PRELIMINARY ENGINEERING REPORT

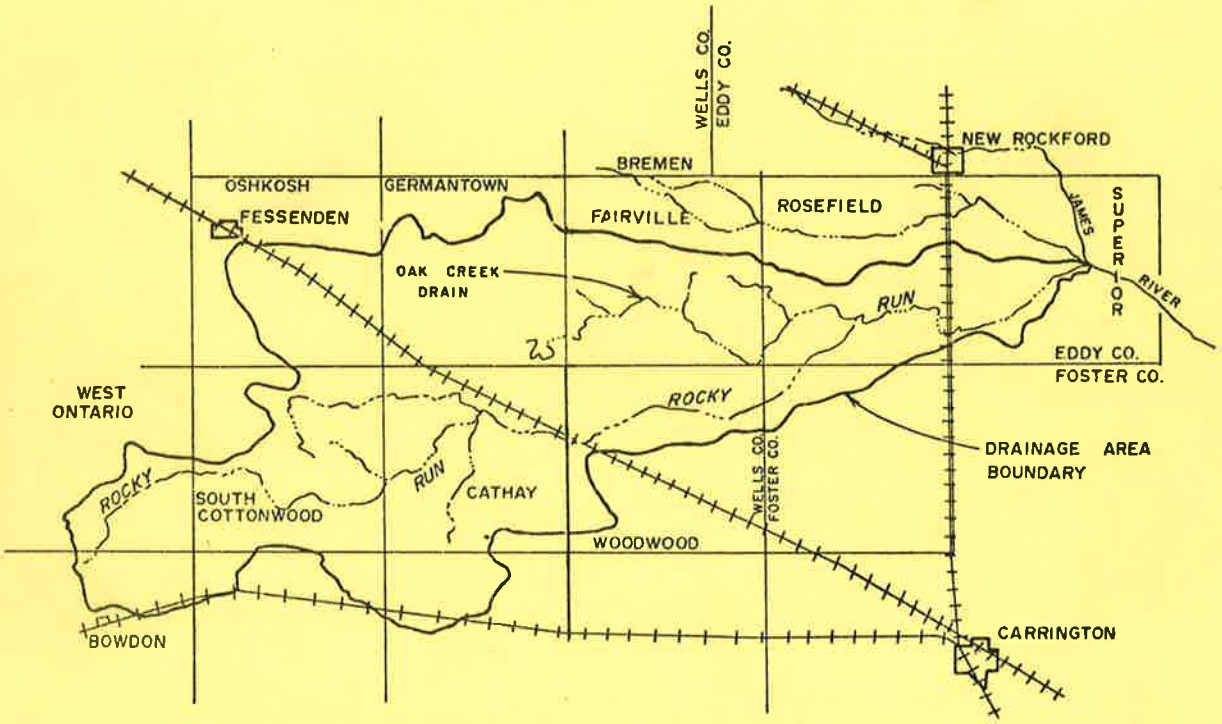
FLOW CAPACITY IMPROVEMENT STUDY

FOR

ROCKY RUN CREEK

AND

OAK CREEK DRAIN



NORTH DAKOTA

STATE WATER COMMISSION

JUNE 1978

SWC PROJECT 1633

FLOW CAPACITY IMPROVEMENT STUDY

ROCKY RUN CREEK

AND

OAK CREEK DRAIN

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SWC Project #1633

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I. INTRODUCTION

PURPOSE AND SCOPE

This report on the Rocky Run Creek watershed contains the result of a study conducted by the State Water Commission in cooperation with the Eddy, Foster and Wells County Water Management Districts. The study's major objective is to develop plans for improving the capacity of Rocky Run Creek and its major tributary, Oak Creek Drain. The implementation of the plans outlined herein would reduce flooding and facilitate agricultural drainage. Prevalent conditions warrant the need for an adequate outlet that will remove the surface runoff from the watershed and allow the adjacent farmland to remain in agricultural production.

Preceding the engineering analysis is a general description of the watershed and a comprehensive discussion of the problem areas. The engineering analysis includes a hydrologic investigation, a water surface profile analysis, and a presentation and discussion of alternatives. This report also contains an economic analysis, an environmental survey and a summary. In addition to the presentation of the alternatives this study assigns priorities for implementation so the development can be pursued in phases. The engineering analysis utilizes the best practical technology to devise alternatives that will sufficiently meet the needs of the watershed. The design of the alternatives comply with criteria established by the State Water Commission. Data used in this report was obtained by the State Water Commission, the U.S. Soil Conversation Service and local individuals. A glossary of terms and the appendixes are contained at the back of the report.

DESCRIPTION OF PLANNING AREA

The project study area is located in Eddy, Foster, and Wells Counties (See Figure 1). Rocky Run Creek is a tributary of the James River which is part of the Missouri River Basin. The creek is classified as an influent stream with intermittent flows. Approximately 85 percent of the watershed contributes directly to surface runoff. The remainder of the drainage area consists of small closed basins, not contributing to area stream flow. Little agricultural drainage has occurred in the area due to the limited capacity of Rocky Run Creek and its tributaries.

The Rocky Run Creek watershed is located on the edge of the Central Lowland physiographic province. More specifically, the area is located in the Drift Prairie region with the west edge infringing on the Missouri Escarpment. The landforms within the watershed are a result of glacial deposition which ended about 13,000 years ago. The area is covered by ground moraine composed primarily of glacial till, a heterogeneous mixture of clay, silt, sand and gravel. Also evident are intermittent strips of glacial outwash, mostly sand and gravel.

The economy of the area is structured around agriculture. Most of the land is productive farmland producing small grains and row crops. Poor surface drainage hinders farming operations in some areas. Area communities include New Rockford, Fessenden, Cathay and Bowdon. The closest major commercial center is Jamestown, located approximately 45 miles south.

Precipitation for crop production is adequate during normal years although occasionally the region suffers from periods of drought. The average annual precipitation is 17 inches most of which occurs during

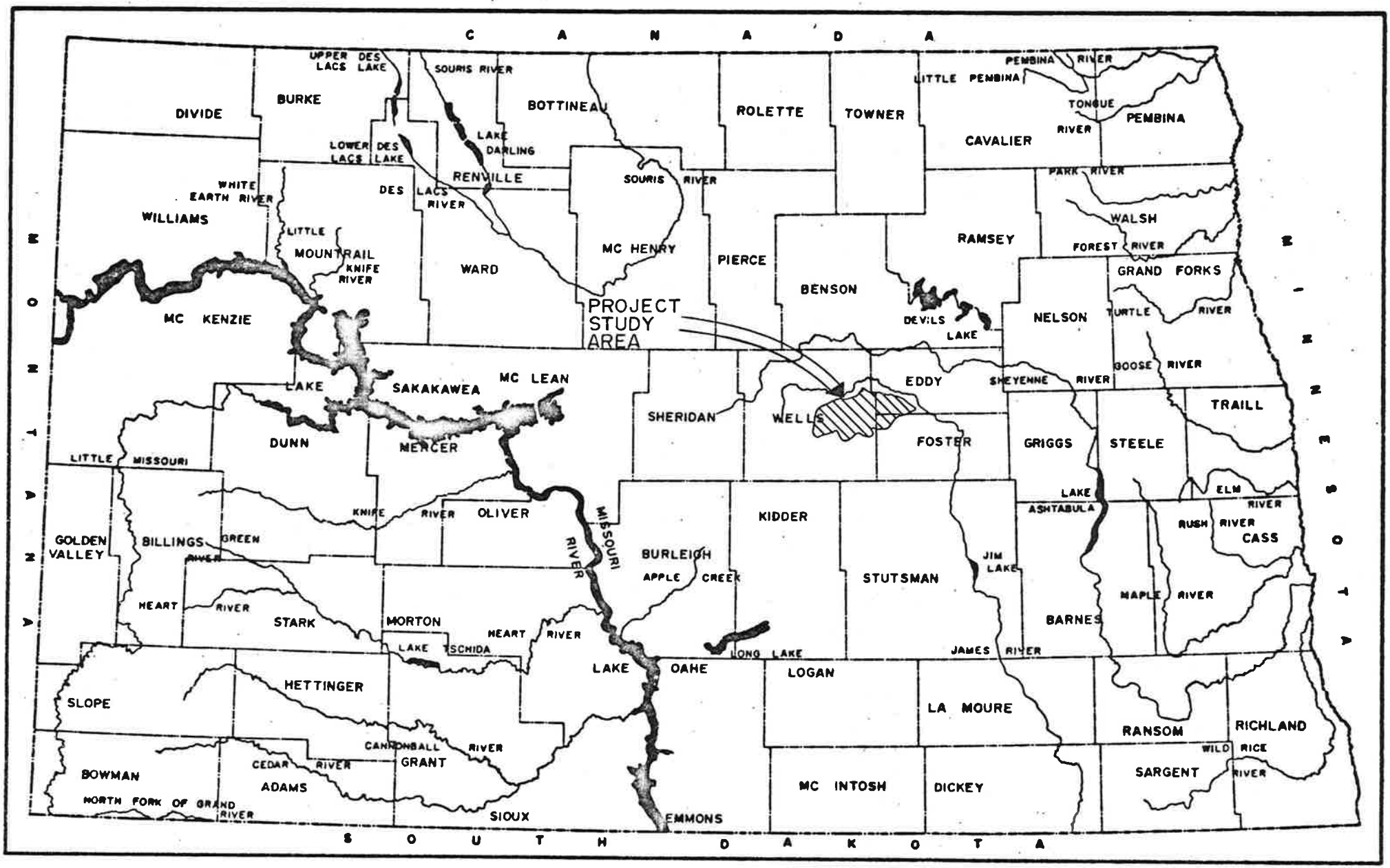


FIGURE 1

ROCKY RUN CREEK WATERSHED

LOCATION MAP

the growing season with 13½ inches falling in the period of April through September. The average annual snowfall is 34 inches with 115 days of one inch or more snow on the ground. The annual mean temperature is 39-40°F.

II. STATEMENT OF PROBLEM

BACKGROUND

Flood problems have been evident for many years within the Rocky Run Creek watershed. A flood proection project was initiated in 1971 when a study was done to locate possible sites for floodwater retention reservoirs. Three possible sites were located, two on the main stem of Rocky Run Creek and one between Scott's Slough and Kelly Creek. No additional work was done on this investigation.

In 1974 the Eddy County Water Management District was organized and it requested that the State Water Commission look at the flooding problems on Rocky Run Creek. The State Water Commission suggested that the Water Management Districts of Eddy, Foster and Wells Counties organize and pursue this project as a joint venture. In July of 1975 the three Water Management Districts formed a joint board. The following month the joint board requested that the State Water Commission conduct a study of the entire Rocky Run Creek watershed. The State Water Commission recoginzed the large scope of the project and suggested that it be approached in stages. The joint board agreed and stated that the main problem is the downstream end of the creek. On October 8, 1975 an investigation agreement was signed with Eddy County Water Management District "To determine the waterway openings and channel capacities required for flood damage reduction on lower Rocky Run Creek extending from the mouth, upstream to the Wells County line." A copy of this agreement is contained in Appendix A.

In the spring of 1976 a field survey was conducted on this lower portion of Rocky Run Creek. In August of this same year the

preliminary design for channel improvements on the lower 14.5 miles of the creek was completed. The proposed channel was designed to handle an 8 year frequency flood and had a bottom width ranging from 80 to 90 feet. The proposal called for 13 new road crossings and a total estimated project cost of 2.7 million dollars. On October 13, 1976 a meeting was held to discuss this proposal. The project cost estimate, the possibilities of stage construction, funding alternatives, assessments and downstream effects were discussed at the meeting. It was determined that the only way to fund a project of this magnitude would be to approach the legislature for a special appropriation. It was further concluded that more study should be done on the project before it could be presented to the legislature.

The degree of further study was defined at a December 7, 1976 meeting. This study would consist of computing a water surface profile on the main channel and the main tributary to the north. This water surface profile would define the major flood problem areas. The additional study would also include an economic analysis which would be completed by the U.S. Soil Conservation Service in cooperation with area landowners.

The economic analysis was completed in July of 1977. An agreement between the State Water Commission and the Wells County Water Management District to complete the water surface profile study was signed on August 19, 1977 (see Appendix B). This report is the result of this agreement.

CURRENT CONDITIONS

Potential flood problems exist within the Rocky Run Creek watershed. In addition to the natural drainage problems that are characteristic of this area of North Dakota, there are problems that have been brought

about by alterations of the natural conditions. Artificial drainage upstream has increased the amount of area that contributes to stream flow. There are several road crossings that do not have adequate capacity to handle the discharge.

There are channel restrictions throughout the entire length of Rocky Run Creek. A serious situation exists in Section 31, Township 148 North, Range 66 West, where channel encroachments back up water until it overflows into Kelly Creek. Channel restrictions are caused by inadequate road crossings, farm access roads across the channel, remains of washed-out dams and debris in the channel.

Flood waters cause limited property damage, but the crop damages are excessive. The crop damages were evaluated in the economic analysis completed by the U.S. Soil Conservation Service. An agricultural drainage project, that would drain some potholes areas southeast of Fessenden, has been delayed until an adequate outlet can be obtained. Subsequent sections of this report will enumerate the problem areas in detail and proposed solutions.

III. ENGINEERING ANALYSIS

HYDROLOGIC INVESTIGATION

The purpose of the hydrologic investigation is to estimate the peak flow throughout the watershed for various frequency floods resulting from snowmelt or rainfall. Several methods have been developed for estimating runoff. Frequently used by the State Water Commission are the TR-20 computer model, the "Crosby method", the multiple regression correlation method and the "Speath method". The method selected depends on its applicability to the study area and the quantity and type of data available.

The Rocky Run Creek drainage area contains 235 square miles of drainage area of which 200 square miles are currently classified as contributing (see Figure 2). There is no historical stream flow data existing for the watershed. Rocky Run Creek has a length of approximately 50 miles and a slope that varies throughout the length of the creek, with the steeper slopes occuring on the upper and lower reaches (See Figure 3). There are several nearby streams that have historic flow data and drainage areas with similar topographic features. The preceding statements represent characteristics of the watershed that will determine which method is most applicable to the watershed.

The TR-20 computer model was derived primarily for watersheds smaller than 100 square miles and it does not take into account any channel storage. The Rocky Run Creek drainage area contains 235 square miles, and the 50 miles of channel would provide some storage. Therefore, the TR-20 computer model does not apply to this watershed. The "Crosby"

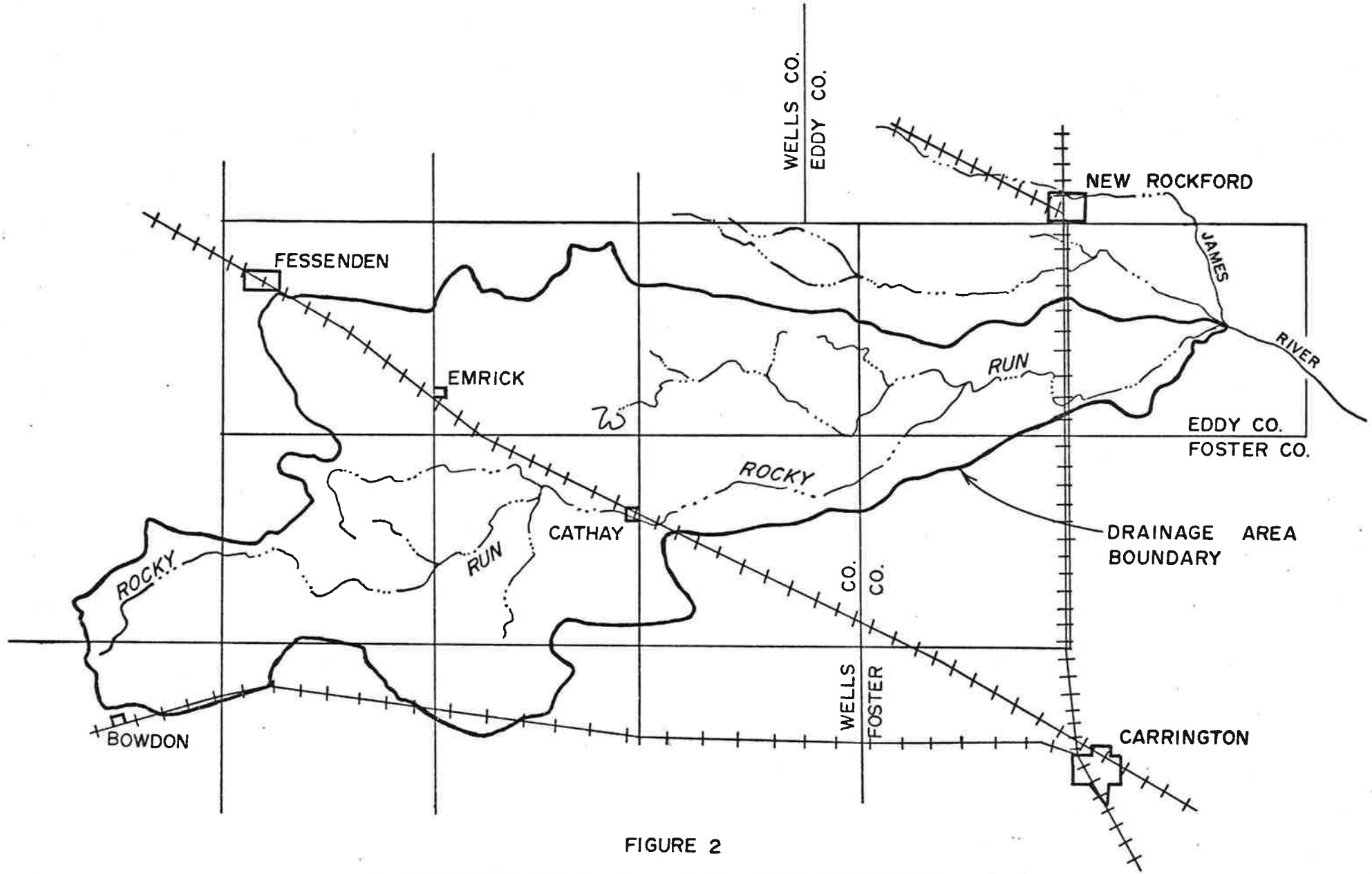


FIGURE 2

ROCKY RUN CREEK WATERSHED

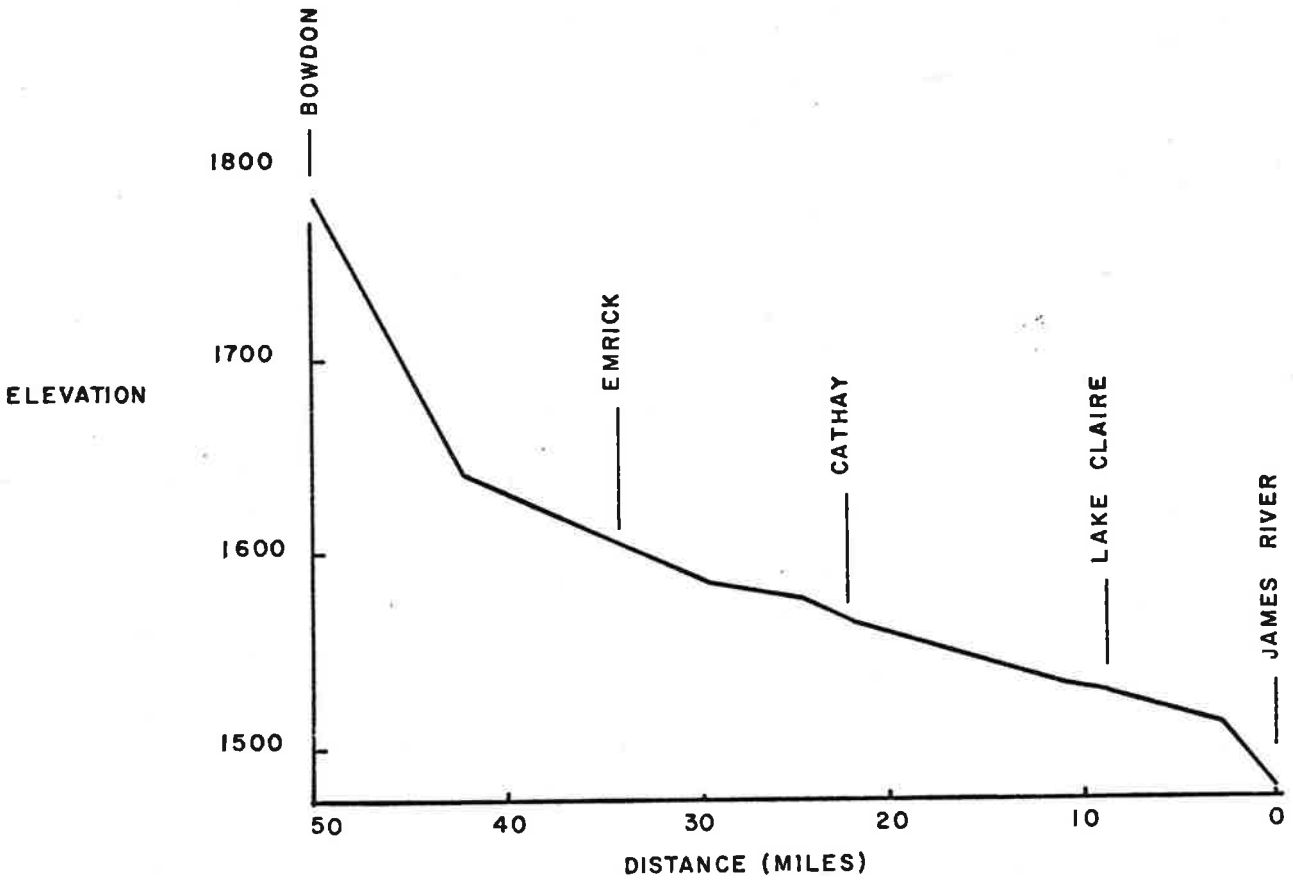


FIGURE 3

ROCKY RUN CREEK – CHANNEL PROFILE

and "Speath" methods were developed for small drainage areas in North Dakota and are based on existing stream records and soil data. They are generally used for small watersheds where historical stream flow data does not exist. These methods would give acceptable results for the Rocky Run Creek drainage area if historical stream flow data were not available for nearby streams. Stream flow data exists at 10 nearby gaging stations, thus a correlation can be made between the existing flow data and the anticipated flows in Rocky Run Creek. The process of deriving this correlation is called a multiple regression analysis. The following regression equations were derived and contain the variables: drainage area, channel slope and channel length.

$$Q_{10} = 26.5 \sqrt{S}\ (\text{ft/mi.})^{0.0054} \cdot L\ (\text{mi})^{-0.2668} \cdot D.A(\text{mi.}^2)^{0.9187}$$

$$Q_{25} = 135.4 \sqrt{S}\ (\text{ft.mi.})^{-0.1915} \cdot L\ (\text{mi.})^{-0.8203} \cdot D.A.\ (\text{mi}^2)^{1.1857}$$

Using these equations the following flows were calculated for the 10 and 25 year frequency floods at various points within the watershed.

TABLE I

Rocky Run Creek Peak Discharges

Location	Drainage Area (Mi^2)	Discharge (cfs) 10 year flood	25 year flood
Confluence with James River	235	1260	2370
Lake Claire	183	1050	2010
Cathay Dam	95	780	1550
6 miles west of Cathay	48	520	1040

Due to the existing conditions of the channel, these flows do not occur on the lower reaches of Rocky Run Creek. Channel obstructions cause the water to overflow the banks and discharge into potholes, small closed drainage basins and an adjancent watershed. After obstructions have been removed and channel improvements made, the overflow will be reduced and the actual discharges will approach the ones given in Table 1.

The Oak Creek Dam sub-basin is located within the Rocky Run Creek drainage area (see Figure 4). The sub-basin contains approximately 54 square miles of drainage area. Approximately 15 square miles in the western portion of the drainage area is not currently contributing. It is assumed, in this analysis, that the entire sub-basin is contributing to allow for future agricultural drainage.

The regression equations derived for the Rocky Run Creek watershed are based on nearby gaging stations with drainage areas of comparable size. Therefore, they are not directly applicable to a smaller sub-basin such as the Oak Creek Drain Sub-basin. As previously stated, the "Crosby method" was derived specifically for small watersheds in North Dakota. Therefore, the "Crosby method" was used to compute the design discharges for Oak Creek Drain. Table 2 contains the design discharge for various points along Oak Creek Drain using this method.

TABLE 2

OAK CREEK DRAIN PEAK DISCHARGES

Location	Discharge (cfs)		
	Drainage Area (mi^2)	10 year Frequency	25 year Frequency
Between Sections 21 & 28-T148N-R68W	~~54~~ 26	310	500
Between Sections 19 & 30-T148N-R67W	41	390	640
Confluence with Rocky Run Creek	~~26~~ 54	450	740

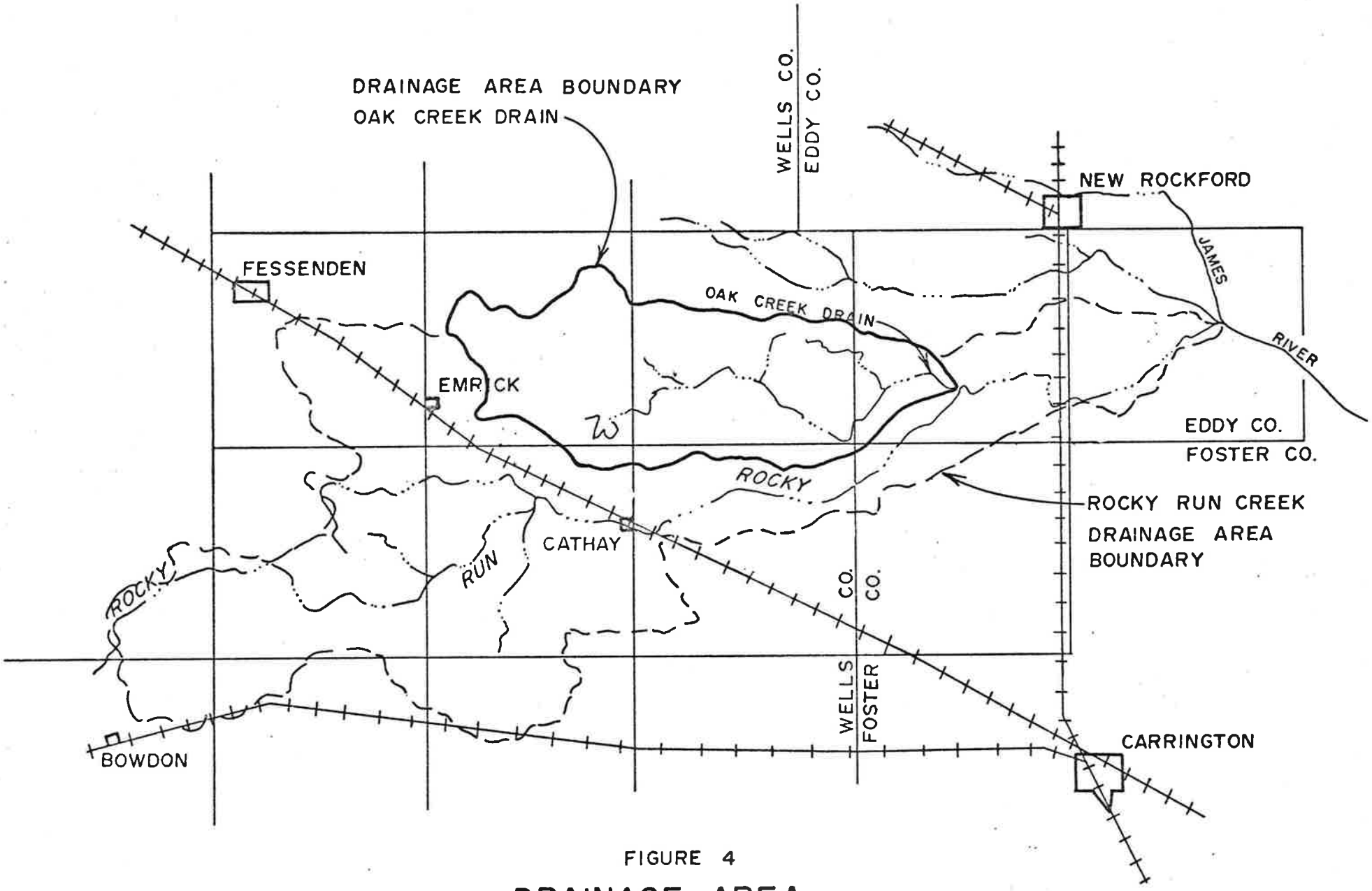


FIGURE 4

DRAINAGE AREA
OAK CREEK DRAIN

WATER SURFACE PROFILE STUDY

The water surface profile is a powerful engineering tool that can be used to effectively model a stream or reservoir for both natural and modified conditions. The effects of various hydraulic structures such as bridges, culverts, weirs, embankments and dams are considered in the computations. The water surface profiles computed for this report are based on actual cross sections obtained by the State Water Commission survey crew. Care was taken and subsequent checks were made to ensure that the completed water surface profiles are accurate and reliable.

Due to the excessive number of calculations involved, it is necessary to utilize a computer model to complete the computations. The model used in this study is the Water Surface Profile Computer Program developed by the U.S. Bureau of Reclamation. This program has been used effectively by the Bureau of Reclamation on several streams in North Dakota. The program utilizes the energy conservation and energy balance theories as they relate to subcritical flow in a natural stream. The computer program input data must include: a rating curve for the most downstream cross section, cross sectional data, the distance between cross sections, an estimate of the roughness coefficients of the channel and overbank areas and the discharges for which the water surface profiles are desired. The computations begin on the most downstream cross section and procede upstream, calculating the water surface elevation for each cross section, including road crossings.

