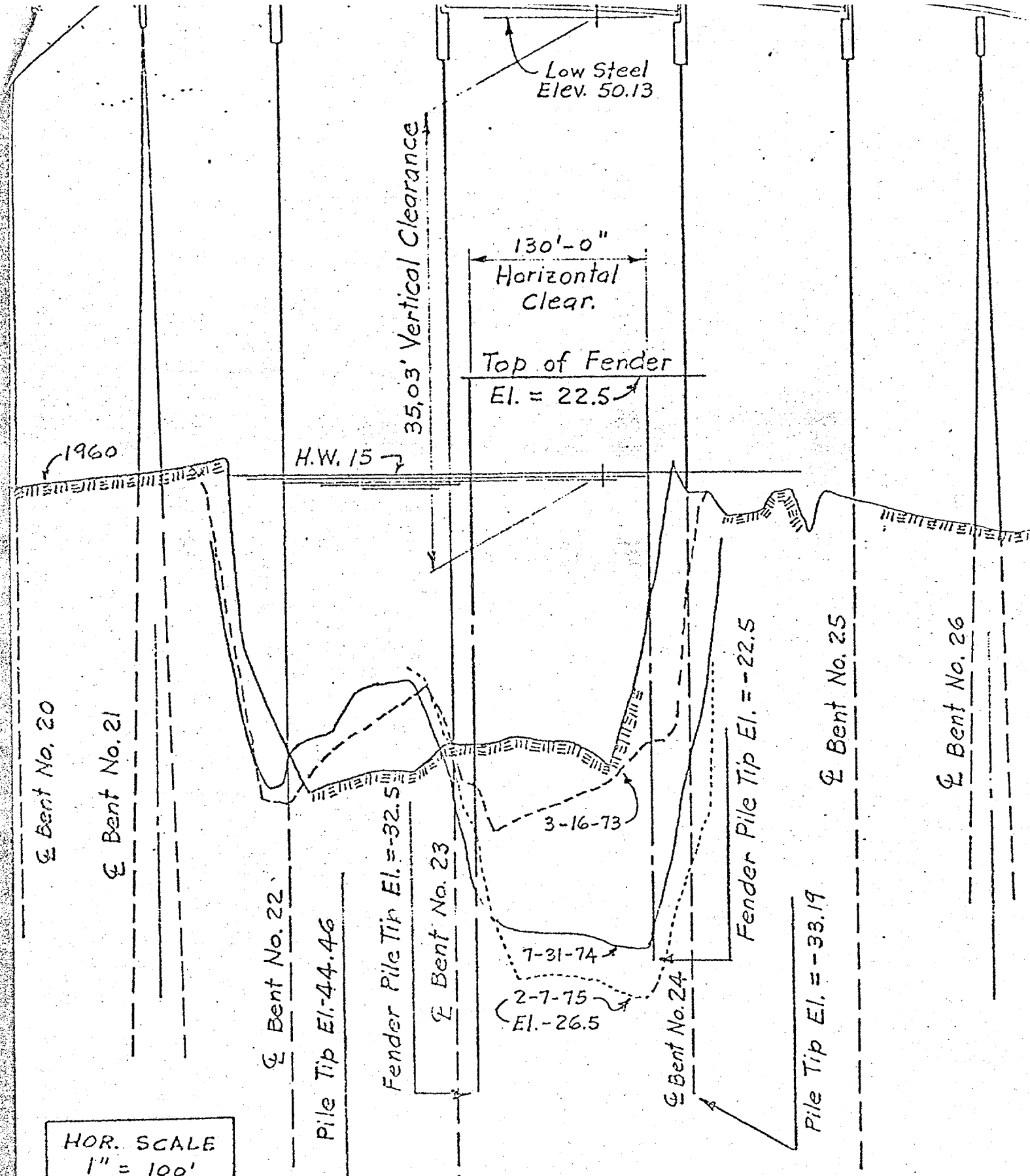
Table 1

Data on Floods of Record

Year	Month	Stage (M)	Discharge (cms)	Maximum velocity (mps)	Recurrence interval in years
1974	Apr	6.10	5665	2.56	125
1900	Apr	6.00	5180	2.50	80
1974	Apr	5.88	4670	2.38	45
1921	Mar	5.67	3850	2.32	21
1961	Feb	5.58	3540	2.23	15
1963	Jan	5.46	3170	2.16	10
1966	Feb	5.36	2860	2.10	7

Gradation Problem

As indicated on Figure 3, the channel of the West Pearl River has shifted to the north since construction of the I-59 bridges in 1963. During the 10 years after construction a small amount of erosion occurred. However, the erosion accompanying the April 1974 flood resulted in a 9- M shift of the channel to the northeast and an increase of depth from about 3.65M below m.s.l.



WEST PEARL RIVER
SECTION THROUGH SOUTH BRIDGE
OF I-59

FIGURE 3

to 6.71M below m.s.l. Since that time, channel depth has increased to 8.1M below m.s.l.

The channel shift and increased channel depth pose a threat to the finder system and bridges. Bent number 24 (on both bridges) is located near the northeast riverbank. Friction pile supporting this bent has a tip elevation of about 10M below m.s.l., 2.13M lower than the lowest channel elevation. Also, the fender system protecting the bridges has some pile tip elevations of 6.86M below m.s.l., 1.21M higher than the lowest channel elevation. Inspection of the site confirms that the fender system is in initial stages of failure.

Based on data given in Table 1 and Figure 3, it is estimated that stream velocities that would accompany a flood with a recurrence interval of once in 45 years will cause severe erosion at the bridge sites. It is also indicated that smaller amounts of erosion are continuing to occur during floods with lesser recurrence intervals. There is no indication that the channel is stabilizing. Consequently, if measures are not taken to prevent further erosion, the foundations of bent 24 (on both bridges) will be undermined in the near future, thus endangering the structures.

Countermeasures

The protection shown on Figures 2 and 3 provides for construction of a timber training structure extending about 122 M upstream from the northeast bridge fender to where it ties into the shore, for 0.6 M -thick riprap protection along the bottom of the training structure and northeast fender, and for 2.4 M -thick riprap protection

around bent 24 on both bridges. The proposed plan also provides for 0.6 M -thick riprap protection of the stream bank for a distance of 29 M upstream of where the proposed training structure ties into the shore.

Repair of the fender system will be accomplished by driving additional piles adjacent to the existing fender piles and bolting them to existing piles and wales, as shown on Plates 4 and 5.

The protection work will prevent erosion near the I-59 bridges in a manner as not to adversely affect the existing railroad bridge and other structures in the area. This would be accomplished by diverting the flow with a timber training dike, away from the eroding streambank and back into its original course at the bridges. To avoid any undesirable effects associated with an abrupt change of alignment, the alignment of the training dike was chosen to coincide generally with the alignment of the existing northeasterly fender. The dike extends from that fender upstream to form a smooth transition with the existing stable streambank; this alignment approximates the stable (1967) streambank existing at each I-59 bridges prior to the recent erosion and channel migration. Intermediate transverse dikes have been added to further reduce the flow behind the training dike. The elevation of the top of the piles forming the dike was chosen to coincide with the top elevation of the fender system. The design, both structural and functional, of the dike is generally the same as that of dikes which have been constructed along the Apalachicola and Alabama Rivers. These dikes have functioned effectively for a number of years. The proposed project was coordinated with the State of Louisiana, the U.S. Fish and Wildlife Service, and the

Southern Railroad System, owner of the railroad bridge located immediately upstream from the proposed improvements. Only the Southern Railway System, who expressed concern over possible increase in stream velocity in the vicinity of their bridge, objected to the proposed project. Considering the alignment and porosity of the proposed training structure, the improvements proposed herein are not expected to cause an increase in stream velocity. Accordingly, the Southern Railway System was advised that the proposed action would not cause erosion in the vicinity of their bridge.

Discussion

There may not be conviencing evidence that this is a general degradation problem. The problem is attributed to increased runoff and inadequate design.

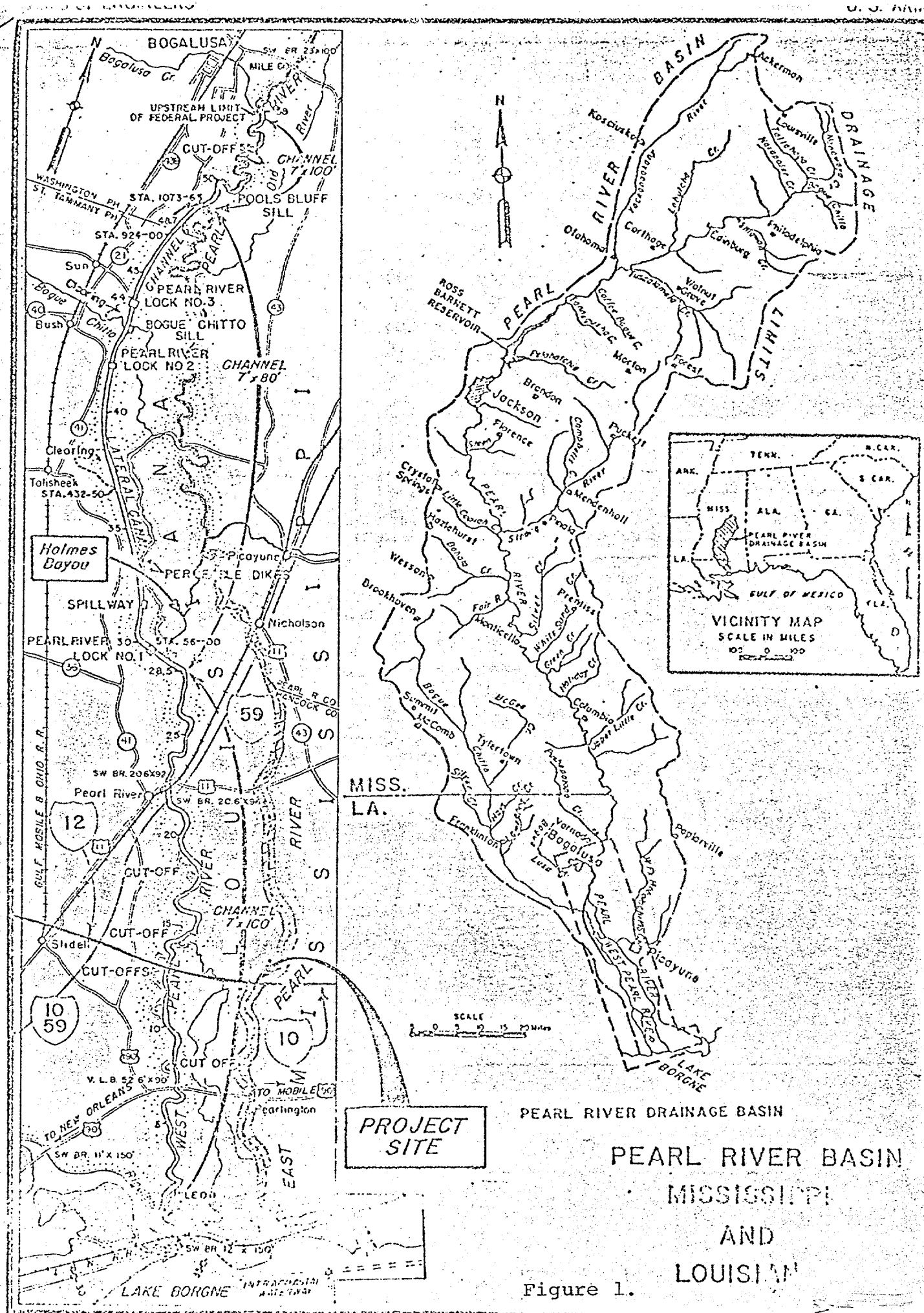
EAST PEARL RIVER AT I-10, ST. TAMMANY PARISH, LOUISIANA

Description

The Pearl River is formed in Neshoba County, Mississippi, by the confluence of Nanawaya and Tallahaga Creeks and flows southwesterly for 209 km to the vicinity of Jackson, then southeasterly 375 km to the head of its outlet channels, the East Pearl and West Pearl Rivers. These channels continue in a generally southerly direction for 77 and 79 km, respectively, to empty into Lake Borgne and the Rigolets. The area is shown on Figure 1.

One bridge for southbound and northbound traffic is provided for the I-10 Highway crossing of the East Pearl River at about River Km 12.9. At this location the river has a top of bank elevation of about 5.18 M above m.s.l., a bottom of channel elevation of about 19.5 M below m.s.l., and a top width of about 91 meters.

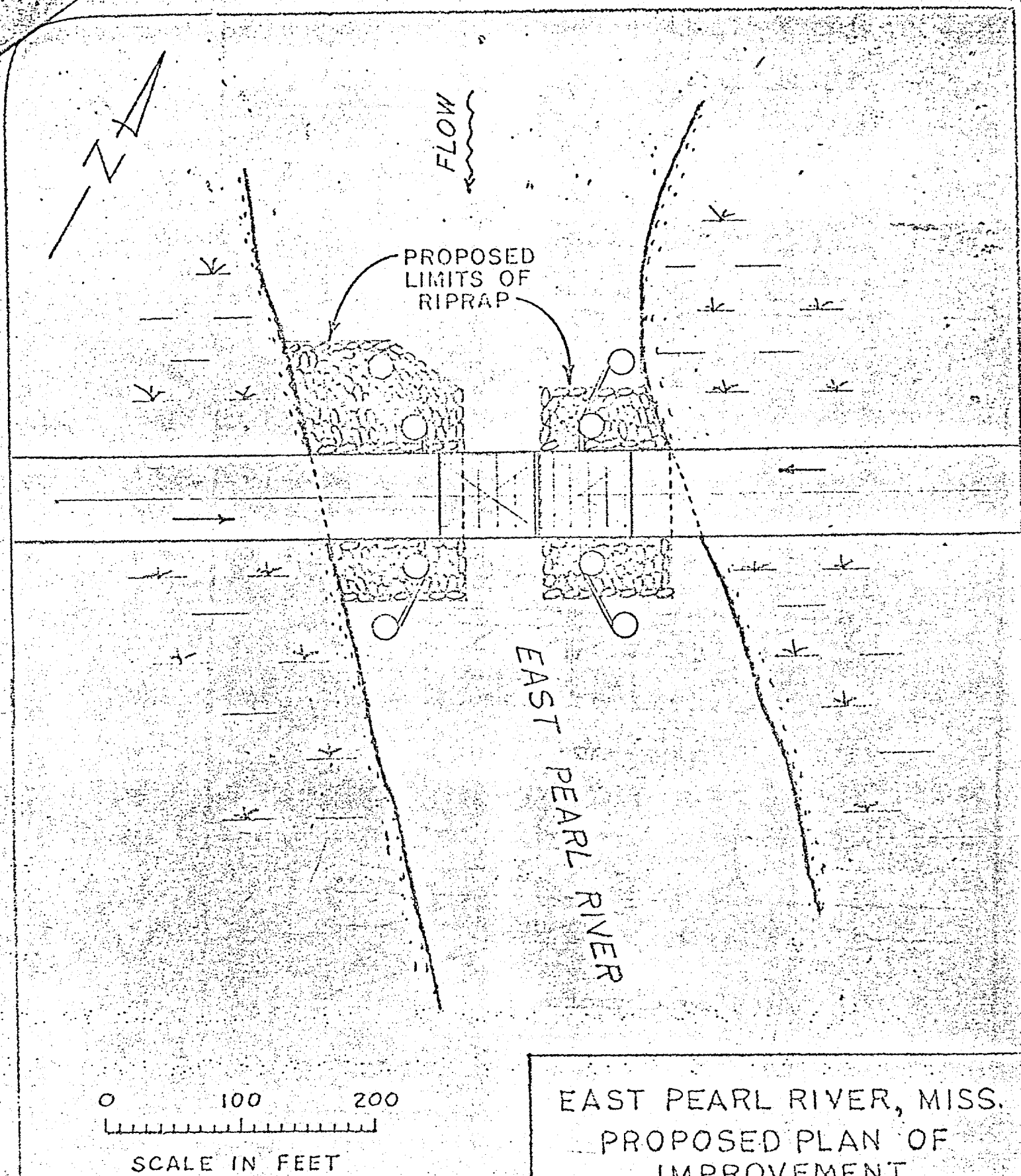
The I-10 Highway bridge, shown on Figure 2, was constructed in 1969 at a cost of about $7,100,000. The bridge has an overall length of about 1.524 M, a maximum elevation of about 29 M above m.s.l. near the center, and a clear center span of about 44 M. The bridge's piers supporting the main span are protected by a timber fender system. A horizontal clearance of about 35 M is provided between the two fenders. The low steel elevation across the navigation channel is 22.3 M above m.s.l. The bridge spans the existing NASA navigation channel which provides for a 3.65M -deep by 46 M -wide channel extending from the Gulf Intracoastal Waterway to an excavated harbor at the NASA test facility near Gainesville, Mississippi.



PEARL RIVER DRAINAGE BASIN

PEARL RIVER BASIN
MISSISSIPPI
AND
LOUISIANA

Figure 1.



EAST PEARL RIVER, MISS.
PROPOSED PLAN OF
IMPROVEMENT
I-10 BRIDGE

Figure 2.

Gradation Problem

As indicated in Figure 3, the channel of the East Pearl River has shifted to the southwest since construction of the I-10 bridge in 1965. During the 8 years following construction a small amount of erosion occurred. However, the erosion accompanying the April 1974 flood resulted in about an 24- M shift of the channel to the southwest and an increase of depth from about 6.7 M below m.s.l. to 18.4 M below m.s.l. Since that time channel depth has increased to 19.7 M below m.s.l.

The channel shift and increased channel depth pose a threat to the fender system and bridge. Pier number 40 is located near the southwest riverbank. Friction pile supporting this pier has a tip elevation of about 33.5 meters below m.s.l., 13.7 M lower than the lowest channel elevation. Also, the fenders protecting the bridge have some pile tip elevations of 18.3 M below m.s.l., 1.4 M higher than the lowest channel elevation. The existing sheet pile of the dolphins projects down to 21.3 M below m.s.l., 1.7 M lower than the lowest channel elevation. Inspection of the site confirms that the fender system is in the initial stages of failure.

There is no indication that the channel is stabilizing. Consequently, if measures are not taken to prevent further erosion, the foundation of pier 40 will be undermined in the near future, thus endangering the structure.

Countermeasures

Repair of the fender system for the affected bridge is not considered necessary for protection of the bridge from streambank erosion. The protection shown in Figures

2 and 3 provided for 0.6-M thick riprap protection placed on an underlayer of gravel around pier 40 and for 0.6 M thick riprap protection around pier 41. A stream velocity of 2.4 mps was used in the design of the riprap protection. Repair of the fender system will be accomplished by driving additional piles adjacent to the existing piles and attaching them to existing piles and wales.

Discussion

There may not be sufficient data to classify this as a general degradation problem. The only data available is at the bridge site. Degradation problems at highway crossings of the Pearl River are common up to Jackson, Mississippi.

2 and 3 provided for 2-foot thick riprap protection placed on an underlayer of gravel around pier 40 and for 2-foot thick riprap protection around pier 41. A stream velocity of 8 f.p.s. was used in the design of the riprap protection. Repair of the fender system will be accomplished by driving additional piles adjacent to the existing piles and attaching them to existing piles and wales.

Discussion

There may not be sufficient data to classify this as a general degradation problem. The only data available is at the bridge site. Degradation problems at highway crossings of the Pearl River are common up to Jackson, Mississippi.

MISSISSIPPI RIVER AT I-494, SOUTH ST. PAUL, MINNESOTA

Description

The location of interest is shown in Figure 1 (Lat 44° 53', Long. 93° 01'). The Bridge is 570 m in length, one 128 m overhead truss arch span, seven girder spans and three beam spans ranging in length from 21 to 70 m. The Bridge has a ten miltiple column concrete piers, each with four square concrete columns as shown in Figure 2. The piers in the channel have concrete footings, 26.5 m in length, and timber pile foundations, pile driven to depth of 12 to 15 m below streambed elevation at time of construction (Figure 3). The piers 8, 8, and 10 at left bank are founded on bedrock.

The drainage area is 95,000 km^2 ; the bankfull discharge is aobut 1,160 m^3/s ; the valley slope is 0.0001 and the channel width is about 300 m . The stream is perennial, regulated (bridge site is in pool of downstream dam), semi-alluvial, sand-silt bed, in valley of moderate relief and confined to a narrow flood plain. The channel is sinuous, locally braided and has silt-sand banks. The bridge was built in 1959 with concrete slope pavement placed at the abutment fill slopes.

Gradation Problem

Between 1960 and 1975 a large volume of material was removed by dredging the stream channel for a distance of about 4.8 km upstream from the bridge, for the purpose of building flood control dikes and a major barge terminal. In addition, spurs were build along the left

bank upstream from the bridge to deflect the flow toward the center of the channel and thus deepen it for barge traffic. The streambed at the bridge was lowered 2-3 m by degradation (Figure 3), and local scour reached elevation 197M at an upstream (northwest) corner of pier 7, 3 m below the base of the concrete seal. Soil borings indicate that the scoured material was fine-to-medium sand and organic silty clay.

Countermeasures

In 1976 revetment was placed over an area 62.5 m in length and 49 m in width at pier 7. After the scoured area beneath the concrete seal (Figure 4) was grouted, the scour hole was filled with granular material to serve as a filter blanket, the surface of which was levelled and topped with Poly-Filter X Cloth. The filter cloth, in overlapping sheets 11 m in width, was sunk and held in place by I-beam sections chained together and secured, on the upstream side, by cables around tubular piling. A second granular filter blanket, about 0.15 m thick, was placed over the filter cloth, and dumped rock riprap (Minnesota Class "C" approximately equivalent to Class II) was placed on the filter blanket. Minimum thickness of the riprap blanket was 0.75 m at the center, and the thickness was increased around the edges to hold the filter cloth in place.

Discussion

The channel is still not completely stable. This statement is based upon little or no actual field data. Some cross section data at the bridge indicates that the channel is still adjusting its gradient. Addition protection of pier 7 has continued from 1976 to 1978. The performance of the revetment at pier 7 has not been evaluated. The scour damage at pier 7 is clearly assignable to local scour superimposed on channel degradation, which resulted from dredging and the effects of upstream spurs.

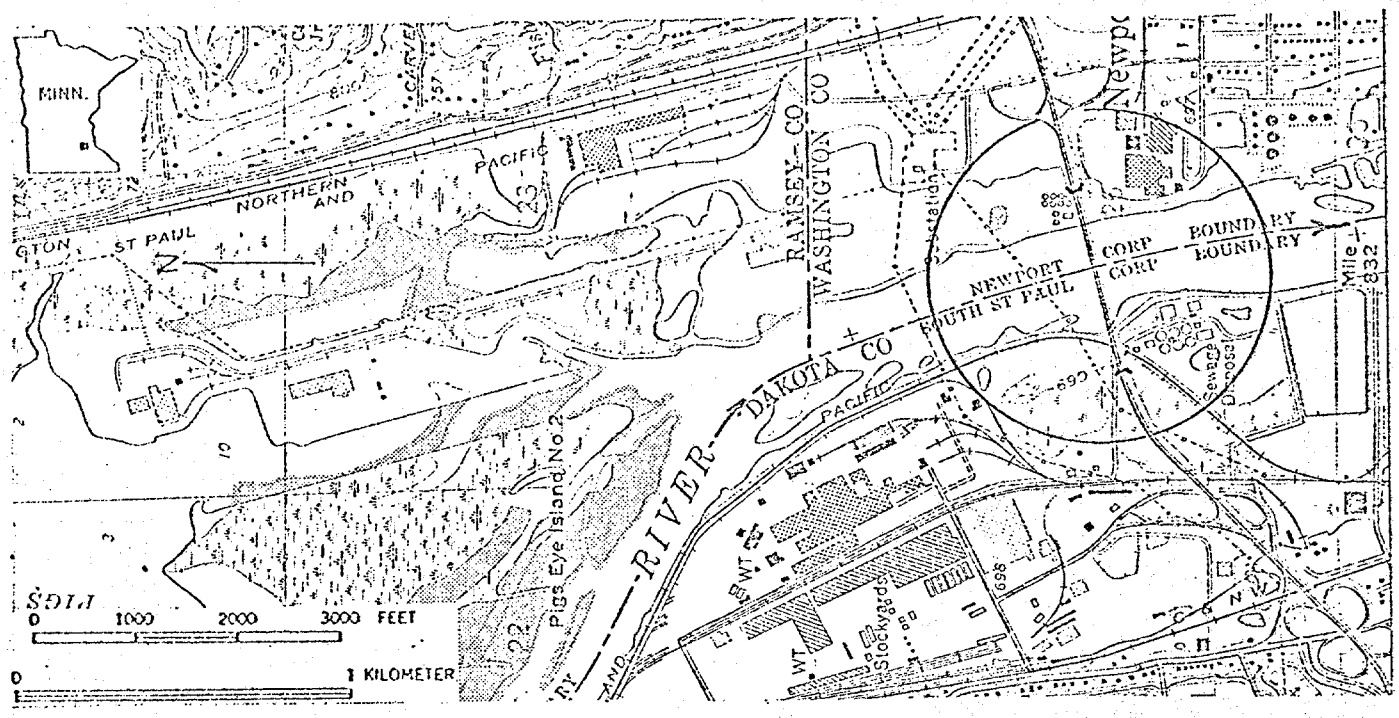


FIGURE .1 MAP SHOWING MISSISSIPPI RIVER AT I-494 CROSSING (CIRCLED). (FROM U. S. GEOLOGICAL SURVEY ST. PAUL EAST, MINN., 7.5' QUADRANGLE, CONTOUR INTERVAL 10 FEET, 1967 PHOTOREVISED 1972).

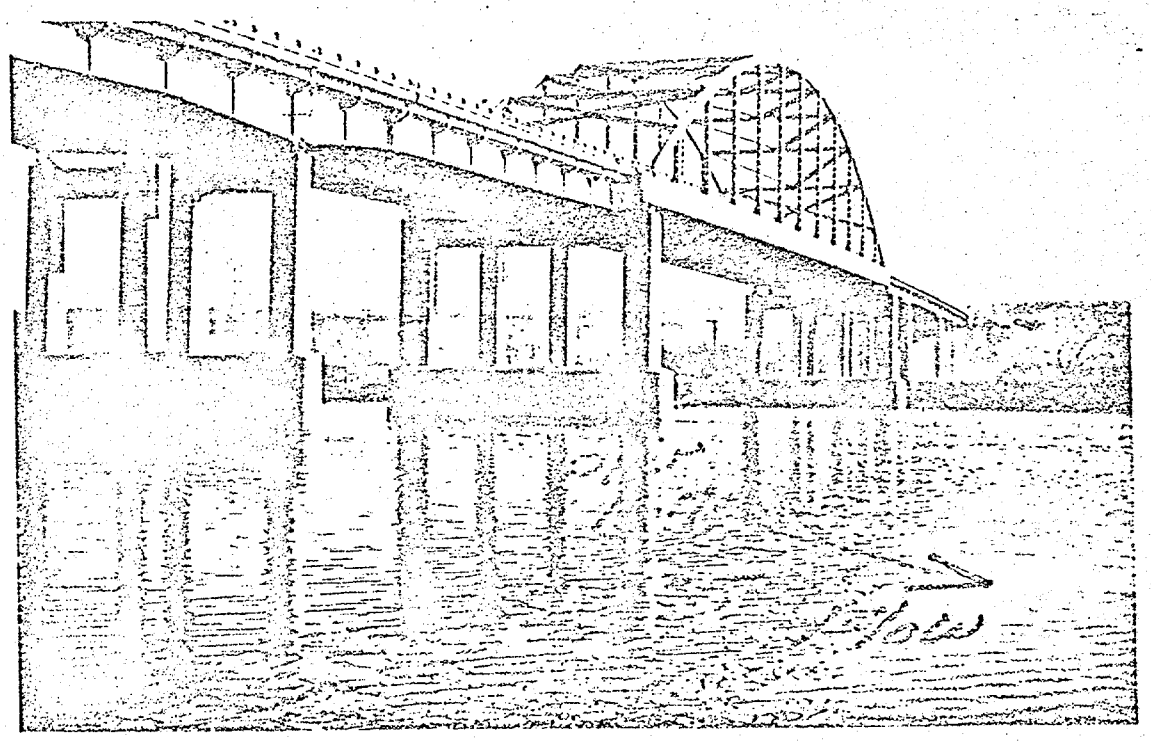
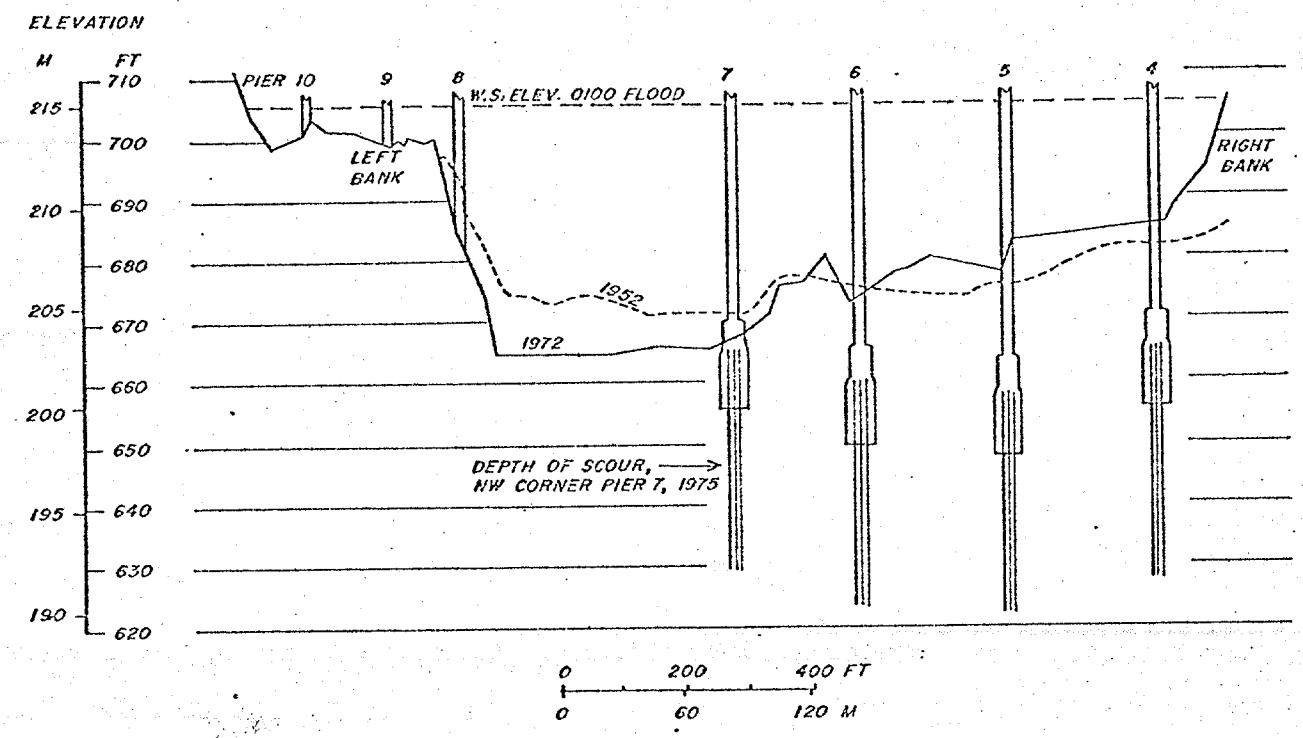
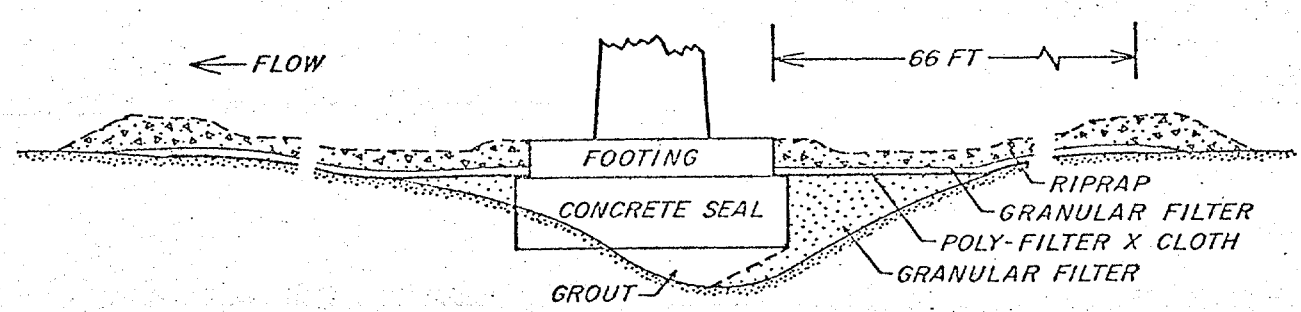


FIGURE .2 VIEW UPSTREAM AND TOWARD LEFT BANK OF I-494 BRIDGE IN JANUARY, 1977. PIER 7 IS AT CENTER.



205.3

FIGURE 3 CHANNEL CROSS SECTION AT I-494 BRIDGE, SHOWING CHANNEL DEGRADATION AND DEPTH OF SCOUR AT PIER 7.



205.4

FIGURE 4 CROSS SECTION SHOWING PLACEMENT OF REVETMENT AT PIER 7.

YALOBUSHA RIVER AT SH-9 NEAR CALHOUN CITY, MISSISSIPPI

Description

The reach of the Yalobusha River and Topashaw Creek system of interest is in Calhoun County and the highway crossing of interest is State Highway 9 1.93 km south of Calhoun City. The combined drainage area of all channels is 790 km. Both streams were canalized in 1967 by the U.S. Department of Agriculture, Soil Conservation Service, both channels being significantly straightened and enlarged. Figure 1 is a location map of the area that also illustrates the canalization of the natural streams. The streams are perennial, alluvial, sand bed, in a valley of low relief with a wide flood plain. The channels are straight, incised cut banks of silt and sand. The bridge consists of a concrete deck on concrete piers in channel, founded on steel piles. Abutments are the spillthrough type and cross the stream at a right angle.

Gradation Problem

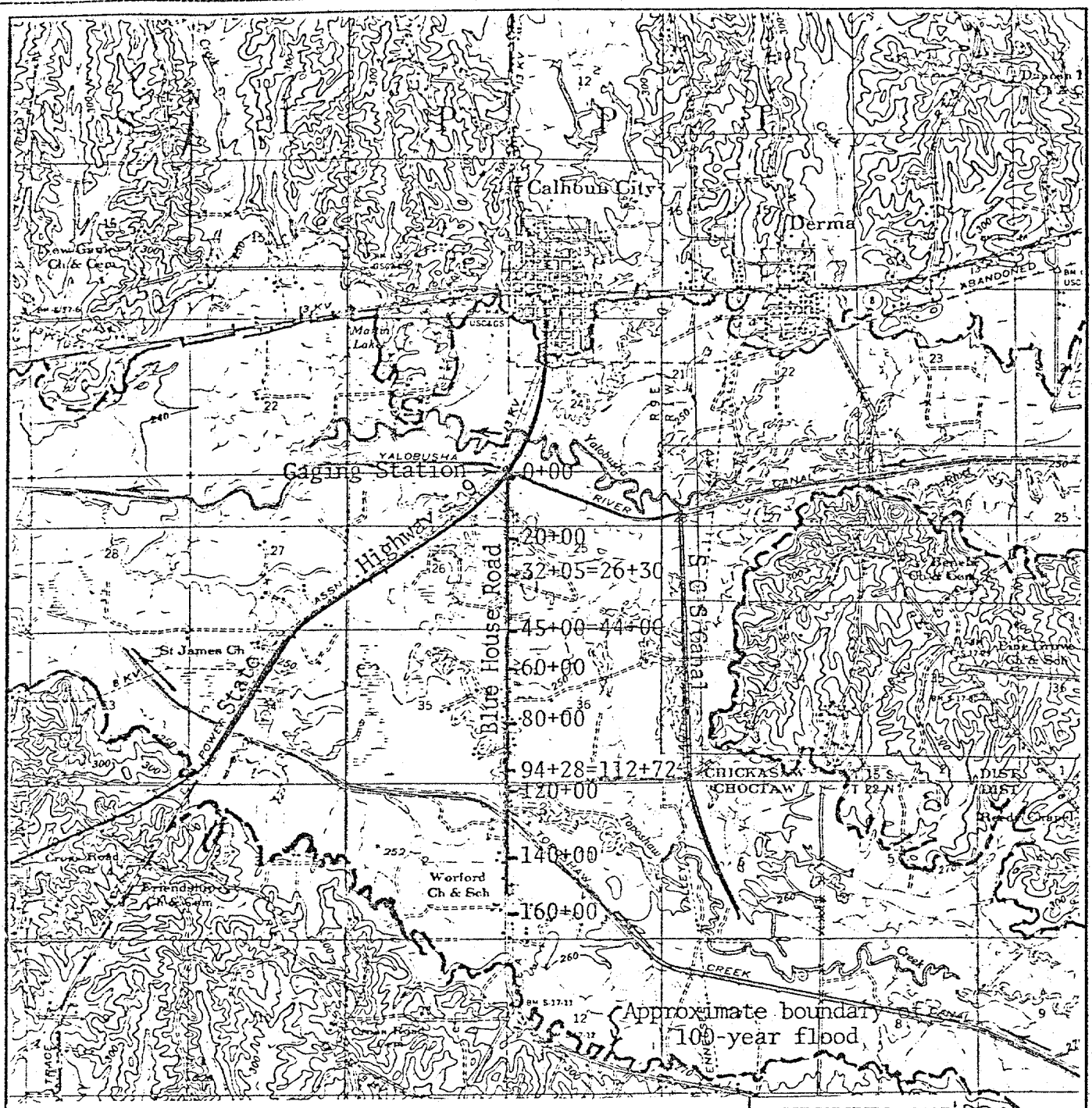
Because of the large changes in hydrologic characteristics of the Yalobusha-Topashaw Stream system resulting from the extensive canalization in 1967, many changes have taken place including degradation, bank caving and debris problems. Prior to the extensive canalization in 1967, Yalobusha River reached its highest peak discharge, 651 cubic M per second, at elevation 77 M on March 29, 1951. After canalization the river reached its highest peak discharge, 1472 cubic M per second at elevation 76.2 M on March 16, 1973. Figure 2 illustrates the stage-

FORM 9 - 213C
(Rev. Nov. 69)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
SKETCH FORM

File _____

Figure 1.--General location map, Yalobusha River-Topashaw Creek canal at Blue House Road near Calhoun City, M



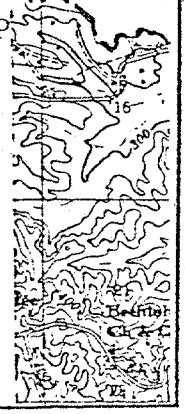
N

0 1 2 3 4

Scale in miles

VICINITY MAP

• Approximate location of project



Sheet No. 8 of 11 Sheets. Prepared by _____ Date _____ Checked by _____ Date _____

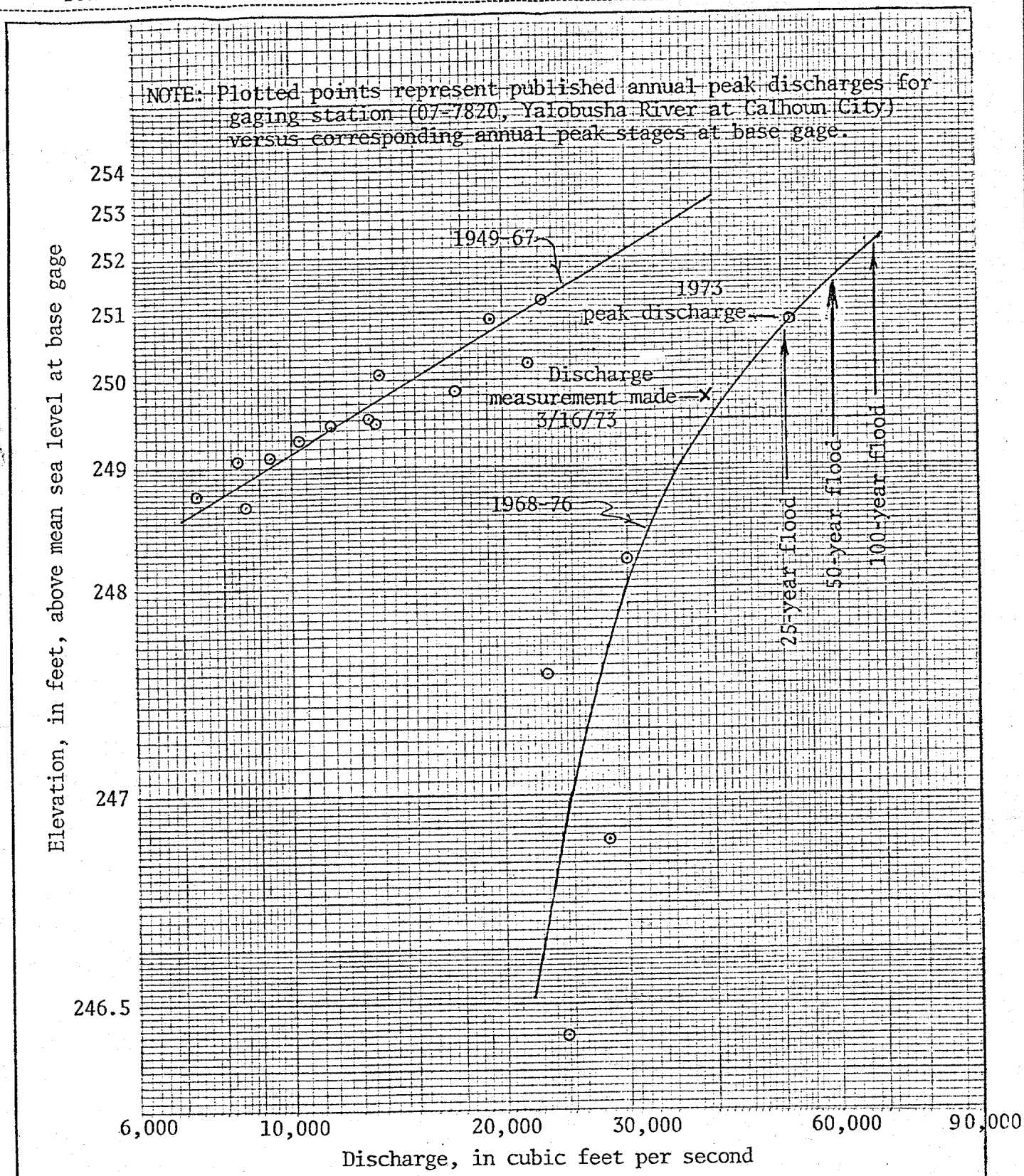
U.S. GOVERNMENT PRINTING OFFICE 16—25896-4

FORM 9 - 213C
Rev. Nov. 69)

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File _____

Figure 3.--Stage-discharge relations, Yalobusha River at State Highway 9 at Calhoun City, Miss.



Sheet No. 10 of 11 Sheets. Prepared by JDS Date 8/76 Checked by KVW Date 9/76

U.S. GOVERNMENT PRINTING OFFICE 16—25896-4

discharge relation of the Yalobusha River at SH-9 before and after canalization. Also indicated on this figure are the results of a recent flood-frequency analysis which approximately doubled the design discharges. Degradation at SH-9 has been over 3 M . The channel width has increased significantly, the banks are unstable resulting in debris problems. These problems are also migrating up the tributaries which are causing serious problems.

Countermeasures

It has been difficult to identify the countermeasures applied to these stream systems. The highway department has riprapped the abutments for protection. The Soil Conservation Service has tried many things up in the watershed that include grade control structures and several flood control structures. There are also numerous relief bridges across the flood plain.

Discussion

The extensive canalization plans are available from the Soil Conservation Service. The channel slope has been increased along with the sediment transport characteristics associated with a degrading stream. The U. S. Geological Survey has conducted brief hydrologic studies on the Yalobusha River at Calhoun City (SH-9), at Grenada (SH-51), and at Holcomb below Grenada Reservoir (SH-8). All of these highway crossings have significant degradation due to man's activities. This river system is a good example of numerous gradation problems due to channel straightening, clear water releases from a reservoir, debris problems resulting from degradation, bank caving, and in general, instabilities due to channel and system modifications.

Case History 58

PERRY CREEK AT I-55 NEAR GRENADA, MISSISSIPPI

Description

Perry Creek watershed is in Grenada County. Interstate 55 crosses Perry Creek about 4.8 km south of Grenada. The drainage area of Perry creek at Interstate 55 is 33.4 square km and the slope of the stream is about 0.0019 in that vicinity. The 50 and 100 year floods are estimated at 195 cms and 225 cms respectively. The stream is perennial, alluvial and has a sand bed. The channel is fairly straight due to several channel modifications. The banks are silt-clay with trees completely removed in some areas and sparsely to densely covered in other areas. Perry Creek is a tributary to Batupan Bogue.

The Interstate 55 crossing is a double 6.7 x 4.3 meter box culvert.

Gradation Problem

Perry Creek has been degrading over a number of years recording to the testimonys of various individuals. In 1975 the apron of this culvert was beginning to break and the degradation at the outlet was estimated at 1.2 to 1.5M During a flood of April, 1977 (about a 1.5M stage in the culvert) the downstream apron continued to break up and the left downstream wingwall broke away from the culvert barrel and turned at an angle of about 10 degrees. The scour hole at the downstream end of the culvert was about 33 m in diameter and the low-water surface was about 8 feet below the

flowline of the box. Degradation in 1978 was about 3M.

The more recent degrading was into a blue-marl soapstone material and this channel has cut 1.5 to 2.1M down into this material.

The degradation is all primarily due to channel changes by the U.S. Soil Conservation Service and degradation of Batupan Bogue which is also unstable due to channel modification of the Yalobusha River. Degradation, bank caving and debris has been a problem below I-55 and down to the junction of Batupan Bogue.

Countermeasures

Extensive corrective measures are now under construction. The State Highway Department is completing a new barrel extension with a 3 m drop. The stilling basin is 54 M long and the width expands to 28 M at the end of the stilling basin. 3175 metric tons of loose riprap (size 136 km) has been placed downstream of the stilling basin and on the banks for bed and bank protection.

The Corp of Engineers has completed several grade control structures on Perry Creek and have plans for several more. A total of eight have been constructed or scheduled for construction. A completed grade control structure just upstream of the mouth of Perry Creek is a weir consisting of steel sheet piles and riprap. Other grade control structures are primarily riprap. These grade control structures and related bank protection is part of a demonstration and research project.

Discussion

The degradation is the result of several channel modifications on Perry Creek and Batupan Bogue. The degradation has been responsible for considerable damage downstream of I-55.

Several grade control structures of various kinds of bank protection have been constructed or are under construction. These countermeasures on Perry Creek should serve as an excellent field laboratory to evaluate various kinds of grade control structures and bank protection. The results of this demonstration and research project should be of great value to control gradation problems and bank erosion.

Case History 59

BATUPAN BOGUE AT SH-8 AT GRENADA, MISSISSIPPI

Description

The reach of Batupan Bogue of interest is in Grenada County. The drainage area of Batupan Bogue at State Highway 8 is 622 square km. About 75 square km are controlled by several U.S. Soil Conservation Service dams, and the uncontrolled drainage area is 548 square km. The slope of the stream is about 0.0009 in the vicinity. The unusually large channel with sandy-silt banks and a sandy bottom carries 90 percent of the 50-year flood discharge. Batupan Bogue empties into Yalobusha River about 2.4 km downstream from State Highway 8. Changes in the channel and flow regime of Yalobusha River by Corps of Engineers projects during the 1950's, (including Grenada Dam) may relate to the instability of Batupan Bogue. The U.S. Soil Conservation Service have made extensive changes to the natural watershed, the main channel and tributaries.

Gradation Problem

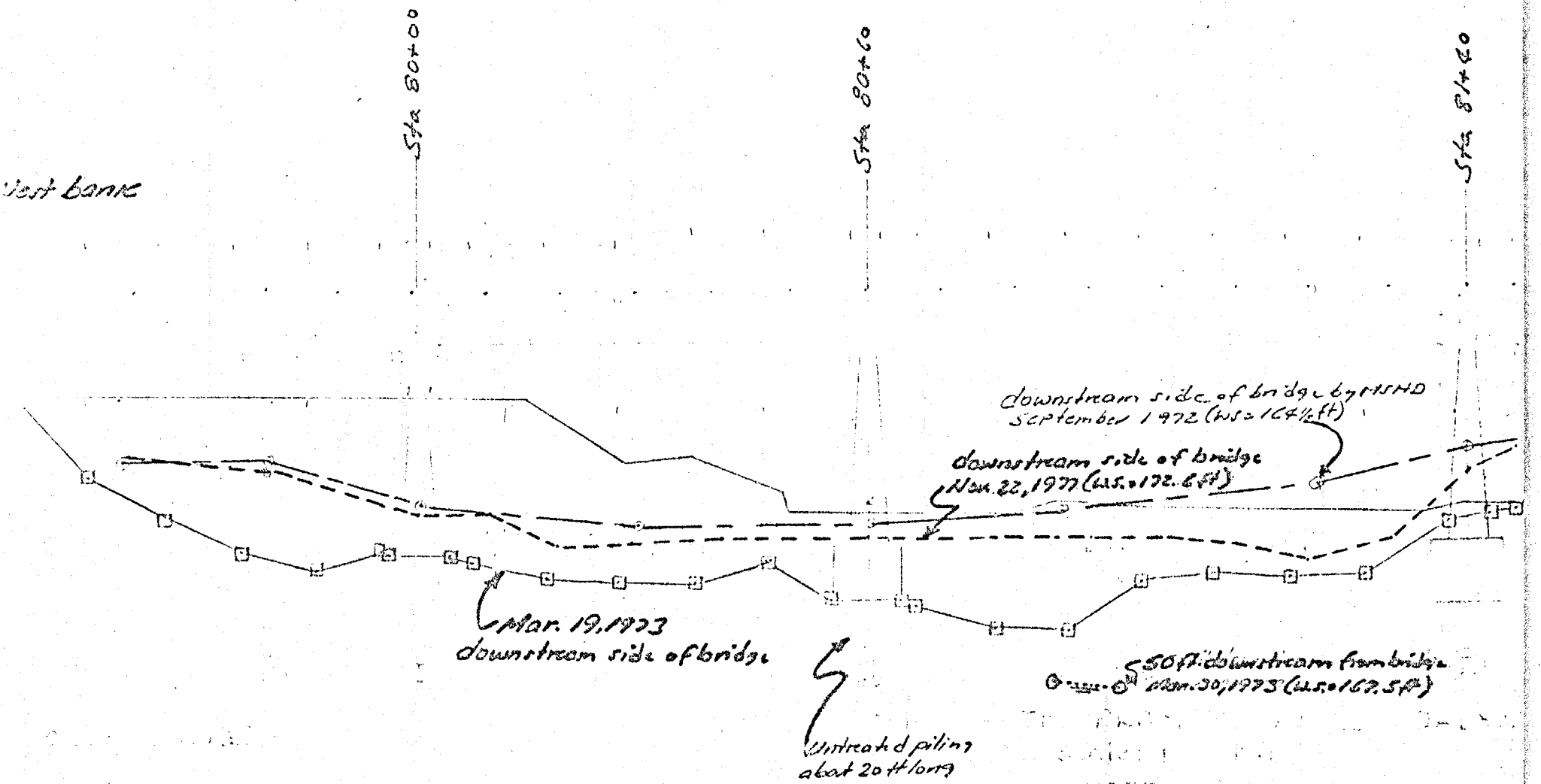
Two Government agencies have made several watershed and channel changes which are primarily responsible for the degradation and loss of the bridge collapse in 1977. Changes in the channel and flow regime of Yalobusha River by the Corps of Engineer during the 1950's and the U.S. Soil Conservation Service watershed modifications may indeed be responsible for the instabilities of Batupan Bogue.

