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COLDWATER CREEK, MISSOURI
FEASIBILITY REPORT
FOR FLOOD CONTROL AND RELATED PURPOSES

ENGINEERING, DESIGN AND COST
SUPPORTING DOCUMENTATION

May 1987

U.S. Army Corps Of Engineers
St. Louis District
Lower Mississippi Valley Division

COLDWATER CREEK, MISSOURI

FEASIBILITY REPORT

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APPENDIX A

HYDROLOGY AND HYDRAULICS

Coldwater Creek

Hydrology and Hydraulics

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SECTION 1 - PURPOSE AND SCOPE

The purpose of this documentation is to present the hydrologic and hydraulic analyses for the Coldwater Creek flood control study. Historical floods are described, flooding problems are identified and potential flood reducing measures are presented. Extensive computer modeling techniques were utilized to simulate existing conditions with no project and to examine impacts of proposed flood control improvements.

SECTION 2 - DESCRIPTION OF STUDY AREA

The study area covered by this appendix includes Coldwater Creek and its tributaries. Coldwater Creek has its headwaters in the community of Overland, Missouri near the intersection of Ashby Road and Midland Boulevard. The stream flows northeast through Overland in a concrete lined rectangular channel to the upstream city limits of Breckenridge Hills. Through Breckenridge Hills, the creek flows northwest in its natural channel through several bridges and culverts including the 420 feet long culvert under St. Charles Rock Road and an adjacent apartment development. Residential development in Breckenridge Hills extends out to the bank of the creek in many cases. From there, the creek flows north through the city of St. Ann. Although much of the floodplain has been used for a golf course and city park, some commercial and residential properties are in the floodplain. Below St. Ann, the creek flows under Interstate Highway I-70 and into the Lambert St. Louis Airport property. At mile 15.04, the creek flows into a double 10 feet by 15 feet box culvert under the airport and exits at mile 13.81 in Hazelwood, Missouri. The creek flows north through industrial and residential areas in Hazelwood to the upstream limit of Florissant, Missouri. In Florissant, the creek flows through highly developed residential and commercial property. Three major tributary streams enter Coldwater Creek in Florissant; Fountain, Daniel Boone, and Paddock Creeks, all of which have been improved with trapezoidal or rectangular concrete channels. North of Florissant, Coldwater Creek flows through an unincorporated area of St. Louis County where residential and commercial development has been taking place. The creek then flows through a residential area of Blackjack, Missouri and on to the Missouri River through an undeveloped reach of St. Louis County. The Coldwater Creek basin, shown on Plate 1 covers an area of 44.8 square miles, most of which is highly developed residential, commercial or industrial areas. The stream is about 20 miles long with an average slope of about 16 feet per mile.

SECTION 3 - AVAILABLE DATA

Stream Gage Records

At the time of this study, there were no streamflow or stage gages for Coldwater Creek or its tributaries. Several years ago, three U.S.G.S, stage gages were operational in the basin for a total of 4 to 7 years. However, because of the short period of record, extensive urbanization and channel improvements, the data was of little use. However, two recent flood events produced many well-documented high water marks throughout the basin and were helpful in model calibrations of Coldwater Creek, as will be explained later. High water marks were obtained from personal interviews with local citizens and community officials and by direct field observation by Corps of Engineers personnel.

Rainfall Records

The National Weather Service maintains an hourly, recording precipitation station at the St. Louis airport, which is within the basin.

SECTION 4 - HISTORICAL EVENTS

Flooding from Coldwater Creek and its tributaries generally occurs in the spring and summer months as a result of intense thunderstorms over the watershed, but could occur during any month of the year. These floods have a rapid rate of rise and are of short duration, but have caused considerable damage in recent years. Significant floods were experienced in 1957, 1978, 1979 and 1982. On 14 June 1957, 4.74 inches of rain were recorded at Lambert-St.Louis International Airport in 14 hours. The resultant flood was the highest flood of recent years at many locations in the basin. However, there was relatively little development in the floodplain at that time. In the 14 July 1978 storm, 2.50 inches of rain were recorded at the airport in 4 hours with a maximum one hour amount of 2.21 inches. This storm produced flood heights which exceeded those of the 1957 flood upstream of the airport. The storms of 11 April 1979 produced 4.90 inches of rain in 20 hours with a maximum one hour amount of 1.35 inches. A description of the damages caused by the

1979 flood was presented in the Coldwater Creek Reconnaissance Report of January 1982. Smaller floods have occurred frequently, including those of 30 April 1970, 16 September 1980, and 21 June 1981. On 4 July 1982, a total of 2.99 inches of rain were recorded at the airport in three hours. Six days later on 10 July 1982, another 3.36 inches of rain were recorded in seven hours with 2.98 inches in the maximum three hour period. Although major flooding did not occur throughout the lower part of the basin, residents in Breckenridge Hills in the upper basin experienced the highest flood levels in 20 years.

SECTION 5 - EXISTING PROTECTION

Most of the main channel of Coldwater Creek between Lewis and Clark Boulevard (mile 1.9) and St. Charles Rock Road (mile 17.7) has been realigned and deepened as urban development occurred over the years. Today, this portion of the channel can carry a flood with about a 50 percent chance of occurrence without significant damage. Above Baltimore Avenue (mile 18.5), Coldwater Creek flows in a concrete lined open channel with vertical walls, and in enclosed culverts in the uppermost part of the basin. The channel improvements in this reach afford protection from the flood with a 20-50 percent chance of occurrence.

The main channel of Coldwater Creek is enclosed in a double 10 ft. by 15 ft. box culvert through Lambert-St. Louis International Airport from mile 13.8 to 15.0. Several storm sewers that drain the airport area enter the double box culvert in this reach. A flood with about a 20-50 percent chance of occurrence will exceed the capacity of the culverts causing a backwater effect at the upstream end and temporary ponding of water on airport property.

The Metropolitan St. Louis Sewer District (MSD) has been constructing concrete lined channels on several main tributaries of Coldwater Creek downstream of the airport. The purpose of these channel improvements is flood control and bank stabilization and include Fountain Creek and its tributary Anthony Creek, Paddock Creek and Daniel Boone Creek. Each of these improved channels provide protection against flooding up to the one percent chance event on the tributaries. Numerous other smaller tributaries both upstream and downstream of the airport have either been enclosed in culverts or flow in open concrete lined channels and have varying degrees of flood protection.

At the Lambert-St. Louis International Airport, a levee was built in 1981 to provide protection to the airport field maintenance area which was damaged in the 1978 and 1979 floods. The levee provides protection from approximately the 7 percent chance flood. Several small retention areas and improvements to drainage facilities were also constructed at about the same time.

SECTION 6 - HYDROLOGIC AND HYDRAULIC ANALYSES

The mathematical models used to perform the hydrologic and hydraulic analyses are discussed in this section. Also presented are the methods used to verify the model results.

Hydrologic Modeling

The computer model "HEC-1, Flood Hydrograph Package" was used in performing the hydrologic analyses. The Coldwater Creek basin was divided into 57 subareas as shown on Plate 1. For the 21 subareas above the airport, and several subareas below the airport, runoff was computed by the kinematic wave method which transforms rainfall excess into subbasin outflow. Overland flow elements are described by flow length, slope and roughness factor. Overland flow lengths and slopes were computed from U.S.G.S. quad sheets and the overland flow roughness factors were estimated using typical values published in the HEC-2 user's manual and from values used in earlier studies for similar basins. Parameters used in computing overland flow elements are found in Table 1. Flow from these overland flow elements travels to the subbasin outlet through one or two successive channel elements. A channel element is described by its length, slope, roughness, shape, width or diameter, and side slope. Channel parameters were taken from data published in the MSD report "Coldwater Creek Drainage Survey, Phase I, Stormwater Management Program," dated January 1981. Channel parameters used in computing outflows by the kinematic wave method are shown in Table 2.

Soil Conservation Service (SCS) dimensionless unit hydrographs with five minute intervals were developed for the remaining subareas using HEC-1. Soil type maps furnished by the SCS office in St. Louis County indicate that the dominant soil types in the basin were in the hydrologic soil group B. Present land use maps and the SCS Handbook of Hydrology were used to compute a weighted SCS runoff curve number for each subarea. The time of concentration was computed for each subarea using the Kirpich formula, $TC=0.0078\ (L/S)^{0.770}$.

Those values were then multiplied by lag modification factors to account for the effects of urbanization. The factors which are functions of the percent of the channel length which has been modified and the percent of drainage area which is impervious were obtained from SCS Technical Release No. 55 "Urban Hydrology for Small Watershed," dated January 1975. The physical parameters, SCS curve numbers, computed time of concentration, adjustment factors and adjusted time of concentration for present conditions are shown in Table 3. for those subareas where the SCS method was used.

All main channel routing was done by the Modified Puls method. Storage-outflow data was obtained directly from the HEC-2 model by computing a series of water surface profiles using flow values covering the range of possible flows. Storage outflow data for the airport area was taken from data previously developed for the Florissant, Missouri Flood Insurance Study. When the double 10 feet x 15 feet box culverts have reached their capacity, flow is stored in low lying areas of the airport. Although for very large storms, some overland flow may occur from the upstream end to the downstream end of the culverts, it would take considerable time to fill one low area, flow to the next, fill it and flow to the next and so on. For that reason, it was assumed that any overload flow across the airport property would arrive too late to have any effect on the peak of the hydrograph at the downstream end of the culverts. A schematic of the hydrologic modeling technique is shown on Plate 2.

TABLE 1

KINEMATIC WAVE METHOD

OVERLAND FLOW ELEMENTS

SUB-AREA	FLOW LENGTH(ft)	SLOPE (ft/ft)	ROUGHNESS COEFF.	PERCENT OF AREA
10	1000	.090	.025	75
	1000	.090	.005	25
20	600	.060	.025	68
	600	.060	.005	32
30	1400	.060	.025	65
	1400	.060	.005	35
40	1500	.090	.025	57
	1500	.090	.005	43
50	3500	.035	.025	51
	3500	.035	.005	49
60	2100	.060	.025	68
	2100	.060	.005	32
65	1800	.060	.025	65
	1800	.060	.005	35
70	2500	.035	.025	61
	2500	.035	.005	39
80	3000	.090	.025	69
	3000	.090	.005	31

TABLE 1 (continued)

SUB-AREA	FLOW LENGTH(ft)	SLOPE (ft/ft)	ROUGHNESS COEFF.	PERCENT OF AREA
90	1100	.090	.025	65
	1100	.090	.005	35
100	2100	.060	.025	71
	2100	.060	.005	29
110	3000	.060	.025	74
	3000	.060	.005	26
115	1100	.090	.025	70
	1100	.090	.005	30
120	2000	.035	.025	55
	2000	.035	.005	45
125	2200	.060	.025	51
	2200	.060	.005	49
130	4200	.050	.025	39
	4200	.050	.005	61
140	1000	.035	.025	64
	1000	.035	.005	36
150	800	.035	.025	83
	800	.035	.005	17
160	1500	.035	.025	45
	1500	.035	.005	55

TABLE 1 (continued)

SUB-AREA	FLOW LENGTH(ft)	SLOPE (ft/ft)	ROUGHNESS COEFF.	PERCENT OF AREA
170	2800	.035	.025	73
	2800	.035	.005	27
180	1400	.035	.025	61
	1400	.035	.005	39
270	1000	.017	.025	60
	1000	.017	.005	40
280	1000	.017	.025	66
	1000	.017	.005	34
290	2000	.017	.025	61
	2000	.017	.005	39
420	1000	.038	.025	77
	1000	.038	.005	23
440	1000	.021	.025	64
	1000	.021	.005	36
480	3000	.015	.025	60
	3000	.015	.005	40

TABLE 2

KINEMATIC WAVE METHOD

CHANNEL FLOW ELEMENTS

SUB-AREA	CHANNEL LENGTH(ft)	CHANNEL SLOPE(ft/ft)	n	AREA Mi^2	SHAPE	BOT. WIDTH	SIDE SLOPES
10	1000	.010	.090	.211	TRAP	3	1
	2445	.010	.013		CIRC	4	
20	2500	.010	.020	.200	TRAP	1	1
	1800	.016	.060		TRAP	10	1.725
30	849	.0088	.016	.448	TRAP	10	0
	4575	.0078	.016		TRAP	10	3
40	2100	.019	.050	.549	TRAP	6	2
	1900	.019	.016		CIRC	5	
50	429	.010	.017	.549	TRAP	10	0
60	1500	.010	.016	.376	TRAP	6	0
	1975	.0085	.054		TRAP	5	1
65	1000	.016	.072		CIRC	2.8	
	250	.016	.072		TRAP	12	1.67
70	3755	.0043	.072	.525	TRAP	12	1.67
80	1050	.010	.013	.454	TRAP	7	0
90	2975	.039	.013	.212	CIRC	3	
100	2400	.010	.013	.223	TRAP	7	0
110	3530	.004	.013	.498	TRAP	5	0

TABLE 2 (continued)

KINEMATIC WAVE METHOD

CHANNEL FLOW ELEMENTS

SUB-AREA	CHANNEL LENGTH(ft)	CHANNEL SLOPE(ft/ft)	n	AREA Mi^2	SHAPE	BOT. WIDTH	SIDE SLOPES
115	3350	.010	.016	.227	CIRC	5	
120	3200	.023	.060	.307	TRAP	50	1
	2277	.016	.072		TRAP	22	.86
125	1300	.008	.085	.196	TRAP	4	1
130	725	.016	.013	1.142	TRAP	7	.14
	3050	.010	.013		TRAP	7.5	0
140	3500	.017	.060	.260	TRAP	6	1
150	2000	.018	.060	.172	TRAP	6	1
160	3340	.007	.023	.330	TRAP	5	1
170	1622	.0037	.020	.799	TRAP	6	0
	5500	.0212	.042		TRAP	7	1.67
180	2000	.005	.060	.278	TRAP	5	1
	220	.003	.020		TRAP	10	0
270	3500	.017	.013	.350	CIRC	3.5	
	1500	.002	.065	.400	TRAP	4	1
280	3700	.0069	.085	.300	TRAP	4	1
	1000	.0065	.016	.430	CIRC	8	

TABLE 2 (continued)

KINEMATIC WAVE METHOD

CHANNEL FLOW ELEMENTS

SUB-AREA	CHANNEL LENGTH(ft)	CHANNEL SLOPE(ft/ft)	n	AREA Mi^2	SHAPE	BOT. WIDTH	SIDE SLOPES
290	3205	.007	.065	.500	TRAP	4	1.5
	1495	.003	.015	.750	TRAP	10	0
420	3100	.008	.013	.450	CIRC	4	
440	900	.010	.055	.300	TRAP	8	0
480	3345	.009	.013	1.980	TRAP	5	0.7

TABLE 3

BASIN CHARACTERISTICS - EXISTING CONDITIONS

SUB-AREA	LENGTH (ft)	HEIGHT (ft)	SCS CN	UNADJUST. TC (hr)	Lf_1	Lf_2	ADJUSTED TC (hr)
210	8420	125	84	.69	1.00	.67	.46
220	8760	118	84	.74	.87	.53	.34
230	16890	134	82	1.51	1.00	.75	1.13
240	9140	117	87	.78	1.00	.74	.58
250	10240	104	77	.83	.64	.75	.40
260	8360	117	80	.71	1.00	.77	.55
300	4400	126	73	.33	1.00	.77	.25
310	7610	122	77	.62	.72	.75	.33
320	6100	115	78	.49	.80	.72	.28
330	7580	86	75	.71	.64	.75	.34
340	8590	119	74	.76	.71	.71	.30
350	6980	91	75	.63	.62	.68	.27
360	7400	83	72	.70	.90	.89	.56
370	5180	82	84	.47	.77	.77	.29
380	6300	155	83	.46	.70	.79	.25
390	8750	102	82	.78	1.00	.82	.64
400	7650	109	76	.66	1.00	.72	.48
410	6600	94	75	.58	1.00	.74	.43
430	6800	113	77	.56	.95	.75	.40

TABLE 3 (continued)

BASIN CHARACTERISTICS - EXISTING CONDITIONS

SUB-AREA	LENGTH (ft)	HEIGHT (ft)	SCS CN	UNADJUST. TC (hr)	Lf_1	Lf_2	ADJUSTED TC (hr)
450	15400	196	79	1.17	.67	.88	.69
460	5880	60	80	.61	1.00	.84	.51
470	13250	189	79	1.00	.85	.88	.75
490	10300	108	77	.93	.84	.94	.73
500	5210	122	71	.40	1.00	.85	.34
510	8580	169	71	.63	1.00	.90	.57
520	6820	154	68	.50	1.00	.89	.45
530	12500	124	72	1.10	.97	.95	1.01
540	18450	192	72	1.45	.97	.87	1.22
580	13500	157	68	1.10	1.00	.99	1.09

Hydraulic Modeling.

The computer program "HEC-2, Water Surface Profiles" was used to compute water surface profiles for Coldwater Creek from mile 0.154 to 13.812, and from 15.044 and 19.438. As stated earlier, Coldwater Creek is enclosed in a double 10 ft. by 15 ft. concrete box culvert under the airport property between miles 13.812 and 15.044 and no water surface profiles were computed for that reach. Starting water surface elevations were estimated using the slope-area option in the program. Cross section data for the channel and overbank areas were obtained from field surveys and topographic aerial photographs with a contour interval of two feet. Mannings roughness coefficients were estimated after field reconnaissance and aerial photography analysis. The "n" values used for existing channel varied from 0.013 to 0.085 and from 0.015 to 0.120 for overbank areas. Typical cross sections are shown on Plates 3 through 8. Expansion and contraction coefficients were selected from values recommended in the HEC-2 Users Manual. For gradual transitions 0.3 and 0.1 were used and for abrupt transitions 0.5 and 0.3 were used for expansion and contraction coefficients, respectively. Coldwater Creek is crossed by three railroads, thirty-five roads (including two major interstate highways) and seven foot bridges. Bridge data were obtained from field surveys and from as-built bridge drawings furnished by state or lcoal highway departments.

Calibration of Models.

The storms of 14 July 1978 and 11 April 1979 were analyzed in detail in an attempt to verify the mathematical models. Although the 1957 flood was one of the higher known floods in the basin, it occurred before much of the urbanization had taken place. Because land use and channel improvements have changed significantly since 1957, it was decided not to use the June 1957 storm for verification. Rainfall for the two storms was available at the hourly recording station at the airport. The hourly amounts were further divided into five minute intervals in accordance with the method presented in NOAA Technical Memorandum NWS-HYDRO35.

Runoff hydrographs for the two storms were computed for the subareas by the two methods described earlier. Then, using the HEC-1 program, the individual hydrographs were combined and routed using the Modified Puls method throughout the system. The 1978 and 1979 storms produced discharges with about a 20-50 percent chance of occurrence on Coldwater Creek.

The HEC-2 model was then used to compute water surface profiles for the computed discharges for the July 1978 and April 1979 floods. These computed water surface profiles were compared to the actual high water mark elevations for both storms. Adjustments were made until acceptable reproductions of the known flood profiles were achieved. A comparison of actual high water marks and computed water surface elevations are given in Plates 9 through 11.

SECTION 7 - WATER SURFACE PROFILES

Water surface profiles were developed for the main stem of Coldwater Creek for both existing conditions and for future conditions with no Corps project.

Existing Conditions.

Point rainfall amounts were obtained for the 50, 20, 10, 4, 2 and 1 percent chance storms from Technical Papers 40 and 49 and are shown in Table 4. Rainfall for the .2 percent chance storm was obtained by extrapolation of a plot of rainfall versus frequency of occurrence on log-probability paper. The point rainfall values were first adjusted for annual series and then for depth-area relationship. Runoff hydrographs were computed on all the hypothetical storms by applying the adjusted rainfall excesses to the SCS and hydrograph ordinates or kinematic wave equations using the HEC-1 Model. The Standard Project Storm runoff hydrographs were computed using the HEC-1 model with a 24 hour duration. The 50, 20, 10, 4, 2 and 1 percent chance peak discharges were compared to those computed by two empirical equations at several locations. The first method was developed by the U.S.G.S. and was published in "Techniques for Estimating the Magnitude and Frequency of Floods in St. Louis County, Missouri" in 1978. The other was developed by E. E. Gann of the U.S.G.S. and was published in 1971 in a report entitled "Generalized Flood Frequency Estimates for Urban Areas in Missouri." The results of the flow comparisons are shown in Table 5. The HEC-1 values appear very reasonable when compared to the values obtained by the other methods.

Water surface profiles were then developed for the computed HEC-1 flows for existing conditions using the HEC-2 model.

TABLE 4

RAINFALL DEPTH (INCHES) AT ST.LOUIS, MISSOURI

DURATION		PROBABILITY						
HRS	MIN	50.0%	20.0%	10.0%	4.0%	2.0%	1.0%	.2%
.08	5	.45	.53	.59	.68	.75	.82	.87
.17	10	.72	.86	.97	1.13	1.25	1.37	1.46
.25	15	.90	1.10	1.23	1.44	1.59	1.75	1.87
.50	30	1.22	1.52	1.74	2.04	2.28	2.52	2.72
1.00	60	1.55	1.97	2.26	2.68	3.00	3.32	3.60
2.00	120	1.91	2.43	2.76	3.20	3.49	3.90	4.55
3.00	180	2.15	2.68	3.10	3.49	3.87	4.26	5.00
6.00	360	2.57	3.20	3.64	4.22	4.70	5.10	5.95
12.00	720	3.07	3.75	4.30	4.90	5.45	6.00	6.90
24.00	1440	3.50	4.35	4.96	5.68	6.37	6.98	8.20
48.00	2880	4.07	5.09	5.79	6.82	7.62	8.35	9.70
96.00	5760	4.69	6.08	7.02	8.40	9.25	10.30	12.20
168.00	10080	5.60	7.05	8.10	9.60	10.50	12.00	14.40
240.00	14400	6.10	7.65	9.10	10.60	12.20	13.25	16.80

TABLE 5

DISCHARGE COMPARISONS

SUB-AREA	PROBABILITY .500	.200	.100	.040	.020	.010
270	451	664	825	1043	1184	1322
	462	716	918	1165	1377	1571
	448	703	866	1086	1277	1445
280	459	678	845	1070	1219	1362
	373	596	764	995	1151	1341
	383	672	861	1075	1329	1487
290	634	945	1184	1515	1745	1974
	543	841	1081	1368	1618	1846
	824	1247	1537	1913	2222	2541
300 thru 350	1380	2116	2695	3539	4204	4904
	1461	2220	2863	3652	4324	4937
	1535	2601	3332	4167	4852	5458
320 thru 330	754	1129	1419	1824	2115	2408
	820	1246	1607	2049	2426	2770
	768	1271	1624	2044	2389	2732

TABLE 5 (continued)

DISCHARGE COMPARISONS

SUB-AREA	PROBABILITY .500	.200	.100	.040	.020	.010
360 thru 380	920	1405	1787	2318	2718	3130
	887	1437	1845	2474	2874	3282
	878	1595	1890	2336	2657	2990
400 plus 440	1376	2119	2704	3556	4124	4940
	1510	2370	3065	3925	4605	5269
	1363	2394	3177	4048	4712	5478
420	444	663	830	1055	1204	1348
	364	600	771	1037	1238	1401
	285	558	767	1045	1247	1451
450	1176	1820	2324	3053	3620	4213
	1232	2044	2599	3461	4077	4631
	1292	2213	2867	3651	4295	4950

NOTE: Line 1 - USGS "Magnitude and Frequency of Floods in ST. Louis Co."

Line 2 - E.E. Gann,"Frequency Estimates for Urban Areas in Mo."