For the purpose of this study, Rocky Run Creek has been divided into four reaches (see Figure 5). Reach 1 extends from the confluence with the James River to Lake Claire. Reach 2 extends from Lake Claire to the county line between Wells and Foster Counties. Reach 3 extends from the county line to the city of Cathay. The length of channel

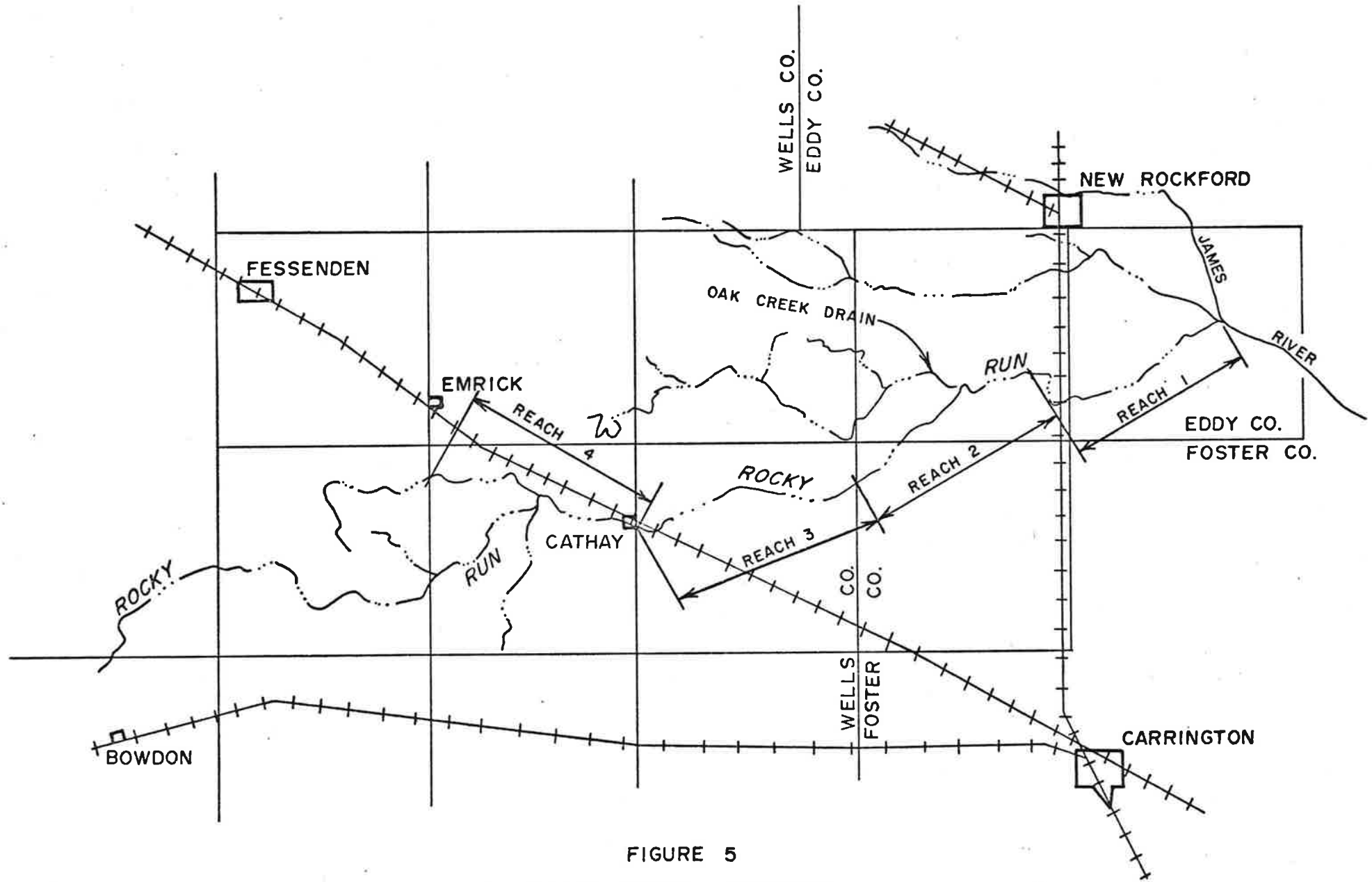


FIGURE 5

ROCKY RUN CREEK
LOCATION OF REACHES

between Cathay and the section line between Sections 6 and 11, Township 147 North, Range 69 and 70 West, constitutes Reach 4. Oak Creek Drain, the main northern tributary of Rocky Run Creek which flows through Rosefield Slough, is also analysed in this report.

In order to prioritize the necessary improvements, each reach was analyzed for three conditions: The first involves computing the water surface profile for the existing conditions. The second includes computing the water surface profiles for each reach after Phase 1 improvements have been made. Phase 1 improvements refer to minor localized changes that would effect the water surface profile. These improvements would not have a significant effect on the overall capacity of the stream, but they will eliminate some localized flooding. The third condition involves computing the water surface profiles after Phase 2 improvements have been made. Phase 2 improvements involve upgrading certain channel sections and road crossings such that the overall stream capacity is increased and general flooding throughout the area is reduced.

State Water Commission criteria states that all channels and corresponding structures that provide drainage to agricultural lands must be designed to handle the 10 and 25 year frequecny floods, respectively. A previous investigation by the State Water Commission and the succeeding profiles illustrate that it is not economically feasible to improve the Rocky Run Creek stream channel to handle a 10 year discharge along the entire channel because of the large channel cuts required, due to the flatness of the natural terrain. The Phase 2 improvements presented in this report provide for the 10 year frequency flood being maintained within the floodplain. The floodplain includes the channel and the overbank

areas. Under this system, land adjacent to the channel is temporarily flooded, but water will not overflow onto farmland where it can not drain off.

All roadway crossings designated for improvement under Phase 2 are designed for a 25 year discharge if the upstream and downstream floodplains can handle this discharge. If the crossing is inundated by backup water caused by the inadequacy of the downstream channel, the crossing will be designed for a discharge slightly greater than the discharge in the downstream channel when inundation of the crossing is pending.

REACH 1

Reach 1 extends upstream from Rocky Run Creek's confluence with the James River to Lake Claire. Detailed field survey data was obtained for this reach in the spring of 1976 with supplemental data obtained in the fall of 1977. Figure 6 shows the location of the channel and the cross sections that were used in the water surface profile computations. This reach is a critical area of Rocky Run Creek for it contains numerous channel obstructions and does not have a uniform gradient. The hydrologic analysis indicated that the 10 and 25 year frequency discharges within this reach would be approximately 1,100 cfs and 2,200 cfs, respectively. The capacity of the existing channel is much less than the 10 year frequency discharge.

The water surface profile model was used to evaluate the existing conditions. Figure 7 shows a profile of the channel bottom and water surface profiles for 200 cfs and 400 cfs discharges. A flow of 400 cfs represents the approximate flow capacity of the floodplain. At higher discharges, water overflows the banks and is contained in potholes, therefore not contributing to stream discharge. If this did not occur, many of the inadequate road crossings would be washed out during high flows.

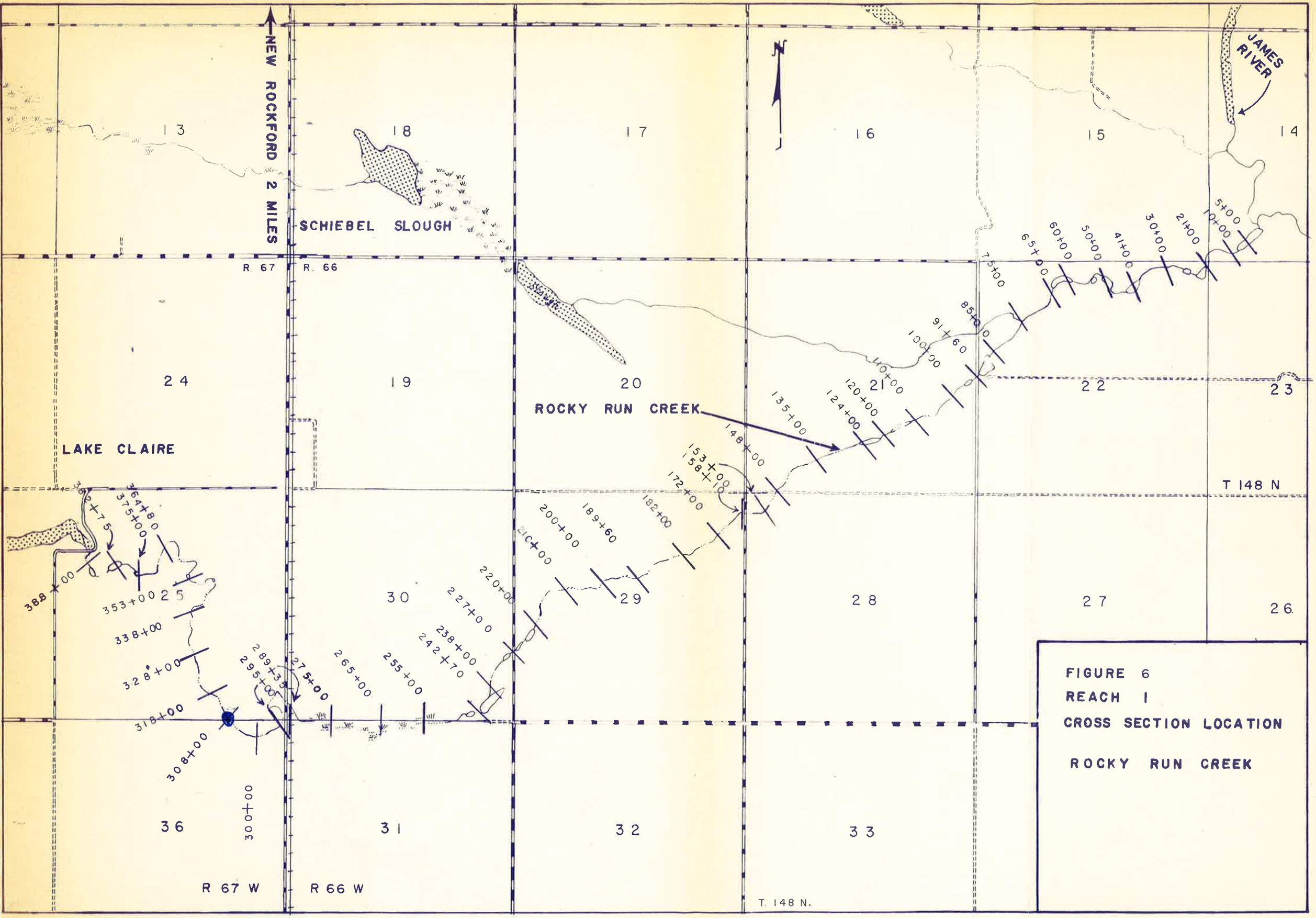
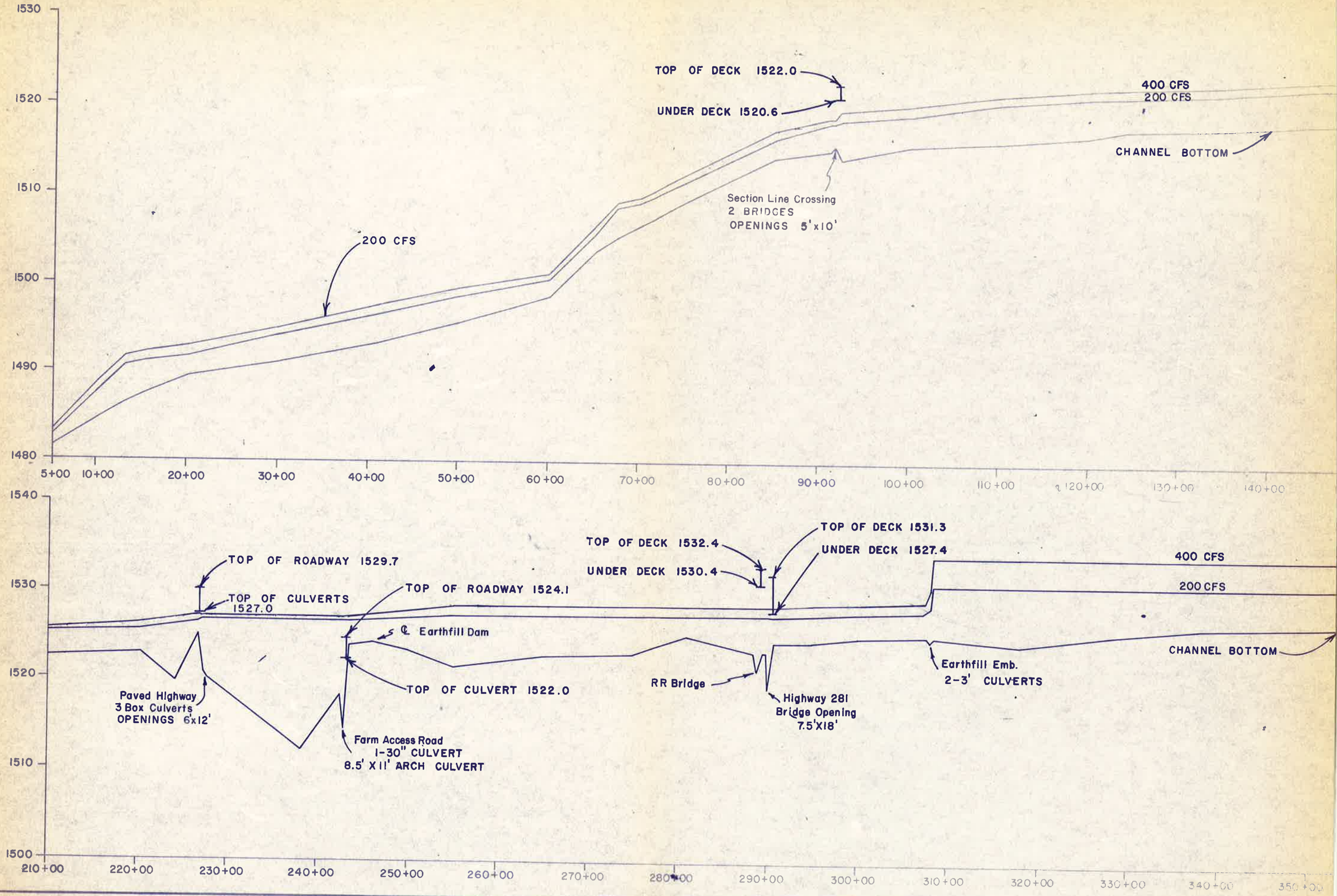


FIGURE 6
REACH 1
CROSS SECTION LOCATION

ROCKY RUN CREEK


1530
1520
1510
1500
1490
1480
TOP OF DECK 1522.0
UNDER DECK 1520.6
400 CFS
200 CFS
CHANNEL BOTTOM
Section Line Crossing
2 BRIDGES
OPENINGS 5'x10'
200 CFS
5+00
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
90+00
100+00
110+00
120+00
130+00
140+00
1540
1530
1520
1510
1500
TOP OF DECK 1532.4
UNDER DECK 1530.4
TOP OF DECK 1531.3
UNDER DECK 1527.4
400 CFS
200 CFS
TOP OF ROADWAY 1529.7
TOP OF CULVERTS
1527.0
TOP OF ROADWAY 1524.1
℄ Earthfill Dam
CHANNEL BOTTOM
TOP OF CULVERT 1522.0
RR Bridge
Earthfill Emb.
2-3' CULVERTS
Paved Highway
3 Box Culverts
OPENINGS 6'x12'
Highway 281
Bridge Opening
7.5'X18'
Farm Access Road
1-30" CULVERT
8.5' X 11' ARCH CULVERT
210+00
220+00
230+00
240+00
250+00
260+00
270+00
280+00
290+00
300+00
310+00
320+00
330+00
340+00
350+00

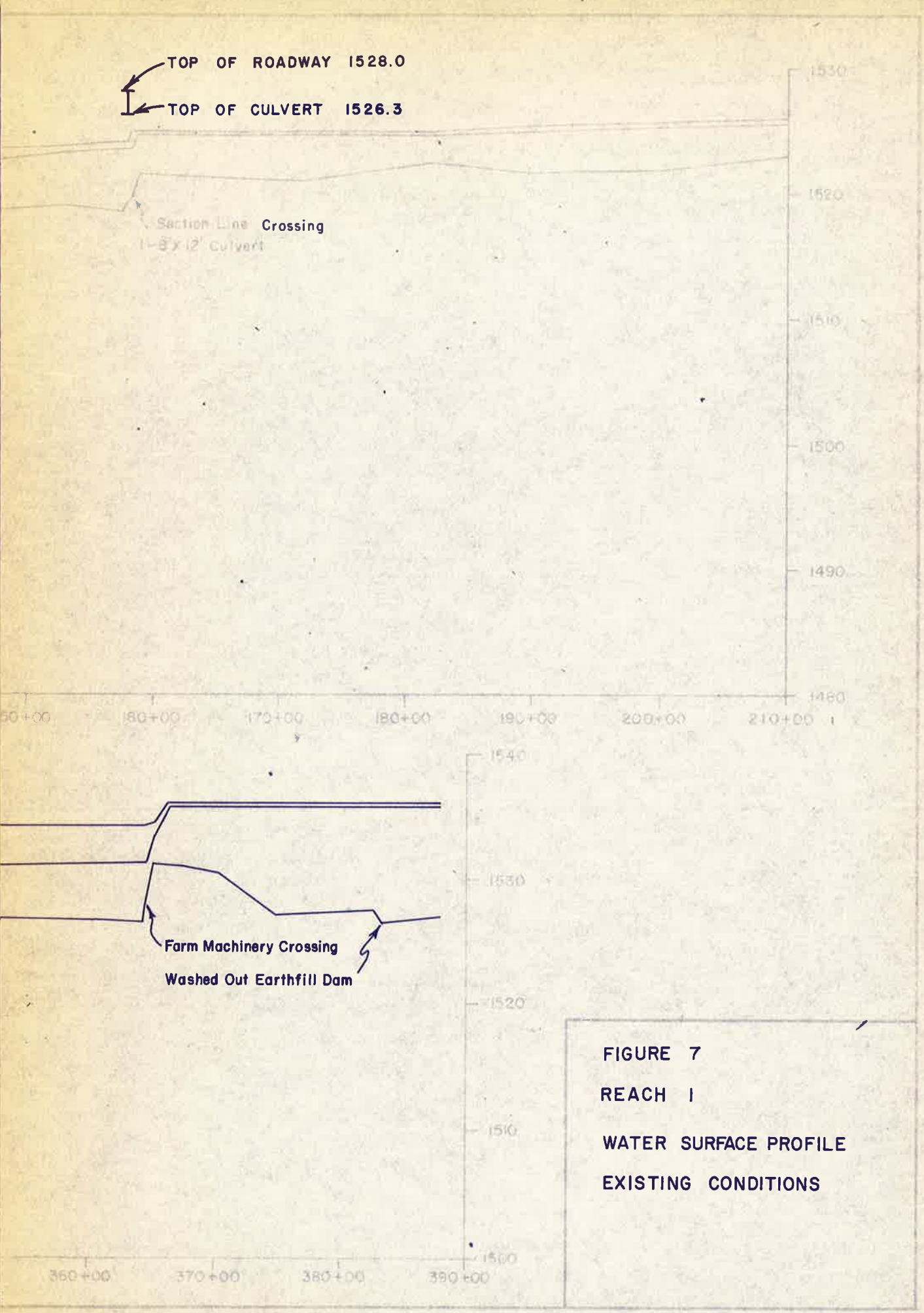


FIGURE 7

REACH 1

WATER SURFACE PROFILE

EXISTING CONDITIONS

The profiles in Figure 7 show the irregularity of the channel bottom and the sudden increases in the water surface profile. The channel bottom has a steep gradient between stations 5+00 and 90+00. Velocities within this area may cause erosion problems during flows exceeding 400 cfs. The water surface profiles between these stations are uniform, and the water surface elevations do not approach the stream bank elevations. Between stations 90+00 and 220+00 the channel is considerably flatter, but it does maintain a gradual rise. There are also no major sudden increases in the water surface profiles between these two stations. From station 220+00 to the end of the reach, the channel bottom elevations are very irregular. High points in the channel bottom at stations 226+50 and 246+00 control the flow upstream to station 295+00. Channel crossings at stations 308+00 and 365+00 cause large increases in the water surface profile. These crossings are inadequate and back up water for a considerable distance. It is within this latter half of Reach 1 that the water surface elevations for the 400 cfs discharge are near the overflow elevations of the floodplain.

These profiles indicate specific areas within the reach that cause major problems in the ability of the channel to convey high discharges. Phase 1 improvements would consist of removing channel obstructions, as well as a general cleanup of the channel. The following specific improvements would be completed under Phase 1.

TABLE 3
PHASE I IMPROVEMENTS - REACH I

Improvment No.	Location	Improvement
1	STA. 95+00 to STA. 388+00	Clean out excessive rock & debris in channel.
2.	STA. 225+50 to STA. 227+70	Lower channel to elevation 1523.0.

Improvement No.	Location	Improvement
3	STA. 246+00	Remove small earthfill dam.
4	STA. 308+00	Remove earthfill and rock dam.
5	STA. 364+00	Remove farm machinery crossing.
6	STA. 383+00	Remove remaining portions of washed out dam.

(machinery crossing) put in Texas Crossing

It is anticipated that these improvements would make a significant improvement in the water surface profile and reduce localized flooding, without excessive costs. Table 3 contains a cost estimate for these improvements.

TABLE 4
COST ESTIMATE - PHASE I IMPROVEMENTS - REACH I

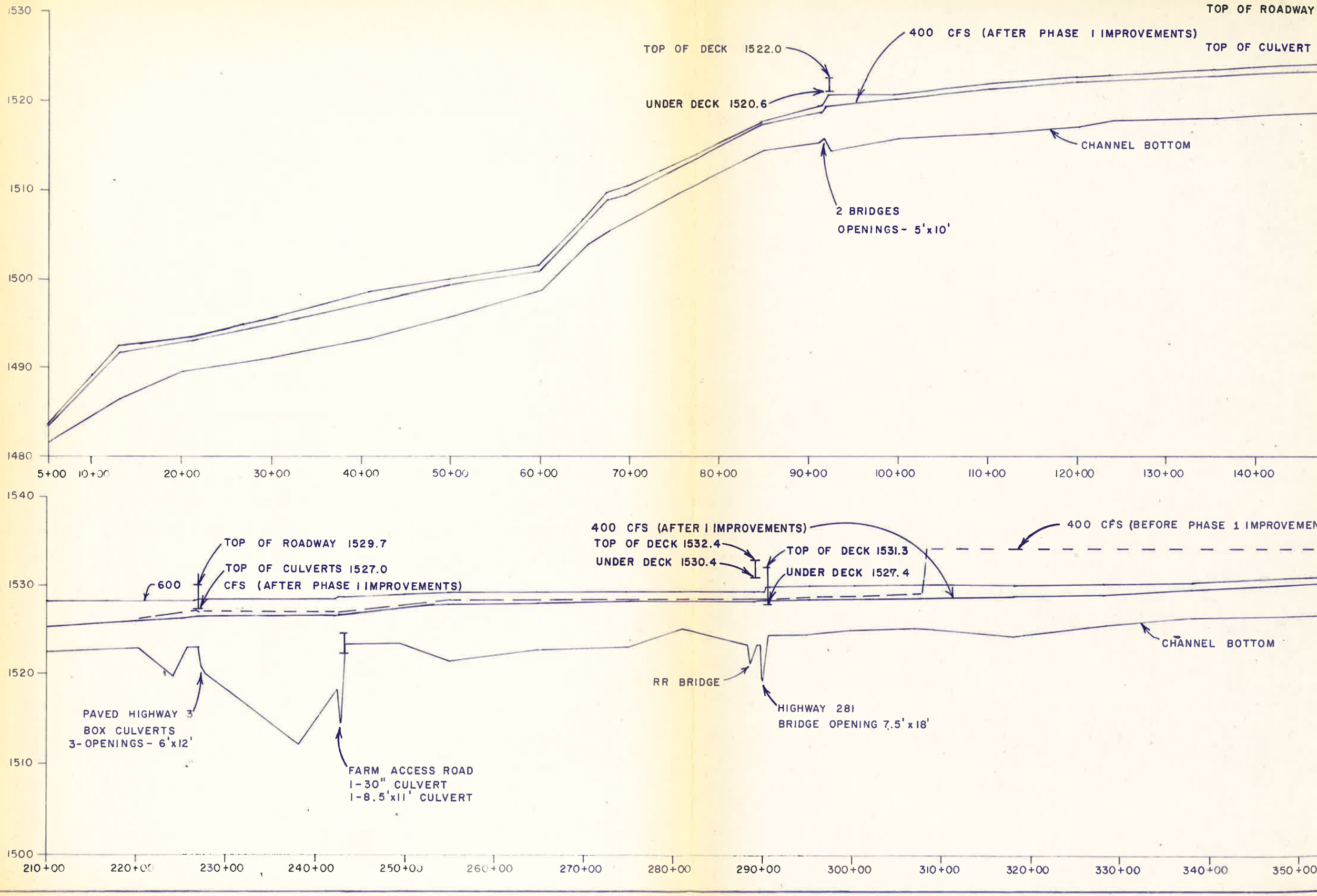
Improvement No.	Item	Units	Quantity	Unit Price	Extended Price
1	Channel Cleanout	LS	1 ea.	$ 7,000.00	$ 7,000.00
2	Lower Channel	Yd^3	1200	0.90	1,080.00
3 & 4	Remove Earthfill Dams (Stations: 246+00, 308+00)	LS	2 ea.	1,500.00	~~1,080.00~~ 3000.00
5	Remove Farm Machinery Crossing (Station 364+80)	LS	1 ea.	1,500.00	1,500.00
6	Remove Washed Out Dam	LS	1 ea.	1,000.00	1,000.00
			Subtotal		$13,580.00
			Engineering, Construction Inspection and Contract Administration (15%+)		2,060.00
			Contingencies		1,360.00
			Estimated Cost For Phase I Improvements		$17,000.00

After updating the input data to reflect the Phase 1 improvements, another set of profiles was computed. Figure 8 shows the water surface profiles for 400 to 600 cfs after Phase 1 improvements have been made and the profile for 400 cfs before these improvements were made. As a result of the Phase 1 improvements, the capacity of the floodplain has been increased from 400 to 600 cfs. Flows above 600 cfs will cause water to flow out of the floodplain.

The profiles shown in Figure 8 indicate that the specific problem areas are less evident, therefore, the solutions will be more complex. The Phase 2 improvements proposed in this section meet the critieria stated in the previous section. The general goal of these improvements is to increase the capacity of the floodplain such that water overflowing into small closed basins and the adjacent watershed would be prevented for a 10 year frequency flood. Several computer runs were made to evaluate different types of improvements to determine the ones that would have the most significant effects on the water surface profiles. Table 5 summarizes the proposed Phase 2 improvements. It is assumed in this portion of the analysis that the Phase 1 improvements have been made.

TABLE 5
PHASE 2 IMPROVEMENTS - REACH 1

Improvement No.	Location	Improvement
1	STA. 5+00 to STA 90+00	Erosion protection as required.
2	STA. 91+60	Improve road crossing.
3	STA. 158+10	Improve road crossing.
4	STA. 158+60 to STA 226+50	Lower and reshape existing stream channel.
5	STA. 243+30 to STA. 255+00	Lower and reshape existing stream channel.