In a 1972 Corps of Engineers report, "Flood Plain Information, Yalobusha River and Tributaries, Grenada, Mississippi", Batupan Bogue is described as follows:

> "Batupan Bogue is undergoing an adjustment in stability. The meandering has worked itself upstream past Tie Plant, where a geologic control, perhaps a rock outcrop, has slowed down the erosional, bank caving process.
>
> The stream now appears to be approaching some sort of an equilibrium condition which is gradually working its way upstream from the confluence with the Yalobusha River. However, any area in the flood plain of the Batupan Bogue is subject to bank caving at some time in the future unless the river is completely stabilized into a permanent channel."

The channel doubles its width about 305 M downstream from State Highway 8 and is wide from that point to Yalobusha River. Changes in the streams cross section at State Highway 8 are shown on Figure 1. A Highway Department cross section of September 1972 shows a deterioration of the west bank but shows little change in flowline since the bridge plans were developed about 1938. During the measurement of March 19, 1973, the stream had degraded to the bottom of the footing (Sta. 80+60), and on March 30, 1973, the channel 15 M downstream from the bridge was about 3 M below the footing. Cross-section data obtained November 22, 1977, (26 hours after the bridge collapsed) are also shown on Figure 1. The November 22, 1977, data shows surprisingly little local scour compared to that which probably existed a day earlier when the bridge collapsed. An inspector for the Corps of Engineers witnessed

Figure 2.-Cross-sections of Batupan Bogue at State Highway 8 at Grenada, M



the bridge collapse. He described a large drift accumulation on the upstream side of the pier (Sta. 80+60). Water diving under the drift came up downstream turbulent and "soupy" with sediment. The downstream end of the pier settled 0.3 to 0.5 about 11 a.m., compressing the concrete deck spans which cracked and broke up about 15 minutes later. According to the inspector, the concrete pier collapsed straight down as if undermined by scour and the 24-meter to 18-meter spans collapsed with it.

The peak discharge of November 21, 1977, was about 8500 cms cubic meters per second), which is less than a 10-year event. The upper reaches of Batupan Bogue had lower order floods, At the Tie Plant crossing 5 km upstream, the flood was about a 2-year event. Perry Creek and Browns Creek which are tributaries in the vicinity of State Highway 8 had extreme floods, especially in their lower reaches. At the Interstate Highway 55 crossing of Perry Creek 5 km southwest of Grenada, the flood was about a 10-year event.

Additional evidence of degradation was observed at the crossing in 1979. The stilling well used for stream gaging in previous years was resting on dry ground and yet the flow was approximately 212 cms.

Countermeasures

The Corps of Engineers are presently involved in bank stabilization work along Batupan Bogue for several miles upstream of SH-8 and constructing grade control structures and bank protection on Perry Creek, a tributary just upstream of SH-8.

The replacement bridge has been designed with two piers essential out of the channel except during extreme floods. The minimum pile length is 18 M and the center span is a now 55 M.

Discussion

The degradation or headcutting upstream from the Yalobusha River is primarily responsible for the instability of Batupan Bogue which has resulted in:

1) An increase width of channel below SH-8 and lateral or meandering upstream past Tie Plant.
2) An increase in bank erosion and the bank caving process which is responsible for the debris problem.
3) The degradation and headcutting in the Perry Creek watershed.

BLACK CREEK AT SR-7 NEAR AVALON, MISSISSIPPI

Description

Black Creek is in Grenada County and is a tributary to the Yalobusha River about 3.2 km downstream of State Road 7 highway crossing. SR-7 crosses Black Creek just inside the delta approximately 152 M west of the escarpment that bounds the delta. The crossing is situated in the zone of transition from a state of degradation to aggradation of the stream bed. This condition is characterized by the change from steep slopes, high velocities, and high sediment carrying capacity. The drainage area above SR-7 is about 54 square km and the slope varies from steep in the foothills to fairly flat in the delta. The stream at SR-7 is perennial, alluvial, sand band, in a valley of low relief with a wide flood plain. The channel is meandering, trees cover the banks in many locations and the banks are silt-clay. The bridge consists of a concrete deck on concrete piers in channel, founded on steel piles. Abutments are not the spillthrough type and the bridge crosses the stream at a slight skew. Figure 1 shows the location of SR-7, the abandoned railroad and the significant topographic changes in the foothills and the delta.

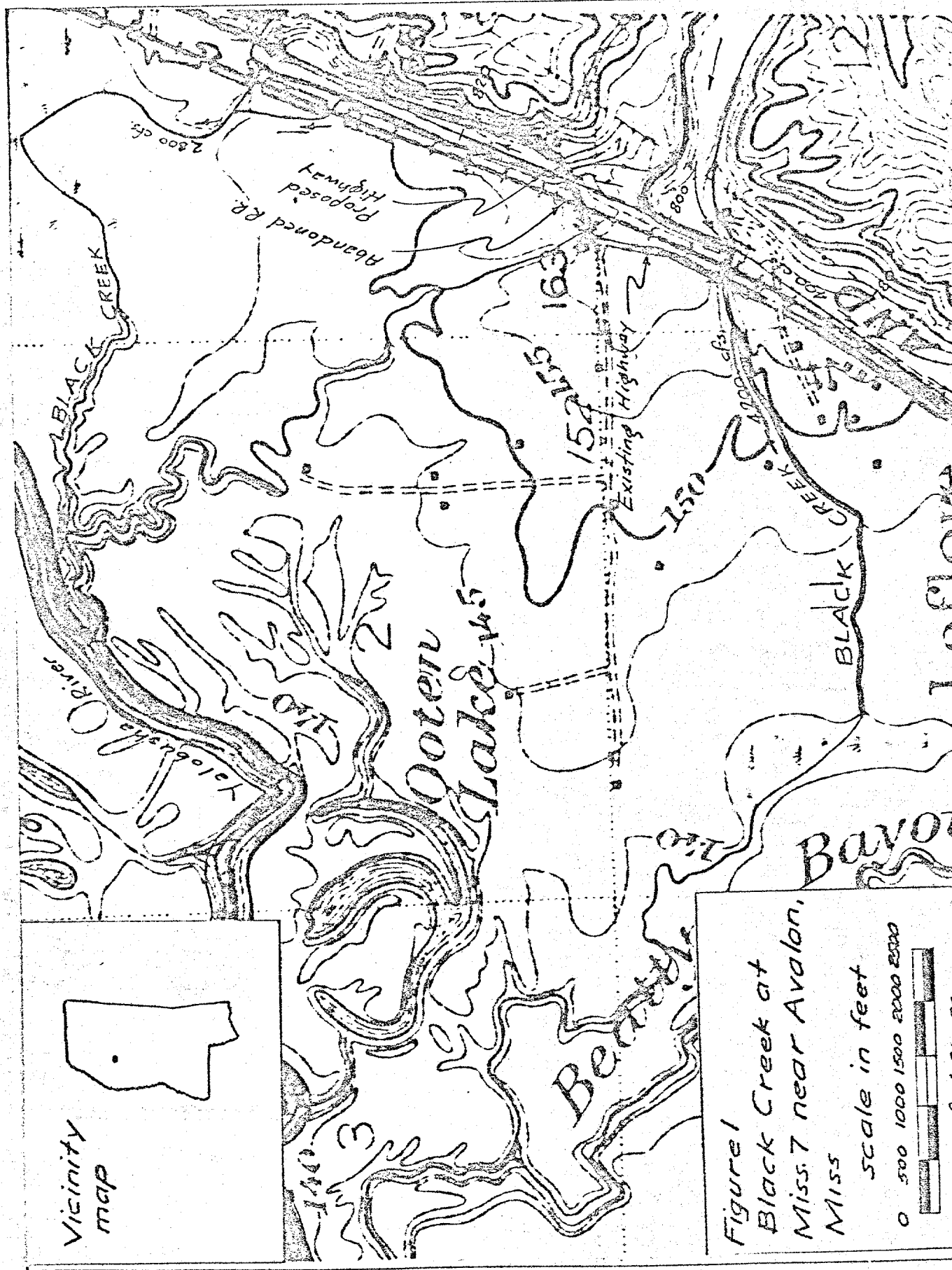
Gradation Problems

The Yazoo and Mississippi Valley Railroad operated a line until 1947 that crossed Black Creek in the vicinity of the SR-7 crossing. In 1913 the railroad fill at the river crossing was 1 to 1.2 M higher than natural ground on either side of the track and there was a deep clearance

9-213-C
(Feb. 1937)
Excel Form

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File .....



Sheet No. ..... of ..... Sheets. Prepared by ...HHR..... Date ..... Checked by ..... Date .....

U. S. GOVERNMENT PRINTING OFFICE 16—21596-3

beneath the stringers of the main channel bridge. By 1947 the entire flood plain in the crossing area had filled to approximately the same level as the railroad fill, particularly along the upstream side. The clearance beneath the main channel bridge had decreased from 3 to 1.5 M from 1940 to 1947. By 1953 there were sections of the old railroad fill that could not be identified by its topography due to deposition of sand and drift and the clearance under the old railroad had further decreased to 1 meter.

With this knowledge, the State Highway Department constructed the bridge crossings over Black Creek in 1954.

Extensive flooding of Black Creek in 1968 precipitated an investigation of Black Creek and the SR-7 crossings. It was reported in 1969 that the SR-7 crossing was characterized by the continual aggradation of the stream beds and a general building-up of the fan-shaped valley at the foot of the hills. The sand, drift and debris which had deposited through the years in the North Fork, had reduced the hydraulic capacity to nearly zero. Further, the natural ground elevation in the area between the highway at the levee has been built up about 1.5 M above natural ground of 1954. During the flood in November 1968, it was reported that water was flowing over the road at depths of 1.2 M. After the flood the sand had filled in to the elevation of the highway in most places and piles of drift and debris was several feet higher than the centerline of the highway.

From 1969 to 1979 there has been a continual problem of aggradation at SR-7 on Black Creek.

Countermeasures

A levee system was installed to protect the local residence, but the actual date is not known. This was not

a countermeasure to alleviate aggradation and perhaps aggravated the problem.

Several culverts have been installed between the south and north forks of Black Creek to provide more conveyance. The removal of sand and debris has been the major countermeasure since the bridge was constructed in 1954. This has included maintaining a channel on the North Fork, keeping the culverts open between the south and north forks, as well as maintaining the main channel. This has been necessary several times a year.

Discussion

Detailed reports are available in 1953, 1962 and 1969. These reports include detailed descriptions of the area as well as discussions of flood history, frequency of floods, fluvial deposits, stage and distribution of flood flow. Several profiles are available, but emphasis flood information and not aggradation information.

This aggradation problem will require a more detailed study than has been done in the past to resolve and design a better maintenance-free highway crossing.

PIGEON ROOST CREEK AT SR-305 NEAR LEWISBURG, MISSISSIPPI

Description

The reach of Pigeon Roost Creek of interest is in De Soto County. The highway crossing of Pigeon Roost Creek is State Road 305 bridge 3.9 km south of Lewisburg.

The drainage area above SR-305 is 591 km^2; bankfull discharge is 976 m^3/s; valley slope is 0.0009; and width of artificial channel is 69 m. The stream is perennial, alluvial, sand bed, in valley of low relief with a wide flood plain. The channel is straight. It was first straightened about 1920 and again straightened and widened in 1968. The banks are silt-clay; tree cover was entirely removed from the banklines during 1968 chanenlization. Pigeon Roost Creek is a tributary to Coldwater River. The bridge consists of a concrete deck on prestressed concrete beams which are supported by steel piles encased in concrete. The length of bridge is about 107 m; three 24 m spans and one 34 m span. Abutments are the spillthrough type. The bridge crosses the stream at right angles.

Gradation Problem

The original channel, following improvements made about 1920, was about 30 m wide. The U.S. Soil Conservation Service rechanneled the creek in 1968. The new channel was enlarged from a 15 m to a 62 m bottom width, and excavated several feet deeper than the earlier channel. The enlarged channel placed several bents in the main flow of the channel, thus subjecting the bents to debris and scour.

In 1969 the channel bed had degraded over 3 meters. This degradation caused bank caving, serious debris problems and lateral shifting and movement of the channel.

Countermeasures

The bridge was built in 1950 which included provision for an 18 meter span across the main channel and use of concrete slope paving to protect the abutments. In 1968, in junction with the rechannelization, the following countermeasures for the bridge included:

1. Two new double-pile bents driven to 9 meters below the channel bed to reinforce the existing bridge piling,
2. Construction of nose piles to deflect debris,
3. Timber sheathing to encase the double pile bents to prevent lodging of debris at the pile bents,
4. Protection of spill-through abutments with rock riprap for 15 meters upstream and downstream of the bridge.

The enlarged channel placed several bents in the main thread of flow, thus subjecting the bents to increased flow velocities and heavy drift. During the flood of April 10, 1969, the structural failure occurred with a settlement of 0.23 m at bent 8, and 0.15 m at bent 11. Scour about 6.1 m deep was observed at bent 8. Bridge damage was due to reduced pile penetration associated with scour caused by high velocities and drift. The bridge was later repaired to original condition. Site inspection in 1970 indicated the channel was shifting away from the 18 m main span. Aggradation of the original channel was occurring and the low-water channel had shifted toward the shorter spans. The flood of April 19, 1973, caused complete failure of bridge and changed the

main channel location. Following the flood, a new bridge was built with several measures to protect the bridge from damage by lateral erosion and lodging of drift at the bents.

1. Individual steel piles for a bent were encased in concrete sheathing to protect against lodging of drift. The concrete encasement was extended below the ground surface at least 0.5 m .
2. The upstream pile in a bent with a batter of 3/4 to 0.02 to 0.30 m was placed to act as a drift deflector.
3. Broken concrete riprap was placed on the channel banks to prevent lateral erosion.
4. The bridge spans were increased from 7.3 m to a minimum of 24 m to reduce the chance for debris lodging.

Although there have been no problems reported at the new bridge, the channel is still undergoing many changes. The evidence includes unstable banks, lateral movement and changes in the bed elevation.

Discussion

1. The enlargement of the channel by widening and deepening did not insure a stable channel size and location.
2. For this stream, which carried large amounts of drift, bents spaced at 7.3 m were inadequate to pass debris without lodging on the bridge.
3. The amount of scour, caused by debris lodged at the bridge and fast flow velocities, exceeded 6.1 m below the normal streambed.
4. Encasement of steel piles by concrete sheathing to act as a drift deflector were used to prevent

the collection of debris at bridge bents or between piles.

5. Even though the stream gradient was less than 0.1 percent, local scour problems were caused by contraction of flow and lodging of debris at the bridge that decreased the size of the effective waterway.
6. The degradation associated with the stream was and has not been evaluated as a major and important issue by the Highway Department or other federal government agencies involved.

HOMOCHITTO RIVER AT SR-33 AT ROSETTA, MISSISSIPPI

Description

The Homochitto River is a tributary to the Mississippi River and is the boundary between Adams and Wilkinson Counties in the area of interest.

The original bridge was built in 1940 by the U.S. Forest Service. It consisted of 18-24-18-m main spans flanked by several 5.8-m approach spans on timber-pile bents. Four concrete piers in the main channel had concrete footings on timber-pile foundations. In 1963, the bridge was rebuilt to a length of 184 m by the Mississippi State Highway Department and countermeasures were added, that are described later. The Illinois Central Railroad bridge, about 213 m upstream from the highway bridge, tends to catch drift at one or another of its 12-m spans and thus to alter the direction of approach flow at the highway bridge.

Drainage area is 1,442 km^2 ; valley slope is 0.0004; channel width in 1971, about 152 m . Stream is perennial, alluvial, sand bed, in valley of moderate relief, wide flood plain having distinct natural levees. In 1971, the channel was meandering, locally braided, wider at bends, point bars, cut banks general, silt-sand banks.

Gradation Problem

In 1906, the channel width of the Homochitto was less than 30 m at the U.S. Geological Survey gage at Rosetta. In 1938, the lower course of the Homochitto (beginning at Doloroso, MS, about 26 km downstream from Rosetta) was diverted into the Mississippi

River by a new channel, which shortened the course from about 27 km to about 14.5 km. In 1940, 14 meander cutoffs were made in the 48-km reach between Doloroso and Rosetta, reducing the river distance between these points by about 6.4 km. Channel degradation began at Rosetta in the late 1940's and amounted to about 1 m by 1949, about 2.4 m for the period 1949-66, no measured change for 1966-71, and about 4 ft (1.2 m) for 1973-74. Total degradation at Rosetta amounted to more than 4.6 m in 1974. The degradation has been accompanied by severe bank erosion, channel widening (Figure 1), and sift in position of the main channel.

Countermeasures

During a series of minor floods in 1953, pile bents of bridge subsided because of degradation. Mississippi State Highway Department drove steel sheet pile encasements around main piers to depth of about 6 m below footings and filled them with concrete. Approach spans, supported by steel pile bents, were added, and dumped rock riprap was palced on streambanks and approach embankments. In addition, seven timber pile spurs were built on the north bank (Figure 2) and several clusters of three timber pile were driven. Each timber pile spur consisted of three single rows of pile. A series of minor floods in 1955 resulted in scour to a depth of 8 m below top of pier footings. The upstream spur was badly damaged, as was riprap on north bank between highway and railroad. Pier scour attributed to poor configuration of piers, which obstructed flow and caught drift, to skewness of piers to flood flow, to high mean stream velocity (about 2.2 m/s), and to progressive degradation of channel.

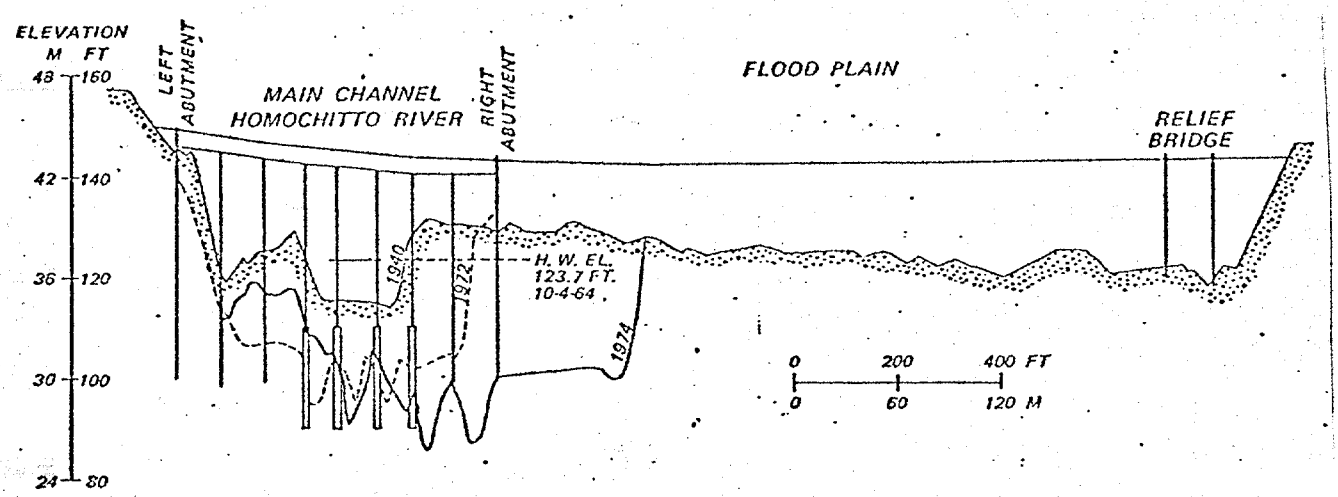


Figure 1. Cross Sections of Homochitto River, SR-33 Crossing at Rosetta, Showing Degradation and Lateral Erosion During the Period 1940-1974.

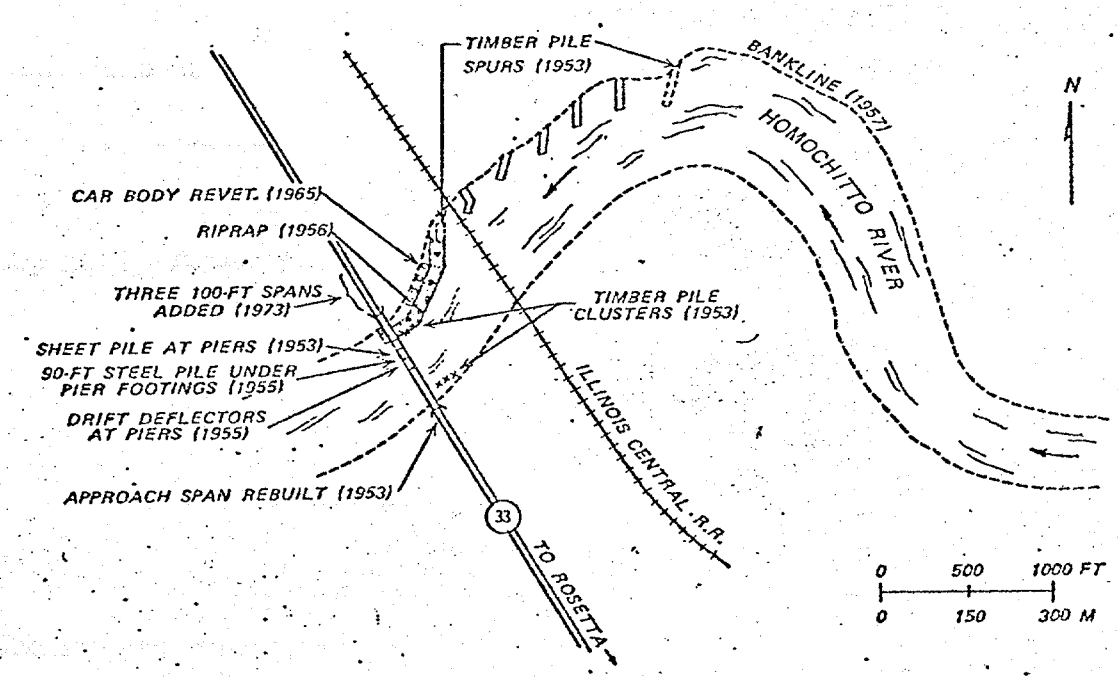


Figure 2. Plan Sketch of Homochitto River, SR-33 Crossing at Rosetta, Showing Placement of Counter-measures

In 1956, the right (north) streambank was riprapped for a distance of 180 m between highway and railroad bridges. Steel pile was driven to a depth of 27 m beneath footings of main piers. Drift deflectors, consisting of railroad rails driven at 45° to main piers on upstream side of pier, installed.

A series of floods between 1957-64 having a maximum peak discharge of 3,990 m^3/s, R.I. 10 yr, mean velocity in bridge waterway 3.2 m/s. Drift defectors on piers were destroyed. Riprap on right bank eroded and bank recession endangered approach spans. Deflection of current toward right bank probably due to drift accumulation in center spans of railroad bridge.

Revetment made of 160 car bodies anchored with steel cable placed at right bank, to replace eroded riprap.

A flood of March 24, 1973 (peak discharge 3,472 m^3/s) destroyed car-body revetment, during the same time that three new 30-m spans were being added to north end of bridge. North bank eroded to point 45 m from new abutment.

In 1974 a flood of April 13 (peak discharge 4250 cms, R.I. in range of 10-25 yr), eroded laterally against pile bents of new spans (which had been driven 18-21 m below streambed) causing them to fail; and two of the new spans fell into the river.

Lateral erosion of right bank in 1975 and 1976 had probressed to a point beyond the abutment of the failed bridge. A new bridge 450 m in length was under construction; it was to have round concrete piers whose footing tops are 9 m below streambed. Steel foundation pile beneath the footings were driven to a depth of 30 m below streambed. No bank protection is planned.

Discussion

Of the many types of countermeasures tried at the SR-33 bridge, none was adequate against the combination of unfavorable hydraulic factors: recurrent floods, severe degradation, abundant drift, high stream velocity, and rapid lateral migration of a high streambank. Failure of the timber pile spurs is attributed to the impact of drift during floods, which broke off the piling. Failure of the riprap bank revetment is apparently due to undercutting of the bank and, in view of the depth of degradation and local scour in the channel (about 12 m below flood plain elevation), the toe of the riprap would be difficult to protect. According to available information, the riprap used was approimately equivalent to class I, and class II riprap was needed.

Approach spans of the Illinois Central Railroad bridge have been lost (one in 1955) and the bridge has been rebuilt and lengthened. In spite of a rather battered appearance, the main piers are intact and the bridge was kept in service. The ability of railroads to move bridge spans from one place to another gives them a decided advantage in coping with a river that migrates laterally.

Although no bank protection is planned for the new SR-33 bridge, this may be needed to hold the river in its present course. By continued erosion of the right bank near the railroad bridge, the river may be diverted from its present course to a new course that intersects SR-33 at the present relief bridge. The probability that this diversion may occur within the next 50 years is estimated at 50 percent.

During excavation for pier construction at the new bridge, several car bodies were found at depths of about 9 m below streambed elevation, and broken concrete

riprap was found at a depth of about 14 m , at the top of a clay stratum. The car bodies, torn from the bank revetment, may have lodged against the piers of the old bridge, inducing local scour and perhaps failure of the bridge.

There are indications at the present time that the stream system is approaching stability once again. Many reports and a great deal of information is available at this classic site.

TILLATOBA CREEK AT SH-35 AT CHARLESTON, MISSISSIPPI

Description

Tillatoba Creek is located in Tallahatchie County and is a tributary to the Tallahatchie River. The river crossing of interest is at State Highway 35 just south of Charleston. The channel was straightened at the time of bridge construction, both upstream and downstream of the bridge. The drainage area above SH-35 is 135 square kilometers, the valley slope is 0.0015 and the channel width is approximately 45 meters. The stream is perennial, alluvial, gavel bed, in a valley of moderate relief (foothills) and is confined to a narrow flood plain. The channel is meandering, incised, and cut banks of silt and sand. The bridge is 73 meters in length, I-beam and reinforced concrete slab spans, and founded on steel pile bents. The bridge was constructed in 1956.

Gradation Problems

The previous bridge, located 75 meters upstream, had been outflanked by the stream and spans had been added over the years. A replacement bridge was constructed in 1956 and the channel was straightened both upstream and downstream from the bridge. In 1958 lateral erosion was a problem to the right bank upstream of the bridge and the right abutment. In 1976, observed exposure of the bridge substructure indicated that the channel had degraded 1 to 2 meters since 1956.

Countermeasures

In 1958, four timber pile spurs, ranging in length from 20 to 40 meters and spaced 30 meters apart, were constructed (Figure 1). They were connected by timber stringers and riprap was placed on the bed and banks at each spur. In 1976, the U.S. Army Corps of Engineers installed riprap bank protection downstream from the bridge on the left bank. Tillatoba Creek was also selected by the U.S. Army Corps of Engineers as a site for their stream bank protection demonstration project. In 1978 there were plans to install some grade control structures and additional bank protection of various types.

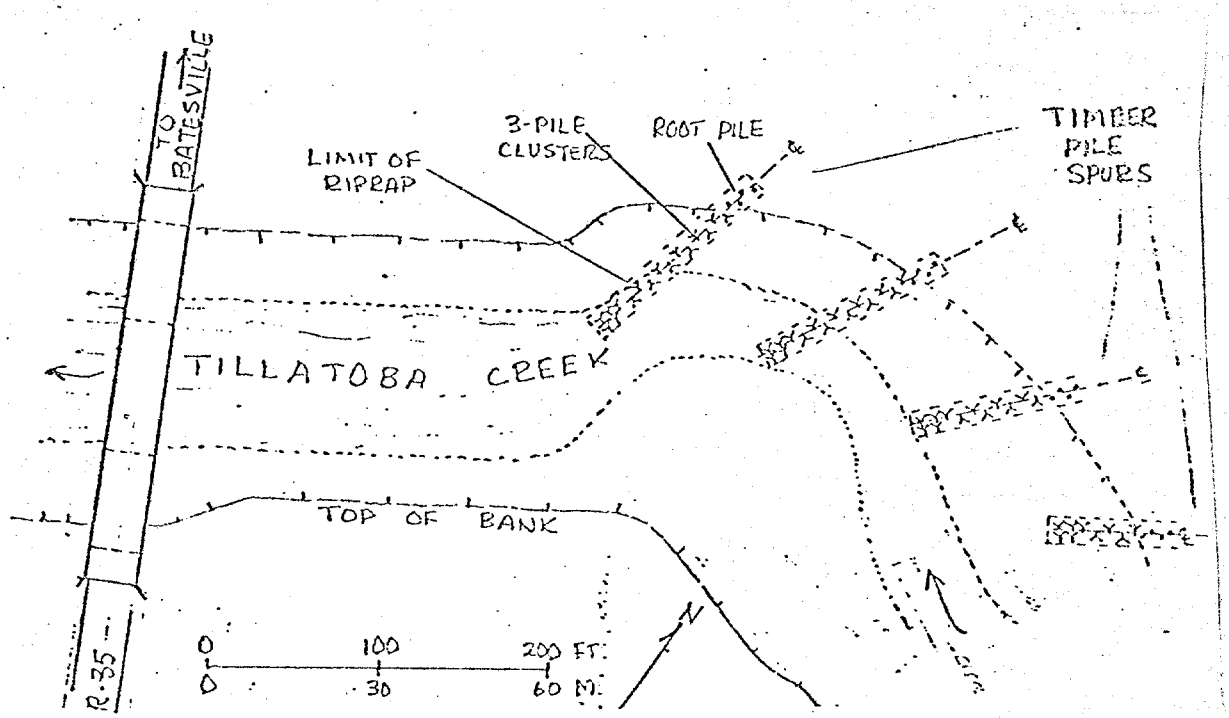


Figure 1. Plan Sketch Showing Location of Spurs at SR-35 Crossing

Discussion

A major source of difficulty in channel straightening is the junction between the straightened reach and the natural channel. In this case, erosion occurred where flow from the natural channel impinged at an angle against the straightened reach. However, general instability and degradation of the channel is not attributed to local straightening at the bridge, but there is a general instability of the channels in this area, probably due to runoff from increased cultivated area.

Case History 64

KIMSEY CREEK AT I-29 NEAR MOUND CITY, MISSOURI

Description

Lat. 40° 07', Long. 95° 13'. Kimsey Creek in Holt County, Missouri flows in a southwesterly direction into Squaw Creek which drains into the Missouri River. The drainage area at Mound City is approximately 15.4 square km of moderately hilly terrain.

Gradation Problem

Minor straightening and channelization projects were done on both Kimsey Creek and Squaw Creek at various times since the turn of the century. These projects were done on a local basis and there are very few records to show the extent of the projects. One result of the local straightening projects has been degradation on Kimsey Creek.

At the site of the I-29 bridge over Kimsey Creek there was 1.4 M of degradation from 1957 to 1969 and 1.2 M from 1964 to 1969.

A large channel straightening project, called 5 Mile Lane, was completed on Squaw Creek in 1969. This project extends downstream to the Missouri River from the confluence of Kimsey Creek and Squaw Creek.

The I-29 bridge over Kimsey Creek was built in 1972 and since then the degradation has continued but there is no accurate information as to the extent of the continued degradation.

Countermeasures

The State Highway Commission has records of the degradation that occurred on Kimsey Creek prior to construction of the I-29 bridge. This information was used in the design and the pile supports for the bridge were driven to a depth at which the Highway Commission feels the bridge will not soon be placed in jeopardy by continued degradation of the channel.

Discussion

The presence of degradation activities in Kimsey Creek was known at the time of construction of the I-29 bridges and was used as a parameter in the design of the bridges to protect against problems caused by future degradation. What was not taken into account is the possibility of major degradation occurring at an increased rate due to the channel changes in Squaw Creek that were completed in 1969. These changes may cause sufficient degradation to present problems to the I-20 bridges.

MIDDLE FORK GRAND RIVER, SH-46, NEAR GRANT CITY, MISSOURI

Description

Lat. 40° 29', Long. 94° 23'. The Middle Fork Grand River in Worth County flows in a southwesterly direction and then heads southeasterly and joins the Grand River near Pattonsburg, Missouri. The drainage area in the study reach is approximately 65 square km , with a valley slope of .0014. The river is in a valley with low relief, a wide flood plain and the channel with a sand-silt bed is about 70M wide. The banks are near vertical and composed of silt-clay.

Gradation Problem

As a result of channel straightening, probably done by local drainage districts in the 1920's, degradation has become a problem on the Middle Fork Grand River.

The Highway 46 bridge over Middle Fork Grand River was built in 1930. By 1967 the channel had degraded and in doing so shifted to the west where it seriously eroded around the foundation piles of pier 6 and around pile bents 4 and 5. Total streambed degradation by 1976 was over 3 meters (Figure 35).

Countermeasures

When the channel degraded and shifted to the west it left the pile bents at 4 and 5 with only 2.4 M of penetration. The pile bents at 4 and 5 were supplemented by

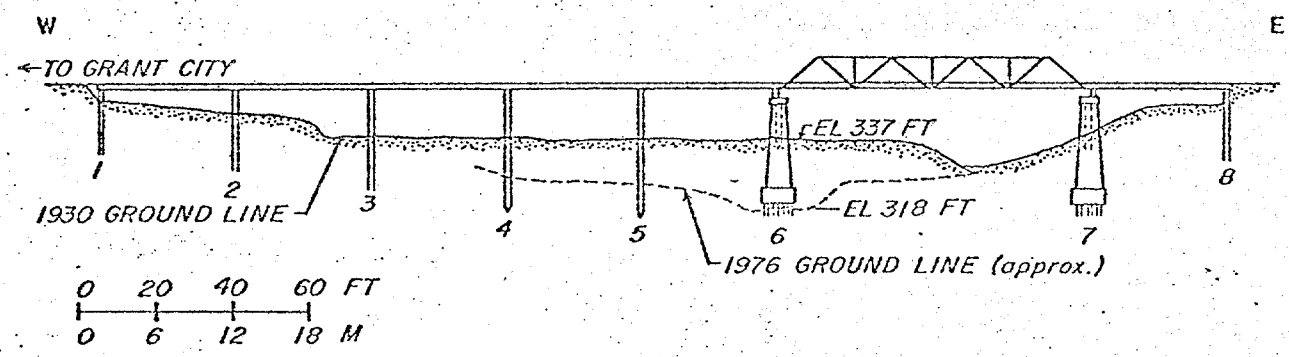


Figure 35 - Middle Fork Grand River near Grant City, MO
Streambed degradation at Highway 46

new H-piles in 1968-1972 and a riprap retard was built to shift the channel away from pier 6. The retard has protected pile bents 4 and 5, but pier 6 is now in the middle of the low water channel.

Discussion

The channel degradation at the Highway 46 site may have reached its limit due to the fact that channel degradation usually occurs at the fastest rate soon after the channel equilibrium is disturbed as by straightening. The rock retard has been successful at controlling the tendency of the river to move to the west.

Case History 66

DAVIS CREEK AT I-70 NEAR SWEET SPRINGS, MISSOURI

Description

Lat. 38° 58', Long. 93° 24'. Davis Creek in Fayette and Saline Counties, Missouri flows in an easterly direction into the Blackwater River. The Blackwater River joins the LaMine River near LaMine, Missouri and then flows into the Missouri River. Davis Creek near Sweet Springs has a drainage area of 603 square km of rolling hills.

Gradation Problem

Three highway bridges have been constructed over Davis Creek near Sweet Springs. The first bridge was for U.S. Highway 40 and was constructed in 1944. In 1957 a bridge was built just north of the existing bridge and the highway became I-70. The third bridge was a local bridge and was built south of the other two bridges in 1972.

The period between the construction of the first and second bridges (1944-1957) was a stable period in Davis Creek as indicated by a lack of either degradation or aggradation at the I-70 bridge site during that period.

When the last bridge was built in 1972, it was discovered that the streambed in Davis Creek had aggraded nearly 1.5 M (Figure 27).

Salt Pond Creek is a tributary to Davis Creek and has shown aggradation at the Highway 127 bridge. The bridge was built in 1935 and in 1979 it was estimated that 1.2-1.8 M of aggradation had occurred. Continued aggradation may reduce the size of the opening to a critical point and cause flooding in the area or flow over the roadway.

Countermeasures

No countermeasures have been taken at either site. Countermeasures are probably not called for at this time at the I-70 bridges because the size of the bridge openings is still sufficient to handle all design floods. The bridge over Salt Pond Creek may become a problem if countermeasures aren't taken in the near future.

Discussion

The cause of the aggradation in Davis Creek is not readily apparent although it is known that Blackwater River is also going through an aggradation cycle at this time.

Case History 67

WEST GALLATIN RIVER AT I-9 NEAR BOZEMAN, MONTANA

Description:

This bridge is a prestressed concrete beam structure supported by 5 piers, and with a total length of 52.2M . The drainage area is approximately 2494km^2 and the watershed cover varies from heavy forest to irrigated pasture land. Upstream from the bridge, the river is braided and meanders significantly downstream from the site. Both the bed and banks of the river are composed of cobbles and coarse gravels, and the lower part of the watershed area is a pronounced alluvial fan. Extensive irrigation activity is present in the site area, and numerous irrigation canals have been constructed from the river.

Gradation Problem:

Immediately upstream from the bridge a large point bar has formed that has armoured itself and formed a barrier in the main channel. The bed slope has been decreased at the site, with consequential aggradation induced. This aggradation is causing the river to further braid itself upstream and channels have been cut beside the Interstate Highway to divert high flows to Baker Creek.

Countermeasures:

No major countermeasures have been undertaken at this site, other than the diversion channel to Baker Creek.

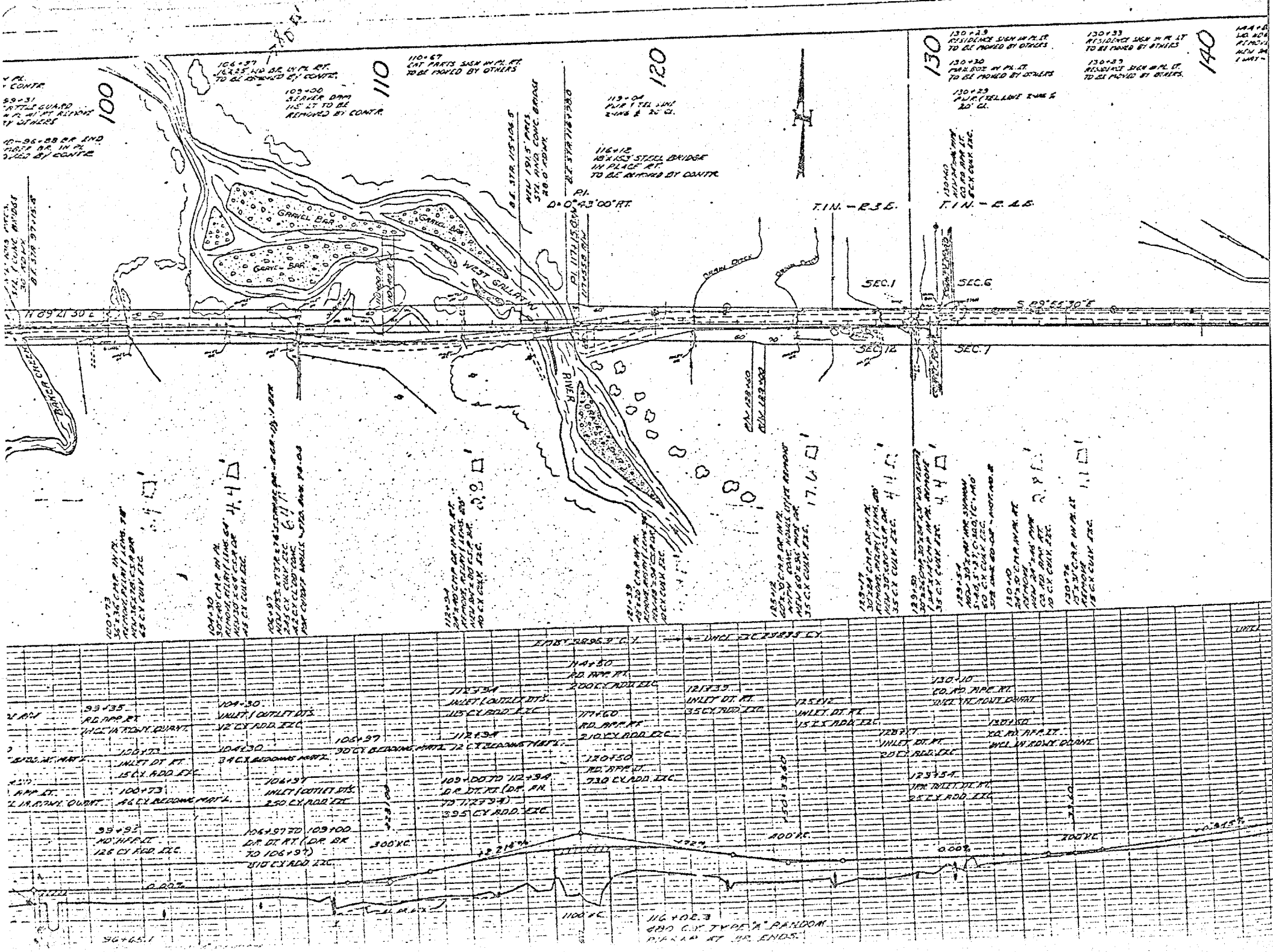
Discussion:

This site is not a problem area with regards to the integrity of the bridge at the present moment, though upstream land holders are concerned about the increased braiding. The majority of the flow at the present moment is between the east abutment and the

adjacent pier. A channel has been cut by the river at this point approximately 1.22 to 1.52M deep.

Original bridge plans, aerial photography and re-survey plans are available at this tie, together with extensive hygrologic and hydraulic data for the entire West Gallatin River.

Fill existing Channel
375' Radius ±
Existing
Rip Rap to top of natural Ground
P.C. STA. 51+70.08
Type 3 Random Rip Rap
Toe of fill
R/W LINE
465' Radius (Max)
GALLATIN RIVER
WESTBOUND
EASTBOUND
120' Bolt
Baker Ditch Headgate in R. (Use as is)
Overflow Ch.
Existing Dike
NORTHERN PACIFIC RAILWAY CO.
EXISTING T.S.TO
Rail Line


100
110
120
130
140
GRAVEL BAR
GRAVEL BAR
GRAVEL BAR
WEST GALLATIN
RIVER
DRAIN DITCH
DRAIN DITCH
SEC. 1
SEC. 6
SEC. 12
SEC. 7
T. 1 N. - R. 3 E.
T. 1 N. - R. 4 E.
P.I.
D = 0°43'00" RT.
S 89°55'30" E
N 89°21'30" E
116+12
18 X 153' STEEL BRIDGE
IN PLACE RT.
TO BE REMOVED BY CONTR.
110+67
CAT PARTS SIGN IN PL. RT.
TO BE MOVED BY OTHERS
103+00
BEAVER DAM
115' LT TO BE
REMOVED BY CONTR.
130+29
RESIDENCE SIGN IN PL. RT.
TO BE MOVED BY OTHERS
130+30
PAR. BOX IN PL. LT.
TO BE MOVED BY OTHERS
130+33
RESIDENCE SIGN IN PL. LT.
TO BE MOVED BY OTHERS
130+23
PAR. CELLAR ZONE 2
20' CL.
93+35
RD. APP. RT.
INCL. IN ROWY. QUANT.
100+73
INLET DT. RT.
15 CY. ADD. EXC.
100+73
46 CY. BEDDING MAT'L.
93+92
NO. HAP. RT.
126 CY. ADD. EXC.
104+30
INLET, OUTLET DTS.
72 CY. ADD. EXC.
104+30
34 CY. BEDDING MAT'L.
106+97
INLET, OUTLET DTS.
250 CY. ADD. EXC.
106+97 TO 109+00
D.P. DT. RT. (D.P. BR.
TO 106+97)
810 CY. ADD. EXC.
106+97
90 CY. BEDDING MAT'L.
112+94
INLET, OUTLET DTS.
115 CY. ADD. EXC.
112+94
72 CY. BEDDING MAT'L.
109+00 TO 112+94
D.P. DT. RT. (D.P. BR.
TO 112+94)
395 CY. ADD. EXC.
114+80
RD. APP. RT.
200 CY. ADD. EXC.
117+60
RD. APP. RT.
210 CY. ADD. EXC.
120+50
RD. APP. RT.
330 CY. ADD. EXC.
121+33
INLET DT. RT.
35 CY. ADD. EXC.
125+12
INLET DT. RT.
15 CY. ADD. EXC.
128+77
INLET DT. RT.
20 CY. ADD. EXC.
129+54
INLET DT. RT.
25 CY. ADD. EXC.
130+10
CO. RD. APP. RT.
INCL. IN ROWY. QUANT.
130+50
CO. RD. APP. RT.
INCL. IN ROWY. QUANT.
0.00%
3.214%
4.22%
0.00%
0.845%
300' V.C.
400' V.C.
200' V.C.
1100' V.C.
116+02.3
490 C.Y. TYPE "A" RANDOM
RIPRAP AT BR. ENDS.
96+65.1

Case History 68

NIOBRARA RIVER AT SR-12 NEAR NIOBRARA, NEBRASKA

Description

The reach of the Niobrara River of interest is in Knox County. The highway crossing of the Niobrara River is State Road 12 Bridge about 1.6 km south of Niobrara. It is of equal importance to discuss in detail the Missouri River. Its confluence with the Niobrara River is only about 2.4 km downstream of SR-12.

The natural state of the Missouri River near its confluence with the Niobrara is best described by its serpentine channel alginment that meanders at random across an alluvial flood plain that is entrenched between steep valley bluffs. The bank-full flow channel averaged about 610 meters in width but was generally divided into several channels by large islands or lower elevation sandbars. See Figure 1. Its general shape was rectangular. Flood plain bank heights averaged between 3.7 and 4.6 M in height with a channel capacity of about 4250 cms. At normal stages, water surface slopes generally varied from 0.09 to 0.12 meters per km; channel widths from 213 to 457 meters and mean depths between 1.2 and 3.35M. The greater widths and shallower depths occurred in the diagonal crossings where the channel meandered between bluff contacts. Channel bed forms were constantly in a state of change due to the shifting movements of ripples, dunes and bars. Although this movement would produce characteristic, seasonal shifts in the stage-discharge relationship, the long-term rating at station locations remained relatively consistent. The natural sediment transport capability of Missouri River

flows was both great and variable. Annual sediment load volumes for the Missouri River near Niobrara probably ranged between 73 and 218 million metric tons with an average near 135 million metric tons. The particle size distribution of the suspended sediments averaged about 30 percent sand, 30 percent silts and 40 percent clays. The bed material sediments generally ranged within the very fine to fine sand sizes. A normal D size would be 0.20 mm with the percent finer at D_{10} and D_{90} being 0.08 and 0.30 mm, respectively.

The Niobrara River is, in contrast, a shallow braided stream. The total channel width generally varies from 305 to 457 meters but the flow is divided into numerous separate channels by barren or sparsely vegetated sandbars and higher elevation islands. Note the braided conditions in Figure 2. The heights of the sandbars above low flow stages are usually less than .30 to .46 M. The height of the channel bank, flood plain and island elevations range between 1.2 to 1.8M above low flow stages; however, the flood plain contains many remnants of old flow channel chutes which are, at times, subject to inundation at less than bankfull stages. Natural levees, of slightly higher elevation, along both the active and older chutes are also common. The average slope of the lower Niobrara River over long reaches appears to be quite uniform at about 1.3 meters/km. But short reach slopes can vary quickly over a wide range as shifts in the flow channel shape or alignment occur.

The sands which comprise the streambed of the Niobrara are, like the Missouri River, quite uniform in size but slightly coarser. Their range from fine to coarse sand makes them easily transportable even under the energy gradient of low flows. This characteristic is, of course,

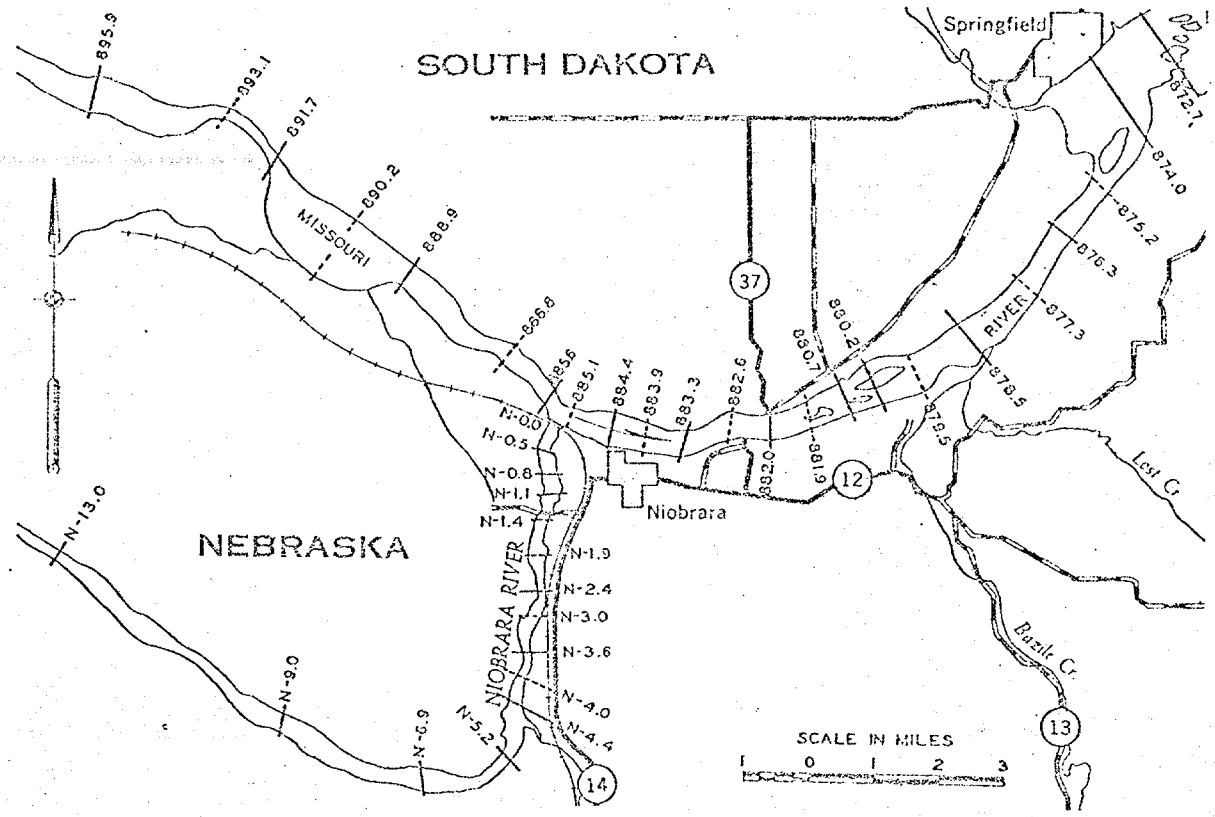


Figure 1. Confluence of Missouri and Niobrara Rivers.