Line 3 - HEC-1, Flood Hydrograph Package

Future Conditions Without Project

Future land use maps prepared in 1981 by the St. Louis County Planning Department were used to modify the existing condition models for future conditions without a Corps flood control project. The area upstream of the airport was considered fully developed without any significant land use changes. Downstream of the airport, the land use maps indicated that residential development will spread north and west from existing development. Although St. Louis County has adopted runoff control policies, they are applied only to the larger developments in the unincorporated areas. Some developments such as highway improvements and development within corporate boundaries, are exempt from these policies. Therefore, to take a conservative approach in this analysis, the policies were assumed to be non-effective. New, weighted SCS curve numbers were computed for each subarea for the future conditions and are presented in Table 5. The Metropolitan Sewer District furnished plans for projected channel improvements in the basin. Times of concentration were reduced for areas where urban development or channel improvements were expected to occur. No improvement to the airport double box culvert is planned at this time. The estimated time of concentration for future conditions is also shown in Table 6.

TABLE 6

BASIN CHARACTERISTICS - FUTURE CONDITIONS

SUB-AREA	LENGTH (ft)	HEIGHT (ft)	SCS CN	UNADJUST. TC (hr)	Lf_1	Lf_2	ADJUSTED TC (hr)
210	8420	125	85	.69	1.00	.67	.46
220	8760	118	86	.74	.91	.55	.37
230	16890	134	83	1.51	1.00	.76	1.15
240	9140	117	87	.78	1.00	.69	.54
250	10240	104	80	.83	.70	.76	.44
260	8360	117	81	.71	1.00	.77	.55
300	4400	126	77	.33	.81	.75	.20
310	7610	122	81	.62	.77	.77	.37
320	6100	115	81	.49	.81	.75	.30
330	7580	86	79	.71	.67	.76	.36
340	8590	119	82	.72	.77	.75	.44
350	6980	91	82	.63	.59	.70	.26
360	7400	83	74	.70	.84	.80	.47
370	5180	82	84	.47	.77	.79	.29
380	6300	155	83	.46	.70	.79	.25
390	8750	102	82	.78	1.00	.82	.64
400	7650	109	80	.66	1.00	.72	.48
410	6600	94	79	.58	1.00	.76	.44
430	6800	113	82	.56	.73	.78	.32
450	15400	196	79	1.17	.55	.76	.49

TABLE 6 (continued)

BASIN CHARACTERISTICS - FUTURE CONDITIONS

SUB-AREA	LENGTH (ft)	HEIGHT (ft)	SCS CN	UNADJUST. TC (hr)	Lf_1	Lf_2	ADJUSTED TC (hr)
460	5880	60	83	.61	1.00	.78	.48
470	13250	189	81	1.00	.72	.77	.55
490	10300	108	77	.93	.88	.75	.61
500	5210	122	76	.40	1.00	.75	.30
510	8580	169	75	.63	1.00	.75	.47
520	6820	154	75	.50	1.00	.75	.38
530	12500	124	76	1.10	.94	.75	.78
540	18450	192	76	1.45	.87	.75	.95
580	13500	157	81	1.10	1.00	.66	.73

Runoff hydrographs for the storms with a 50, 20, 10, 4, 2, 1 and .2 percent chance of occurrence as well as the Standard Project Storm were computed for future conditions using the revised HEC-1 model.

The State of Missouri and St. Louis County Highway Departments furnished proposed bridge replacement plans for several bridges crossing Coldwater Creek. The HEC-2 model was adjusted for these proposed changes and used to produce water surface profiles for the 50, 20, 10, 4, 2, 1 and .2 percent chance floods plus the Standard Project Flood for future conditions. Profiles for the floods with a 50, 10, 4, and 1 percent chance of occurrence and the Standard Project Flood for future conditions with no project are shown on Plates 6 through 8 of the Feasibility Report. The areas flooded by the 10 percent and 1 percent probability floods and the SPF are shown on Plates 9 through 15 of the Feasibility Report. The extent of these areas was determined by plotting the computed water surface elevations on the topographic maps at each cross section location and interpolating between them. Flooded area maps of the airport area were not prepared since flooding occurs as overland sheet flow and ponding of low lying areas when the capacity of the double box culvert is exceeded.

Backwater from the Missouri River causes no significant flood problems in the Coldwater Creek basin due to the steep, narrow and undeveloped nature of the lower end of the basin near the mouth of the creek. On the Coldwater Creek water surface profiles, Missouri River backwater is plotted as a horizontal line from the mouth to the point at which the creek profile is intersected. Since the SPF for the Missouri River is unavailable, the .2% chance flood was extended horizontally up Coldwater Creek until it intersected the SPF for the creek.

SECTION 8 - DEVELOPMENT OF ALTERNATIVE SOLUTIONS

Development of the final alternative solutions and selection of the recommended plan is accomplished through an iterative plan formulation process. The plan formulation process used in the Coldwater Creek study is presented in detail in Section 4 of the Feasibility Report. For each of the measures considered in the process, an evaluation was made of the impact that measure had on flood damage reduction. Measures that were initially considered included both nonstructural and structural measures.

Non-structural Measures.

Non-structural measures that were examined included demolition of the most floodprone buildings or moving them out of the floodplain, and a flood forecasting and warning system. Demolition of buildings was found to be economically infeasible, as was moving buildings out of the floodplain. A flood forecasting and warning system was considered feasible and is described in the Feasibility Report.

Structural Measures.

Structural measures that were considered include small levees, detention reservoirs, diversions, channel improvements and bridge modifications. Several sites were examined where small levees, three to five feet high, could provide protection from the 10 percent chance flood. The levees were low in height and overtopping would not pose a serious safety hazard. Gravity drains with flap gates were included in the designs to provide interior drainage. Many of the sites were eliminated because of a lack of space between the creek and existing buildings, utilities or other developments, or because the levee would encroach into the floodway area. Of the remaining seven sites, two were economically feasible. Due to the high degree of urbanization in the upper and middle parts of the basin, no suitable reservoir sites were found which were cost effective. The diversion measures consisted of constructing a 12,000 feet long tunnel to divert water from Coldwater Creek near the airport to a new open channel which would flow directly to the Missouri River. However, due to the high cost of such a measure, it was not economically feasible. The measure which was found to be most effective was channel enlargement in several reaches. For each proposed channel enlargement, the HEC-2 model was modified to reflect the changed channel geometry, roughness factors, bridge data, etc. Preliminary water surface profiles were then computed using a full range of flows. Storage-outflow relationships for the improved channel reach were then input into the HEC-1 model and new flows computed throughout the basin. Then, using the correct flows for each percent chance flood, new water surface profiles were computed using the HEC-2 model. The hydrologic and hydraulic responses for each measure were evaluated using the two models.

Output from the HEC-2 model (elevation vs. frequency) was then used in the St. Louis District's Urban Damage II model to obtain a frequency-damage relationship for all structures in the floodplain. By comparing average annual damages with each proposed measure to those without a project, the flood damage reduction benefit and related benefits could be calculated. When compared to the cost of such a measure, the net benefits, of the measure could be calculated. A summary of actual costs, benefits, net annual benefits, benefit/cost ratio and level of protection for all measures is presented in Tables 8, 9 and 10 of the Feasibility Report. This process was repeated for various channel widths, side slopes, reach lengths and linings to obtain the channel improvement measures with positive net benefits.

Combinations of Measures.

The next iteration in the process was to combine the channel improvements having positive net benefits with the other economically justified measures and calculate the net benefits using the models described above. The combination of measures which had positive net benefits were called Plans 1, 2 and 3 and will be described in detail later. A summary of total annual benefits, and costs, net annual benefits, benefit/cost ratio and level of protection is given in Table 16 of the Feasibility Report. As can be seen in the table, Plan 2 has the maximum net benefits and is the recommended plan.

SECTION 9 - DESCRIPTION OF PLANS

Plan 1.

Plan 1 consists of clearing and snagging the lower reaches of Coldwater Creek, channel improvements in the highly developed reaches, small levees protecting the Old St. Ferdinand Shrine area and Fox Tree Drive residential area, a flood forecasting and warning system and recreation facilities both above and below Lambert Airport, R1 and R2. Plan 1 is shown on Plate 21 of the Feasibility Report. The resulting water surface profiles are shown on Plates 12 through 14 of this appendix.

The clearing and snagging would be done between the Burlington Railroad bridge at mile 1.63 and New Halls Ferry Road at mile 7.83. Trees, brush and debris would be removed between the high banks to improve the efficiency of the channel by reducing the Mannings roughness coefficient from values in the range of .050 to 0.035. Channel geometry would not be significantly changed by clearing and snagging. A typical section showing clearing and snagging is shown on Plate 17 of the Feasibilty Report.

Plan 1 channel improvements include measures C-5 downstream of the airport and C-20 upstream. Measure C-5 would provide flood protection from a flood with about a 10 percent chance of occurrence from New Halls Ferry Road (mile 7.83) to McDonnell Blvd., (mile 13.70). The channel improvement would consist of widening the bottom of the channel at the existing invert, laying back the side slopes to 2 horizontal to 1 vertical, planting the slopes with a vegetative cover and protecting the toe with riprap. Riprap would be designed to withstand velocities produced by the 1 percent chance flood. A typical section of channel improvement is shown on Plate 17 of the Feasibility Report. The improved channel will follow the alignment of the existing channel. Bottom widths will vary from 60 feet near the lower end to 35 feet near the upper end. Plates 28 through 32 of the Feasibility Report show the alignment, bottom widths, side slopes, type of lining and other details of measure C-5.

From the confluence of Paddock Creek to a point about 950 feet downstream, the proposed 60 feet wide channel improvement would consist of vertical reinforced concrete retaining walls, 10 feet in height. Above that height, the earth slope would be laid back to 2 horizontal to 1 vertical and grassed. The vertical walls were necessary because of width restrictions and to accommodate the confluence of Paddock Creek with its existing vertical walled channel improvement. For a typical section of the channel improvement in this reach see Plate 17 of the Feasibility Report.

A 45 feet wide by 15 feet deep reinforced concrete rectangular channel would be required at the St. Denis Avenue bridge just upstream of the confluence of Fountain Creek. The rectangular section was required to fit the improved channel beneath the bridge and to tie into the junction with Fountain Creek. A typical section of this proposed improvement is also shown on Plate 17 of the Feasibility Report.

Upstream of the airport, measure C-20 would provide protection from the more frequent floods on Coldwater Creek. From Interstate 70 to Elsa Avenue (mile 17.17) the proposed channel provides protection against the 10 percent chance flood for the City of St. Ann. From Elsa Avenue to Breckenridge Road (mile 18.30) the improvement would provide protection to reckenridge Hills against the 20 percent chance flood. The improvement consists of widening the existing channel at the existing invert and laying back the side slopes to a 2 horizontal to 1 vertical slope and providing either a combined grass and riprap toe protection or in some reaches complete riprap lining. No vehicular bridge replacements would be required by measure C-20. The improvement would extend from the Airport Access Road, mile 15.58 to Breckenridge Avenue at mile 18.30 with no improvement through the St. Ann Golf Course. Bottom widths would vary from 35 feet to 15 feet wide. Plates 33 through 35 of the Feasibility Report show details of measure C-20.

Plan 1 also includes two small levees, L-7 and L-8. Based on hydraulic sensitivity studies and the fact that overtopping would not pose a serious safety hazard, both levees were assigned 0.5 feet of freeboard. However, in the preconstruction engineering and planning phase of this study, more detailed levee designs will be analyzed and the need for additional freeboard will be examined. Because of comments by higher authority, a minimum of 1.0 foot of freeboard will be provided in the final design. Levee L-7 would extend from mile 10.35 to mile 10.45 and tie into high ground. The crown elevation of the levee would be 509 feet

NGVD and in combination with C-5 would provide protection from the 1 percent chance flood for five structures at the Old St. Ferdinand Shrine. Levee L-7 includes a 30 inch CMP with flapgate to provide for interior drainage. Levee L-8 would extend from mile 11.72 to 11.84. The crown would be at elevation 511 to 512 feet NGVD and would provide flood protection to nine residences from the 4 percent chance flood, with C-5 in place. However, the crown elevation may be raised slightly in the final design in order to provide the required 1.0 foot of freeboard. Levee L-8 would include a 30 inch CMP with flapgate for a gravity drain. A non-structural feature of the plan is the flood forecasting and warning system described in paragraph 4.1.1 of the Feasibility Report.

Recreation measures R1 and R2 include hiking and biking trails, picnic sites, fencing and a foot bridge. They are described in paragraph 4.1.7 and on Plate 19 of the Feasibility Report.

Plan 2 (Recommended Plan).

Plan 2 consists of measure C-9, which includes alterations to the Burlington Northern Railroad embankment and channel improvements from old Halls Ferry Road at mile 5.86 to the New Halls Ferry Road at mile 7.83; channel improvements C-5 and C-20, described above; small levees L-7 and L-8 with 0.5 feet of freeboard ; the flood forecasting and warning system; and recreation measures 1, 2 and 3. Details of Plan 2 can be found on Plates 24 through 35 of the Feasibility Report. As stated earlier, the final levee designs will include a minimum of 1.0 foot of freeboard.

The existing opening through the 50 feet high Burlington Northern Railroad Embankment is a 25 feet x 25 feet brick arch which forms a constriction and causes a backwater effect upstream during higher flows. Several alternative means of increasing the opening such as replacement with a bridge or providing additional openings of various sizes were analyzed. The plan which was most cost effective and achieved the desired hydraulic effect was the addition of five circular openings 8 feet in diameter. The openings would be tunnelled through the right overbank and lined with bituminous covered galvanized steel liner plates. The invert would be lined with 6-8 inches of concrete and would be set at elevation 445.7 ft. NGVD. The additional openings would flow only when floodwaters exceeded the right high bank.

A channel improvement extending from Old Halls Ferry Road at mile 5.86 to New Halls Ferry Road at mile 7.83 is also a component of measure C-9 and is included in Plan 2. The trapezoidal channel improvement has a bottom width of 40 feet, side slopes of 2 horizontal to 1 vertical, grassed slopes with riprap at the toe. Included is concrete paving beneath the Lindbergh Boulevard and New Halls Ferry bridges.

The non-structural element of Plan 2 is the flood forecasting and warning system.

Recreation features include R1, R2 and R3. R1 and R2 were described in Plan 1. R3 is a 1.97 mile long trail alongside the channel improvement of measure C-9 with fencing between the trail and developed areas.

Plan 3.

Plan 3 is the same as Plan 1 without the clearing and snagging measure between miles 1.63 and 7.83. All other features of Plan 3 are identical to Plan 1. It was carried forward as an alternate workable plan, and may be more environmentally acceptable than the clearing and snagging of Plan 1. The features of Plan 3 are shown on Plate 23 of the Feasibility Report and the resulting water surface profiles are shown on Plates 15 through 17 of this appendix.

SECTION 10 IMPACTS OF RECOMMENDED PLAN

The Recommended Plan (Plan 2) provides significant reductions in flood damages utilizing both structural and non-structural measures, provides for recreation, and is economically feasible. The plan provides protection against the flood with 10% chance of occurrence downstream of the airport and a 20% chance of occurrence upstream. The plan will have no significant impact on flooding at the airport.

Impacts on Flow.

Plates 18 through 22 show the effect of the recommended plan on the flow frequency relationship at several locations in the basin. Above the airport there were no significant changes in the flow frequency relationship due to the small size of channel enlargement, reaches of no improvement and controlling structures such as the St. Charles Rock Road culvert and the airport culverts. Downstream of the airport, flows are higher with the Recommended Plan due to the efficiency of the channel after enlargement. Without a project, the peak flows from the improved tributaries such as Fountain, Daniel Boone, and Paddock Creeks reach the main channel ahead of the peak flow from Coldwater Creek. By improving the main channel, peak flows from Coldwater Creek more closely coincide with the peak flows from the tributaries and cause an increase in the flows for the improved condition.

Impacts on Water Surface Profiles.

The effect of the proposed Plan 2 improvements on water surface profiles can be seen by comparing Plates 6, 7 and 8 with Plates 36, 37, and 38 of the Feasibility Report. These plates show that downstream of the Burlington Northern Railroad, water surface profiles will be raised by about 2 to 3 feet as a result of the improvements upstream. In the reach from the Burlington Northern Railroad to about Lindbergh Blvd. (mile 1.63 to 6.70), the water surface profiles are generally 1 to 2 feet higher due to increased flows from upstream channel improvements. The more infrequent floods, such as the Standard Project Flood are lowered due to the additional relief openings at the Burlington Northern Railroad Embankment which significantly reduces the large swellhead for very high flows. In the lower reach of the improved channel (miles 6.70 to 8.3) water surface profiles are increased very slightly except for the SPF which is lowered by 2-3 feet. Although water surface elevations have been raised slightly for some floods below mile 8.3, development of the floodplain is very limited so that additional damages are not significant. In the highly developed reaches of Coldwater Creek through Florissant and Hazelwood, miles 8.3 to 13.8, water surface elevations are lowered by 3 to 5 feet, reducing flood damages significantly. Upstream of the airport, profiles would be lowered by a few tenths of a foot to about 2 feet between Interstate 70 and Breckenridge Road. The proposed plan would have no effects on flooding at the airport or in the existing concrete lined channel above Baltimore Avenue.

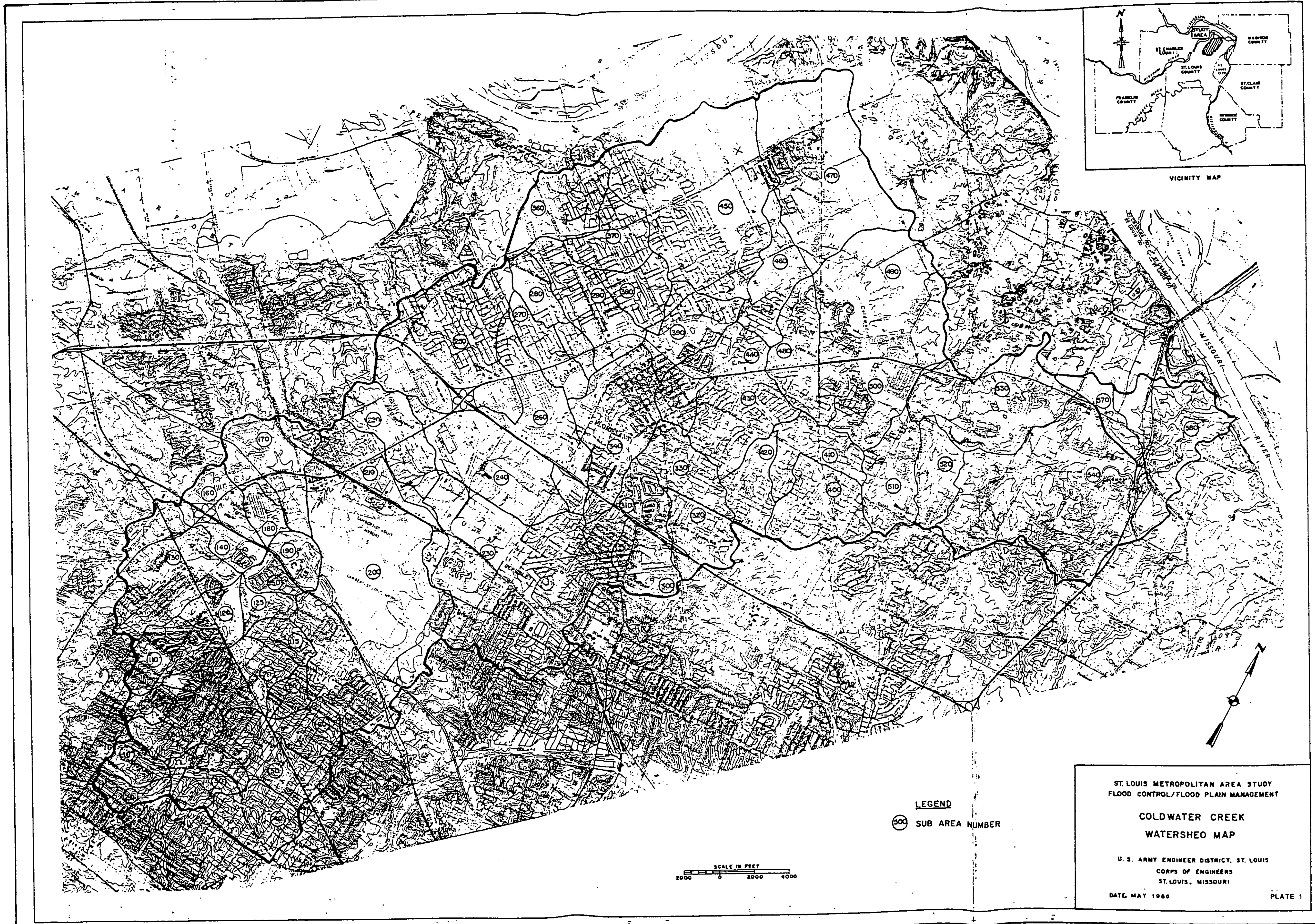
Impact on Past Floods.

The discharges for the 14 July 1978 and the 11 April 1979 floods were compared to the discharges for the Recommended Plan. Downstream of the airport, the two historical events were produced by flows less than the 10 percent chance flood. Upstream of the airport, the '78 and '79 flows were less than the 20 percent chance flood. Therefore, should the 1978 or 1979 flows again occur in Coldwater Creek with the project in place, they would be essentially non-damaging floods.

Impact on Sediment and Scour.

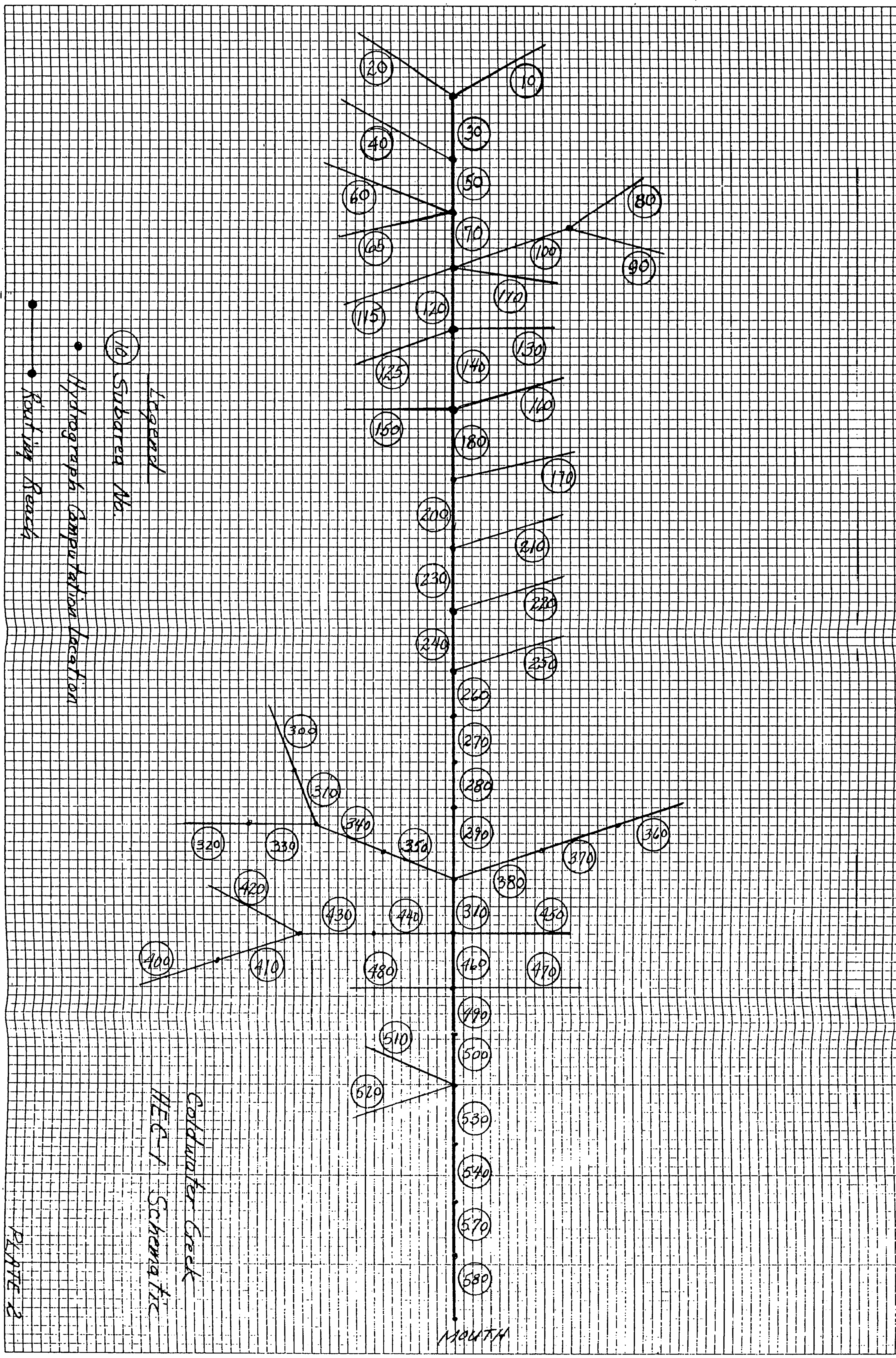
The firm of Simons, Li and Associates, Inc., performed qualitative analyses on the erosion and sedimentation characteristics of both the existing channel and the proposed channel improvements of the Recommended Plan for Coldwater Creek. Their findings are presented in the report "Qualitative Erosion and Sedimentation Investigation for Coldwater Creek" which is available in the St. Louis District office. They found that although the channel has a natural tendency to erode, the channel bottom and banks were composed primarily of erosion resistant silty clay material with limestone outcrops in the lower reaches which inhibit erosion. Although only limited vertical channel degradation has occurred over the past 20 years, numerous areas are experiencing active bank erosion. As a result of the proposed Recommended Plan, average channel velocities would be increased due to increased discharges. Velocity profiles for the 10% and 1% floods are furnished in the Simons and Li report. Since the greatest increase occurs in the lower reaches of the creek, the increased velocities will have little effect due to the existence of the bedrock channel invert. In other reaches where the bed is composed of the cohesive silty clay material, the channel may have a tendency to erode very slowly. In reaches where channel improvements were proposed, the grassed slopes with riprap toe protection should prevent bank erosion but may increase the tendency for channel degradation in the center of the channel between the ends of the riprap.