TOP OF ROADWAY
400 CFS (AFTER PHASE I IMPROVEMENTS)
TOP OF CULVERT
TOP OF DECK 1522.0
UNDER DECK 1520.6
CHANNEL BOTTOM
2 BRIDGES
OPENINGS - 5'x10'
1530
1520
1510
1500
1490
1480
5+00
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
90+00
100+00
110+00
120+00
130+00
140+00
400 CFS (AFTER I IMPROVEMENTS)
TOP OF DECK 1532.4
UNDER DECK 1530.4
TOP OF DECK 1531.3
UNDER DECK 1527.4
400 CFS (BEFORE PHASE 1 IMPROVEMEN
TOP OF ROADWAY 1529.7
TOP OF CULVERTS 1527.0
600 CFS (AFTER PHASE I IMPROVEMENTS)
CHANNEL BOTTOM
RR BRIDGE
HIGHWAY 281
BRIDGE OPENING 7.5' x 18'
PAVED HIGHWAY 3
BOX CULVERTS
3-OPENINGS - 6'x12'
FARM ACCESS ROAD
1-30" CULVERT
1-8.5'x11' CULVERT
1540
1530
1520
1510
1500
210+00
220+00
230+00
240+00
250+00
260+00
270+00
280+00
290+00
300+00
310+00
320+00
330+00
340+00
350+00

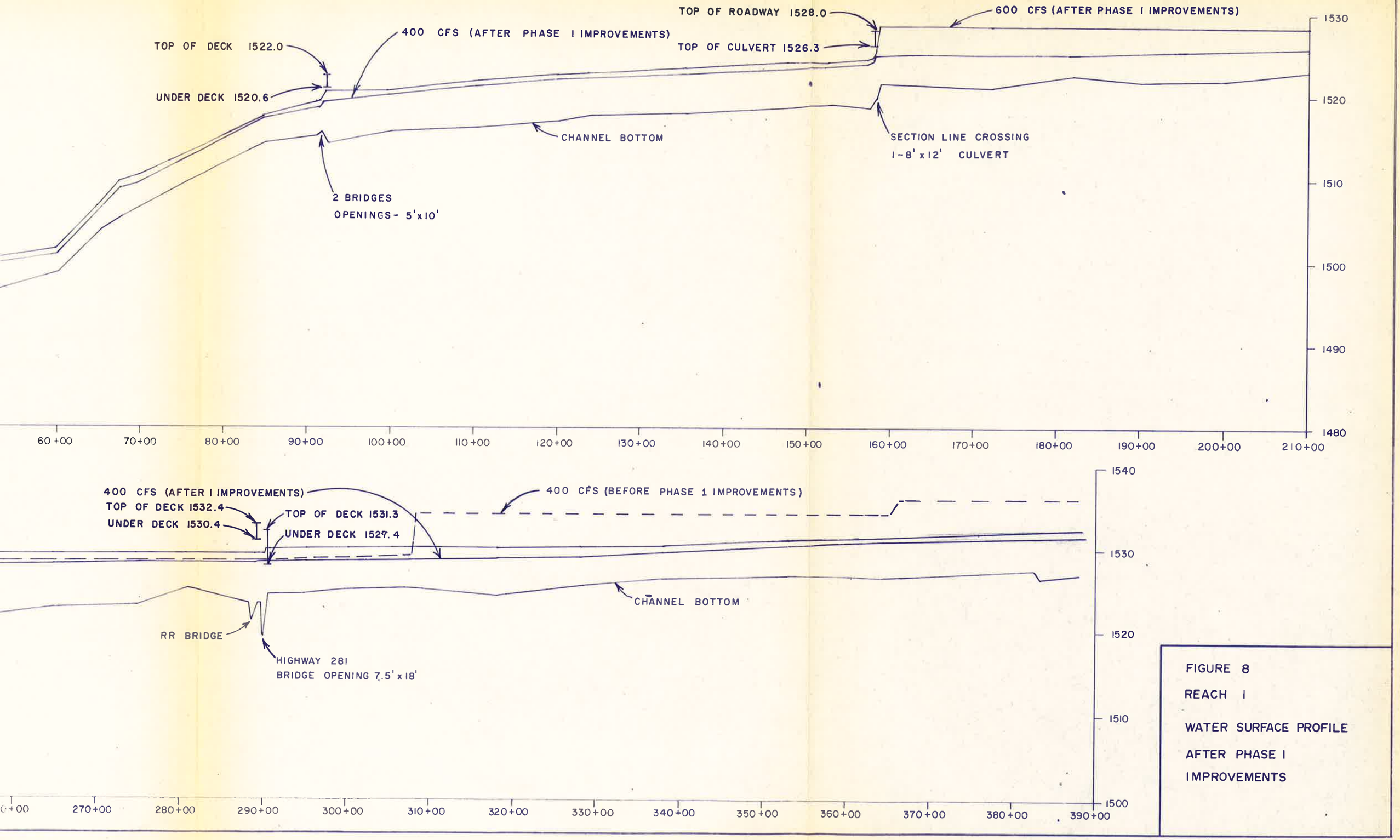


FIGURE 8

REACH 1

WATER SURFACE PROFILE

AFTER PHASE I

IMPROVEMENTS

6	STA. 295+00	Remove localized high in stream channel.

The steep channel gradient between station 5+00 and 90+00 makes this portion of Reach 1 susceptable to erosion. The erosion potential can be illustrated by the flow velocities and the tractive forces. Table 6 shows the flow velocities and tractive forces for various stations within this area. The general locations where erosion may occur are delineated by an asterisk. Generally, velocities greater than 3.5 feet per second can cause erosion of the stream channel.

TABLE 6
Velocities and Tractive Forces
(Q=1100 cfs = 10 year frequency flood)

STATION	VELOCITY (ft/sec.)	TRACTIVE FORCE (lbs.)
*5+00	5.32	0.783
*10+00	8.09	1.809
*13+00	3.77	0.344
15+50	2.77	0.193
21+00	2.47	0.154
*30+00	4.97	0.614
41+00	3.55	0.303
50+00	2.81	0.202
60+00	3.48	0.296
*65+00	8.02	1.769
*67+50	4.28	0.449
*70+00	5.19	0.689
*85+00	3.73	0.398
91+10	1.75	0.085

* denotes an area where erosion may occur

Erosion protection for these areas will be provided by the placement of rock riprap in specific areas as determined by the field engineer. A cost estimate for erosion protection will be included in the total project cost.

The existing road crossing at station 91+60, between Sections 21 and 22, Township 148 North, Range 66 West, consists of two small bridges

which are inadequate for flows exceeding 800 cfs. The bridge openings are too small and the creek bottom elevation is too high under the bridges and immediately downstream of the crossing. The Phase 2 improvement for this crossing would consist of the following: 1) add two 87"x63" arch corregated metal pipe (CMP) culverts; and 2) lower the inverts of the installed culverts to elevation 1514.6 and lower the channel bottom just downstream of the crossing to conform to the lowered invert elevations.

The area extending from station 158+10 to station 255+00 is a very critical portion of Rocky Run Creek. Extensive flooding occurs within this area and water will occasionally overflow into the Kelly Creek watershed. The first improvement within this area would be made to the road crossing at station 158+10, between Section 28 and 29, Townshp 148 North, Range 66 West. Three 95"x67" arch CMP culverts would be added to this crossing to increase its capacity to the 25 year frequency discharge of 2200 cfs.

The existing channel between stations 158+10 and 227+00 has a high channel bottom elevation and controls the flow for a considerable distance upstream. This portion of the channel would be lowered and reshaped. The channel would have a bottom width of 60 feet and a slope of 0.00017.

The existing highway crossing at station 227+00 between Section 29 and 30, Township 148 North, Range 66 West would be inundated on a 25 year frequency flood with 0.7 foot of water flowing over the road. This crossing consists of concrete box culverts that were just recently installed, therefore, they would not be replaced under this project. The farm access road located at station 242+70 was thought to be a control section within this reach. It has been determined that this

crossing is inundated by back up water from the downstream channel during discharges as low as 400 cfs. Therefore, it would not help to increase the capacity of the structure. If the road is in poor condition, it should be graveled to protect it from serious erosion caused by water flowing over the road.

The other proposed improvements to Reach 1 would consist of lowering and reshaping the existing channel between stations 243+30 and 255+00 and near station 295+00. The railroad and highway bridges located near station 290+00 would be very near their capacity during a 25 year frequency flood. It would be expensive to upgrade these structures and a small amount of water flowing over them would not endanger their existence. Therefore, the improvement of these structures is not included as part of this project.

The implementation of the above improvements would result in a significant lowering of the water surface profile throughout most of this reach. For example, in the later portions of Reach 1 the water surface elevation for a discharge of 400 cfs would be lowered 5 to 6 feet with the implementation of the Phase 1 and Phase 2 improvements. Figure 9 shows the water surface profiles for various discharges after the Phase 1 and Phase 2 improvements have been made. Also shown is the water surface profile for 400 cfs under existing conditions. The capacity of the floodplain would increased from 600 cfs to approximately 2200 cfs with these improvements. A flow of 2200 cfs represents a 25 year frequency discharge.

Table 7 contains a detailed cost estimate for the Phase 2 improvements and a total cost estimate for the Phase 1 and Phase 2 improvements for this reach.

TABLE 7

COST ESTIMATE - PHASE 2 IMPROVEMENTS - REACH 1

Improvement Number	Item	Units	Quantity	Unit Price	Extended Price
1	Rock Rip Rap	Yds^3	1,700	$ 12.00	$ 20,400.00
2	87"x63" Arch CMP	L.F.	90	85.00	7,650.00
	Excavation	Yds^3	250	0.95	240.00
	Reseeding	Acres	0.5	100.00	50.00
3	95"x67" Arch CMP	L.F.	135	95.00	12,830.00
4	Excavation	Yds^3	49,800	0.95	47,310.00
	Reseeding	Acres	31	100.00	3,100.00
5	Excavation	Yds^3	8,200	0.95	7,790.00
	Reseeding	Acres	5.5	100.00	550.00
6	Excavation	Yds^3	250	0.95	240.00
	Reseeding	Acres	0.5	100.00	50.00
				Estimated Construction Cost	$100,210.00
				Engineering, Construction Inspection and Contract Administration	15,370.00
				Contingencies	10,020.00
				Estimated Cost For Phase 2 Improvements	$125,600.00

TOTAL FOR PHASE 1 AND PHASE 2 IMPROVEMENTS:

Phase 1	-	$ 17,000.00
Phase 2	-	125,600.00
		$142,600.00

TOP OF ROADWAY

TOP OF CULVERT

2200 CFS AFTER PHASE 1&2 IMPROVEMENTS

TOP OF DECK 1522.0

UNDER DECK 1520.6

1100 CFS AFTER PHASE 1&2 IMPROVEMENTS

CHANNEL BOTTOM

SECTION LINE CROSSING
2 BRIDGES
OPENINGS 5' x 10' (EXISTING)
ADDED: 2-87" x 63" ARCH CMP

400 CFS AFTER PHASE 1&2 IMPROVEMENTS

1530
1520
1510
1500
1490
1480

5+00 10+00 20+00 30+00 40+00 50+00 60+00 70+00 80+00 90+00 100+00 110+00 120+00 130+00 140+00

TOP OF DECK 1532.4

UNDER DECK 1530.4

TOP OF DECK 1531.3

TOP OF ROADWAY 1529.7

TOP OF CULVERTS 1527.0

1100 CFS AFTER PHASE 1&2 IMPROVEMENTS)

2200 CFS (AFTER PHASE 1&2 IMPROVEMENTS)

400 CFS AFTER PHASE 1&2 (IMPROVEMENTS)

UNDER DECK
1527.4

RR BRIDGE
(EXISTING)

HIGHWAY 281
BRIDGE OPENING 7.5' x 18' (EXISTING)

PAVED HIGHWAY
3 BOX CULVERTS
OPENINGS 6'x12' (EXISTING)

FARM ACCESS ROAD
1-30" CMP (EXISTING)
1-8.5'x11' ARCH CMP (EXISTING)

1550
1540
1530
1520
1510

210+00 220+00 230+00 240+00 250+00 260+00 270+00 280+00 290+00 300+00 310+00 320+00 330+00 340+00 350+00

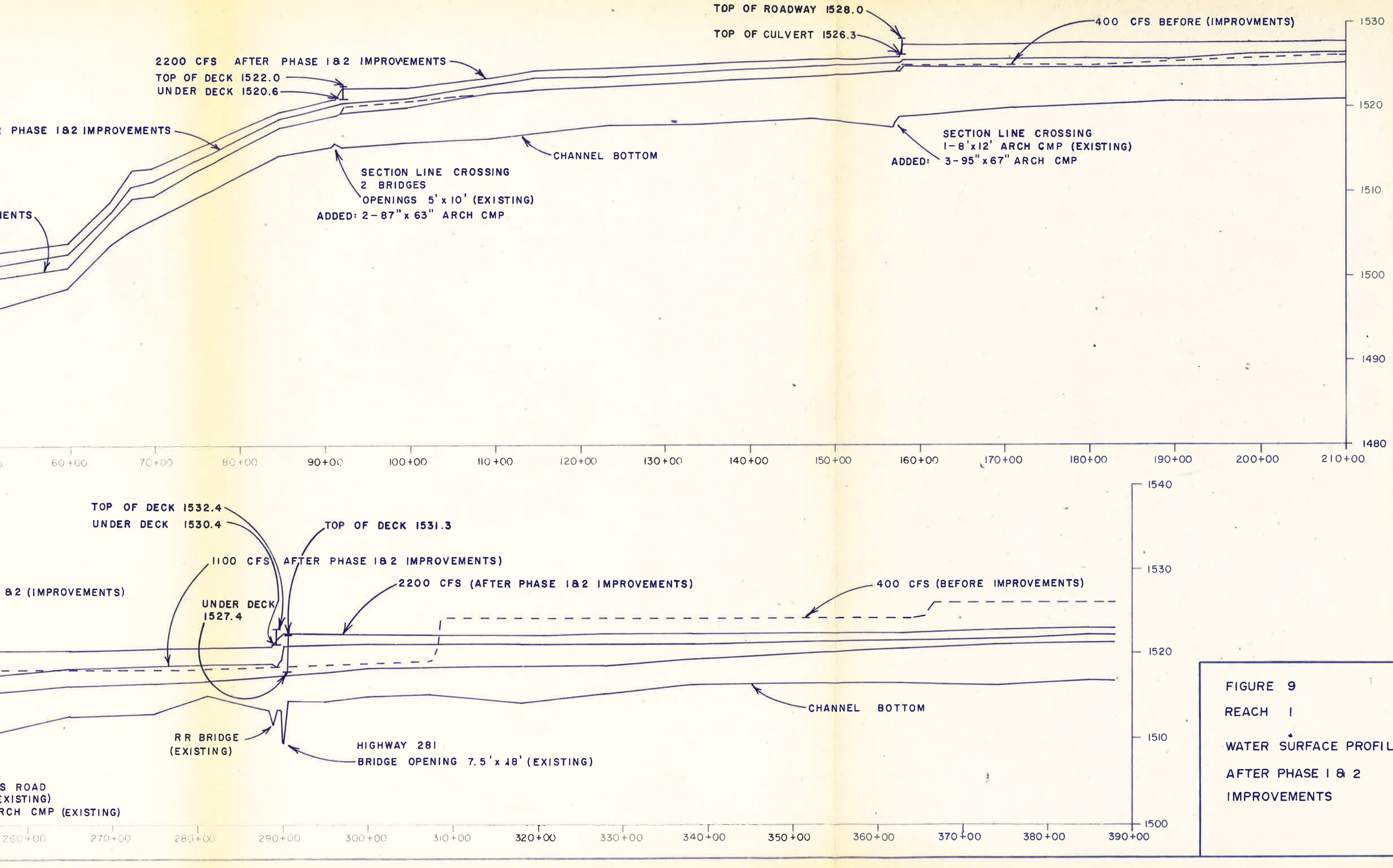


FIGURE 9

REACH 1

WATER SURFACE PROFILE

AFTER PHASE 1 & 2

IMPROVEMENTS

REACH 2

Reach 2 extends from Lake Claire to the Foster-Wells county line. Detailed survey data for this reach was obtained by the State Water Commission survey crew in the fall of 1977. Figure 10 shows the locations of the cross sections that were used in the water surface profile computations. Reach 2 has a more uniform gradient and fewer obstructions than Reach 1, however, it does have some problem areas that cause flooding. The hydrologic analysis indicated that the 10 and 25 year discharges within this reach are approximately 900 cfs and 1700 cfs, respectfully.

The water surface profiles for the existing conditions are shown in Figure 11. These profiles were computed assuming that the Phase 1 improvements have been made on Reach 1. The profiles are very uniform, except near some road crossings which cause abrupt increases in the water surface elevations. From station 388+00 to station 465+00 the water surface profiles show no sudden increases in stage. The depression in the channel bottom profile between these stations forms Lake Claire. The abrupt increases in the water surface elevations at stations 465+00 and 529+00 are caused by road crossings. From station 529+00 to station 615+00 the water surface profiles are fairly uniform but there are three farm machinery crossings that cause some localized flooding. The remainder of the reach has a uniform water surface profile with the exception of five road crossings that cause abrupt stage increases.

The road crossings that cause abrupt increases in the water surface profiles in this reach are major crossings. Therefore, they will be included as Phase 2 improvements. The Phase 1 improvements, as earlier defined, will consist of making minor channel improvements, removing

ROSEFIELD SLOUGH

LAKE CLAIRE

CREEK

ROCKY RUN

539+00
529+00
520+00
510+00
500+00
490+00
480+00
470+00
464+85
455+00
445+00
435+00
425+00
415+00
405+50
400+00
395+65
545+80
555+00
561+27
566+00
571+00
586+94
596+00
603+78
615+00
626+00
636+00
646+00
656+14
666+00
676+00
686+00
694+34
705+00
715+00
725+00
735+00
745+00
755+96
761+00
767+80

30 29 28 27 26

31 32 33 34 35

6 5 4 3 2

7 8 9 10

R. 68 R. 67

WELLS CO

EDDY CO
FOSTER CO

T. 148 N.
T. 147 N.

FIGURE 10

REACH 2

CROSS SECTION LOCATION

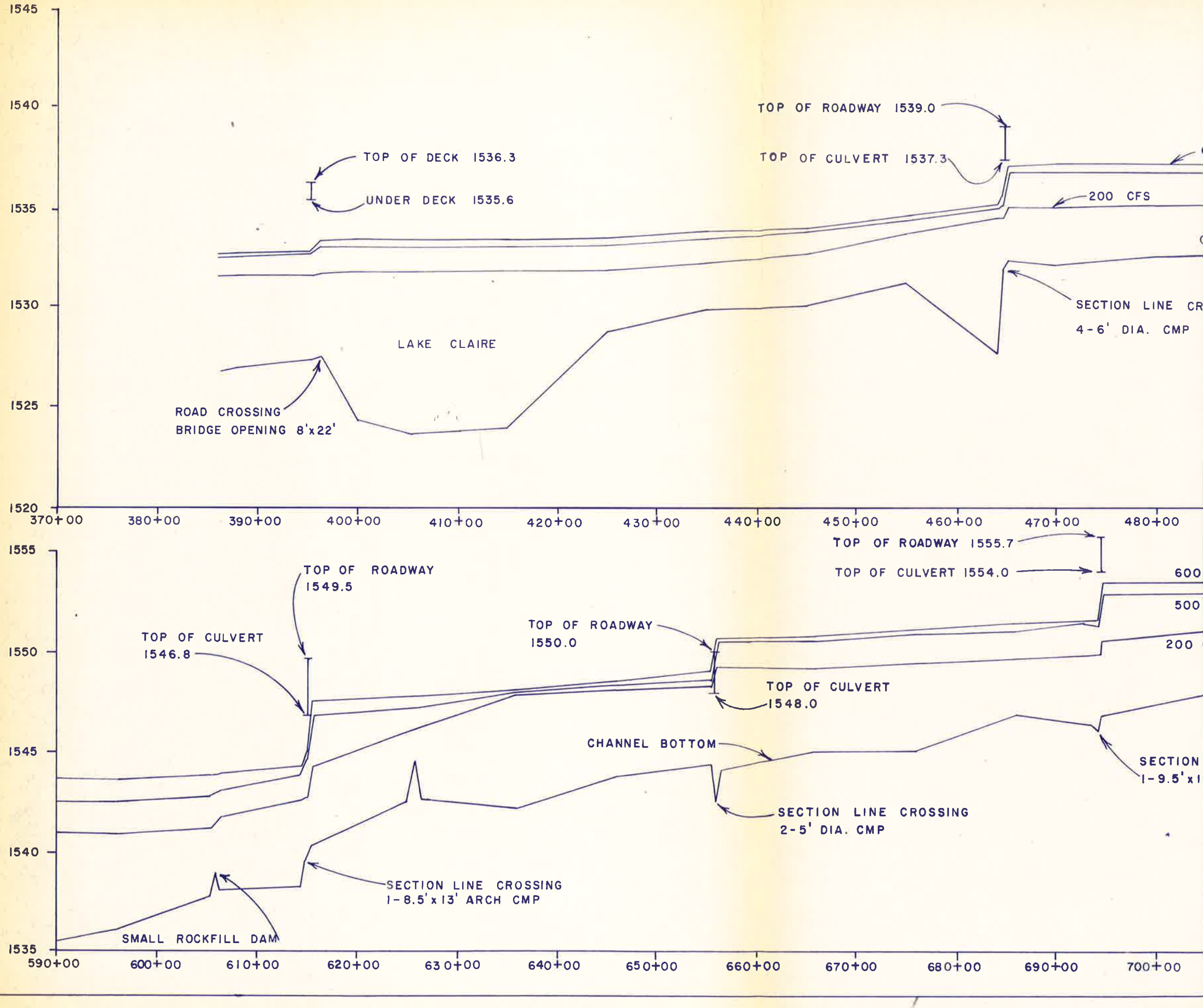
ROCKY RUN CREEK

channel obstructions and removing debris from the channel within the reach. The specific Phase 1 improvements proposed for Reach 2 are listed in Table 8.

TABLE 8
PHASE 1 IMPROVEMENTS - REACH 2

Improvement No.	Location	Improvements
1	STA. 388+00 to STA. 767+50	Remove excessive rock and debris in channel.
2	STA. 465+35	Lower localized high point in stream channel.
3	STA. 529+50	Lower localized high point in stream channel.
4	STA. 545+80	Remove farm machinery crossing.
5	STA. 566+00	Remove farm machinery crossing.
6	STA. 587+00	Remove rockfill embankment.
7	STA. 605+80	Remove rockfill embankment.
8	STA. 626+00	Lower localized high point in stream channel.

The Phase 1 improvements delineated in Table 8 will reduce localized flooding near the area of the improvements, but they will not have a significant effect on the water surface profiles for the higher discharges. Therefore, another set of profiles showing the results of these improvements would not be significantly different from the profiles shown in Figure 11. Table 9 contains a detailed cost estimate for the Phase 1 improvements.


1545
1540
1535
1530
1525
1520
370+00
380+00
390+00
400+00
410+00
420+00
430+00
440+00
450+00
460+00
470+00
480+00
TOP OF ROADWAY 1539.0
TOP OF CULVERT 1537.3
TOP OF DECK 1536.3
UNDER DECK 1535.6
200 CFS
LAKE CLAIRE
SECTION LINE CR
4-6' DIA. CMP
ROAD CROSSING
BRIDGE OPENING 8'x22'
TOP OF ROADWAY 1555.7
TOP OF CULVERT 1554.0
1555
1550
1545
1540
1535
590+00
600+00
610+00
620+00
630+00
640+00
650+00
660+00
670+00
680+00
690+00
700+00
600
500
200
TOP OF ROADWAY
1549.5
TOP OF CULVERT
1546.8
TOP OF ROADWAY
1550.0
TOP OF CULVERT
1548.0
CHANNEL BOTTOM
SECTION
1-9.5'x1
SECTION LINE CROSSING
2-5' DIA. CMP
SECTION LINE CROSSING
1-8.5'x13' ARCH CMP
SMALL ROCKFILL DAM

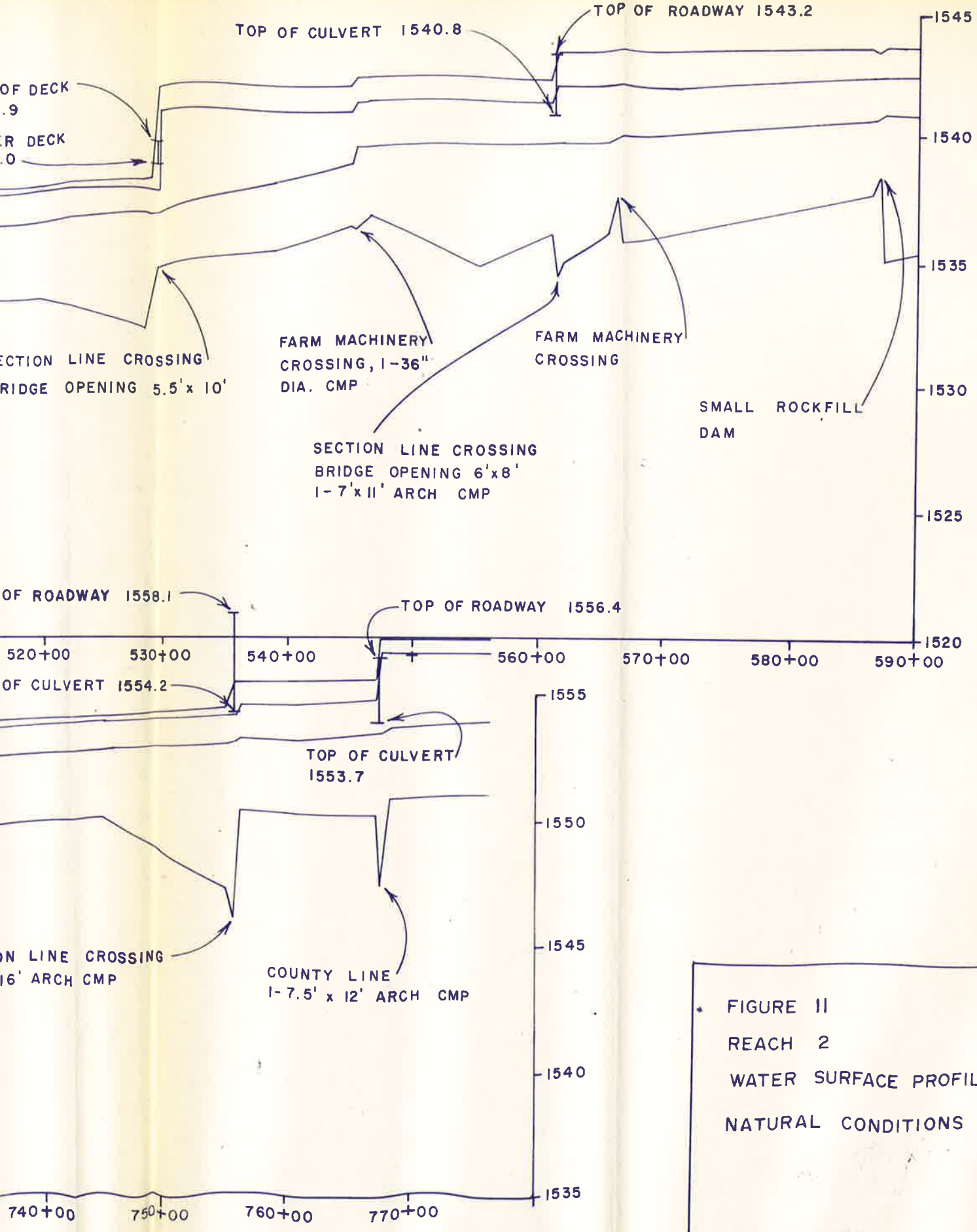


FIGURE 11

REACH 2

WATER SURFACE PROFILE

NATURAL CONDITIONS

TABLE 9
COST ESTIMATE - PHASE 1 IMPROVEMENTS - REACH 2

Improvement Number	Item	Units	Quantity	Unit Price	Extended Price
1	Channel Cleanout	Lump Sum	1 ea.	$ 7,000.00	$ 7,000.00
2,3 & 8	Remove Channel High Points	Lump Sum	3 ea.	1,500.00	1,500.00
4	Remove Farm Machinery Crossing	Lump Sum	1 ea.	1,500.00	1,500.00
5	Remove Remaining Portions of Farm Machinery Crossing	Lump Sum	1 ea.	1,000.00	1,000.00
6 & 7	Remove Rockfill Embankment	Lump Sum	2 ea.	1,500.00	3,000.00
				Estimated Construction Cost	$ 14,000.00
				Engineering, Construction Inspection & Contract Administration (15%±)	2,100.00
				Contingencies (10%±)	1,400.00
				Estimated Cost for Phase I Improvements	$ 17,500.00

The Phase 2 improvements would consist exclusively of upgrading road crossings. The entire reach has a fairly uniform gradient, so no channel modification will be required. Table 10 describes the specific improvements that are proposed under Phase 2.

TABLE 10
PHASE 2 IMPROVEMENTS - REACH 2

Improvement #	Location	Improvements
1	STA. 465+00	Improve Road Crossing
2	STA. 529+00	Improve Road Crossing
3	STA. 561+30	Improve Road Crossing
4	STA. 615+00	Improve Road Crossing
5	STA. 656+00	Improve Road Crossing
6	STA. 694+30	Improve Road Crossing
7	STA. 756+00	Improve Road Crossing
8	STA. 767+90	Improve Road Crossing

The road crossing at station 465+00, between Sections 26 and 27, Township 148 North, Range 67 West, currently consists of four 6' diameter CMP culverts. This crossing has a capacity of approximately 1000 cfs. The addition of two 103"x71" arch CMP culverts would increase the capacity of this crossing to 1700 cfs, the 25 year frequency discharge. The next phase 2 improvement is at station 529+00, a road crossing between Sections 27 and 29, Township 148 North, Range 67 West. The existing bridge with a 5.5'x10' opening is inadequate. This crossing is effected by backup water from the downstream channel which reduces the capacity of the structure. The upgrading of this crossing would require 6 large culverts in addition to the existing bridge. Therefore, it is recommended that the bridge be replaced by a series of five reinforced concrete box culverts with openings of 5'x10'.