Figure 2. An example of active delta growth - June 1961.

associated with a braided stream and accounts for the lack of any stable stage-discharge relationship over the range of base flows. Year round, this base varies between 28 and 57 cms. Spring snowmelt runoff in March, combined with ice jams, accounts for maximum stages and peak flows but the greater volume is sometimes produced during late spring and early summer. Table 1 presents a summary of experienced discharge variations for the Niobrara River near Verdel, Nebraska for the 20-year period 1953-1973. (The time increments shown will remain consistent in later tables to permit a comparative assessment of variations in stream and sediment discharge, channel dimensions and deposition volumes).

TABLE 1

VARIATIONS IN STREAM DISCHARGE

Stream	Location	Period (Water Year)	Total Runoff Volume (AF)	Mean Annual Discharge (CFS)	Maximum Mean Daily Discharge (CFS)
Missouri	Below Fort Randall Dam	1953-1955	49,750,000	22,900	105,000
		1956-1960	65,390,000	18,000	50,500
		1961-1965	61,168,000	16,900	38,400
		1966-1970	95,030,000	26,250	52,000
		1971-1973	69,330,000	31,900	50,500
Niobrara	Verdel	1953-1955	4,084,000	1,710	15,700
		1956-1960	6,168,000	1,730	25,100
		1961-1965	6,436,000	1,780	16,600
		1966-1970	5,407,000	1,490	10,000
		1971-1973	3,345,000	1,540	6,500

The long-term, average-annual sediment load of the Niobrara River is estimated at 2,639,000 metric tons. This estimate is based upon a limited record of sampling measurements where total suspended sediment load computations provided a relationship with annual runoff volumes and permitted an extrapolation for a 41-year flow record. It correlates very well with the volume of deposited sediments measured by hydrographic surveys in the Missouri River channel and Lewis and Clark Lake. Unlike the relatively constant annual runoff volumes, the annual sediment volumes vary by a factor of 2 or more. The peak flood discharges account for some of this variance but high transport rates during periods when moderate flows produce sustaining scour capcility, may be an equal or greater influence. During normal flow periods, the transport rates during periods when moderate flows produce sustaining scour capability, may be an equal or greater influence. During normal flow periods, the transport rate of sand is near 75-80 percent, silt ranges from 10 to 20 percent and clays usually less than 10 percent. However, during peak flows the wash load will at times dominate with the sand contribution dropping to 25 percent or less. The bed material sizes probably increase with discharge but the average D_{50} size is about 0.25 mm with the D_{10} and D_{90} percent finer being 0.15 and 0.4 mm, respectively. Gravel size particles or larger are very uncommon. Table 2 presents a summary of estimated suspended sediment discharges for the Niobrara River near Verdel, Nebraska for the period 1953-1973.

TABLE 2

ESTIMATED VARIATIONS IN SUSPENDED SEDIMENT DISCHARGE

Stream	Location	Period (Water Yr.)	Total Suspended Sediment Discharge (Tons)	Annual Variations (Tons) Mean	Maximum	Minimum
Missouri	Range 893.1	1953-1955	3,008,000	1,000,000	1,606,000	701,000
		1956-1960	2,390,000	480,000	916,000	219,000
		1961-1965	1,967,000	390,000	507,000	106,000
		1966-1970	7,811,000	1,560,000	2,263,000	1,022,000
		1971-1973	8,979,000	3,000,000	4,015,000	1,570,000
Niobrara	Verdel	1953-1955	8,950,000	2,980,000	3,700,000	2,000,000
		1956-1960	12,560,000	2,510,000	3,350,000	1,610,000
		1961-1965	14,920,000	2,980,000	5,500,000	1,850,000
		1966-1970	10,250,000	2,050,000	2,320,000	1,800,000
		1971-1973	6,610,000	2,200,000	2,640,000	1,900,000

The first step toward regulation of the Missouri River started with construction and closure of Fort Peck Dam in Montana in 1937. Although it provided regulation of the extreme upper basin, its influence on the flow duration trends of the Missouri near Niobrara were insignificant. The next two quick steps, with closure of Fort Randall in 1952 and Garrison in 1953, produced a decisive and positive change in the flow regime to complete regulation. Later, closure of Oahe in 1958 and Big Bend in 1963 completed a regulation capability for storage of over 9,382,000 million hectare meters of water. With the closure of Forts Randall and Garrison, an immediate need developed for the initial filling of almost 2.7 million hectare meters of operational storage from an anticipated mean annual supply of about 3.0 million hectare

meters. Under normal hydrologic conditions this filling aspect would induce some minor downstream flow restrictions but an orderly accumulation of operational storage in the system was probably within a few years. But coincident with this need, in 1954 there began a seven-year drought over the upper basin which effectively extended the filling period to 1968. Abnormally low inflow rates occurred in 1954, 1955, 1958 and 1961.

Releases from the reservoir system, via Fort Randall, were held to a minimum during these years. Peak discharges ranges up to 1275 cms during periods of maximum power demands but night-time releases were frequently zero. During the March to November open water season, the mean daily flow of the Missouri River passing the confluence of the Niobrara River seldom exceeded 991 cms . Winter flows were consistently less than 283 cms . It was not until 1969, when it became necessary to evacuate flood control storage in the upstream system, that releases exceeded the 1416 cms level, or about an expected 5-year flow event. The magnitude of these discharges, plus the need to release similar flows again in 1971 and 1972, effectively demonstrated the influence of the Niobrara delta growth on the main stem channel capacity.

Gradation Problem

The regulated flow regime of the upstream reservoir system and the start of the Niobrara aggradations or delta growth began one year after the historic 1952 flood of record flushed the Missouri River channel clean at the confluence. For the next 17 years, until 1969, the mean daily flow of the Missouri passing Niobrara was usually

850 cms or less. However, during the first decade of this period, above normal flows from the Niobrara basin, including the flood of record, continued to add sediments to the delta at an average growth rate of about 56 hectare meters per year. This produced a deltaic blockage of the Missouri River channel for several miles downstream from the Missouri-Niobrara confluence. The Figure 2 photo depicts typical conditions during an active delta growth period. The resultant effect of the shallow, weir-like delta produced (1) a progressive upward shift of at least five feet in the Missouri River rating curve at Niobrara; (2) a reduction in the channel capacity from about 3400 cms to 1700 cms at this same point; (3) significant backwater influences at upstream points along both the Missouri and Niobrara Rivers. The first consequence of this delta became apparent after the mid-1960's when adverse groundwater levels were experienced within the town of Niobrara and at the nearby Niobrara State Park. The next impact occurred during the late summer and through the fall of 1969 when it became necessary, for the first time, to evacuate water from upstream reservoir flood control storage zones, prior to winter, in preparation for the next flood seasons runoff. Sustained releases in the 1416 cms range produced near bank-full stages and the inundation of some 710 hectares of lower elevation flood plain lands. Similar inundations occurred again in 1971 and 1972 for the same reasons.

The most sensitive indicator for assessing the delta growth has been shifts in the Missouri River stage-discharge relationship at gage 884.2. This gage is strategically located just downstream of the Missouri-Niobrara confluence near the apex of any delta growth.

The changes in channel dimensions which account for such stage-discharge trends have been documented by periodic surveys of channel ranges. These cross-sectional measurements provide the basic means for assessing variations in hydraulic parameters and sediment deposition volumes. Tables 3 and 4 present comparisons of such measurements and

TABLE 3

VARIATIONS IN CHANNEL DIMENSIONS

Range	Date	Bank Top Elev. (MSL)	Cross Section Area (Sq.Ft.)	Cross Section Width (Ft.)	Cross Section Depth (Ft.)	Width Depth Ratio
M-885.6	Oct 1955	1220	29,048	2,740	10.60	258
	Jul 1960		26,658	2,784	9.58	291
	Aug 1965		25,155	2,788	9.02	309
	May 1970		25,245	2,818	8.96	314
	Sep 1973		24,871	2,919	8.52	343
M-884.4	May 1955	1220	36,872	2,952	12.46	237
	Jul 1960		30,148	3,103	9.72	319
	Aug 1965		24,592	3,208	7.67	418
	Aug 1970		23,513	3,236	7.27	445
	Sep 1973		21,366	3,227	6.62	487
M-882.0	May 1955	1215	23,902	2,349	10.18	231
	Jul 1960		21,174	2,355	8.99	262
	Aug 1965		14,410	2,356	6.12	385
	Aug 1970		14,725	2,363	6.23	379
	Sep 1973		14,539	2,353	6.18	381
N-0.0	Sep 1956	1224	11,684	1,272	9.18	138
	Jul 1960		10,061	1,276	7.88	162
	Aug 1965		9,015	1,277	7.06	181
	Aug 1970		7,822	1,278	6.12	209
N-0.8	Sep 1956	1225	17,816	2,303	7.74	298
	Jul 1960		15,997	2,319	6.90	336
	Aug 1965		12,988	2,347	5.53	424
	Aug 1970		11,049	2,355	4.69	502

TABLE 4

VARIATIONS IN CHANNEL DEPOSITION

Stream Reach	Period	Deposition Volume (AF)	Deposition Rate (AF/YR)	Bed Material Size D_{50} (mm)
M-885.6 to M-884.4	1955-1960	664	133	0.26
	1960-1965	513	103	0.27
	1965-1970	72	14	0.20
	1970-1973	183	61	0.26
M-884.4 to M-882.0	1955-1960	1375	275	0.31
	1960-1965	1792	358	0.31
	1965-1970	110	22	0.30
	1970-1973	340	113	0.32
N-0.0 to N-0.8	1955-1960	167	42	0.27
	1960-1965	196	39	0.25
	1965-1970	154	31	0.29
	1970-1973	90*	30*	0.23

Assessment of the data presented in Tables 1 through 4 provides several interesting insights related to the rate growth, attainment of a stability level and the sensitivity of this equilibrium to change. Reference is made to a composite summary on Table 5 for the following interim evaluation on these items. It is intended that final study

TABLE 5

RELATIONSHIP OF STREAMFLOW AND SEDIMENT DISCHARGES

TO DELTA GROWTH

Period	Average Annual Missouri River Discharge (CFS)	Total Sediment Discharge* (AF)	Delta Growth Volume Change (AF)	Delta Growth Deposition Rate (AF/YR)	Percent Sediment Inflow Deposited (%)
1953-1955	24,600	6,780	800**	400	11.8
1955-1960	19,700	8,475	2210	442	26.0
1960-1965	18,700	9,575	2500	500	26.1
1965-1970	27,700	10,240	336	67	3.3
1970-1973	33,400	8,840	613	204	6.9
TOTAL	24,100	43,910	6459	323	14.7

assessments, to be presented in a comprehensive manner in a future paper, will amplify this discussion and produce quantitative conclusions.

(1) The combination of greater than normal sediment contributions from the Niobrara drainage and less than normal releases from the Missouri reservoir system strongly influenced the rate of early

delta growth. During the periods when the Niobrara produced from 85 to 90 percent of the total sediment inflow, the growth rate of the delta remained relatively constant at about 450 acre feet per year. However, this rate accounts for only 25 percent of the available sediment supply. These values probably establish near maximum rates for expected delta growth and its trap efficiency.

(2) The relative stable channel widths observed on both the Missouri and Niobrara, while deposition depleted the channel capacity, was not anticipated. A much greater degree of change was expected. A cursory review of additional data indicates that the average channel-forming velocities immediately downstream of the confluence were significantly higher. This could account for the coarsening of the D_{50} bed material sizes noted at range 884.4 in Table 4. The higher width-depth ratios indicate an expected increase in bed material transport but total load computations are not sufficiently complete to isolate the significance of this bed coarsening.

(4) The delta equilibrium appears to be most sensitive to variances in Missouri River discharges. Stage-discharge trends during the higher flow periods after 1969 indicate the possibility of delta scour or at least more efficient channel conditions. Lower deposition rates also tend to confirm this even though the upstream Missouri River channel is transporting significantly greater

sediment loads. Defining the hydraulic combinations that trigger a shift in the bed material transport capability from deposition to scour will provide the much needed key to predicting the degree of future delta growth.

Discussion

The dynamic balance in sediment transport that occurred under a natural regime at the confluence of the Missouri and Niobrara Rivers was dependent on the frequency, magnitude and duration of main stem flows. Regulation of these flows after 1952 by a system of upstream reservoirs interrupted this equilibrium and permitted the tributary sediment contributions to accumulate in the Missouri River channel. The growth of this Niobrara delta was accelerated due to two concurrent factors; first, below normal runoff from the upper Missouri River basin during the "filling" of operational reservoir storage and second, above normal sediment yield from the Niobrara drainage. The resultant effect has been a significant reduction in channel capacity with attendent consequences of operational restrictions, frequent low land inundation and higher groundwater levels.

Field measurements of sediment and hydraulic parameters have documented the growth of this delta over a 20-year period. Study assessments of this data are not complete but preliminary results indicate (1) the probably maximum growth rate to be expected would be 56 hectare meters per year with a trap efficiency factor of 25 percent; (2) surprisingly, relatively stable channel widths have prevailed while the channel capacity has been reduced by as least 50 percent; and (3) delta scour has probably occurred due to high releases from the reservoir system but the accompanying

variances in bed material transport have not, as yet, been quantified. It is planned that a comprehensive report of study findings, including the complete documentation of field data, will appear in a future addition to the Missouri River Division Sediment Series publications.

Case History 69

MUDDY CREEK AT SR-50 IN OTOE COUNTY, NEBRASKA

Description

Muddy Creek is located between Syracuse and Cook, Nebraska and is a tributary to the Little Nemaha River. The bridge of interest, on State Road 50 (Lat 40° 33', Long 96° 10') was constructed in 1949 over the realigned channel of Muddy Creek. The bridge is 37 M long, concrete pier bents in the channel, steel pile foundations, spillthrough abutments and concrete wingwalls. The stream is perennial but flashy, alluvial, silt bed and in a valley of low relief with a wide flood plain. The channel is sinuous, artifically straightened, incised by degradation, but banks and has silt-clay banks.

Gradation Problem

Since the bridge was built in 1949, the stream bed has degraded about 6.7 M exposing the pier footings. This is primarily due to channel straightening which reduced the channel length about 40 percent and increased the slope accordingly. The degradation has been responsible for bank caving. The lateral erosion and loss of farm land has become a serious problem.

Countermeasures

No countermeasures have been applied, but lengthening the bridge may be required. The estimate remaining life is 15 years.

Discussion

Channel degradation, resulting from channel straightening is general throughout the Nemaha River Systems. Failure of this bridge due to degradation is not likely because of the depth to which bridge foundations have been placed. The lateral erosion accompanying channel degradation has been the more serious problem.

Case History 70

SOUTH FORK LITTLE NEMAHA RIVER AT SR-50 NEAR COOK, NEBRASKA

Description

Lat 40°30', long 97°11'. The State Road 50 Bridge is 55 m in length, concrete wall-type piers in channel, steel pile foundations, spillthrough abutments and concrete wingwalls. Minimum penetration of foundation pile below cut-off elevation is 15 m at abutments and 7 m at piers. The bottom of the seat at the piers is about 2 m below streambet elevation and channel width is 55 m. The Stream is perennial but flashy, alluvial, silt bed in a valley of low relief with a wide flood plain. The Channel is sinuous, artifically straightened, incised by degradation, cut banks general, and has silt-clay banks.

Gradation Problem

Since the bridge was built in 1950, the channel has degraded about 2.4 m exposing pier footings and about 0.6 m of the foundation pile. Lateral erosion has removed most of the abutment fill slopes. Slump cracks in soil behind right abutment were noted in a 1971 bridge inspection report. An inspection in 1979 indicated that the channel has continued to degrade gradually, causing bank caving and some debris problems. Lateral erosion and loss of farm land has become a serious problem.

Countermeasures

No countermeasures have been applied, but lengthening of bridge will probably be required.

Discussion

Channel degradation, resulting from channel straightening, is general throughout the Nemaha River system. Few bridge failures have resulted from degradation because of the depth to which bridge foundations have been placed in Nebraska. The lateral erosion accompanying channel degradation has been the more serious problem.

Case History 71

LOGAN CREEK AT SR-9 NEAR PENDER, NEBRASKA

Description

The entire length of Logan Creek is of interest. But signigicant historical data is only available in Thurston and Cuming Counties. There are three State Road Bridges that could be documented. These are:

- SR-9 Bridge just north of Pender, (Lat. 42° 08', Long. 96°44')
- SR-94 Bridge just east of Pender, and
- SR-51 Bridge just east of Bancroft.

Because these sites and gradation problems are similar only SR-9 north of Pender will be discussed in detail.

The drainage area is about 1875 km^2 ; the valley slope is 0.0006 and the channel width in 1977 is about 75 m . The stream is perennial but flashy, alluvial, sand bed, in valley of moderate relief with a wide flood plain. The channel has been straightened with cut banks general and silt banks. An entirely new channel was dredged for Logan Creek prior to the bridge construction, and the new channel has less than half the length (and about twice the slope) of the old channel.

The bridge is 76 m in length, two round concrete-filled steel sheet pile piers in channel with spillthrough abutments. The sheet pile at the piers were driven to a depth of 16.5 m below cutoff elevation, or about 10.5 m below streambet elevation at time of construction. The steel foundation pile at the abutments were driven to depth of 13.5 m below cutoff elevation. The bridge was build in 1947.

Gradation Problem

Between 1948-1970 the channel degraded about 2 m and increased in width from about 45 m to about 75 m.

In 1971, a flood with a peak discharge of about 905 M^3/s and point velocities as high as 4 M/s were measured at the gaging station 3.2 km below Pender. As a result the footings and foundation pile of the left abutment are exposed and the sheet pile at the piers are exposed for a vertical distance of about 2 m.

In 1979 there has been additional degradation of a foot or two and many steel H-Pile spurs upstream and downstream of the bridge has been pushed over by ice and debris resulting in some additional widening and bank erosion.

Countermeasures

No revetment or grade control structures were installed when the channel was straightened or when the bridge was built in 1947. The foundations were, however, driven to substantial depth for a stream of this size.

At some time during the mid-1960's, steel H-Pile spurs were installed both upstream and down stream from the bridge, to control the bank recession.

Discussion

Although steel H-pile spurs have been effective in controlling bank erosion on streams similar to this one in Nebraska and Iowa, they cannot control channel degradation. Also, their effectiveness in controlling bank erosion depends on accumulation of debris and sediment at the spur, which is inhibited by progressive degradation. The channel has probably approached an equilibrium adjustment of depth and slope, and the spurs may now serve to maintain channel alignment and control further widening. Maintenance of the spurs has been prevented by lack of access over privately owned land. Depth of foundations at piers and abutments has so far prevented damage to bridge.

ELK CREEK AT SR-15 NEAR JACKSON, NEBRASKA

Description

Elk Creek is located in Dakota County and is a tributary of the Missouri River. It flows into the Mississippi River just upstream of Sioux City, Iowa. The State Road 15 Bridge just west of Jackson is of interest. The stream is perennial but flashy, alluvial, sand-silt bed and in a valley of low relief with a wide flood plain. The channel is sinuous, incised by degradation and has silt-clay banks.

Gradation Problems

The stream bed has degraded at least 3 m since 1955. There are two primary reasons for this degradation. First, some channel modifications have been made to improve and maximize agricultural production. As a result, the channel has been straightened and changed at isolated locations. Second, and probably more important, is the general degradation below Gavins Point Dam. Missouri River Stage Trends for almost 100 years for eight of the key main stem gaging stations below Sioux City, indicated at least 3 m of degradation at Sioux City as indicated in Figure 1. This degradation is probably due to three main reasons as follows:

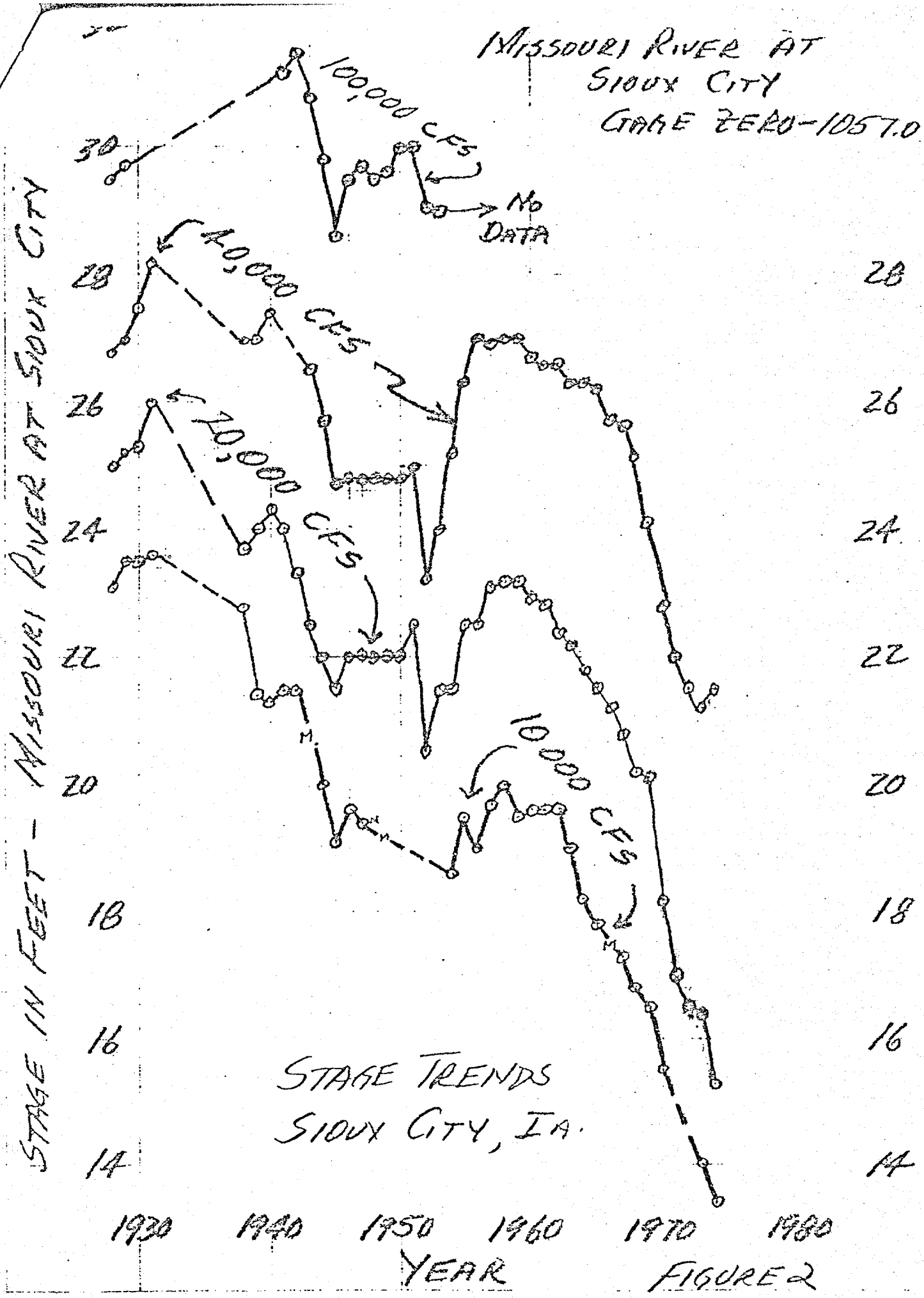

MISSOURI RIVER AT
SIOUX CITY
GAGE ZERO-1057.0
100,000 CFS
NO DATA
40,000 CFS
20,000 CFS
10,000 CFS
STAGE TRENDS
SIOUX CITY, IA.
STAGE IN FEET - MISSOURI RIVER AT SIOUX CITY
30
28
26
24
22
20
18
16
14
1930
1940
1950
1960
1970
1980
YEAR

FIGURE 2

1) Between 1890 and 1960 the Missouri River length from Sioux City to Omaha has been reduced 21 percent by the Corps of Engineers. As a result the stream bed slope has increased accordingly.

2) The sediment free water released at Gavin's Point Dam is continually transporting the bed sediment that is available.

3) The rather high sustained flows of the regulated Missouri River System does not allow for any aggradation or filling.

The degradation is primarily responsible for lateral instability as the channel has almost doubled in width. The degradation has exposed the pier footing.

Countermeasures

No countermeasures have been applied at this time.

Discussion

Tributary degradation, resulting from stream bed degradation on the mainstream of the Missouri River is to be expected. The Missouri River is continually degrading as indicated in the Missouri River stage trends. This condition should be evaluated on an annual basis and bridges inspected that are subject to this headcutting that is experienced by each tributary that is not protected by a grade control structure.

Failure of this bridge due to degradation is not likely because of the depth to which bridge foundations have been placed.

Case History 73

LITTLE NEMAHA RIVER, COUNTY ROAD, NEAR UNADILLA, NEBRASKA

Description

The reach of interest is in Otoe County. The bridge is South of Unadilla on a county road. The bridge is 78 M in length, concrete wall-type piers in the channel, steel pile foundations, spillthrough abutments and concrete wingwalls.

The stream is perennial but flashy, alluvial, silt bed and in a valley of low relief with a wide flood plain. The channel is sinuous. Artifically straightened, incised by degradation and has cut banks of silt and clay.

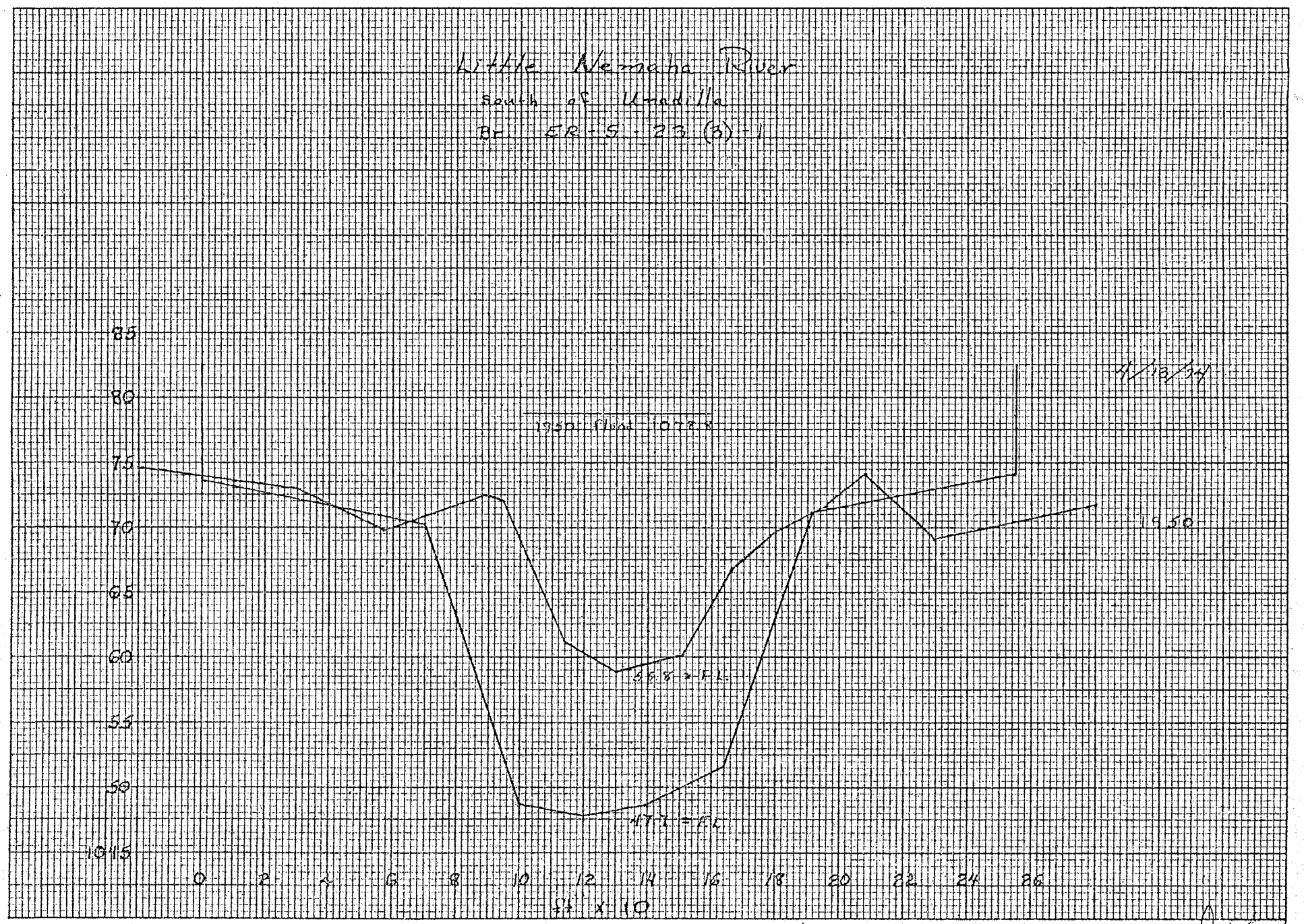
Gradation Problem

Figure 1 indicates that from 1950 to 1974 the channel has degraded about 3.4 M and the channel width has increased from about 24 meters to 37 meters. The degradation has exposed the pier footings and about 1.2M of the foundation pile.

Countermeasures

No countermeasures have been applied.

K+E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.



Discussion

Channel degradation, resulting from channel straightening, is general throughout the Nemaha River system. Few bridge failures have resulted form degradation because of the depth to which bridge foundations have been placed in Nebraska. The lateral erosion accompanying channel degradation has been the more serious problem.

This documentation could also be duplicated at the State Road 50 Bridge South of Syracuse.

SMALL CREEK AT US-73 SOUTH OF DECATUR, NEBRASKA

Description

This small creek is located in Burt County. The bridge highway crossing is just south of Decatur on U.S. Highway 73. The creek is a small tributary of the Missouri River at Decatur. The drainage area is less than 130 square km. The stream is perennial but flashy, alluvial, sand-silt bed and in a fairly narrow flood plain. The channel is sinuous, definitely incised by degradation and the banks are silt-clay. The bridge has two concrete piers in the channel, steel pile foundations, spillthrough abutments and concrete wingwalls.

Gradation Problem

The creek has degraded at least 3 m. The channel is about 9.1 M deep and 15.2 M wide. The width has also increased due to caving banks and lateral movement due to the degradation. 1.5 M of the steel piles are exposed and the area between the piers and the abutments has been eroded away exposing the abutments.

There has been little or no channel modifications to the creek system. There has been about 3 m of degradation in the Missouri River. As a result of the degradation in the Missouri, a head cutting of about 3 m has been progressing upstream up the creek system over the last 15 years.

Countermeasures

No countermeasures have been applied. The State Highway Department is not aware of this particular problem. The bridge abutment will require some protection soon.

Discussion

Tributary degradation, resulting from stream bed degradation on the mainstream of the Missouri River is to be expected. The Missouri River is continually degrading as indicated in the Missouri River stage trends (See Elk Creek). This condition should be evaluated on an annual basis and bridges inspected that are subject to this headcutting that is experienced by each tributary that is not protected by a grade control structure.

Failure of this bridge due to degradation is not likely because of the depth to which bridge foundations have been placed.

Case History 75

PAPILLION CREEK AT SR-64, US-6, SR-92, I-50, SR-370 NEAR OMAHA, NEBRASKA

Description

Most of the Papillion Creek System is located in Douglas and Sarpy Counties. There are several highway bridge crossings of interest as follows:

1) State Road 64 in West Omaha,
2) U.S. Highway 6 in West Omaha,
3) State Road 92 in West Omaha,
4) Interstate 50 in West Omaha, and
5) State Road 370 near Papillion.

There are too many bridges to describe in detail. Most bridges are concrete pier bents in the channel, steel pile foundations, spillthrough abutments and concrete wingwalls. The stream is perennial but flashy, alluvial, sand-silt bed and in a fairly narrow flood plain. The channel is sinuous, partial straightened, incised by degradation, and the banks are silt-clay.

Gradation Problems

The Papillion Creek system was dredged and straightened in 1909 and 1910. Levee's were added in the 1950's for flood protection to low residential areas. There is about 2 m of degradation at the bridges exposing the pier footings. Bank caving is a problem and some bank protection has been installed.

In the last 5 years, there has been tremendous housing developments in West Omaha between State Road 31

and Interstate 80/680. This urban impact has resulted in a significant increase in runoff which has resulted in more degradation and bank instability problems.

Countermeasures

Some bank protection has been installed. No countermeasures have been applied to protect the bridges.

Discussion

The significant impact in urban area and change in land use has resulted in a change in the hydrology of the Papillion Creek System. The hydrographs have increased in the peak value by a factor of two, the duration has changed and there has been an increase in the flow runoff.

Several of the bridges will have to be replaced due to both degradation, an increase in channel width and just the inability to transport the volume of traffic.

Channel degradation, resulting from early channel straightening and increased urban runoff is general throughout the Papillion Creek System. Few bridge failures have resulted from degradation because of the depth to which bridge foundations have been placed in Nebraska. The lateral erosion accompanying channel degradation has been the more serious problem.

EAST BRANCH PEMIGEWASSET RIVER
NEAR LINCOLN, NEW HAMPSHIRE

Description

The bridge crossing site is located in the White Mountain National Forest about 102 km north of Concord, in the Town of Lincoln, approximately 2.4 km east of Lincoln adjacent to the Kancamagus Highway leading to the Loon Mountain recretational area. The structure is a three-span deck girder bridge supported by stub abutments with two intermediate piers. The piers are supported by spread footings which rested on the gravel and boulders in the stream bed. Due to a sharp bend in the channel alinement a few hundred feet upstream, the bulk of the floodflow passing under the bridge is concentrated in the deepest portion of the channel where one of the piers is located. The river is a typical mountain stream having a steep slope.

Gradation Problem

A dam existed in the channel approximately 366 meters downstream from the bridge until the dam's center was breached by the July 1973 flood. When the dam was breached, the water level dropped thereby increasing the gradient in the vicinity of the dam. The steepened gradient caused headcutting, beginning at the dam and progressing upstream. As the channel headcut, the velocity of the water increased, which also caused scour. The process of headcutting and increasing velocity "fed on each other" and the erosion advanced upstream.

Apparently the dam had existed for many years and reportedly was owned by the Town of Lincoln. The dam was apparently constructed of rock-filled timber cribbing covered with wooden sheathing. During restoration work following the July 1973 flood, the remaining segments of the dam were removed by the Federal Disaster Assistance Administration, at the request of the Town of Lincoln, because it no longer served a useful purpose. It was also reported that the reach upstream from the bridge had been improved after the flood.

Another flood occurred in December 1973. When the river subsided, it was apparent that a severe scour problem existed at the pier in question, for its footing was exposed. Immediate remedial work was indicated to avert the collapse of the bridge. As a temporary measure, heavy rock was placed around the pier to prevent further scour. After the spring runoff passed, the pier was underpinned.

It was apparent that the stream banks and the channel in the vicinity of the dam were reshaped and graded after the July 1973 flood. The contrast between the smoothly graded banks and the irregular jagged slash up the center of the channel from the dam site towards the bridge provides clear evidence of headcutting and scour. It is doubtful that the reach has stabilized and additional scour can be expected. It is no accident that the deepest headcutting is in the channel upstream of the point where the dam was breached. Degradation in the central part of the channel was unmistakable.

There was a difference of approximately 6.6M feet between the channel elevation at the scoured pier and the dam site. This corresponded to a channel slope of nearly 2 percent in this 366 Meters reach, which meant that a substantial flow probably would border on, if not actually

be in, a supercritical condition. As a consequence, there is a strong likelihood that additional scour will occur.

In July 1975, the reach referred to above had almost completely armored itself.

Countermeasures

As soon as the spring runoff concluded, the State stabilized the foundations of both piers by constructing pressure grouted subfootings. This was accomplished by sheeting an area around the piers and stabilizing the area beneath the footings by intrusion grouting that reached to bed rock. A concrete cap, doweled to the present pier footing, was then poured.

Discussion

This is an unusual degradation problem and is included to indicate the action and reaction of the stream environment. It also indicates the natural ability of a stream to adjust to a stable equilibrium condition.

Case History 77

Arroyo Seco at US 84 near Espanola, New Mexico

Description:

This site consists of a concrete box culvert, 65M long. The northern most 8 sections are separated by 1.22M splitter walls which extend 6.10M upstream. The skew angel is 45° and the upstream channel has been extensively realigned and revetted. There are spur dikes upstream, and an interceptor channel which parallels the road and the east, and enters the channel from the south just upstream of the crossing.

The upstream watershed is primarily rolling desert hills with a drainage area of approximately 54.75 km^2 The interceptor channel drains an area of 2.59km^2 with a Q_{50} of 220 cms, at a computed depth of 3.17M . The natural channel is ephemeral, 45.72 to 68.58M wide with 3.05 M banks. Bed material is sand and gravel and the bank material is silt, sand and gravel.

Gradation Problem:

Between 1954 and 1967, there was a continual problem with aggradation at the site. The southern most sections filled with sediment to within .30M of the top, forcing the two north sections to carry most of the flow. The road has been overtopped on numerous occasions. The upstream and downstream channel appears to be stable in this configuration.

Countermeasures:

Four additional 3.05 x 2.44 x 64.01M CBC culverts were added on the southern end of the crossing. These sections have also filled with sediment, and the original aggradation problem persisted. In 1972, the channel was reworked

with a change in upstream alignment and addition of railbank and spur dikes. Curved portions of splitters were removed, to align them with the new channel, and a drop structure was placed downstream.

Presently, the 1972 configuration has worked successfully. The channel has stabilized at a present level of 0.61M above the invert level of the culverts. The present structure successfully passed a large flood in 1978 which washed out a downstream wood bridge.

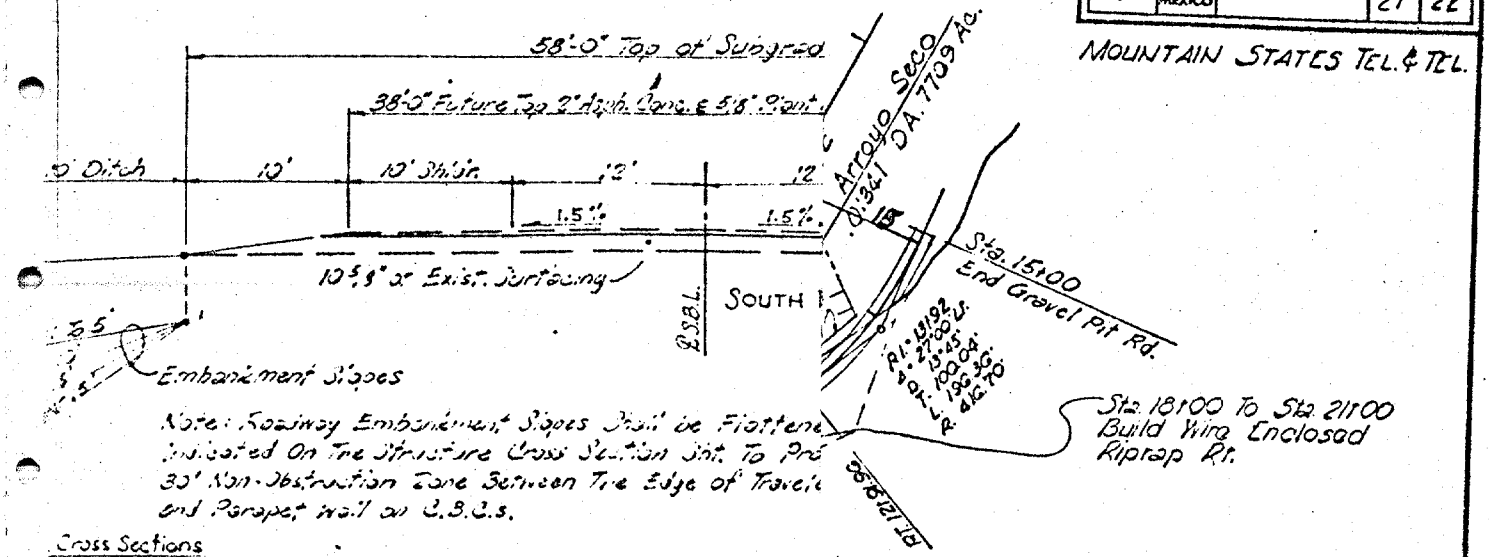
Discussion:

The current configuration of spur dikes, splitters, revetted approaches, and cutoff wall has been successful. The bed has stabilized at the desired level. State design personnel believe that the splitters might have been more effective had they been built level with the top of the culvert sections.

Available supporting documentation includes recent slides and plans for the 1972 construction.

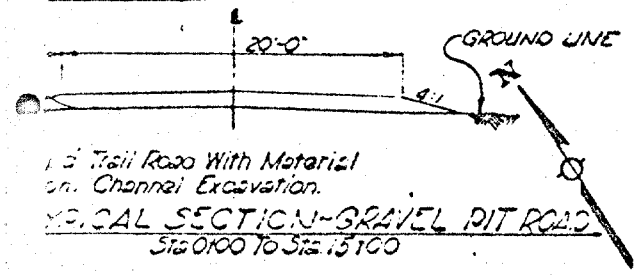
F.H.W.A. Region No.	STATE		SHEET NO.	TOTAL SHEETS
6	NEW MEXICO	F-051-1(32)	27	22

MOUNTAIN STATES TEL. & TEL.



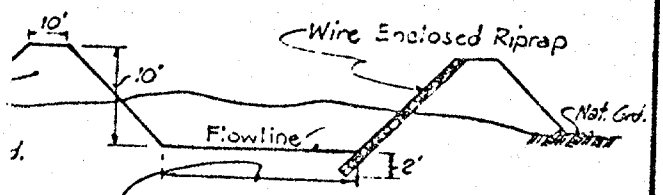
Note: Roadway Embankment Slopes Shall be Flattened As Indicated On The Structure Cross Section Sht. To Provide 30' Non-Obstruction Zone Between The Edge of Travel and Parapet Wall on C.B.C.s.

Cross Sections



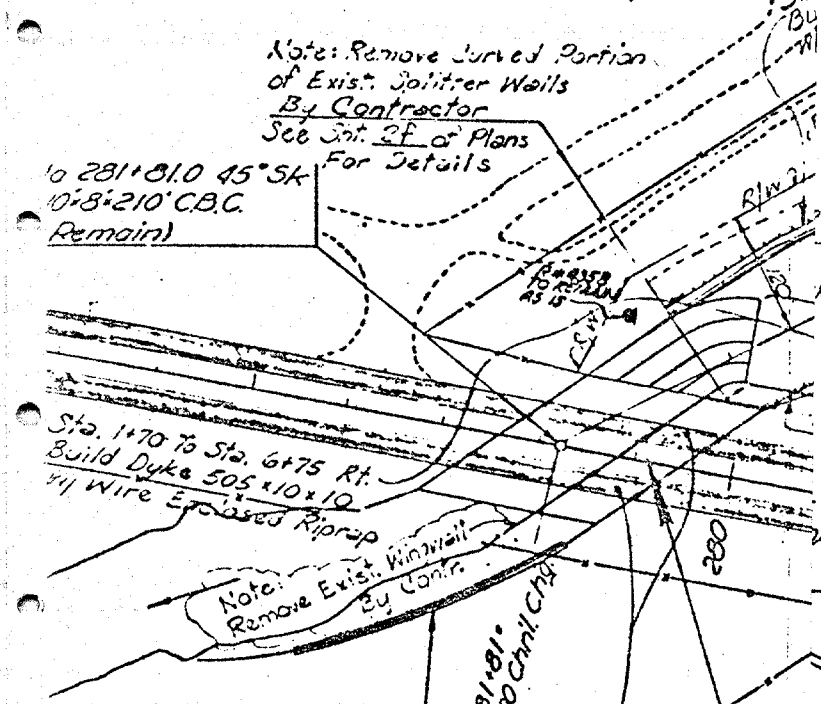
...d Trail Road With Material
...on. Channel Excavation.

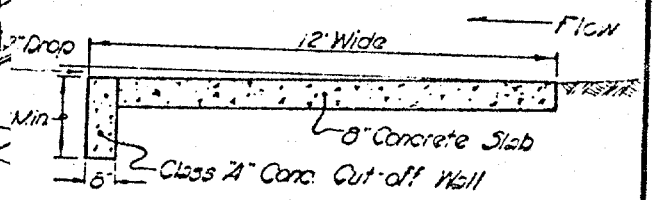
TYPICAL SECTION-GRAVEL PIT ROAD
Sta 0+00 To Sta. 15+00



CHANNEL SECTION

NOT TO SCALE

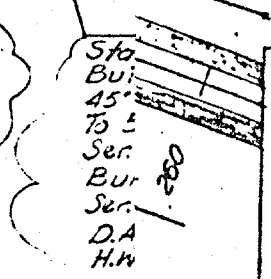




OVERFLOW SECTION

Sta. 280+88 Pavement Cut By Contractor. Cost of Replacing Embankment and Surfacing Shall Be Considered Incidental To The Completion of Project and No Payment Will Be Made Therefore.

BM. 75' Rt. Sta 281+97
Iron Pin Elev. 5725.78



ARROYO SECO

LAYOUT MAP

Chupaderos Arroyo at SR30 near Espanola, New Mexico

Description:

The northern bridge at this site spans a channel which has been straightened and revetted for 1.21km upstream. The south channel is revetted for a shorter distnace upstream. Both channels empty inot the Rio Grande River approximately 1.609km downstream from the crossings. The upstream drainage is an alluvila fan with a Q_{100} of approximately 122 cms.

There are two bridges at this site, within 1.609km of each other. Both bridges are prestressed girders, supported by CIPpiers. The lengths are approximately 15.24M and clear spans are approximately 12.19M

Gradation Problem:

In 1967, the original construction was across the natural arroyo. The main crossing was between the two present bridges. The channel tended to aggrade and meander across the road to the north.

Countermeasures:

In 1972, new bridges were constructed, the channel excavated and a pilot channel dug upstream. The main channel was placed so as to intercept the runoff which had previously flowed into the natural arroyo. Presently, the bed levels are 1.22 to 1.52M from stringers at both bridges. The crossings will not pass Q_{100} in this configuration.

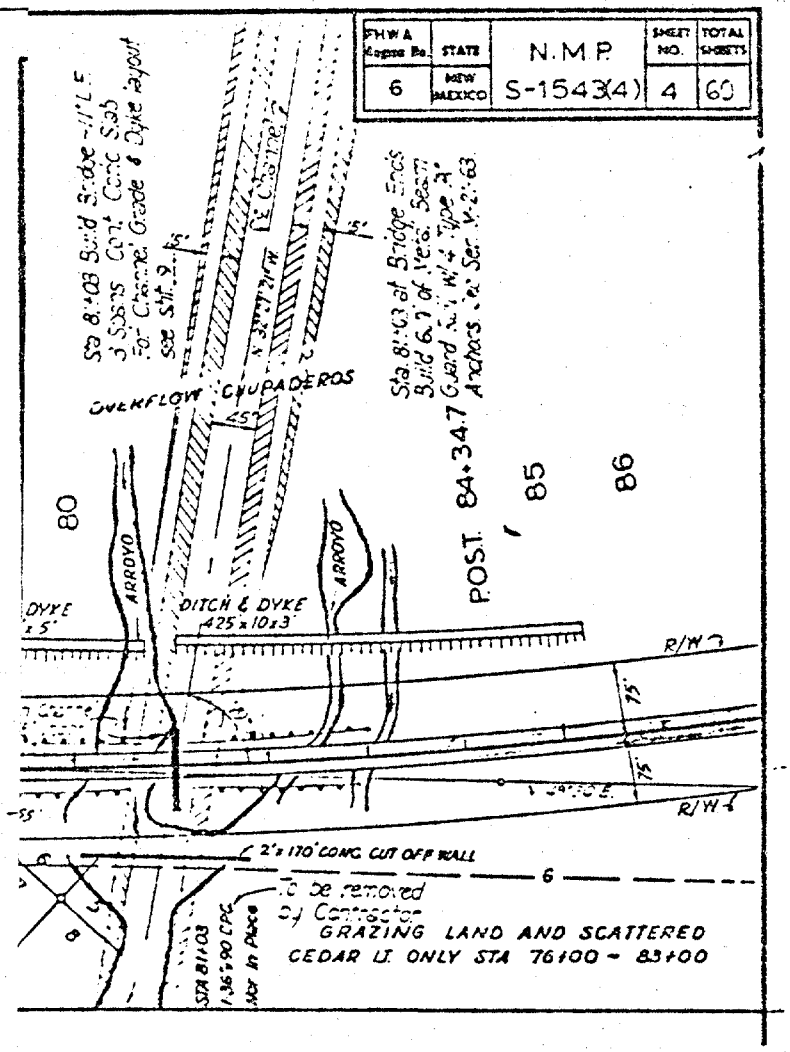
Discussion:

The objectives of the channel work were to contain the channel and to develop sufficient velocity to prevent depostion at the bridges. The solution has been partially successfyl as the

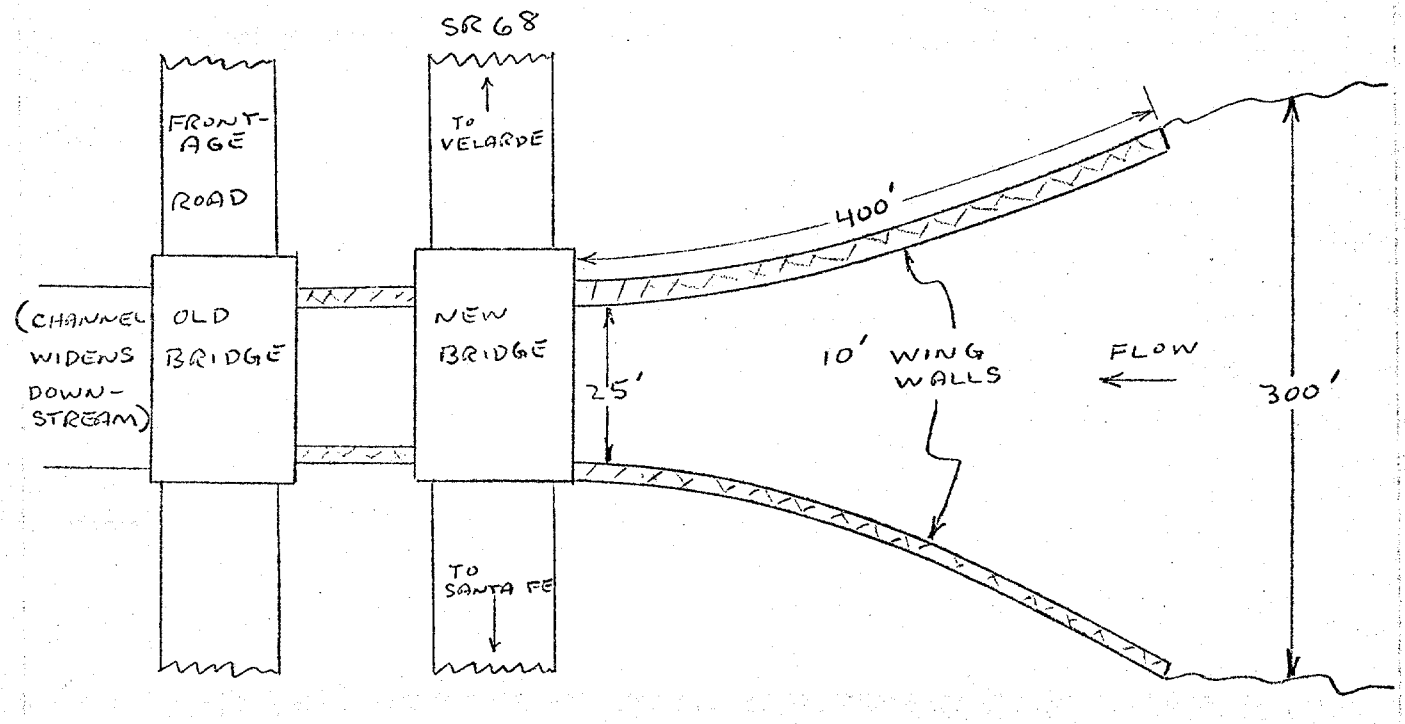
channel has ceased migrating, but continues to aggrade excessively at the crossings.