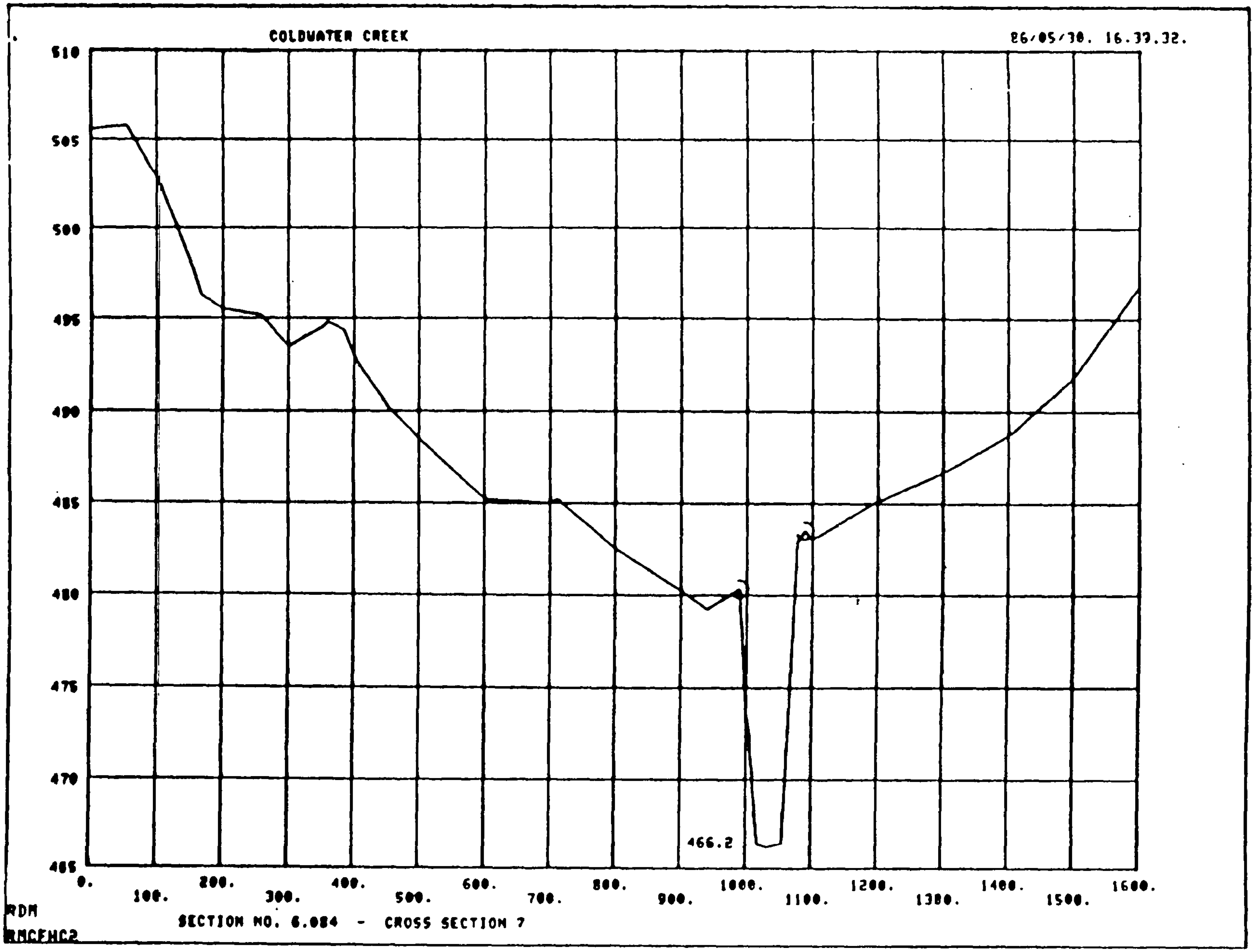
With the recommended plan in place, potential channel degredation would be controlled at many locations along the stream, including concrete linings under the bridges at Lindbergh and New Halls Ferry, at the confluence of Paddock Creek, under the St. Denis Street bridge, the existing airport culverts, riprapped slopes and bottom through the airport access road and Interstate 70, concrete paving at the Isolda, Geraldine, and Wright Avenue bridges, the existing concrete box culverts at Lynntown Drive, St. Charles Rock Road, Dix, Calvert and Edmundson Streets plus the proposed box culvert at Marvin Street. Also, upstream of the project is the concrete box culvert under Baltimore Avenue and the MSD concrete channel. In addition, there are several locations where concrete encased sanitary sewers cross the channel at the invert elevation. The St. Louis District believes that grade control structures are not needed in the recommended plan, and were not included. However, the need for grade control structures will be reexamined during the preconstruction engineering and design phase of the project.



VICINITY MAP
STUDY AREA
MADISON COUNTY
ST. CHARLES COUNTY
ST. LOUIS COUNTY
ST. CLAIR COUNTY
FRANKLIN COUNTY
JEFFERSON COUNTY
MONROE COUNTY
MISSOURI RIVER
LEGEND
500 SUB AREA NUMBER
SCALE IN FEET
2000 0 2000 4000
ST. LOUIS METROPOLITAN AREA STUDY
FLOOD CONTROL/FLOOD PLAIN MANAGEMENT
COLDWATER CREEK
WATERSHEO MAP
U. S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
DATE MAY 1986
PLATE 1

K•E 10 X 10 TO THE INCH • 10 X 15 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 47 0702

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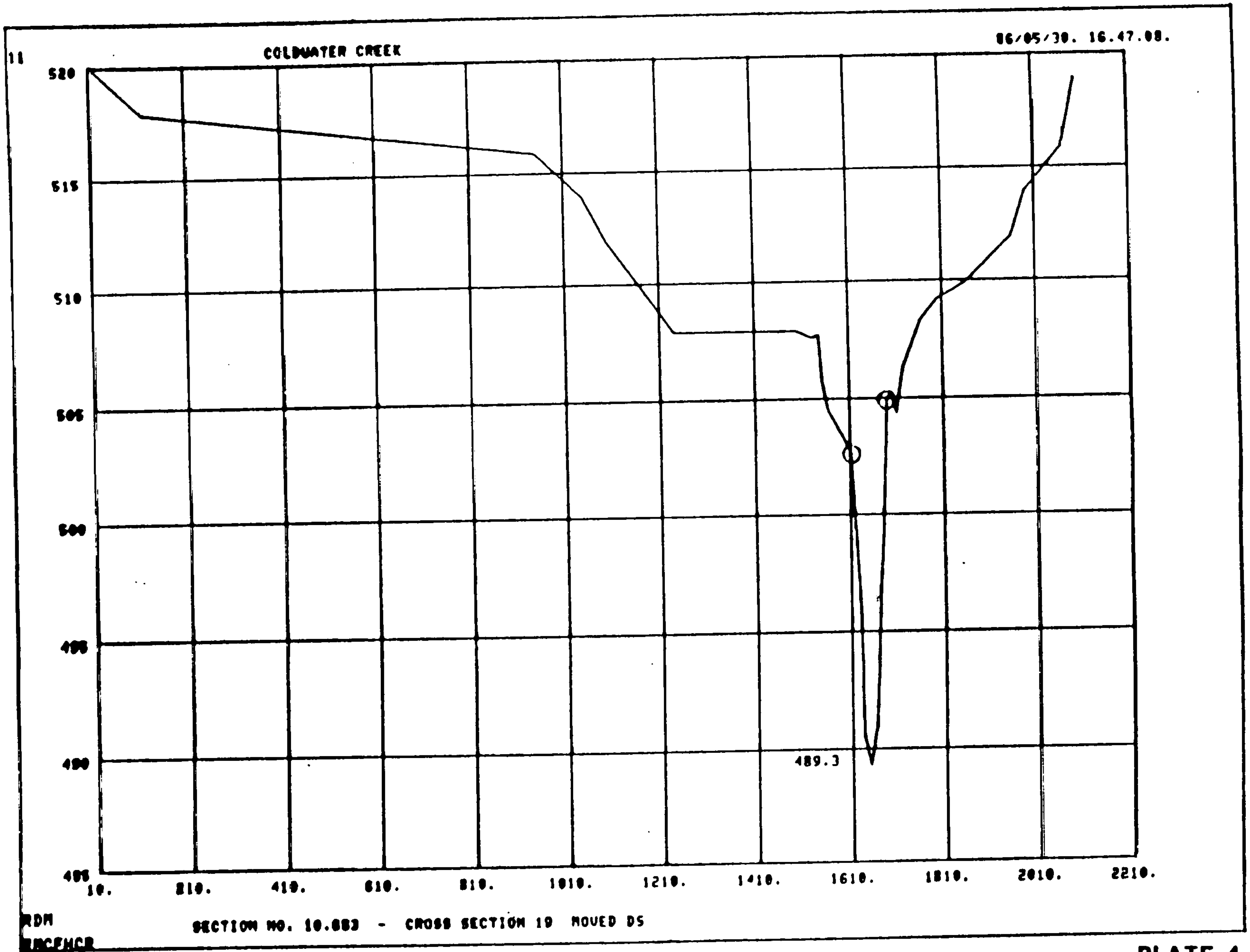
475
470
465
466.2
0. 100. 200. 300. 400. 500. 600. 700. 800. 900. 1000. 1100. 1200. 1300. 1400. 1500. 1600.
RDM
RMCFHC2
SECTION NO. 6.084 - CROSS SECTION 7

PLATE 3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410.
610.
810.
1010.
1210.
1410.
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1810.
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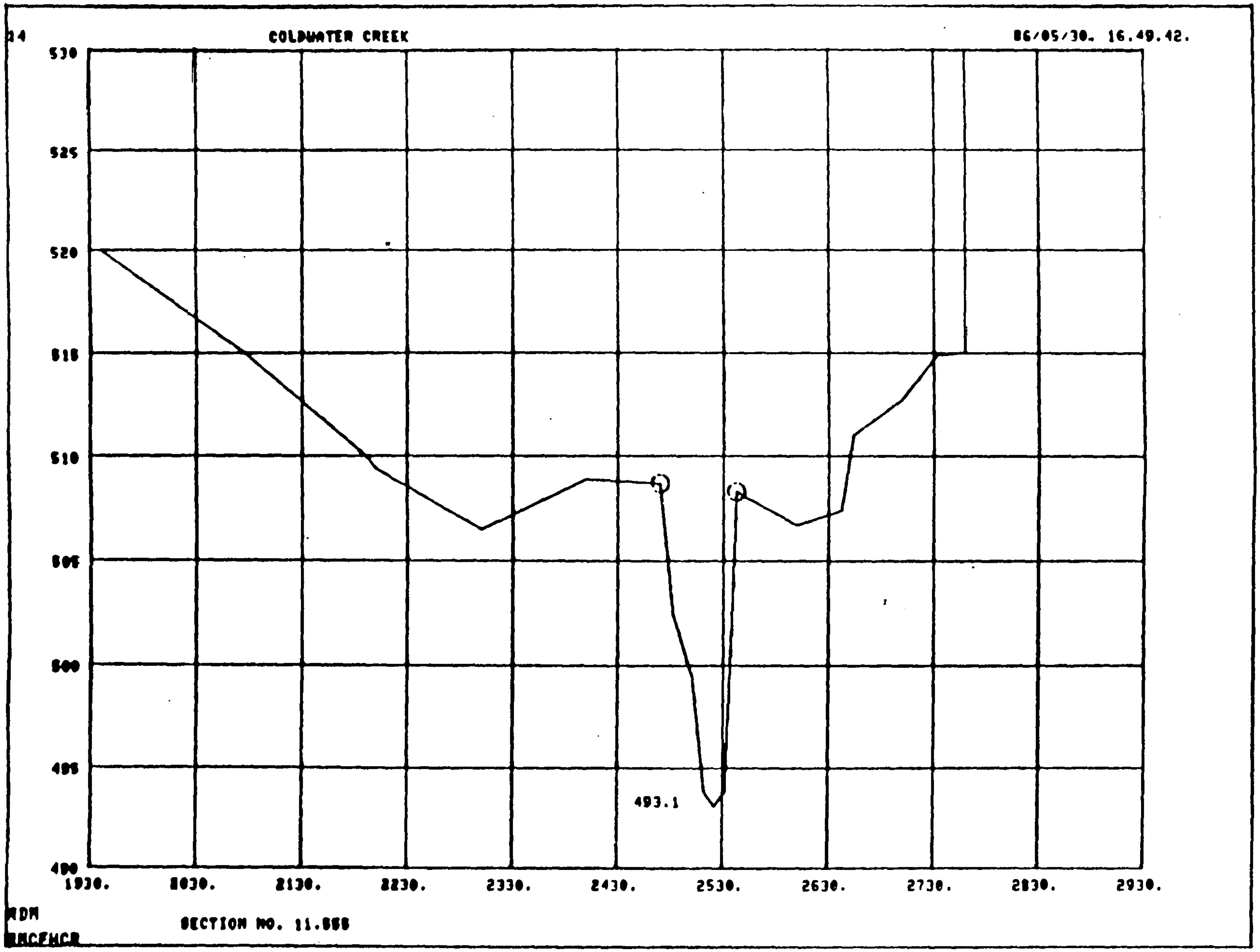
SECTION NO. 10.883 - CROSS SECTION 19 MOVED DS
RDM

PLATE 4


14
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2830.
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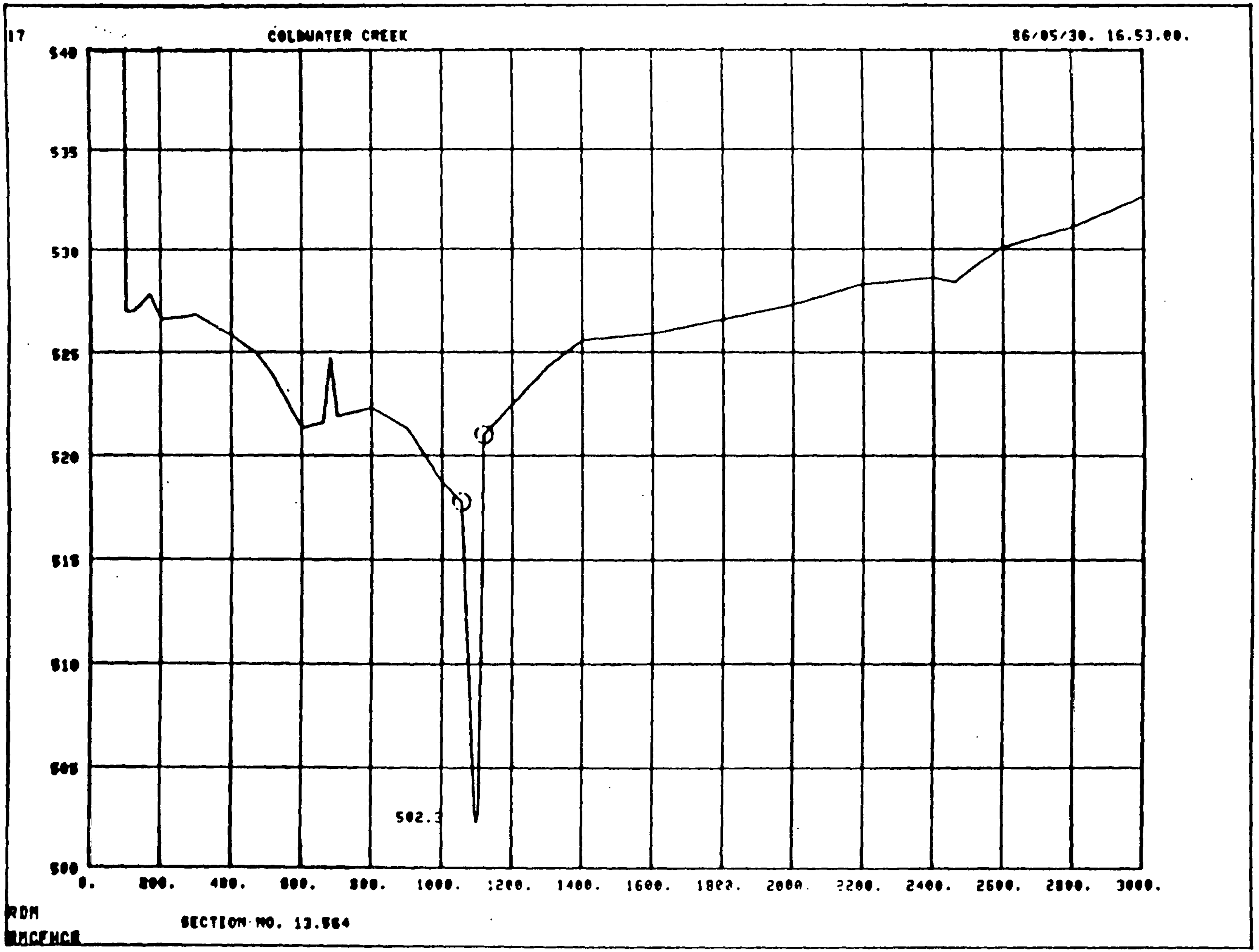
RDM
SECTION NO. 11.858
HMCFHCR

PLATE 5



17
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535
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525
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505
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502.3
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800.
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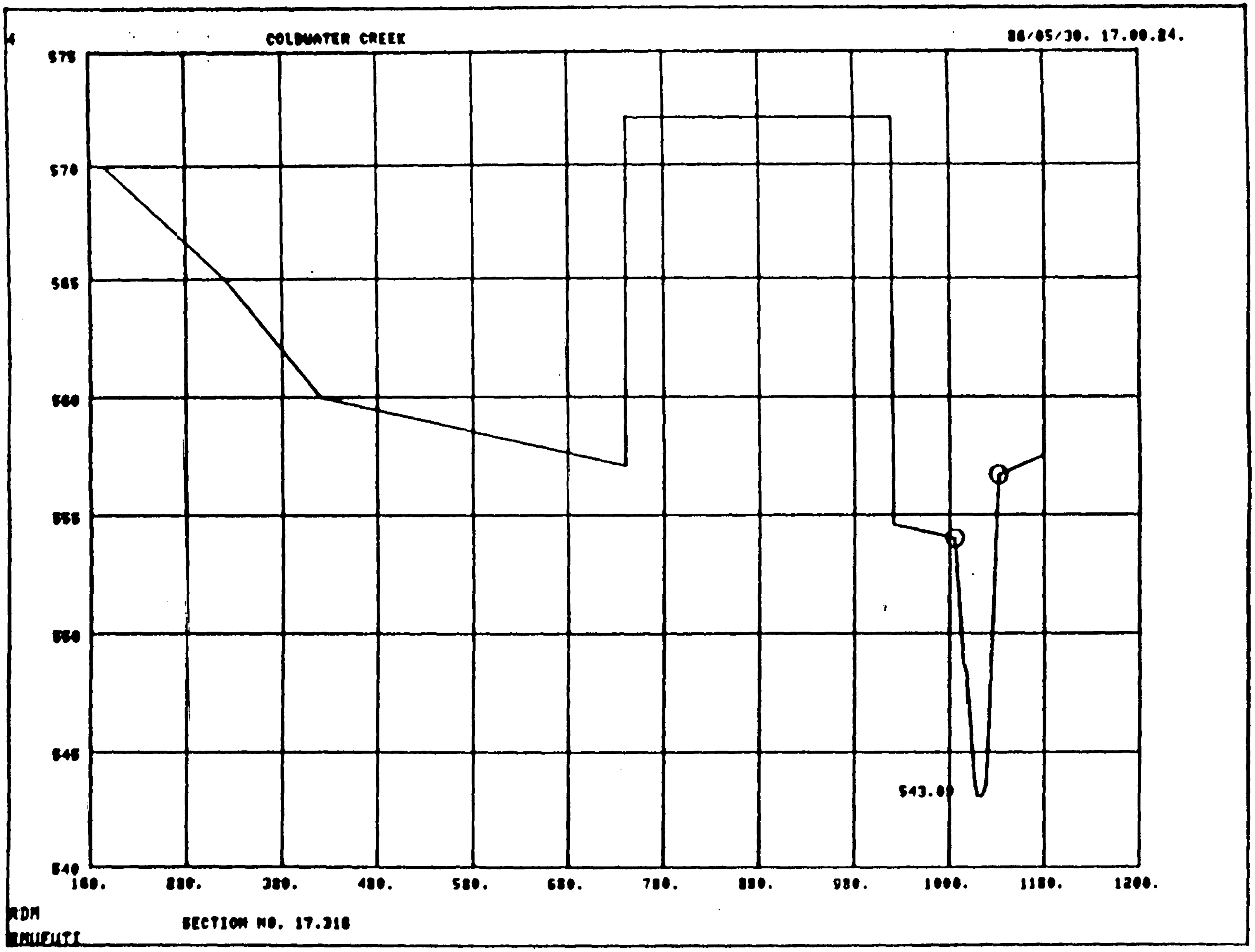
NMCFHCR
SECTION NO. 13.564