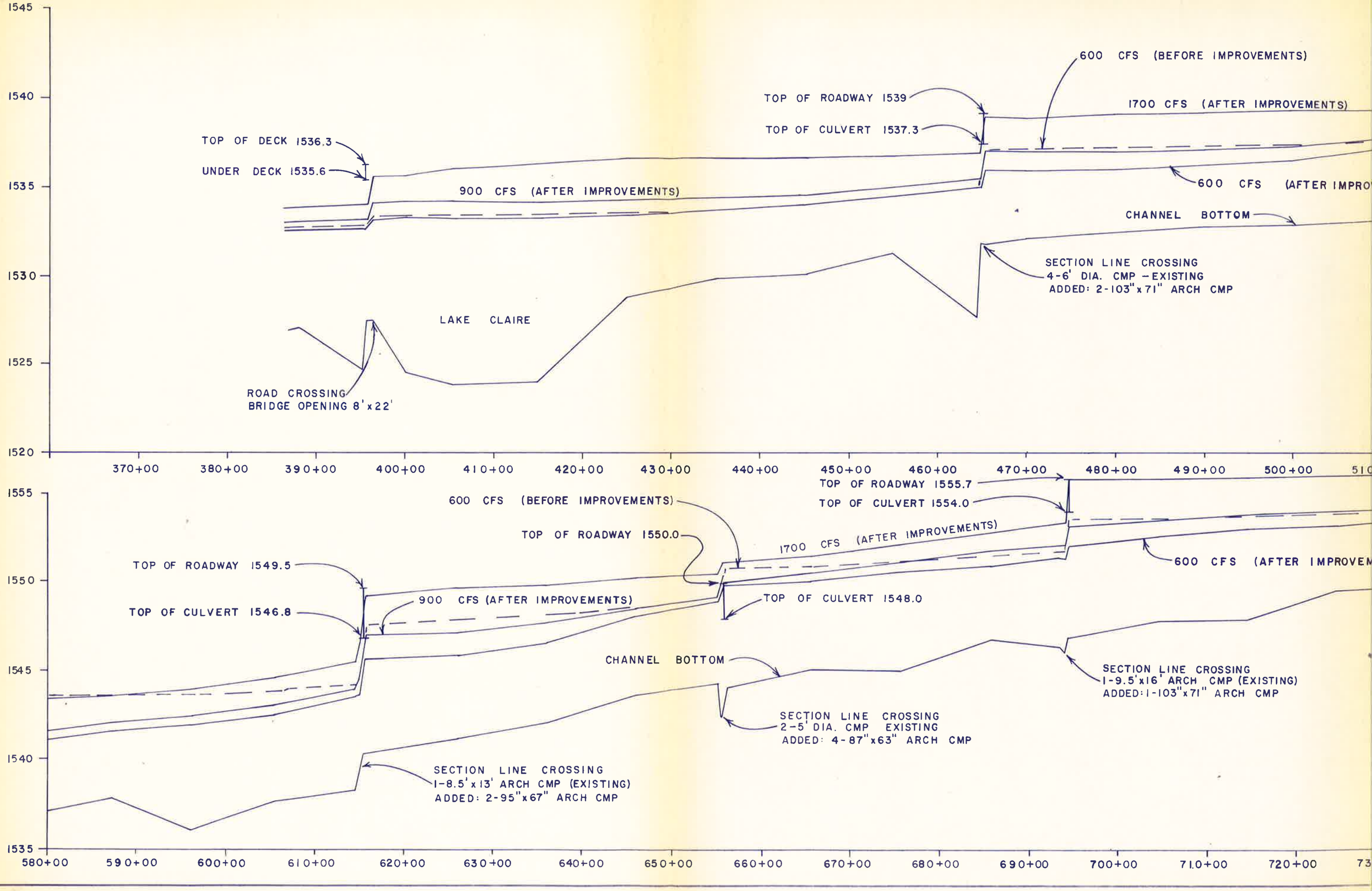
The road crossing at station 561+30, between Section 28 and 33, Township 148 North, Range 67 West, has a bridge with an opening of 6'x8' and an 11'x7' arch CMP culvert. The roadway at this crossing is 8.5'

above the invert elevations of the bridge and culvert, which helps to prevent overtopping of the road at high discharges. The Phase 2 improvement for this crossing would consist of the addition of one 81"x59" arch CMP culvert.. The next upstream road crossing, located at station 615+00, consists of one 8.5'x13' arch CMP culvert. The addition of two 95"x67" arch CMP culverts would increase the capacity of this crossing to a 25 year frequency discharge.

Backup water caused by the downstream channel inundates the crossing at station 656+00 at a discharge of approximately 1,300 cfs. The existing structure consists of two 5' diameter CMP culverts. Because of the back water effect, this crossing would be improved to a capacity slightly larger than 1300 cfs. The addition of four 87"x63" arch CMP culverts would increase the capacity of this crossing to approximately 1400 cfs. The road crossing at station 694+30, between Sections 5 and 6, Township 147 North, Range 67 West, has an existing 9.5'x16' arch CMP culvert. The addition of one 103"x71" arch CMP culvert would increase the capacity of this crossing to a 25 year frequency discharge of 1700 cfs. The next upstream road crossing at station 756+00 also has an existing 9.5'x16' arch CMP culvert under the roadway. The improvements of this crossing would also consist of the addition of one 103"x71" arch CMP culvert. The last road crossing in this reach is located at station 767+90 and has an existing 7.5'x12' arch CMP culvert under the roadway. This crossing is inundated by back up water from the downstream channel at a discharge of approximately 1100 cfs. The addition of two 87"x63" arch CMP culverts would increase the capacity of this crossing to approximately 1150 cfs.

The input data to the water surface profile computer model was updated to reflect the above changes. Figure 12 shows the water surface profiles after the Phase 1 and Phase 2 improvements have been made along with the profile for 600 cfs under existing conditions. The figure indicates that the implementation of the Phase 1 and Phase 2 improvements would lower the water surface elevation 1 to 2 feet for a 600 cfs discharge within this reach.

Table 10 contains a detailed cost estimate for the proposed Phase 2 improvements and a total cost estimated for the Phase 1 and Phase 2 improvements.


1545
1540
1535
1530
1525
1520
370+00
380+00
390+00
400+00
410+00
420+00
430+00
440+00
450+00
460+00
470+00
480+00
490+00
500+00
TOP OF DECK 1536.3
UNDER DECK 1535.6
900 CFS (AFTER IMPROVEMENTS)
TOP OF ROADWAY 1539
TOP OF CULVERT 1537.3
600 CFS (BEFORE IMPROVEMENTS)
1700 CFS (AFTER IMPROVEMENTS)
600 CFS (AFTER IMPRO
CHANNEL BOTTOM
SECTION LINE CROSSING
4-6' DIA. CMP - EXISTING
ADDED: 2-103"x71" ARCH CMP
LAKE CLAIRE
ROAD CROSSING
BRIDGE OPENING 8'x22'
1555
1550
1545
1540
1535
580+00
590+00
600+00
610+00
620+00
630+00
640+00
650+00
660+00
670+00
680+00
690+00
700+00
710+00
720+00
TOP OF ROADWAY 1555.7
TOP OF CULVERT 1554.0
600 CFS (BEFORE IMPROVEMENTS)
TOP OF ROADWAY 1550.0
1700 CFS (AFTER IMPROVEMENTS)
600 CFS (AFTER IMPROVEM
TOP OF ROADWAY 1549.5
TOP OF CULVERT 1546.8
900 CFS (AFTER IMPROVEMENTS)
TOP OF CULVERT 1548.0
CHANNEL BOTTOM
SECTION LINE CROSSING
1-9.5'x16' ARCH CMP (EXISTING)
ADDED: 1-103"x71" ARCH CMP
SECTION LINE CROSSING
2-5' DIA. CMP EXISTING
ADDED: 4-87"x63" ARCH CMP
SECTION LINE CROSSING
1-8.5'x13' ARCH CMP (EXISTING)
ADDED: 2-95"x67" ARCH CMP

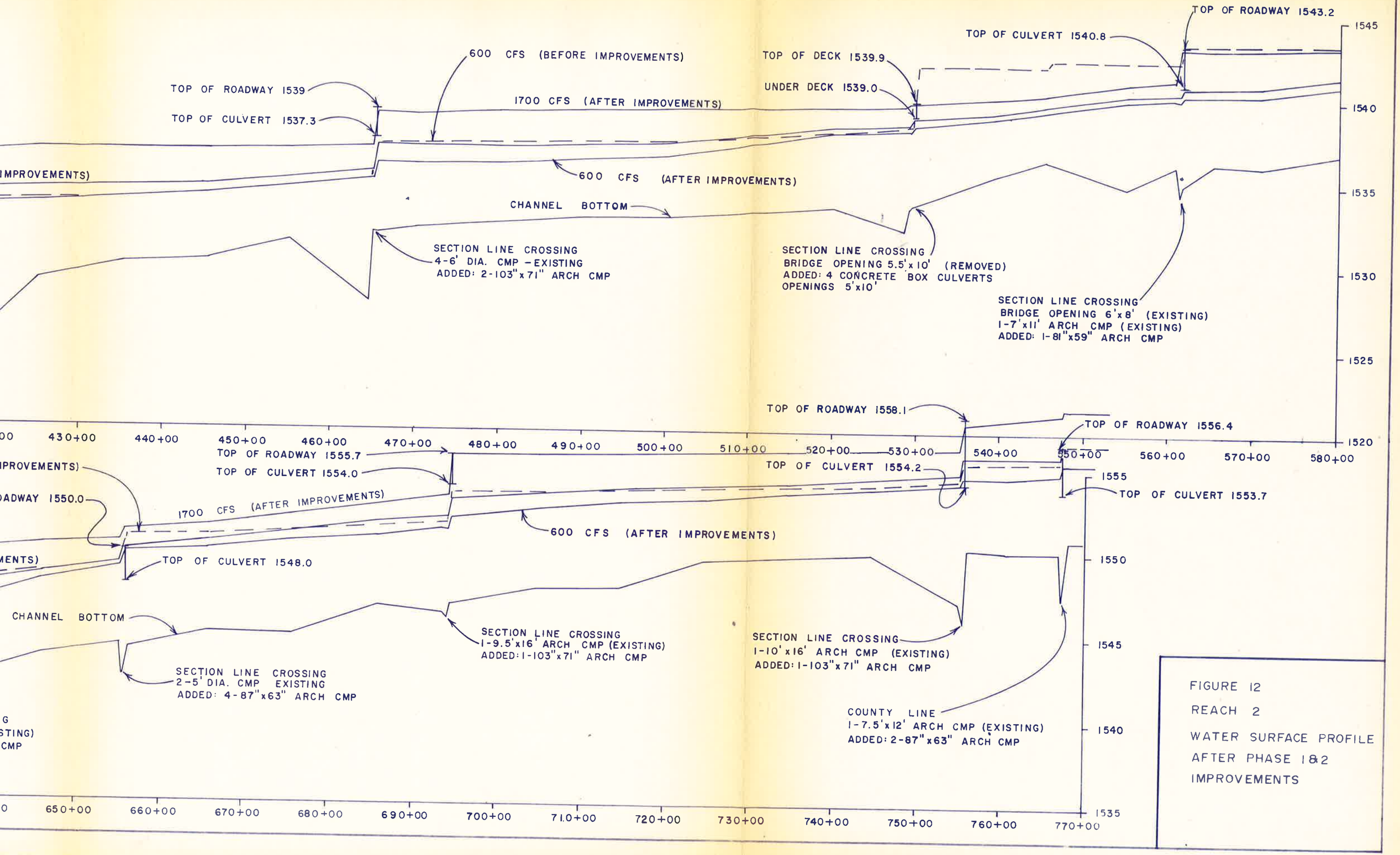


FIGURE 12

REACH 2

WATER SURFACE PROFILE

AFTER PHASE 1&2

IMPROVEMENTS

TABLE 11
COST ESTIMATE - PHASE 2 IMPROVEMENTS - REACH 2

Improvement No.	Item	Unit	Quantity	Unit Price	Extended Price
1	103"x71" Arch CMP	L.F.	90	$ 110.00	$ 9,900.00
2	Concrete Box Culverts	Lump Sum	1 ea.	35,000.00	35,000.00
3	81"x59" Arch CMP	L.F.	45	75.00	3,375.00
4	95"x67" Arch CMP	L.F.	90	95.00	8,550.00
5	87"x63" Arch CMP	L.F.	180	85.00	15,300.00
6	103"x71" Arch CMP	L.F.	45	110.00	4,950.00
7	103"x71" Arch SMP	L.F.	45	110.00	4,950.00
8	87"x63"	L.F.	90	85.00	7,650.00
				Estimated Construction Cost	89,675.00
				Engineering, Construction Inspection & Contract Administration (15±)	13,450.00
				Contingencies (10%±)	8,975.00
				Estimated Cost for Phase 2 Improvements	$ 112,100.00

ESTIMATED COST FOR PHASE 1 AND PHASE 2 IMPROVEMENTS:

Phase 1 Improvements	$ 17,500.00
Phase 2 Improvements	112,100.00
Total	$ 129,600.00

R E A C H 3

Reach 3 begins at the county line between Wells and Foster Counties and extends to a point just downstream of Cathay Dam. Figure 13 shows the location of the channel within this reach and the location of the cross sections which were used in the water surface profile computations. The detailed cross section data was obtained by the State Water Commission survey crew in the fall of 1977. The Hydrologic analysis indicated that the design discharges for this reach are approximately 800 cfs and 1600 cfs for 10 and 25 year floods, respectively.

The stream channel is well defined throughout this reach and there is a wide valley to contain the higher discharges. This reach does not have the problem with channel obstructions that were evident on the first two reaches. Figure 14 shows the profile of the channel bottom and water surface profiles for various discharges under existing conditions. This is a continuation of the profiles for existing conditions on Reach 2. The profile of the channel bottom indicates a fairly uniform gradient with some localized high and low areas. The water surface profiles are very uniform between stations 770+00 and 827+00. The road crossing at station 828+00, between Sections 11 and 12, Township 147 North, Range 68 West, causes a very small increase in the water surface profiles, but the road is overtopped at the 400 and 600 cfs discharges. Upstream from this crossing the profiles are quite uniform up to station 998+00. However, within this area of the reach there are two road crossings that are close to their capacity at the 600 cfs discharge. The road crossing at station 998+80, between Sections 8 and 9, Township 147 North, Range 68 West, does not have adequate capacity to handle the 400 cfs or the 600 cfs discharges. This crossing creates a backwater effect for 3000 feet upstream. The next road crossing is at station 1047+35. This crossing does not create a backwater effect but it is overtopped at

T. 147 N.

N

1 6 5 4 3

12 7 8 9 10

964 +00 937 +00 911 + 25 884+15

950+85 924 +15 897 + 15

977+20 998 + 80 RUN

1024 + 90 1047+35 1011 +80

1042 + 60 1068 + 10 1036+10

1055+35

1116 + 10 1093 + 90 ROCKY

CATHAY 1081 + 40 17 16 15

CORPORATE LIMITS 1130+60

1103 + 10

13 18

24 19 20 21 22

R 69 R 68 WELLS CO.

N

6 5 4 3 2 1

7 8 9 10 11 12

17 16 15 14 13

18 19 20 21 22 23

964 +00
937 + 00
950+85
977+20
998 + 80
1024 + 90
1011 +80
1047+35
1036+10
1068 + 10
1055+35
1116 + 10
1093 + 90
1081 + 40
1103 + 10
+60
911 + 25
924 +15
897 + 15
884+15
887+80
864 + 80
852 +80
840+00
828+00
819 + 80
807+80
793 + 80
780 +80

RUN

ROCKY

CREEK

R 69 R 68 WELLS CO.

FIGURE 13

REACH 3

CROSS SECTION LOCATION

ROCKY RUN CREEK

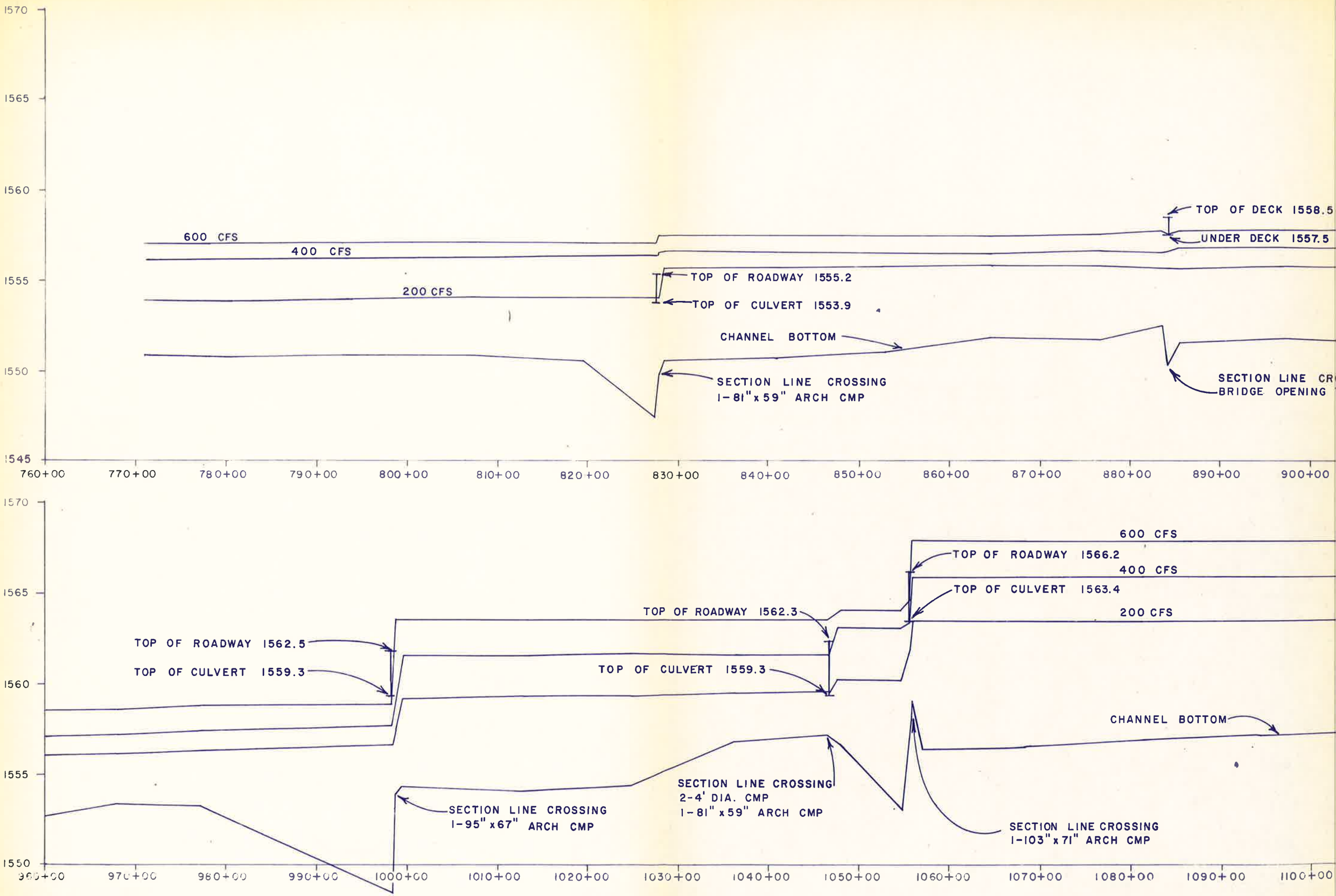
discharges of 400 cfs and 600 cfs. The road crossing at station 1055+35 causes a sudden increase in the water surface elevation for all three discharges. However, the 600 cfs discharge is the only one that overtops the road. The backwater effect of this crossing is evident throughout the rest of the reach. The road crossing at station 1116+10 consists of only one 3' culvert and is inundated at the 400 cfs discharge.

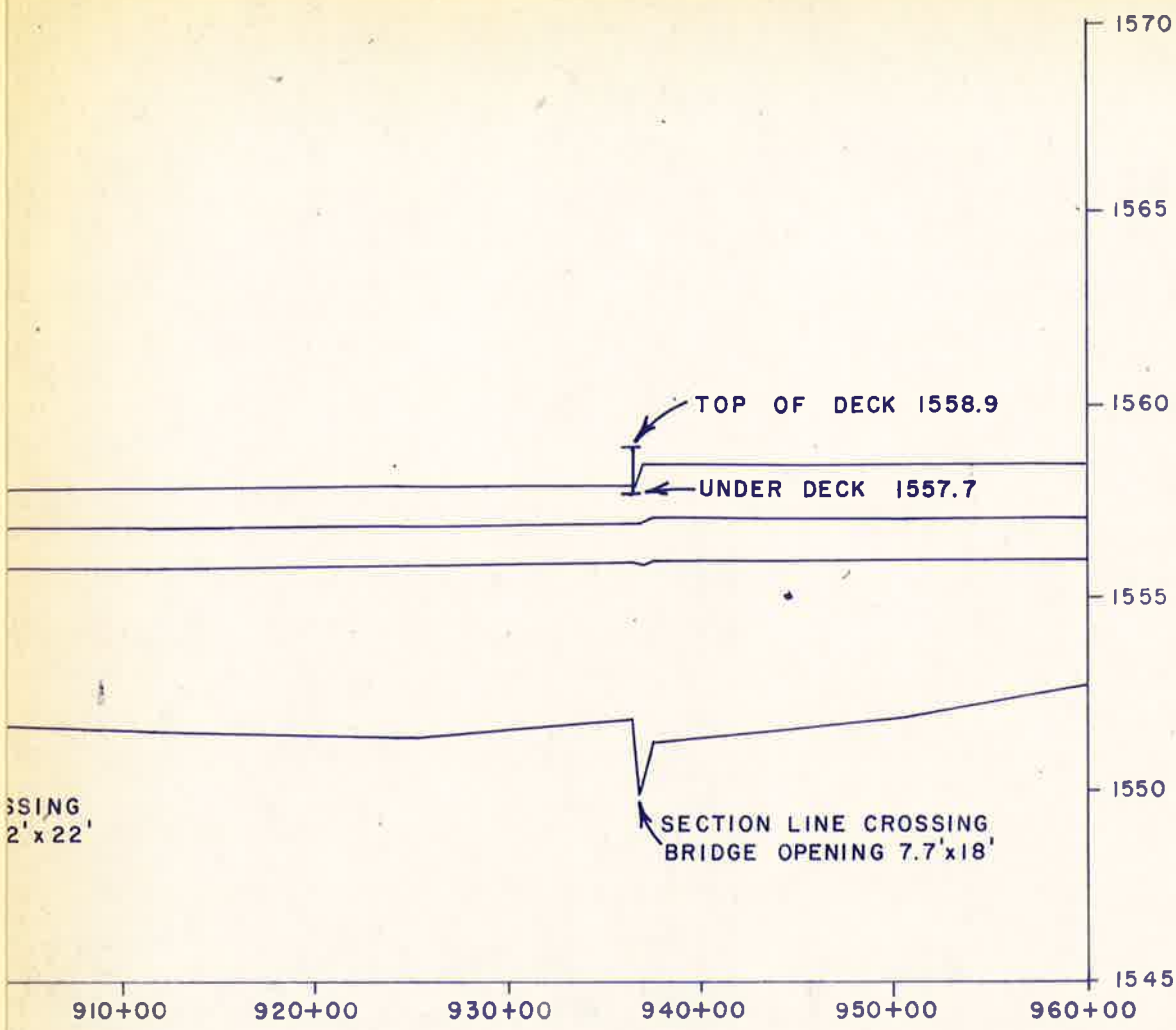
The preceding discussion of the water surface profiles for this reach indicates that there are not any improvements that can be classified as Phase 1, with the exception of a general removal of debris from the channel. There is not an excessive amount of rock and debris in the channel within this reach. Therefore, the channel cleanup could be conducted on a voluntary basis by the adjacent landowners.

The Phase 2 improvements would consist exclusively of improving inadequate road crossings. There aren't any channel improvements that could be made that would have a significant effect on the water surface profile. Table 12 contains the specific improvements that are proposed under Phase 2.

TABLE 12
PHASE 2 IMPROVEMENTS - REACH 3

Improvement No.	Location	Improvement
1	STA 828+00	Improve Road Crossing
2	STA 884+15	Improve Road Crossing
3	STA 937+00	Improve Road Crossing
4	STA 998+80	Improve Road Crossing
5	STA 1047+35	Improve Road Crossing
6	STA 1055+35	Improve Road Crossing
7	STA 1116+10	Improve Road Crossing


1570
1565
1560
1555
1550
1545
760+00
770+00
780+00
790+00
800+00
810+00
820+00
830+00
840+00
850+00
860+00
870+00
880+00
890+00
900+00
600 CFS
400 CFS
200 CFS
TOP OF DECK 1558.5
UNDER DECK 1557.5
TOP OF ROADWAY 1555.2
TOP OF CULVERT 1553.9
CHANNEL BOTTOM
SECTION LINE CROSSING
1-81"x59" ARCH CMP
SECTION LINE CR
BRIDGE OPENING
1570
1565
1560
1555
1550
960+00
970+00
980+00
990+00
1000+00
1010+00
1020+00
1030+00
1040+00
1050+00
1060+00
1070+00
1080+00
1090+00
1100+00
600 CFS
TOP OF ROADWAY 1566.2
400 CFS
TOP OF CULVERT 1563.4
200 CFS
TOP OF ROADWAY 1562.3
TOP OF ROADWAY 1562.5
TOP OF CULVERT 1559.3
TOP OF CULVERT 1559.3
CHANNEL BOTTOM
SECTION LINE CROSSING
1-95"x67" ARCH CMP
SECTION LINE CROSSING
2-4' DIA. CMP
1-81"x59" ARCH CMP
SECTION LINE CROSSING
1-103"x71" ARCH CMP



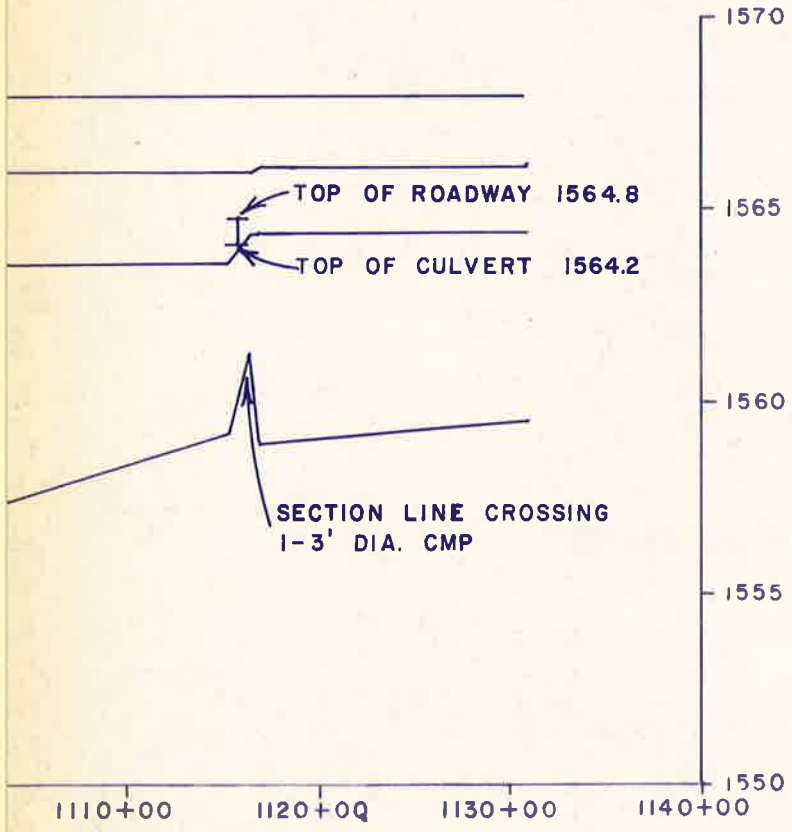


FIGURE 14

REACH 3

WATER SURFACE PROFILE

EXISTING CONDITIONS

As previously indicated the improvements proposed for Reach 3 consist exclusively of improving road crossings. The first crossing is located at station 828+00. This crossing is inundated by backup water from the downstream channel at discharges exceeding 400 cfs. Therefore, this crossing would be designed for a discharge of 400 cfs. This crossing has an existing 81"x59" arch CMP culvert and would be improved by the addition of one more 81"x59" arch CMP culvert.