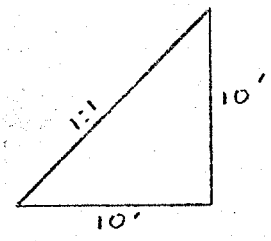
Documentation includes recent slides, location plan, contour map of surrounding area, and a longitudinal profile of the new channel.

FHWA Region No.	STATE	N.M.P.	SHEET NO.	TOTAL SHEETS
6	NEW MEXICO	S-1543(4)	4	60



PLAN SKETCH OF VELARDE CROSSINGS (TYPICAL)





WING WALLS ARE WIRE-ENCLOSED RIPRAP. FILL IS ROUNDED ROCK, 1/6 FT^3 ESD MINIMUM.
WALL IS SECURED BY 3" ANGLE STEEL PICKETS DRIVEN ABOUT 6 FT INTO BANK. FILL IS APPR. 3' THICK. WIRE IS INTERWOVEN STEEL MESH.

THIS LAYOUT PROVIDES SUFFICIENT VELOCITY AT CROSSING TO KEEP CHANNEL CLEAR.

Case History 80

White Water Creek at US180 near Glenwood, New Mexico

Description:

This site is located about 304.8M upstream from the confluence of the White Water Creek and the San Francisco River. The natural channel is 15.24M wide with low, sloping banks and the slope of this reach is approximately 0.02. The natural stream is ephemeral, but overflow from a state hatchery 1.3 km upstream keeps a minimum of about 1.4cms in the channel at the bridge. The bed material varies with the extent of artificial reworking activity, but is generally sand, gravel and cobble. Natural bank material is fairly uniformly graded silt, sand, gravel, cobbles and boulders. Water during moderate flow, is usually clear, as the bed tends to armor itself. During peak flows the reach tends to degrade initially, then aggrade due to backwater effect from the San Francisco River. The upstream watershed is composed of steep canyons, with significant clay content in the soil The Q_{50} for the site is approximately 227 cms.

The bridge is of the concrete girder type, supported by 7 precast pile bents. Over-all length is 65.84M with a 8.23M clear span.

Gradation Problem:

Original construction in 1929, had the freeboard at 2.13 to 2.44M . The pilings were driven approximately 7.62M below the existing bed level. Over the years, the annual cycle of scour during peak flow and fill during moderate flow has produced a general trend of aggradation.

Countermeasures:

Presently, the reach is extensively revetted with soil dikes to protect adjacent buildings. The bed level is within .30M of the stringers at the four south bents, and the channel flows entirely in an aritficial channel 1.52M below the strings at the two north bents.

Discussion:

This bridge has existed in its state of inadequate clearance for many years. According to local residents, neither the bridge nor the approach roadway has ever been overtopped. Apparently, the initial increase in flood velocity has been sufficient to scour a channel deep enough to pass peak flows. Since the creek has a faster response than the San Francisco River, the reach tends to re-aggrade from backwater effects as a flood peak recedes.

The state intends to construct a new bridge at this site within two years. Tentative plans include slab-type construction with a supercritical con-rete inlet structure to overcome the aggradation trend. The channel will be concrete-lined from the bridge inlet to the downstream confluence.

Available documentation includes recent slides, original plans, and 1972 cross-section survey notes.

CADDO CREEK AT SH-53 WEST OF MILO, OKLAHOMA

Description

Caddo Creek is located in Stephens and Carter Counties and is a tributary to the Washita River. The bridge is 89M in length, concrete piers in channel, wood pile foundations, spillthrough abutments and concrete wingwalls.

The drainage area is about 518 square km and the valley slope is 0.0016. The stream is perennial, alluvial with a sand bed. The channel is fairly straight, cut banks, with silt sand banks.

Gradation Problem

Figure 1 illustrates the degradation problem at SH-53. Information from maintenance Records can be summarized as follows:

Date	Meters Below Deck to Average Stream Bed
6-02-50	6.09
4-12-55	6.52
9-07-60	6.89
7-13-61	7.32
10-11-62	7.56
1-12-65	7.99
6-17-66	8.23
11-16-67	8.23
2-26-68	9.27
8-17-70	8.75
3-16-71	9.33
3-28-73	9.72
8-14-74	9.69

The degradation problem has not been isolated at this site. The channel has been modified and straightened at

several locations. There has been an increase in productive agricultural land and significant changes in farm land practices.

The degradation problem is primarily responsible for caving banks, the loss of productive farm land and debris problems.

Countermeasures

No countermeasures have been applied to this site. The pilings have been exposed from time to time. The piling are to a depth of 10 meters below the concrete footings.

Discussion

The highway department has no plans to protect the bridge from additional degradation. This site should be evaluated for a grade control structure to protect the bridge.

Very little information and data exists at this site. The U.S. Geological Survey does have a gaging station downstream at Ardmore.

Case History 82

NORTH FORK OF WALNUT CREEK AT US-62
NEAR BLANCHARD, OKLAHOMA

Description

The north fork of Walnut Creek is located in McClain County and is a tributary to the South Canadian River. The bridge is 55 M in length, concrete piers in channel, wood pile foundations, spillthrough abutments and concrete wingwalls.

The drainage area is 119 square km. The stream is ephemeral, alluvial with a sand bed. The channel is fairly straight, cut banks, with silt sand banks.

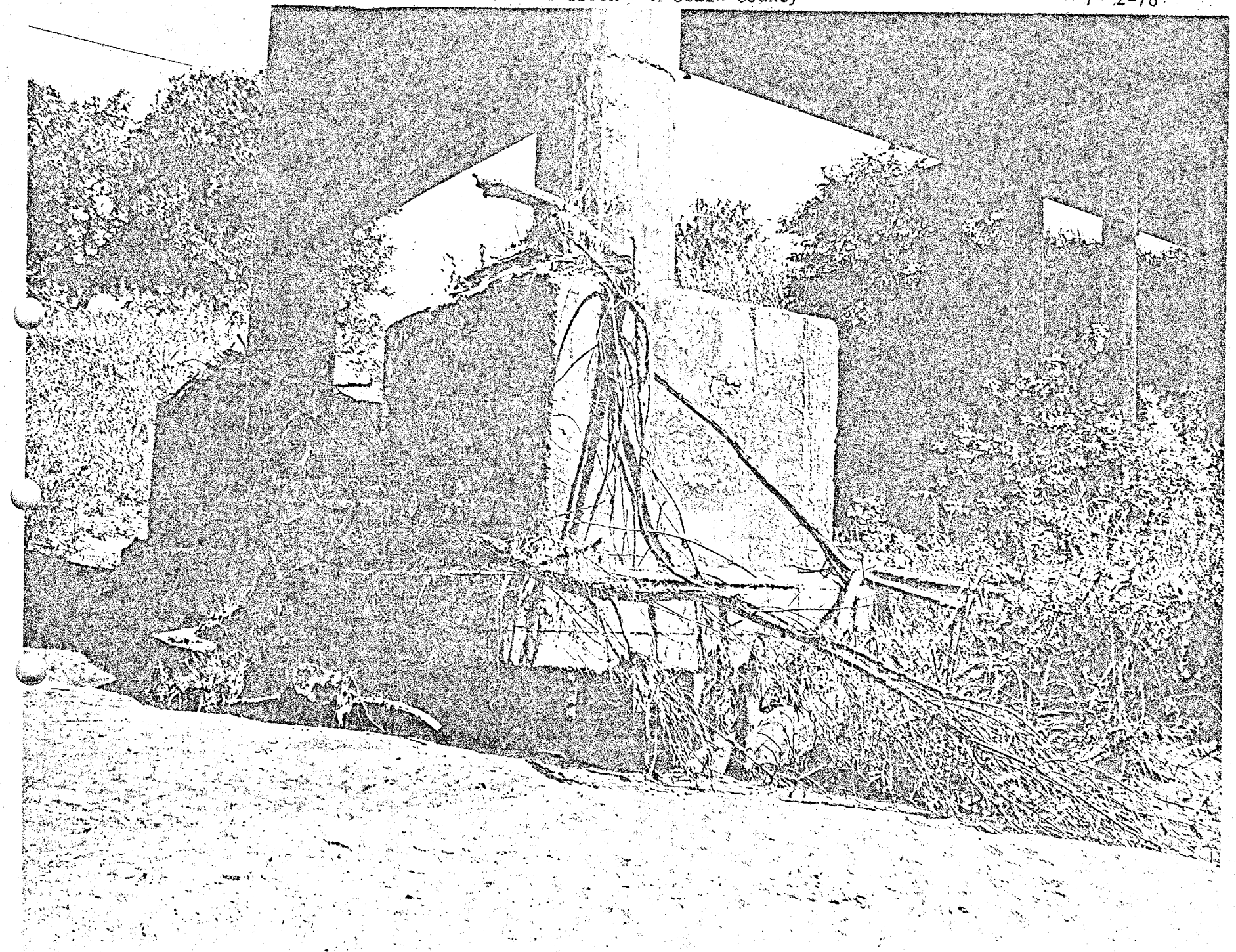
Gradation Problem

Figure 1 illustrates the degradation problem at US-62. Information from maintenance records can be summarized as follows:

Date	Feet Below Deck to Average Stream Bed
1938	6.40
1950	8.08
4-06-61	8.63
2-10-67	8.87
10-27-69	9.14
3-04-70	9.30
2-11-71	9.30
7-09-73	9.60
7-16-75	9.60
8-24-77	9.60

The degradation problem at this site is due to channel modifications and straightening, as well as a significant change in land use to more productive agricultural land. The degradation is not only impacting this highway crossing,

62-44-02-X0424 U.S.62 at North Fork of Walnut Creek McClain County 7-12-78



but is primarily responsible for caving bank, loss of productive farm land and debris problems. The channel is not only 3 to 4 meters deeper and 2 to 3 times wider, but is unstable laterally as the channel seeks to adjust its slope.

Countermeasures

No countermeasures have been applied to this site.

Discussion

The highway department has no plans to protect the bridge from additional degradation. The exposed piling should demand some plan or action. This site should be evaluated for a grade control structure to protect the bridge.

Very little information and data exists at this site. The U.S. Geological Survey does have a gaging station downstream just before Walnut Creek joins the South Canadian River.

Case History 83

Wallowa Lake Bridge over Grande Ronde River near Island City, Oregon

Description:

The site is located in the valley formed by the Wallowa Mountains on the east and the Blue Mountains on the west. The river bed is historically armored with cobble and gravel and the site has a drainage are of 1771.56km^2. The Q_{50} at the site is 308 cms.

The highway bridge is a steel truss supported by 3 timber and concrete piers, with a clear span of 15.24M and a railway bridge is located immediately downstream.

Gradation Problem:

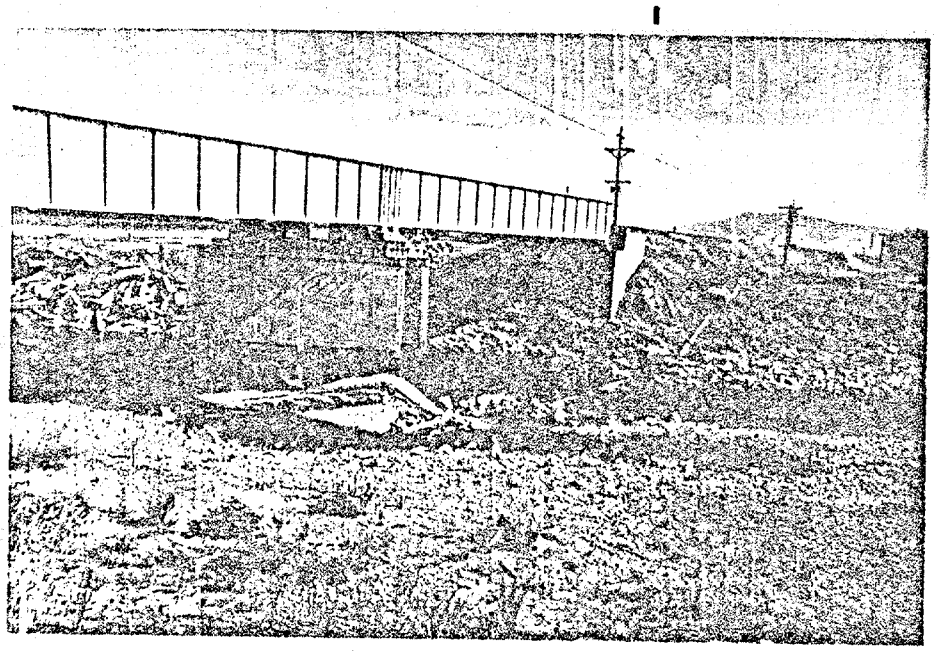
From 1963 to 1973, noticeable scour of the channel in the vicinity of the bridge occured exposing the lower portions of the center pier. A 100 year event was recorded on January 30, 1965 (400 cms) which produced a general enlargement of the upstream channel and significant degradation between the highway bridge and the Union Pacific Railroad bridge. This degradation caused the loss of the center span of the Railroad bridge through undermining of the center pier.

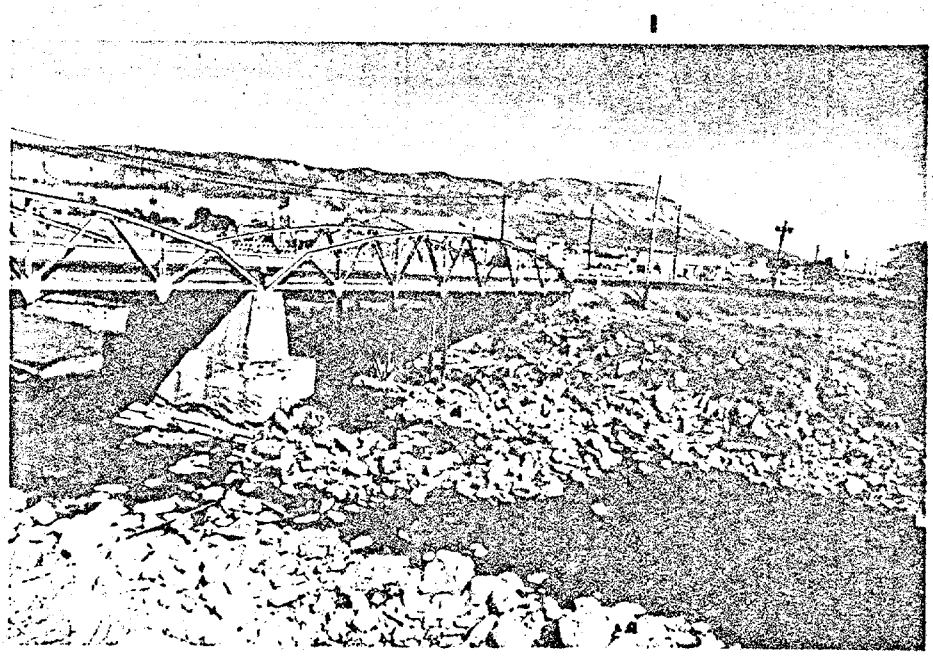
Countermeasures:

In 1973, the old bridge was replaced by a new bridge of prestressed concrete. The channel has been paved with riprap and a uniform channel gradient has been established in the localized area.

Discussion:

State personnel believe that the degradation was a result of gravel mining operations upstream and downstream of the bridge and was only amplified by the 1965 flood.





Pacific Highway West Bridge over the Willamette River near Harrisburg, Oregon.

Description:

This bridge is a steel truss supported by four piers. The site is located on an alluvial plain and the meandering river channel has a gravel bed.

The surrounding area is densely vegetated with trees and brush The bank material is primarily sand.

Gradation Problem:

In span No. 3, the stream bed has, over a period of many years, been lowered 2.44 to 4.27M from the 1935 elevation of 82.91M Many reasons have bben attributed to the channel degradation; channel shifting upstream, constricted flow, control construction, gravel mining upstream and downstream reduced velocity and consequently reduced sediment load.

Countermeasures:

With the original construction, the left bank was revetted 650.75M upstream. In 1926, flooding took out 146.30 M of the revetment just upstream of the bridge. The revetment was reconstructed and three wing walls were added. A batter pile revetment and fascines with rock slopes were placed along the east bank for 30.48M upstream.

32 years later (1958), the Corps of Engineers constructed a rock and steel trash barrier upstream of the highway revetment, approximately 309.60M .

In 1965, the Corps of Engineers had to repair damage caused by a December 1964 flood and extended the revetment another 132.59M upstream.

In 1966, the Highway Department constructed a treated pile and timber fender 70.10M long on the left bank to protect pier No. 4 and riprap was placed around the pier.

In 1967, the Corps of Engineers again extended their revetment, anouther 243.84M downstream.

Discussion:

The stream bed has lowered between 2.44 and 4.27M in span No. 3 from the 1935 elevation 82.91M which the state engineers believe to have resulted from the following:

1. Channel shigting upstream which confined the flow to the left bank.

2. Gradual extension of an island tip downstream to tie into pier No. 2 and constricting the main flow to spans No. 2 and 3.

3. Construction of controls upstream and subsequant reduction in bed load.

4. Gravel mining downstream causing headcutting upstream.

5. Gravel mining upstream causing large pools which act as sinks for bed material being transported downstream.

6. Upstream controls have reduced velocity and consequently reduced bed load.

Recommendations are to further stream control measures upstream and downstream of the bridge and open gravel mining operation on the island that ties in with pier No. 2 and cause a gradual retraction away from the pier.

No plans or additional documentation of this site are currently available.

Case History 85

Mt. Hood Highway Bridge over White River, Oregon

Description:

This bridge is located downstream of the steep glacial fields of Mt. Hood. The current bridge is constructed of concrete decking and timber piers with an approximate clear span fo 17.1 M The river may be classified as straight, with approximately 3M high banks. Bed material is non-cohesive sand and glacial till, and the banks are composed primarily of sand.

Gradation Problem:

The primary problem at the site is the development of an alluvial fan immediately downstream of the bridge. Significant quantities of glacial till are moved by the river during the spring runoff. The sediment load accurs primarily in the form of slug flow when small sediment dams are developed upstream and then overtopped as the hydrostatic pressure exceeds the dams holding capacity. This creates a wall of sediment laden water to route through the river, with a large percentage of the sediment being depositec in the vicinity of the bridge.

Conntermeasures:

Since 1924, three bridges have been constructed at this site due to previous bridge washouts. The original brdige was placed 4.27M above the bed of the river, and the current bridge placed 9.5M above the original level. There is currently approximately 1.8M freeboard under the bridge, indicating that the river has aggraded approximately 7.6M since 1924. No countermeasures to control this slug glow, and prevent the severe aggradation have been taken.

Discussion:

Although discharges are reported to be comparatively small at this site, the slug flow phenomena is reported to be more in the form of mud flow, and it is usually one event lasting less then 24hours. Unfortunately, very little data are available for this site or actual observations of the bridge washouts.

1950

EQUATION

24" C.M. Pipe - 73' (in place)
Extend 20' Lt. - 25' Rt.

Special Use Permit RW 11534

Proposed R/W

WHITE RIVER

Green Alder

+00 Install 54" C.M. Pipe

10" C.M. Pipe - 32' (in place)
Extend 10' Lt.

EQUATION

575 + 70.9 Rt.
576 + 02.14 P.T.
26° C.R.
Δ 75°55'
Ts 171.91'

573 + 13.14 P.C.

+90

568 + 99

567 + 43

565

570

573

S. 43° 19' 30" W.

Existing Bridge

Obliterate Existing Hwy

Existing Hwy.

Proposed R/W

S. 71° 44' W.

+00

+95

566 + 94.06 P.T.

4° C.L.
Δ 28° 24' 30"
Ts 322.55'

559 + 83.85 P.C.

Section 16
Section 21

SOUTH END OF CONTRACT

24" Corr. Metal Pipe - 28' (in place)
Extend 20' Lt. - 25' Rt.
Tr. Ex. 20 C.Y.

+90

End of Tr.

+50

1032.50

End of Br.

1200' V.C.

Inst. 54" C.M. Pipe Proceed Inlet-Cl
+00 Tr. Ex. 120 C.Y.

10" Corr. Metal Pipe - 32' (in place)
+95 Except 20' Left
Tr. Ex. 2 C.Y.

NORTH END OF CONTRACT

Finished Grade 9' Lt.

Finished Grade 9' Rt.

Finished Grade 9' Rt.

Finished Grade 9' Lt.

2.50

7' Tr. Ex.
3 Holes
12 Piers

Case History 86

SOUTH FORK FORKED DEER RIVER AT US-51 NEAR HALLS, TENNESSEE

Description

The location of interest is near the Dyer and Lauderdale County lines as seen in Figure 1 (Lat. 35°57', long. 89°24'). Dual bridges were built in 1963, with a 16 m main span supported by wall-type piers in the main channel, and thirty 8 m approach spans supported by concrete pile bents. In 1975, both bridges over the main channel were rebuilt, with 22.5 m main span supported by hammerhead piers. Spillthrough abutments, set well back from the main channel, were protected with sacked concrete in 1963 and have remained stable.

The drainage area is 2,688 km^2; the bankfull discharge is 28m^3/s and the width where bordered by natural vegetation is 24 m. The stream is perennial, alluvial, sand bed, in a valley of moderate relief and in a wide flood plain. The natural channel had a sinuosity of about 2.5 but the channel has been straightened. The natural channel is equiwidth, not incised, cut banks are rare, with silt-sand banks.

Gradation Problem

The channel was first straightened and enlarged in the 1920's by local drainage districts; but, probably because the natural flood plain forest was not cleared, the banks remained stable. In 1969, the Corps of Engineers straightened and enlarged a reach about 4.8 km in length downstream from the bridge, reducing the length about 20 percent. During the past few decades, and particu-

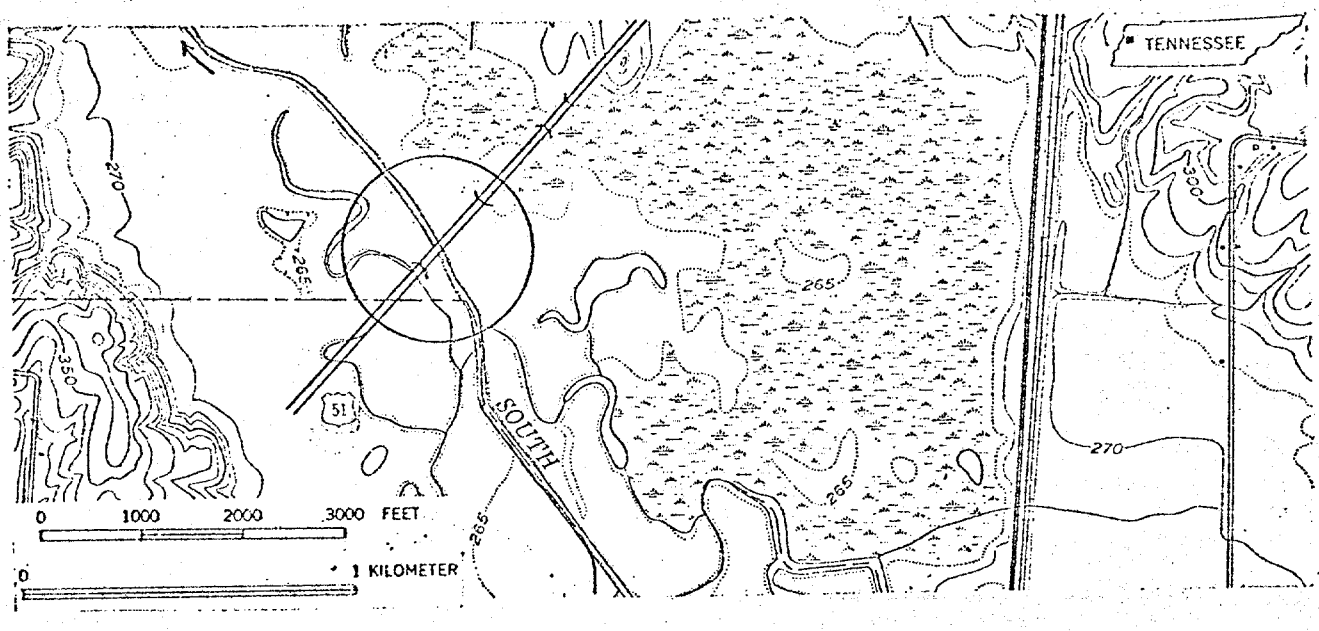


FIGURE 2 MAP SHOWING SOUTH FORK FORKED DEER RIVER AT US-51 CROSSING (CIRCLED). (FROM U. S. GEOL SURVEY FOWLKES, TENN., 7.5' QUADRANGLE, CONTOUR INTERVAL 10 FEET, 1952).

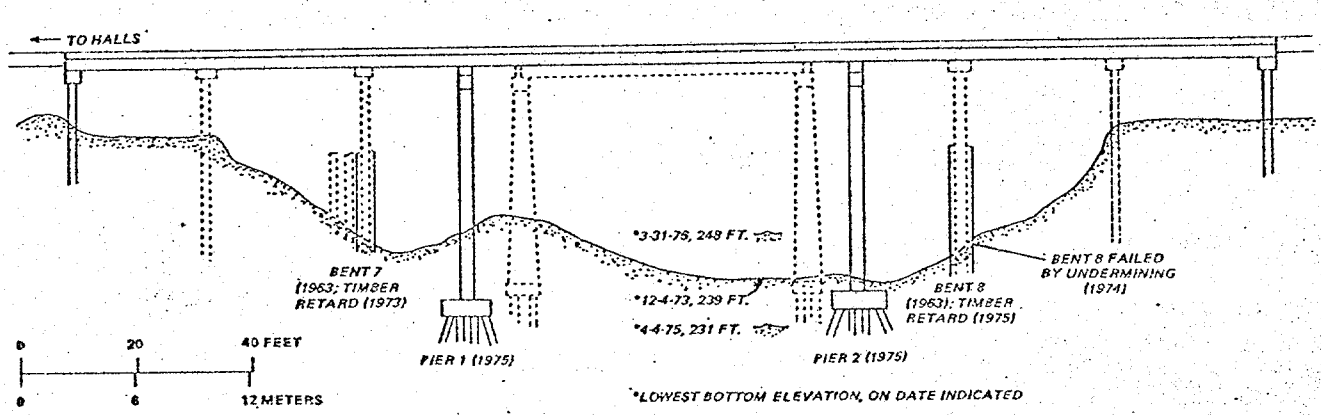
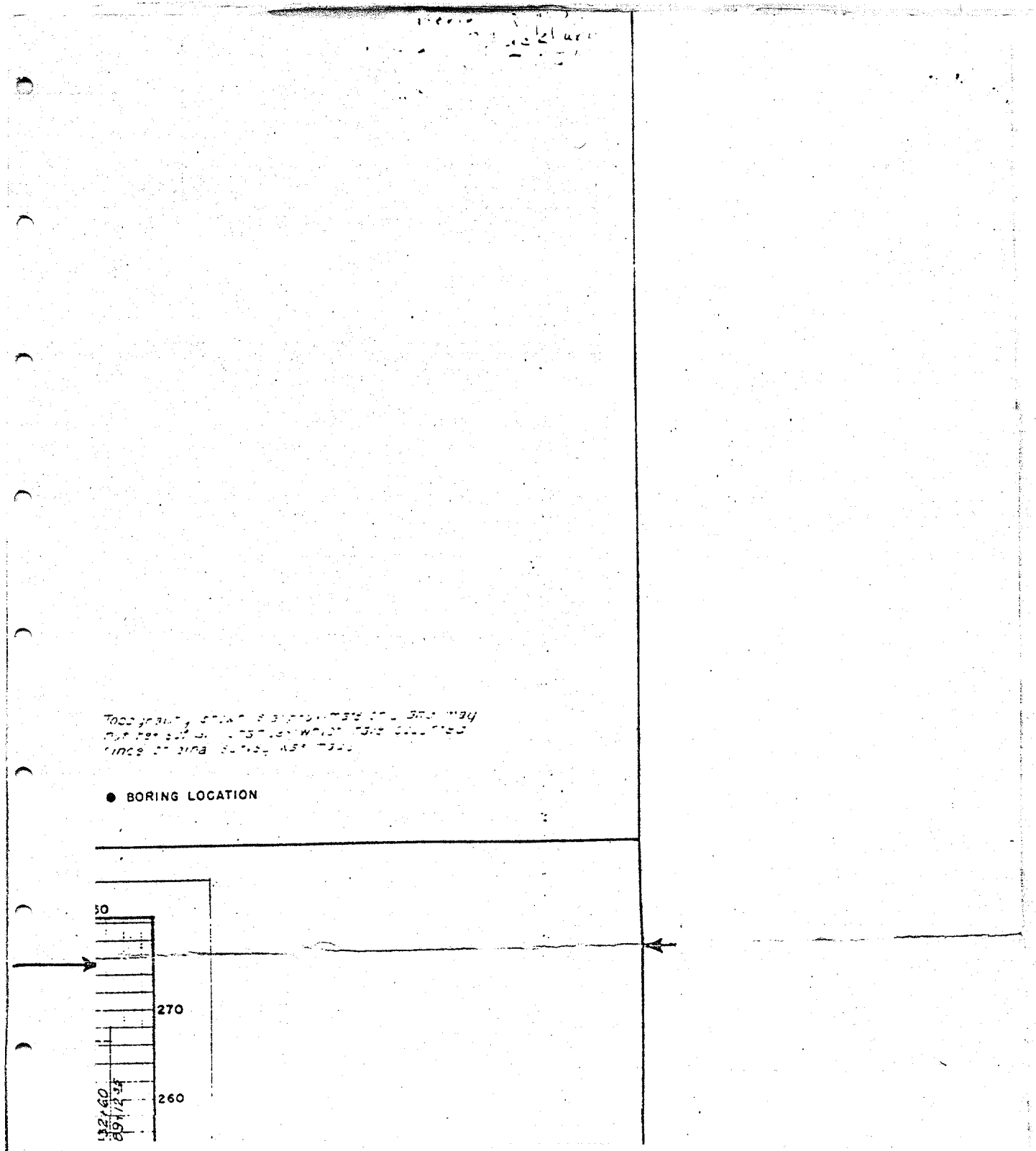
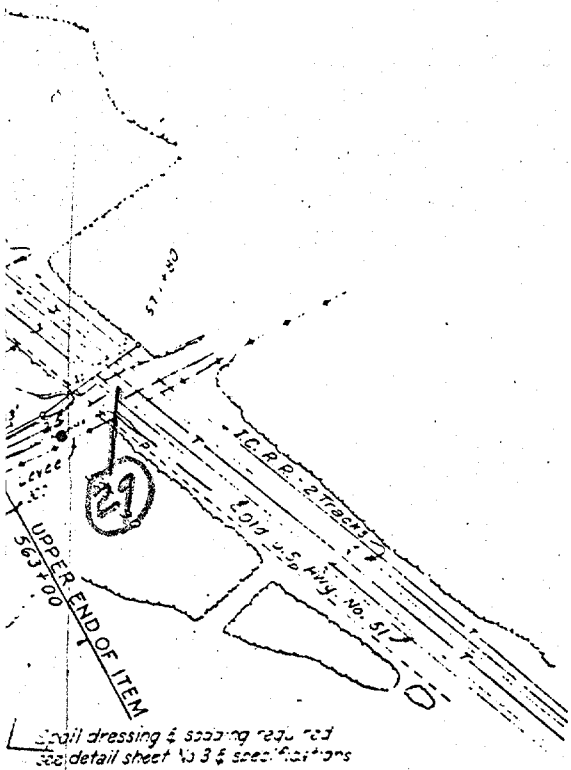
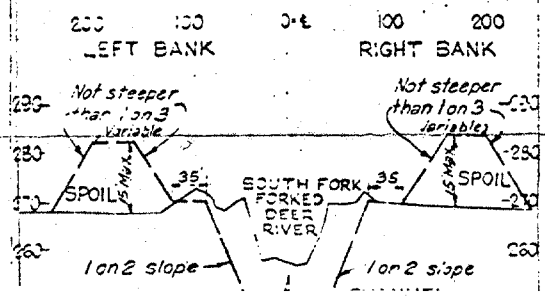


FIGURE 3 ELEVATION SKETCH OF US-51 BRIDGE. PIERS AND PILE BENTS OF 1963 BRIDGE, REMOVED DURING CONSTRUCTION OF 1975 BRIDGE, ARE SHOWN IN DASHED LINES.


BORING LOCATION
270
260



Spoil dressing & seeding required
see detail sheet No 3 & specifications



larly in recent years, the flood plain has been cleared of trees for agricultural purposes.

Figure 2 illustrates the Corps of Engineers channel modifications which reduced the channel length 20 percent and increased the channel slope. Figure 2 also provides an accurate channel profile before any modifications were made and in 1975. Several cross sections are illustrated at various longitudinal stationing showing the extent of the channel modifications.

Between 1970 and 1971 the left bank receded an average distance of 4 m. The peak discharge during this period was 215 m^3/s (R.I. of flood, 1.5 yr.). Timber pile retards were built at the left bank near bent 7 and a single row of pile with wood face planks, extending from the downstream end of bent 7 for a distance of 37.5 m upstream.

Between 1971 and 1973 the peak discharge during this period was 751 m^3/s (Q_{17} frequency). Bankfull stage occurred several times, high flows sustained for periods of weeks. The left bank continued to erode behind retard, average distance of recession was about 2 m. Bent 7 became exposed below the ground line. Concrete was poured at base to prevent further erosion. Slumping from the left bank deflected flow toward the right bank, causing rapid erosion and failure of bent 8. The South lane of the bridge was closed. A detailed inspection was made in 1973, but little field data were collected. What data was collected, indicated a large local scour problem at the bridge. No profile date was collected to evaluate the gradation problem.

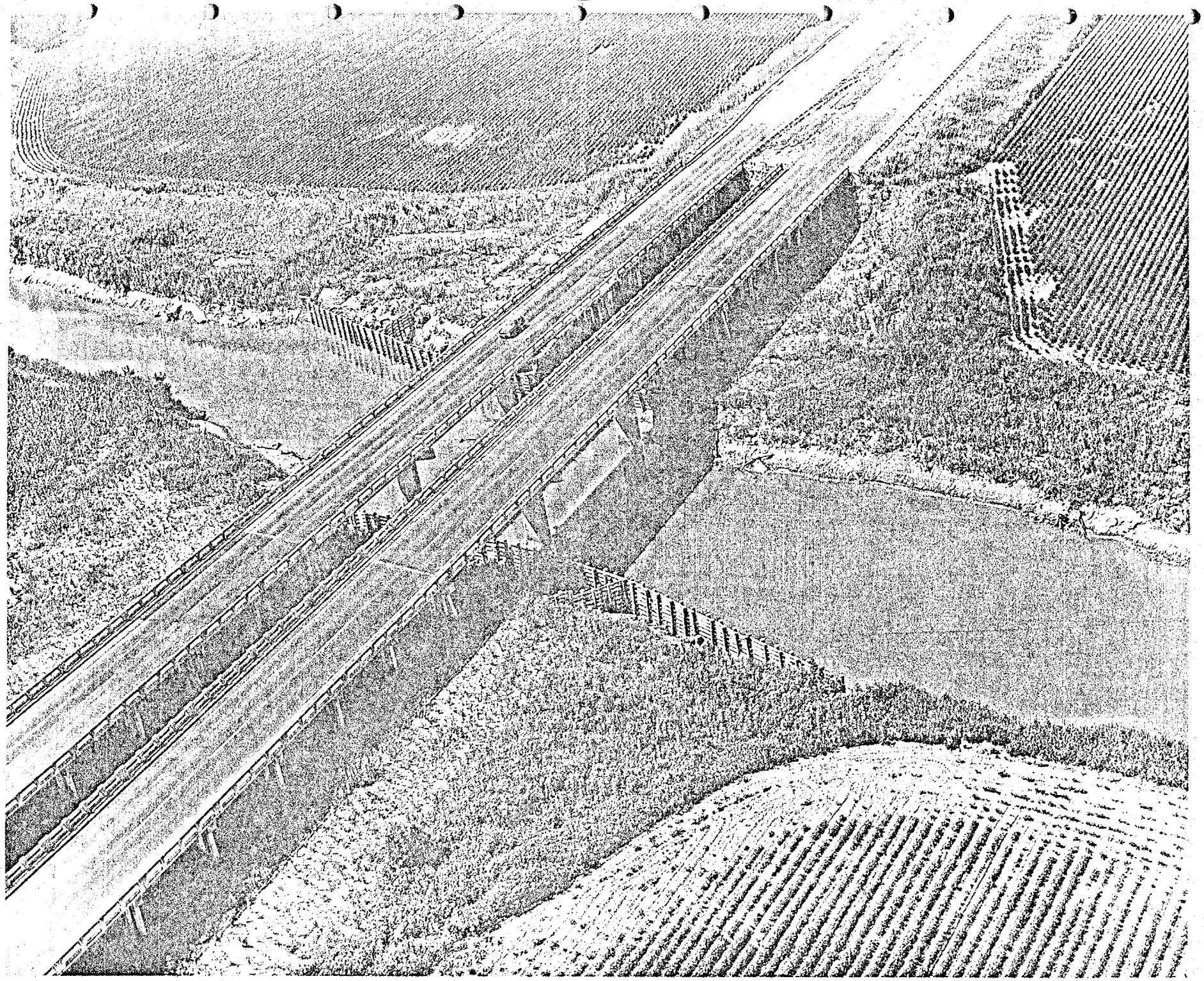
Countermeasures

In 1975 both lanes of the bridge were rebuilt, with new piers having deeper footings and less area normal to flow (Figure 3). Single-row, timber pile retards were built along both banks in the vicinity of the bridge (Figure 4). A large scour hole in the center of the channel downstream from the bridge, attributed to flow constriction during bridge construction, was filled with gravel. In 1975 a detailed inspection was made and the 1975 profile is plotted in Figure 2 to indicate the extent of the degradation problem.

In 1977 a detailed inspection was made and cross section data at the bridge indicated that the local scour problem was somewhat corrected and the gradation problem was fairly stable. Effectiveness of timber-pile retard has not yet been tested, and the area between the retard and the bank is not accumulating sediment. The lowermost face plank on the retard is about 1.5 m above the streambed. From experience in Oklahoma, Keeley (1971) recommends that face planks be extended to, or below, stream bed elevation. In addition, the upstream end of the retard seems to be keyed into the bank for an insufficient distance. Vegetation is becoming re-established on the banks, which appear more stable now than in the recent past.

Discussion

The 1973 bridge failed because of channel degradation and concurrent bank recession, which are directly attributable to straightening of the channel for drainage purposes and clearing of the banks and flood plain for agricultural purposes. Channel width increased by a factor of 2, approximately, between 1969 and 1976. The clearing of vege-



tation is apparently one of the most critical factors, because channel straightening in the 1920's, which was not accompanied by extensive clearing, did not result in significant bank instability. The timber pile retard installed in 1971 was of inadequate design, in view of the seriousness of the problem. Bank recession might have been controlled by an adequate retard or other countermeasure, but channel degradation is more difficult to control.

The site was inspected in 1973, 1974, four times in 1975, and in 1976 by numerous federal and state agency employees. It should be pointed out that little actual field date were collected to document the progressive channel changes. All inspectors have concluded that the channel changes were responsible for the gradation problems and other related hydraulic problems.

CANE CREEK AT US-51, SR-19, CR-8044, NEAR RIPLEY, LAUDERDALE COUNTY, TENNESSEE

Description

Cane Creek is located in the central portion of Lauderdale County, Tennessee. There are three highway bridges near Ripley, Tennessee of interest: U.S. Highway 51 bridge (North of Ripley), State Road 19 bridge (West of Ripley) and County Road 8044 bridge between SR-19 and US 51. At US-51 the Cane Creek drainage area is about 30 square miles. The present bridge at US-51 is a box bridge consisting of three boxes 4.6 meters wide, 5.6 meters high and 16.8 M long. It is a replacement bridge completed in 1978. The other two bridges are also box bridges.

Gradation Problem

In May of 1960 a watershed work plan agreement became effective between the Cane Creek Watershed District, the Lauderdale County Soil Conservation District, the United States Forest Service, and the Soil Conservation Service. The plan was supplemented February, 1963, March 1964, and April 1968.

Problems on the land which led to project planning were floodwater damage to crops and fixed improvements on flood plain land, scour and sediment damages to flood plain lands, and sheet and gully erosion of upland areas.

The Cane Creek Watershed Work Plan, as amended, proposed construction of 10 floodwater retarding structures and 67,000 M of channel work and/or brush and snag removal to help relieve crop damage due to flooding,

flood plain scour, and sediment damages. The plan also proposed vegetation of 6.4 hectares of eroding roadbanks and the application of erosion control, by means of land treatment, on 416 hectares of critically eroding uplands. Conservation land treatment was planned to complete land treatment of over 2430 hectares of the 23,000 hectares watershed.

By 1968, seven floodwater retarding structures had been built and more than 80 percent of the planned land treatment had been applied.

Additional planned action consisted of completing remaining land treatment measures throughout the watershed and channel work on that portion of the channel upstream from U.S. Highway 51 bridge (North of Ripley). Channel work consists of approximately 18,000 M of brush and snag removal and/or channel excavation. The portion of Cane Creek where remaining channel work is planned has intermittent flow. Within this reach an excavated channel is planned to have a bottom width of from 1.8 to 6.1 M and a depth of 1.5 to 2.4 meters. Brush and other debris will be removed from the wetted perimeter of the channel. Disturbed channel banks will be revegetated; construction will be from one side only. Increased channel capacities will afford protection from flooding during the growing season for two out of every three years on a long-term basis.

Figure 1 shows the Cane Creek watershed and the proposed channel improvements. A detailed set of plans exist that indicated the channel profile, new channel slope, reduction in channel length and constructed channel cross sections. The channel length was reduced significantly and the channel slope was increased about 25 percent.

Countermeasures

In 1975 emergency watershed protection requests were proposed because of severe degradation. The countermeasures

Figure 1

TO BE INCLUDED IN FINAL DRAFT

included:

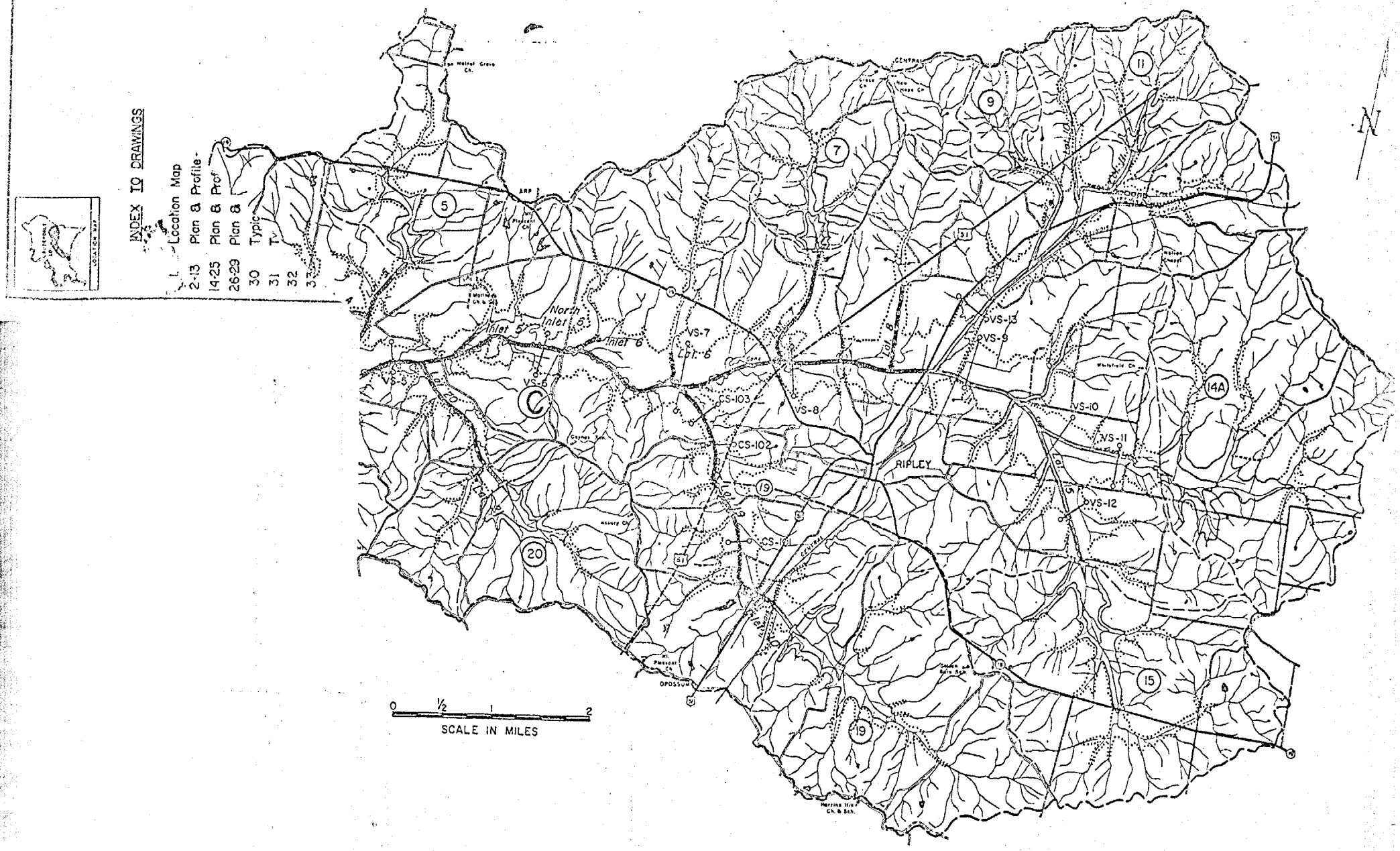
- Bank shaping and riprap
- 6 pipe drops
- 2 grade control structures
- 80 pipe drops repaired

Figure 2 is a plot of the channel profile upstream of U.S. 51 in 1968 and 1976. At the bridge there is about 6 feet of degradation.

Today the channel is still not stable. Data collected in 1978 indicated 7 to 8 feet of degradation over a two mile reach above U.S. 51. The highway maintenance district has completely riprap the channel 1000 feet upstream and 1000 feet downstream of U.S. 51. Some water is flowing under the box bridge on the County Road 8044. The three box bridges have serious gradation problems and annaully riprap is placed downstream of the structures.

Discussion

The channel improvements in the 1960's are responsible for 7 to 8 feet of degradation in Cane Creek. As a result of degradation, the channel banks became unstable which is evidenced by caving banks and large sediment loads. The caving banks are then the primary contributor to serious debris problems.



ɔvated

CHANNEL IMPROVEMENT

North Suplhur River at F.M. 68 near Paris, Texas

Description:

The bridge is a concrete slab supported by four CIP concrete piers with spread footings. The ov er-all length is 60.95M with a clear span of 12.19M . This bridge is one of two cases extracted from a comprehensive report on this site.

This crossing is located at the upstream end of the Sulphur River rectification project (see Vol. 1 of Texas Degradation Survey) The upstream channel has not been modified. The main channel is 15.24 to 18.29M across with sloping, 3.05 to 6.10M high banks, with evidence of sluffing. The bank and bed material are primarily clay and loam.

Gradation Problem:

In 1970, erosion began to exceed the limits of the bridge on the northeast abutment. A roadway 42.67M beyond the abutment was also undermined by sluffing. Between 1970 and 1975, slides had occured on both ends of the bridge.

Countermeasures:

In the early 1930's, the North Sulphur River was rectified by the U.S. Corps of Engineers as part of an erosion control project.

Original construction of the bridge took place in 1942. At that time, the finished bed level was 3.66M above the tips of the footings at the center of the channel. The abutment slopes were about 4:1 from the interior piers to the tops of the abutments.

The site required maintenance each year to control the erosion. A cost analysis is given in the full report. The channel degraded progressively since then. The erosion that occured in 1970 was repaired by placing borrow fill into slide.

To date, additonal slabs have been placed on the ends of the bridge. The bed is now approximately .3M above the tops of the interior bent footings.

Discussion:

This case, along with 16 others, is documented in the report entitled, "North Sulph-r River Degradation Survey, District One, Fannin, Delta, and Lamar Counties," submitted to the Texas Highway Department by the district engineer in 1975. This case study illustrates how a successful erosion control project produced unexpectedly severe results on highway structures. According to Texas state personnel, the Corps esimated that the channel would stabilize at 400% enlargement from the original pilot channel. This figure was exceeded several years ago, and the rate of erosion is increasing.

Supporting documentation includes recent slides, a copy of the referenced report, a 1:24,000 location map, and a 1:62,500 map. The numbers identifying crossings in report Volume 1 and location maps, correspond to slide key titles in parentheses.

Rowdy Creek at F.M.38 near Paris, Texas

Description:

This bridge is a concrete slab supported by two 3-pier bents The over-all length is 22.85M with a 9.45M clear span. This bridge is one of two cases extracted from a comprehensive report on this area.

The crossing is located on a tributary to the North Sulphur River about halfway through the rectification project. Degradation in the North Sulphur River produced headcutting in all the tributaries. In this case, the tributary was both degraded and severely sidecut. The present channel is about 15.24M across with sidecut and sluffing banks. The banks are 3.05 to 6.10M high and the bed and bank materials are clay and loam.

Gradation Problem:

Between 1955 and 1970, erosion progressed at a fairly constant rate at the site. There is no record of any maintenance during this period.

In 1970, havey runoff caused the banks to begin sluffing, and in 1973, the backwall and abutment at the west end of the bridge were undermined. By 1975, the north roadway ditch began to sluff, endangering the approach. The bed had degraded 2.44 to 3.05M and the channel width had extended the length of the bridge.