PLATE 6



COLDWATER CREEK
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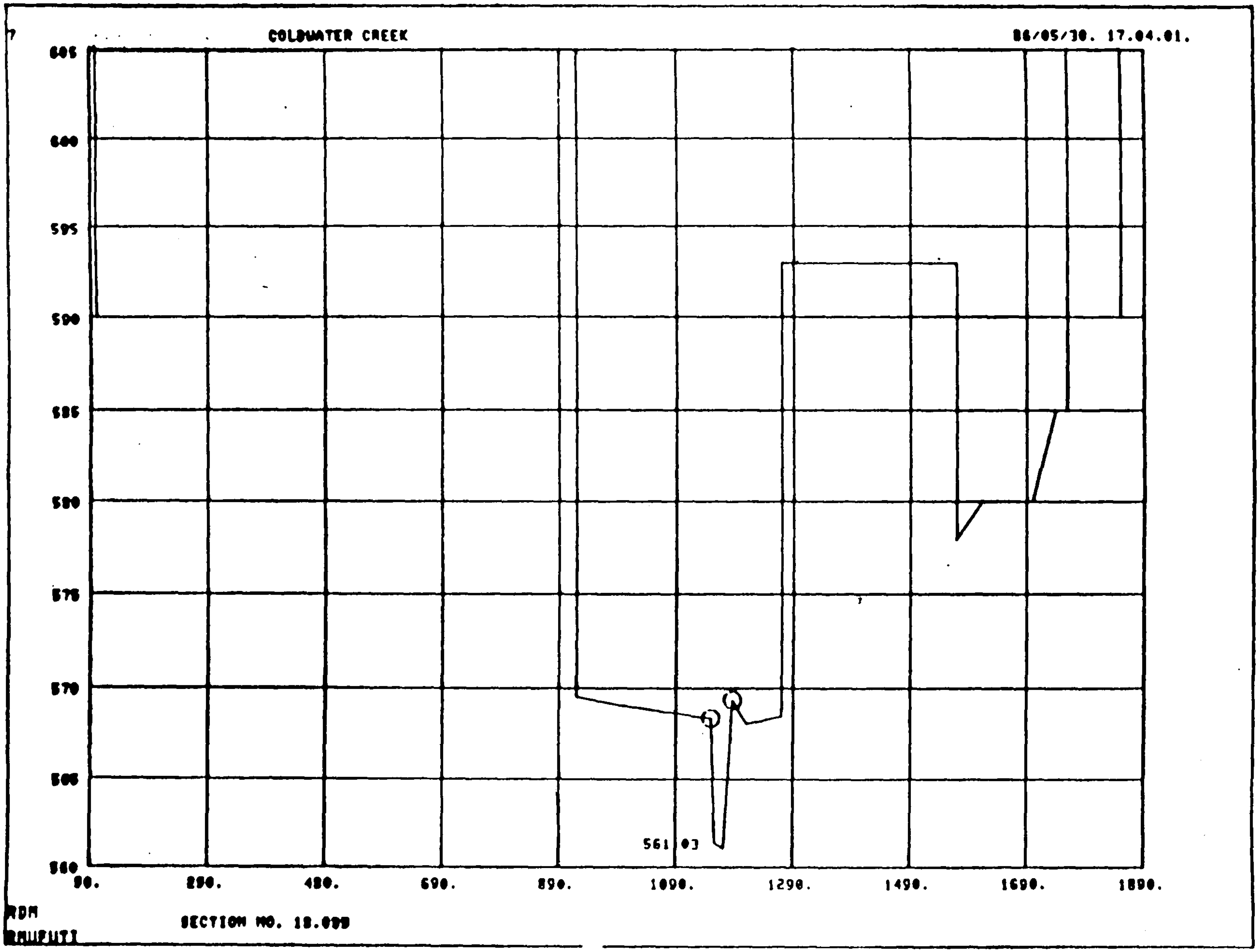
SECTION NO. 17.318

PLATE 7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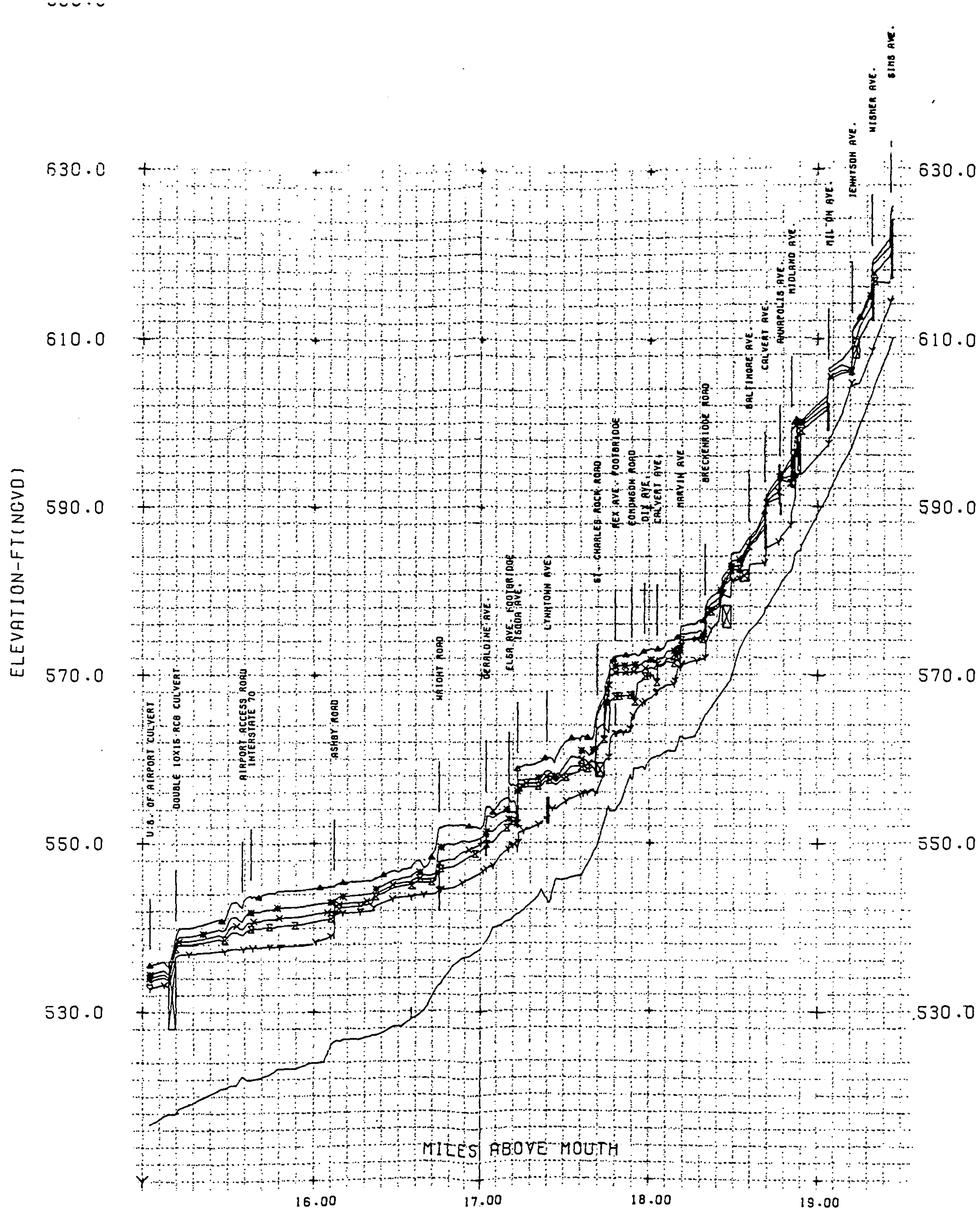
SECTION NO. 18.099

PLATE 8



LEGEND

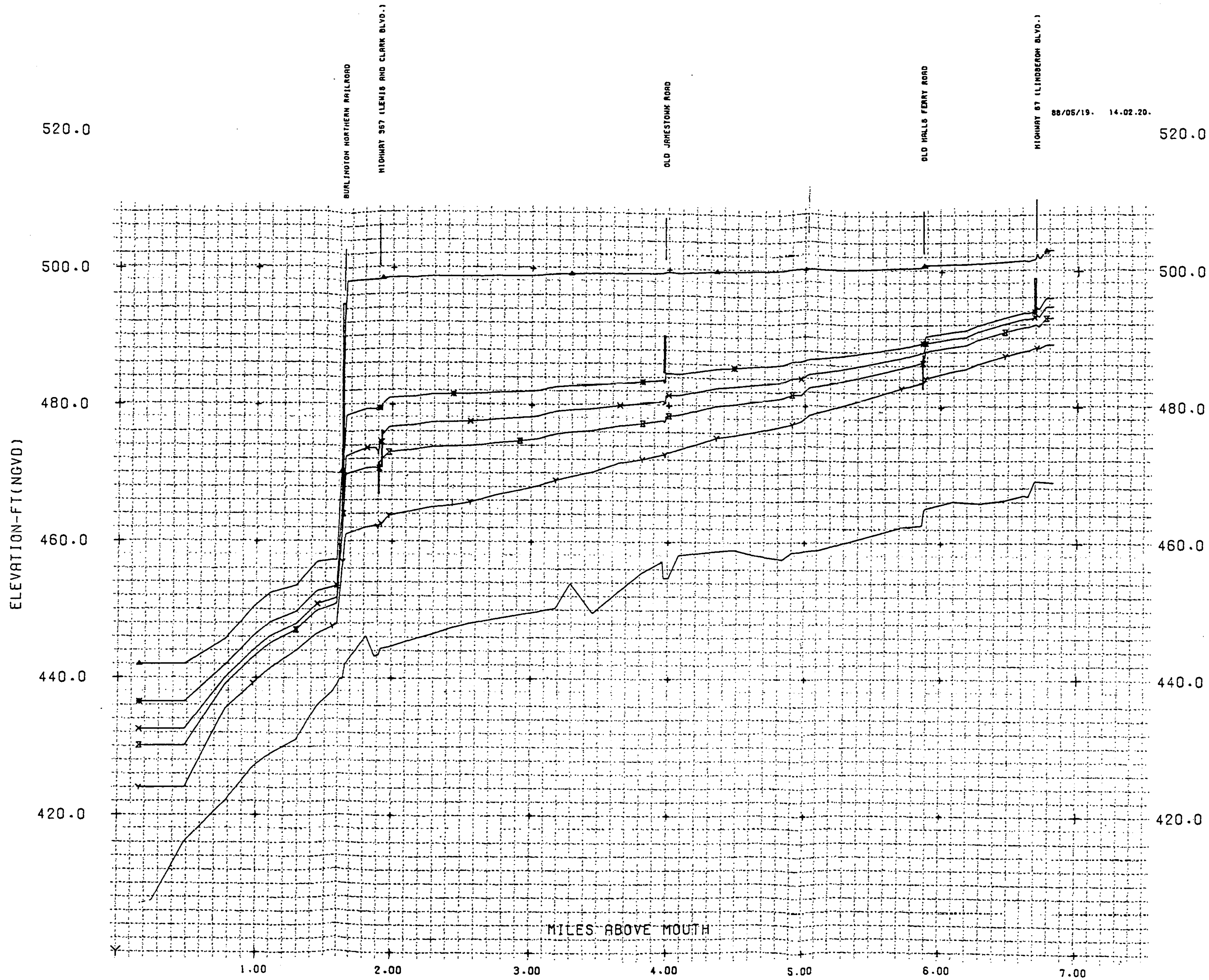
- △ STANDARD PROJECT FLOOD
- ✱ 1% PROBABILITY FLOOD
- X 4% PROBABILITY FLOOD
- ⧗ 10% PROBABILITY FLOOD
- Y 50% PROBABILITY FLOOD

COLDWATER CREEK

WATER SURFACE PROFILES

FUTURE-CONDITIONS

WITH PLAN 3



LEGEND

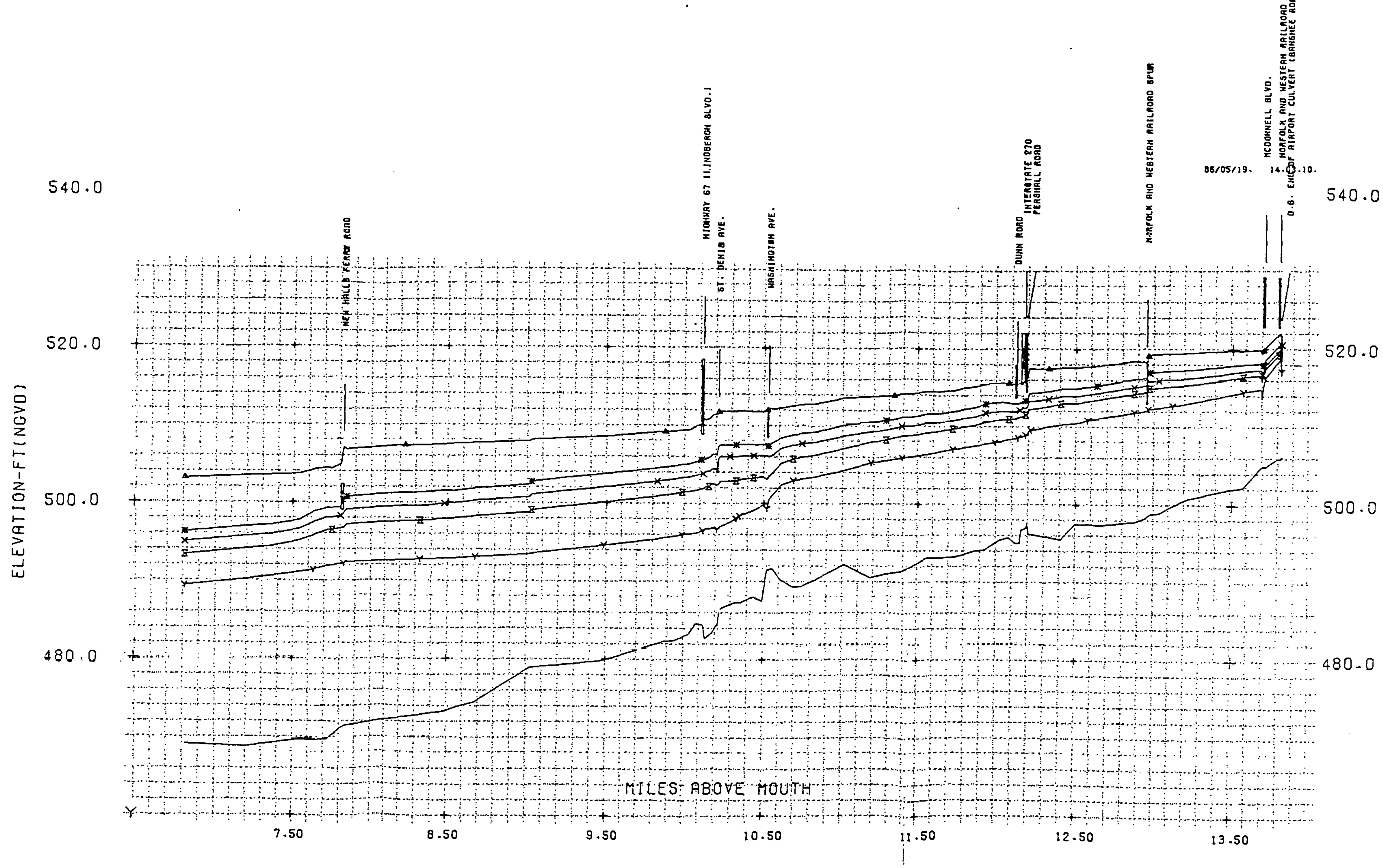
- △ STANDARD PROJECT FLOOD
- ✱ 1% PROBABILITY FLOOD
- X 4% PROBABILITY FLOOD
- ⧗ 10% PROBABILITY FLOOD
- Y 50% PROBABILITY FLOOD

COLDWATER CREEK

WATER SURFACE PROFILES

FUTURE CONDITIONS

WITH PLAN 3



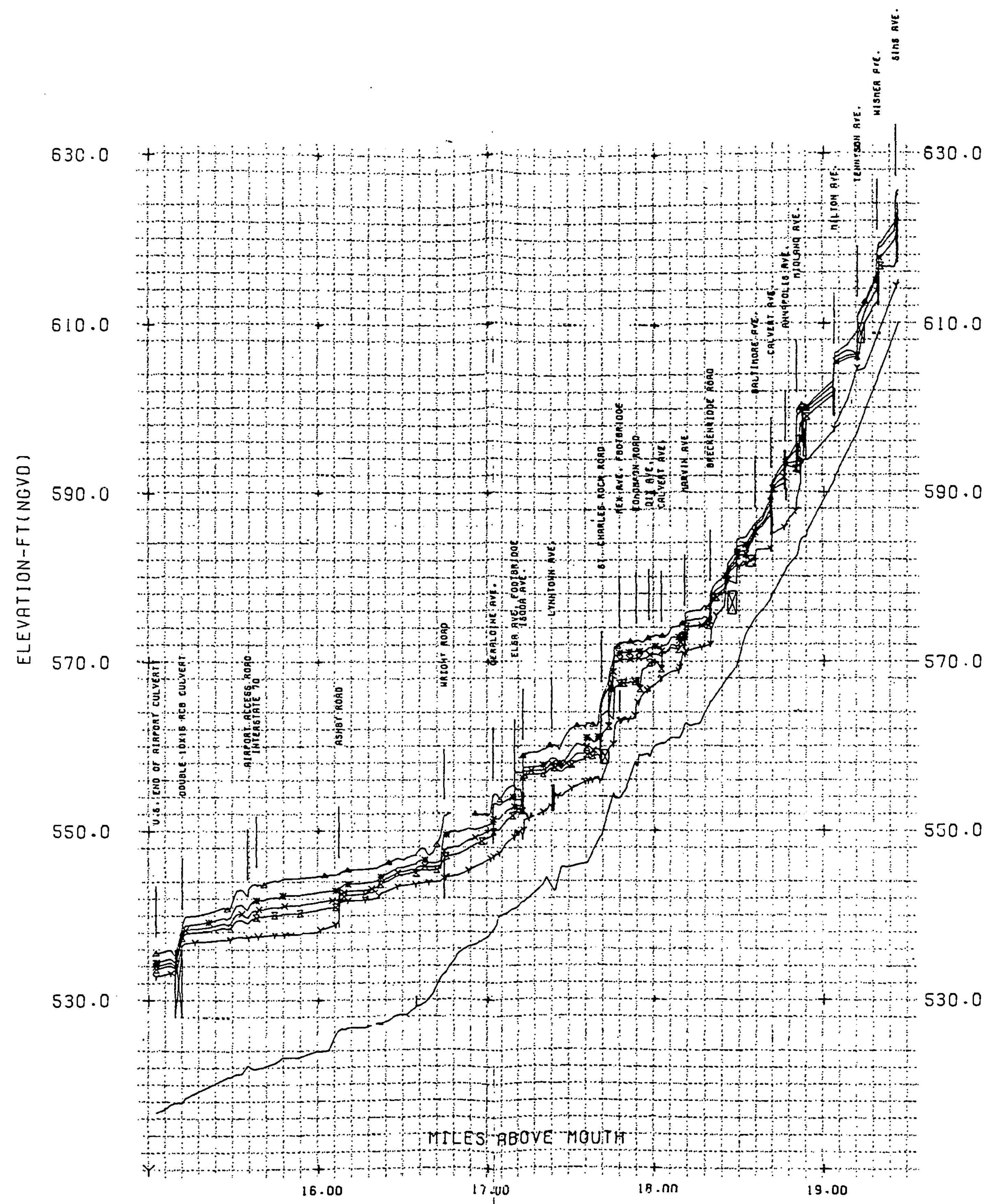
LEGEND

△ STANDARD PROJECT FLOOD
✱ 1% PROBABILITY FLOOD
× 4% PROBABILITY FLOOD
⧗ 10% PROBABILITY FLOOD
Y 50% PROBABILITY FLOOD

COLDWATER CREEK

WATER SURFACE PROFILES
FUTURE CONDITIONS
WITH PLAN 3

PLATE 16



LEGEND

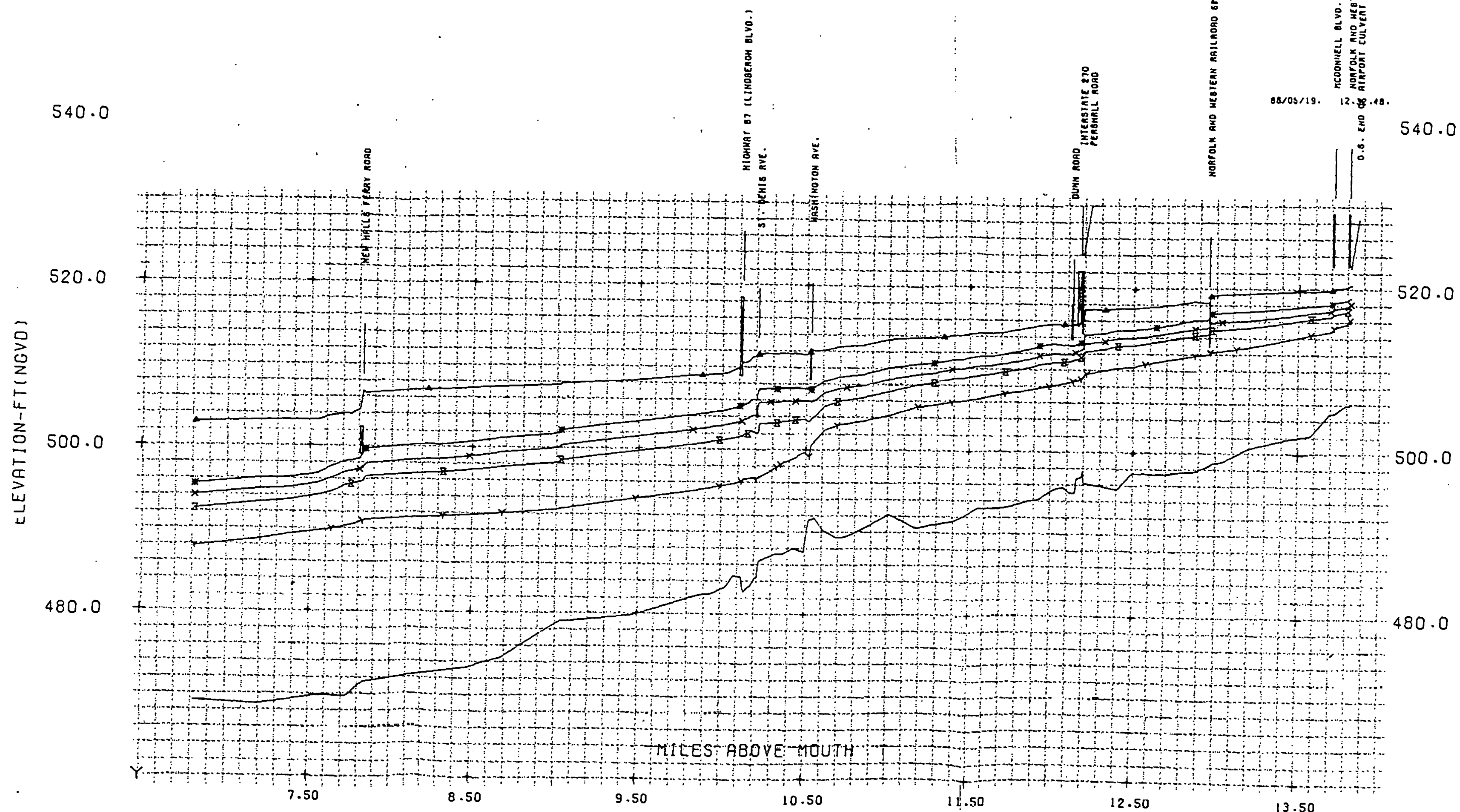
- △ STANDARD PROJECT FLOOD
- ✱ 1% PROBABILITY FLOOD
- X 4% PROBABILITY FLOOD
- ⌛ 10% PROBABILITY FLOOD
- Y 50% PROBABILITY FLOOD