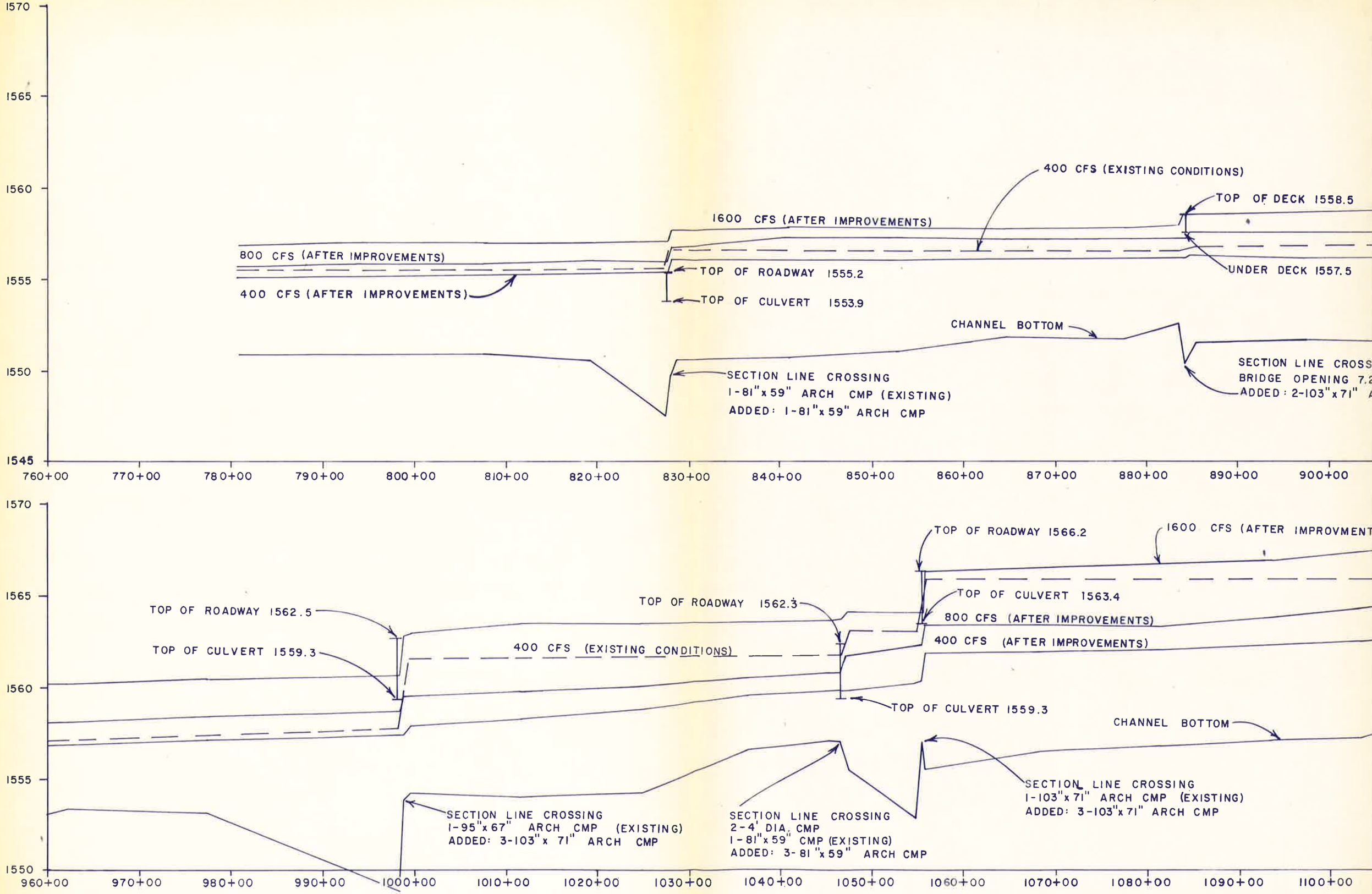
The crossing at station 884+15 has an existing bridge with an opening of 7.2'x22'. The downstream channel does not backup water over this structure, so it has to be designed to handle a 25 year frequency discharge. The addition of two 103"x71" arch CMP culverts would increase the capacity of this crossing so it will handle the 25 year frequency discharge of 1600 cfs. The next upstream crossing is located at station 937+00. This crossing is inundated by back up water from the downstream channel at a discharge just below the 25 year frequency discharge. The existing crossing which consists of a bridge with an opening of 7.7'x18' will be improved by the addition of two 103"x71" arch CMP culverts.

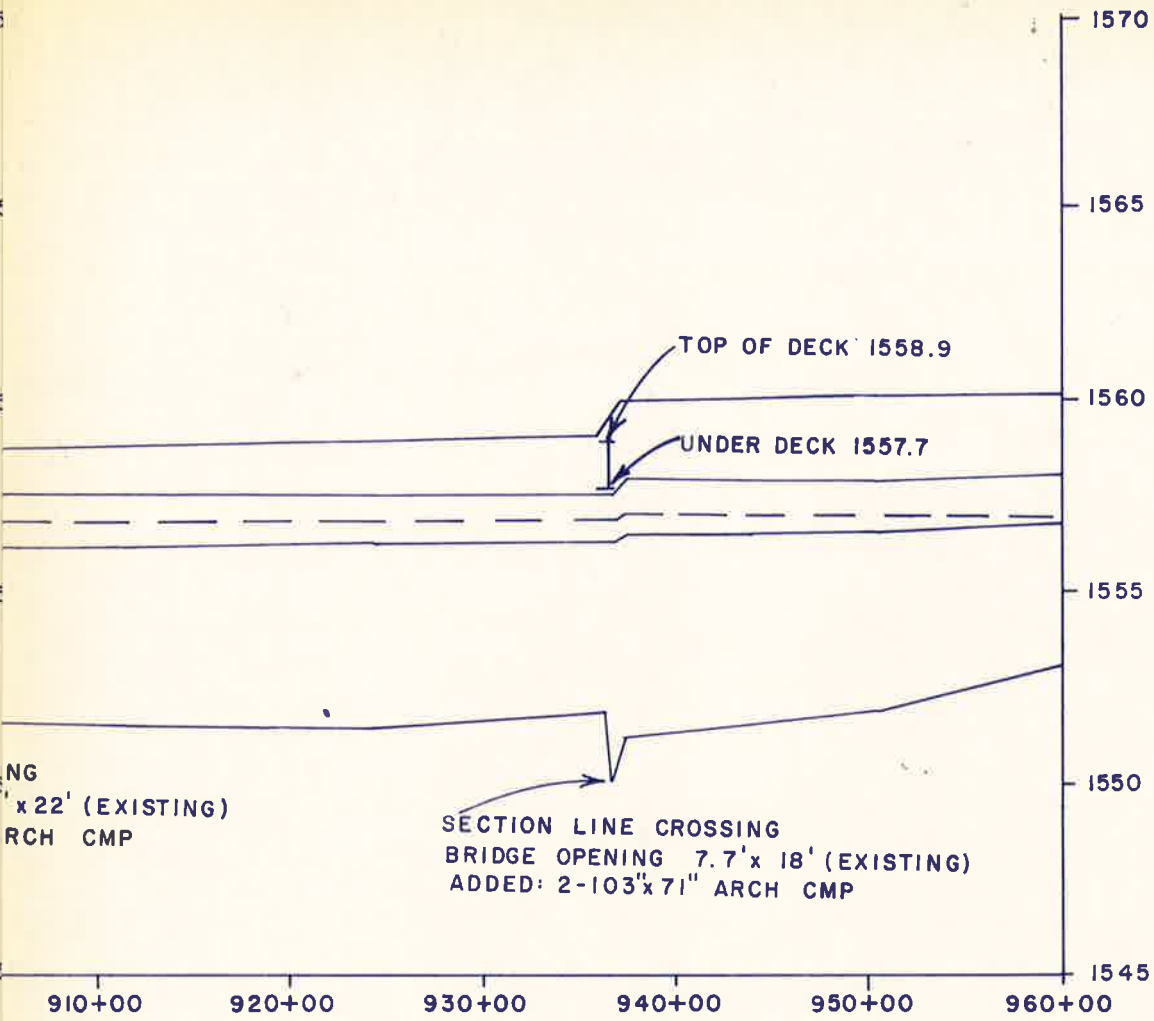
The crossing at station 998+80 has an existing 95"x67" arch CMP culvert which has inadequate capacity even for low discharges. The downstream floodplain has adequate capacity to handle the 25 year frequency discharge, so there is no backup effect on the crossing. The addition of three 103"x71" arch CMP culverts will make this crossing adequate for a 25 year frequency discharge. The next upstream crossing, located at station 1047+35, has two 4' diameter and one 81"x59" arch CMP culverts under the existing roadway. This crossing is inundated by backup water at a discharge of approximately 1300 cfs. Therefore, the crossing

must be designed to handle a discharge of 1300 cfs. The addition of three 81"x59" arch CMP culverts would increase the capacity of this crossing to 1400 cfs.

Just upstream from the previous crossing, at station 1055+35, is another inadequate road crossing. This crossing consists of one 103"x71" arch CMP under the roadway. The improvement of this crossing would consist of the addition of two 103"x71" arch CMP culverts. This would increase the capacity of this crossing to a 25 year frequency discharge. The crossing at station 1116+10 is inundated by backup water from the downstream channel for flows exceeding 600 cfs. Therefore, the capacity of this crossing would be increased to 600 cfs. This would involve the addition of six 65"x40" arch CMP culverts.

The input data to the water surface profile computer program was updated to reflect the above improvements. Figure 15 shows the water surface profiles obtained after the Phase 1 and Phase 2 improvements have been made. These profiles are a continuation of the profiles for Reach 2 after its Phase 2 improvements have been made. The improved road crossings would have capacities equivalent to the 25 year frequency discharge, where backup water is not significant. Comparison of the water surface profiles in Figure 15 indicates that the water surface elevations for 400 cfs under existing conditions would be reduced 2 to 3 feet with the implementation of the Phase 2 improvements. A detailed cost estimate for the Phase 2 improvements is contained in Table 13.


1570
1565
1560
1555
1550
1545
760+00
770+00
780+00
790+00
800+00
810+00
820+00
830+00
840+00
850+00
860+00
870+00
880+00
890+00
900+00
400 CFS (EXISTING CONDITIONS)
TOP OF DECK 1558.5
1600 CFS (AFTER IMPROVEMENTS)
800 CFS (AFTER IMPROVEMENTS)
TOP OF ROADWAY 1555.2
UNDER DECK 1557.5
400 CFS (AFTER IMPROVEMENTS)
TOP OF CULVERT 1553.9
CHANNEL BOTTOM
SECTION LINE CROSS
BRIDGE OPENING 7.2
ADDED: 2-103"x71"
SECTION LINE CROSSING
1-81"x59" ARCH CMP (EXISTING)
ADDED: 1-81"x59" ARCH CMP
1570
1565
1560
1555
1550
960+00
970+00
980+00
990+00
1000+00
1010+00
1020+00
1030+00
1040+00
1050+00
1060+00
1070+00
1080+00
1090+00
1100+00
TOP OF ROADWAY 1566.2
1600 CFS (AFTER IMPROVMENT
TOP OF ROADWAY 1562.5
TOP OF ROADWAY 1562.3
TOP OF CULVERT 1563.4
800 CFS (AFTER IMPROVEMENTS)
TOP OF CULVERT 1559.3
400 CFS (EXISTING CONDITIONS)
400 CFS (AFTER IMPROVEMENTS)
TOP OF CULVERT 1559.3
CHANNEL BOTTOM
SECTION LINE CROSSING
1-95"x67" ARCH CMP (EXISTING)
ADDED: 3-103"x 71" ARCH CMP
SECTION LINE CROSSING
2-4' DIA. CMP
1-81"x59" CMP (EXISTING)
ADDED: 3-81"x59" ARCH CMP
SECTION LINE CROSSING
1-103"x71" ARCH CMP (EXISTING)
ADDED: 3-103"x71" ARCH CMP



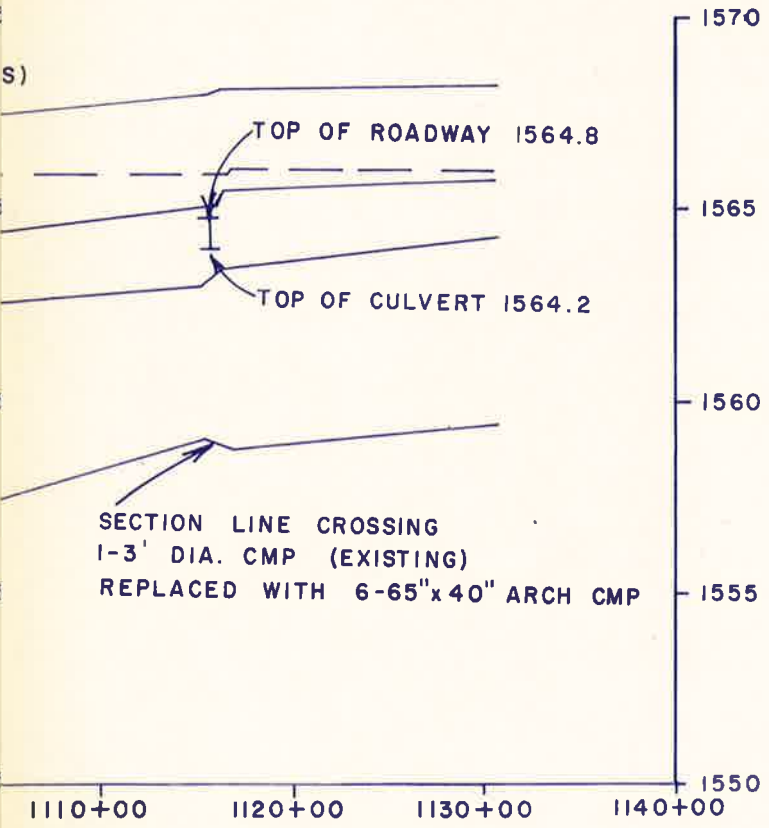


FIGURE 15
REACH 3
WATER SURFACE PROFILE
AFTER PHASE 2
IMPROVEMENTS

TABLE 13
REACH 3 - COST ESTIMATE - PHASE 2 IMPROVEMENTS

Improvement No.	Item	Quantity	Units	Unit Price	Extended Price
1	81"x59" Arch CMP	55	L.F.	$ 75.00	$ 4,125.00
2	103"x71" Arch CMP	110	L.F.	95.00	10,450.00
3	103"x71" Arch CMP	110	L.F.	95.00	10,450.00
4	103"x71" Arch CMP	165	L.F.	95.00	15,675.00
5	81"x59" Arch CMP	165	L.F.	75.00	12,375.00
6	103"x71" Arch CMP	165	L.F.	95.00	15,675.00
7	65"x40" Arch CMP	330	L.F.	55.00	18,150.00
				Estimated Construction Cost	$ 86,900.00
				Engineering, Construction Inspection & Contract Administration	13,000.00
				Contingencies	8,700.00
				Estimated Cost for Phase 2 Improvements	$108,600.00

R E A C H 4

Reach 4 begins just downstream of Cathay Dam and continues upstream through Section 7, Township 147 North, Range 69 West, the west edge of Cathay Township. Figure 16 shows the location of the channel and the location of the cross sections that were used in the water surface profile computations. The cross sectional data for this reach was obtained by State Water Commission survey crew in the Fall of 1977. The design discharges for this reach are approximately 700 cfs and 1300 cfs for the 10 and 25 year frequency floods, respectively.

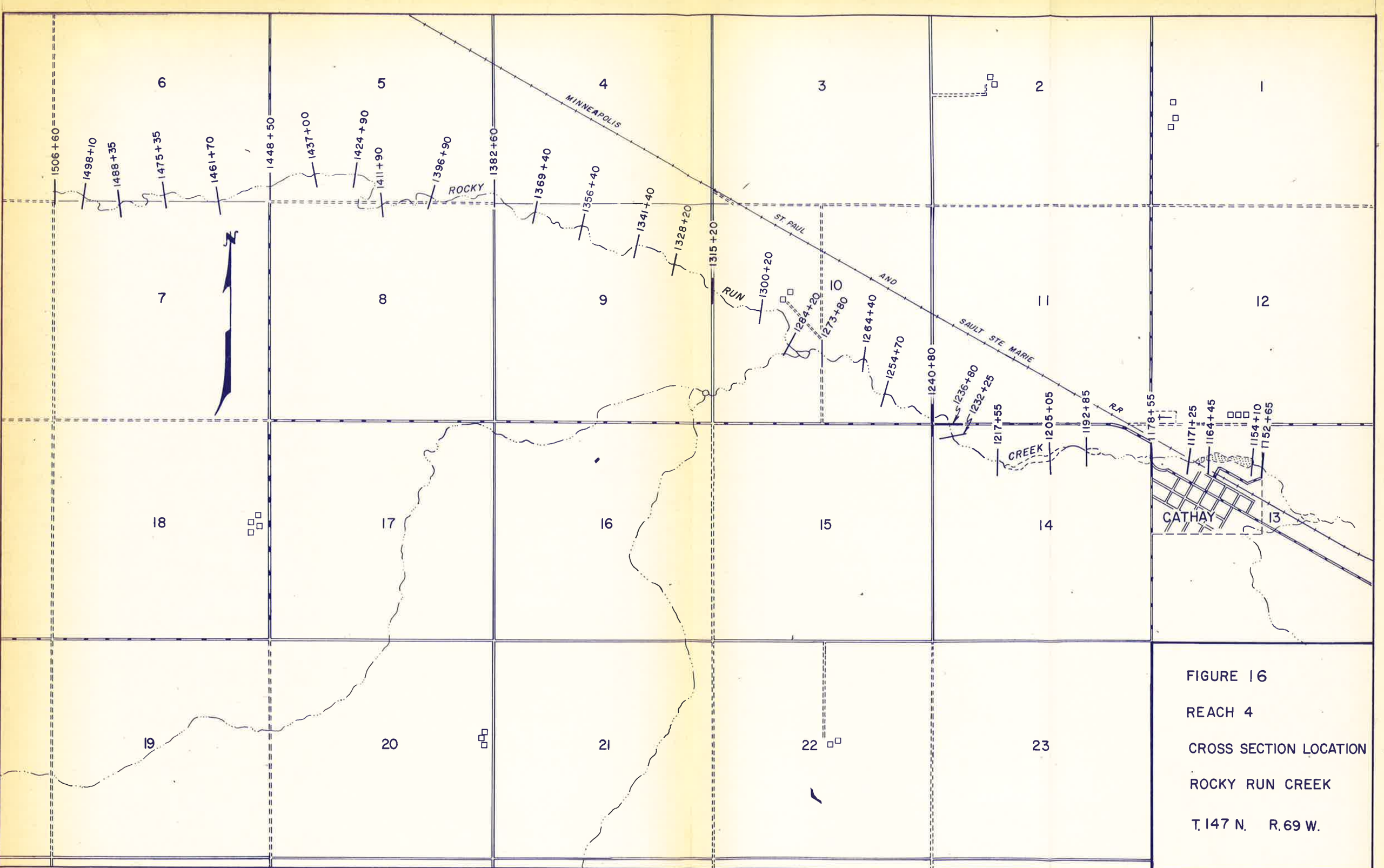


FIGURE 16

REACH 4

CROSS SECTION LOCATION

ROCKY RUN CREEK

T. 147 N. R. 69 W.

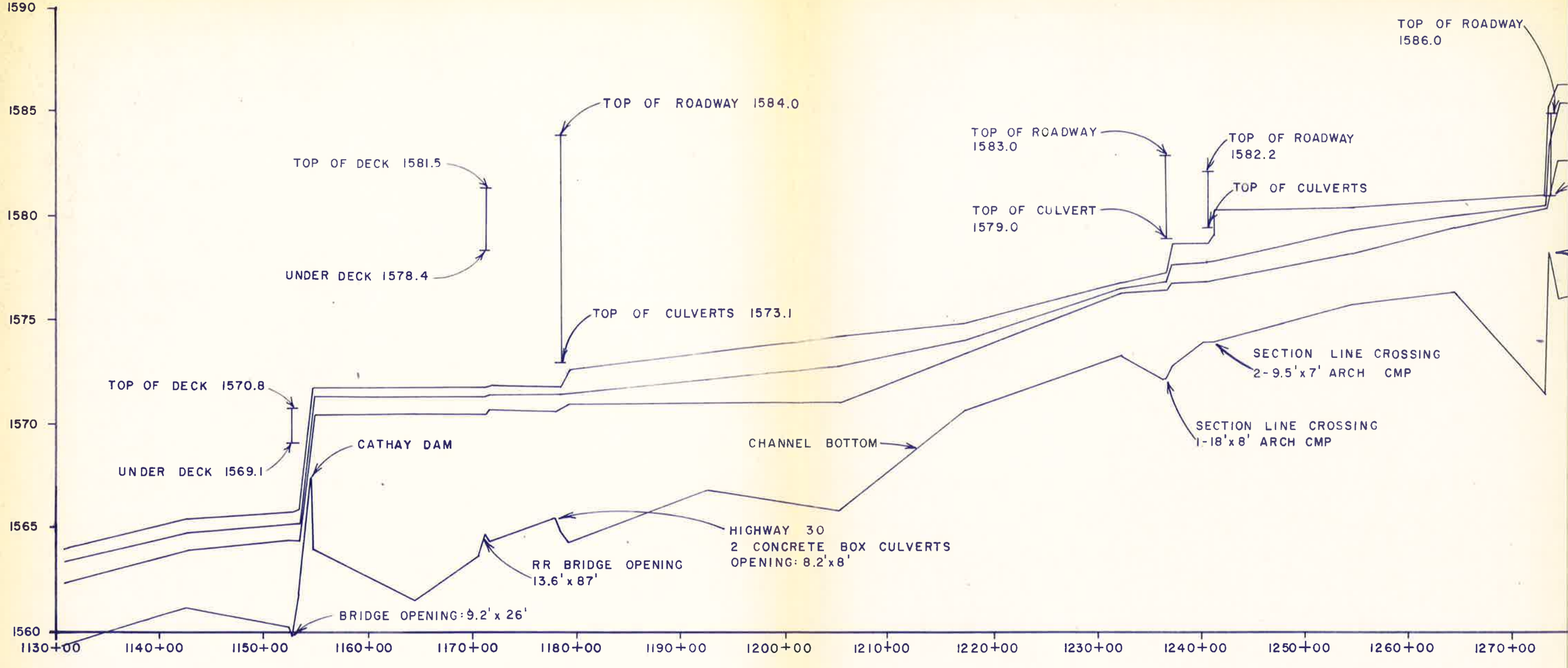
The water surface profile computer model was utilized to compute the water surface profiles for 400 cfs and 600 cfs discharges under the existing stream conditions. Figure 17 shows the resulting water surface profiles and a profile of the channel bottom. These profiles were computed assuming that the Phase 2 improvements were made to Reach 3 to elimiate the back-water effect onto Reach 4.

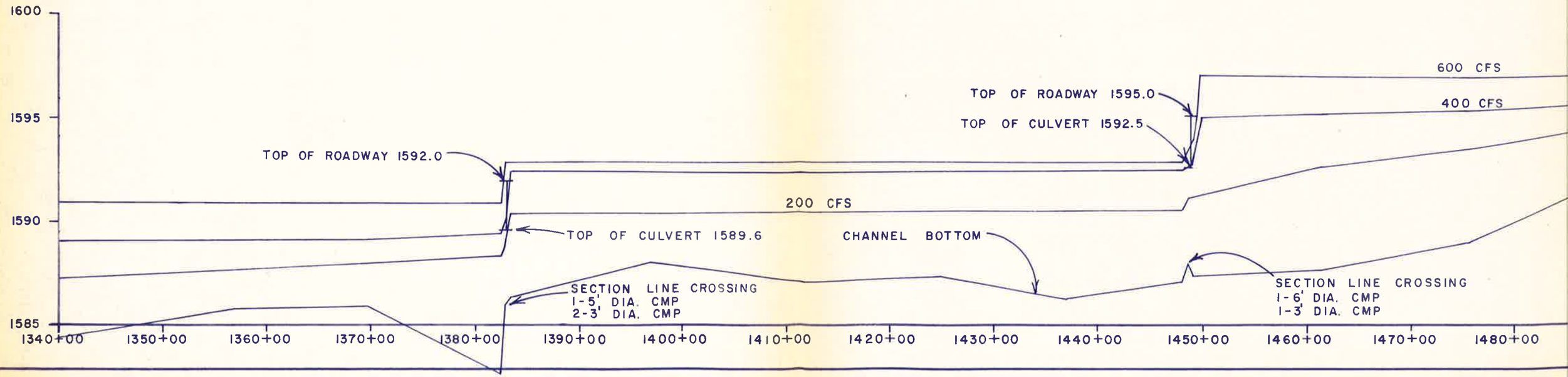
The first sudden increase in the water surface profiles for this reach occurs at station 1153+00. This sudden increase is caused by the embankment of Cathay Dam. The water surface profiles proceed upstream in a uniform manner through the railroad and Highway #30 bridges. The remainder of the reach shows several sudden increases in the water surface profiles, caused by inadequate road crossings.

Reach 4 does not have any improvements, with the exception of a general cleanup of the channel, that can be classified as Phase 1 improvements as defined in this report. There is not an excessive amount of rock and debris in the channel within the reach, so the channel cleanup could be conducted on a voluntary basis by the adjacent landowners. The Phase 2 improvements would consist of upgrading the inadequate road crossings and lowering a high point in the channel near station 1397+00. Table 14 contains the specific improvements that are proposed under Phase 2.

TABLE 14
PHASE 2 IMPROVEMENTS - REACH 4

Improvement No.	Location	Improvement
1	1236+80	Improve Road Crossing
2	1240+80	Improve Road Crossing
3	1273+80	Improve Road Crossing


1590
1585
1580
1575
1570
1565
1560
TOP OF ROADWAY 1584.0
TOP OF DECK 1581.5
UNDER DECK 1578.4
TOP OF CULVERTS 1573.1
TOP OF DECK 1570.8
UNDER DECK 1569.1
CATHAY DAM
BRIDGE OPENING: 9.2' x 26'
CHANNEL BOTTOM
RR BRIDGE OPENING
13.6' x 87'
HIGHWAY 30
2 CONCRETE BOX CULVERTS
OPENING: 8.2' x 8'
TOP OF ROADWAY
1586.0
TOP OF ROADWAY
1583.0
TOP OF ROADWAY
1582.2
TOP OF CULVERTS
TOP OF CULVERT
1579.0
SECTION LINE CROSSING
2-9.5' x 7' ARCH CMP
SECTION LINE CROSSING
1-18' x 8' ARCH CMP
1130+00
1140+00
1150+00
1160+00
1170+00
1180+00
1190+00
1200+00
1210+00
1220+00
1230+00
1240+00
1250+00
1260+00
1270+00


1600
1595
1590
1585
600 CFS
400 CFS
200 CFS
TOP OF ROADWAY 1595.0
TOP OF CULVERT 1592.5
TOP OF ROADWAY 1592.0
TOP OF CULVERT 1589.6
CHANNEL BOTTOM
SECTION LINE CROSSING
1-5' DIA. CMP
2-3' DIA. CMP
SECTION LINE CROSSING
1-6' DIA. CMP
1-3' DIA. CMP
1340+00
1350+00
1360+00
1370+00
1380+00
1390+00
1400+00
1410+00
1420+00
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1440+00
1450+00
1460+00
1470+00
1480+00

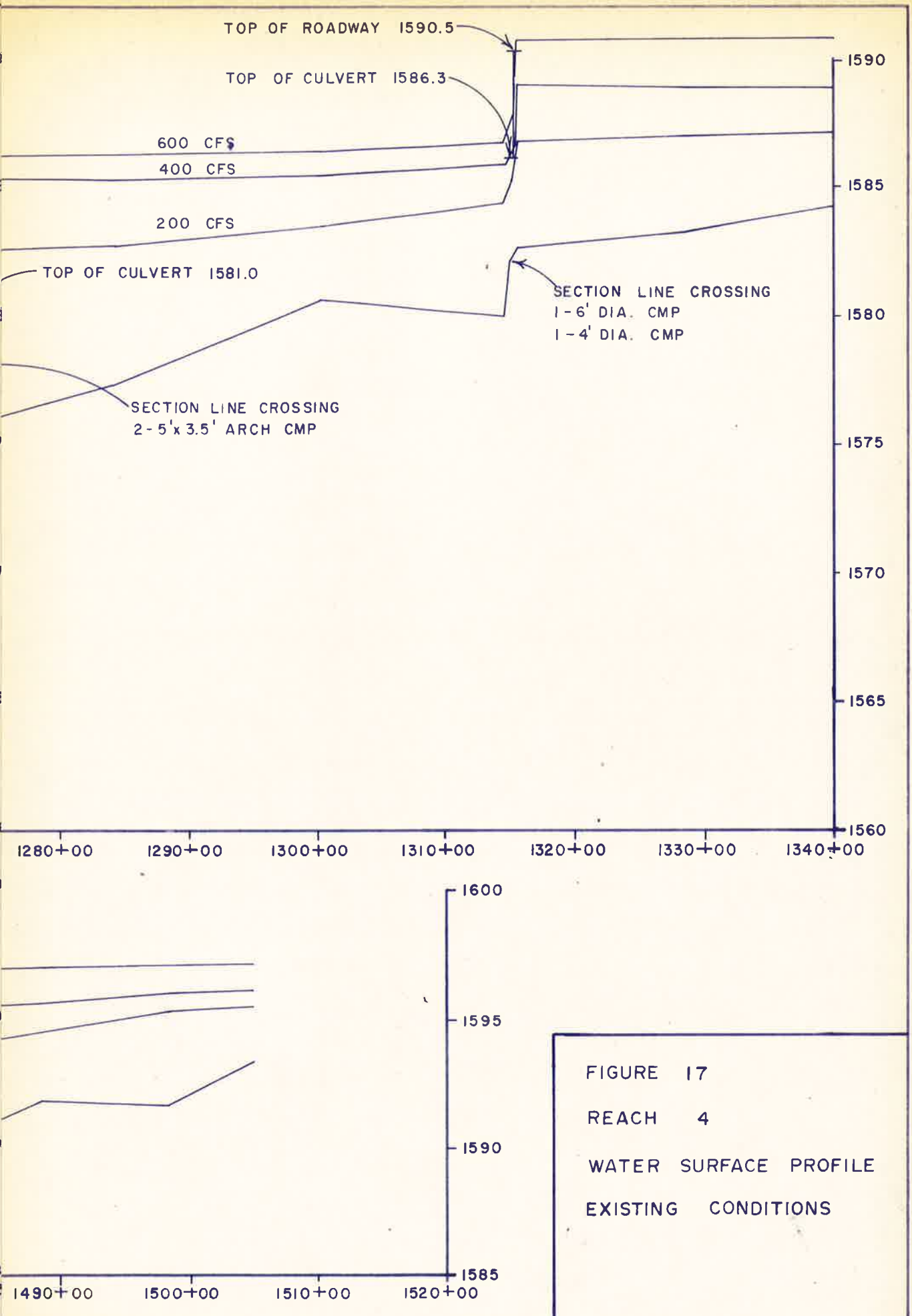


FIGURE 17

REACH 4

WATER SURFACE PROFILE

EXISTING CONDITIONS

4	1315+20	Improve Road Crossing
5	1382+60	Improve Road Crossing
6	1397+00	Lower High Point in Channel
7	1448+50	Improve Road Crossing

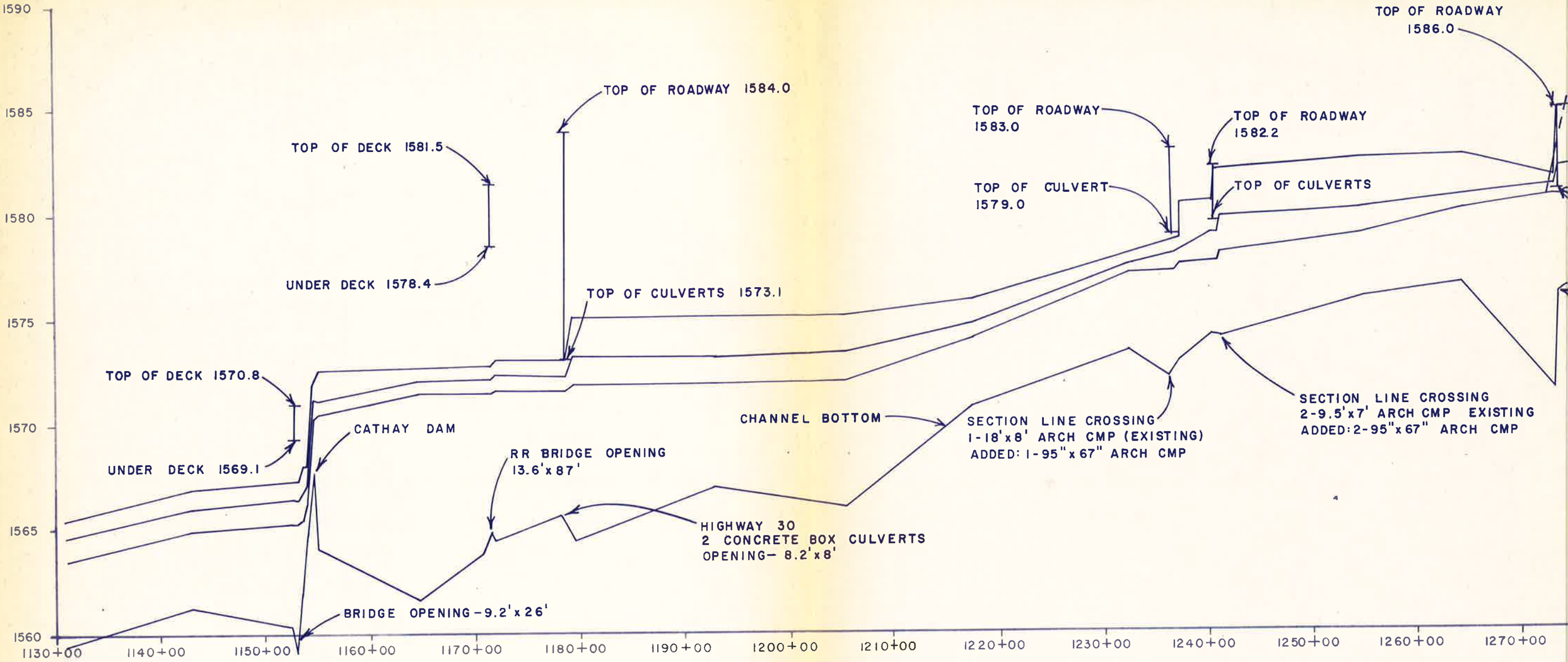
The first proposed improvement is located at a road crossing at station 1236+80, betweem Sections 11 and 14, Township 147 North, Range 69 West. This road crossing consists of one 18'x8' arch CMP culvert. The addition of one 95"x67" arch CMP culvert would increase the capacity of this crossing to 1300 cfs, the 25 year frequency discharge. The crossing at station 1240+80 consists of two 9.5'x7' arch CMP culverts. The roadway at this crossing is lower than the roadway of the preceding crossing so more flow area would be required for the same discharge. The addition of two 95"x67" arch CMP culverts would increase the capacity of this crossing to the 25 year frequency discharge.