Countermeasures:

In the early 1930's, the North Sulphur River was rectified by the U.S. Corps of Engineers as part of an erosion control project. Original construction took place in 1954, where the finished bed level was 6.10M above the pile tips and the abutment

slopes were 2:1 from the bents to the tops of the abutments. When the undermining began in 1973, rip-rap was placed in the channel and on the slopes.

Discussion:

(See discussion of North Sulphur River at F.M.68)

Case History 90

Merrill Creek at SR34 near Ladonia, Texas

Description:

Merrill Creek is a tributary to the North Sulphur River. The stream is perennial, with steep, sluffing banks. The drainage area is located in an agricultural area which has a hisotry of heavy annual rainfall with some associated flooding.

The bridge is six concrete slabs on steel piles with a length of 47M

Gradation Problem;

In the early 1930's. the North Sulphur River was rectified by the U.S. Corps of Engineers as a flood control measure. The rectified channel did in fact alleviate some flooding. Additionally, however, the new channel has degraded severely. The Corps of estimated that the pilot channel would stabilize at 400% enlargement from the original cross-section. This value was exceeded several years ago, and the degradation still continues at present. The main channel and additionally, most of the tributaries are regardedas unstable by Texas DOT personnel. In the case of this bridge, the bed dropped 3.to 6M from the construction elevation in 1955 to 1975. The banks are sluffing for a considerable distance outside of the bridge easement.

Countermeasures:

Additional slabs have been constructed at the ends of the bridge. Since 1965, maintenance crews have placed rock rip-rap and dirt to retard bank sluffing.

Discussion:

Available data is limited to comparative cross sections taken

in 1955 and 1975. Degradation can be expected to continue until the main channel has stabilized. Countermeasures wuch as rip-rap and additional bridge sections will be constructed as required in response to continued degradation.

Case History 91

Merrill Creek at FM 1550 near Ladonia, Texas

Description:

Merrill Creek is a tributary to the North Sulphur River in northeast Texas. The stream is perennial, with steep sluffing banks. The drainage area is an agricultural area with a history of high annual rainfall and associated flooding.

The bridge consists of elevan concrete slab spans on steel "H" piles with a total length of 84M .

Gradation Problem:

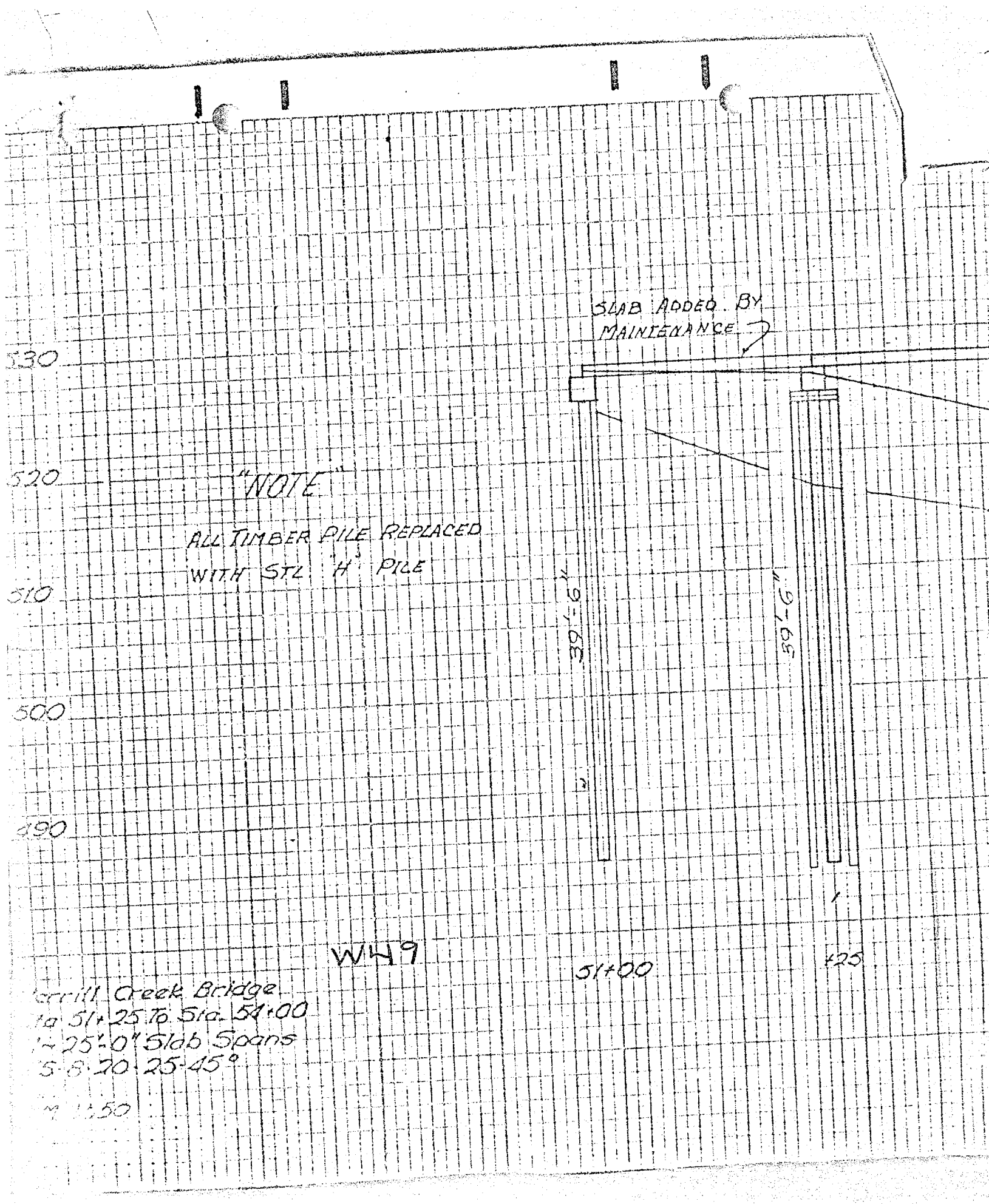
In the early 1930's, the North Sulphur River was rectified by the U.S. Corps of Engineers as a flood control measure. The rectified channel has alleviated some flooding, but has also degraded severely. The Corps estimated that the pilot channel would stabilize at 400% enlargement from the original cross-section. This value was exceeded years ago, and degradation continues at present. The main channel and most of the tributaries in the rectified reach are regarded as unstable by Texas DOT personnel. In the case of this bridge, the channel bed dropped 3 to 6M from 1953 to 1975.

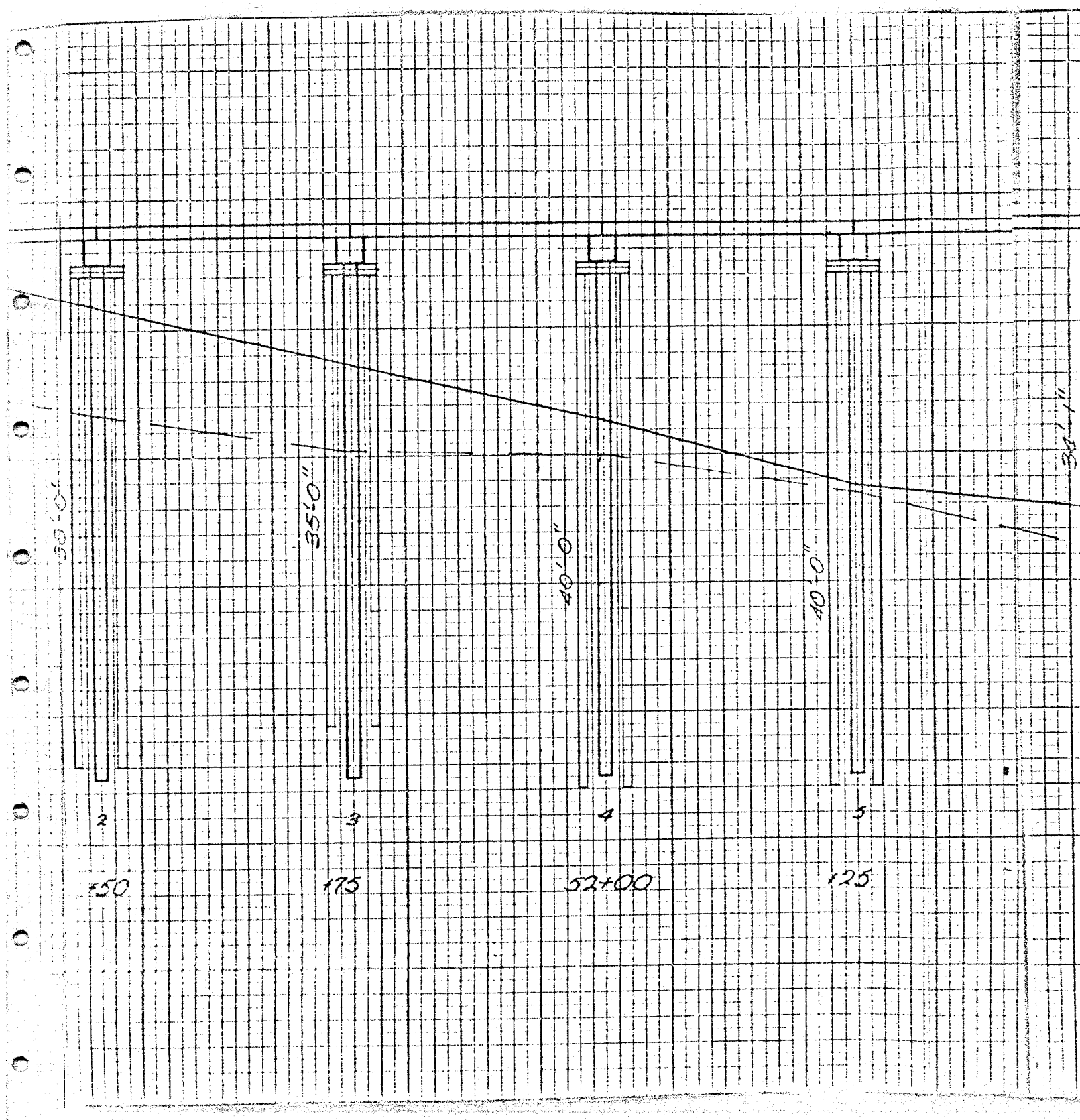
Countermeasures:

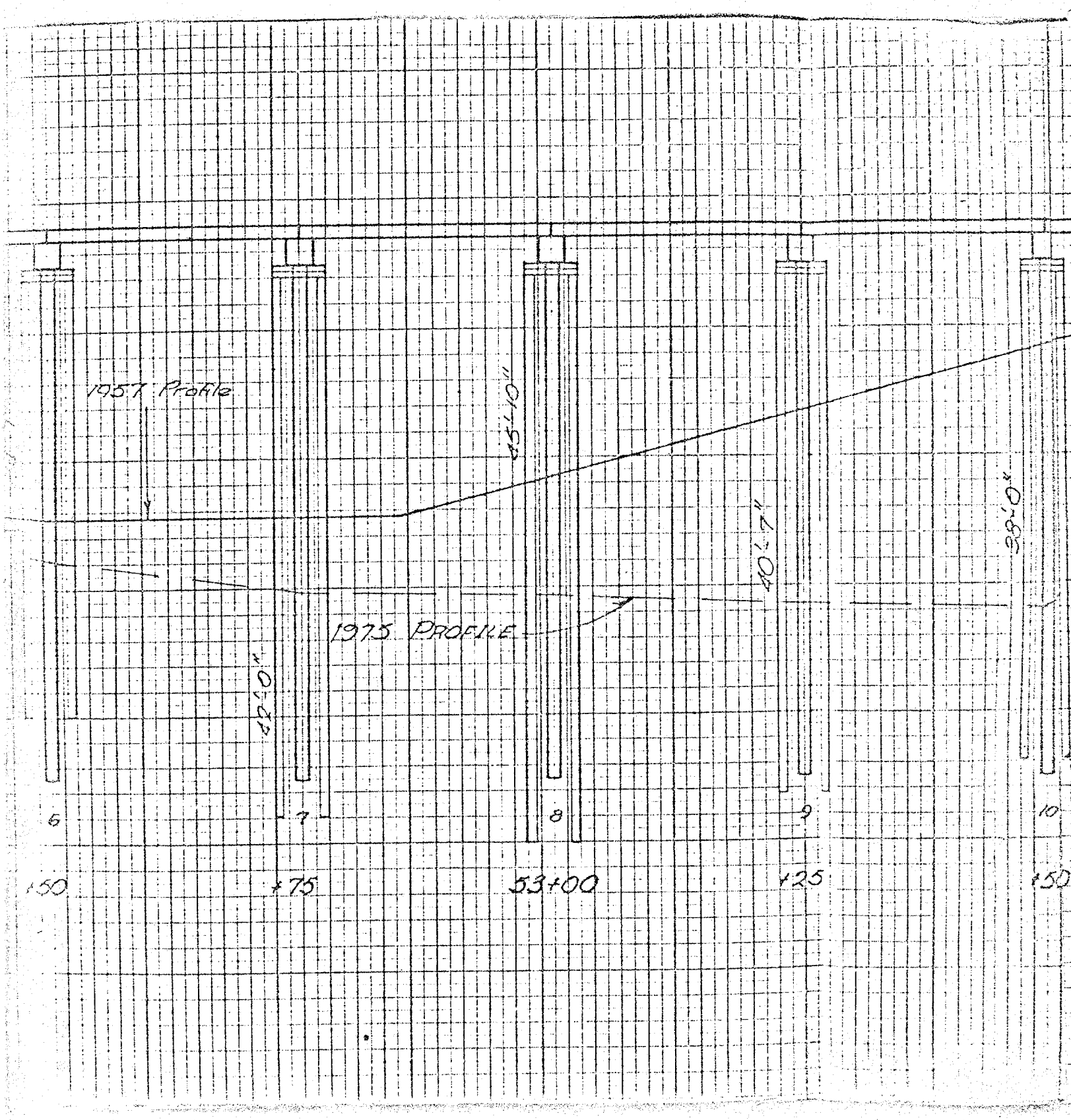
Additional end slabs have been constructed as the abutments slopes continued to sluff.

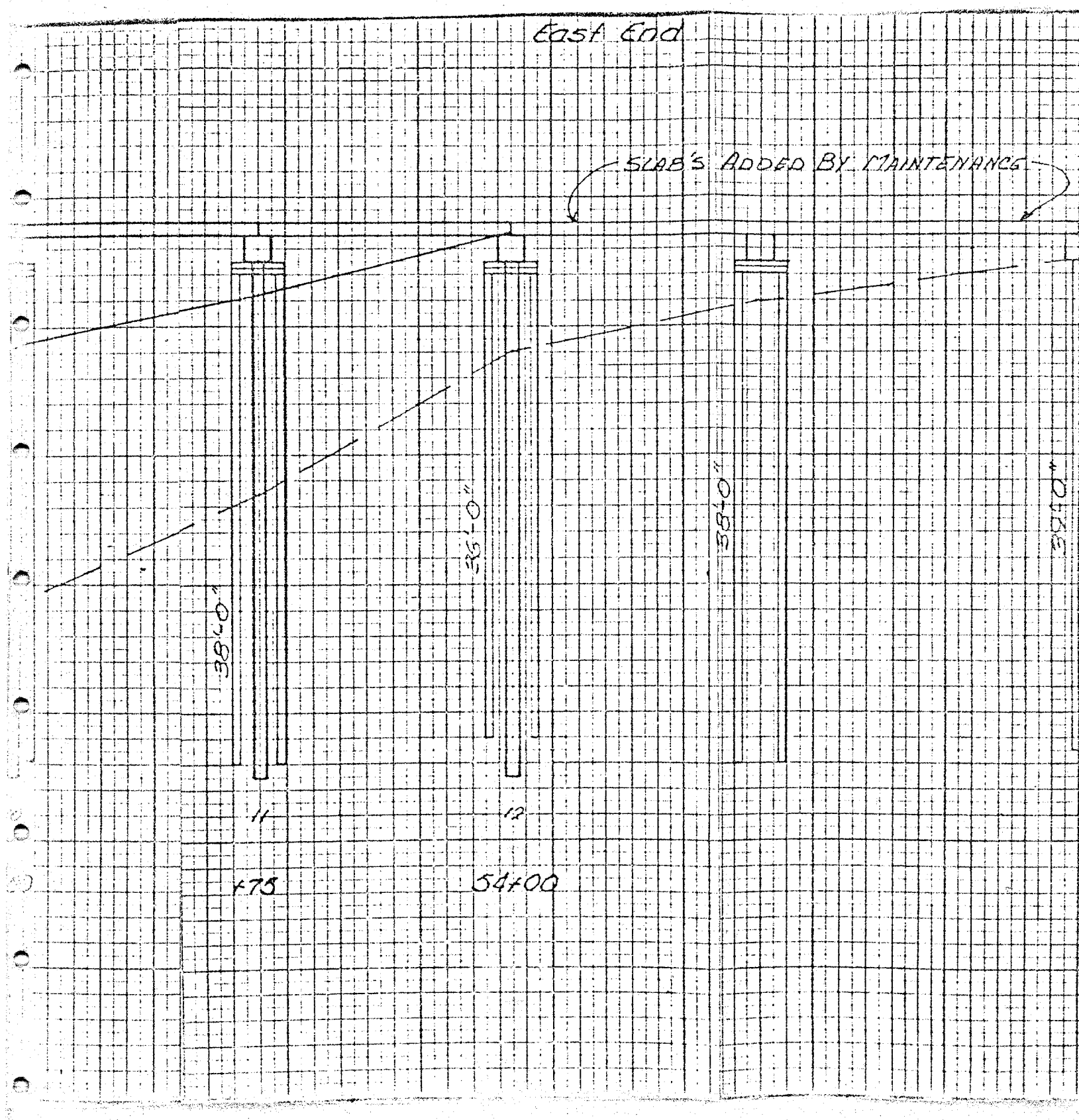
Discussion:

Available data is limited to comparative cross sections taken in 1957 and 1975. Degradation can be expected to continue until the main channel has stabilized. Countermeasures such as rip-rap dirt fill, sway bracing and additonal end sections will be constructed as required.


SLAB ADDED BY MAINTENANCE
530
520
510
500
490
"NOTE"
ALL TIMBER PILE REPLACED WITH STL "H" PILE
39'-6"
39'-6"
W49
51+00
+25
rrill Creek Bridge
a 51+25 To Sta. 54+00
~25'-0" Slab Spans
5-8-70 25-45°
50


30'-0"
35'-0"
40'-0"
40'-0"
30'-1"
2
3
4
5
+50
+75
52+00
+25


1957 Profile
45'-10"
40'-7"
38'-0"
40'-0"
1975 PROFILE
6
7
8
9
10
+50
+75
53+00
+25
+50


East End
SLAB'S ADDED BY MAINTENANCE
38'-0"
36'-0"
38'-0"
38'-0"
11
12
+75
54+00

Case History 92

Baker Creek at FM1550 near Ladonia, Texas

Description:

Baker Creek is a tributary to the North Sulphur River in northeast Texas. The stream is perennial with steep, sluffing banks. The drainage area is an agricultural area with a history of high annual rainfall and associated flooding.

The bridge is four concrete slab spans on steel H-piling bents with a total length of 30M

Gradation Problem:

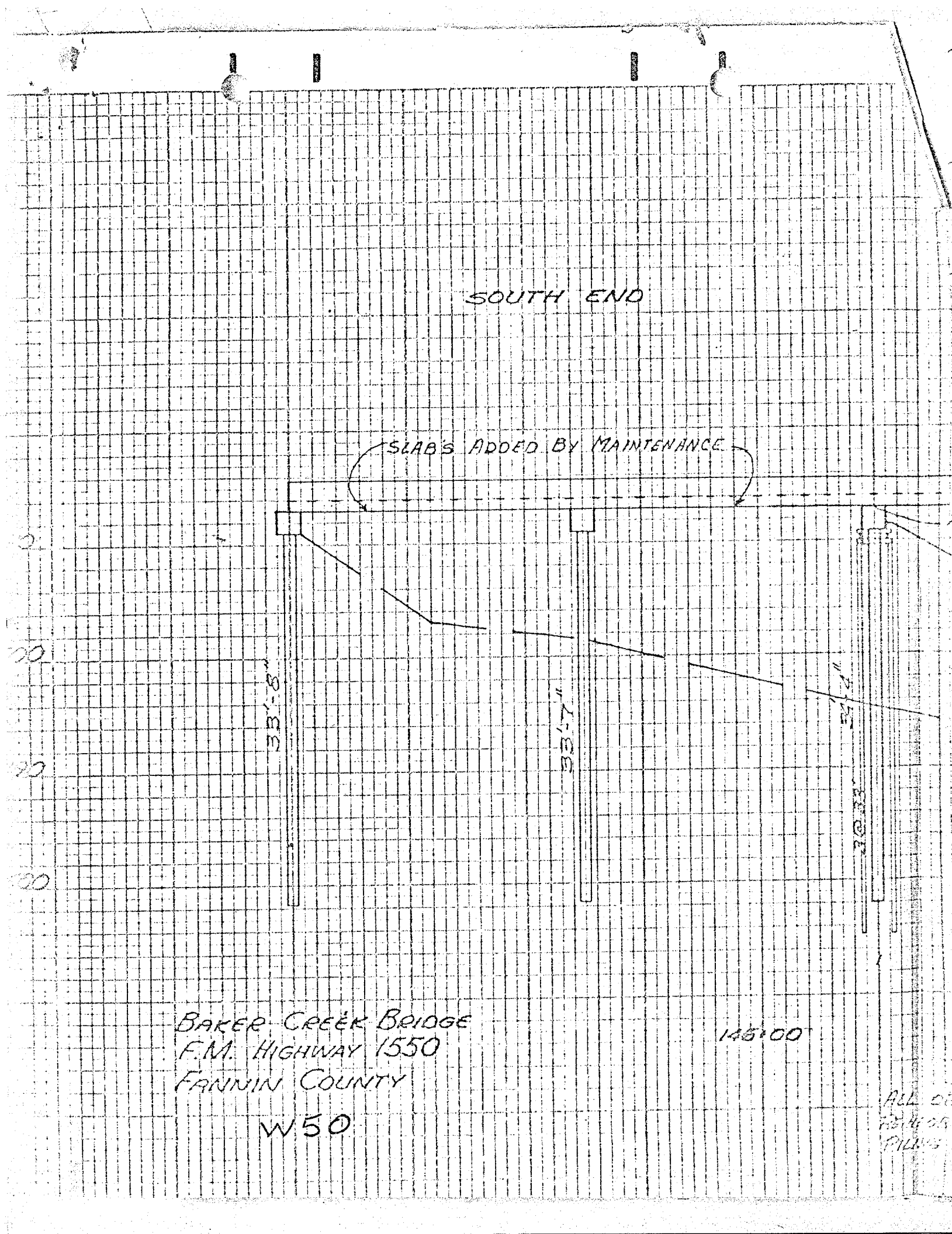
This site has experienced the same instability and degradation as Merrill Creek at SR54 and FM1550. In this particular case the channel bed has degraded from 3.o to 4.6M and the channel width has increased approximately 24.4M

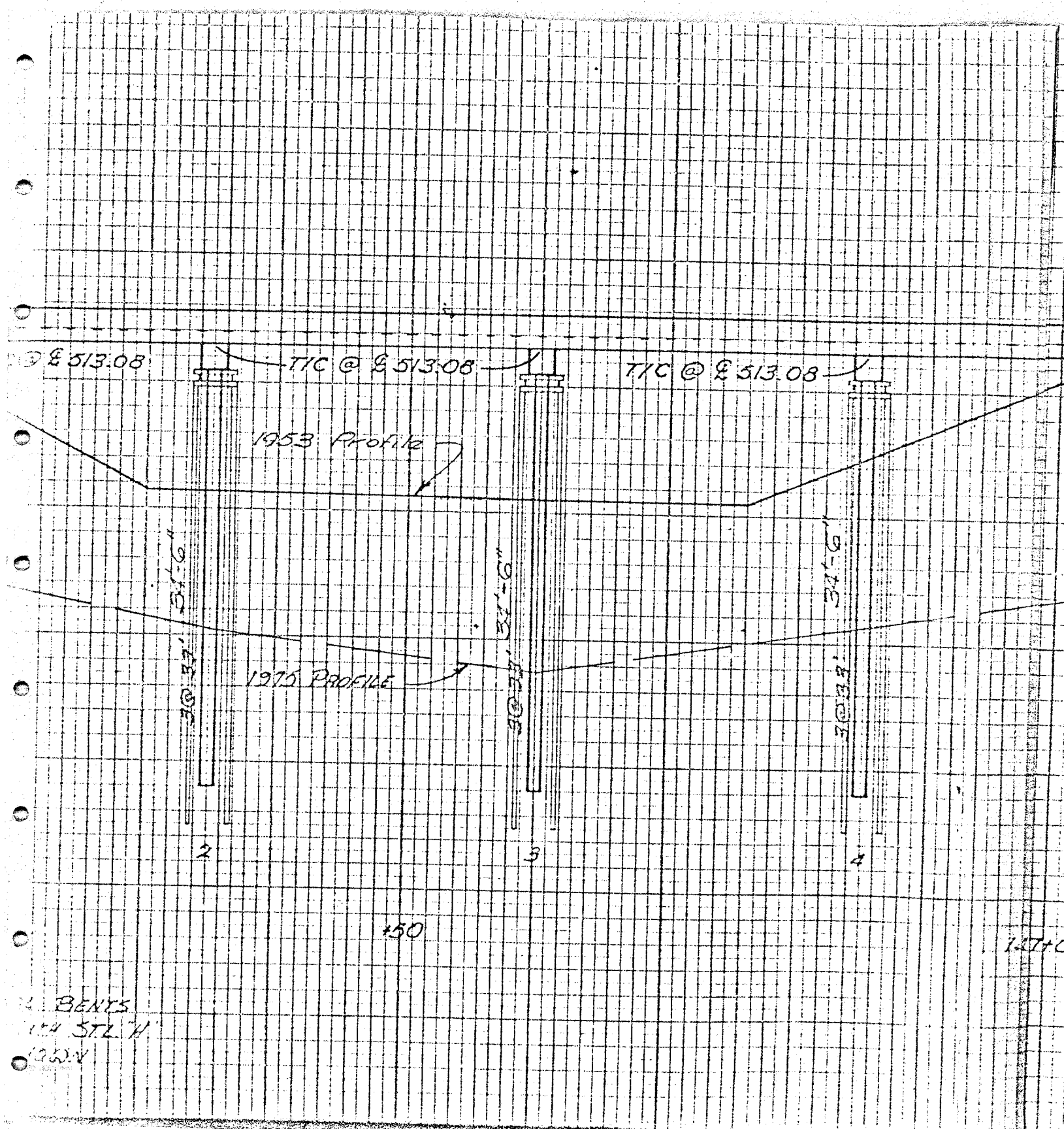
Countermeasures:

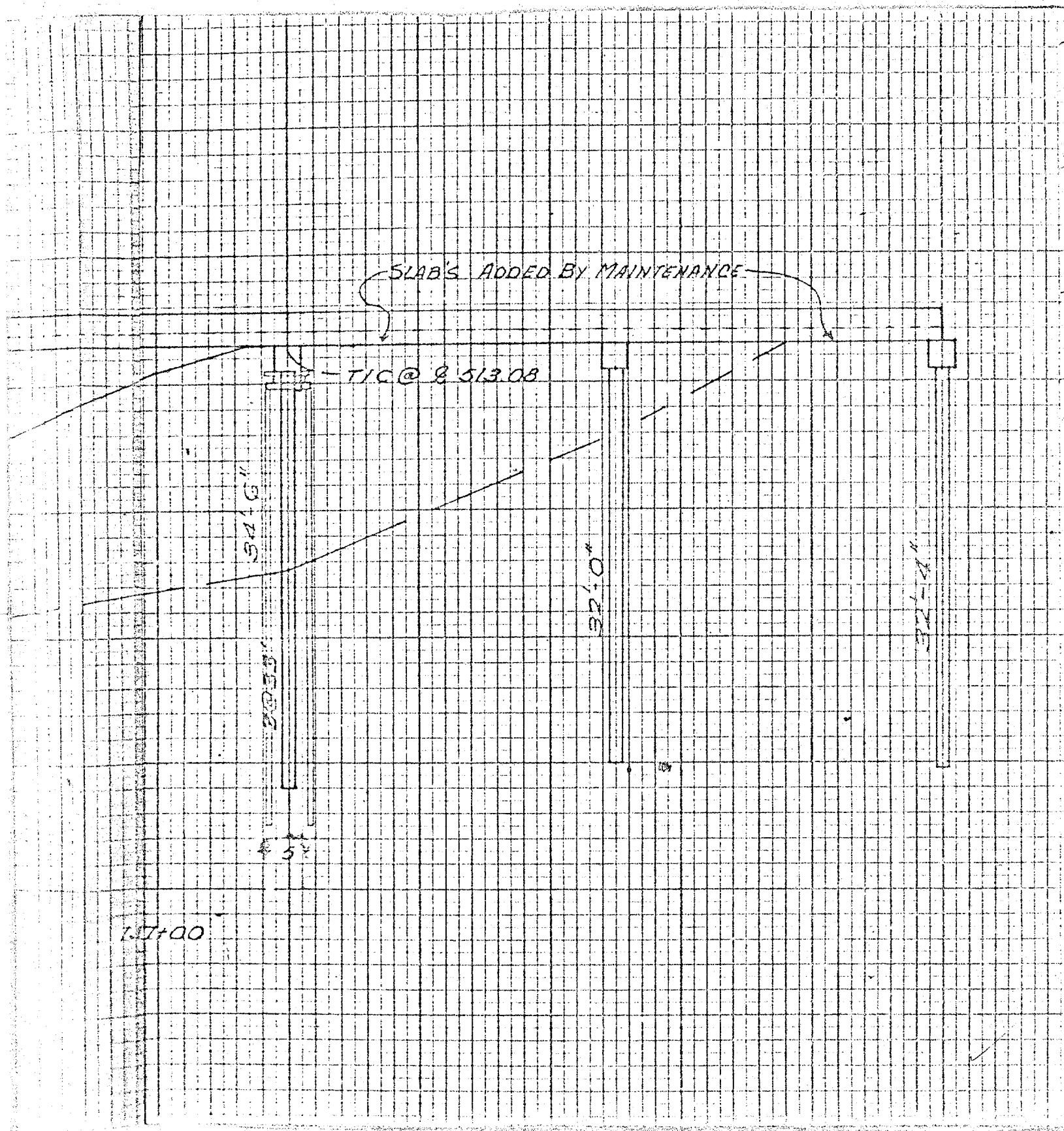
Since 1966, there has been a continuous maintenance effort at this crossing. Countermeasures include piling replacement, additional end slabs, and concrete block and rock riprap emplacement.

Discussion:

Available data is limited to comparative cross-sections taken in 1953 and 1975. Degradation can be expected to continue until the main channel has stabilized. Countermeasures will be constructed as required.


SOUTH END
SLAB'S ADDED BY MAINTENANCE
33'-8"
33'-7"
3@33'
145'-00
BAKER CREEK BRIDGE
F.M. HIGHWAY 1550
FANNIN COUNTY
W50


℄ 513.08
T/C @ ℄ 513.08
T/C @ ℄ 513.08
1953 Profile
1975 PROFILE
3@ 32'-6"
3@ 32'-6"
3@ 32'-6"
2
3
4
+50
BENTS


SLAB'S ADDED BY MAINTENANCE
TIC @ ℄ 513.08
34'-6"
30'-3"
32'-0"
32'-4"
5'
11+00

Case History 93

Mallory Creek at FM 137 near Howland, Texas

Description:

Mallory Creek is a tributary to the North Sulphur River in northeast Texas. This stream is perennial with steep sluffing banks. The drainage area is an agricultural area with a history of high annual rainfall and associated flooding.

The bridge is three concrete slabs on steel H-pile bents with a total length of 23M.

Gradation Problem:

This site has also experienced the same instability and degradation as Merrill Creek at SR54 and FM1550. Approximately 3M of degradation has occured at this site between 1953 and 1975.

Countermeasures:

Broken concrete rip-rap has been emplaced to retard bank sluffing. An 8M slab has been added on the east end of the bridge.

Discussion:

Available data on the bed level change is limited to comparative cross-sections taken in 1957 and 1975. Degradation can be expected to continue until the rectified main channel has stabilized. Countermeasures such as riprap and additional end sections will be constructed as required.

EAST EN

400

500

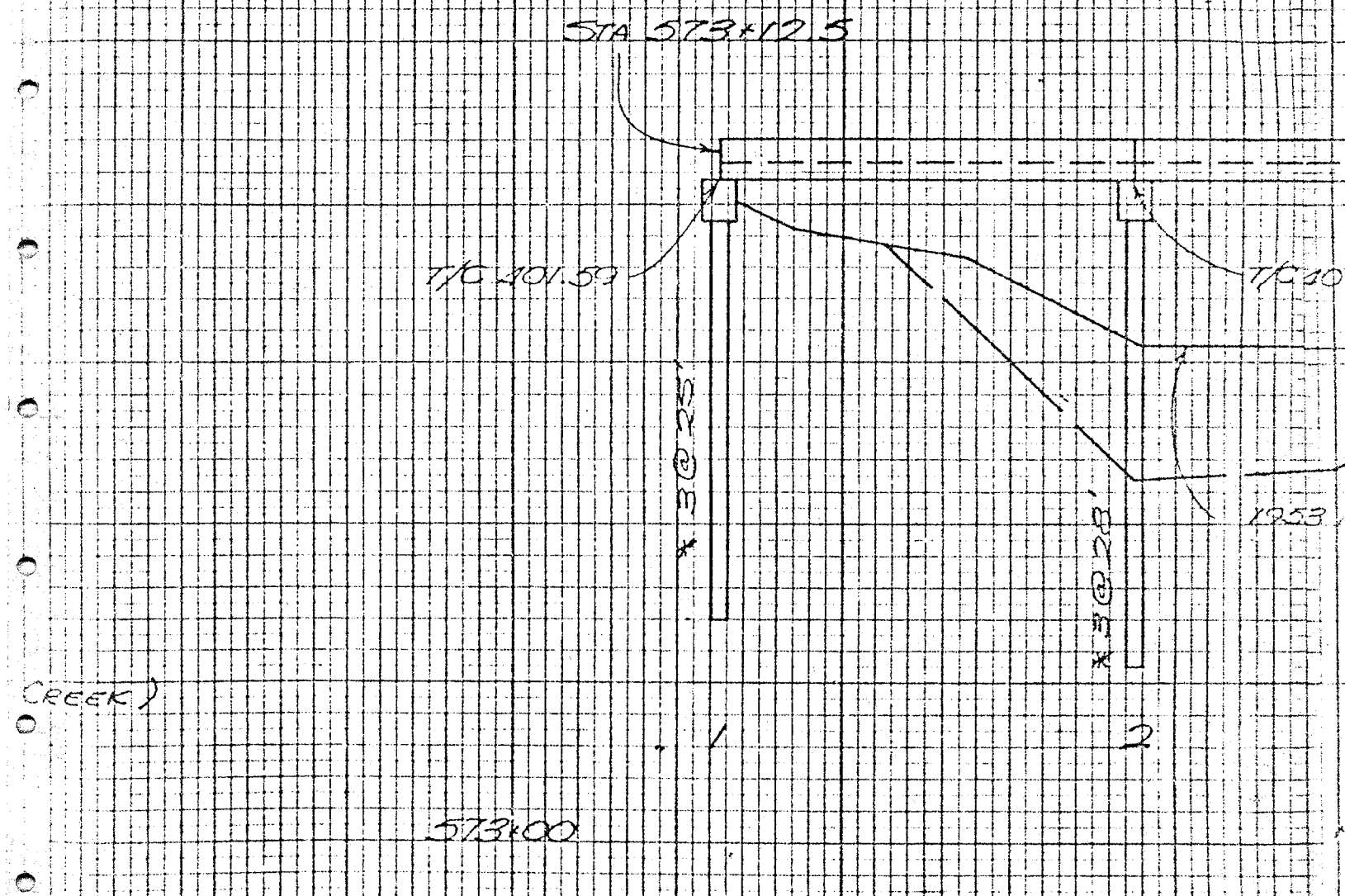
380

510

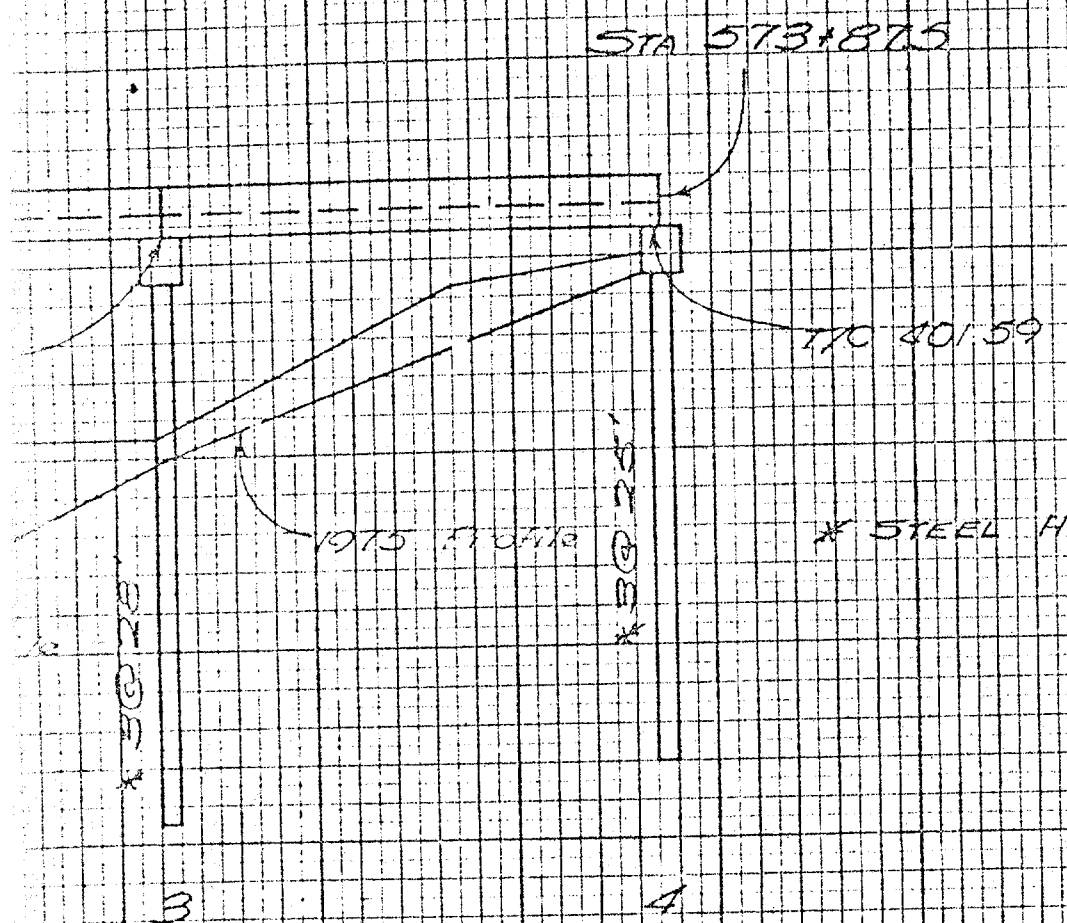
WEST HOWLAND CREEK (MALLO
F.M. HIGHWAY 137
LAMAR COUNTY

W55

3-25 Cont: 52.
TOTAL LE



SPANS F5-8-24-25
@ 75'-0"



400

390

380

370

Case History 94

Cherry Creek at FM1184 near Howland, Texas

Description:

Cherry Creek is a tributary to the North Sulphur River in northeast Texas. The stream is perennial with steep sluffing banks. The drainage is an agricultural area with a history of high annual rainfall and associated flooding.

The bridge is three concrete slabs on steel H-piling bents with a total length of 23M .

Gradation Problem:

This site has also experienced the same instability and degradation as Merrill Creek at SR54 and FM1550. The southwest bank and channel bed has degraded approximately 3M between 1953 and 1975.

Countermeasures:

An additional slab has been added to the southwest end of the bridge and rock riprap has been emplaced in an attempt to stabilize the abutment slopes, and the channel bed.

Discussion:

Available data is limited to comparative cross sections taken in 1953 and 1975. Degradation can be expected to occur as with the previous sites in the Sulphur River watershed. No channel modificaiton are anticipated at present, though countermeasures such as additional end sections, rip-rap and load limits will be applied as required.

450

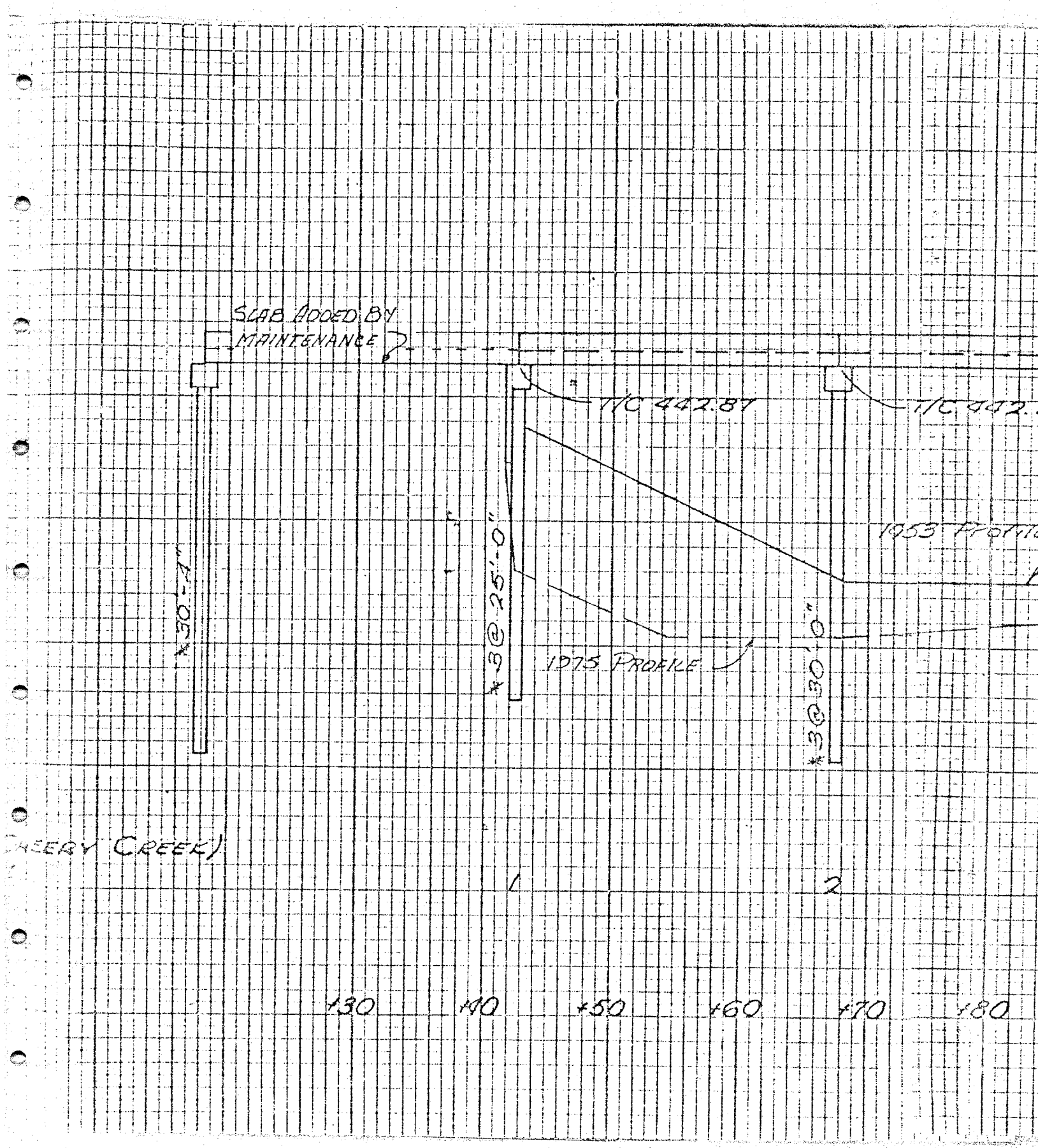
440

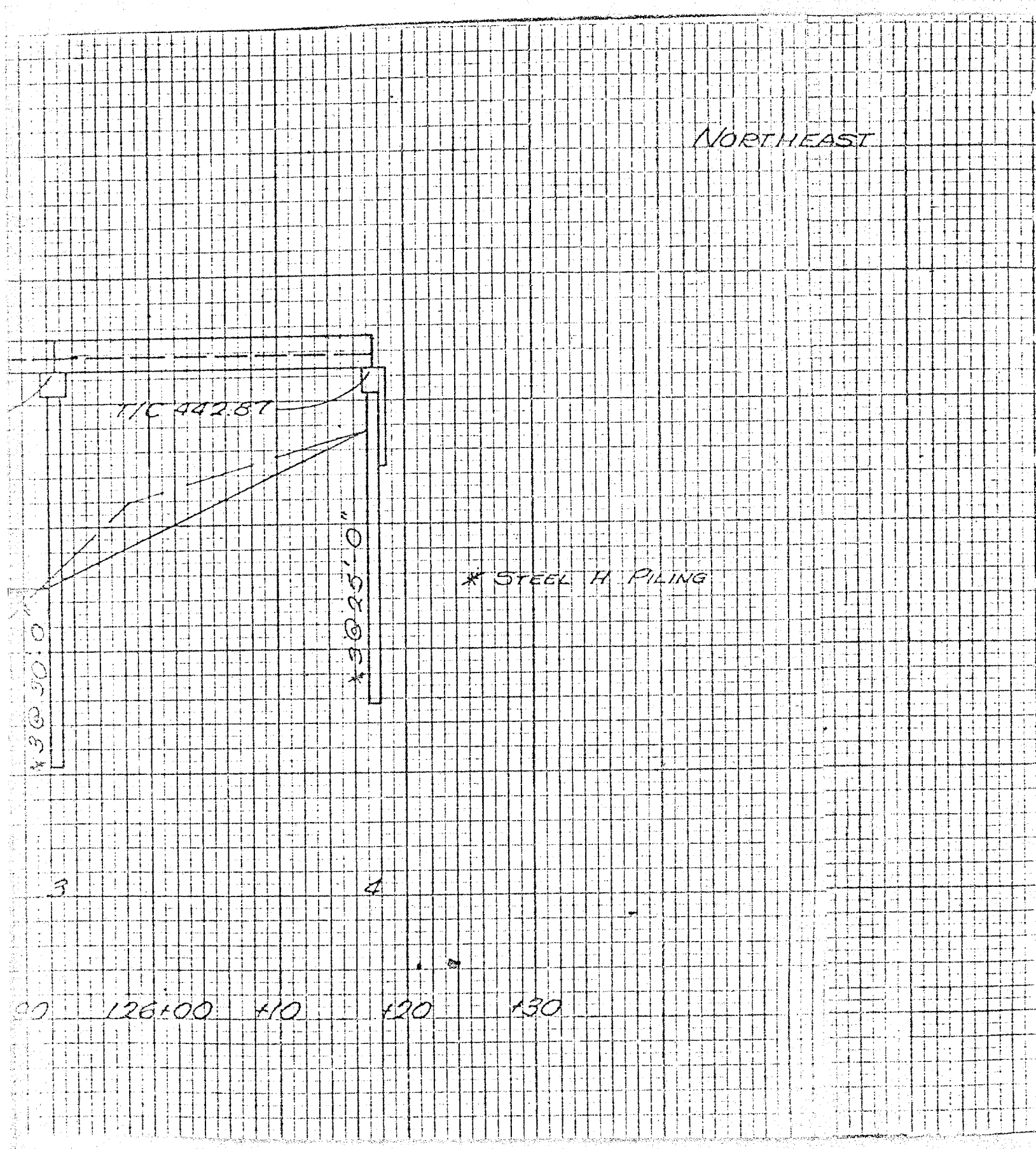
430

420

ANDERSON CREE
F.M. HIGHWAY
LAMAR COUNTY

W56


SLAB ADDED BY MAINTENANCE
T/C 442.87
T/C 442.
1953 Profile
1975 PROFILE
3@25'-0"
3@30'-0"
50'-0"
CREEK)
130
140
150
160
170
180


NORTHEAST
T/C 442.87
* 30 @ 25'-0"
* 30 @ 30'-0"
* STEEL H PILING
3
4
00
126+00
+10
+20
+30

? →

Description

Lat. 41° 03', Long. 111° 39'. Weber River in Morgan and Summit Counties, Utah flows in a northwesterly direction in Weber Canyon coming out of the Uinta Mountains. The draingage area at Riverdale is approximately 4400 square kms of mountainous terrain. Weber River flows in a narrow canyon with steep side slopes.

Gradation Problem

During construction of I-80N up Weber Canyon in 1969-1970, it was necessary to make numerous channel changes in the Weber River (Figure 28) in order to accomodate the river, I-80 and the railroad in the same narrow canyon. Most of the channel changes involved straightening and cutting out bends in the river.

Degradation in the Weber River has been noticed at the narrows near Uinta Jet.

Countermeasures

Realizing that the channel changes undertaken in the Weber River would cause degradation, the Highway Department constructed a number of different stream stabilization structures (Figure 29).