COLDWATER CREEK

WATER SURFACE PROFILES

FUTURE CONDITIONS

WITH PLAN 1



LEGEND

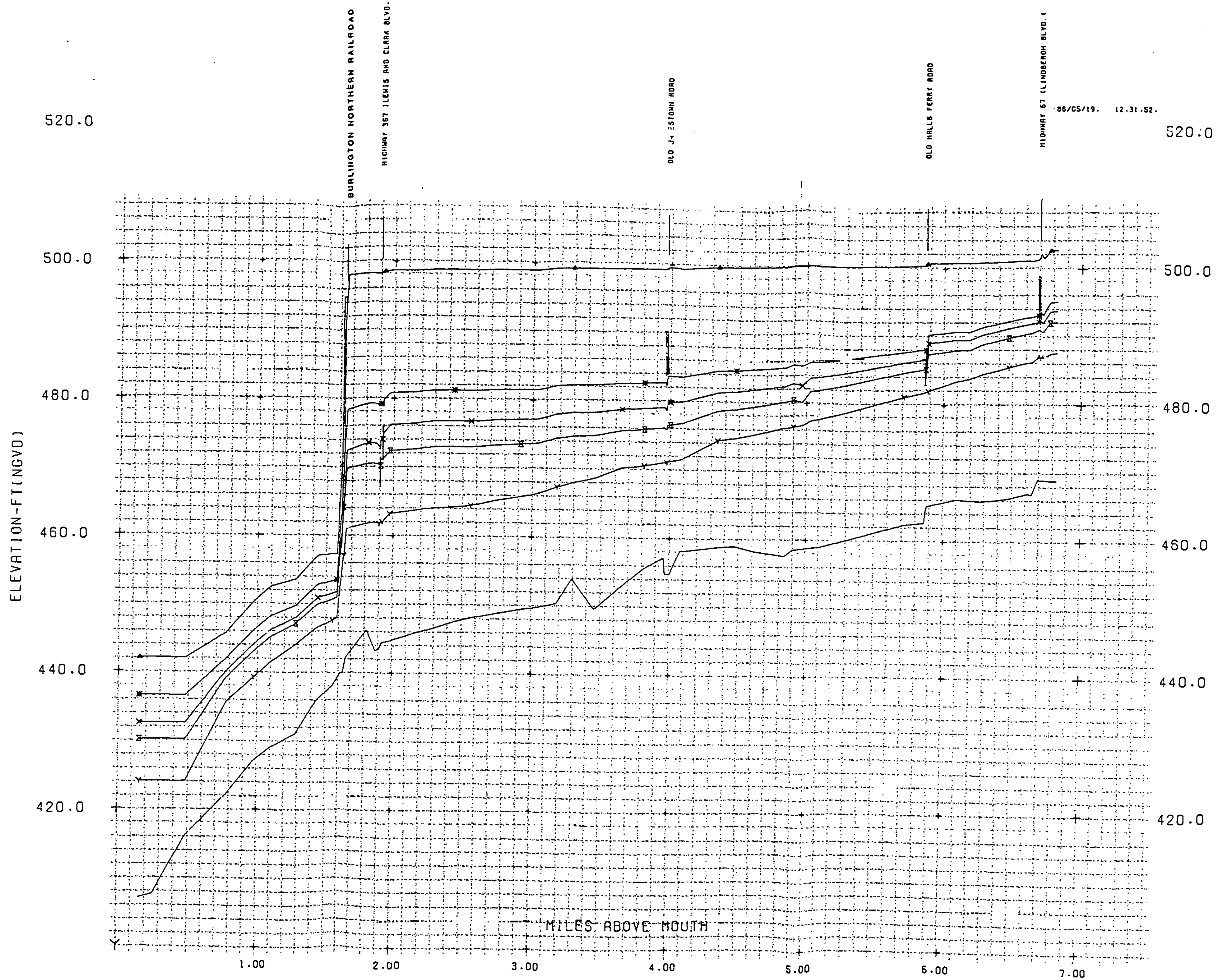
- △ STANDARD PROJECT FLOOD
- ✱ 1% PROBABILITY FLOOD
- X 4% PROBABILITY FLOOD
- ⧗ 10% PROBABILITY FLOOD
- Y 50% PROBABILITY FLOOD

COLDWATER CREEK

WATER SURFACE PROFILES

FUTURE CONDITIONS

WITH PLAN 1



LEGEND

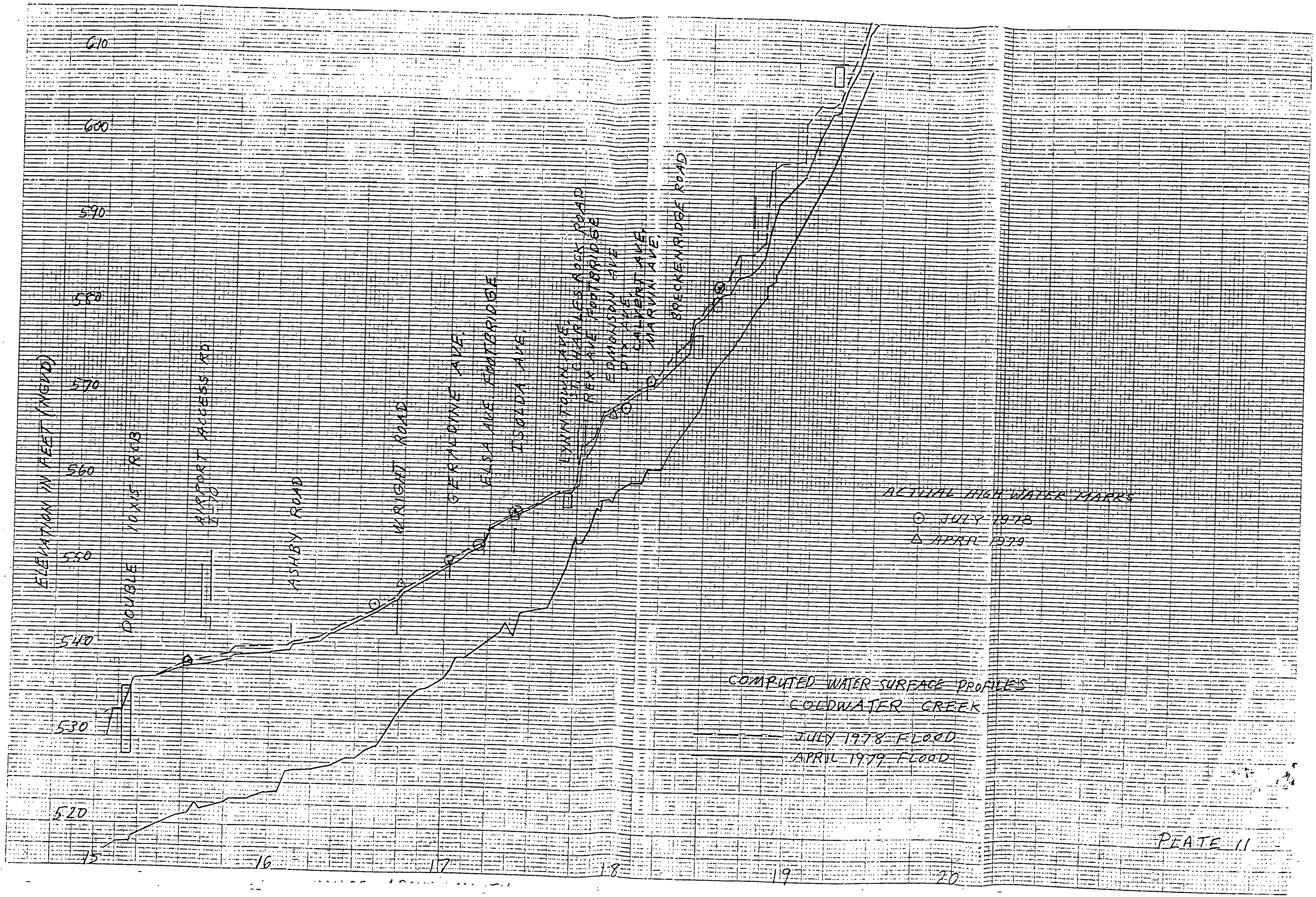
- △ STANDARD PROJECT FLOOD
- ✱ 1% PROBABILITY FLOOD
- X 4% PROBABILITY FLOOD
- Ⅹ 10% PROBABILITY FLOOD
- Y 50% PROBABILITY FLOOD

COLDWATER CREEK

WATER SURFACE PROFILES

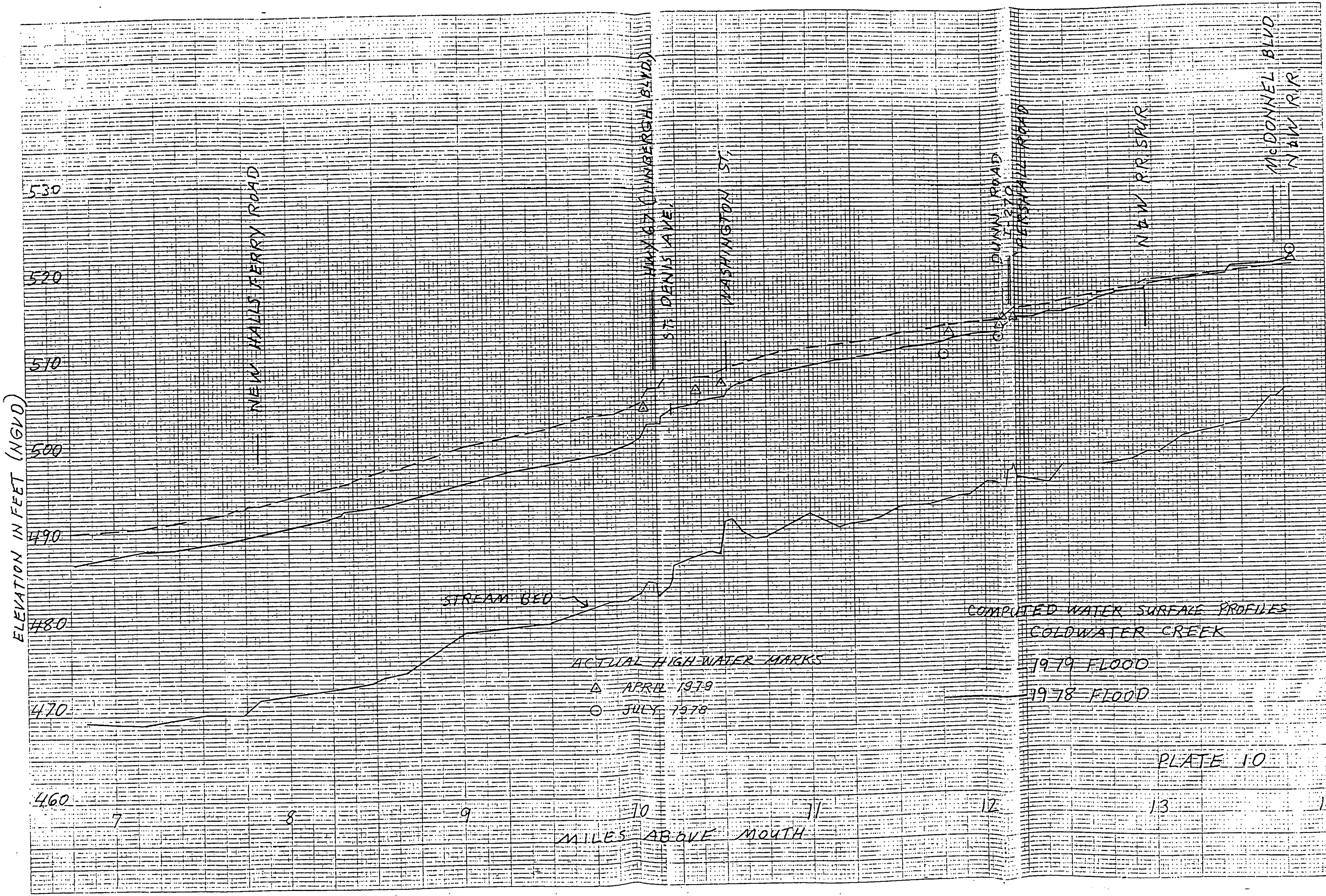
FUTURE CONDITIONS

WITH PLAN 1

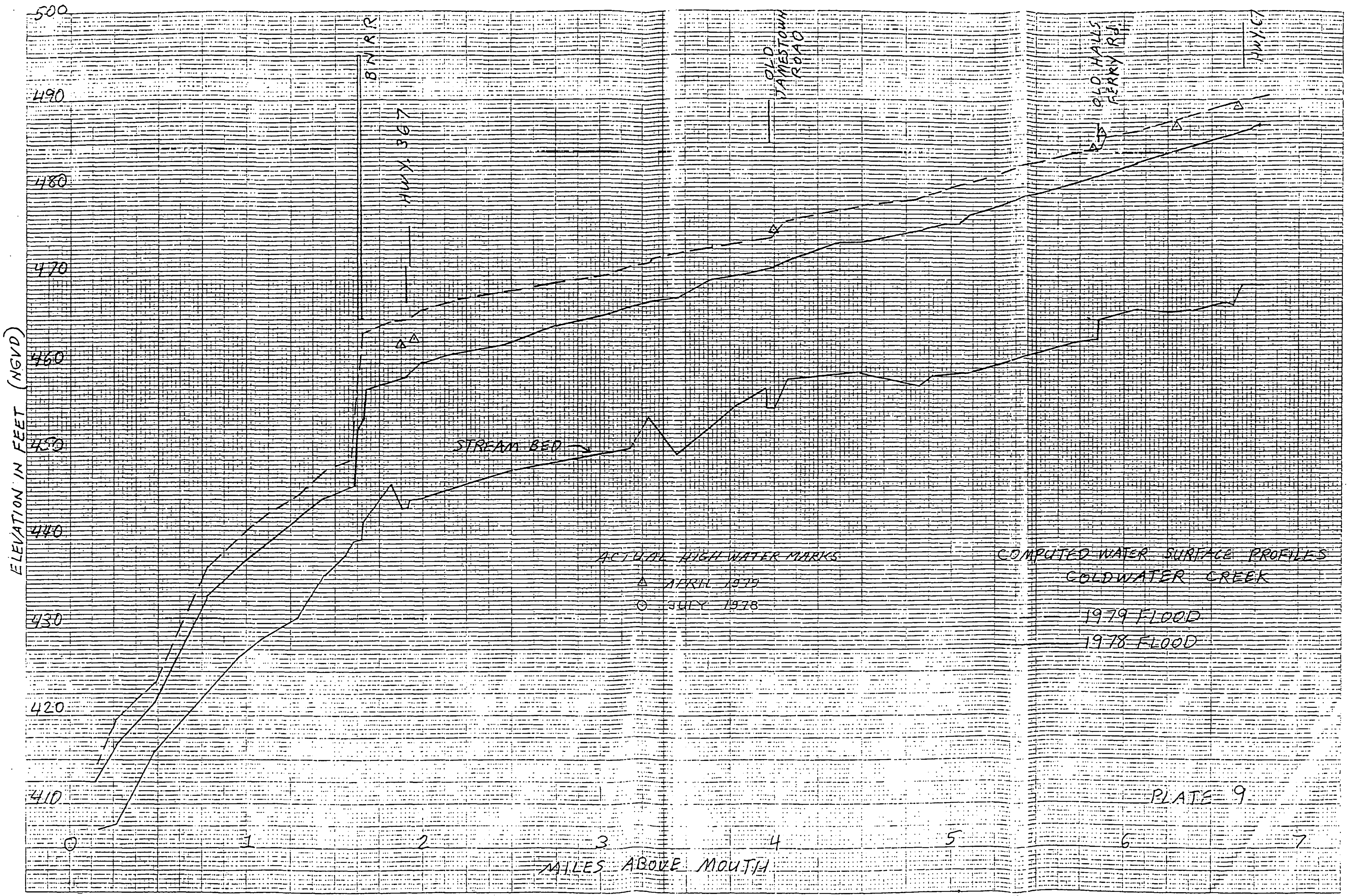


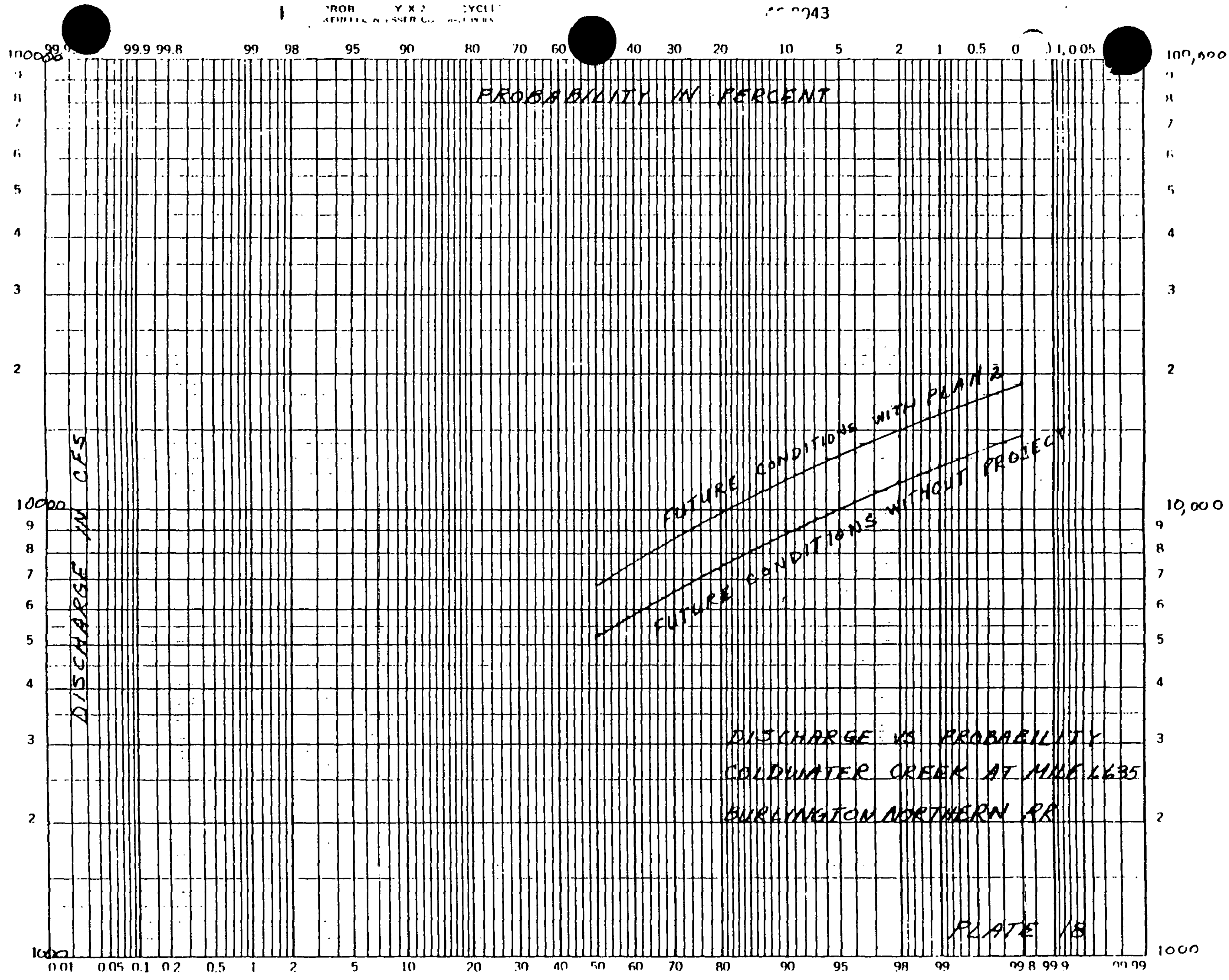
ELEVATION IN FEET (NGVD)
610
600
590
580
570
560
550
540
530
520
15
16
17
18
19
20
DOUBLE 10X15 RCB
AIRPORT ACCESS RD
I-70
ASHBY ROAD
WRIGHT ROAD
GERALDINE AVE.
ELSA AVE. FOOTBRIDGE
ISOLDA AVE.
LYNNTOWN AVE.
ST. CHARLES ROCK ROAD
REX AVE. FOOTBRIDGE
EDMONSON AVE.
DIX AVE.
CALVERT AVE.
MARVIN AVE.
BRECKENRIDGE ROAD
ACTUAL HIGH WATER MARKS
JULY 1978
APRIL 1979
COMPUTED WATER SURFACE PROFILES
COLDWATER CREEK
JULY 1978 FLOOD
APRIL 1979 FLOOD
PLATE 11

47 1323



ELEVATION IN FEET (NGVD)
530
520
510
500
490
480
470
460
7
8
9
10
11
12
13
14
MILES ABOVE MOUTH
NEW HALLS FERRY ROAD
HWY 67 (LINDBERGH BLVD.)
ST. DENIS AVE.
WASHINGTON ST.
DUNN ROAD
I-270
PERSHALL ROAD
NEW R.R. SPUR
McDONNEL BLVD
NEW R.R.
STREAM BED
COMPUTED WATER SURFACE PROFILES
COLDWATER CREEK
1979 FLOOD
1978 FLOOD
ACTUAL HIGH WATER MARKS
APRIL 1979
JULY 1978
PLATE 10


500
490
480
470
460
450
440
430
420
410
ELEVATION IN FEET (NGVD)
BNRR
HWY. 367
OLD JAMESTOWN ROAD
OLD HALLS FERRY RD.
HWY. 67
STREAM BED
ACTUAL HIGH WATER MARKS
△ APRIL 1979
⊙ JULY 1978
COMPUTED WATER SURFACE PROFILES
COLDWATER CREEK
1979 FLOOD
1978 FLOOD
PLATE 9
0
1
2
3
4
5
6
7
MILES ABOVE MOUTH


PROBABILITY IN PERCENT
DISCHARGE IN CFS
FUTURE CONDITIONS WITH PLAN 2
FUTURE CONDITIONS WITHOUT PROJECT
DISCHARGE VS PROBABILITY
COLDWATER CREEK AT MILE L635
BURLINGTON NORTHERN RR
PLATE 18
100,000
10,000
1000