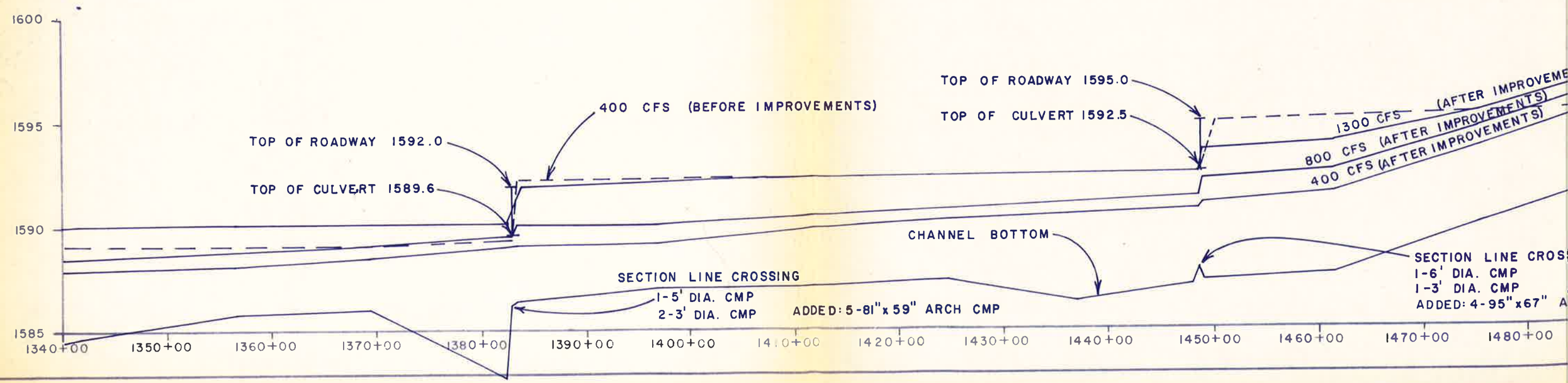
A large increase in the water surface profiles occurs at the farm access road crossing at station 1273+80. The roadway is overtopped at a discharge of 400 cfs. The crossing consists of two 65"x40" arch CMP culverts. The channel bottom profile indicates that the culvert inverts are approximately two feet higher than they should be. The low roadway at this crossing would require the addition of four 95"x67" arch CMP culverts to upgrade this crossing to a capacity of 1300 cfs. A similar condition exists at the next upstream crossing located at station 1315+20. This crossing consists of one 6' diameter CMP culvert and one 4' diameter CMP culvert. A discharge of 600 cfs represents the maximum capacity of this crossing. The proposed improvement of this crossing comprises the addition of four 87"x63" arch CMP culverts.

The crossing at station 1382+60, between Sections 4 and 5, Township 147 North, Range 69 West, has one 5' diameter CMP culvert and two 3' diameter CMP culverts under the existing roadway. The roadway is overtopped at a discharge of 400 cfs because the bottoms of the culverts are only six feet below the top of the roadway. The improvement of this crossing would consist of the addition of five 81"x59" arch CMP culverts. Just upstream of this crossing at station 1397+00 is a high point in the channel that causes a backup of water to the next road crossing at station 1448+50. The lowering of this high point approximately one foot would prevent this backup effect. The final Phase 2 improvement for this reach is located at station 1448+50. This road crossing consists of one 6' diameter CMP culvert and one 3' diameter CMP culvert and has a capacity of 400 cfs. The addition of four 95"x67" arch CMP culverts would upgrade the capacity of this crossing to 1300 cfs, the 25 year frequency discharge.

The input data to the water surface profile computer model was updated to reflect the above improvements. Figure 18 shows the resulting water surface profiles along with the profile for 400 cfs under existing conditions. These profiles are a continuation of the Reach 3 profiles shown in Figure 15. The profiles indicate that the water surface elevation for a discharge of 400 cfs is reduced four feet in the latter portions of the reach as a result of the Phase 2 improvements. A cost estimate for these improvements is contained in Table 15.

400 CFS (BEFOR
IMPROVEMENT





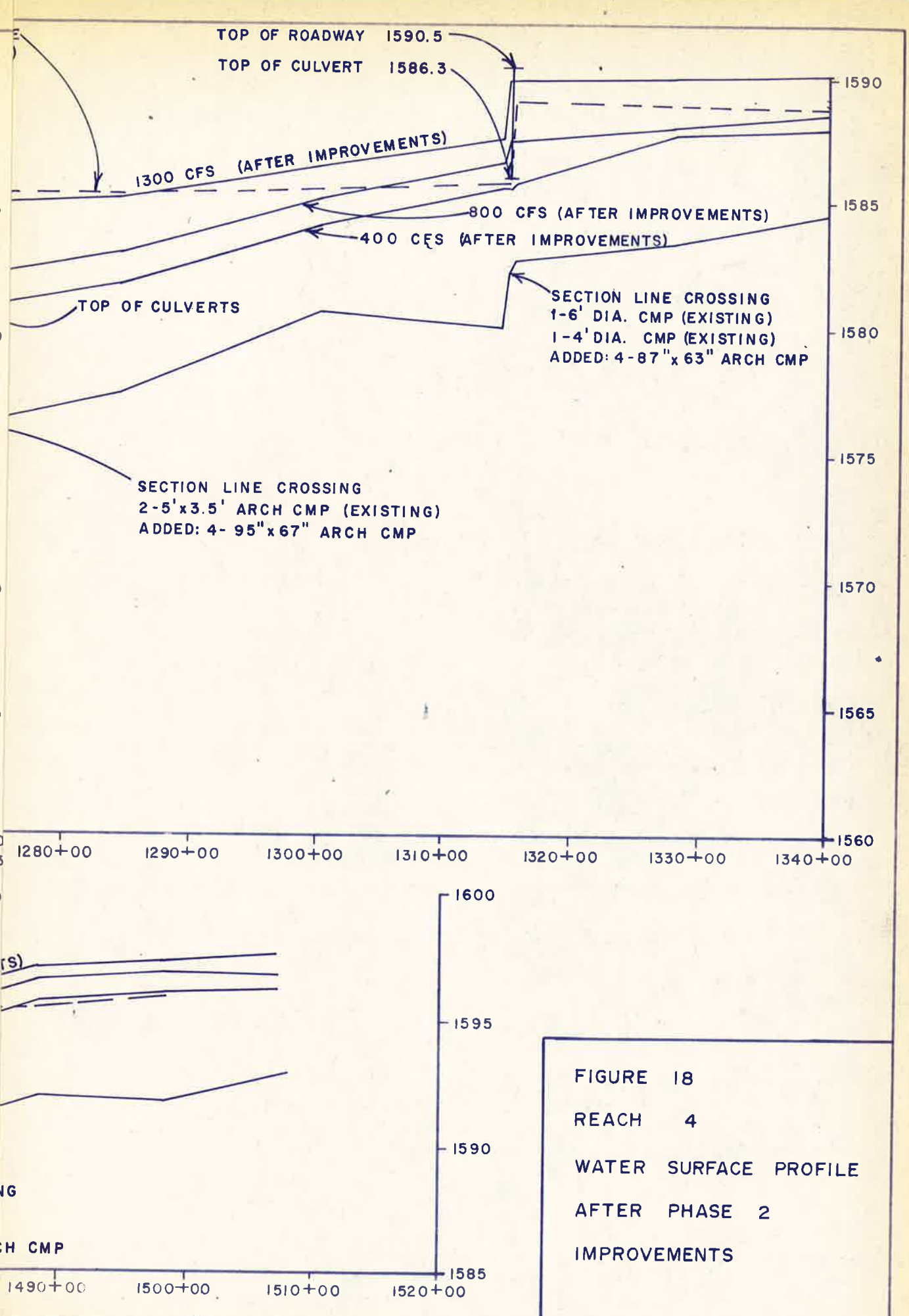


FIGURE 18

REACH 4

WATER SURFACE PROFILE

AFTER PHASE 2

IMPROVEMENTS

TABLE 15

COST ESTIMATE - PHASE 2 IMPROVEMENTS - REACH 4

Improvement #	Item	Units	Quantity	Unit Price	Extended Price
1	95"x67" Arch CMP	L.F.	45	$ 95.00	$ 4,275.00
2	95"67" Arch CMP	L.F.	90	95.00	8,550.00
3	95"x67" Arch CMP	L.F.	180	95.00	17,100.00
4	87"x63" Arch CMP	L.F.	180	85.00	15,300.00
5	81"x59" Arch CMP	L.F.	225	75.00	16,875.00
6	Excavation	Yds^3	500	1.00	500.00
7	95"x67" Arch CMP	L.F.	180	95.00	17,100.00
				Estimated Construction Cost	$79,700.00
				Engineering, Construction Inspection & Contract Administration (15%+)	12,000.00
				Contingencies (10%+)	8,000.00
				Estimated Project Cost	$99,700.00

OAK CREEK DRAIN

Oak Creek Drain is a major triburary to Rocky Run Creek. It is a natural drainage channel with a length of approximately 20 miles. The flow capacity of the channel has been analyzed in two segments. Water surface profiles were computed for the channel from its confluence with Rocky Run Creek through Section 19, Township 148 North, Range 67 West, a distance of approximately 4 miles. From this point upstream the channel capacity is very limited and the overbank areas are very flat creating a nearly complete overland flow condition . The capacity of the channel within this segment will be estimated and a diversion channel will be considered. The succeeding paragraphs will give the details of the investigations outlined above.

A general location map showing the cross sections used in the water surface profile computations is shown in Figure 19. The detailed cross sectional data was obtained by the State Water Commission survey crew in the fall of 1977. The water surface profile computer model was used to compute water surface profiles for this segment of Oak Creek Drain. The confluence of Oak Creek Drain and Rocky Run Creek occurs at station 535+00 on Rocky Run Creek and station 0+00 on Oak Creek Drain. The Rocky Run Creek profiles indicate that backup water from Rocky Run Creek is not a problem near the confluence with Oak Creek Drain. The hydrologic analysis indicated that the design discharges for the 10 and 25 year frequency floods are approximately 400 cfs and 700 cfs, respectively. The water surface profile computer program was utilized to generate the profiles for 400 cfs and 700 cfs under existing conditions. Figure 20 shows these profiles along with a profile of the channel bottom.

The water surface profiles indicate that there are problems at the road crossings. The profiles between the crossings are fairly uniform. There are a few localized high points, but they do not cause any significant backup of water. The improvements proposed for this segment of Oak Creek Drain consist exculsively of improving inadequate road crossings. Table 16 contains the specific improvements proposed for this segment.

TABLE 16
PROPOSED IMPROVEMENTS - SEGMENT ONE - OAK CREEK DRAIN

Improvement No.	Location	Improvement
1	Station 25+70	Improve Road Crossing
2	Station 128+30	Improve Road Crossing
3	Station 145+60	Improve Road Crossing

The first sudden increase in the water surface profiles occurs at station 25+70. This is a farm access road crossing located just downstream from Rosefield Slough. The crossing consists of one 4' diameter CMP culvert, four 18" diameter CMP culverts and one 24" diameter CMP culvert. The roadway is inundated for discharges exceeding 400 cfs. The upgrading of this crossing would consist of the replacement of the 18" and 24" diameter culverts with four 79"x49" arch CMP culverts. The next upstream road crossing at station 68+50 is on the upstream edge of Rosefield Slough. This crossing has an estimated capacity of 400 cfs. At a discharge of 500 cfs the roadway is inundated by backup water from Rosefield Slough. The improvement of this crossing with additional culverts would not prevent the overtopping of the road. Therefore, it is not proposed that this crossing be improved.

The road crossing located at station 128+30 consists of one 6' diameter CMP culvert. The estimated capacity of this crossing is 300 cfs. The addition of three 87"x63" arch CMP culverts would upgrade the capacity of this crossing to a 25 year frequency discharge of 700 cfs. The final improvement proposed for this segment of Oak Creek Drain is on the farm access road crossing at station 145+60. This crossing has two 30" diameter CMP culverts under the existing roadway. The improvement would consist of the addition of four 79"x49" arch CMP culverts. Upstream from this crossing the channel slope and the water surface profiles are very uniform. The input data to the water surface profile computer model was updated to reflect the above improvements and another set of profiles was computed. These profiles are shown in Figure 21 along with a profile for 400 cfs under existing conditions. The implementation of the proposed improvements would result in a lowering of the water surface profile approximately two feet for a 400 cfs discharge within this segment of Oak Creek Drain.

The second segment of Oak Creek Drain, extending westward from the county line between Eddy and Wells Counties, has very limited capacity, which causes frequent flooding of adjacent farmland. This type of overland flow condition cannot be effectively modeled with the water surface profile computer program. Serious flood problems occur along the channel extending from the county line upstream to the section line between Sections 20 and 21, Township 149 North, Range 68 West (refer to Figure 19). Upstream from this section line the existing channel has the capacity to handle most flood flows.

The capacity of this portion of the channel, which is subject to frequent flooding, was estimated for each section that the channel goes through. Table 17 contains the estimated capacities, based on an average slope and Manning's formula.

TABLE 17
CHANNEL CAPACITIES - OAK CREEK DRAIN

Section No. (T148N,R68W)	Channel Capacity (cfs)
24	160
23	520
22	70
27	130
28	540
21	60
29	730

There is a large variation in channel capacities throughout this segment of Oak Creek Drain as indicated by Table 15. These flows can be compared with the 10 year frequency discharge of 350 cfs. The channel in four of the six sections downstream from Section 29 have a capacity considerably less than 350 cfs.

The road crossings also appear to have inadequate capacities throughout this segement of the channel. The capacity of the crossings was estimated and the results are shown in Table 18.

TABLE 18
ROAD CROSSING CAPACITIES - OAK CREEK DRAIN

Between Sections: (T148N,R68W)	Road Crossing Capacity (cfs)
19 & 24	95
24 & 23	160
22 & 23	50
22 & 27	75
27 & 28	15
21 & 28	40
21 & 20	50
20 & 29	25

All of the crossings analyzed are inadequate when compared to the 25 year frequency discharge of 550 cfs, which is the design discharge established by State Water Commission criteria. The preceeding analysis has indicated that the capacity of the channel and road crossings downstream from Section 29, Township 148 North, Range 68 West are inadequate.

To alleviate this problem a diversion channel is proposed to divert the water in a direct route through this segment of Oak Creek Drain. A plan and profile of the proposed diversion channel is shown in Figure 22. The diversion channel would have a total length of 22,200 feet and a slope of 0.0009. The proposed channel has a trapezoidal cross section with a bottom width of 16 feet and a side slope ratio of 4:1. The channel is designed for a 10 year frequency discharge of 310 cfs at the point of diversion. The diversion channel would be closed to local runoff with the exception of a point in Section 21 and a point in Section 22 where it intersects the natural channel. At these intersections gated culverts would be placed in the natural channel to allow water to flow into the diversion channel but prevent water from the diversion channel to backup into the natural channel. The natural channel of Oak Creek Drain would be handling all of the local runoff between the intersection with the diversion channel in Section 22 and the end of the diversion channel in Section 19.

All road crossings along the diversion channel have been designed for a 25 year frequency discharge of 500 cfs. The two road crossings located near the point of diversion would also be improved under this proposal (see Figure 22). The road crossings consist of six section line crossings and one farm approach road. Consideration was given to the placing of Texas Crossings at the quarter corners to be used for farm machinery crossings. They were determined to be infeasible because the diversion channel would have to be moved farther away from the roadway to allow for the mild side slopes required by these crossings. The diversion channel would have to be moved approximately 50-60 feet further from the roadway.

Although detailed survey data was not obtained for Oak Creek Drain upstream from Section 29, field inspections have indicated that some of the road crossings are underdesigned. The project sponsor should consider an improvement plan for these road crossings.

A cost estimate for the improvements proposed in the water surface profile study of the first segment of Oak Creek Drain and the diversion channel is shown in the following table. This cost estimate does not include right-of-way acquisition or relocation of utility lines.

TABLE 19
COST ESTIMATE - OAK CREEK DRAIN

	ITEM	Units	Quantity	Unit Price	Extended Price
From Water Surface Profile Study	79"x49" Arch CMP	L.F.	360	$ 70.00	$ 25,200.00
	87"x63" Arch CMP	L.F.	135	85.00	11,475.00
Diversion Channel	Excavation	Yds.3	160,400	0.90	144,360.00
	65"x40" Arch CMP	L.F.	450	55.00	24,750.00
	85"x54" Arch CMP	L.F.	450	80.00	36,000.00
	79"x49" Arch CMP	L.F.	135	70.00	9,450.00
	Seeding	Acre	35	100.00	3,500.00
	24" Dia. CMP	L.F.	30	18.00	540.00
	36" Dia. CMP	L.F.	45	30.00	1,350.00
	Flap Gates	Ea.	2	300.00	600.00
Estimated Construction Cost					$257,225.00
Engineering, Construction Inspection and Contract Administration (15±)					38,575.00
Contingencies (10%±)					25,800.00
Estimated Project Cost					$321,600.00

IV. ECONOMIC ANALYSIS

A damage-benefit analysis was conducted by the U.S. Soil Conservation service in July, 1977. A copy of this study is contained in Appendix C. The purpose of the economic analysis is to determine if an improvement project can be justified by calculating the anticipated flood damage reduction that would result if a channel improvement project were implemented.

Selected residents of the watershed conducted a survey on the amount of land that is frequently subject to flooding within each township of the watershed. The total acres surveyed represent a small percentage of the total acreage of the watershed and it is probable that the people who conducted the survey contacted primarily individuals that own land in flood prone areas. For these reasons the analysis was presented in two parts: 1) A conservative approach that assumes that the flooded acres within the areas surveyed are the only areas that are flooded for each township and 2) A more liberal approach in which the surveyed areas are prorated for the entire watershed. The actual value is most likely just below the average of the two extreme values. The calculated value represents the present worth of the damage reduction that can be expected if a channel improvement project is implemented. It was assumed by the Soil Conservation Service in the calculations that an improvement project will reduce current flood damages by 72%. Table 20 summarizes the results of the damage-benefit analysis for the individual townships and the entire watershed. Figure 23 shows the location of the different townships within the watershed.

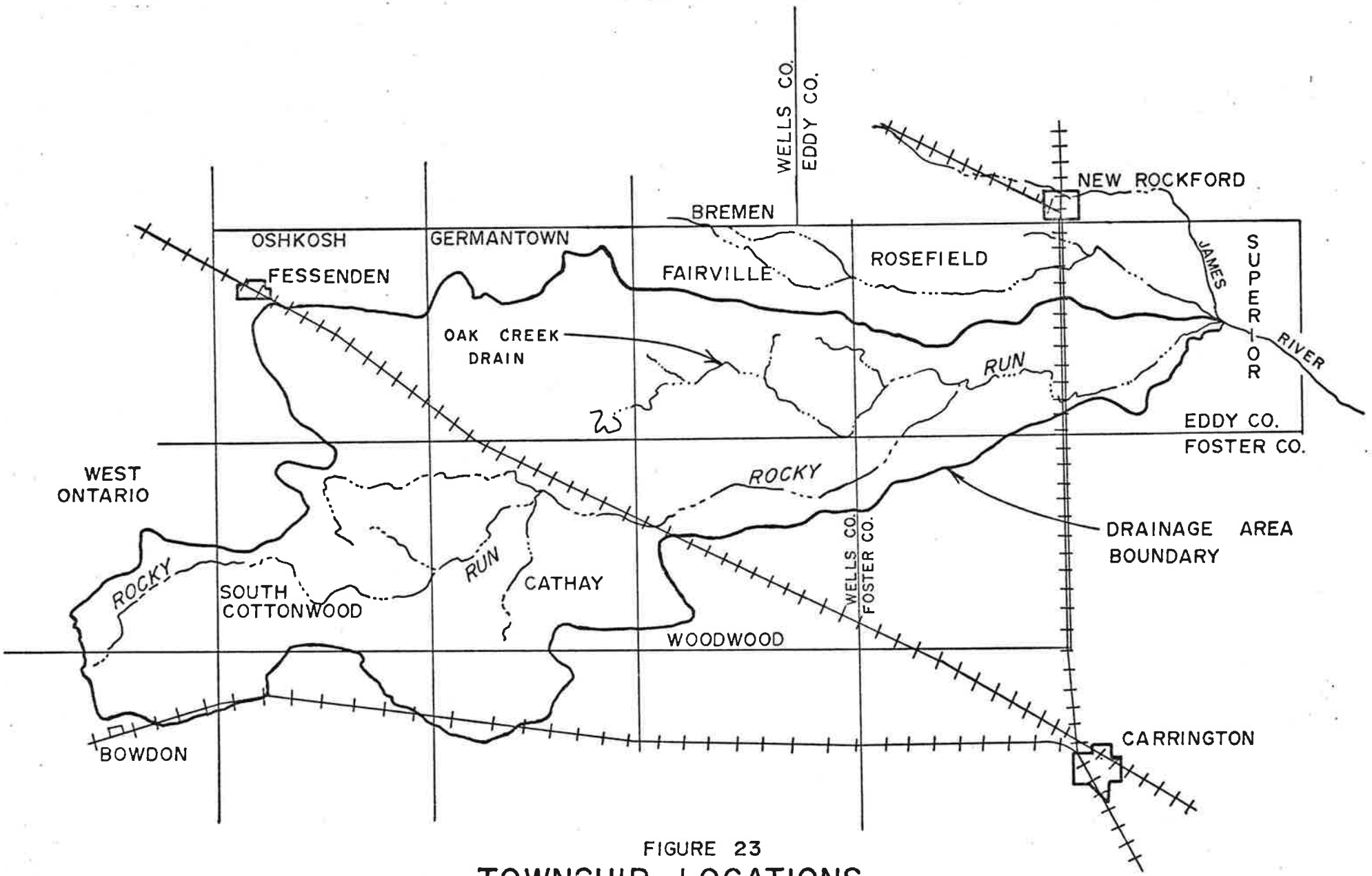


FIGURE 23

TOWNSHIP LOCATIONS
ROCKY RUN CREEK WATERSHED

TABLE 20
RESULTS OF DAMAGE-BENEFIT ANALYSIS

AREA	PRESENT WORTH OF DAMAGE REDUCTION (i=7%, n=50 yrs.)		
	Conservative Value	Liberal Value	Expected Value
Entire Watershed	$ 1,641,000	$5,471,000	$ 3,400,000
Oshkosh Township	250,000	346,000	290,000
Germantown Township	438,000	590,000	510,000
Cathay Township	159,000	400,000	270,000
Woodward Township	159,000	222,000	190,000
Eddy and Foster Counties	386,000	1,550,000	940,000
Fairville Township	228,000	952,000	580,000

Table 20 indicates that a large channel improvement project can be justified. It should be noted that these figures represent flood damage reduction within the entire watershed, not just the land adjacent to Rocky Run Creek. Must of the flooding occurs in small closed basins, especially in Oshkosh and Germantown Townships. The cost of draining these areas must be included in the overall project cost before it can be compared to the values in Table 20.

A comparison can be made between the anticipated damage reduction within the townships along Rocky Run Creek and Oak Creek Drain with the estimated cost of the proposed improvements along these channels. The results of this comparison are shown in Table 21.

TABLE 21

BENEFIT - COST COMPARISONS

Stream	Area	Damage Reduction	Improvement Costs
1. Rocky Run Creek (All 4 reaches)	Eddy & Foster Co. Cathay Township Woodward Township	$ 1,400,000.00 1/	$ 497,400.00
2. Oak Creek Drain	Fairville Township	580,000.00 1/	321,000.00

1/ 72% of Total Damage

The comparison indicates that a channel improvement project can be justified on Rocky Run Creek and Oak Creek Drain. It is not known what the exact damage reduction percentage would be with the implementation of the proposed improvements. However, the damage reduction figures shown exceed the improvement costs by a considerable margin by assuming a 72% damage reduction, so it is anticipated that the damage reduction received by the proposed improvements would exceed the costs of the improvements.

V. ENVIRONMENTAL SURVEY

The following environmental survey will give an overview of the positive and negative environmental impacts that would result from the implementation of this project. This is not intended to be a comprehensive environmental assessment, however, it will identify subjects that would be analyzed in detail in an environmental assessment. In the following paragraphs several environmental catagories are identified and discussed specifically for the Rocky Run Creek watershed.

LAND USE

The Rocky Run Creek watershed currently has the following land use breakdown:

Cropland	
Small Grains	50%
Row Crops	18%
Fallow	15%
Rangeland	10%
Wetlands	4%
Roads	2%
Farmsteads	1%
	100%

No land will be removed from agricultural production as a result of this project. The existing debris in the channel will be removed, including major channel obstructions. Portions of the channel near road crossings will be covered with rock riprap for erosion protection. Heavily eroded areas will be repaired and reseeded with native grasses.

AESTHETICS

The existing channel is in poor condition in some locations. In numerous locations along the channel there are deposits of rock debris. Ther are several small farm machinery crossings that have been completely or partially washed out. During periods of high flows, land adjacent to the channel is inundated for several days, leaving unsightly shallow bodies of water.

The proposed project will not significantly alter the overall appearance of the watershed. The channel will be cleared and several road crossings will be replaced. The excess surface runoff will be expeditiously removed from the watershed, resulting in fewer acres flooded and the flooding will be for shorter periods of time. The implementation of this project would result in an overall improvement of the general appearance of the watershed.