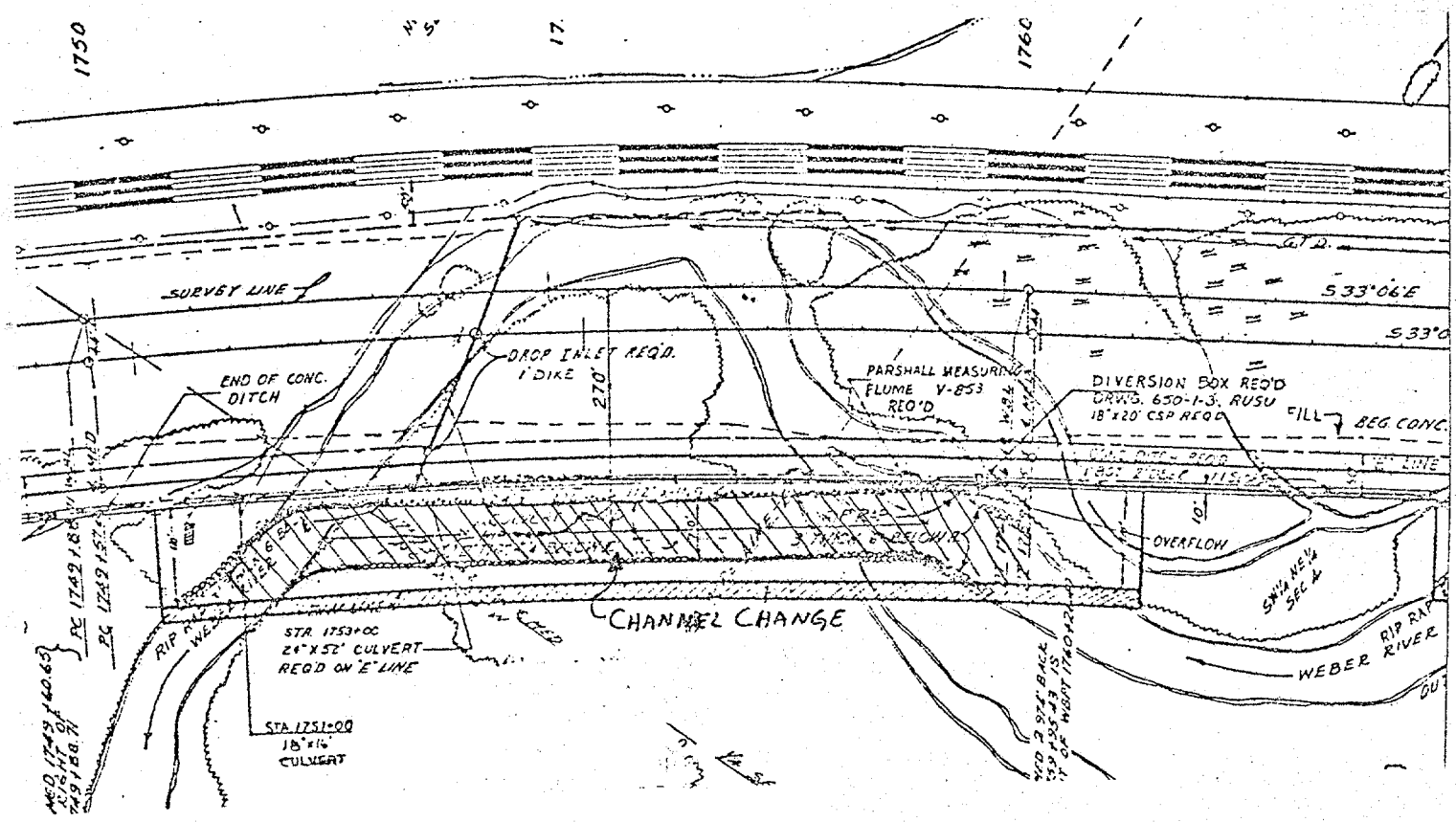


Figure 28 - Weber River near Echo, UT
Typical Channel Change

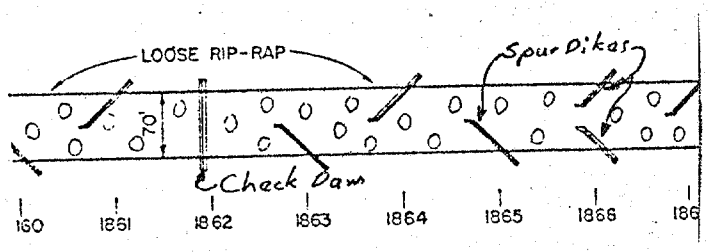


Figure 29 - Weber River near Echo, UT
Typical Stabilization
Structures

The structures used were check dams (Figure 30) and spur dikes (Figures 31 and 32) constructed out of rock filled wire gabions. To this date the stabilization structures have functioned adequately to control degradation in the river.

Discussion

After if became obvious that channel straightening would be required as part of the construction of I-80 up Weber Canyon, the Highway Department had several choices to make. They could either ignore the possibility of a degradation problem occurring and then undertake corrective measures as required or they could construct stabilization structures to prevent degradation problems prior to their occurrence.

Stream stabilization structures prevent or stop degradation by reducing the slope of the energy grade line thus reducing the sediment carrying capacity of the river and the possibilities of degradation.

A check dam performs this function by raising the bed of the channel on the upstream side thus decreasing the slope and then dissipating the elevation head created before the flow continues downstream. This energy dissipation is accomplished through turbulence in some type of stilling pool or dissipation structure.

Spur dikes decrease the stream slope in two ways. First, the length of the stream is artifically increased by causing the stream to flow around the spur dikes. Second, turbulence introduced by the presence of the spur dikes will also act to dissipate excess energy. Care must

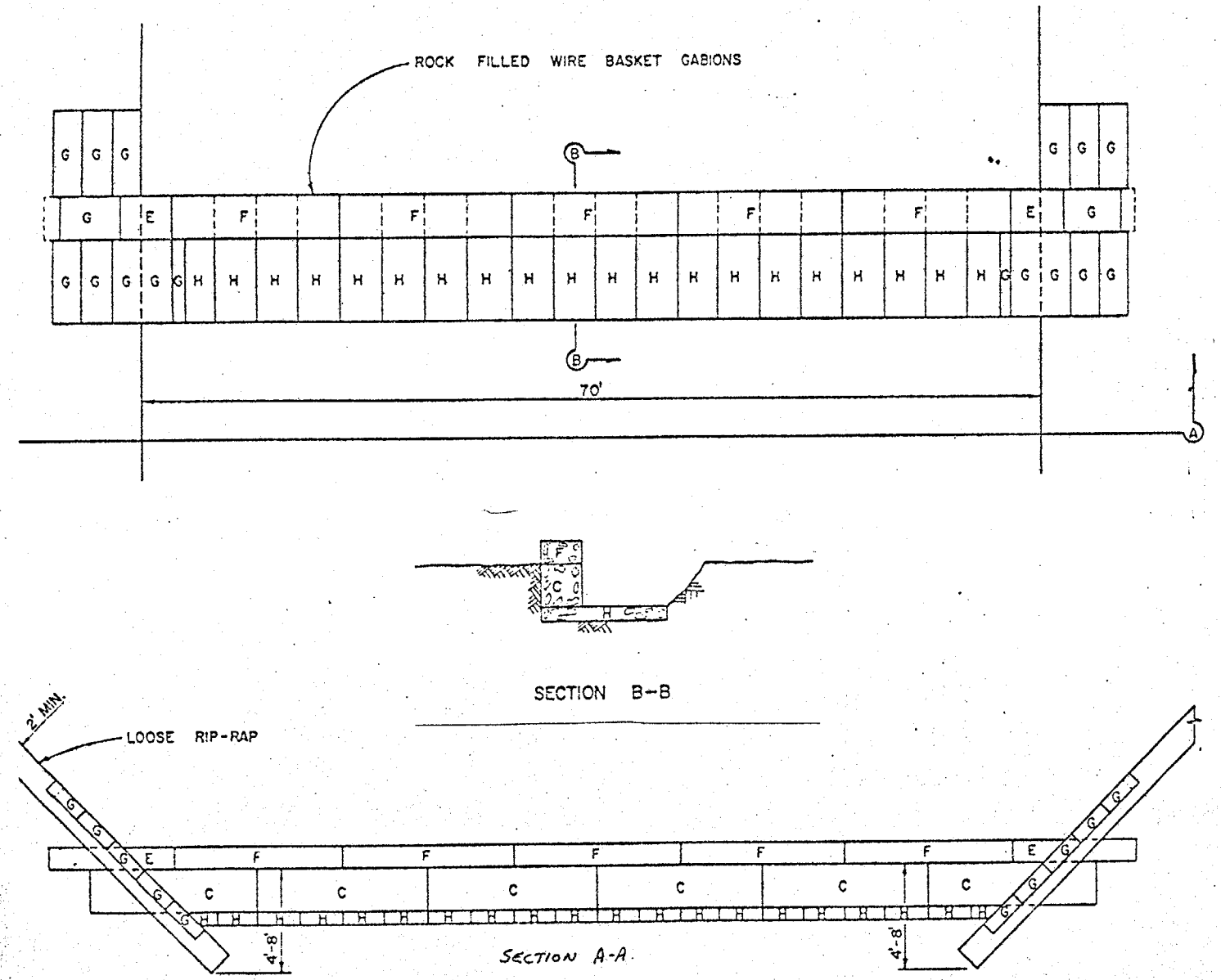
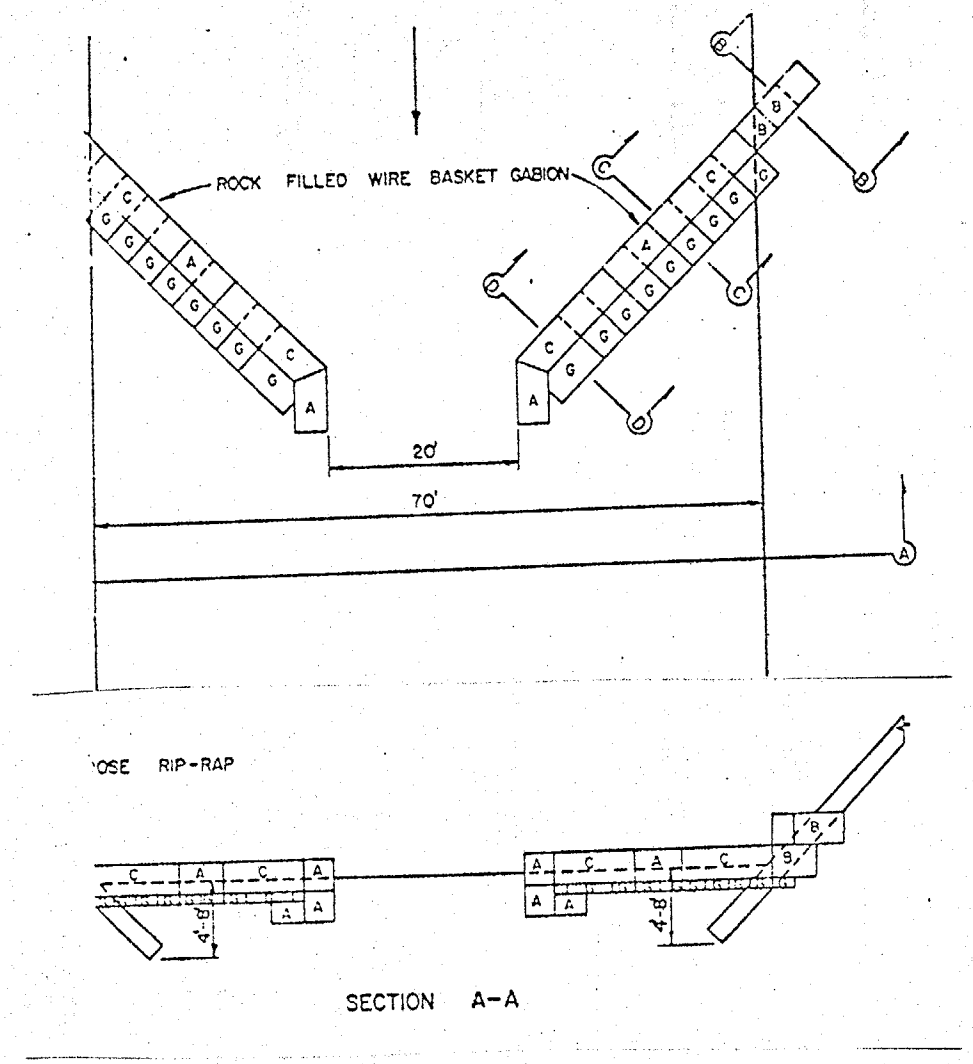


Figure 30 - Weber River near Echo, UT
Check Dam Details



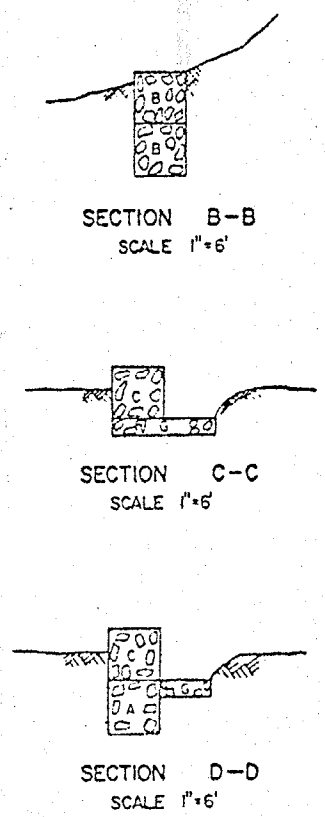


Figure 31 - Weber River near Echo, UT
Double Spur Dikes

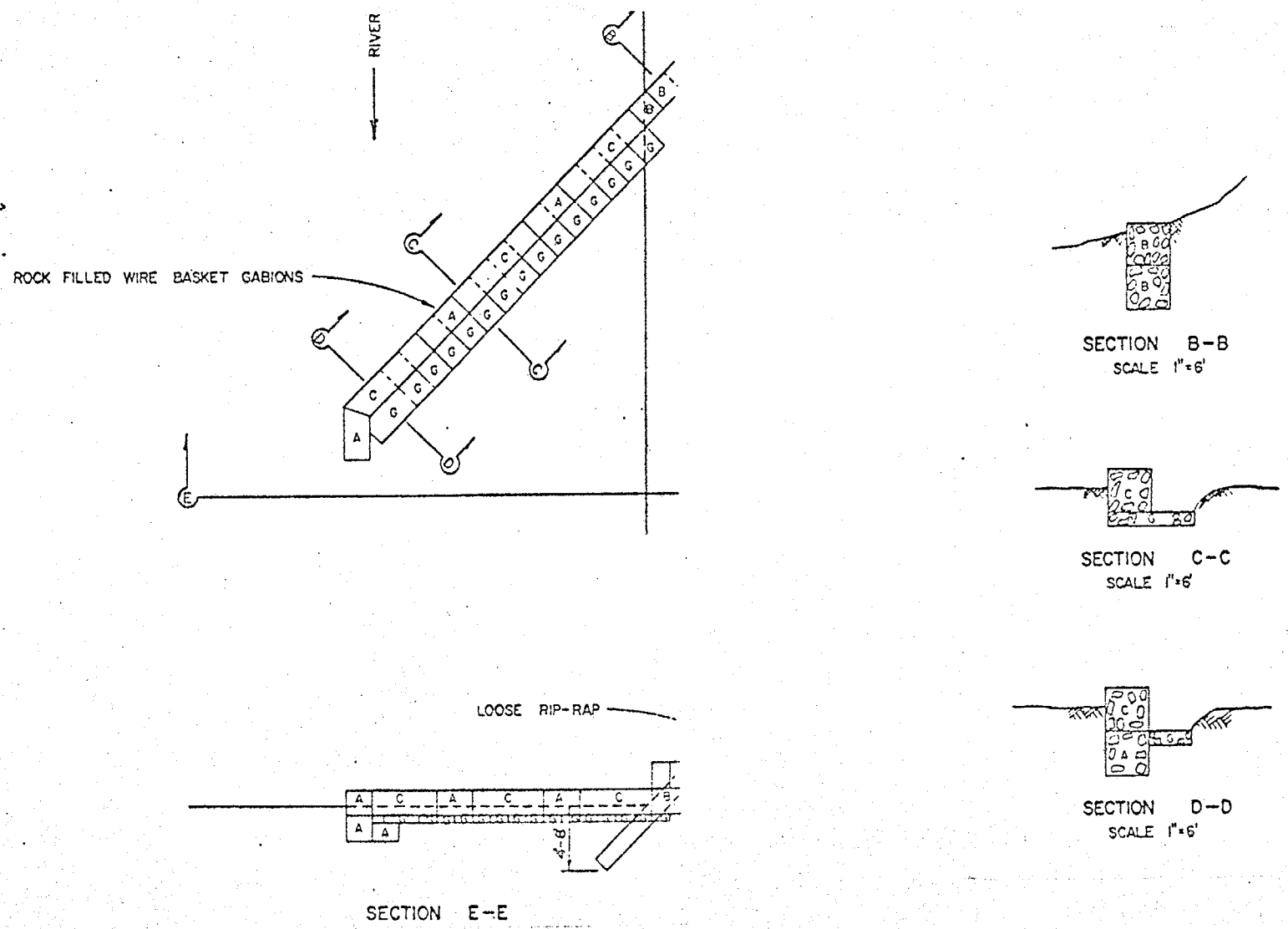


Figure 32 - Weber River near Echo, UT
Single Spur Dike

be taken with the use of spur dikes to prevent erosion of the stream banks at the points where the flow diverted by the dike impinge on the streambank. In the case of Weber River, the Highway Department stabilized the streambanks with appropriately sized riprap.

The spur dikes used function in two ways depending on the stage of the river. At low stages all of the flow will go around the dikes and will lose sediment carrying capacity by going longer distances. At high stages, however, some of the flow will still be diverted as at low stages, but the rest will go over the dike as if it were a small check dam. This design will continue to provide energy dissipation at high flows while helping to prevent serious erosion caused by high flows being totally diverted to impinge on the streambanks.

Construction of stream stabilization structures in Weber Canyon also had to take into account the fish life existing in the stream. Drop structures had to be kept low enough to allow fish movement up and down the river.

Case History 96

SALINA CREEK AT I-70 NEAR SALINA, UTAH

Description

Lat. 38° 57', Long. 111° 52'. Salina Creek in Sevier County, Utah flows southeasterly and joins the Sevier River near Salina, Utah. The drainage area is 751 square km and is very hilly to mountainous. The bed material is highly erodible being composed largely of fine sand. Salina Creek is ephemeral and flows in a channel 3-4 meters wide and 3 meters deep.

Gradation Problem

Several channel changes were made in Salina Creek, Red Creek and tributaries to allow for construction of I-70 in 1973. These changes caused higher stream slopes and resultant higher velocities and sediment carrying capacities.

Countermeasures

As a part of the construction of the channel changes, gabion drop structures and large riprap were placed in several locations to control streambed degradation (fig. 33). To date these measures have performed adequately.

Discussion

Knowing the highly erodible nature of the streambed, the Highway Department decided to take steps to control

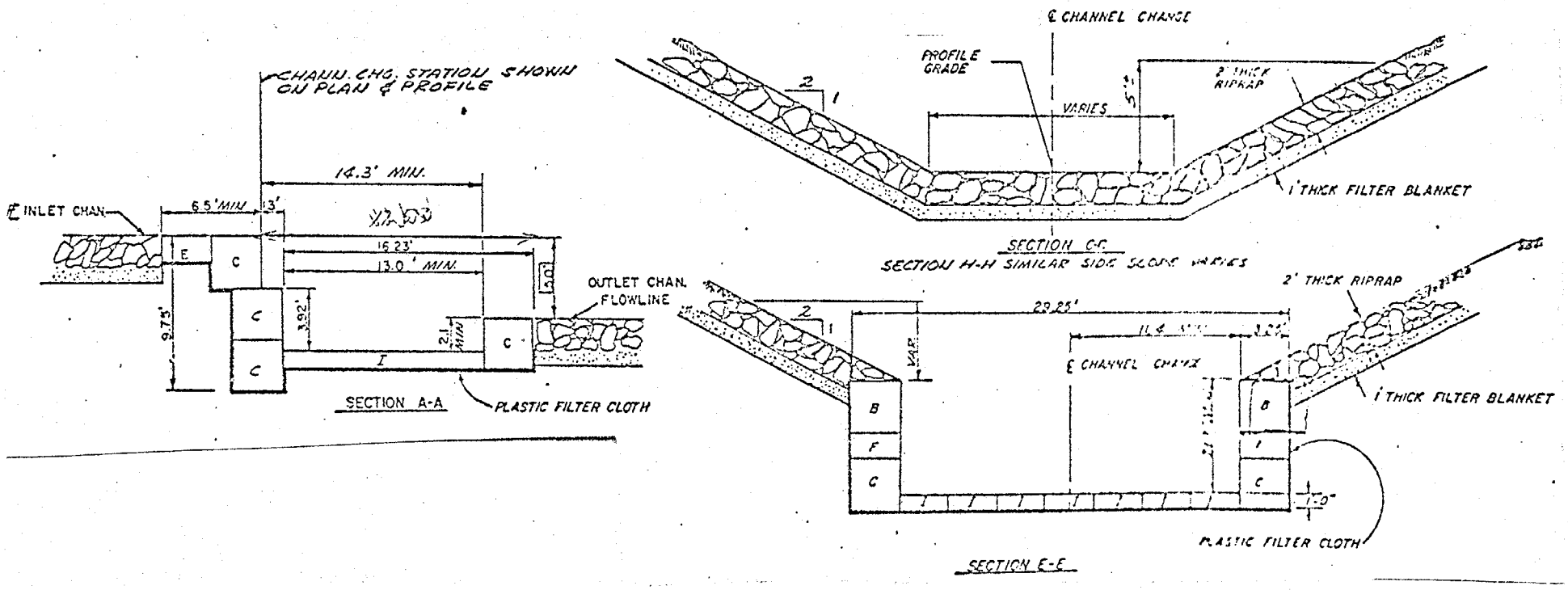


Figure 33. Salina Creek near Salina, UT - Gabion drop structure details

degradation due to the channel changes before it happened. This course is usually cost effective in the long run, it being less costly to install protective structures alone than to repain or replace a bridge and then install protective structures.

Rock filled gabions are used in many places by Utah Department of Transportation to control and prevent degradation. Although the gabions haven't been in service for a long time, records from the last 10-15 years indicate that the structures are stable and perform well.

Case History 97

VIRGIN RIVER AT I-15 NEAR BLOOMINGTON, UTAH

Description

Lat. 37° 03', Long 113° 36'. The Virgin River in Washington County, Utah flows in a southwesterly direction and joins the Colorado River at Lake Mead near Overton, Nevada. The drainage area is approximately 11650 square kms of mountainous terrain. The Virgin River is characterized by high flood peaks and sediment concentrations due to flash flood contributions from dry washes along its entire length. The streambed is composed of sand, gravel and fine silts.

Gradation Problem

The I-15 bridges over the Virgin River near Bloomington was constructed in 1962. At the present time the stream bed underneath the bridge has degraded nearly 7 feet and is undermining the pier footings.

Countermeasures

Plans for some type of stabilization-drop structure downstream from the bridges are being studied by the Department of Transportation at the present time.

Discussion

The Virgin River has not been seriously impacted by activities in the area and thus it would appear that the degradation occurring in the river is caused by natural

factors. These factors include: a) the "flashy" (high peak) nature of the Virgin River; b) the steep slope of the river; and c) the erosibility of the sandstone, sand and silts in the area.

Case History 98

EAST FORK OF THE VIRGIN RIVER AT US-89 NEAR MT. CARMEL, UTAH

Description

Lat. 37° 15', Long. 112° 40'. The East Fork of the Virgin River in Kane and Washington Counties, Utah flows southwesterly and joins the Virgin River near Rockville, Utah. The East Fork of the Virgin River flows in a deep natural channel and canyon and drains approximately 192 square kms of mountainous terrain. The areas rock formations are mostly sandstone with sand and gravel predominating the streambed.

Gradation Problem

A channel change was performed on a portion of this stream during construction of U.S. Highway 89. After construction, the new channel began to degrade to a considerable depth.

Countermeasures

A low head gabion drop structure was constructed downstream from the area of degradation. The gabion drop structure has been performing well as evidenced by the fact that the flowline of the river upstream from the structure has been raised several feet.

Discussion

The channel change shortened the length of the river, thus increasing the sediment carrying capacity of that reach of the river and reinforcing the natural tendency of the river to degrade.

ONE HUNDRED AND TWO RIVER NEAR ROSENDALE, MISSOURI

Description

Lat. 40°6', long. 94°47'. The One Hundred and Two River in Andrew and Buchanan Counties flows in a southerly direction and joins the Platte River near Easton, MO. It drains an approximate area of 1554 sq km of hilly terrain at Rosendale.

Gradation Problem

The One Hundred and Two River was straightened for 48-64 km upstream of Rosendale where the straightening ended as shown in fig. 16. In recent years the Highway Dept. has been getting complaints from residents of the area, because of increased flooding in Rosendale, supposedly caused by a channel constriction at the Highway 48 bridge over the Onehundred and Two River.

The Highway Dept. ran some valley cross-sections in the Rosendale area and discovered that channel aggradation was occurring generally in the reach. An abandoned R.R. bridge just south of Rosendale is becoming more and more of a constriction as aggradation continues in the reach. Records taken during floods show as much as 0.4 meters of head loss through the aforementioned R.R. bridge.

Countermeasures

None.

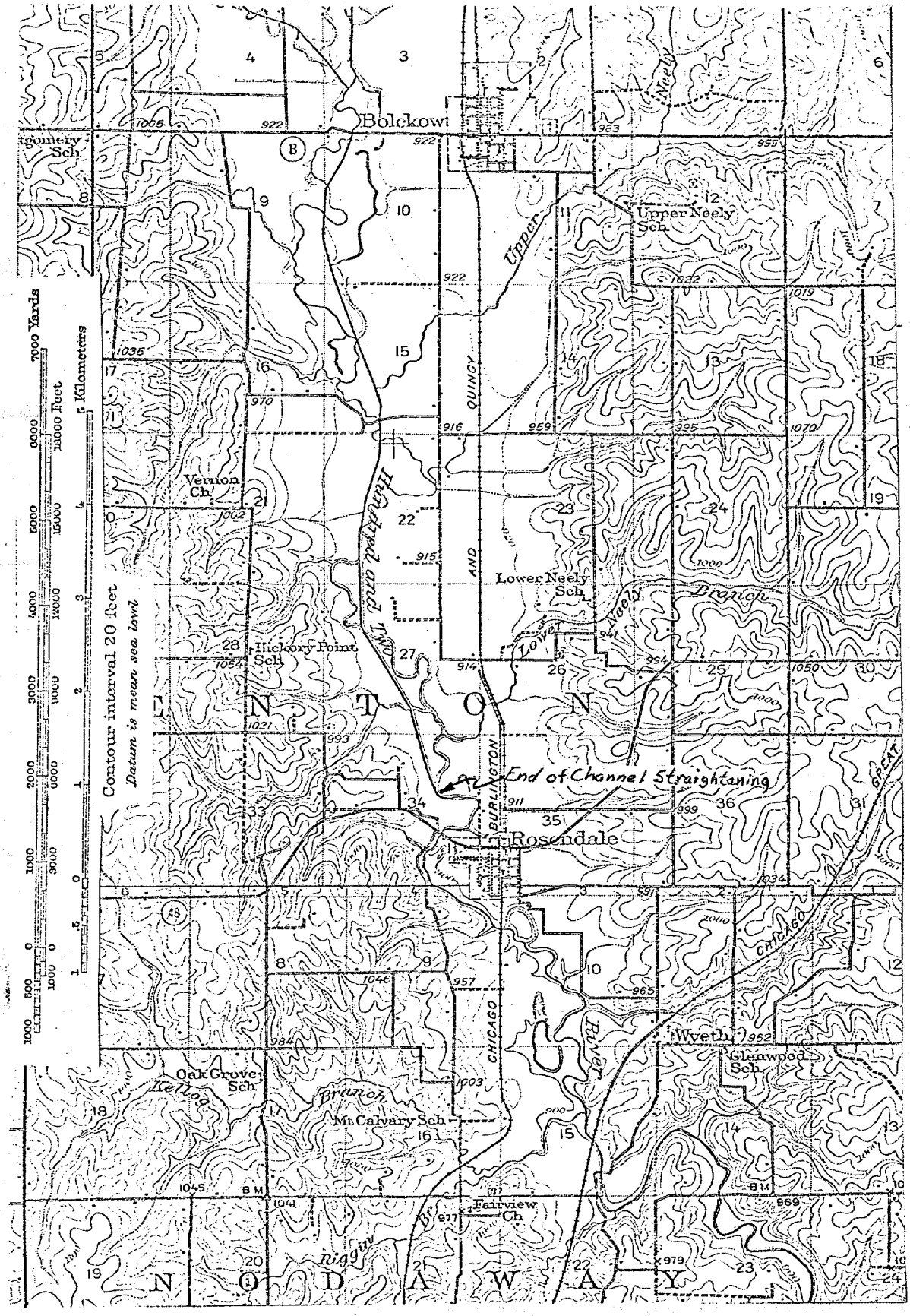


Figure 16 - 102 River near Rosendale, MO
Channel Straightening (from
U.S.G.S. Bolckow, MO 7.5' Quad)

Discussion

The channel straightening of the Onehundred and Two River increased the sediment carrying capacity of the river by increasing the slope of the channel. As the river flows enter the old channel at Rosendale, the sediment carrying capacity is less and all excess sediment drops out, thus causing the aggradation problem. In this case, the constriction caused by the abandoned R.R. bridge is compounding the aggradation problem.

Boxelder Creek at I-25 near Glenrock, Wyoming

Description:

Boxelder Creek at this location is a meandering perennial stream and locally braided with 1.5 to 3M sidecut banks. The drainage area is 440km^2 and the streambed slope is .0036 at the site. Bed material is uniformly graded from silt to large cobbles. The bank material is similar, but contains a larger percentage of clay. The main channel is to 1.5 to 3M wide, with a to 46 to 91M overbank channel. The stream flows in a valley which is predominantly hat meadow, with overlooking clay bluffs.

The bridge is a wide-flange steel girder structure supported by three concrete wall piers with spread footings. Length is 47M .

Gradation Problem:

From the original construction date in 1958, to the mid-1960's, the channel at the bridge degraded several feet, causing concern over stability of the footings. Original construction required channel modification, including the cutoff of a large meander loop downstream. The stream responded to the locally increased gradient by degrading upstream from the cutoff. The situation is currently considered stable.

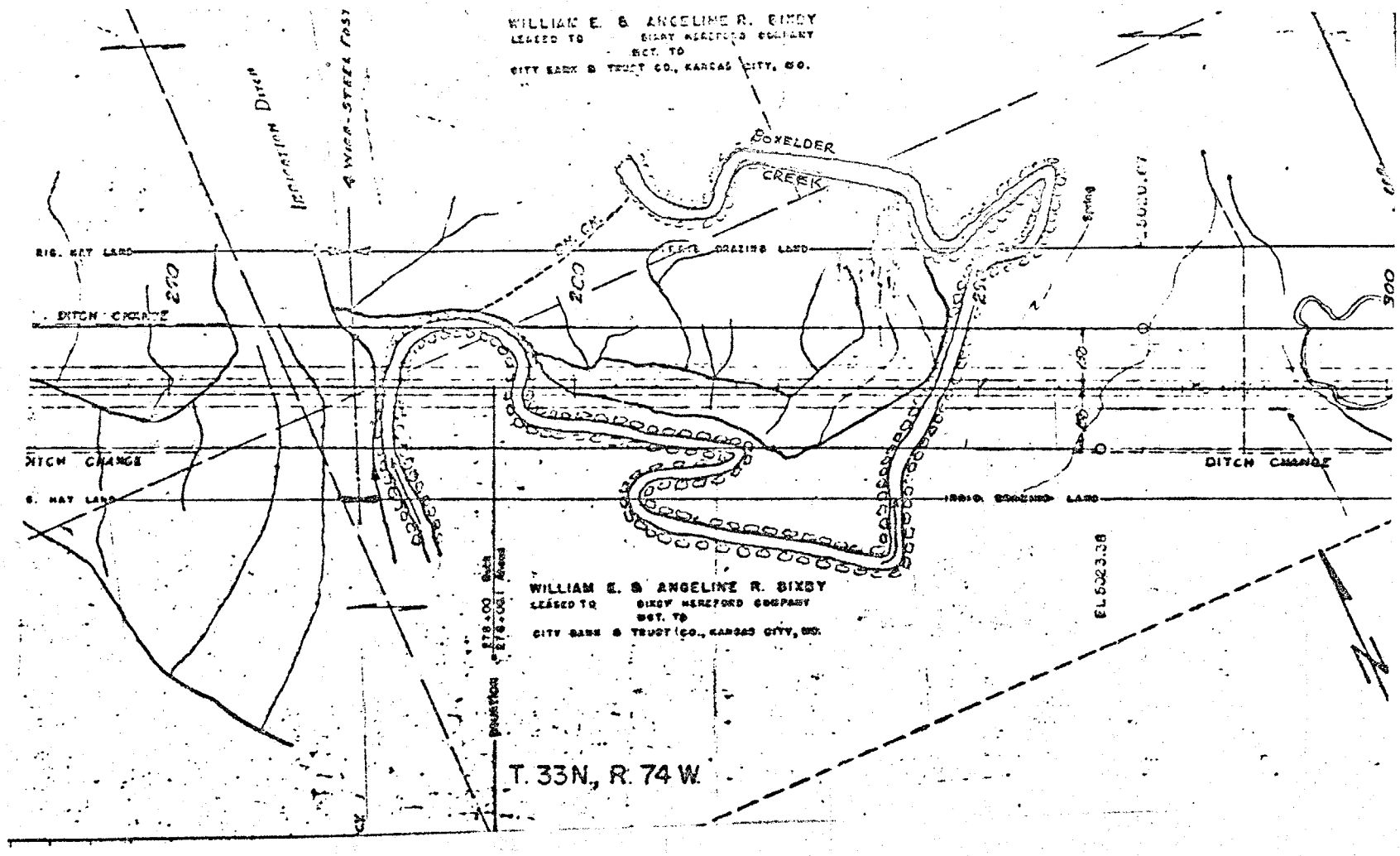
Countermeasures:

Abutments were originally protected with Class 2 rock riprap Following the degradation, banks were protected with 3M high railbank set on a 1:1 slope. A 91M spur dike was constructed along the eastern upstream bank to align the flow with the bridge. The banks are extensively revetted for about

91M downstream, where the channel makes a sharp bend to the east.

Discussion:

Precise data are unavailable for the site. District maintenance crews constructed the countermeasures and detailed chronological records of bed level changes are not available. The bank and abutment protection seem to be adequate, although a slight annual degradation trend has been noted by Wyoming highway personnel.


WILLIAM E. & ANGELINE R. BIXBY
LEASED TO BIXBY HEREFORD COMPANY
SUBT. TO
CITY BANK & TRUST CO., KANSAS CITY, MO.
BOXELDER CREEK
IRRIGATION DITCH
4 WIRE-STEEL FENCE
BIG. HAY LAND
DITCH CHANGE
DITCH CHANGE
DITCH CHANGE
IRRIG. GRAZING LAND
Spring
EL. 5023.38
WILLIAM E. & ANGELINE R. BIXBY
LEASED TO BIXBY HEREFORD COMPANY
SUBT. TO
CITY BANK & TRUST CO., KANSAS CITY, MO.
T. 33N., R. 74 W.

Case History 100

Carpenter Creek at SR 192 near Sussex, Wyoming

Description:

With a drainage area of approximately 30 km^2, Carpenter Creek is perennial, with predominant spring runoff peaks. The main channel is sinuous, 3 to 6M wide, with a 23 to 46M overbank channel. Banks are generally steep, 3 to 6M high, and sidecut. The stream drains into the Powder River about 1.6km downstream from the bridge site. The upstream watershed is rolling to rugged prairie hills. Bed material is composed of sand and silt and the bank material clay, silt and gravel, with stratified veins of coarse gravel. The bed slope at the site is approximately 0.0076. The bridge is prestressed concrete girders supported by concrete pile bents, and has a length of 35M.

Gradation Problem:

Progressive headcutting has caused the bed to degrade from 1956 to 1963. All bank and abutment protection was lost, and some pile tips were exposed. Abutment slopes were nearly vertical. The bed has continued to degrade annually since installation of countermeasures in 1963-64.

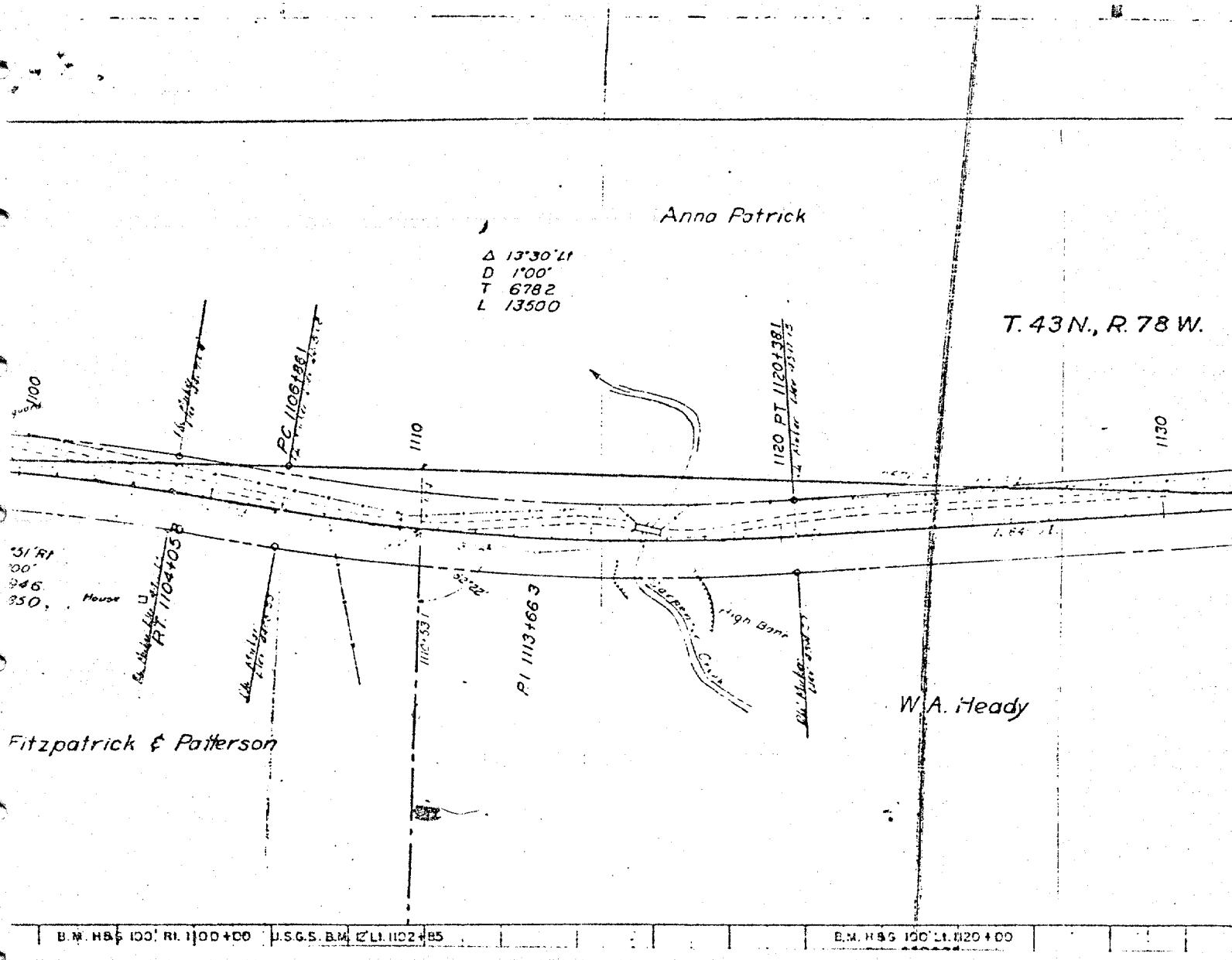
Countermeasures:

Originally, abutment slopes were protected with standard spill slope riprap. Construction cross-section closely matched the existing stream, with very little excavation required. The possibility of a degradaing channel was not considered during original design. In 1963, Wyoming highwat design personnel estimated maximum future degradation by extending the natural slope (.0076) upstream from the furthest downstream headcut. Articulated

wire-enclosed riprap baskets were then constructed which protected piers, abutments, and approach slopes down to the projected degradation level.

Discussion:

Detailed records of bed level changes are not available though the countermeasures have effectively protected the bridge. The channel has degraded about 3M since 1964, and there are headcuts downstream from the bridge.


Anna Patrick
Δ 13°30' Lt
D 1°00'
T 6782
L 13500
T. 43 N., R. 78 W.
PC 1106+38.1
1110
1120 PT 1120+38.1
1130
PT 1104+05.8
House
PI 1113+66.3
High Bank
W. A. Heady
Fitzpatrick & Patterson
B.M. H&G 100' Rt. 1100+00
U.S.G.S. B.M. 12' Lt. 1102+85
B.M. H&G 100' Lt. 1120+00

Case History 101

Cole Creek at SR 192 near Sussex, Wyoming

Description:

This bridge site has a drainage area of approximately 9km^2 and a channel slope of approximately 0.0105. The stream is ephemeral, with a peak design discharge of 53.8cms The drainage basin is rolling to rugged prairie with short grass covering the mild slopes. At present, the channel in the vicinity of the bridge is ill-defined and erosion control activity has changed the natural stream into a series of grass-covered draws.

The bridge is a prestressed concrete girder structure supported by three CIP concrete pile bents. Abutments are protected by Class 1 spill slope riprap, and the bridge length is approximately 27M.

Gradation Problem:

Prior to 1950, the stream experienced severe degradation druing spring runoffs. In the early 1950s', the adjacent landowner constructed a series of stock dams upstream and downstream from the bridge. This reversed the degradation trend, and caused the channel to aggrade into a grass-covered draw. There is still a large gulley downstream from the crossing which empties into the Powder River, apparently acting as a wasteway for flows which top the emergency spillways of the reservoirs.

In 1956, the present bridge was constructed in conjunction with the new road (SR192). During construction the downstream dam was breached and the channel excavated, to improve the conveyance at the crossing. The state was then required to replace the dam. At present, the bed is about 3M below the bridge

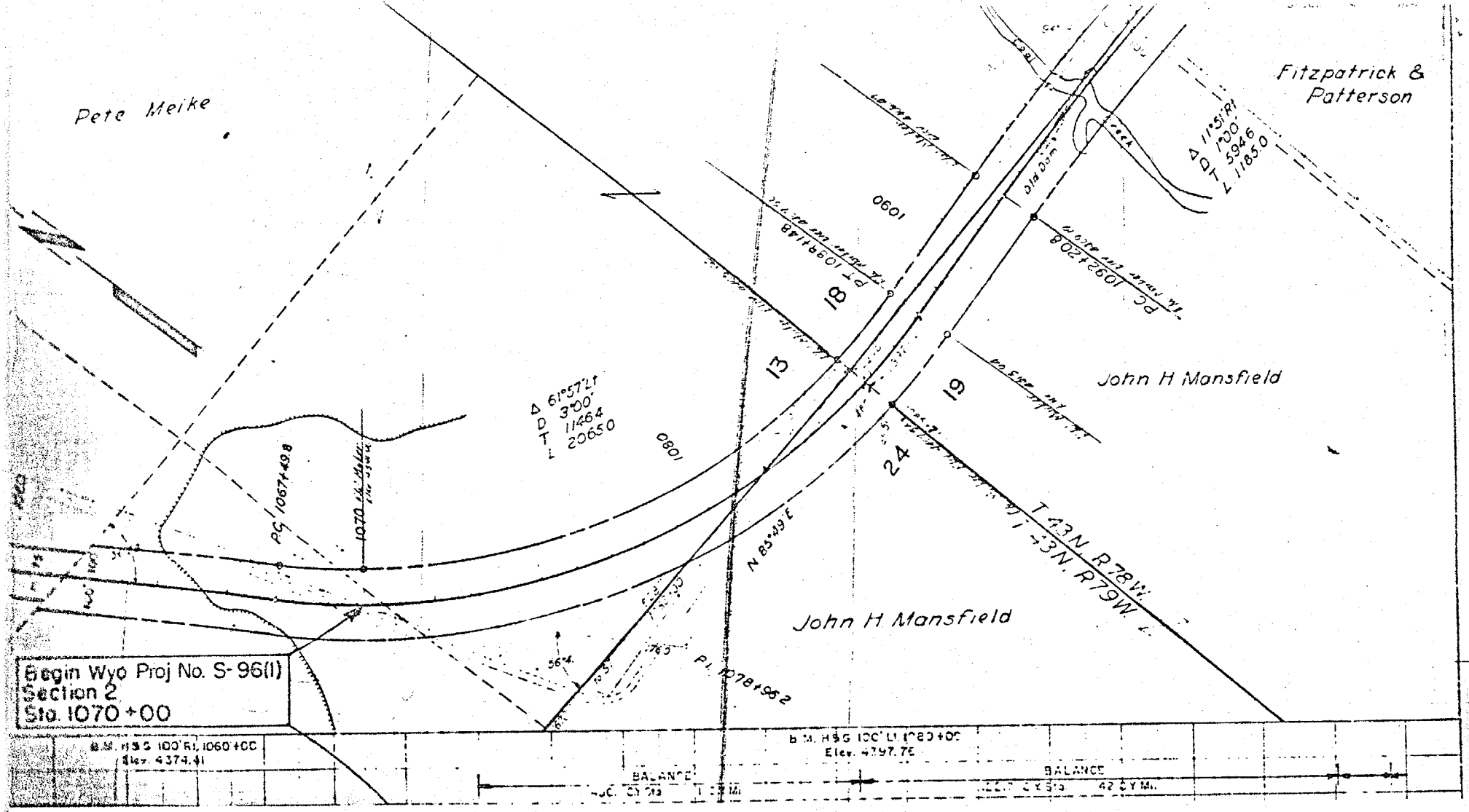
girders. Upstream and downstream overbank channels are 46M wide, and to 0.6 to 1M deep. The bed has covered the original abutment slope protection.

Countermeasures:

No countermeasures have been undertaken at this site.

Discussion:

There is no detailed information available. The erosion protection dams have accomplished the objective of reclaiming a degrading stream into pastureland. This activity has also severely reduced conveyance at the bridge site. If the upstream dams were overtopped during a large event, the bridge and roadway would probably be overtopped.


Pete Meike
Fitzpatrick & Patterson
John H Mansfield
John H Mansfield
T 43N R 78W
T 43N R 79W
Begin Wyo Proj No. S-96(1)
Section 2
Sta. 1070 +00
BALANCE
BALANCE

Unnamed Draw on Kaycee-Mayoworth Road near Kaycee, Wyoming

Description:

This Unnamed Draw is a meandering channel that is a tributary to the Powder River. The inlet is designed with 4M drop, sufficient to bring the flow in the barrel to a supercritical condition. The channel then flows through a 91.44M rock-lined trapezoidal channel, passes through a baffled chute drop structure and flows in an unlined channel 274.32M to the Powder River.

The draw drains a 12.95km^2 area of rolling prairie. Vegetation is primarily buffalo grass.

The structure is a double 2.13 x 2.13M culvert.

Gradation Problem:

The original construction in 1969 replaced a previous culvert which had been insufficient to pass the annual peak flow. As of 1979, the downstream reach to the Powder River has degraded some 2.44 to 3.05M and there is still frequent overtopping of the structure. Undermining is also occuring in the channel between the culvert and the drop structure.

Countermeasures:

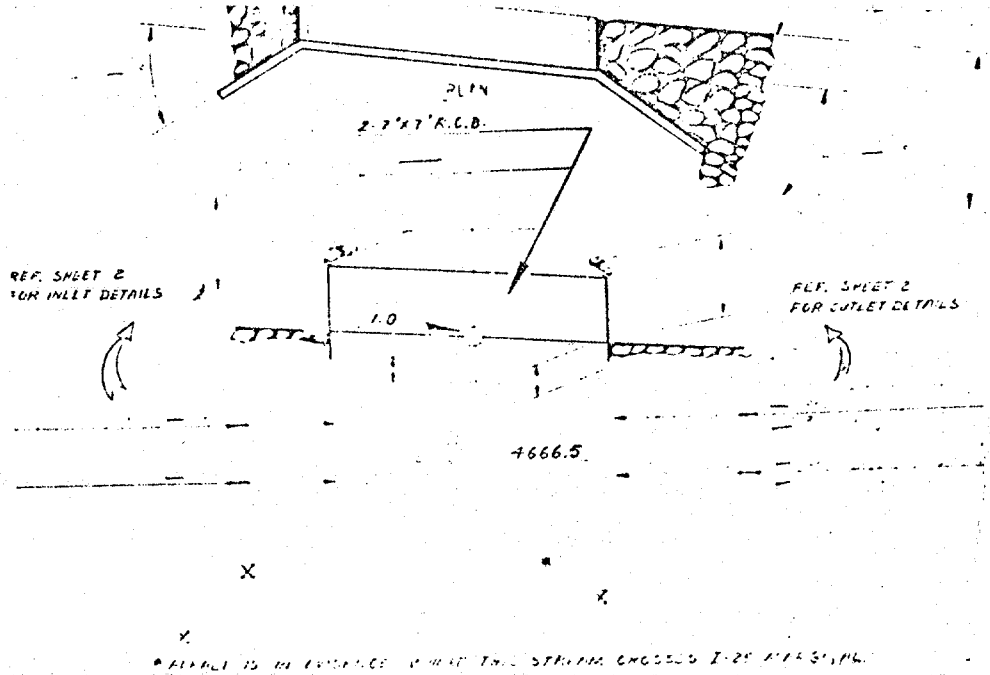
In 1972, a large flood washed out the trapezoidal concrete-lined section. The channel was re-emplaced using .61 x 2.44M rounded rock rip-rap with woven wire mesh apron (railbank)

Discussion:

As previously mentioned, the degradation originally anticipated has already been exceeded. The following was extracted from the 1969 plan notes.

> "The current channel is aggrading immediately upstream from and as direct result of the existing culvert resulting in a silting problem at that culvert ... The proposed construction anticipates improving the silt passing capacity at this site. The downstream channel change (beyond the concrete lining) is anticipated to degrade however, the possibility of a stable or slightly aggrading channel exists depending on future vegetal growth and maintenance."

Although precise data are not available, details of the trapezoidal channel and drop structure, site layout, a hydrologic review, the original longitudinal profile, and recent slides are available.



* FLOWLINE IS IN ALIGNMENT WHERE THE STREAM CROSSES I-25 APPROACHING

STREAM DATA

NATURAL

5 — SQ. MI.

6.7 TO 5.3

LOOSE, ERODIBLE SILTS

2.7

BRUSH & DEBRIS

0

4.2

13.6

10.1

1.477

DESIGN

50

900

WRD REGIONAL CURVES

2-7'x7' RCCB KAPPS

4.74 C

EXCEED PASTURE LAND

19

2-7'x7' RCB

* THE CURRENT CHANNEL IS AGGRADING IMMEDIATELY UPSTREAM FROM & AS A DIRECT RESULT OF THE EXISTING CULVERT RESULTING IN A SIZING PROBLEM AT THAT CULVERT. A DEGRADING SITUATION IS OCCURING AT THE DAM AS A RESULT OF THE EARTH DAM HAVING BEEN BREACHED. THE PROPOSED CONSTRUCTION ANTICIPATES IMPROVING THE SILT PASSING CAPACITY AT THIS SITE. THE DOWNSTREAM CHANNEL CHANGE (BEYOND THE CONCRETE LINING) IS ANTICIPATED TO DEGRADE HOWEVER, THE POSSIBILITY OF A STABLE OR SLIGHTLY AGGRADING CHANNEL EXISTS DEPENDING ON FUTURE VEGETAL GROWTH AND MAINTENANCE.