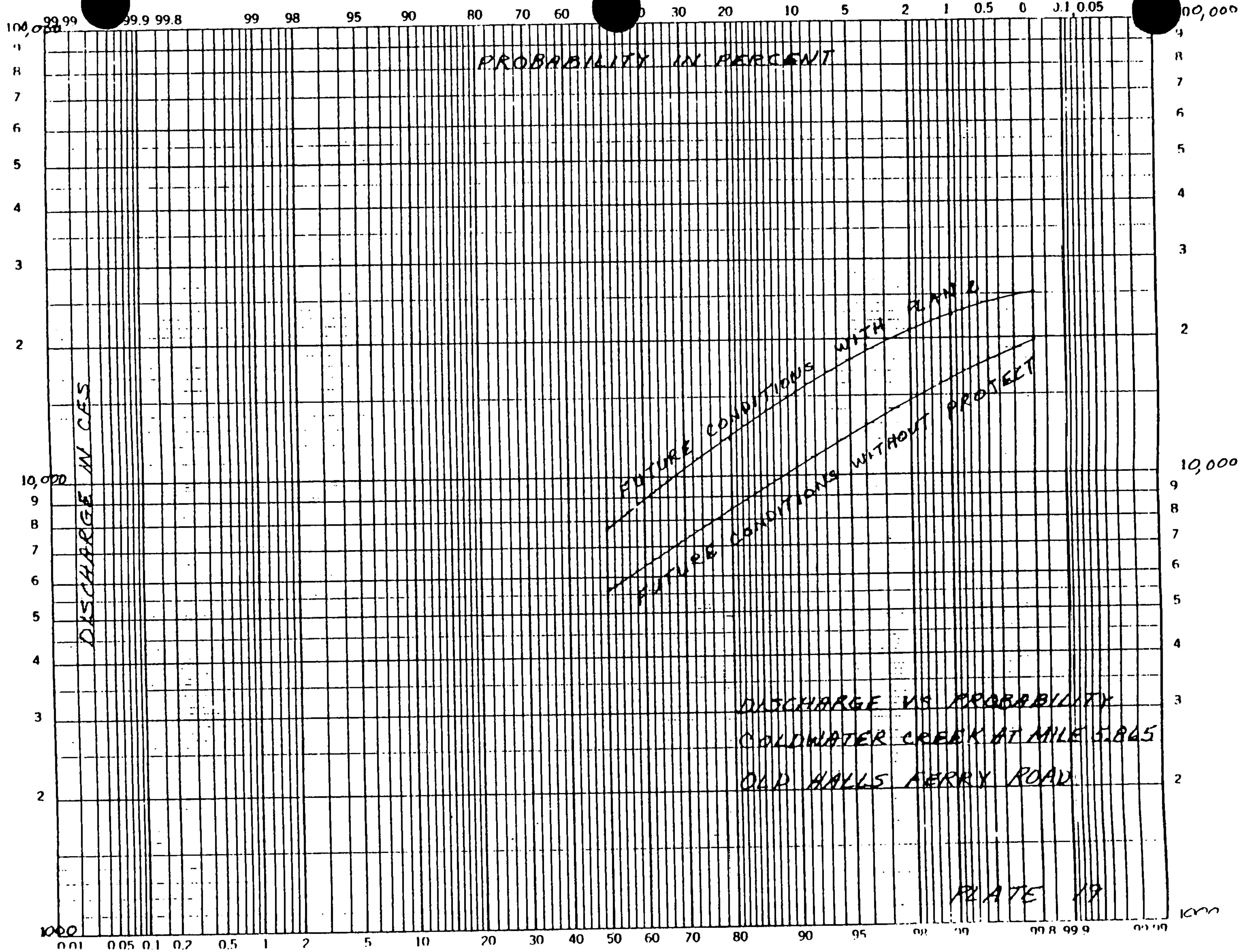
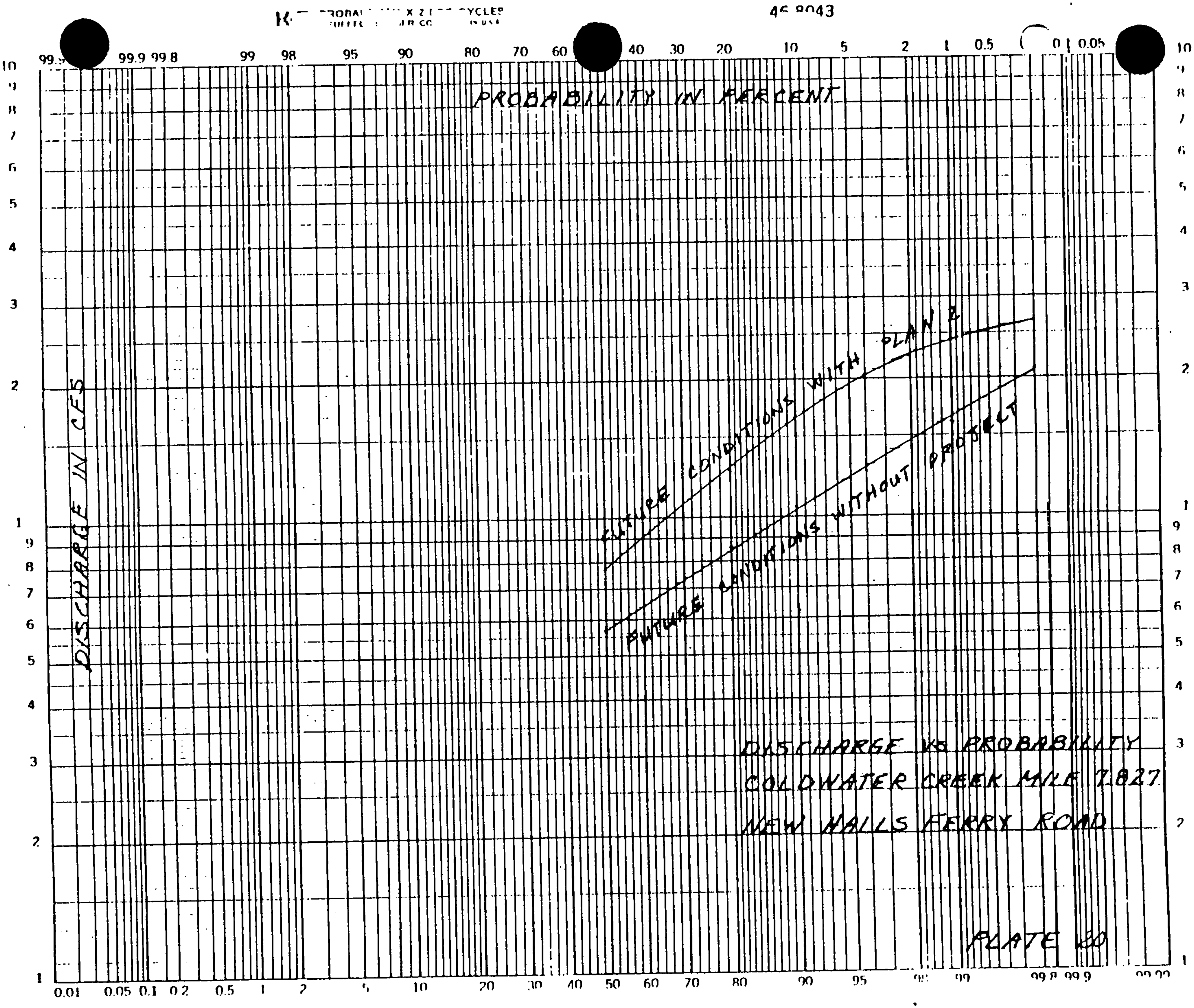
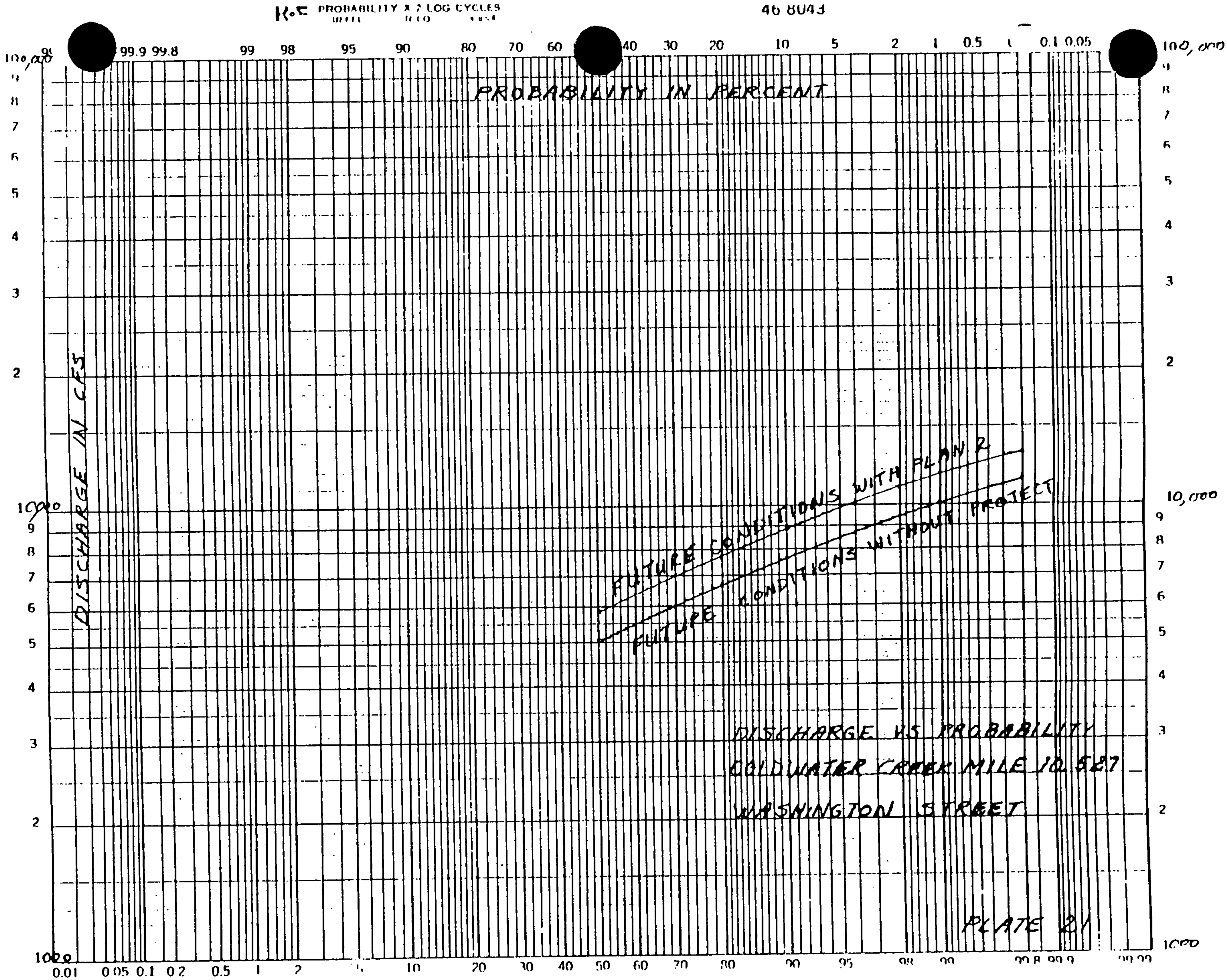
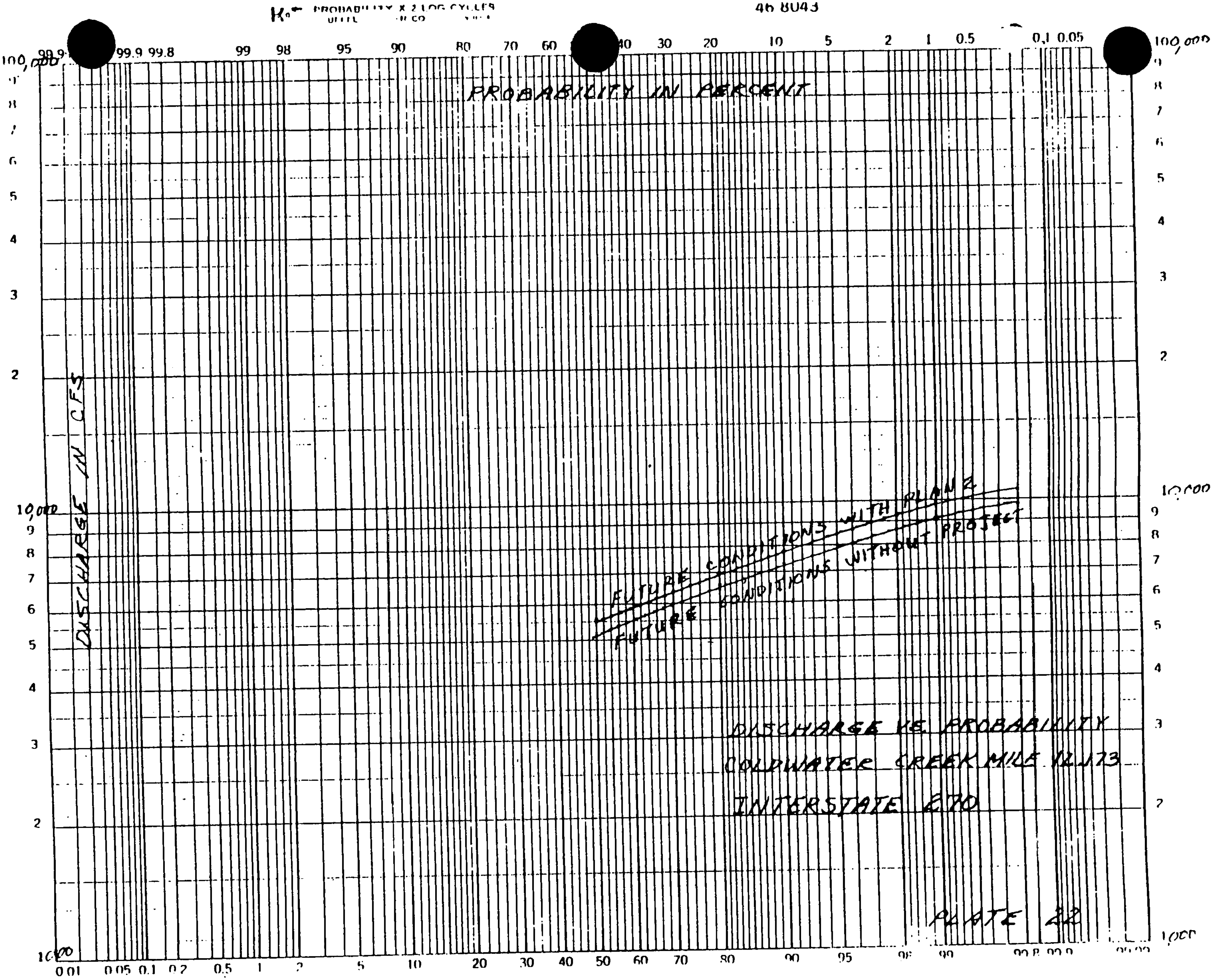

PROBABILITY IN PERCENT
DISCHARGE IN CFS
FUTURE CONDITIONS WITH PLAN 2
FUTURE CONDITIONS WITHOUT PROTECT
DISCHARGE VS PROBABILITY
COLDWATER CREEK AT MILE 5.845
OLD HALLS FERRY ROAD
100,000
10,000
1000

PLATE 17


46 8043
PROBABILITY IN PERCENT
DISCHARGE IN CFS
FUTURE CONDITIONS WITH PLAN 2
FUTURE CONDITIONS WITHOUT PROJECT
DISCHARGE VS PROBABILITY
COLDWATER CREEK MILE 7.827
NEW HALLS FERRY ROAD
PLATE 20


K&E PROBABILITY X 2 LOG CYCLES
46 8043
PROBABILITY IN PERCENT
DISCHARGE IN CFS
FUTURE CONDITIONS WITH PLAN 2
FUTURE CONDITIONS WITHOUT PROJECT
DISCHARGE VS PROBABILITY
COLDWATER CREEK MILE 10.527
WASHINGTON STREET
PLATE 21


K&E PROBABILITY X 2 LOG CYCLES
46 8043
PROBABILITY IN PERCENT
DISCHARGE IN CFS
FUTURE CONDITIONS WITH PLAN 2
FUTURE CONDITIONS WITHOUT PROJECT
DISCHARGE VS. PROBABILITY
COLDWATER CREEK MILE 12.173
INTERSTATE 270
PLATE 22

COLDWATER CREEK, MISSOURI

FEASIBILITY REPORT

APPENDIX B

GEOTECHNICAL

COLDWATER CREEK STUDY

GEOTECHNICAL APPENDIX

1.0 GENERAL. Presented herein are the results of the foundation exploration and testing programs, slope stability analyses, and other geotechnical studies for the Feasibility Report, Coldwater Creek, St. Louis, Mo.

The Coldwater Creek basin lies in the northern part of St. Louis County, Missouri. The 47 square mile watershed has an elongated shape, with a 19.5 mile long main channel and relatively short tributary streams. Coldwater Creek generally flows in a northerly direction from its origin in Overland to a point north of Florissant and then eastward to its confluence with the Missouri River. The stream flows through Overland, Breckenridge Hills, and St. Ann, and under St. Louis International Airport. It then passes through Hazelwood, Florissant and unincorporated St. Louis County and along the northern edge of Black Jack before joining the Missouri River.

There is very little development in the 100-year floodplain of the main channel of Coldwater Creek from its confluence with the Missouri River to the vicinity of New Halls Ferry Road. Between New Halls Ferry Road and Lambert Airport the floodplain includes single family residential areas, apartment complexes, large commercial developments, several industrial buildings and several open space areas. Upstream of the Airport there are some open areas in the floodplain, particularly the St. Ann park and golf course, but the remainder of the floodplain is essentially fully developed with single family residential and commercial development.

The flood protection design for Coldwater Creek as described in this document involves several types of flood protection measures. There are 10 miles of channel improvement within the project boundaries including paving under 6 bridges, .2 miles of I-wall and 9.5 miles of riprap protection.

2.0 FIELD INVESTIGATION. The initial phases of the investigation consisted of field reconnaissance, air photo evaluations of the project area and review of available SCS studies of the soils within the project boundaries. The investigations were made to determine the existing conditions and to locate subsurface explorations necessary to establish the physical characteristics of the foundation and channel soils. The subsequent drilling program was accomplished by equipment and personnel furnished to the St. Louis District, Corps of Engineers, by a contract.

3.0 LABORATORY TESTING. The Southwest Division Laboratory laboratory performed visual classifications, Atterberg limits and mechanical analyses on selected samples to confirm previous visual classifications and to provide more precise data for stability analyses. Design soil data used for geotechnical analyses are shown on Charts 1-12.

4.0 EXISTING CONDITIONS.

4.01 SOILS. A review of available SCS information indicates that within the project boundaries the Coldwater Creek watershed is covered by materials which were deposited under standing water or lake bottom conditions. These lake bed deposits include fine sand(SP), silt(ML), clay(CL and CH) and organic sediment up to 100 feet thick that have been covered by a 5 to 25 foot thick layer of loess. These soils underneath the loess generally exhibit a very high water content, high compressibility, poor drainage and low shear strength.

A number of borings were drilled along the channel bank. These borings were placed in the reaches of the creek where channel improvements are to be. These borings indicate that the surficial soils (5 to 25 foot thick) consists of two layers of loessial soils. The upper layer is a very silty, stiff loess and ranges from 0 to 10 feet thick. The lower layer is a thicker clayey, stiff to very stiff loess ranging from 20 to 50 feet thick.

Below is a brief description of the soils within each reach as denoted on CHART 13.

CC-1 thru CC-3 - No improvements were planned for these reaches, however, one boring was taken in reach CC-3. Boring CW-10 indicates approximately 28 feet of clayey, stiff to very stiff silt (ML) over silty, clay (CL).

CC-4 - Borings CW-6A, CW-6B and CW-8 were drilled within the boundaries of this reach. These borings indicate approximately 15 to 30 feet of clayey, stiff, silts (ML) and or silty, stiff, clays (CL).

CC-5 - Borings CW-5 and CW-12 were drilled within the boundaries of this reach. These borings indicate approximately 18 to 30 feet of silty, stiff, clay (CL) over clayey, stiff, silt (ML).

CC-6 - Borings CW-3 and CW-4 were drilled within the boundaries of this reach. Theses borings indicate that the upstream portion of this reach consists of approximately 10 feet of clayey, stiff silt (ML) over silty, stiff, clay(CL). The downstream portion of this reach consists of approximately 15 feet of silty, stiff, clay (CL) over clayey, stiff, silt (ML).

CC-7 - Boring CW-12 was drilled within the boundaries of this reach. This boring indicates approximately 14 feet of clayey, stiff, silt (ML) over silty, stiff, clay (CL).

CC-8 - This reach consists primarily of the St. Louis Airport and no improvements are planned within its boundaries. No drilling was accomplished in this reach.

CC-9 thru CC-11 - Borings CW-9 and CW-11 were drilled within the boundaries of this reach. These borings indicate approximately 10 to 15 feet of clayey, stiff, silt (ML) over silty, stiff, clay (CL).

4.02 GROUNDWATER. Groundwater data shown on the boring logs denote the elevation recorded during drilling.

4.03 EROSION. A detailed geotechnical study of erosion of this creek was made and the findings have been incorporated into the design of all channel improvements. Generally, the creek banks are very erosive and the erosion is not spread out evenly over the entire creek, but instead is concentrated immediately downstream of such obstruction as sewer outfalls, bank protection, bridge piers, culverts, etc. Erosion usually occurs by undercutting the toe of the creek bank and causing large chunks of material to fall off. This erosion usually occurs during or immediately after a period of high flow. For detailed information on the erosion along this creek see INSERT 1.

5.0 CHANNEL DESIGN.

5.01 GENERAL. Earth channel. Earth channels are the predominant form of channel improvement along this project. All earth channels were designed with 1 on 2 side slopes and vary in height from approximately 10 to 20 feet. As a means of erosion protection riprap is to be place along these earth channel improvements. Some areas call for riprap to the top of bank and others locations call for riprap along the toe of the creek bank. The amount and height of riprap placement was based on the potential erosion of the creek banks.

I-Wall & Paved Channel. Limited amounts of I-wall and paved channel are called for along the project. These areas are usually transition areas between existing concrete channels and the proposed earth channels such as bridge abutments, confluence of existing concrete channel tributary and the proposed new earth channel.

5.02 DESIGN STRENGTHS. The following strengths were assigned based on studies of testing data shown on CHARTS 1-12, design data from Maline Creek Study (adjacent to Coldwater Creek), limited data and observation from existing bridge design, and channel improvements along Coldwater Creek, and engineering judgment. Due to the limited amount of drilling and testing that was accomplished for this phase of design, average soil parameters were assigned to all reaches of the project. These parameters were based on engineering judgment in the area and soil descriptions and testing that was performed on the samples taken in the exploration program. The Average Unit Cohesion (1/2 Unconfined Compressive Strength) was derived from Foundation Engineering by Peck, Hanson and Thornburn, 2nd Edition, Tables 1.5 and 5.3. It is understood by LMSED-GE that the design of this project is in its preliminary stages and that further design studies will be required before a final design is arrived at and plans and specifications are completed. Additional detailed geotechnical design data will be required in subsequent phases of design.

Average Unit Weight of Soil = 100.0pcf

Average Unit Cohesion of Soil = 500.0psf

Average Friction Angle of soil = 0.0 Degrees

5.03 STABILITY. EARTH CHANNEL. The earth channels were designed with 1 on 2 side slopes ranging in height from 10 to 25 feet. For the purpose of this study, given the limited design data mentioned above, the soil profile for all earth channel sections was considered to be the same. The section that was analyzed was one with 1 on 2 slopes with heights of 10, 15, 20, and 25 feet. The method of analysis that was used to analyze shallow slope failures is described in Geotechnical Engineering An Engineering Manual For Slope Stability Studies by Duncan and Buchignani, March 1975, University of California, Berkeley, Pages 27-29, 38-40 and Plate 2. Assumptions and results of these studies are listed below.

ASSUMPTIONS - -

Average Soil Properties are as listed above in Para. 5.02

Stability Number = N = 6.5 (toe circle)

Pd = Average Unit weight(height)

F = N (Average Cohesion / Pd)

F = 6.5 (500. / Pd)

H (ft)	Pd	F	F(with Tension Crack)
10	- 900	3.61	
15	-1350	2.41	
20	-1800	1.81 -	1.59 (Pd = 2045)
25	-2250	1.44	

Analysis of deep foundation failures was accomplished by using the method described in DIVR 1110-1-4 - SEC 2 PART 2 ITEM 2 Feb. 1967 Sliding Stability of Slopes and Structures. The results of these analyses are presented below.

ASSUMPTIONS - -

Average Soil Properties are as listed above in Para. S102.

i = Slope Angle = 26.6 degrees or 1 on 2 slope

c = Average Unit Cohesion = 500.0 psf

= Average Unit Weight of Soil = 100.0 pcf

H = Height of Slope

D = Depth of Failure Surface Below Toe of Slope

N = Stability Number = c / FS( )(H)

H (ft)	D/H	N	FS
10	1	.196	2.6
	.5	.175	2.9
15	1	.196	1.7
	.5	.175	1.9
20	1	.196	1.3
	.5	.175	1.4
25	1	.196	1.02
	.5	.175	1.14

5.04 STABILITY. SMALL LEVEES. The small levees (5 foot high or less) that are called for within the project boundaries were not investigated for slope failure due to the limited size and number of them. Assuming that these levees will be constructed of the same material types as found within the channel of the creek they should perform the same as the channel slopes along the creek as analyzed above.

6.0 TUNNEL DESIGN. Reach C-9 channel improvements include channel widening as described above plus five eight foot diameter tunnels through the railroad embankment at Mile 1.63. This tunnel design was considered after the geotechnical exploration program was accomplished. The design and subsequent cost of tunneling is for the most part influenced by the subsurface conditions which exist at the site. At the present time the St. Louis District has no subsurface exploration or testing that can be used to determine the feasibility and subsequent cost of tunnels in the proposed area. A complete geotechnical investigation will be required in subsequent design levels in order to develope an accurate design and cost estimate.