EFFECTS ON DOWNSTREAM FLOOD FLOWS

Rocky Run Creek discharges into the James River approximately 5 miles southeast of New Rockford. The hydrologic analysis indicated that the 10 year frequency discharge on Rocky Run Creek at its confluence with the James River is 1260 cfs. The water surface profiles computed for the existing conditions combined with observations of area landowners indicate that the maximum discharge from Rocky Run Creek over the years has been approximately 600-700 cfs. Under the existing conditions, discharges above 400cfs result in water flowing out of the floodplain and into an adjacent watershed or isolated subbasins. If the proposed improvements are implemented, the capacity of the channel would be increased such that the 10 year discharge of 1260 cfs would be contained in the floodplain. This is an increase of approximately 600 cfs over existing conditions.

The U.S. Bureau of Reclamation has computed water surface profiles for the James River along its entire length. These profiles indicate that a 600 cfs increase in the discharge on the James River near the confluence with Rocky Run Creek would result in a water surface elevation rise of approximately 2 feet, assuming a base flow of 1000 cfs in the James river. The effect would diminish as the water proceeds downstream on the James River.

DOWNSTREAM WATER QUALITY

The implementation of this project will not have a significant effect on the downstream water quality. The agricultural production practices will not change, therefore, the biological and chemical characteristics of the water will remain the same. The increased flow velocities resulting from the increased discharges on the downstream end of Rocky Run Creek would cause an increase in sediment load if erosion protection measures are not included as part of the project.

FISH AND WILDLIFE

No field data has been obtained for wildlife populations within the watershed. This project will not destroy any fresh water wetlands.

IRREVERSIBLE AND IRRETRIEVABLE COMMITTMENT OF RESOURCES

All materials, labor and energy used in the construction of this project would be irretrievable.

VI SUMMARY

The purpose of this report is to develop plans for improving the capacity of Rocky Run Creek and its major tributary, Oak Creek Drain. Continuing flood problems and the need for improved agricultural drainage warrant the need for an adequate outlet that will remove the surface runoff without hindering agricultural operations.

In 1975, a channelization project was proposed for Rocky Run Creek with an estimated project cost of 2.7 million dollars. The high cost of this project initiated the proposal to perform a water surface profile study to determine what portions of the channel are causing the most flooding. This report is the result of this proposal.

In order to allow for stage construction of the proposed improvements, they are divided into two phases. Phase 1 improvements are minor localized changes that would have an effect on the water surface profile. Phase 2 improvements are major improvements to certain channel sections and road crossings such that the overall stream capacity is increased and general flooding throughout the area is reduced. The improvements proposed for Oak Creek Drain are not presented in stages.

The following table contains a summary of the estimated project costs for the Phase 1 and Phase 2 improvements proposed for Rocky Run Creek and the improvements proposed for Oak Creek Drain.

TABLE 22

COST SUMMARY

PROJECT	ESTIMATED COST
ROCKY RUN CREEK (Total)	~~$ 497,400.00~~ 480,500.00
Reach 1	
Phase 1	17,000.00
Phase 2	125,600.00
Total	142,600.00
Reach 2	
Phase 1	17,500.00
Phase 2	112,100.00
Total	129,600.00
Reach 3	
Phase 2	108,600.00
Reach 4	
Phase 2	99,700.00
OAK CREEK DRAIN (Total)	$ 321,600.00
Total For Watershed	~~$ 819,000.00~~ 802,100.00

The economic analysis indicated that a flood problem does exist and the present worth of the damage reduction exceeds the cost of the improvements. The environmental survey brought out the fact that an improvement project would increase the discharges on the James River. No other adverse environmental effects are anticipated if the proposed project is implemented.

18 17 16 15 14 13 18

19 20 21 22 23 24 19

208+40

196+40

185+20

30 29 28 27 26 25 30

31 32 33 34 35 36 31

R 68 W R 67 W

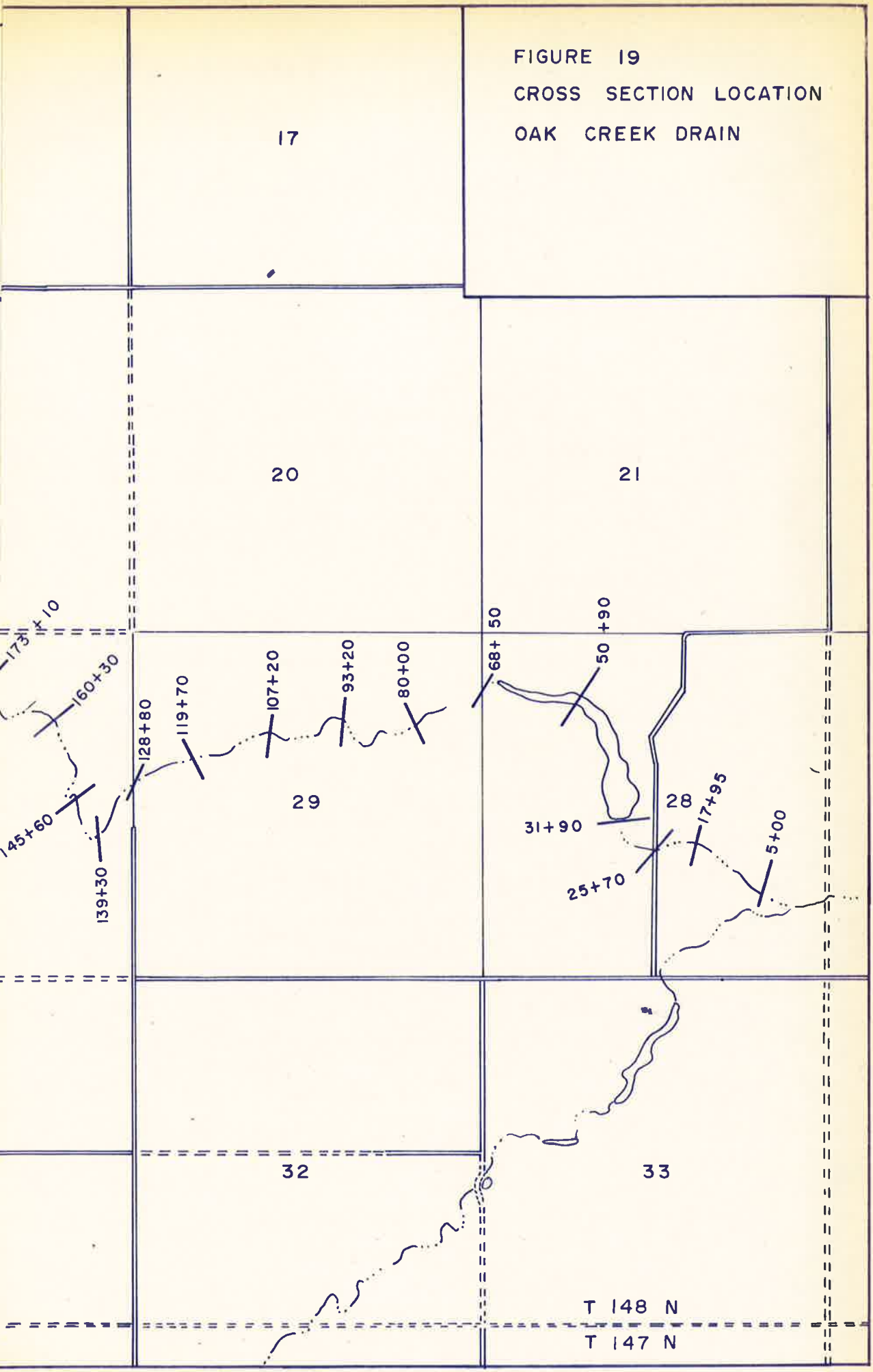
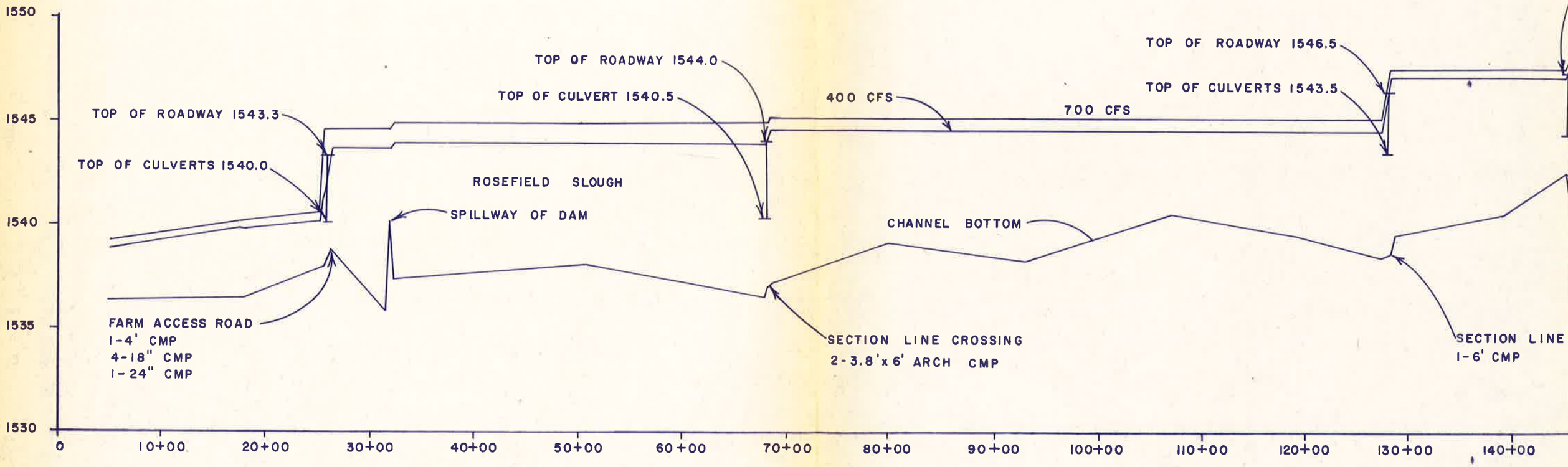


FIGURE 19
CROSS SECTION LOCATION
OAK CREEK DRAIN
17
20
21
29
28
32
33
T 148 N
T 147 N
173I+10
160+30
145+60
139+30
128+80
119+70
107+20
93+20
80+00
68+50
50+90
31+90
25+70
17+95
5+00


1550
1545
1540
1535
1530
TOP OF ROADWAY 1543.3
TOP OF CULVERTS 1540.0
TOP OF ROADWAY 1544.0
TOP OF CULVERT 1540.5
ROSEFIELD SLOUGH
SPILLWAY OF DAM
FARM ACCESS ROAD
1-4' CMP
4-18" CMP
1-24" CMP
400 CFS
700 CFS
TOP OF ROADWAY 1546.5
TOP OF CULVERTS 1543.5
CHANNEL BOTTOM
SECTION LINE CROSSING
2-3.8'x6' ARCH CMP
SECTION LINE
1-6' CMP
0
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
90+00
100+00
110+00
120+00
130+00
140+00

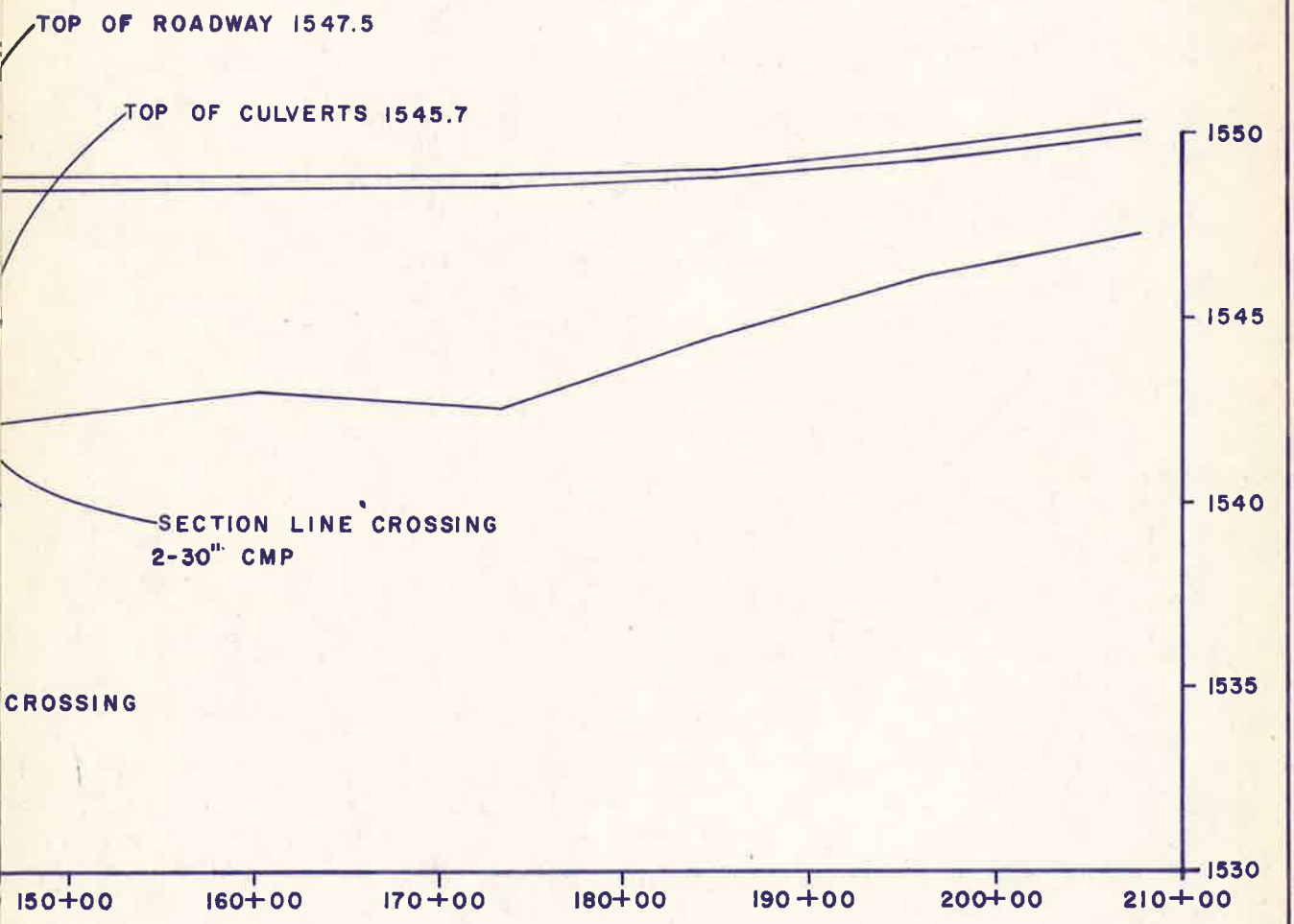
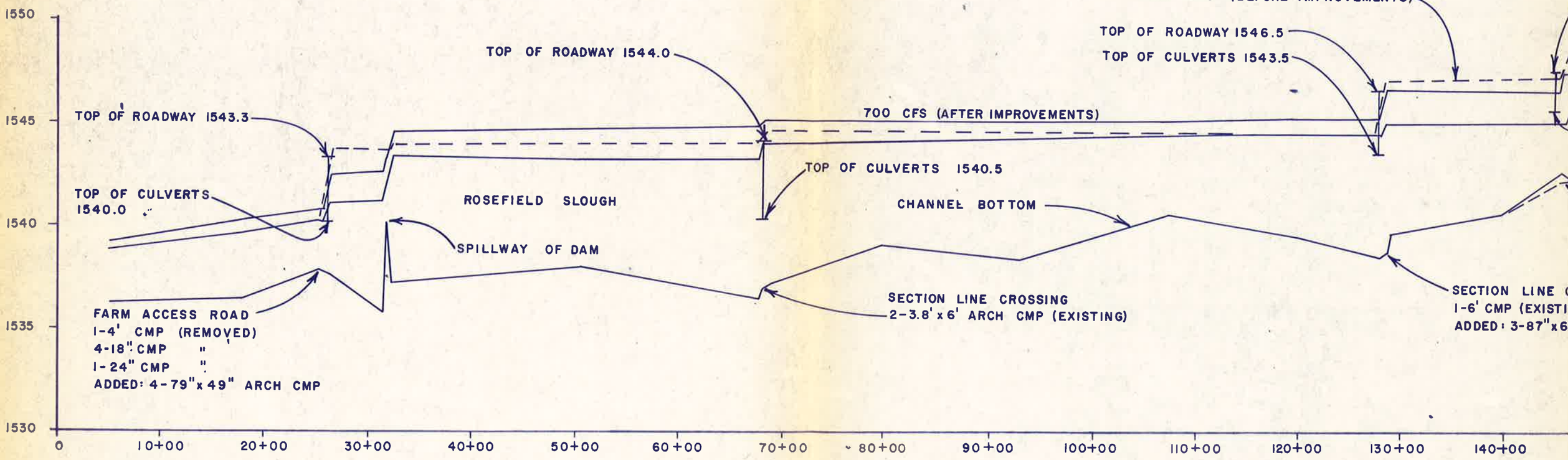


FIGURE 20

OAK CREEK DRAIN

WATER SURFACE PROFILE

EXISTING CONDITIONS


1550
1545
1540
1535
1530
TOP OF ROADWAY 1544.0
TOP OF ROADWAY 1543.3
TOP OF CULVERTS 1540.0
ROSEFIELD SLOUGH
SPILLWAY OF DAM
FARM ACCESS ROAD
1-4' CMP (REMOVED)
4-18" CMP "
1-24" CMP "
ADDED: 4-79"x49" ARCH CMP
700 CFS (AFTER IMPROVEMENTS)
TOP OF CULVERTS 1540.5
CHANNEL BOTTOM
SECTION LINE CROSSING
2-3.8'x6' ARCH CMP (EXISTING)
400 CFS (BEFORE IMPROVEMENTS)
TOP OF ROADWAY 1546.5
TOP OF CULVERTS 1543.5
SECTION LINE
1-6' CMP (EXISTI
ADDED: 3-87"x6
0
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
90+00
100+00
110+00
120+00
130+00
140+00

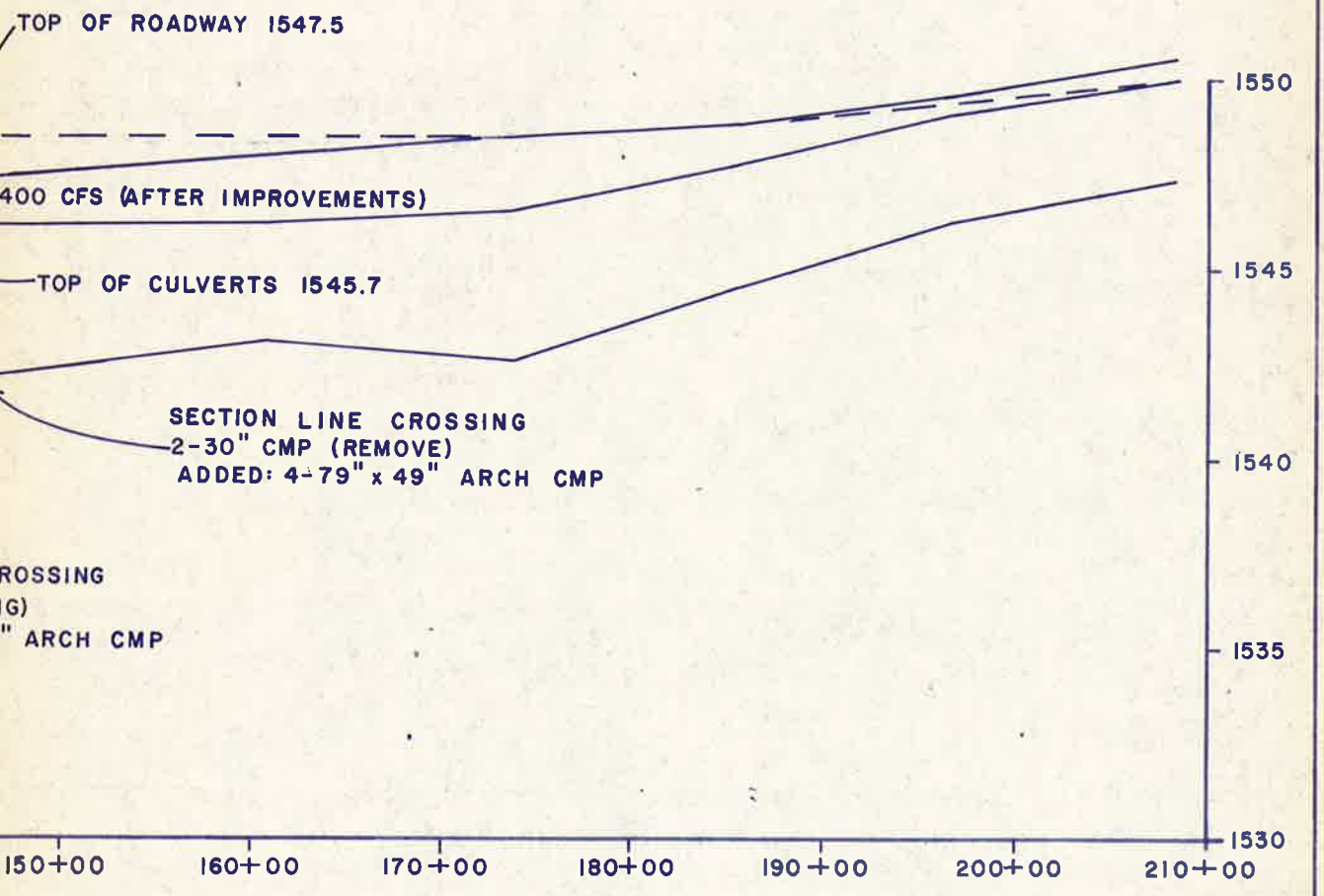


FIGURE 21

OAK CREEK DRAIN

WATER SURFACE PROFILE

AFTER IMPROVEMENTS

1540 1550 1560 1570

0+00 10+00 20+00 30+00 40+00 50+00 60+00 70+00 80+00 90+00 100+00 110+00 120

STA. 28+58
FIELD APPROACH
12" CMP (EXISTING

STA. 37+57
FIELD APPROACH
15" CMP EXISTING

STA. 45+12
SECTION LINE (21,22)
15" CMP (EXISTING)

STA. 54+65
ABANDONED FARM
ACCESS

STA 71+63
1/4 LINE 8
APPROACH
18" CMP (EXISTING)

STA. 79+89
INTERSECT
NATURAL
CHANNEL

STA. 94+50
FIELD APPROACH

STA. 97+77
SECTION LINE
22,23

STA. 99+76
FARM APPROACH

STA. 103+36
FIELD APPROACH

SC

HYDRAULIC DATA
Q = 310 CFS
V= 2.2 FT/SEC
D= 4.3 FT
B= 16.0 FT
S= 0.0009
N= 0.04

5-65"x40" ARCH CMP

28

21

TYPICAL CROSS SECTION
4:1
16'
4:1

3-85"x54" ARCH CMP

27

22

T 148 N

OAK CREEK DRAIN

3-79"x49" ARCH CMP
3-85"x54" ARCH CMP

CENTER-LINE OF
(FOLLOWS

T 148 N

WELLS COUNTY R68W

EDDY COUNTY R67W

23

24

19

26

25

30

OAK CREEK DRAIN

3-79"x49" ARCH CMP

3-85"x54" ARCH CMP

CENTER-LINE OF PROPOSED DIVERSION CHANNEL
(FOLLOWS EXISTING ROAD DITCH)

2-85"x54" ARCH CMP

2-85"x54" ARCH CMP

300'

PLAN

SCALE: 1" = 1000'

STA. 94+50
FIELD APPROACH

STA. 99+76
FARM APPROACH

STA. 103+36
FIELD APPROACH

STA. 137+83
FIELD APPROACH

STA. 150+56
SECTION LINE 23,24

STA. 203+35
SECTION LINE 24,19

STA. 222+10 INTERSECTS DRAIN

EXISTING GROUND SURFACE

PROPOSED CHANNEL BOTTOM

INTERSECTS NATURAL CHANNEL

STA. 97+77
SECTION LINE 22,23

PROFILE

1570

1560

1550

1540

90+00

100+00

110+00

120+00

130+00

140+00

150+00

160+00

170+00

180+00

190+00

200+00

210+00

220+00

FIGURE 22

DIVERSON CHANNEL

OAK CREEK DRAIN

PLAN & PROFILE

GLOSSARY OF TERMS AND ABBREVIATIONS

Back-up Water	-	A channel section or obstruction with limited capacity will cause water to build up upstream of the obstruction and cause flooding.
cfs	-	Cubic feet per second, a flow rate equivalent to 7.5 gallons per second.
Crosby Method	-	A hydrologic prediction model for North Dakota developed by Orlo A. Crosby of the U.S. Geological Survey.
Floodplain	-	Relatively level land adjacent to a stream channel that may be submerged by floodwaters.
Influent Stream		A stream whose channel is above the normal groundwater level.
Physiographic Province	-	A natural geographic subdivision.
Spaethe Method	-	A hydrologic prediction model for North Dakota developed by Jerry Spaethe of the U.S. Soil Conservation Service.
10 Year Frequency Flood	-	A flood with a recurrence interval of 10 years. There is a 10 percent chance that this flood will be equaled or exceeded in any given year. There is a 65 percent chance that this flood will be equaled or exceeded in a given 10 year period.
25 Year Frequency Flood	-	A flood with a recurrence interval of 25 years. There is a 4 percent chance that this flood will be equaled or exceeded in any given year. There is a 64 percent chance that this flood will be equaled or exceeded in a given 25 year period.
Tractive Force	-	A force developed by the pull of water on the wetted area of the streambed.
Water Surface Profile	-	A plotting of the water surface elevations along the length of a channel for a given discharge.

APPENDIX A

NORTH DAKOTA STATE WATER COMMISSION

SWC Project # 1633

AGREEMENT

For Investigation Or Survey

THIS AGREEMENT made and entered into by and between the State Water Commission, hereinafter referred to as the Commission, party of the first part, and Eddy County Water Management District whose post office address is New Rockford, North Dakota hereinafter referred to as the Applicant, party of the second part,

WHEREAS, Eddy County Water Management District (Name of Applicant) has requested the Commission to investigate, or survey, and study the feasibility and desirability of the following proposed undertaking (describe proposed undertaking or project): To determine the waterway openings and channel capacities required for flood damage reduction on lower Rocky Run Creek extending from the mouth, upstream to the Wells County line.

and

WHEREAS, in order to investigate, or survey, and study the undertaking proposed by Applicant, a deposit of $ 1,500.00 is required, under rules and regulations prescribed by the State Water Commission, to cover the cost of such investigation, or survey, and study of the feasibility and desirability of the proposed undertaking; and

WHEREAS, if the cost of such investigation, or survey, and study does not equal or exceed the amount deposited with the Commission, the excess deposit will be credited to and returned to the Applicant, or if the undertaking is approved by the Commission, and carried out, the entire deposit will be applied to the cost of the undertaking as part of local contribution to its construction;

NOW, THEREFORE, the parties hereto agree as follows:

1. Applicant agrees to deposit with the Commission the sum of $ 1,500.00 to partially cover the cost of an investigation, or survey, and study of the desirability and feasibility of the proposed undertaking.

2. Applicant agrees to obtain written permission from all affected landowners whereby permission is granted to the Commission and/or contractors engaged by them, for the purpose of surveying said lands for investigation and subsurface explorations.

3. If, after investigation, or survey, and study of the proposed undertaking it is determined that it is not feasible, or that it will be of no public benefit, or if the Applicant shall notify the Commission of abandonment of the proposed undertaking, or if the Applicant fails to show an intent to proceed with the undertaking within 18 months after the date of the deposit, the Applicant shall be furnished a statement of the expenses incurred in conducting the investigation, or survey, and study thereof, and any balance of Applicant's deposit remaining unexpended shall be returned to Applicant.

4. If, however, the proposed undertaking shall, after investigation, or survey, and study, be found to be feasible, and of benefit to the public, the Applicant shall be notified accordingly.

Dated this 8th day of October, 19 75.

Albert Haas

By: Albert Haas, Chairman

Eddy County Water Management District
(Applicant)

NORTH DAKOTA STATE WATER COMMISSION
By:

Vernon Fahy
Secretary and Chief Engineer

Distribution
Applicant (1)
SWC Project File (1)
SWC Accountant (1)

"Buy North Dakota Products"

(200-4/72)
SWC Form #98

APPENDIX B

SWC Project #1633

August 1977

AGREEMENT

Preliminary Investigation
by the
North Dakota State Water Commission

I. PARTIES

THIS AGREEMENT is between the North Dakota State Water Commission, hereinafter referred to as the Commission, acting through the State Engineer, Vern Fahy; and the Board of Commissioners, Wells County Water Management District, acting through its chairman, Norman Rudel, hereinafter referred to as the Board.