WYOMING HIGHWAY DEPARTMENT

(WEST OF STA 150, KAYCEE MAINLINE)

STA 15+00.00

KAYCEE - MAYOWORTH ROAD

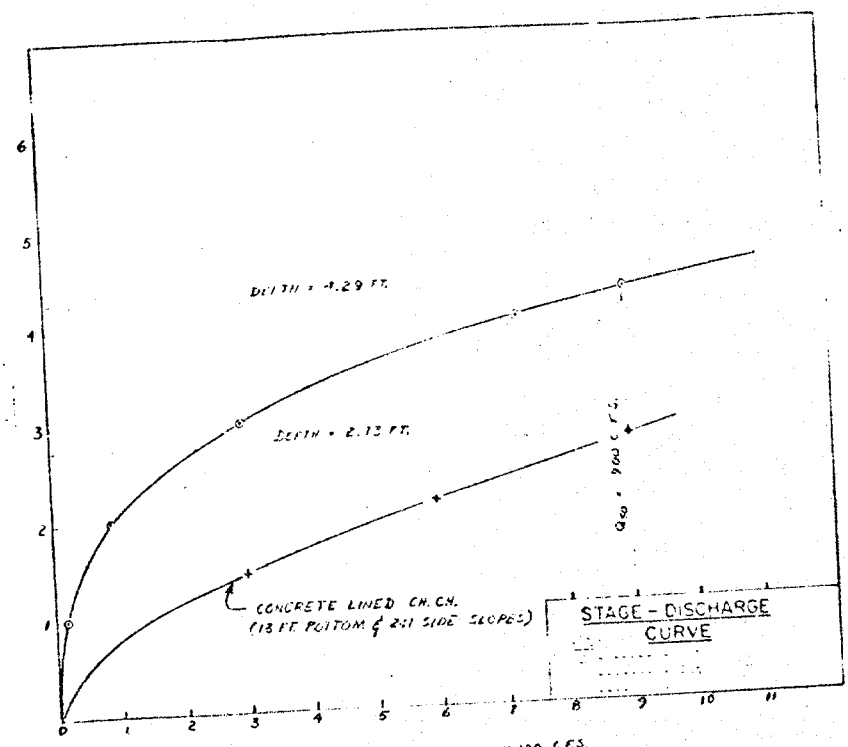
I-25-5(16) JOHNSON

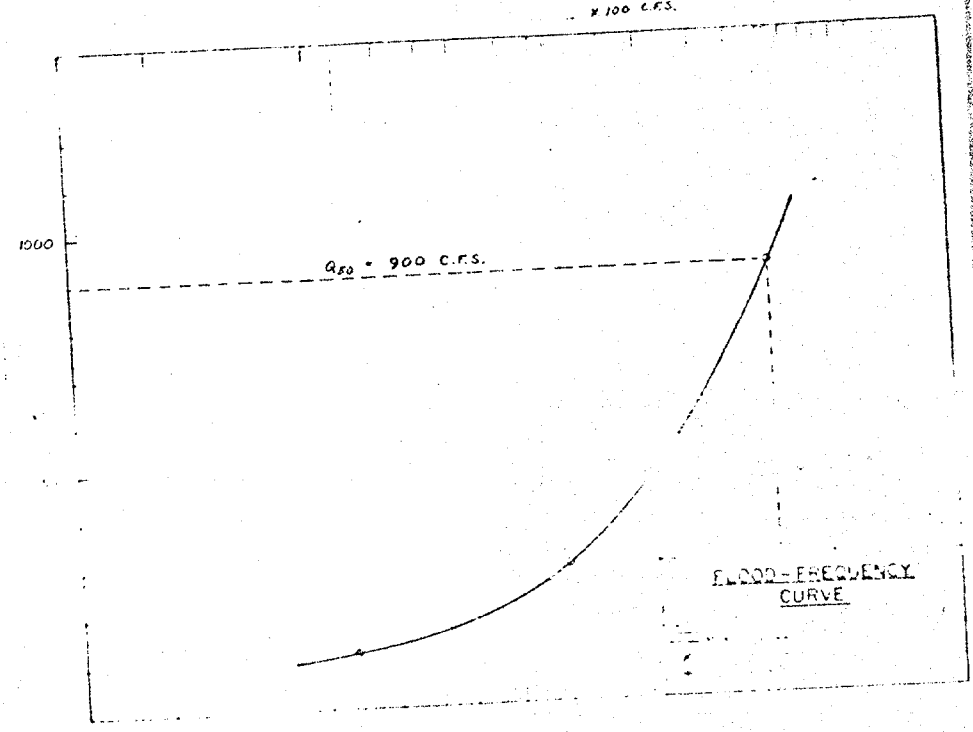
LES

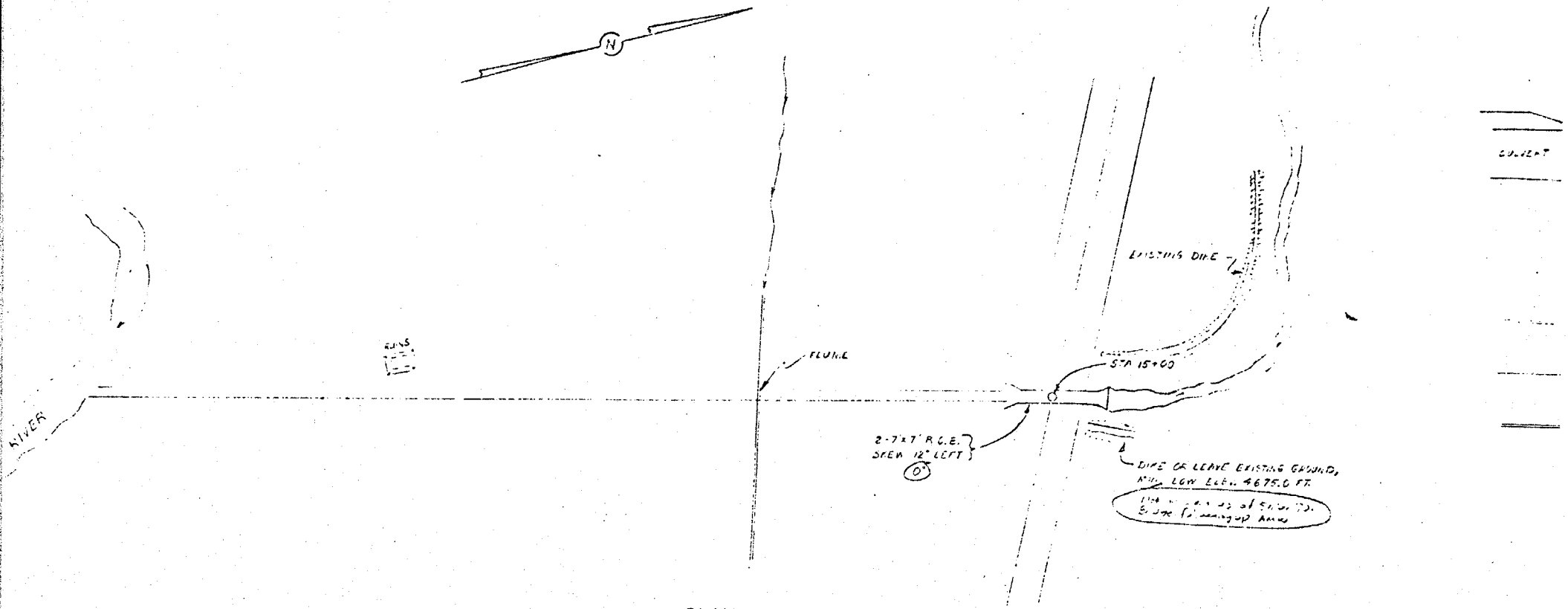
LES

DWG. No

SHEET 1 of 3


DEPTH = 4.29 FT.
DEPTH = 2.13 FT.
CONCRETE LINED CH. CH.
(13 FT. BOTTOM & 2:1 SIDE SLOPES)
STAGE - DISCHARGE CURVE
x 100 C.F.S.


1000
Q_{50} = 900 C.F.S.
FLOOD - FREQUENCY CURVE


N
RIVER
RUINS
FLUME
EXISTING DIKE
STA 15+00
2-7'x7' R.C.E.
SKEW 12° LEFT
0°
DIKE OR LEAVE EXISTING GROUND,
LOW ELEV. 4675.0 FT.
CULVERT

PLAN VIEW

Case History 103

Elk Creek at SR789 near Basin, Wyoming

Description:

The channel at this location is meandering and braided, with to 2.44 to 3.05M sidecut banks. The main channel is 1.83 to 3.05M wide with a broad overbank plain 91.44 to 914.40M . The bed material is primarily sand and silt and the bank material is silt, sand and clay. The channel is overlooked by sand bluffs on the north and south.

The bridge is prestressed concrete girder supported by concrete piers with spread footings and an overall length of 38.4M The clear span is 8.08M . There is a gabion drop just downstream of the bridge and a scour hole below the drop that is armored with 10.05 to 30.48cm concrete fragments.

Gradation Problem:

Between 1956, the date of original construction, and 1970, the bed at the bridge degraded approximately 3.05M . Headcutting was a major problem to the pier footings and abutments.

Countermeasures:

At the date of construction, a great deal of channel reworking was performed. This included meander cutoff and channel narrowing at the bridge site. The interior piers were protected with Class 1 rip-rap, 30.48cm thick.

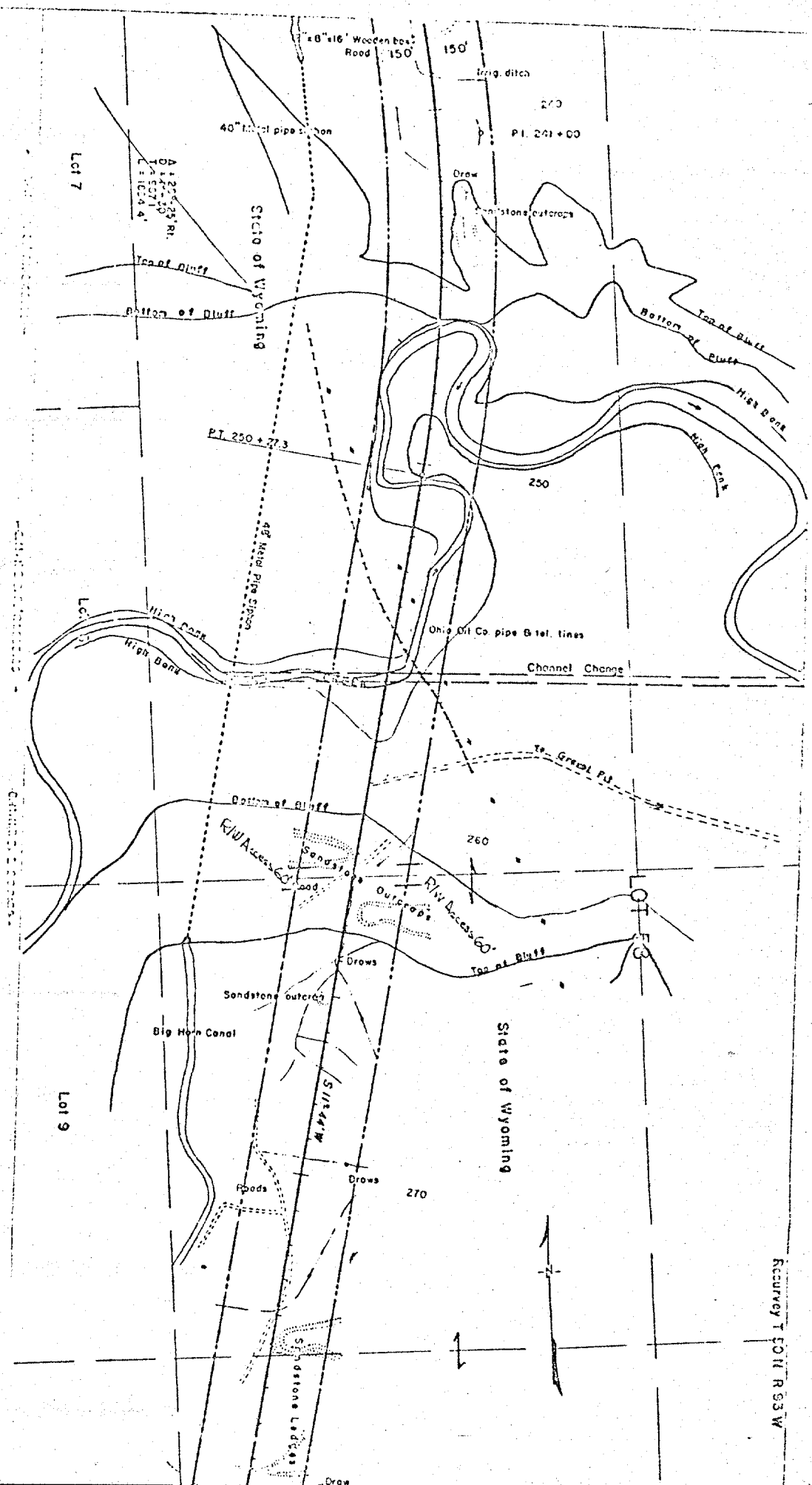
As a result of extensive successive headcuts, the pier footings were exposed and abutment protection destroyed. In 1971, the abutments were repaired and protected by 2.44M retaining walls made of cobbles and boulders, held in place by steel cyclone

fencing and rails. This doubled the channel width at the crossing. A drop structure, made of 20.32cm x 20.32cm treated timber planks and held in place by 25.40cm I-beams driven .91M to 2.13M into the channel bed, was emplaced 3.05M downstream of the bridge.

Discussion:

No major problems have been encountered since the 1971 remedial measures. The problems encountered appear to have been caused by the extensive channel realignment and by trying to fit a trapezoidal section to the design discharge at the crossing.

Available documentation includes recent slides, channel modification plan, bridge plans and foundation borings.


Lot 7
Lot 9
State of Wyoming
State of Wyoming
Top of Bluff
Bottom of Bluff
Top of Bluff
Bottom of Bluff
Top of Bluff
Bottom of Bluff
Top of Bluff
Drow
Sandstone outcrops
P.I. 241 + 00
P.T. 250 + 27.3
250
260
270
High Bank
High Bank
High Bank
High Bank
Ohio Oil Co. pipe & tel. lines
Channel Change
To Gravel Pit
R/W Access 60'
R/W Access 60'
Sandstone Outcrops
Drows
Sandstone outcrop
Big Horn Canal
Roads
Drows
Sandstone Ledges
Drow
Accurvey T 50 N R 93 W

Case History 104

Alkali Creek at Ralston-Badger Basin Rd. near Powell, Wyoming

Description:

Alkali Creek is a perennial stream that drains a 90.65km^2 area of foothils and irrigated farmland. The channel is sinuous with 3.05 to 4.57M sloping banks. The channel slope at the site is .013. The water usually flows clear with the bed material being gravel and covvle with evidence of natural armoring. The bank material is silt, gravel and cobbles, and the upstream banks are somewhat protected by small willows

The bridge itself is prestressed concrete girders supported by concrete piers that bear on treated timber piles. The overall lenfth is 20.42M with a clear span of 7.62M . There are impovised drop structures downstream of the bridge.

Gradation Problem:

By 1971, 14 years after the original construction, the channel had degraded approximately 1.83M . State hydraulic personnel suspect that releases from a large upstream irrigation canal may have caused this.

There is evidence of sidecutting on the banks and the abutment footings have been exposed to the present degraded configuration, due to the 1:1 abutment slope.

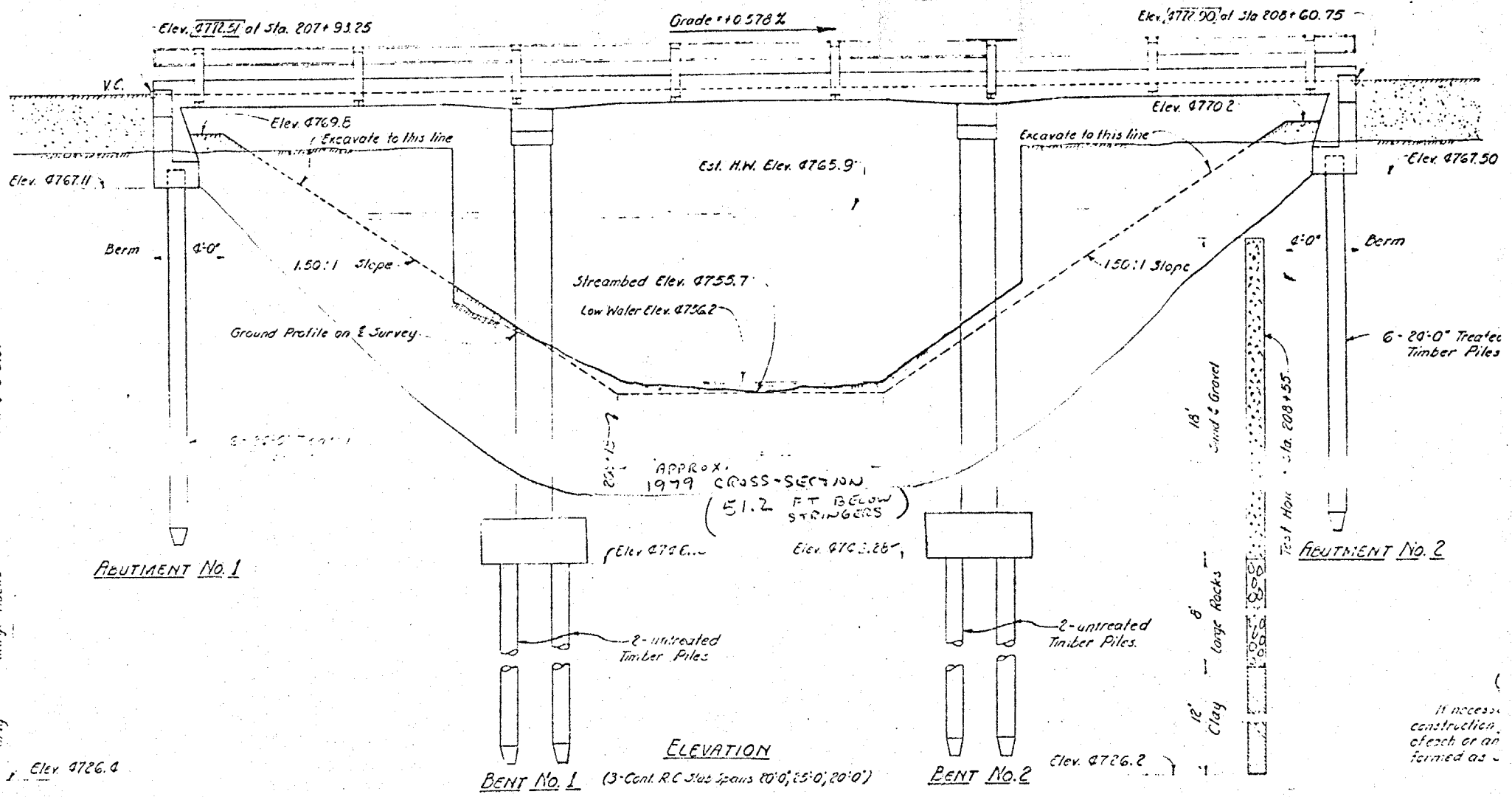
Countermeasures:

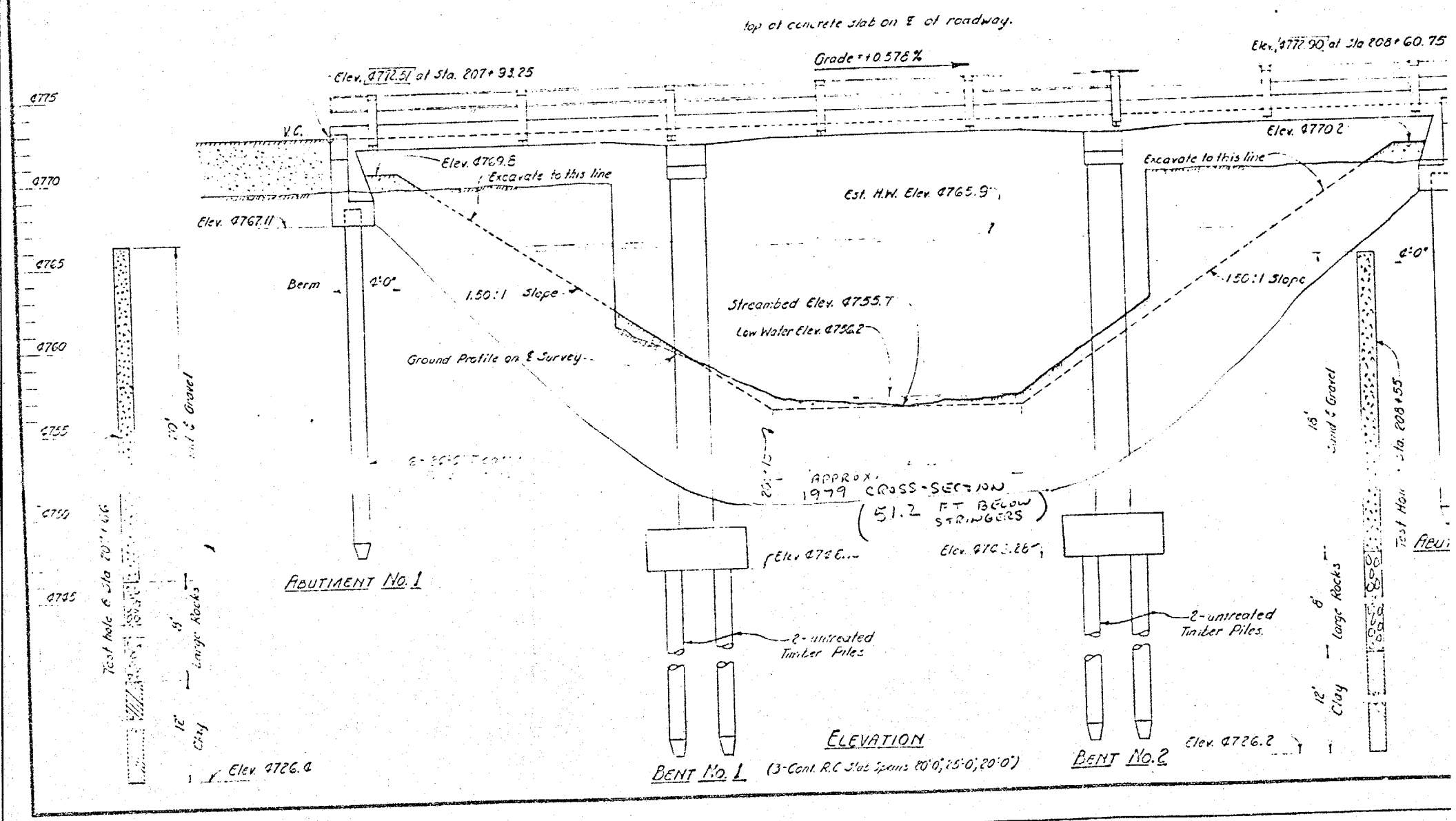
The state has contracted repairs to the abutments and installation of a gabion drop structure just downstream. The abutment fill will be set on a 1.5:1 slope and the channel raised 3.96M at the bridge.

Discussion:

It is anticipated that the drop structure will stabilize the bed at its present level.

Available documentation includes recent slides, original plans with approximately current cross sections and core samples results at each abutment.


Elev. 4772.51 at Sta. 207+93.25
Grade = +0.578%
Elev. 4772.90 at Sta 208+60.75
V.C.
Elev. 4769.5
Excavate to this line
Elev. 4770.2
Excavate to this line
Elev. 4767.11
Est. H.W. Elev. 4765.9
Elev. 4767.50
Berm
4'-0"
1.50:1 Slope
Streambed Elev. 4755.7
Low Water Elev. 4756.2
1.50:1 Slope
4'-0"
Berm
Ground Profile on ℄ Survey
6 - 20'-0" Treated Timber Piles
Sand & Gravel
18'
Test Hole Sta. 208+55
APPROX. 1979 CROSS-SECTION
(51.2 FT BELOW STRINGERS)
ABUTMENT No. 1
ABUTMENT No. 2
Large Rocks
8'
Clay
12'
2-untreated Timber Piles
2-untreated Timber Piles.
ELEVATION
BENT No. 1
(3-Cont. R.C. Slab Spans 20'-0", 25'-0", 20'-0")
BENT No. 2
Elev. 4726.4
Elev. 4726.2


top of concrete slab on ℄ of roadway.
Grade = +0.576%
Elev. 4772.51 at Sta. 207+93.25
Elev. 4772.90 at Sta 208+60.75
4775
4770
4765
4760
4755
4750
4745
V.C.
Elev. 4769.5
Excavate to this line
Elev. 4767.11
Est. H.W. Elev. 4765.9
Elev. 4770.2
Excavate to this line
Berm
4'-0"
1.50:1 Slope
Streambed Elev. 4755.7
Low Water Elev. 4754.2
Ground Profile on ℄ Survey
1.50:1 Slope
4'-0"
APPROX. 1979 CROSS-SECTION
(51.2 FT BELOW STRINGERS)
Elev. 4726.6
Elev. 4726.2
ABUTMENT No. 1
2-untreated Timber Piles
2-untreated Timber Piles
BENT No. 1
BENT No. 2
ELEVATION
(3-Cont. R.C Slab Spans 20'-0", 25'-0", 20'-0")
Test hole ℄ Sta 207+66
19' Sand & Gravel
9' Large Rocks
12' Clay
Elev. 4726.6
18' Sand & Gravel
8' Large Rocks
12' Clay
Test Hole Sta. 208+55
ABUT

Case History 105

Old Badwater Bridge over Badwater Creek near Shoshone, Wyoming

Description:

The bridge site is located on the arid plains of Central Wyoming, approximately 1.61km upstream from Boysen Reservoir. The stream is emphemeral and meandering, and has an approximate bed slope of 0.003 at the site. The bed material is cohesive and the bank material is snad. The soil in the general vicinity is mainly fine sand of silty nature with flat pieces of sandstone and shale mixed in. The north bank is a high sandstone sliff and the south, gentle sloping ground. The watershed area is 2123.8km^2

The original bridge was made of wood with 9 piers (visible) and a clear span of approximately 9.14M .

Gradation Problem:

By 1964, the channel bed had aggraded to within 3.35 to 3.66M of the stringers and by 1979, the bed was .61 to .91M below the stringers. In recent years, ice has formed to such an extent that the stringers have been lifted off the piers.

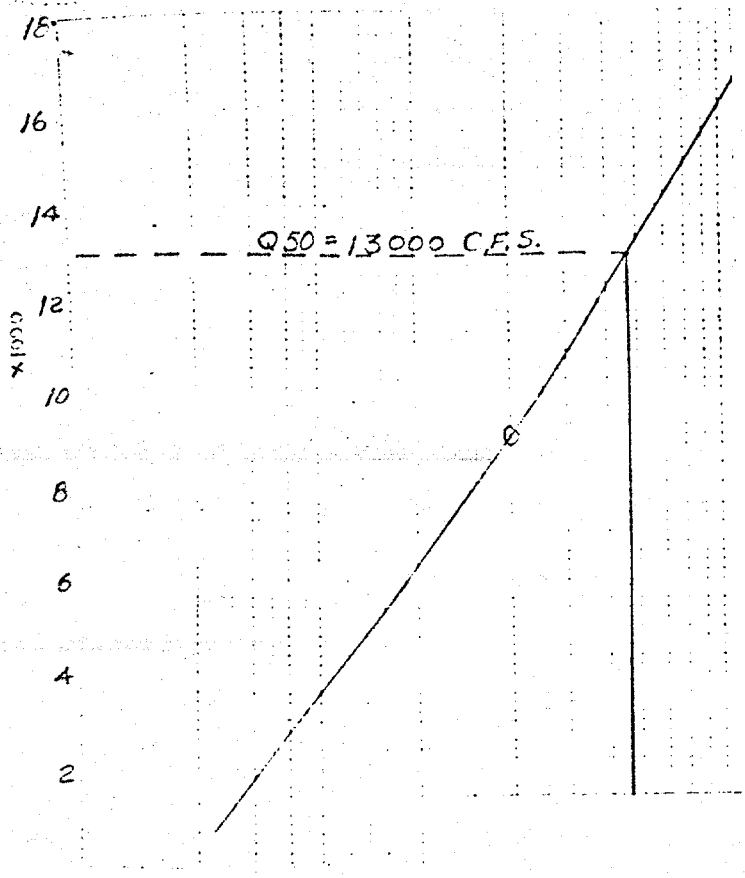
Countermeasures:

No substantial measures have been taken to improve the aggradation problem at this site. The bridge has been replaced however, and a new bridge site located upstream of this site. The new bridge was built considerably higher and longer than the old, in an attempt to accomodate for future bed level changes.

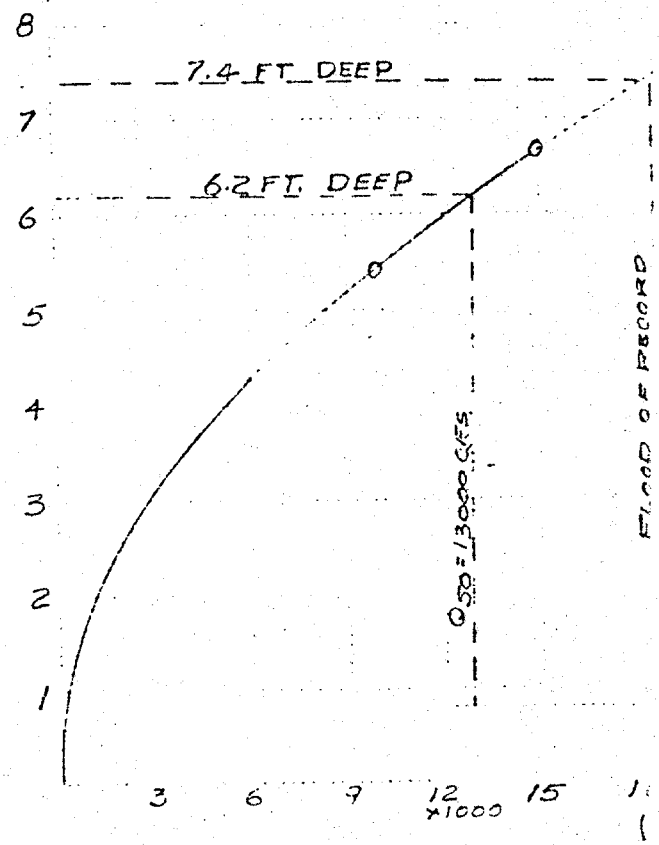
Discussion:

Carl Freeman, the district maintenance supervisor, discussed the history of the old bridge. From his experience of 15 years wokking on the structure, the bed has aggraded some 2.44 to 2.72M . He asid that at the new bridge site there is no visible aggradation, the site apparently being above the reservoir backwater effect. Thalweg approaches the bridge at about 80° - 90° angle deflecting off the sandstone cliff. Mr Freeman also indicated that he expects the old bridge to wash out during the next major event.

Available documentation includes recent slides, and plan and profile sheet, plans for the upstream replacement bridge and a stream hydraulic analysis.



820
2560 87
USGS REPORT
DRY
FLOOD OF RECORD = 18600 C.F.S.



(2)

(1) FROM USGS REPORT
(2) NO E-65 TO OBTAIN THIS INFO FROM ENGINEER, HOWEVER ICE BUILD-UP TO BE SEVERE.

820
0.30

LARGE TREES & LOGS
DRY
4746.5
11.1
5.2

57
13,000

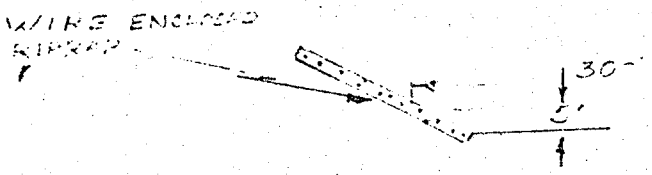
USGS REPORT
CONSTRICTED
4748.17
TREES & BRUSH ON
CHANNEL BANK

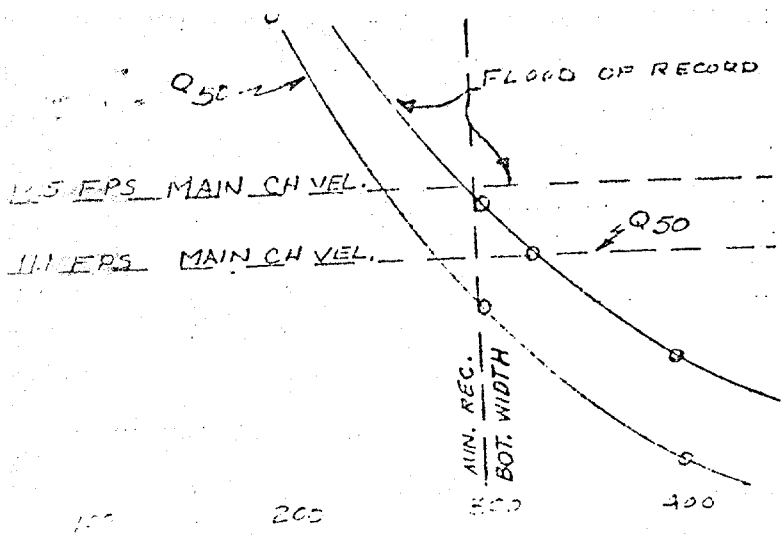
10.0

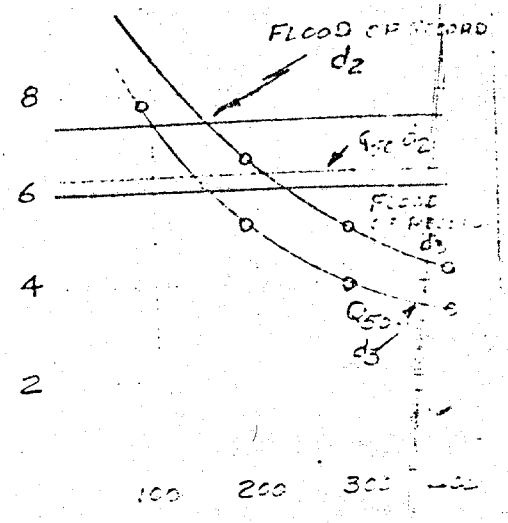
(1) UNABLE TO DETERMINE DUE TO SAND CONDITION OF CHANNEL. SUSPECTED TO BE AGGRADING DUE TO BOYSEN RESERVOIR WITH DEGRADATION OCCURING DURING FLOOD PEAKS. SEVERE DUNE FORMATION DURING PEAKS.

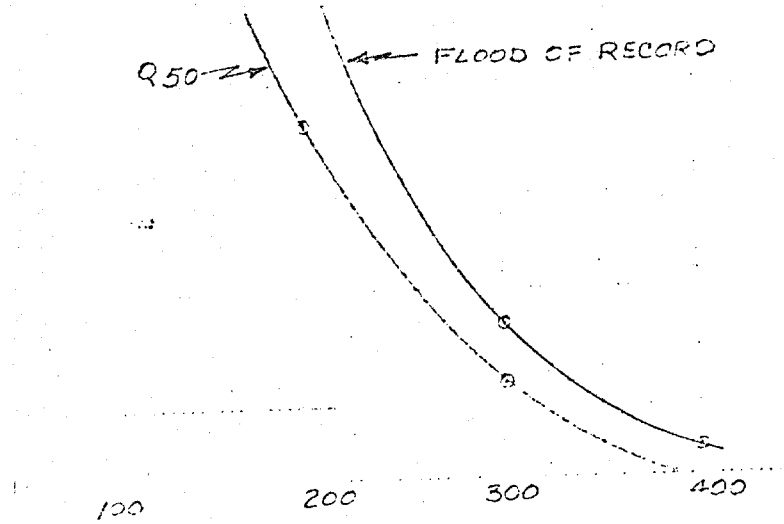
(2) PROVIDE FOR MAX. FLOOD OF RECORD BY USING MORE RIPRAP PROTECTION IN THE BRIDGE AREA TO PREVENT EXCESSIVE EROSION.

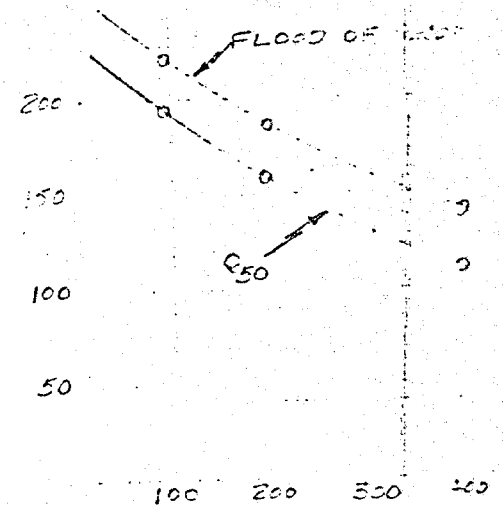
WIRE ENCLOSED RIPRAP











4761.5± OVERTOP GRADE

4740.3'

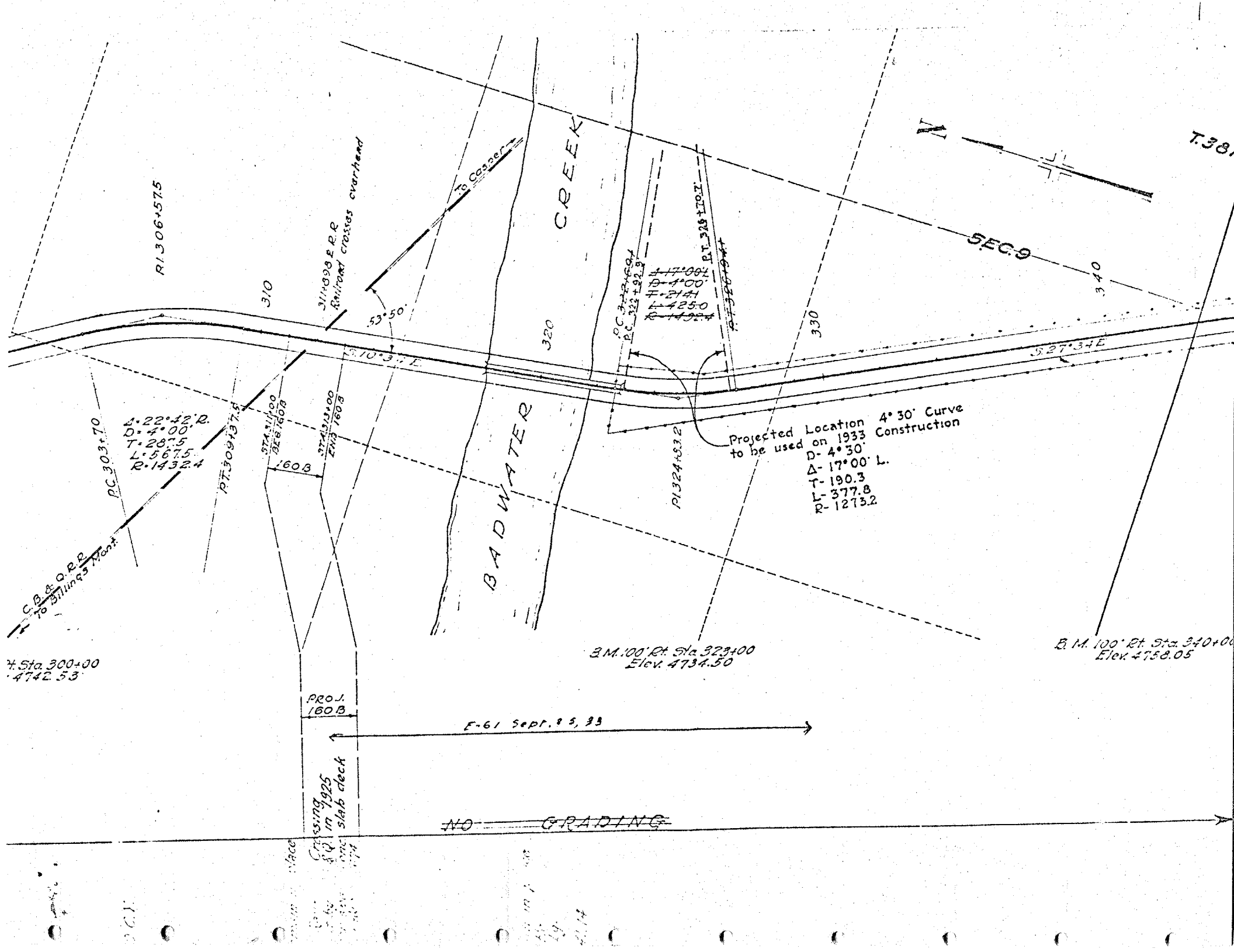
WIDTH

DOUBLE COLUMN USED
IN SCOUR ANALYSIS.

BADWATER CREEK
STA. 141+00
SHOSHONI - THERMOPOLIS RD.

SCR-6167 FR.

APPENDIX D


SEC. 9
T. 38
BADWATER CREEK
To Casper
Railroad crosses overhead
311+098 B.R.R.
PI 306+57.5
310
320
330
340
53°50'
S 10°37' E
S 27°34' E
PC 303+70
Δ-22°42' R.
D-4°00'
T-287.5
L-567.5
R-1432.4
PT 309+37.5
STA 311+00 BEG 160B
STA 313+00 END 160B
160B
C.B.&Q.R.R. To Billings Mont.
PC 322+92.9
PT 328+70.7
Δ-17°00' L.
D-4°00'
T-214.1
L-425.0
R-1432.4
PI 324+83.2
Projected Location 4°30' Curve to be used on 1933 Construction
D-4°30'
Δ-17°00' L.
T-190.3
L-377.8
R-1273.2
B.M. 100' Rt. Sta. 323+00 Elev. 4734.50
B.M. 100' Rt. Sta. 340+00 Elev. 4758.05
Sta. 300+00 4742.53
PROJ. 160B
F-61 Sept. 25, 33
Crossing 80' in 1925 slab deck
NO GRADING

Case History 106

Tenmile Draw Creek at I-80 near Point of Rocks, Wyoming

Description:

This reach has been extensively reworked in order to permit construction of roadway in the original streambed (see plans) The existing channel roughly parallels the road, and makes 90° bends to enter and exit the culvert. The channel is straight to sinuous, with 2.44 to 3.05M sidecut banks. Bed material is fine silt and bank material is silt, sand and clay. The design discharge is 98 cms, and the bed slope is 0.0015 at the site. The watershed area is 414.40km^2

The crossing is a double 2.74 x 2.74 x 6.96M RBC with an improved inlet. Upstream banks are revetted with railbank, and a 60.96cm circular pipe median strip drain empties into the channel from the east downstream bank.

Gradation Problem:

The originally straight trapezoidal channel has been sidecut and has become sinuous. The RBC structures have filled to within .30M of the top with sediment, and the crossing will not carry the design flow in this configuration.

Countermeasures:

The channel was made about 1.609km shorter between the crossing and Bitter Creek, which changed the slope from the original slope of 0.0007 to the present 0.0015.

Discussion:

The final slope has not developed sufficient velocity to keep the structures clear. In addition, a construction error might have occured in excavating the downstream channel; it is possible

that the bed level was arbitrarily raised several feet at some point before continuing to Bitter Creek. This would have contributed to aggradation at the crossing. The present slope is constant from upstream of the crossing to Bitter Creek.

Available documentation includes channel modification plans for the reach, RBC plans, and recent slides.

TENMILE DRAW CREEK

1-80-3
(21) (31) 4 25

R.
N 27
R 101 W

Service Pipe Line

Service Pipe Line Telephone Line

A T & T Underground Cable

Pioneer Pipe Line

A T & T Overhead Line

Ten Mile Draw Creek

Service Pipeline Telephone Line

P.C. = 401 + 16.2

P.I. = 411 + 13.2

Δ = 5°-57' Lt.

SECTION 26
T20N R101W

BITTER CREEK

B.M. Steel Pin & Guard Stake
250' Rt. Sta. 400+00
Elev. 6514.02

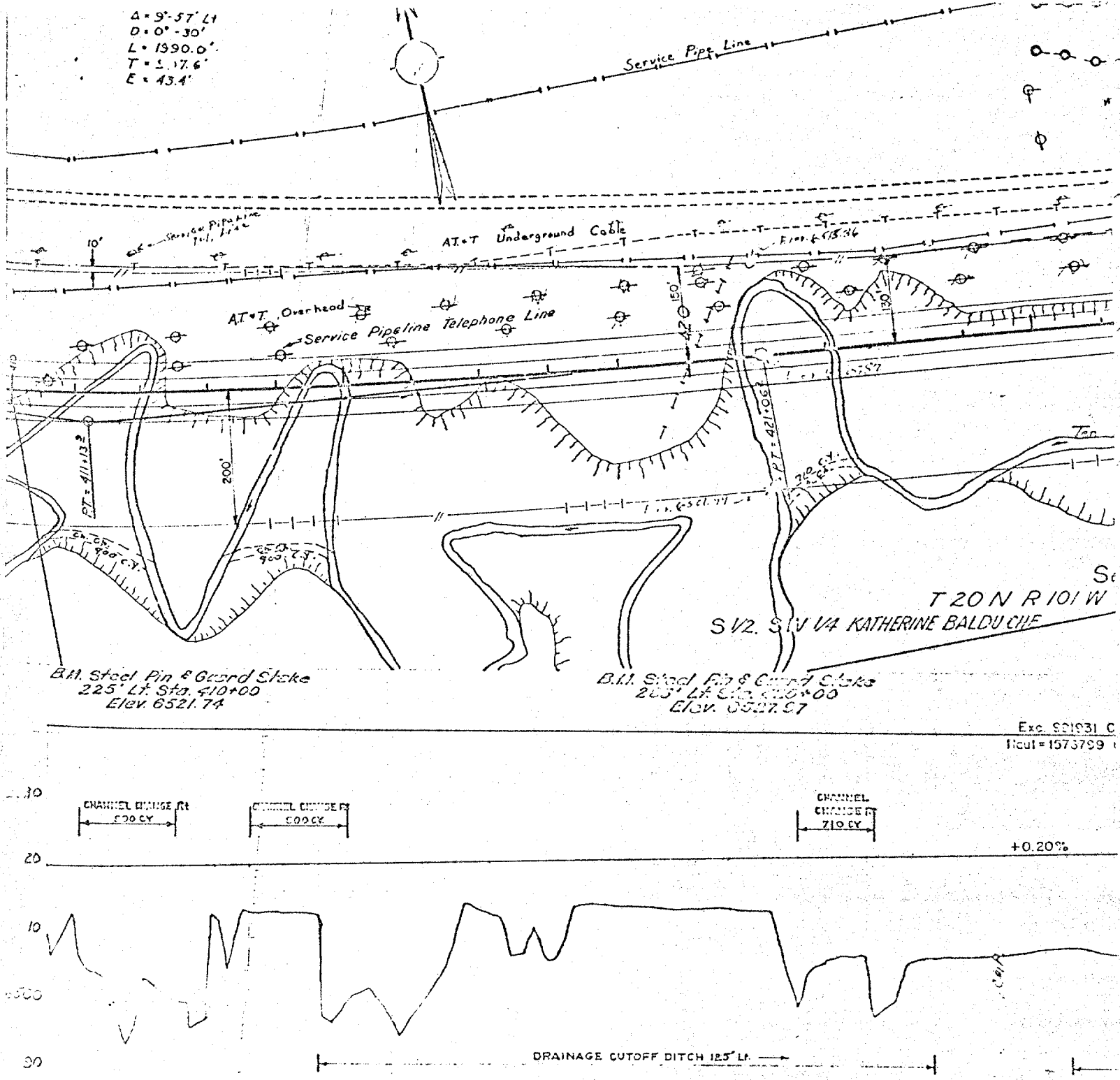
As Constructed
B.M. Steel Pin & Guard Stake
225' Lt. Sta. 410+00
Elev. 6521.74

Exc. 991931 C.Y.
Haul = 1576799 C.Y. Mi.

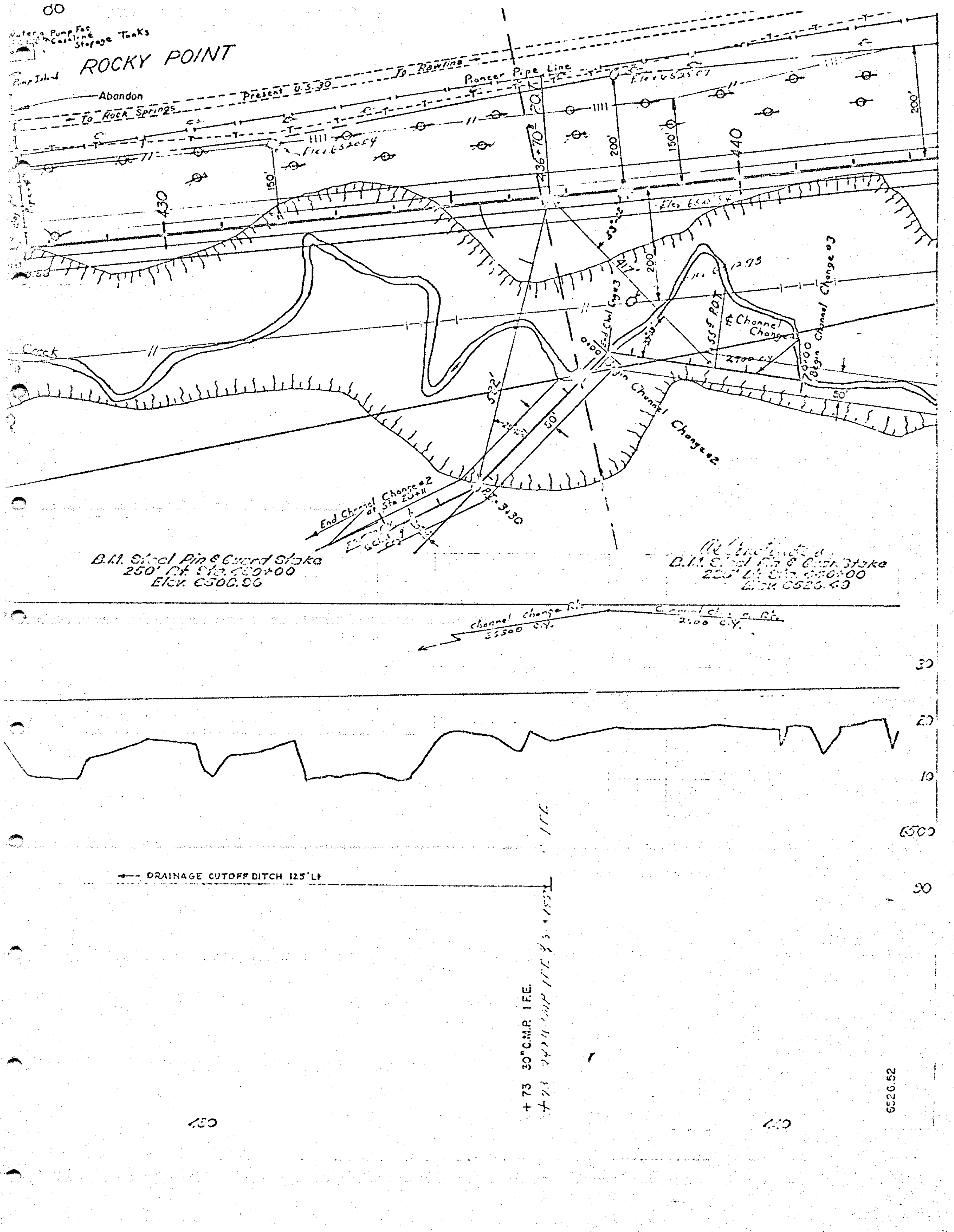
CHANNEL CHANGE 64

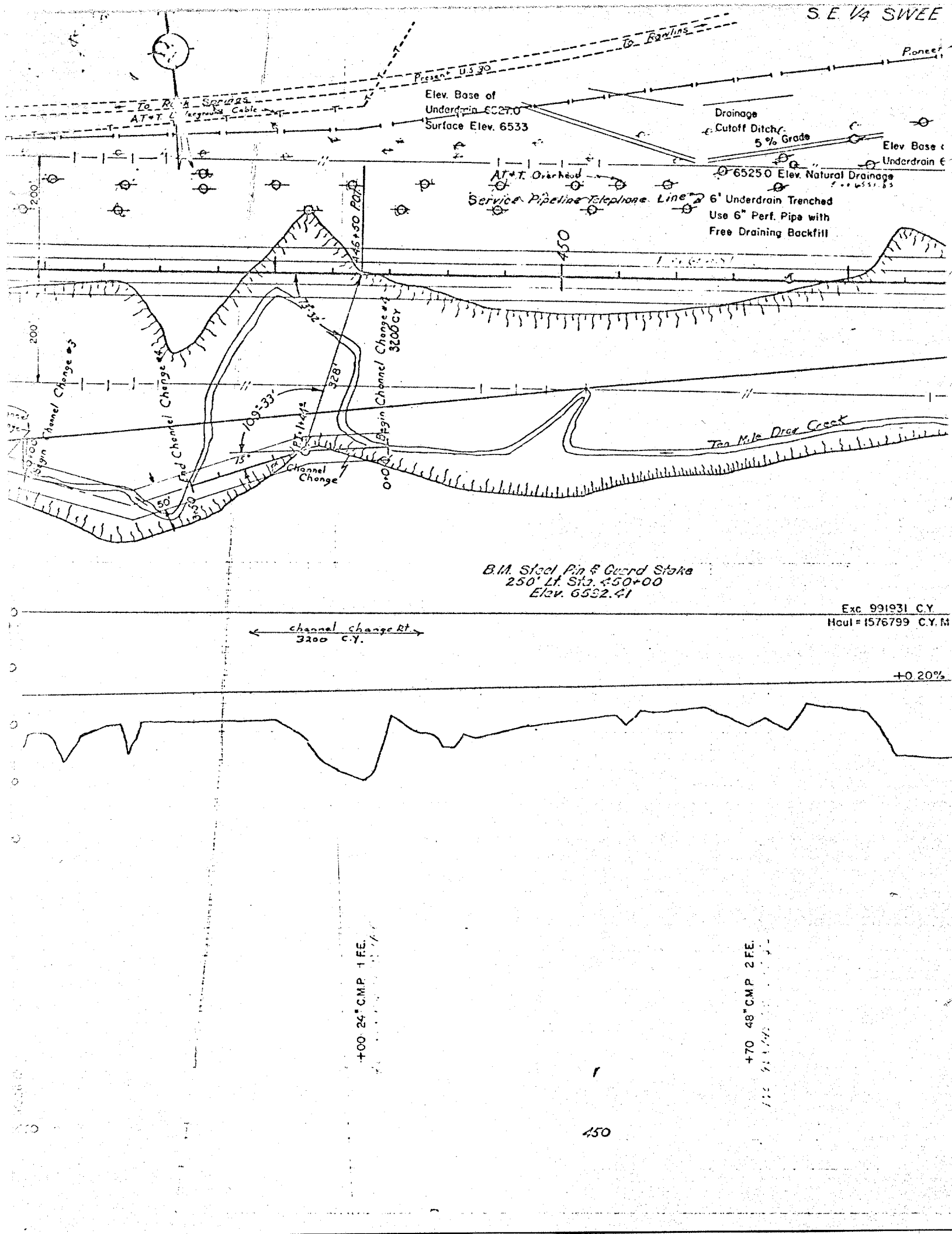
E.B.L.