Project Name: Coldwater Creek
:
Station:
Offset:
Surface Elevation: 504.3
Water @ 0 hrs.: 27'
Angle: Vert

Boring Number: CW2
Job Name (3 ltr.): CWC
Boring Length: 30'
Inspectors' Name: Lynne Hazelip
Drillers' Name: Rich Gotsch
Date: 5 Sep 85

				Plastic Limit	Liquid Limit	D(10) mm	Blows per foot	Natural Moist. Content %	Feet	Visual Classification
									1	(ML)
									2	
									3	
				24	29		8	24.2	4	Br-Gr, Mot, St, Clayey, w/lg
									5	
									6	
									7	
									8	
				23	31		5	21.9	9	Br-Gr, Mot, M, Clayey, w/lg
									10	
									11	
									12	
									13	
				22	33		7	22.5	14	(CL) Br-Gr, M, Silty, w/lg
									15	
									16	
									17	
									18	
				22	38		11	23.5	19	Gr, St, Silty
									20	
									21	
									22	
									23	
				20	37		14	22.3	24	Gr, St, Stily
									25	
									26	
									▽ 27	
									28	
				19	41		4	30.1	29	Gr, M, Silty
									30	

CHART 1

Project Name: Coldwater Creek
:
Station:
Offset:
Surface Elevation: 509.7
Water @ 0 hrs.:
Angle: Vert

Boring Number: CW3
Job Name (3 ltr.): CWC
Boring Length: 30'
Inspectors' Name: Lynne Hazelip
Drillers' Name: Rich Gotsch
Date: 28 Aug 85

				Plastic Limit	Liquid Limit	D(10) mm	Blows per foot	Natural Moist. Content %	Feet	Visual Classification
									1	[ML]
									2	
									3	
							18		4	Br, St, Clayey
									5	
									6	
									7	
									8	
							17		9	[CL] Br-Gr, Silty
									10	
									11	
									12	
									13	
							10		14	Gr, St, vSilty
									15	
									16	
									17	
									18	
							9		19	Gr, St, vSilty, more silt
									20	w/depth
									21	
									22	
									23	
							10		24	[ML] Gr, St, Clayey
									25	
									26	
									27	
									28	
							12		29	
									30	

CHART 2

Project Name: Coldwater Creek
:
Station:
Offset:
Surface Elevation: 583.6
Water @ 0 hrs.:
Angle: Vert

Boring Number: CW4
Job Name (3 ltr.): CWC
Boring Length: 30'
Inspectors' Name: Lynne Hazelip
Drillers' Name: Rich Gotsch
Date: 20 Aug 85

				Plastic Limit	Liquid Limit	D(10) mm	Blows per foot	Natural Moist. Content %	Feet	Visual Classification
									1	[CL]
									2	
									3	
				24	38		15	21.5	4	Br, St, Silty
									5	
									6	
									7	
									8	
				18	46		12	24.4	9	Gr, St, Silty
									10	
									11	
									12	
									13	
				24	33		6	25.5	14	[ML] Gr, M, Clayey w/iron stains
									15	
									16	
									17	
									18	
				23	30		10	25.8	19	Gr, S, Clayey, w/iron stains
									20	
									21	
									22	
									23	
				26	27		15	22.9	24	Gr, St
									25	
									26	
									27	
									28	
				31	32		7	31.9	29	Gr, M, grading to sand
									30	

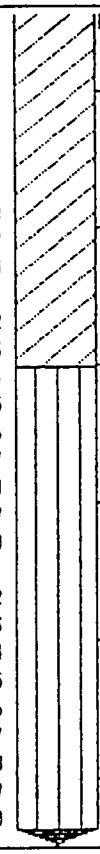


CHART 3

Project Name: Coldwater Creek
:
Station:
Offset:
Surface Elevation: 583.6
Water @ 0 hrs.:
Angle: Vert

Boring Number: CW5
Job Name (3 ltr.): CWC
Boring Length: 30'
Inspectors' Name: Lynne Hazelip
Drillers' Name: Rich Gotsch
Date: 29 Aug 85

				Plastic Limit	Liquid Limit	D(10) mm	Blows per foot	Natural Moist. Content %	Feet	Visual Classification
									1	[CL]
									2	
									3	
				21	32		13	27.0	4	Br, St, Silty
									5	
									6	
									7	
									8	
				21	29		9	24.7	9	Br, St, F Sand, Silty
									10	
									11	
									12	
									13	
							10		14	Br, S, F Sand, Silty
									15	
									16	
									17	
									18	
							14		19	Gr, St, Silty
									20	
									21	
									22	
									23	
							13		24	Gr, St, Silty
									25	
									26	
									27	
									28	
							12		29	Gr, St, Silty
									30	

CHART 4

Project Name: Coldwater Creek
:
Station:
Offset:
Surface Elevation: 492.2
Water @ 0 hrs.: 9'
Angle: Vert

Boring Number: CW6A
Job Name (3 ltr.): CWC
Boring Length: 30'
Inspectors' Name: Lynne Hazelip
Drillers' Name: Rich Gotsch
Date: 28 Aug 85

				Plastic Limit	Liquid Limit	D(10) mm	Blows per foot	Natural Moist. Content %	Feet	Visual Classification
									1	[CL]
									2	
									3	
				22	38		7	28.6	4	Br, M, vSilty
									5	
									6	
									7	
									8	
				26	30		2	32.1	9	[ML] Br, So, Clayey
									10	
									11	
									12	
									13	
				21	37		4	30.1	14	[CL] Br, M, Silty, S, w/gravel
									15	
									16	
									17	
									18	
				23	28		11	22.7	19	[ML] Br-Gr, St, Clayey
									20	
									21	
									22	
									23	
				24	29		9	27.8	24	Gr, St, F, S, w/Sl
									25	
									26	
									27	
									28	
							7		29	Gr, M, Clayey
									30	

CHART 5

Project Name: Coldwater Creek
:
Station:
Offset:
Surface Elevation: 491.2
Water @ 0 hrs.: 9'
Angle: Vert

Boring Number: CW6B
Job Name (3 ltr.): CWC
Boring Length: 30'
Inspectors' Name: Lynne Hazelip
Drillers' Name: Rich Gotsch
Date: 28 Aug 85

				Plastic Limit	Liquid Limit	D(10) mm	Blows per foot	Natural Moist. Content %	Feet	Visual Classification
									1	[ML]
									2	
									3	
				25	35		4	28.8	4	Br, M, Clayey
									5	
									6	
									7	
									8	
				23	41		4	36.1 ▽	9	[CL] Br-Gr, M, vSilty
									10	
									11	
									12	
									13	
				25	39		5	32.8	14	Gr, M. vSilty
									15	
									16	
									17	
									18	
				25	37		5	33.5	19	[ML] Gr, M. Clayey, w/Wd rubble
									20	
									21	
									22	
									23	
				26	28		12	29.8	24	Gr, St, Clayey, w/Wd & Sl
									25	
									26	
									27	
									28	
				23	68		9	39.4	29	[CH] Gr, St, Silty
									30	

CHART 6

Project Name: Coldwater Creek
:
Station:
Offset:
Surface Elevation: 496.3
Water @ 0 hrs.: 14'
Angle: Vert

Boring Number: CW7
Job Name (3 ltr.): CWC
Boring Length: 30'
Inspectors' Name: Lynne Hazelip
Drillers' Name: Rich Gotsch
Date: 28 Aug 85

				Plastic Limit	Liquid Limit	D(10) mm	Blows per foot	Natural Moist. Content %		Feet	Visual Classification
										1	[CL]
										2	
										3	
				22	32		7	27.4		4	Br, M, Silty
										5	
										6	
										7	
										8	
							6			9	
										10	
										11	
										12	
										13	
				22	32		5	27.4	▽	14	Br, M, vSilty
										15	
										16	
										17	
										18	
				19	37		16	23.5		19	Br-Gr, vSt, Silty
										20	
										21	
										22	
										23	
				19	51		16	24.7		24	[CH] Gr, vSt, Silty
										25	
										26	
										27	
										28	
				23	63		13	31.2		29	Bl-Gr, St
										30	

CHART 7

Project Name: Coldwater Creek
:
Station:
Offset:
Surface Elevation: 485.7
Water @ 0 hrs.:
Angle: Vert

Boring Number: CW8
Job Name (3 ltr.): CWC
Boring Length: 30'
Inspectors' Name: Lynne Hazelip
Drillers' Name: Rich Gotsch
Date: 28 Aug 85

				Plastic Limit	Liquid Limit	D(10) mm	Blows per foot	Natural Moist. Content %	Feet	Visual Classification
									1	[CL]
									2	
									3	
				23	33		10	19.9	4	Br, St, vSilty
									5	
									6	
									7	
									8	
				22	38		10	23.5	9	
									10	
									11	
									12	
									13	
				23	27		15	23.7	14	[ML] Br, M, S, Clayey, F Sand
									15	w/depth
									16	
									17	
									18	
				25	27		20	22.3	19	Gr, vSt, S, Clayey
									20	
									21	
									22	
									23	
							9		24	Gr, St, S, Clayey
									25	
									26	
									27	
									28	
							6		29	Gr, M, Clayey
									30	

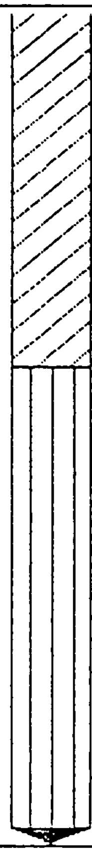


CHART 8

Project Name: Coldwater Creek
:
Station:
Offset:
Surface Elevation: 565.91
Water @ 0 hrs.:
Angle: Vert

Boring Number: CW9
Job Name (3 ltr.): CWC
Boring Length: 30'
Inspectors' Name: Lynne Hazelip
Drillers' Name: Rich Gotsch
Date: 26 Aug 85

				Plastic Limit	Liquid Limit	D(10) mm	Blows per foot	Natural Moist. Content %	Feet	Visual Classification
									1	[ML]
									2	
									3	
				26	37		8	20.1	4	Br, St, w/10% coal/gravel rubble
									5	
									6	
									7	
									8	
				27	34		8	22.5	9	[SM] Br, St, 70% rubble
									10	
									11	
									12	
									13	
				24	35		9	23.4	14	[CL] Gr, St, Silty, w/iron stains
									15	
									16	
									17	
									18	
				21	34		14	18.3	19	Br-Gr, Mot, St, Silty
									20	
									21	
									22	
									23	
				22	32		14	20.7	24	Br-Gr, Mot, St, Silty, F Gravel, iron stained
									25	
									26	
									27	
									28	
					33		33	20.7	29	[GC] Gr, C, F-C Sand
									30	

CHART 9

Project Name: Coldwater Creek
:
Station:
Offset:
Surface Elevation: 486.4
Water @ 0 hrs.:
Angle: Vert

Boring Number: CW10
Job Name (3 ltr.): CWC
Boring Length: 30'
Inspectors' Name: Lynne Hazelip
Drillers' Name: Rich Gotsch
Date: 28 Aug 85

Plastic Limit	Liquid Limit	D(10) mm	Blows per foot	Natural Moist. Content %	Feet	Visual Classification
					1	[ML]
					2	
					3	
			5		4	Gr, M, Clayey
					5	
					6	
					7	
					8	
27	29		6	21.3	9	Gr, M, S, Clayey
					10	
					11	
					12	
					13	
			11	23.1	14	Gr, St, S, Clayey
					15	
					16	
					17	
					18	
			17	23.1	19	Gr, vSt, Clayey, F Sand
					20	
					21	
					22	
					23	
			9	23.6	24	Br-Gr, St, Clayey, S
					25	
					26	
					27	
					28	
21	44		39	16.8	29	(CL) Gr, H, Silty
					30	

CHART 10

Project Name: Coldwater Creek
:
Station:
Offset:
Surface Elevation: 558.39
Water @ 8 hrs.: 17.5'
Angle: Vert

Boring Number: CW11
Job Name (3 ltr.): CWC
Boring Length: 30'
Inspectors' Name: Lynne Hazelip
Drillers' Name: Rich Gotsch
Date: 26 Aug 85

				Plastic Limit	Liquid Limit	D(10) mm	Blows per foot	Natural Moist. Content %	Feet	Visual Classification
									1	[ML]
									2	
									3	
							13	19.7	4	Gr, St, Clayey, F-C gravel rubble
									5	
									6	
									7	
									8	
				21	50		8	21.9	9	[CL] Gr, M, Silty, w/C gravel rubble
									10	
									11	
									12	
									13	
				23	33		5	27.1	14	Gr, M, Silty, w/iron stains
									15	
									16	
									17	
									18	
				29	37		5	34.4	19	[ML] Gr, M
									20	
									21	
									22	
									23	
				27	30		5	31.1	24	Gr, M, Clayey
									25	
									26	
									27	
									28	
				21	35		11	26.5	29	[CL] Bl-Gr, M, Silty
									30	

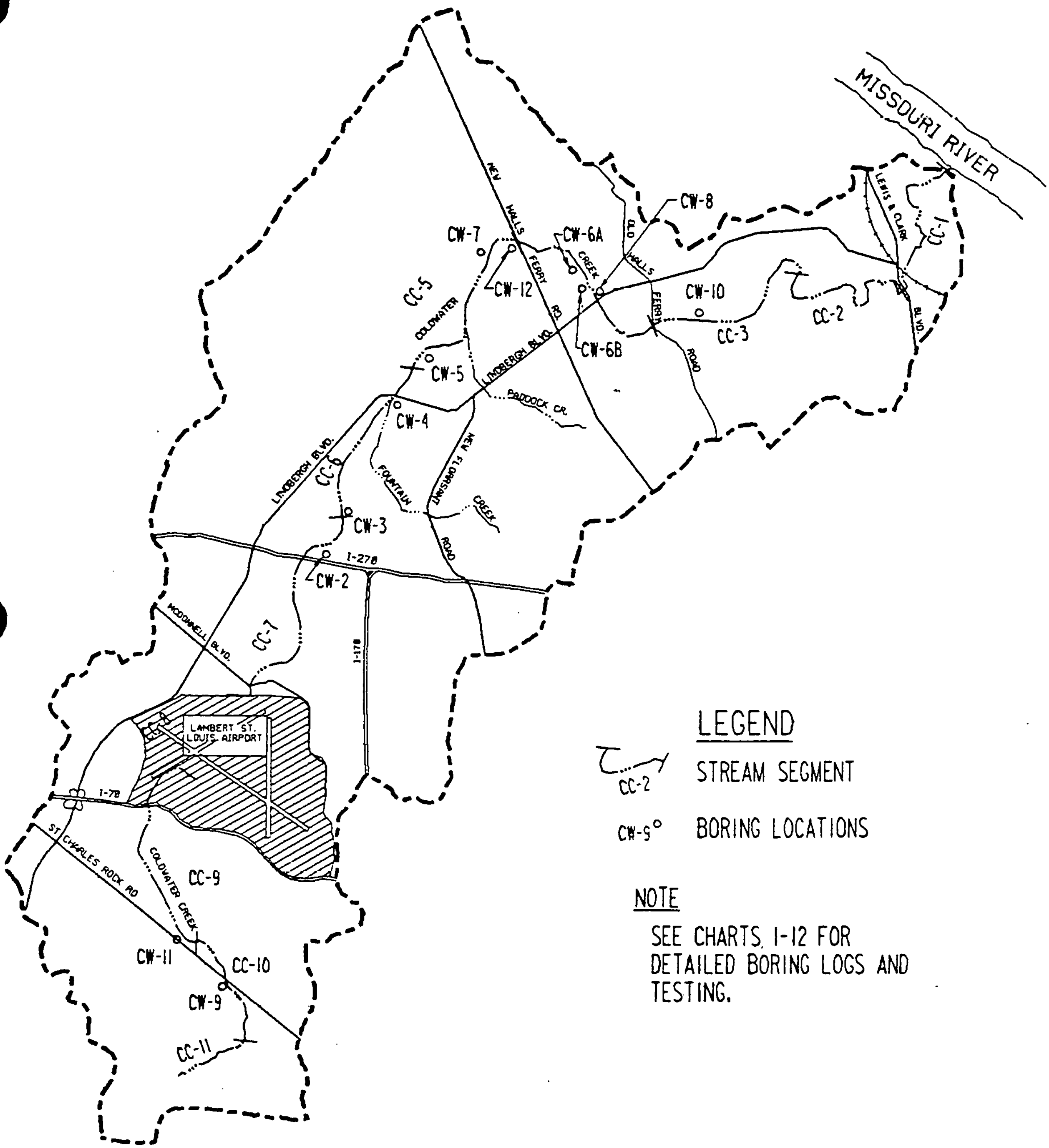
CHART 11

Project Name: Coldwater Creek
:
Station:
Offset:
Surface Elevation:
Water @ 0 hrs.: 19
Angle: Vert

Boring Number: CW12
Job Name (3 ltr.): CWC
Boring Length: 30'
Inspectors' Name: Lynne Hazelip
Drillers' Name: Rich Gotsch
Date: 29 Aug 85

				Plastic Limit	Liquid Limit	D((B) mm	Blows per foot	Natural Moist. Content %	Feet	Visual Classification
									1	[CL]
									2	
									3	
							9		4	Br, St, Silty, w/iron stains
									5	
									6	
									7	
									8	
							8		9	Gr, M, Silty
									10	
									11	
									12	
									13	
							6		14	
									15	
									16	
									17	
									18	
							8	▽	19	[ML] Gr, M, S, Clayey
									20	
									21	
									22	
									23	
							7	28.0	24	Gr, M, S, Clayey
									25	
									26	
									27	
									28	
				19	37		22	24.2	29	[CL] Gr, vSt, Silty, S
									30	

CHART 12



LEGEND

CC-2 — STREAM SEGMENT

CW-9 ○ — BORING LOCATIONS

NOTE

SEE CHARTS 1-12 FOR DETAILED BORING LOGS AND TESTING.

COLDWATER CREEK, MISSOURI
BORING LOCATIONS

CHART 13

COLDWATER CREEK

EROSION STUDY

MARCH 1984

INSERT 1

15 March 1984
ED-FS

COLDWATER CREEK EROSION STUDY - PHASE I

1.0 INTRODUCTION

An estimate of streambank erosion for the next 50 years was needed to determine the benefits and costs of several different alternatives proposed for Coldwater Creek. The term "erosion" as used in the top of the streambank, and the associated loss of usable acreage. Economic losses are generaly developed using this definition of erosion. The estimates developed in this study (Appendix I) give the average predicted loss of useable land for both sides of the creek combined. It does not imply that the cross sectional area of the stream will increase by the same magnitude. In the case of a deep seated sliding failure which is typical for this stream, a large mass of soil may slide toward the creek, leaving behind a two or three foot scrap. This action effectively removes a portion of the useable acerage available for commercial, residential or agricultural purposes, but the soil mass is still, to a large extent, present in the creek and therefore the cross sectional area used to compute flood carrying ability is relatively unchanged. In many cases the slide mass can actually reduce the cross-sectional area of the channel at low water profiles.

In order to estimate the future erosion of the entire creek, it was first divided into reaches, and then an estimate of erosion for each reach was determined using available geologic information along with personal observation of the study area. It should be stressed that these erosion estimates have not been verified with actual field measurements. It is proposed that a phase II study be authorized in which study sections are established and actual measurements of streambank erosion are taken over a period of time and then extrapolated out to a fifty year period (Appendix 3).

2.0 STUDY METHODS

2.1 SITES

The entire mainline creek was used as a study site. The creek was divided into 11 reaches to facilitate field and office work. The stream bank erosion study used the same eleven stream reaches that had been set up for plan formulation and economics studies. The reaches represent a wide range in conditions with respect to urban development, soils exposed in the banks and apparent severity and causes of erosion.

2.2 METHODOLOGY

The technique that was developed for this study was divided into three steps applied independently to each reach of creek:

1. Study exsisting soil maps and charts along with rock outcrop information developed in an earlier study by the geology section.

2. Walk the entire study area documenting existing causes and types of erosion, soil types, potential development of study area, existing erosion protection, and severity of existing erosion.

3. Compare results of steps 1 and 2 using engineering judgement to quantify potential erosion for a 50 year period in increments of 10 years.

3.0 ANALYSIS

3.1 EXISTING EROSION PROBLEMS

Coldwater creek is an urban drainage system located in North St. Louis County. The head of the creek is located in Overland and aproximately the first 1 1/2 miles is concrete lined (cc-11). Erosion in cc-11 was considered non-existent even though maintenance may be required. The creek then heads in a northerly direction until it reaches Lambert-St. Louis Airport (cc-9 and cc-10). These two reaches are experiencing moderate erosion. Residential and commercial developments near the creek may require bank stabilization to protect against loss of land since there is very limited unoccuppied land between the creek and buildings, fences, parking lots, etc. some private land owners have already placed bank protection, usually in the form of rock gabions, on limited areas in this stretch of creek. Upon reaching Lambert Airport, the creek enters concrete culvert and proceeds underneath the airport (cc-8). After exiting the airport the creek continues northward through Hazelwood. The first reach north of the airport (cc-7) has moderate to major erosion problems. This area is industrial and some businesses including Continental Manufactoring Co. bldg 105A are in danger of losing substantial portions of land. The creek continues northward through two reaches (cc-5 and cc-6) of high urban development (Florissant) which are experiencing minor to moderate erosion. Most developments have included sufficient common ground ajoining the creek but some were built too close to the creek and may require protection. At this point, the creek turns and runs eastward past Black Jack and Jamestown before it empties into the Missouri River (cc-4 through cc-1). These reaches are experiencing moderate to severe erosion, but the area is mostly wooded and undeveloped and therfore very little damage is being inflicted upon improved property.

3.3 ESTIMATING FUTURE EROSION

Streambank erosion can be divided into two major categories. Aggradation and degradation are changes that occur over long periods of time and affect long reaches of the channel. Fill and scour are more local and usually due to hydraulic distrubances that do not affect the stream over long distances. The only foreseen change to the degradation rate on Coldwater Creek would be the widening and deepening of the channel due to increased flows from runoff caused by large scale development of the eastern portion of the basin. In contrast, many examples of localized scour have occured and will continue to occur due to small scale hydraulic disturbances. Erosion along the outside of a bend and erosion opposite a sewer outfall are examples of localized scour. The limited areas of bank protection already in place (gabions, sheet piling, rip rap, etc.) helped control erosion in the stretch where it was placed but had a negative affect upon the areas immediately downstream from the protection.

Several assumptions were made concerning the amount of future development and the affect the development would have on the creek. The basin upstream from reaches cc-5 through cc-11 is highly developed and no further development is expected due to the lack of room. Therfore, the amount of runoff in these reaches is expected to remain essentially the same and, as the stream reaches equilibrium and the streambanks stabilize, the rate of erosion should decrease. This hypothesis would change, however, if further channelization of the creek occurs. If, for example, reaches cc-9 and cc-10 were improved with a concrete lined channel, then the estimates for erosion would be inaccurate as erosion would be essentially eliminated in the improved reaches and erosion would probably accelerate in the reaches downstream from the improvements.

The watershed downstream from cc-5 contains land which in all probability will be developed in the future. If implemented, this development will cause an increase in the amount of surface runoff that will flow into the creek and will therfore increase the rate of erosion in reaches cc-4 through cc-1. Also, any further expansion in this area may necesitate an increase in the amount of sewage treated at the Metropoliton Sewer District's Coldwater Creek plant whose effluent is discharged into Coldwater Creek.

3.4 UNCERTAINTIES

This report has been developed without the benfit of field measurements taken over an extended period of time. While the report represents our best effort using limited available geologic information and engineering judgement, trying to quantify streambank erosion is a very difficult task. In order to confirm or revise the present erosion estimates, a phase II study is recommended in which actual field measurements are taken of the landward retreat of the streambank (Appendix 3).

4.0 CONCLUSION

Streambank erosion along Coldwater Creek has occurred in the past and will continue to occur in the future. Our best estimate of erosion is given in Appendix 1. This erosion estimate is an average loss of ground for both sides of the creek combined for a given reach. Actual erosion in the field will not be evenly distributed, but instead will be concentrated immediately downstream of such obstruction/hydraulic distrubances as sewer outfalls, bank protection, bridge piers, culverts, etc. In order to more accurately estimate erosion rates, a phase II field study is recommended.