II. INTENT OF AGREEMENT

The Commission and the Boards have concurrent jurisdiction to alleviate, to the extent possible, flooding in the state:

> 61-02-01. WATER CONSERVATION, FLOOD CONTROL, AND ABATEMENT OF STREAM POLLUTION DECLARED A PUBLIC PURPOSE.) It is hereby declared that the general welfare and the protection of the lives, health, property, and the rights of all the people of this state require that the conservation and control of waters in this state, public or private, navigable or unnavigable, surface or subsurface, the control of floods, and the regulation and prevention of water pollution, involve and necessitate the exercise of the sovereign powers of this state in investigating, constructing, maintaining, regulating, supervising, and controlling any system of works involving such subject matter embraces and concerns a single object, and that the state water conservation commission in the exercise of its powers, and in the performance of all its official duties, shall be considered and construed to be performing a governmental function for the benefit, welfare, and prosperity of all the people of this state.
>
> 61-02-14. POWERS AND DUTIES OF THE COMMISSION.) The commission shall have the full and complete power, authority, and general jurisdiction:
>
> 1. To investigate, plan, regulate, undertake, construct, establish, maintain, control, operate, and supervise all works, dams, and projects, public and private, which in its judgment may be necessary or advisable:
>
> * * *
>
> c. To control and regulate flood flow in the streams of the state to minimize the damage of such flood waters;
>
> * * *
>
> g. To develop, restore and stabilize the waters of the state for domestic, agricultural and municipal needs, irrigation, flood control, recreation, and wildlife conservation, by the construction and maintenance of dams, reservoirs and diversion canals;
>
> h. To promote the maintenance of existing drainage channels in agricultural lands and to construct any needed channels;
>
> * * *
>
> j. To finance the construction, establishment, operation, and maintenance of public and private works, dams, and irrigation projects, which in its judgment may be necessary and advisable;

* * *

1. To provide for the drainage of lands injured by or susceptible of injury from excessive rainfall or from the utilization of irrigation water, and subject to the limitations prescribed by law, to aid and co-operate with the United States and any department, agency, or officer thereof, and with any county, township, drainage district or irrigation district of this state, or of other states, in the construction or improvement of such drains;

* * *

2. To define, declare, and establish rules and regulations:

* * *

b. For the full and complete supervision, regulation, and control of the water supplies within the state;

* * *

d. Establish rules and regulations governing and providing for financing by local participants to the maximum extent deemed practical and equitable in any water development project in which the state participates in cooperation with the United States or with political subdivisions or local entities.

* * *

5. To exercise all express and implied rights, power and authority, that may be necessary, and to do, perform, and carry out all of the expressed purposes of this chapter and all of the purposes reasonably implied incidentally thereto or lawfully connected therewith;

61-02-24.1 COOPERATION AND PARTICIPATION OF POLITICAL SUPERVISORS.) All political subdivisions, including but not limited to, counties, townships, cities, villages, park districts, and water management districts may separately or jointly with other political subdivisions, the state or federal departments or agencies, investigate, plan and do all things necessary for participating in or undertaking underground or surface water surveys, development, construction, reconstruction and maintenance of works, dams, and projects for the beneficial utilization and control of water resources.

61-16-11. POWERS AND DUTIES OF BOARD OF COMMISSIONERS.) The board of commissioners shall have the power:

* * *

5. To plan, locate, relocate, construct, reconstruct, modify, maintain, repair, and control all dams and water conservation devices of every nature and water channels and to control and regulate the same and all reservoirs, artificial lakes, and other water storage devices within the district;

* * *

6. To maintain and control the water levels and the flow of water in the bodies of water and streams involved in water conservation and flood control projects within its district, and regulate streams, channels or watercourses and the flow of water therein by changing, widening, deepening, straightening the same or otherwise improving the use and capacity thereof;

7. To regulate and control flood waters for the prevention of floods, by deepening, widening, straightening or dyking the channels of any stream or watercourse within its district, and construct reservoirs or other means to hold and control such waters;

* * *

11. To have, in addition to any powers provided in this chapter, all of the powers conferred by statutes upon a board of county drain commissioners;

61-21-02. WATERCOURSES, DITCHES, AND DRAINS MAY BE CONSTRUCTED, MAINTAINED, REPAIRED, IMPROVED, OR EXTENDED.) Watercourses, ditches, drains, and improvements thereto for the drainage of sloughs and other low lands may be surveyed and investigated and established, constructed, maintained, repaired, improved, and cleaned out in the several counties of this state under the provisions of this chapter wherever the same shall be conductive to the public health, convenience, or welfare. The powers conferred by this chapter and this section shall extend to and include but shall not be limited to:

1. The deepening and widening of any necessary improvement of drains which have been or hereafter may be constructed;

2. The straightening, clearing, or cleaning out and deepening of channels of creeks, streams, and rivers, and the construction, maintenance, remodeling, repairing, and extension of levees, dikes, and barriers for the purpose of drainage;

3. The location or extension of any drain if such location or extension is necessary to provide a suitable outlet or reasonably drain lands within a practical drainage area of such drains;

4. The establishment, in whole or in part, of a drain and the completion of the same on the line of an abandoned or invalid drain; and

5. The establishment and construction of lateral drains with outlets in drains already constructed.

Attached to this agreement, and made a part hereof, is a letter dated August 2, 1977, from the Board to the Commission. The letter, and accompanying discussions, indicate the Board will act as the lead board for Wells, Eddy and Foster Counties in this joint project. Therefore, this agreement will be between only the Commission and the Board; other supplementary agreements between the Board and the Boards of Commissioners for Eddy and Foster Counties Water Management Districts will be the responsibility of the Board.

It is the intent of the Commission that the funds discussed herein will be utilized to develop water surface profiles along Rocky Run Creek and portions of its tributaries to determine the effect of existing channel conditions and structures on selected flows. These water surface profiles will show actual depth of flow in the channels at these flows, taking into account all back water due to obstruction in the channel, as well as inadequate bridge or culvert openings.

III. PROJECT LOCATION

The investigation will include Rocky Run Creek and portions of its tributaries as they occur in Foster, Eddy and Wells Counties.

IV. COST

The Board shall deposit $500 with the Commission. Upon completion of the water surface profile investigation, the Commission will bill the Board for 50% of the costs to do the investigation as incurred by the Commission (but not to exceed $5,000) and will include all fees necessary to conduct the investigation. 50% (but not to exceed $5,000) will be provided by the Commission. Cost accrual will begin on August 22, 1977. Payment shall be made by the Board within thirty days of receipt of the billing statement.

V. RIGHTS OF ENTRY

The Board agrees to obtain written permission from any affected landowner for surveys or surface investigations by the Commission which are required for the preliminary investigations.

VI. INDEMNIFICATION

The Board hereby accepts reponsibility for, and holds the Commission free from, all claims and damages to public or private properties, rights, or persons arising out of this investigation. In the event a suit is initiated or judgment entered against the Commission, the Board shall indemnify it for any judgment arrived at or judgment satisfied.

BOARD OF COMMISSIONERS
WELLS COUNTY WATER MANAGEMENT DISTRICT

Norman Rudel
Chairman

Sept 1 - 77
DATE

NORTH DAKOTA STATE WATER COMMISSION

Vernon Fahy
Vern Fahy
State Engineer

8-19-77
DATE

APPENDIX C

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

P. O. Box 1458, Bismarck, ND 58501

SUBJECT: Rocky Run Watershed - Economic Data

DATE: August 4, 1977

TO: David A. Sprynczynatyk
State Water Commission
900 East Boulevard
Bismarck, ND 58505

Attached is economic analysis for the Rocky Run Watershed. The analysis is based upon interview data gathered by several local individuals.

Yield data information under flooding and flood free conditions were projected to the approximate midpoint of the project by use of Economic Research Service (ERS) projections. These yield projections are a normal economic consideration to properly reflect the expected technological advances that will occur over time.

The prices used on Page 3 for various crops, in some cases, show a wide deviation from actual present day prices. The Soil Conservation Service Economist is locked into and compelled to use prices set up by the Water Resources Council (WRC). These prices reflect a ten year average less government payments. Usually when one attempts to project into the future these prices are somewhat more comfortable to present than the current market price.

As you will notice on the attached Damage-Benefit Analysis sheets, the acres included in the interview in comparison to the acres in the township, county or watershed, in some cases, is a very small percentage. With this in mind, we have presented the material under two analysis; (1) a conservative approach or as listed (unexpanded data) and (2) a more liberal approach in which we say the uninterviewed acres suffer damage to the same degree and extent as those interviewed and this approach is listed as (expanded data). It is safe to assume that the people making the interviews probably contacted those individuals more subject to a problem. The conclussion would be that the most accurate economic interpretation is somewhere between these two presentations.

It has been an enjoyable experience working with you and your agency on this project. If I can be of further help on this or similar projects, give me a call.

Bruce O. Clark
Economist

cc: Richard Axvig, SCS, DC, Fessenden, ND 58438

SCS-MCT-7
PTV 1-71

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Tabular Computations

Pg 3

Locky - Run W/S

Code #		Acres in Tabulation		Acres with Problem	Freq. of Problem		Yields: Wheat no with Problem	Barley no with Problem	Hay no with Problem	Corn no with Problem	Oats no with Problem	Durum Wheat no with Problem	Sun Flower no with Problem	Pasture no with Problem	HAY no with Problem	Other Agric Damage	Land Damage
Eddy	E-1	160		40	Every Year									Affected			
	E-2	640		50	Every Year		30 15										
	E-3	480		120	4-6		35-10		15-0								
	E-4	160		40	Every Year									Affected			
	E-5	320		25	Every Year		35-10										
	E-6	320		80	4-10		35-10	40-10									
	E-7	320		160	8-10		38-19							Affected			
	E-8	320		160	Every Year												
	E-9	160		25	2-10		40-20										
	E-10	960		45	Every Year		40-20		15-2								
	E-11	160		30	Every Year										30-10		
	E-12	320		175	1-3		40-25										
Fairdale	F-1	960		250	7-8		30-17	40-30	12-7								
	F-2	640															
	F-3	1600		300													
	F-4	1440		325													
	F-5	1650		450	7-8		30-21.5	40-35	12-7								
Ger-Bancroft	G-1	1280		350	1-10		30-20	50-40									
	G-2	1920		800	Every Year		40-15	50-20									
	G-3	320		20	1-10		35-30										
	G-4	640		200	1-10		35-25		12-8		70-50						
	G-5	1040		480	1-10		40-20	50-25	12-7								
	G-6	1440		550	1-5		30-20	30-18									
		47,760		8,880	18.6%												

Pat.

REV. 1-71 SOIL CONSERVATION SERVICE

Rocky-Run W/S

Fields

Code #		ACres IN Interview		Acres With Problem	Freq. of Problem		Wheat No with Problem	Barley No with Problem	Flax No with Problem	Corn No with Problem	OATS No with Problem	Durum Wheat No with Problem	Sunflower No with Problem	Pasture Problem	HAY Problem	Other Agric. Damage	Land Damage
CATHAY																	
C-1		1110		75	every year		30								25-0		
C-2		320		45			27-0				55-0					75	
C-3		320		25	Rarely		27-0							Affects Grazing			
C-4		640		70			25-0							"	Affects Hay Crop		
C-5		1120		40	every year		35-0										
C-6		960															
C-7		480		200	8-10		35-0										
C-8		720		40	Rarely		27-0										
C-9		640															
C-10		1280															
C-11		960		135	Rarely		30	45					1000#			75	
					✓												
WEST ONTARIO																	
WO-1		320		NONE													
WO-2		320		NONE													
WO-3																	
WO-4		960															
BREMAN																	
B-1		1280		79	3-5		40-50	40-25	10 —			30-50		Affects			
B-2					1-4		40-	60-				110 —					
B-3		640			1-3												
B-4		720			1-3		40	50				40-					
B-5		480					45										
B-6		480			1-3		40	60									

REV. 1-71

SOIL CONSERVATION SERVICE

Koeky - Kuw W/S

Tabular Computations

Page 1.

	Code #		Acres in Interview		Acres with Problem	Freq. of problem		Wheat No with Problem	Barley No with Problem	Flax No with Problem	Corn No with Problem	Oats No with Problem	Durum Wheat No with Problem	Sunflower No with Problem	Pasture No with Problem	Hay No with Problem	Other Agri Damage	Land Damage
Oshkosh	O-1		960		280	3-10		42 -	55 -								920	3111
	O-2		1160		101	3-10		40 -	50 -								550	4530
	O-3		960		173	3-10		41 -	54 -	12 -							850	3150
	O-4		320		64	4-10		45-38	60-48	25-15							600	1365
	O-5		1160		446	3-10		40	50	12 -							1300	3400
	O-6		640		160	3-10		48-40	60-50								641	535
	O-7		720		290	3-10		38-	50-								900	4117
	O-8		1440		200	3-10		50-40	60-55-40	12-10	13-10	80-60					1111	1997
Foster	Fo-1		1600		180	2-3-1-4		35-25					35-15					
	Fo-2		1160		65	1-4			35-10									
	Fo-3		1900		100	1-4		35-0										
	Fo-4		1160		20				50-35									
	Fo-5		640														25	
	Fo-6		480		160	1-10		35-30	60-45								30	
Woodward	Wo-1		1900		150	1-9		40-0						[illegible]				
	Wo-2		[illegible]		270	1-8		30-0										
	Wo-3		560		105	1-8												
	Wo-4		560		60	1-9												
	Wo-5		960		40	1-20												
	Wo-6		960		117	1-5		30	50			75						
	Wo-7		480		35	1-4		32	45									
	Wo-8		480		120	1-5		35	60			75						
	Wo-9		1760		475	1-2		35	60	12				[illegible]				

ROCKY RUN WATERSHED
E.R.S. YIELD PROJECTIONS

LRA (Land Resource Area) 55
SRG (Soil Resource Group) 120

Crop	Yield 1980	Year 2000	Factor
Wheat (Bu.) (Durum included)	33	42	1.3
Barley (Bu.)	42	53	1.3
Oats (Bu.)	45	56	1.2
Flax (Bu.)	12	15	1.2
Hay (Tons)	1.8	2.4	1.3
Sunflowers (Cwt.)			1.3

ROCKY RUN WATERSHED

NET COMPOSITE ACRE VALUE
W/O PROJECT

Crop	Yield (Projected)	Price 1/	Gross Return Per Acre	Production Costs 2/	Net Return Per Acre	% Comp. Acre	Net Comp. Return
Wheat	29.5 bu.	4.19	$124	$87	$37	41.4	$15.32
Barley	39.5	2.58	102	67	35	6.9	2.42
Flax	9.6	6.46	62	49	13	5.3	.69
Oats	42.0	1.32	55	36	19	5.1	.97
Hay (all)	1.7 tons	37.04	63	30	33	11.9	3.31
Sunflowers	1170 lbs.	10.00	117	70	47	4.7	2.21
Fallow						24.7	
		TOTALS				100%	$24.92

1/ Price Base - WRC (Water Resource Council) October 1976.

2/ Production costs include all operations necessary to produce a harvestable crop, such items as seed, fertilizer, herbicide, crop insurance, fuel, repair, labor, interest on capitol, harvest costs, ownership costs, land and management charges.

ROCKY RUN WATERSHED

NET COMPOSITE ACRE VALUE
WITH PROJECT

Crop	Yield (Projected)	Price 1/	Gross Return Per Acre	Production Costs 2/	Net Return Per Acre	% Comp. Acre	Net Comp. Return
Wheat	48.2 bu.	4.19	$202	$95	$107	41.4	$44.30
Barley	63.6	2.58	164	74	90	6.9	6.21
Flax	17.2	6.46	111	54	57	5.3	3.02
Oats	60.0	1.32	79	40	39	5.1	1.99
Hay (all)	2.0 tons	37.04	74	33	41	11.9	4.88
Sunflowers	1248 lbs.	10.00	125	75	50	4.7	2.35
Fallow						24.7	
		TOTALS				100%	$62.75

Difference (with project) $62.75
(without project) $24.92
$37.83

1/ Price Base - WRC (Water Resource Council) October 1976.
2/ Refer to footnote #2, page 3.

DAMAGE - BENEFIT ANALYSIS
Rocky Run W/S

Acres in watershed: (approx.) 163,000
Acres in w/s included in interview: (approx.) 39,340 ~~49,340~~ ←
Interview acres with a water problem: 1/ 8,880 ←
Frequency of problem: Interview data showed that a frequency of the water problem varied from a very rare event, to one of an annual event; this computed to 3,780 acres with an annual problem.

Unexpanded Data:

Benefit analysis: 3,780 acres (x) 37.83 2/ = 142,997

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	142,997	40,039	102,958
Other Agric. (5%)	7,150	2,002	5,148
Sub-total	150,147	42,041	108,106
Indirect (10%)	15,015	4,204	10,811
Total	165,162	46,425	118,917 4/

Expanded Data:

163,000 w/s acres (÷) ~~39,340~~ 49,340 = ~~4.14~~ 3.30
8,880 problem acres (x) ~~4.14~~ 3.30 = ~~36,432~~ 29,304
3,780 acres (÷) 8,880 acres = ~~42%~~ 43%
~~36,432~~ 29,304 acres (x) ~~42%~~ = ~~15,301~~ 12,601

Benefit Analysis: ~~15,301~~ 12,601 (x) 37.83 2/ = ~~578,837~~ 476,616

Item	Present Damage		Damage W/Project		Damage Reduction 3/	
Crops	~~578,837~~	476,616	162,075	~~162,074~~	416,541	~~416,763~~
Other Agric. (5%)	~~28,942~~	23,835	8,104	~~8,104~~	15,731	~~20,823~~
Sub-total	~~607,779~~	500,451	170,179	~~170,178~~	430,272	~~437,601~~
Indirect (10%)	~~60,778~~	50,045	17,018	~~17,018~~	33,027	~~43,760~~
Total	~~668,557~~	550,496	187,196	~~187,196~~	463,299	~~481,361~~ 5/

1/ The area described a water problem area has not been fully field observed as to the exact nature of the problem, but includes such items as flooding, drainage, wetlands, salt or saline and etc.

2/ Net return per composite acre for with project condition less without project condition $62.75 (-) $24.92 = $37.83.

3/ Approximately 72% reduction in damages due to structural works.

4/ 118,917 average annual will support approximately the follwoing works of improvement.

Interest Rate	Total Installation Dollars
6 3/8 (amortized for 50 yrs.)	(approx.) 1,780,000
7	(approx.) 1,641,000
8	(approx.) 1,452,000

5/ 481,361 average ann. will support approximately the following works of improvement.

Interest Rate	Total Installation Dollars
6 3/8 (amortized for 50 yrs.)	(approx.) ~~7,207,000~~ 5,935,000
7	(approx.) ~~6,643,000~~ 5,471,000
8	(approx.) ~~5,878,000~~ 4,841,000

DAMAGE - BENEFIT ANALYSIS
For Oshkosh Twp. of Rocky Run W/S

Township acres in watershed: (approx.) 9,600
Acres in township included in interview: (approx.) 6,800 ✓
Interview acres with a water problem: 1/ 1,714 ✓

Frequency of problem: Interview data showed that from 3 to 4 years out of every 10, a water problem was experienced; this computed to 576 interview acres with an annual problem.

Unexpanded data:

Benefit analysis: 576 acres (x) 37.83 2/ = 21,790

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	21,790	6,101	15,689
Other Agric. (5%)	1,090	305	785
Sub-Total	22,880	6,406	16,474
Indirect (10%)	2,288	641	1,647
TOTAL	25,168	7,047	18,121 4/

Expanded data:

9,600 Twp w/s acres (÷) 6,800 acres interview = 1.41
1,714 problem acres (x) 1.41 = 2,417
1,714 acres (÷) 576 = 33
2,417 acres (x) 33 = 798 acres with annual probler

Benefit analysis: 798 acres (x) 37.83 2/ = 30,188

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	30,188	8,453	21,735
Other Agric. (5%)	1,509	423	1,086
Sub-Total	31,697	8,876	22,821
Indirect (10%)	3,170	888	2,282
TOTAL	34,867	9,764	25,103 5/

1/ Refer to footnote #1, page 5.
2/ Refer to footnote #3, page 5.
3/ Refer to footnote #4, page 5.
4/ 18,121 average ann. will support approximately the following works of improvem

Interest Rate	Total Installation Dollars
6 3/8 (amortized for 50 years)	(approx.) 271,000
7	(approx.) 250,000
8	(approx.) 221,000

5/ 25,103 average ann. will support approximately the following works of improver

Interest Rate	Total Installation Dollars
6 3/8 (amortized for 50 years)	(approx.) 376,000
7	(approx.) 346,000
8	(approx.) 307,000

DAMAGE - BENEFIT ANALYSIS
For Germantown Twp of Rocky Run W/S

Township acres in watershed: (approx.) 17,000
Acres in township included in interview: (approx.) 6,640 ✓
Interview acres with a water problem: 1/ 2,326 ✓

Frequency of problem: Interview data revieled that the frequency of the water problem varied from an annual problem, to 1 year out of every 10, this water problem was experianced; this computed to 1,008 interview acres with an annual problem.

Unexpanded data:
Benefit analysis: 1,008 acres (x) 37.83 2/ = 38,133

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	38,133	10,677	27,456
Other Agric. (5%)	1,907	534	1,373
Sub-Total	40,040	11,211	28,829
Indirect (10%)	4,004	1,121	2,883
TOTAL	44,044	12,332	31,712 4/

Expanded data:
17,000 Twp w/s acres (÷) 6,640 acres interview = 2.56
2,326 problem acres (x) 2.56 = 5,955
2,326 acres (÷) 1,008 = 23%
5,955 acres (x) 23 = 1,370 acres with annual problem

Benefit analysis: 1,370 acres (x) 37.83 2/ = 51,827

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	51,827	14,512	37,315
Other Agric. (5%)	2,591	726	1,865
Sub-Total	54,418	15,238	39,180
Indirect (10%)	5,442	1,524	3,918
TOTAL	59,860	16,762	43,098 5/

1/ Refer to footnote #1, page 5.
2/ Refer to footnote #3, page 5.
3/ Refer to footnote #4, page 5.
4/ 31,712 average ann. will support approximately the following works of improvem

Interest Rate	Total Installation Dollars
6 3/8 (amortized for 50 years)	(approx.) 475,000
7	(approx.) 438,000
8	(approx.) 387,000

5/ 43,098 average ann. will support approximately the following works of improver

Interest Rate	Total Installation Dollars
6 3/8 (amortized for 50 years)	(approx.) 645,000
7	(approx.) 590,000
8	(approx.) 526,000

DAMAGE - BENEFIT ANALYSIS
For Cathy Twp of Rocky Run W/S

Township acres in watershed: (approx.) 23,000
Acres in township included in interview: (approx.) 9,080 ✓
Interview acres with a water problem: 1/ 639 ✓

Frequency of problem: Interview data showed that the frequency of the water problem varied from an occassional occurance, to on of almost every year; this computed to 367 acres with an annual problem.

Unexpanded data:

Benefit analysis: 367 acres (x) 37.83 2/ = 13,884

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	13,884	3,887	9,997
Other Agric. (5%)	694	194	500
Sub-Total	14,578	4,081	10,497
Indirect (10%)	1,458	408	1,050
TOTAL	16,036	4,489	11,547 4/

Expanded data:

23,000 Twp w/s acres (÷) 9,080 acres interview = 2.53
639 problem acres (x) 2.53 = 1,617
367 acres (÷) 639 = 57%
1,617 acres (x) 57% = 922 acres with annual problem

Benefit analysis: 922 acres (x) 37.83 2/ = 34,879

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	34,879	9,766	25,113
Other Agric. (5%)	1,744	488	1,256
Sub-Total	36,623	10,254	26,369
Indirect (10%)	3,662	1,025	2,637
TOTAL	40,285	11,279	29,006 5/

1/ Refer to footnote #1, page 5.
2/ Refer to footnote #3, page 5.
3/ Refer to footnote #4, page 5.
4/ 11,547 average ann. will support approximately the following works of improvement:

Interest Rate	Total Installation Dollars
6 3/8 (amortized for 50 years)	(approx.) 175,000
7	(approx.) 159,000
8	(approx.) 141,000

5/ 29,006 average ann. will support approximately the following works of improvement:

Interest Rate	Total Installation Dollars
6 3/8 (amortized for 50 years)	(approx.) 434,000
7	(approx.) 400,000
8	(approx.) 354,000

DAMAGE - BENEFIT ANALYSIS

For Woodward Twp of Rocky Run W/S

Township acres in watershed: (approx.) 11,000
Acres in township included in interview: (approx.) 8,000 ✓
Interview acres with a water problem: 1/ 1,332 ✓

Frequency of problem: Interview data showed that the frequency of the water problem varied from 1 year in 2 to 1 year in 20, this computed to 367 acres with an annual problem.

Unexpanded data:

Benefit analysis: 367 acres (x) 37.83 2/ = 13,884

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	13,884	3,887	9,997
Other Agric. (5%)	694	- 194	500
Sub-Total	14,578	4,081	10,497
Indirect (10%)	1,458	408	1,050
TOTAL	16,036	4,489	11,547 4/

Expanded data:

11,000 Twp w/s acres (÷) 8,000 acres interview = 1,375
1,332 problem acres (x) 1.37 = 1,825
367 acres (÷) 1,332 = 28%
1,825 acres (x) 287 = 511 acres with annual problem

Benefit analysis: 511 acres (x) 37.83 2/ = 19,331

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	19,331	5,413	13,918
Other Agric. (5%)	967	271	696
Sub-Total	20,298	5,684	14,614
Indirect (10%)	2,030	568	1,462
TOTAL	22,328	6,252	16,076 5/

1/ Refer to footnote #1, page 5.
2/ Refer to footnote #3, page 5.
3/ Refer to footnote #4, page 5.
4/ 11,547 average ann. will support approximately the following works of improvement

Interest Rate	Total Installation Dollars
6 3/8 (amortized for 50 years)	(approx.) 173,000
7	(approx.) 159,000
8	(approx.) 141,000

5/ 16,076 average ann. will support approximately the following works of improvement

Interest Rate	Total Installation Dollars
6 3/8 (amortized for 50 years)	(approx.) 241,000
7	(approx.) 222,000
8	(approx.) 196,000

DAMAGE - BENEFIT ANALYSIS — Rocky Run W/S

For Eddy & Foster Counties of Rocky Run W/S

Eddy County acres in w/s:	(approx.)	36,500
Foster County acres in w/s:	(approx.)	2,500
Acres included in interview:		9,650
Interview acres with a water problem: 1/		2265

Frequency of problem: Interview data showed that the frequency of the water problem varied from an annual problem, to one year in three; this computed to 890 acres with an annual problem.

Benefit Analysis: 890 acres (x) 37.83 2/ = 33,669

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	33,669	9,427	24,242
Other Agric. (5%)	1,684	472	1,212
Sub-total	35,353	9,899	25,454
Indirect (10%)	3,535	990	2,545
Total	38,888	10,889	27,999 4/

Expanded Data:

39,000 County w/s acres (÷) 9,650	=	4.04
2,265 problem acres (x) 4.04	=	9,151
890 acres (÷) 2,265	=	39%
9,151 acres (x) 39%	=	3,569 acres with annual problem.

Benefit analysis: 3,569 acres x 37.83 2/ = 135,015

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	135,015	37,804	97,211
Other Agric. (5%)	6,751	1,890	4,861
Sub-total	141,766	39,694	102,072
Indirect (10%)	14,177	3,970	10,207
Total	155,943	43,664	112,279 5/

1/ Refer to footnote #1, page 5.

2/ Refer to footnote #3, page 5.

3/ Refer to footnote #4, page 5.

4/ 27,999 average annual will support approximately the following works of improvement.

Interest Rate	Total Installation Dollars
6 3/8 (amorized for	(approx.) 419,000
7 50 years)	(approx.) 386,000
8	(approx.) 342,000

5/ 112,279 average ann. will support approximately the following works of improvement.

Interest Rate	Total Installation Dollars
6 3/8 (amortized for	(approx.) 1,681,000
7 50 years)	(approx.) 1,550,000
8	(approx.) 1,371,000

DAMAGE - BENEFIT ANALYSIS
For Fairville Twp of Rocky Run W/S

Township acres in watershed: (approx.) 23,000
Acres in township included in interview: (approx.) 5,490 ✓
Interview acres with a water problem: 1/ 1,275 ✓

Frequency of problem: Interview data showed that the frequency of the water problem varied from an occasional event; to other areas that experienced water problems 7 years out of every 8, this computed to 525 acres with an annual problem.

Unexpanded data:

Benefit analysis: 525 acres (x) 37.83 2/ = 19,860

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	19,860	5,561	14,299
Other Agric. (5%)	993	278	715
Sub-Total	20,853	5,839	15,014
Indirect (10%)	2,085	584	1,501
TOTAL	22,938	6,423	16,515 4/

Expanded data:

23,000 Twp w/s acres (÷) 5,490 acres interview = 4.19
1,275 problem acres (x) 4.19 = 5,342
525 acres (÷) 1,275 = 41%
5,342 acres (x) 41% = 2,190 acres with annual problem

Benefit analysis: 2,190 acres (x) 37.83 2/ = 82,848

Item	Present Damage	Damage W/Project	Damage Reduction 3/
Crops	82,848	23,197	59,651
Other Agric. (5%)	4,142	1,160	2,982
Sub-Total	86,990	24,357	62,633
Indirect (10%)	8,699	2,436	6,263
TOTAL	95,689	26,793	68,896 5/

1/ Refer to footnote #1, page 5.
2/ Refer to footnote #3, page 5.
3/ Refer to footnote #4, page 5.
4/ 16,515 average ann. will support approximately the following works of improvement

Interest Rate	Total Installation Dollars
6 3/8 (amortized for 50 years)	(approx.) 247,000
7	(approx.) 228,000
8	(approx.) 202,000

5/ 68,986 average ann. will support approximately the following works of improvement

Interest Rate	Total Installation Dollars
6 3/8 (amortized for 50 years)	(approx.) 1,055,000
7	(approx.) 952,000
8	(approx.) 842,000

Sample Twp.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Acres in Twp 640 x 36 = 23,040
Acres in Interview III 640 x 6 = 3,840
Interview Acres with a water problem = 800
Frequency of water problem = 400
Expanded data:

23040 ÷ 3840 = 6.0
800 x 6 = 4800
400 ÷ 800 = 50%
4800 (X) 50% = 2400 Acres in Twp. with an annual water problem.