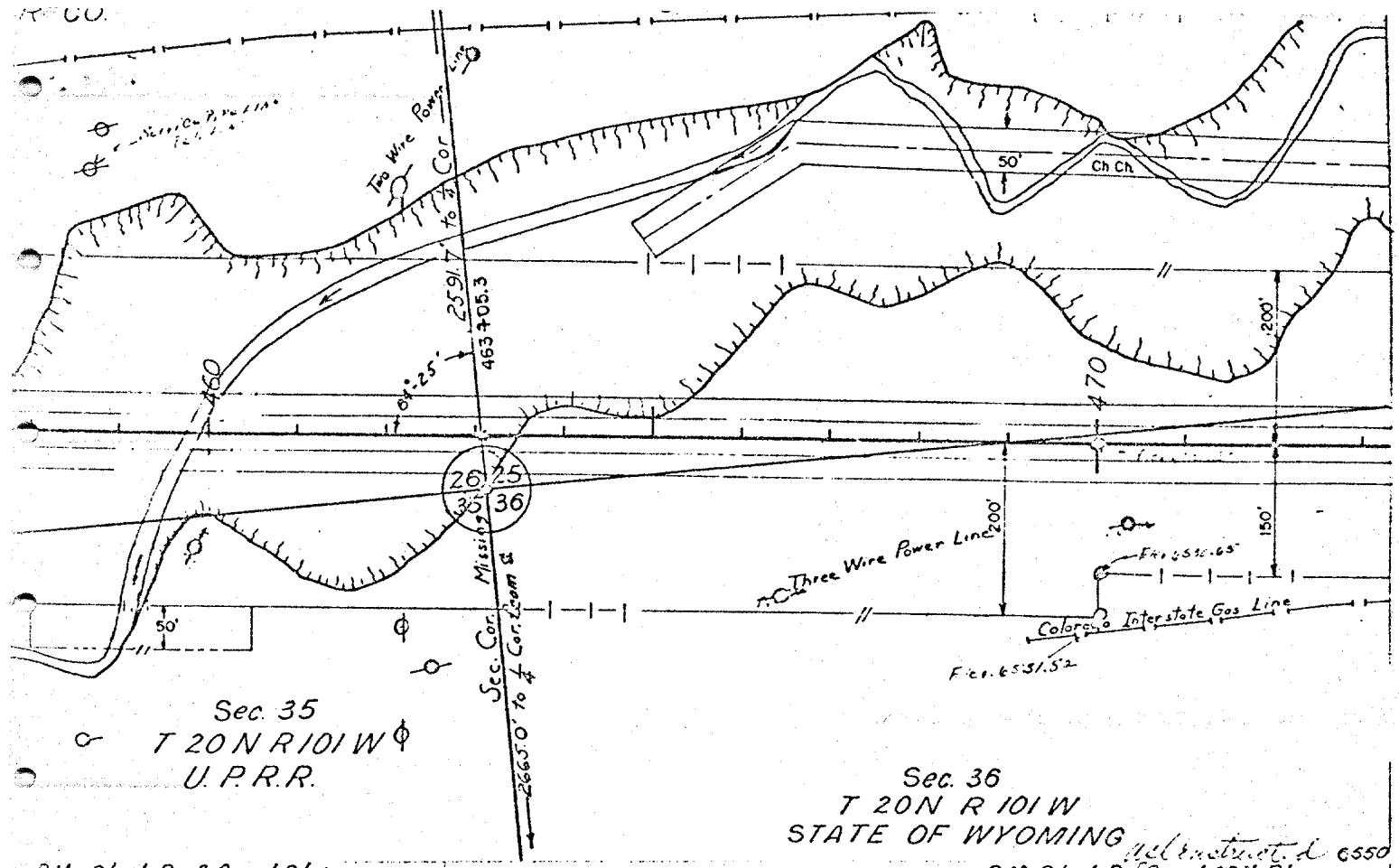
0.65%

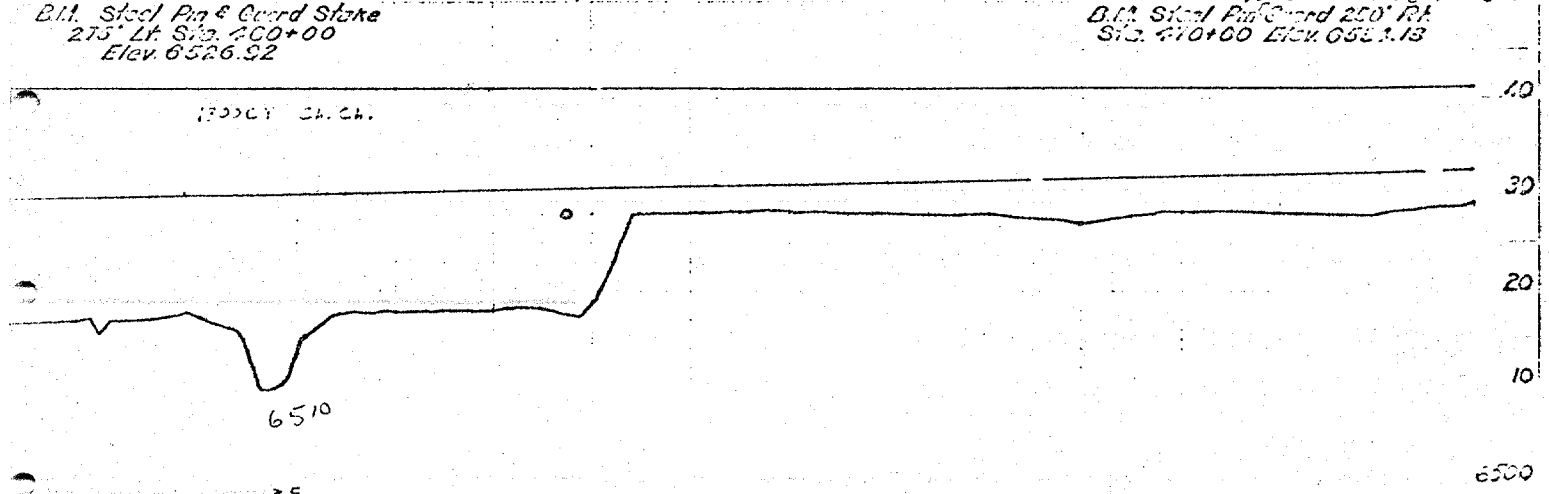

Δ = 9°-57' Lt
D = 0°-30'
L = 1990.0'
T = 5,17.6'
E = 43.4'
Service Pipe Line
Service Pipeline Tel. Line
A.T.&T. Underground Cable
A.T.&T. Overhead
Service Pipeline Telephone Line
10'
150'
200'
PT = 411+13.2
PT = 421+06.2
T 20 N R 101 W
S 1/2. S 1/2 1/4 KATHERINE BALDU CHE
B.M. Steel Pin & Guard Stake
225' Lt. Sta. 410+00
Elev. 6521.74
B.M. Steel Pin & Guard Stake
Elev. 6527.97

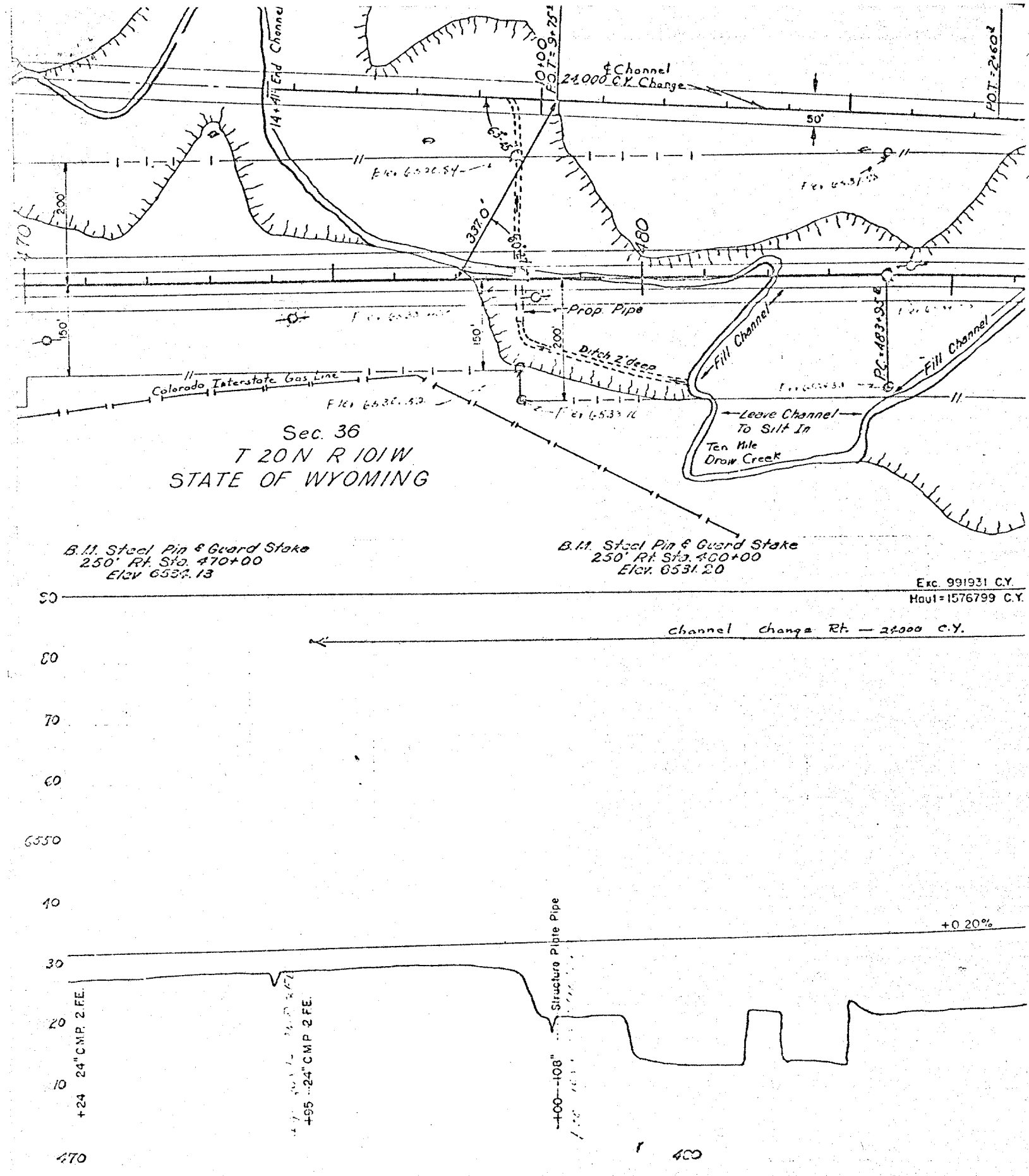
Exc. 551931 C
Haul = 1573799
CHANNEL CHANGE
520 CY
CHANNEL CHANGE
500 CY
CHANNEL CHANGE
710 CY
+0.20%
DRAINAGE CUTOFF DITCH 125' Lt.
+40 24" CMP 1 F.E.
+63 30" CMP 1 F.E.

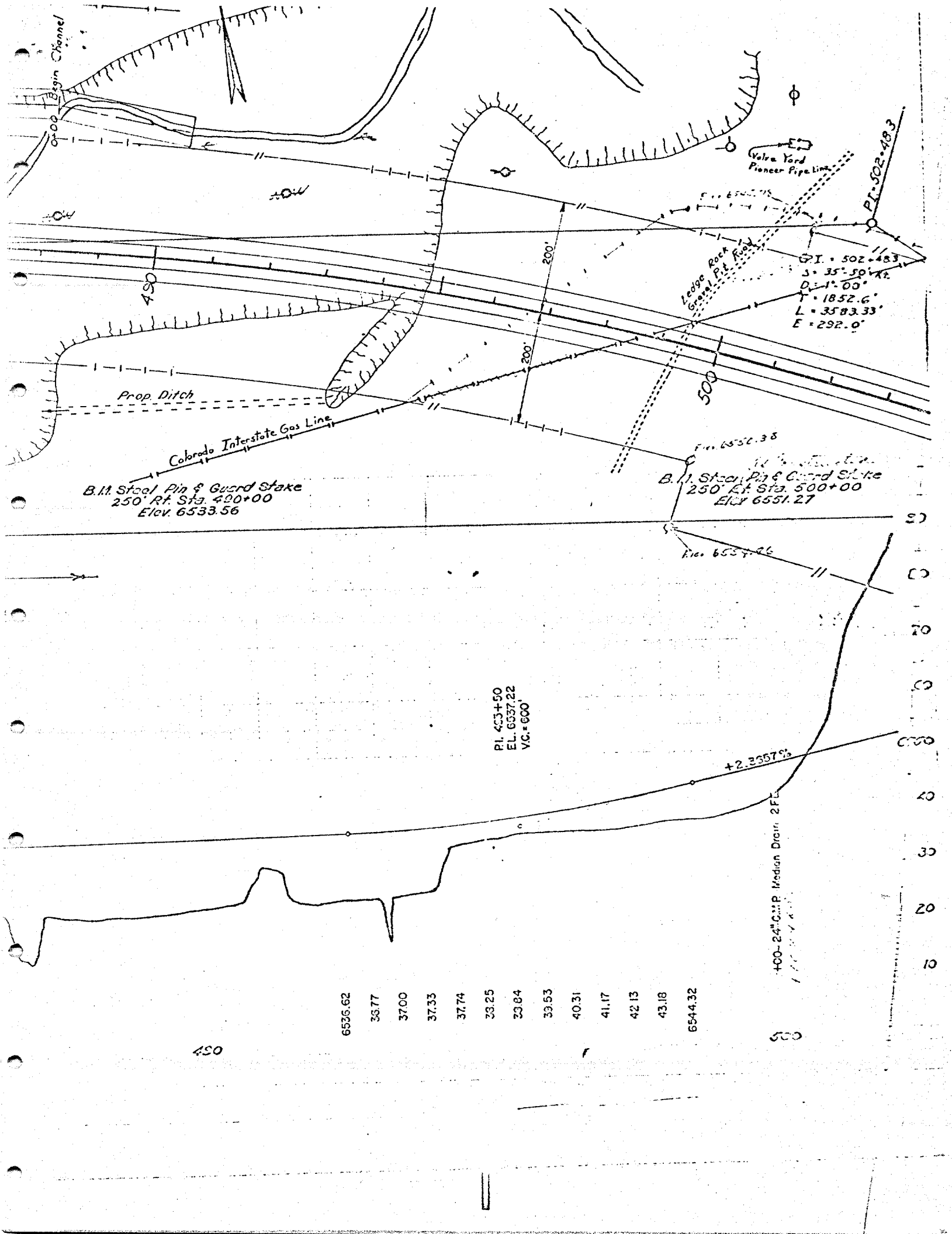

ROCKY POINT
Water & Pump Fac.
Gasoline Storage Tanks
Abandon
To Rock Springs
Present U.S. 30
To Rawlins
Pioneer Pipe Line
436+70±
430
440
150'
200'
150'
200'
200'
Creek
End Chnl Chg #3
Begin Channel Change #2
Channel Change #2
Begin Channel Change #3
50'
50'
2400 C.Y.
End Channel Change #2 at Sta 20+11
P.T.
B.M. Steel Pin & Guard Stake
250' Rt. Sta. 429+00
Elev. 6500.96
B.M. Steel Pin & Guard Stake
Channel Change Rt.
33500 C.Y.
Channel Ch. Rt.
2400 C.Y.
30
20
10
6500
90
DRAINAGE CUTOFF DITCH 125' Lt
+73 30" C.M.P. I.F.E.
6526.52


S.E. 1/4 SWEE
To Rawlins
Present U.S. 30
Pioneer
To Rock Springs
A.T.&T. Underground Cable
Elev. Base of Underdrain 6527.0
Surface Elev. 6533
Drainage Cutoff Ditch
5 % Grade
Elev Base of Underdrain 6
A.T.&T. Overhead
Service Pipeline Telephone Line
6525.0 Elev. Natural Drainage
6' Underdrain Trenched
Use 6" Perf. Pipe with
Free Draining Backfill
200'
200'
446+50 P.O.T.
450
Begin Channel Change #3
End Channel Change #4
Begin Channel Change #4
3200 CY
328'
109.33'
P.T. Ledge
Channel Change
Ten Mile Draw Creek
50'
B.M. Steel Pin & Guard Stake
250' Lt. Sta. 450+00
Elev. 6552.41
Exc 991931 C.Y.
Haul = 1576799 C.Y. M
channel change Rt.
3200 C.Y.
+0.20%
+00 24" C.M.P. 1 F.E.
+70 48" C.M.P. 2 F.E.
450


Two Wire Power Line
Cor. to ¼
2591.7'
463+05.3
64°-25'
460
470
50'
Ch Ch
200'
150'
26
25
35
36
Three Wire Power Line
Colorado Interstate Gas Line
Sec. Cor.
Missing
2665.0' to ¼ Cor. Lost
Sec. 35
T 20 N R 101 W
U.P.R.R.
Sec. 36
T 20 N R 101 W
STATE OF WYOMING
B.M. Steel Pin & Board Stake
275' Lt. Sta. 400+00
Elev. 6526.92
B.M. Steel Pin Board 250' Rt.
Sta. 470+00 Elev. 6523.13


6550
40
30
20
10
6500
6510
+80.125 Bridge Over Ten Mile Draw
Twin-4 Cont R.C. Slab Span
+24—24" C.M.P. 3-F.E.
6532.52
450
470
458+90


14+41 End Channel
0+00 P.O.T.=9+75
℄ Channel
24,000 C.Y. Change
P.O.T.=2+60
50'
Elev. 6526.54
Elev. 6531.15
337.0'
480
Prop. Pipe
Ditch 2' deep
Fill Channel
Fill Channel
PC=483+95
Colorado Interstate Gas Line
Elev. 6530.52
Elev. 6533.11
Leave Channel To Silt In
Ten Mile Draw Creek
Sec. 36
T 20 N R 101 W
STATE OF WYOMING
B.M. Steel Pin & Guard Stake
250' Rt. Sta. 470+00
Elev. 6532.13
B.M. Steel Pin & Guard Stake
250' Rt. Sta. 400+00
Elev. 6531.20
Exc. 991931 C.Y.
Haul = 1576799 C.Y.
Channel Change Rt. — 24,000 C.Y.
90
80
70
60
6550
40
30
20
10
470
+0.20%
+24 24" CMP 2 F.E.
+95 24" CMP 2 F.E.
Structure Plate Pipe
+00 108"
400


Begin Channel
Valve Yard
Pioneer Pipe Line
P.I. 502+48.3
G.I. = 502+48.3
Δ = 35°-50' Rt.
D = 1°-00'
T = 1852.6'
L = 3583.33'
E = 292.0'
Ledge Rock
Gravel Pit Road
200'
200'
400
500
Prop. Ditch
Colorado Interstate Gas Line
B.M. Steel Pin & Guard Stake
250' Rt. Sta. 400+00
Elev. 6533.56
B.M. Steel Pin & Guard Stake
250' Rt. Sta. 500+00
Elev. 6551.27
P.I. 403+50
E.L. 6537.22
V.C. = 600'
+2.3557%
+00-24" C.M.P. Median Drain 2 F.L.
6536.62
36.77
37.00
37.33
37.74
38.25
38.84
39.53
40.31
41.17
42.13
43.18
6544.32
400
500

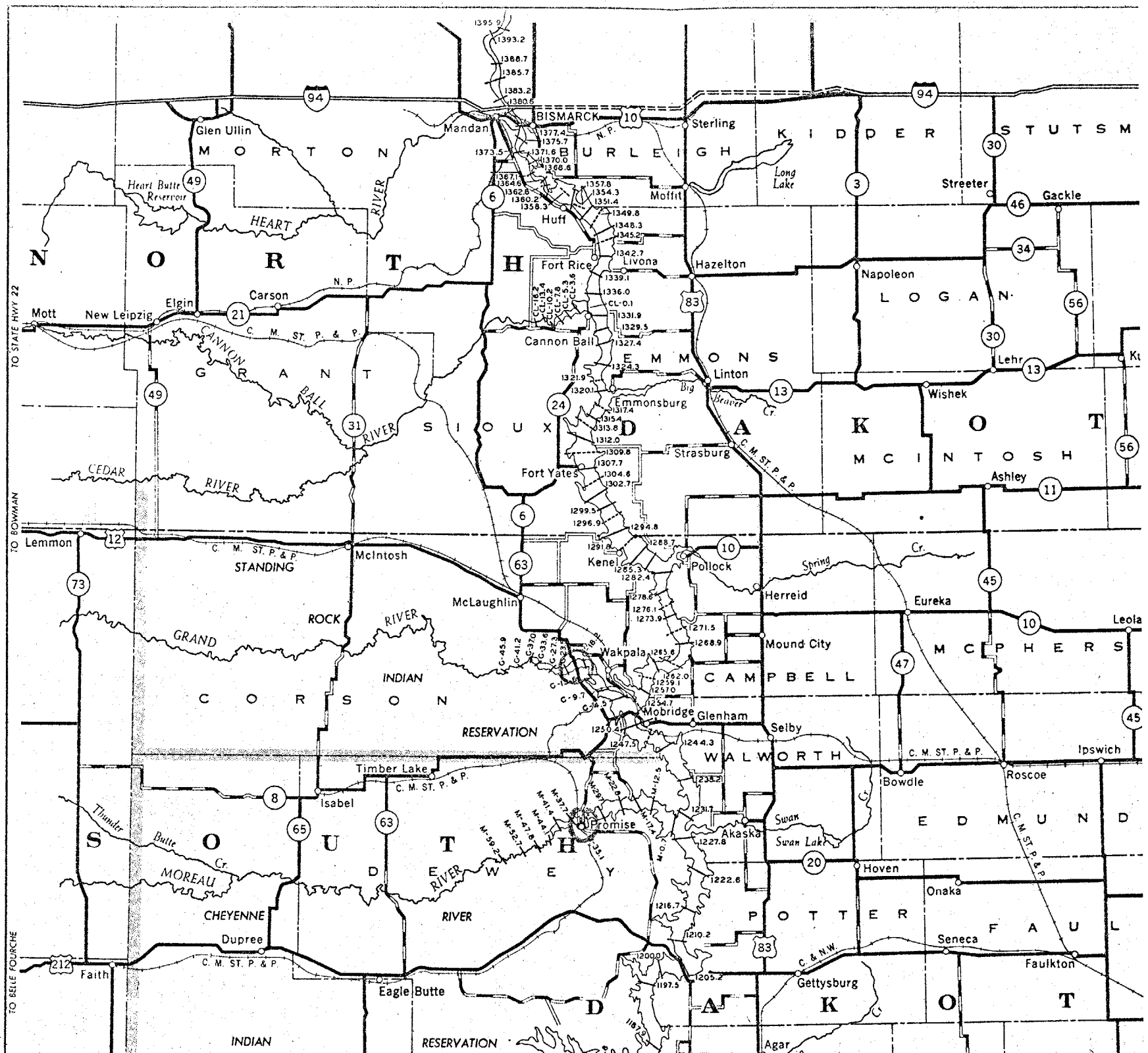
CHEYENNE RIVER AT SR-63 SOUTH OF EAGLE BUTTE, SOUTH DAKOTA

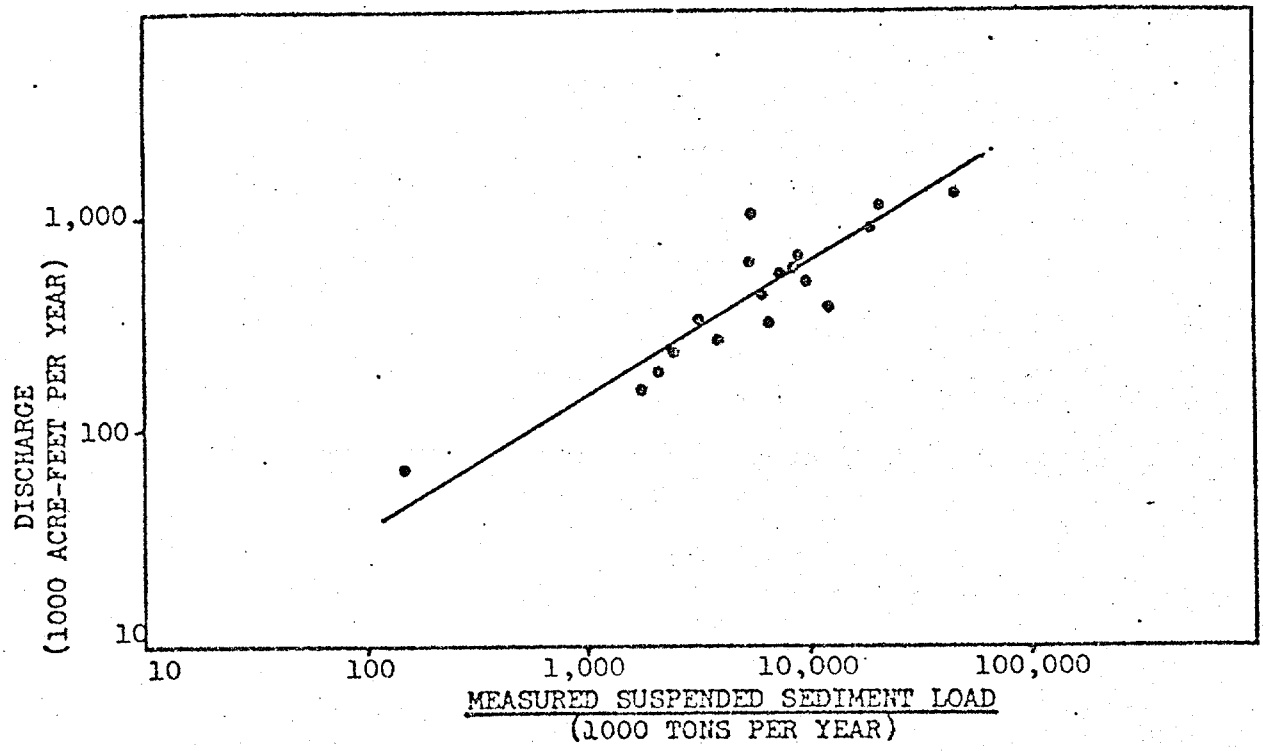
Description

The reach of the Cheyenne River of interest is in Ziebach County. The highway crossing is about 33.6 km south of Eagle Butte on State Road 63 and is known as Carlin Bridge. The highway crossing is in the backwater of Oahe Reservoir on the Missouri River. The drainage area above State Road 63 is 63,000 km^2 where there is a gaging station. Water and sediment discharge have been recorded at this site for 30 years. The bridge has concrete piers, steel pile foundations. Spillthrough abutments and concrete wingwalls. The stream is perennial, alluvial, sand bed (d_{50} = 4.0 mm), and in a fairly narrow flood plain. The channel is sinuous and the banks are a coarse sand. The Corps of Engineers have collected sufficient data to document this site in detail.

Gradation Problem

There has been about 3 m of aggradation at the highway crossing between 1959 and 1972. Oahe Dam was closed in 1958 and over the next few years the backwater condition from Oahe Reservoir had begun to impact Carlin Bridge. Figure 1 shows the aggradation ranges where cross-section data is collected approximately every five years by the Corps of Engineers. Figure 2 is a summary


NORTH DAKOTA
SOUTH DAKOTA
MORTON
BURLEIGH
KIDDER
STUTSMAN
GRANT
SIOUX
EMMONS
LOGAN
MCINTOSH
CORSON
CAMPBELL
MCPHERSON
WALWORTH
EDMUNDS
POTTER
FAULK
BISMARCK
Mandan
Glen Ullin
Sterling
Streeter
Gackle
Moffit
Huff
Fort Rice
Livona
Hazelton
Napoleon
Lehr
Wishek
Linton
Emmonsburg
Cannon Ball
Carson
Elgin
New Leipzig
Mott
Strasburg
Fort Yates
Ashley
Lemmon
McIntosh
Kenel
Pollock
Herreid
Eureka
Leola
McLaughlin
Wakpala
Mound City
Mobridge
Glenham
Selby
Timber Lake
Isabel
Bowdle
Roscoe
Ipswich
Promise
Akaska
Hoven
Onaka
Dupree
Faith
Eagle Butte
Seneca
Faulkton
Gettysburg
Agar
Heart Butte Reservoir
HEART RIVER
CANNON BALL RIVER
CEDAR RIVER
STANDING ROCK
GRAND RIVER
INDIAN RESERVATION
Long Lake
Big Beaver Cr.
Spring Cr.
Swan Lake
Thunder Butte Cr.
MOREAU RIVER
CHEYENNE RIVER
INDIAN RESERVATION
TO STATE HWY 22
TO BOWMAN
TO BELLE FOURCHE
N. P.
C. M. ST. P. & P.
C. & N.W.



WATER DISCHARGE AND SEDIMENT LOAD RECORD

YEAR	DISCHARGE (AC-FT)	SEDIMENT (TONS/YR)	YEAR	DISCHARGE (AC-FT)	SEDIMENT (TONS/YR)
1948	573,600	8,736,511	1966	606,500	5,582,600
1949	1,092,000	5,687,423	1967	1,120,000	21,134,400
1950	650,700	9,251,370	1968	334,600	3,406,800
1951	236,300	2,533,134	1969	436,700	6,554,100
1958	324,100	6,810,469	1970	507,500	-------
1959	159,000	1,800,582	1971	1,101,000	-------
1960	192,200	2,163,300	1972	382,675	12,897,195
1961	68,790	153,200	1973	270,871	4,087,447
1962	1,263,000	46,182,200			
1963	537,200	7,723,000			
1964	495,000	10,054,400			
1965	862,200	19,308,900			

LOCATION -- U.S.G.S. OFFICE OF WATER DATA COORDINATION STATION NO. 54745

WATER DISCHARGE RECORDS AVAILABLE -- August 1928 through September 1967 (Station discontinued)

Figure 2

MISSOURI RIVER
LAKE OAHE
SUSPENDED SEDIMENT RECORD AND RATING CURVE
CHEYENNE RIVER AT
EAGLE BUTTE, SOUTH DAKOTA
U S ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS, OMAHA, NEBRASKA
JULY 1975

of the sediment data collected at Carlin Bridge. Figure 3 summarizes the capacity and deposition by reaches of the Cheyenne River upstream and downstream of Carlin Bridge down to the confluence of the Missouri River. The capacity of the river has been reduced considerably and there exists a visual delta at aggradation range C-3.7. The growth of the delta has been fairly predictable and the conditions at the bridge are presently fairly stable.

Countermeasures

The State Highway Department is now replacing this bridge. The foundation work is just about completed. The new bridge has been lengthened several hundred feet and raised above the channel to pass the fifty-year flood and allow the channel to aggrade several more feet since the last few years the aggradation rate has been about one foot per year.

Discussion

The new bridge was designed to take into account additional aggradation.

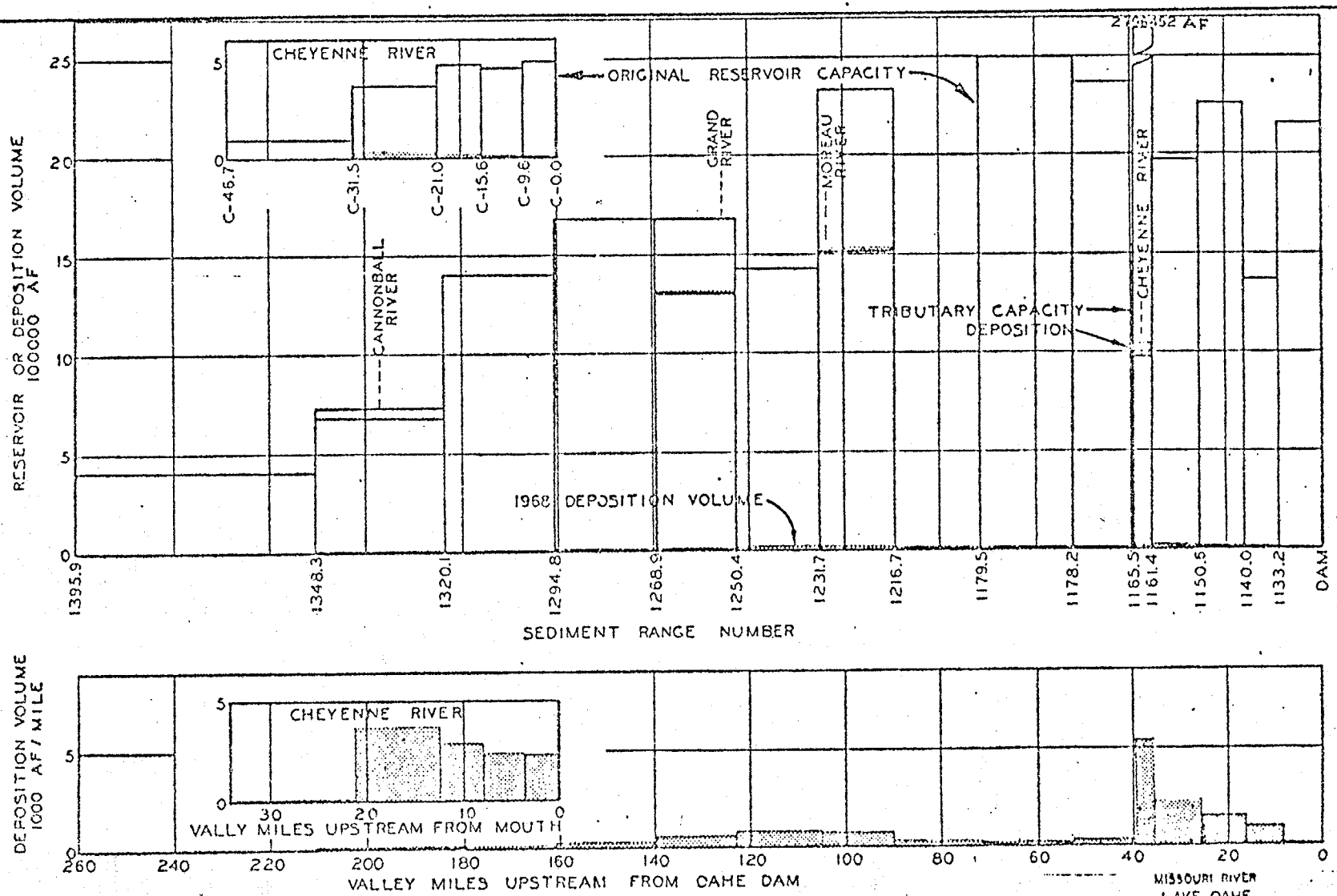

RESERVOIR OR DEPOSITION VOLUME 100000 AF
CHEYENNE RIVER
ORIGINAL RESERVOIR CAPACITY
C-46.7
C-31.5
C-21.0
C-15.6
C-9.6
C-0.0
CANNONBALL RIVER
GRAND RIVER
MOREAU RIVER
CHEYENNE RIVER
TRIBUTARY CAPACITY
DEPOSITION
1968 DEPOSITION VOLUME
1395.9
1348.3
1320.1
1294.8
1268.9
1250.4
1231.7
1216.7
1179.5
1178.2
1165.5
1161.4
1150.5
1140.0
1133.2
DAM
SEDIMENT RANGE NUMBER
DEPOSITION VOLUME 1000 AF/MILE
VALLY MILES UPSTREAM FROM MOUTH
VALLEY MILES UPSTREAM FROM OAHE DAM
MISSOURI RIVER
LAKE OAHE
CAPACITY AND DEPOSITION BY REACHES
US ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS, OMAHA, NEBRASKA

Figure 3

Case History 109
Polo Creek at I-90 near Whitewood, South Dakota

Description

Polo Creek is in Lawrence County, originates in the Black Hills, and is a tributary of the Belle Fourche River. I-90 crosses Polo Creek on an alluvial fan where the channel is not well defined. The channel slope is over 10 percent in the Black Hills, but where I-90 crosses Polo Creek, the slope is only about 1 percent. The creek is intermittent and the bed material is gravel and cobbles. The drainage area upstream of I-90 is 78 km^2 and the design discharge was 59 m^3/sec. The bridge was built in 1971, has concrete spread footing, flow through abutments, and a concrete deck.

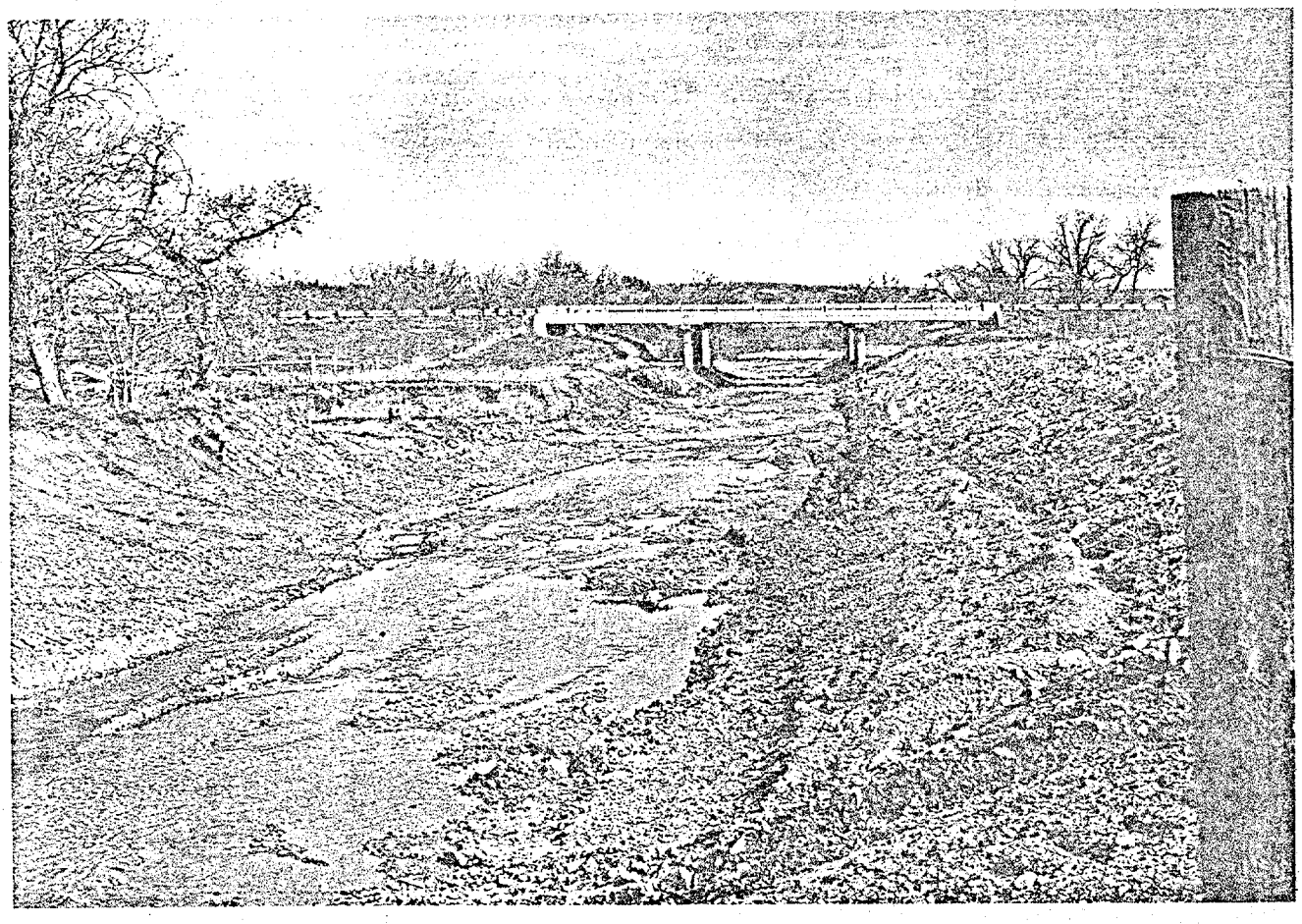
Gradation Problem

A serious aggradation problem exists at this highway crossing. Excavation or deposited bed material has been an annual occurrence in order to pass the spring snowmelt runoff each spring. Figure 109-1 is a photograph of the channel and bridge just after excavation. The aggradation problem is primarily due to the fact that the highway crossing is on an annual fan where the channel is not well defined and the alope or energy is inadequate to transport the bed material transported downstream from a rather steep slope in the Black Hills.

Countermeasures

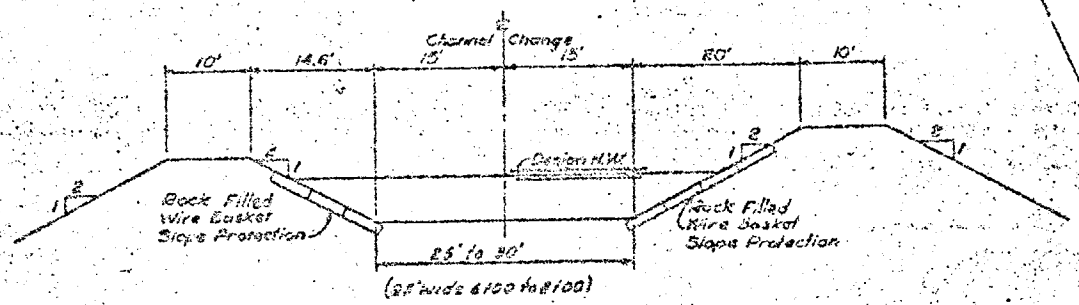
The state highway department tried to narrow the channel to increase the velocity and transport characteristics. This was not very effective and the narrow channel was soon filled with gravel and cobbles. They next acquired an easement to straighten the channel to improve the slope and increase the transport characteristics. This slope increase was not enough to significantly increase the transport characteristics.

The state highway department has also been sued for creating flooding, which is not due to the highway crossing.

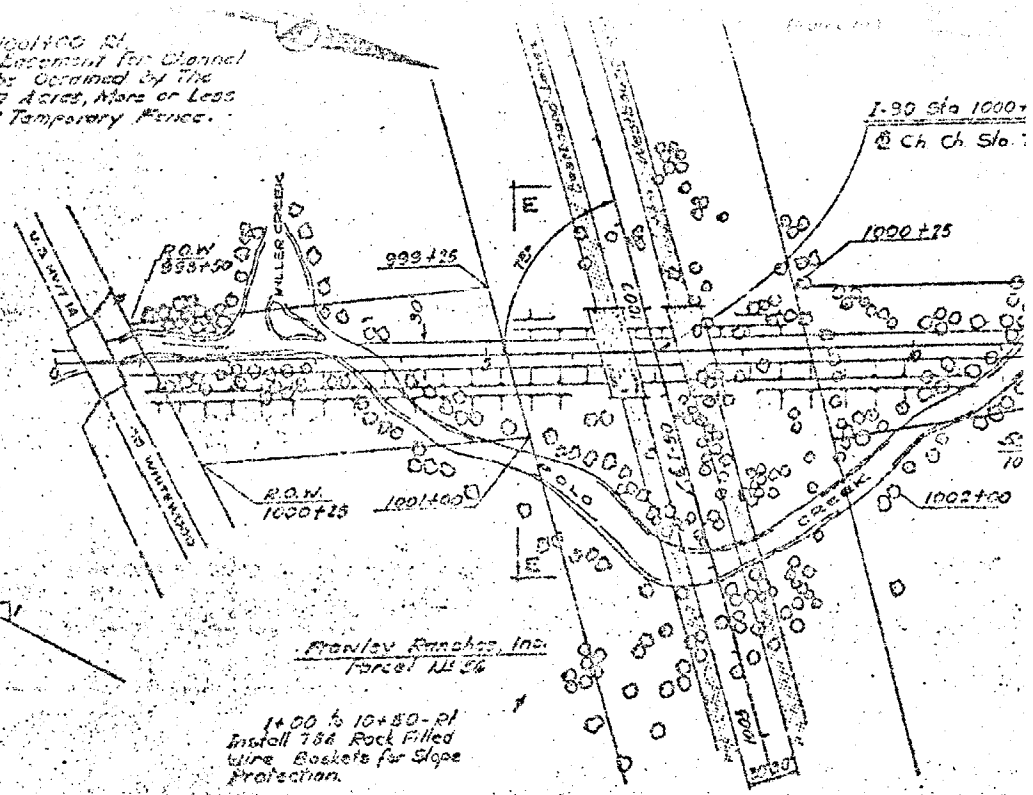


998+50 to 1001+00 Rt.
Temporary Easement for Channel
Change to be Obtained by the
State - 1.47 Acres, More or Less
Erect 800' Temporary Fence.

Q	1360 cfs
A	217 Sq. Ft
V	9.0 f.p.s

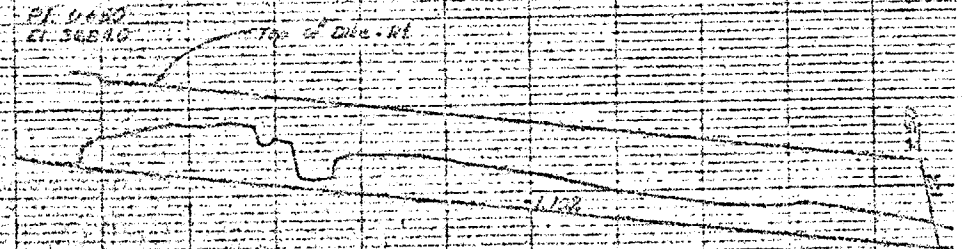


SECTION E-E



Exc.	4,620	Emb.	10,571
Option Borrow Pit No. 3	7,375	+14%	1,480
	12,051		12,051

Haul: 3200 c.y. sta.'s
Op. Bor. Haul: 12,900 c.y. sta.'s



Discussion

Highway crossings are difficult on alluvial fans. A debris basin upstream of I-90 and U.S. 14 may be a solution. This would provide a good source of gravel. One way or another, excavation of bed material will be necessary.

Case History 110
Bear Butte Creek at I-90 near Sturgis, South Dakota

Description

Bear Butte Creek is in Lawrence and Meade Counties, originates in the Black Hills National Forest, and is a tributary of the Belle Fourche River. I-90 crosses Bear Butte Creek where the slope is more than 10 percent and at high flows, the flow is supercritical. There is a bad alignment problem with about a 50-deg skew upstream and downstream. The creek is intermittent and the bed material is gravel with some cobbles. The drainage area is 178 km^2 and the design discharge is 1130 m^3/sec; the maximum flood of record,in 1972, was 5521 m^3/sec. The bridge was built in 1963, has concrete spread footings, flow through abutments, and a concrete deck.

Gradation Problem

A degradation problem of about 4 m exposed the spread footings. At high discharges, the flow is supercritical, and the transport characteristics are capable of scouring the channel bed. Metal angle and plate protection was mounted on the pier to protect them from rock abrasion. Velocities at high flows have been estimated at 6 to 7 m^3/sec.

Countermeasures

Figure 110-1 illustrates the countermeasures applied below I-90 to control degradation and protect the bridge foundation. Two 2-m check dams were built downstream and 200 rock and wire bank protection baskets were installed along the channel to protect the banks. The construction was completed in 1979 and has not yet been tested for effectiveness. Hundreds of thousands of dollars were spent to control degradation and protect the bridge.

Discussion

This site would be an excellent example to do additional analyses. The design discharge was obviously too low. The bed load transport characteristics at 10 percent slope and with belocities of 6 to 7 m/sec should reveal that this problem could have been predicted, and a check dam and dissipation structure should have been part of the original design.

Figure 110-1 to be included in Next Draft