APPENDIX 1 EROSION ESTIMATES

REACH	10	20	30	40	50 (YEARS)	
FEET OF EROSION (AVG FOR BOTH SIDES)						
CC-1	4	4	5	5	6	
CC-2	5	5	5	6	6	
CC-3	5	5	5	6	6	
CC-4	5	5	5	5	5	
CC-5	4	4	3	3	3	
CC-6	3	3	3	2	2	
CC-7	3	3	2	2	2	
CC-8	0	0	0	0	0	**CONCRETE LINED**
CC-9	3	3	2	2	2	
CC-10	3	3	2	1	1	
CC-11	0	0	0	0	0	**CONCRETE LINED**

APPENDIX 2 FIELD NOTES

A2.1
REACH CC-1 THRU CC-4

Channel slopes vary from 2 on 1 to vertical. Bank heights vary from 15 to 30 feet throughout the reaches. The soils in this area are brown silts and silty clays overlying a dense brown - yellow brown clay, highly erodable and well drained. Rock outcrops at several locations. The creek bottom varies from clay to gravel with some areas of rock.

Land adjscent to the creek in this area is primarily wooded. The potential for future development in this area does exist.

A2.2

REACH CC-5 THRU CC-6

Channel slopes vary from 2 on 1 to vertical. Bank heights vary from 15 to 30 feet throughout the reach. The soils in this area are greyish brown silts and clays overlying a mottled dark brown clay. Reach C-5 is generally a well drained, highly erodable soil and CC-6 is a poorly drained soil with low erodability. The creek bottom varies from clay to clay and gravel.

The land adjacent to the creek in these reaches is very urban and highly developed. Parking lots and public parks are the predominant use of adjacent lands.

A2.3

REACH CC-7

Channel slopes are 2 on 1 except for areas where undercutting of the slopes has caused localized vertical scarps. Banks in this area vary from 10 to 20 feet in height. The soils in this reach are a poorly drained, highly erodable, black silty clay overlying a yellow brown clay. The creek bottom is predominantly clay and gravel.

This reach of creek is highly developed with large parking lots, industrial buildings and some public recreation development. The potential for future development in the area is almost non-exsitent.

A2.4

REACH CC-8 AND CC-11

These reaches are concrete lined and erosion was not considered in these areas. However, the effect of these reaches on erosion in areas upstream and downstream of the concrete channels was considered.

A2.5

REACH CC-9 AND CC-10

Channel slopes are 2 on 1 to vertical. Creek banks in the reach vary from 5 to 15 feet in height. The soils in these reaches are poorly drained, highly erodable, black silty clay overlying a yellow brown clay. The creek bottom is clay and gravel.

This reach of creek is highly developed with parking lots, public parks, public and private buildings and a golf course. The potential for future development in the area is almost non-existent.

APPENDIX 3 PROPOSED PHASE II STUDY

The proposed Phase II Study would consist of installing 36 survey markers (3/4" iron water pipe 5 feet long) approximately 25 feet from the bank. The landward retreat of the bank would then be indicated by the change in the distance measured between the survey markers and the bank over a period of time. Measurements will be taken every 3 months for the first year and every 6 months for the second year (7 surveys total). The survey markers will be placed on 9 reaches of the creek with 4 markers per reach. The condition of the bank at each survey marker will be documented with photographs before during and after the study. Each survey point will be referenced to witness posts or major structures such as bridge piers or buildings.

The Study Will Require the Following Resources:

A. 180 FT. 3/4" Iron Pipe in 5 FT. Lengths
B. 15 Rolls of Film Including Developing
C. Manpower Requirements

1. Installing Markers & Intial Survey	2 WKS x 2 Man Crew =	4 Man-Weeks
2. Additional & Surveys	6 Surveys x 2 Man Crew =	12
3. Reducing Data		1
4. Writing Report		2
	Total	19 Man-Weeks

D. Supervisory Requirements — 1 Man-Week

E. Total Estimated Cost of Approximately $30,000 Spread Over a 3 Year Period

COLDWATER CREEK, MISSOURI

FEASIBILITY REPORT

APPENDIX C

DESIGN

COLDWATER CREEK STUDY
DESIGN APPENDIX

1. General. During the plan formulation process, a number of measures were considered and developed. Contained in these measures was a variety of structures and channel improvements, which will be addressed in this section. Selected measures were combined to form plans. Of the three plans selected to be presented in this document, design details pertaining to Plan 2 (recommended plan) shall be described. Since Plan 1 and Plan 3 contain measures similar to those contained in Plan 2, it was not necessary to present all three plans.

All design and analyses produced for the various project components are based on current applicable Corps of Engineers design practices and regulations. In conjunction with the Corps' guidance, all applicable private industry codes were adhered to. Designs were based on the best information available at the time the work was performed. In some instances, the use of engineering judgement was necessary, due to the lack or absence of data not normally developed for a report in this stage of design. It is believed the designs are sufficient for this stage of development.

2. Tunnels. Five 8-foot diameter tunnels will be constructed through the Burlington Northern Railroad embankment, located near Highway 367. The tunnels will be situated on the south side of Coldwater Creek. Each tunnel will be over-excavated to allow for erection of galvanized steel liner plates. After the plates are in place, the void between the tunnel wall and liner plate will be grouted. A reinforced concrete slab will be placed in the invert of each tunnel. The length of the tunnels will be approximately 120 feet.

3. Channel Paving. Scour protection for the channel, consisting of reinforced concrete slabs placed in the Coldwater Creek invert and on both sloping banks, will be provided at the downstream Lindbergh Blvd. Bridge and the New Halls Ferry Road Bridge located in measure C-9. A cutoff wall will be provided around the perimeter of the concrete, and weep holes will be placed through the sloping bank concrete, near the channel invert.

Another method of paving will be utilized at Wright Road, Geraldine Ave., and Isolda Ave. bridge locations in measure C-20, due to channel width limitations. Reinforced concrete slabs will be placed in the channel invert between the vertical walls of the existing bridge abutments. A transition section will be located adjacent to the existing bridge abutments, both upstream and downstream of the channel paving.

4. Transition Section. The function of the transition section is to convert the typical sloping channel banks to vertical walls. The length of all transitions is 50 feet, measured parallel to flow. Each transition is comprised of reinforced concrete slabs placed in the channel invert and on the sloping banks. Additionally, a vertical reinforced concrete wall is placed

perpendicular to the channel at the sloping end of the transition. The wall is supported by a reinforced concrete footing. For typical transition details, see Plate 17. The only exception to the typical transition described above, is located at the downstream end of the two retaining walls near the Paddock Creek junction. This transition will not have a paved invert (See Figure 1). Weep holes will be provided in all transition sections.

5. Retaining Walls.

a. Cantilever. A typical channel widening, with two horizontal to one vertical side slopes, could not be used near the Paddock Creek junction due to right-of-way constraints (the possibility of using a u-frame retaining wall in this vicinity was investigated but rejected, since the excessive channel depth coupled with the 850 feet of walls required, made this proposal uneconomical). It was then decided to use a reinforced concrete cantilever retaining wall on both sides of the channel, approximately half the depth of the channel, in conjunction with two horizontal to one vertical earth side slopes (See Figure 1). The channel invert will be paved with reinforced concrete, approximately 60 feet upstream and 50 feet downstream of the centerline intersection of Paddock Creek with Coldwater Creek. The downstream edge of concrete paving will incorporate a cutoff wall the full width of the channel bottom. Weep holes will be provided in the walls to reduce hydrostatic pressure. In addition, a concrete transition section will be provided, both upstream and downstream of the retaining walls.

b. U-Frame. It was necessary to steepen the side slopes of the channel widening beneath the St. Denis Avenue bridge, to avoid interference with the bridge abutments. In order to pave the side slopes with concrete, preliminary designs indicated the need for counterforts with footings to stabilize the paving. This concept proved to be uneconomical. The final selection was a reinforced concrete u-frame retaining wall. The design consists of a vertical wall on both sides of the channel, cast with a base slab connecting the two walls (See Figure 2). Weep holes will be provided in the walls to reduce hydrostatic pressure. Concrete transition sections will be located at each end of the retaining wall.

6. Pedestrian Bridges. Due to the channel widening in the St. Ferdinand Park area, the existing pedestrian bridge at approximate mile 9.83 will need to be replaced with a new bridge. The new bridge length will be 152 feet, and divided into four spans (See Figure 3). The end spans are 36 feet long, and the intermediate spans are 40 feet. The superstructure will be constructed of precast concrete voided slabs, 5.5 feet wide, designed as simple spans. Handrails will be provided on both sides of the slabs. Single column concrete piers on footings, will be used to support the superstructure. The abutments will be concrete beams with formed stairs, and supported on a concrete footing.

The existing pedestrian bridges located at Rex Ave., Elsa Ave., St. Ann Park, and St. Cin Park will also be replaced. The type of construction proposed will be similar to that of the St. Ferdinand Park Bridge, except the total bridge lengths will vary from approximately 60 feet to 130 feet.

7. Pipe Support. An 18-inch diameter, natural gas pipeline, crosses Coldwater Creek on the north side of the Lindbergh Blvd. bridge (located near Fountain Creek). The channel widening proposed for this area will require additional support for the elevated pipeline. Based on the spacing of the existing pipe supports, it appears only one additional support is required. The new support will consist of a horizontal concrete cap on two battered precast concrete piles.

8. Channel. The major change proposed for the Coldwater Creek channel improvement, is widening the bottom width. The invert elevation of the improved channel will follow the existing elevation and alinement as closely as possible, and maintain a reasonably smooth profile grade. Earth side slopes for the improved channel will be two horizontal to one vertical. Scour protection for the improved channel will be provided throughout most of the length of the recommended plan. The method of scour protection is the placement of 12 inches of riprap on 6 inches of bedding material. For the most part, riprap and bedding will be placed at the toe of the channel side slopes, extending 7 feet up the slopes, with a 5 foot berm at the toe. For details of channel and scour protection, see Plate 17. In some isolated locations, the riprap and bedding will completely cover the side slopes and channel bottom, and in one location, no scour protection is recommended. For the locations of scour protection, see Plates 24 through 35. In addition to the scour protection methods described, another form is used in conjunction with the transition sections. The first hundred feet of earth side slopes adjacent to transition sections, not protected with riprap and bedding, will be covered with ground stabilizing fabric (Enkamat). The fabric provides stabilizing support to the soil, yet allows grass to grow through it.

Unused, excavated material will be placed in open areas, to be designated at a later date, except no excavated material will be placed upstream of Lambert Airport. A 10-foot permanent easement will be located on each side of the channel, where the 2 horizontal to 1 vertical side slopes intersect the existing ground line outside the limits of the channel proper.

9. Levees.

a. General. Both of the proposed levees would have a maximum height of 5 feet. The side slopes would be 1V on 3h. The crown would be 5 feet wide. The slopes would be seeded.

b. St. Ferdinand Levee. The proposed levee would be about 1,200 feet long. The protected area would be drained by an 30 inch diameter corrugated metal pipe with a flapgate.

c. Foxtree Drive Levee. The proposed levee would be about 900 feet long. The protected area would be drained with a 30 inch diameter corrugated metal pipe with a flap gate.

4057D

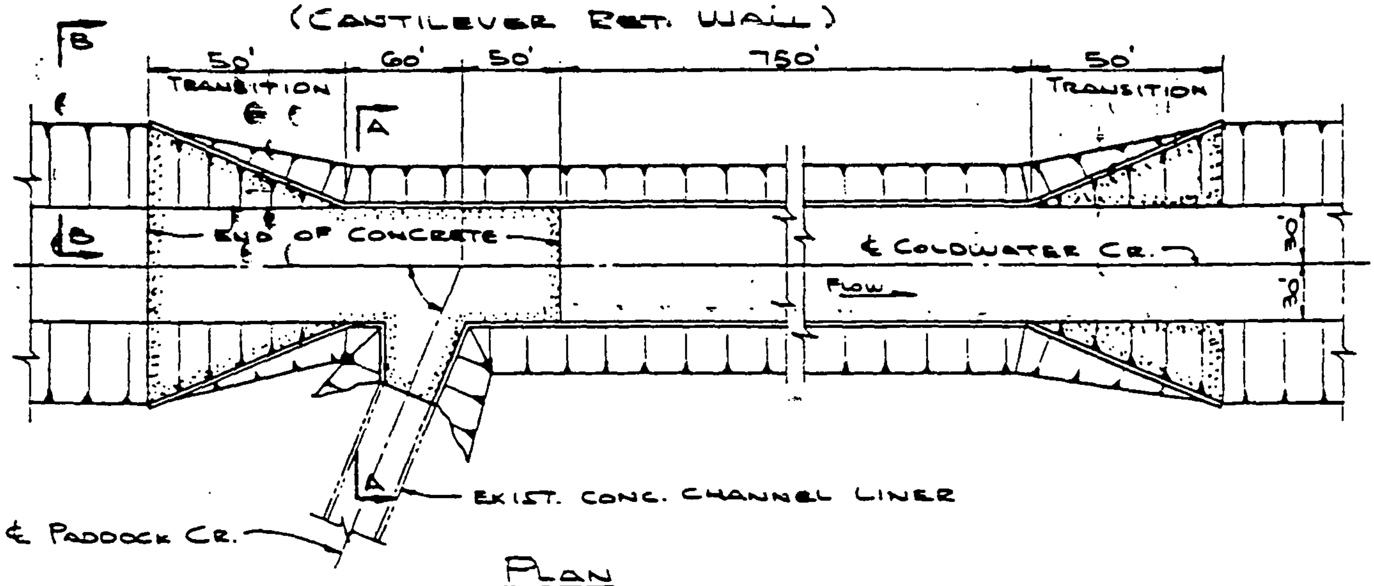
PROJECT		COMPUTED BY	DATE
COLDWATER CREEK STUDY	Page 3 of __	STOHL	7 DEC. 83
SUBJECT		CHECKED BY	DATE
LOWER COLDWATER - 10 YEAR PLAN - MEASURE C-5			

REV.: 28 APR 86

CONCRETE CHANNEL LINERS

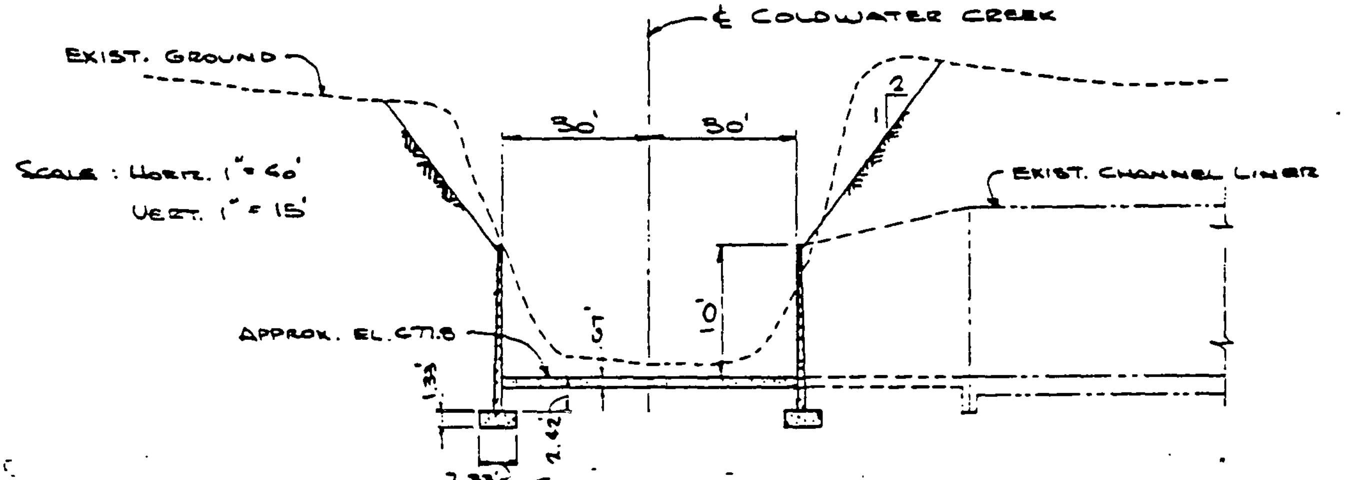
PADDOCK CR. JUNCTION

(CANTILEVER RET. WALL)

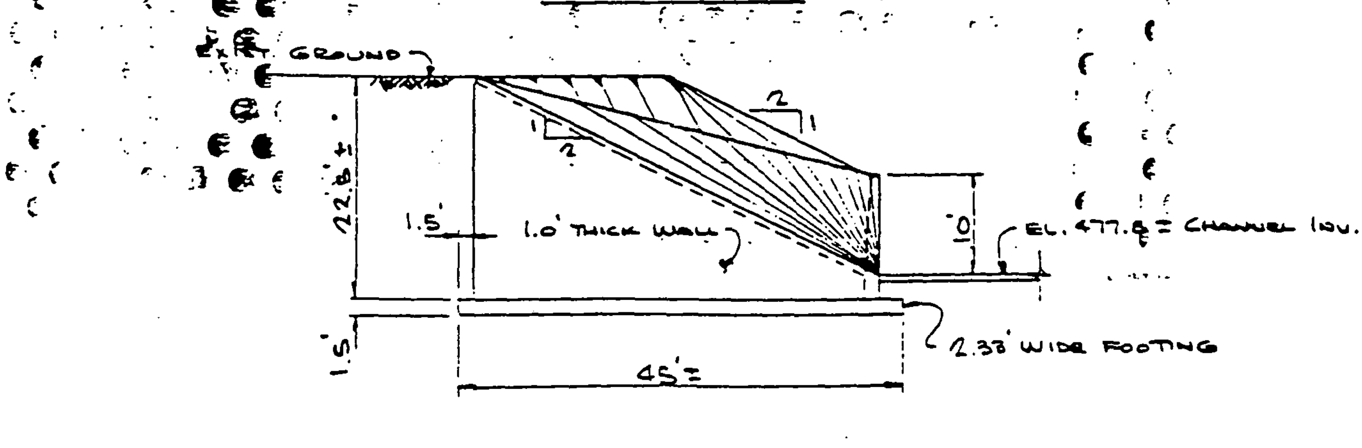


PLAN

SCALE: 1" = 100'



SECTION A-A



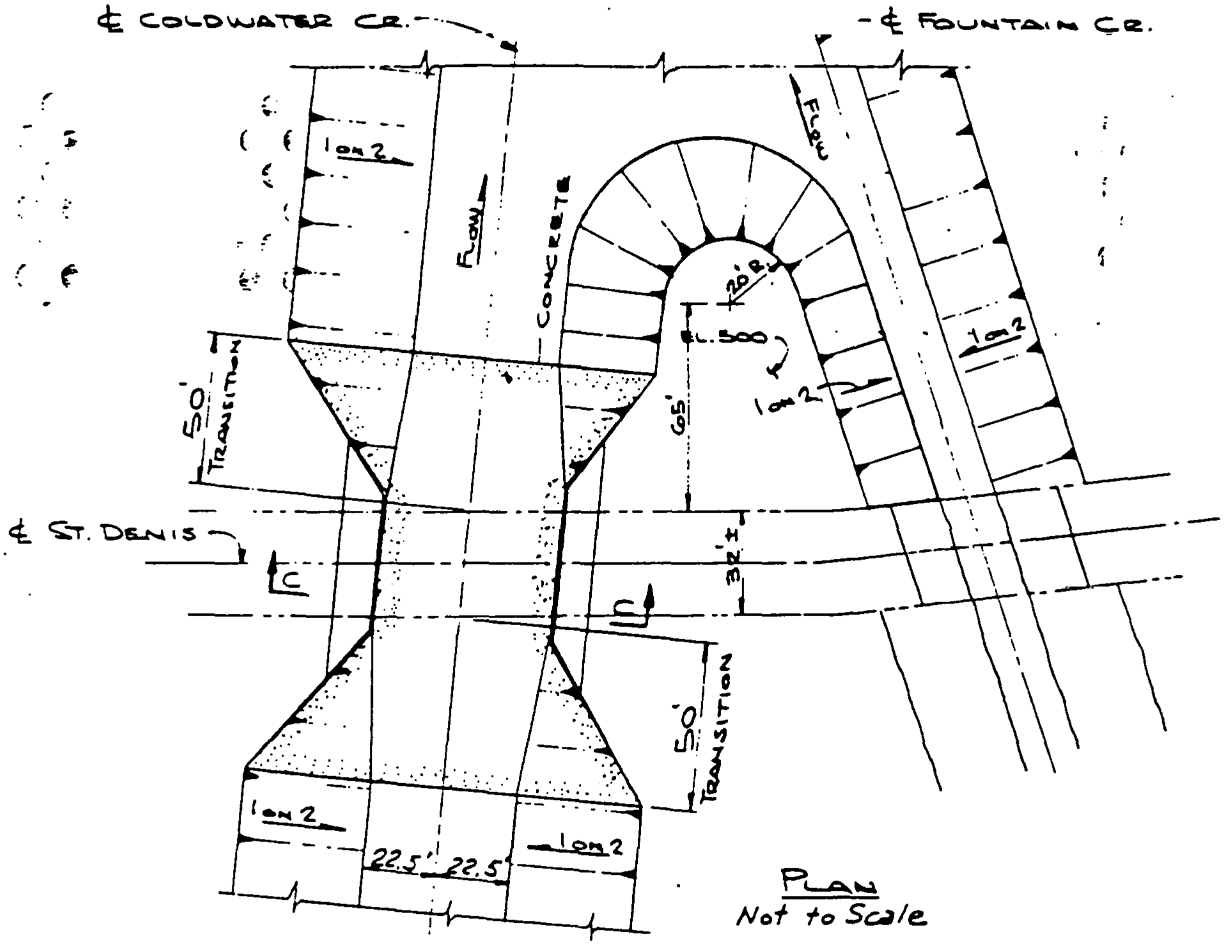
SECTION B-B

SCALE: 1" = 20'

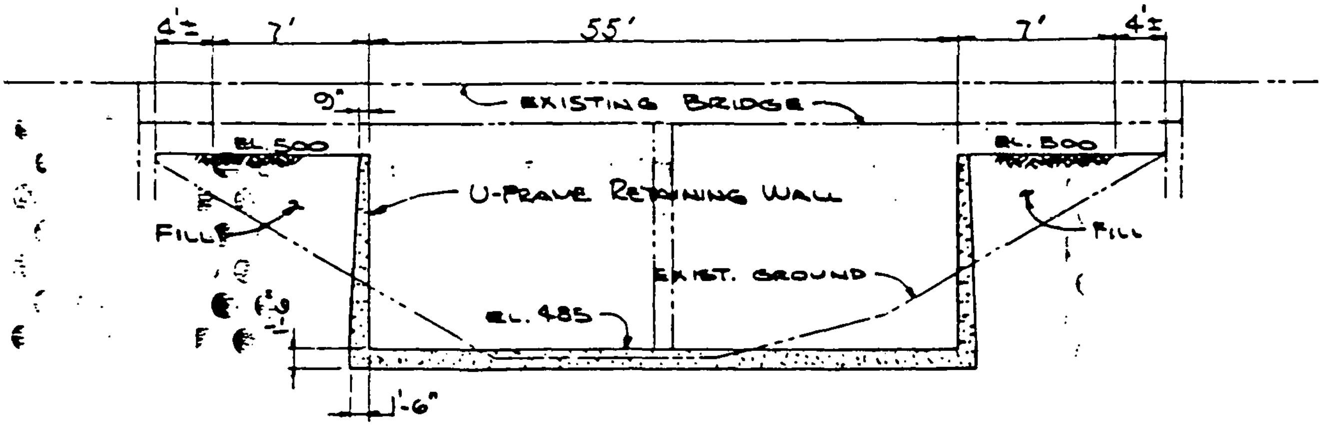
PROJECT		COMPUTED BY	DATE
Coldwater Creek Study	Page 6 of __	Stohl	7 Dec 83
SUBJECT		CHECKED BY	DATE
Lower Coldwater - 10 Year Plan - Measure C-5			

REV.: 28 APR 86

St. Denis Avenue



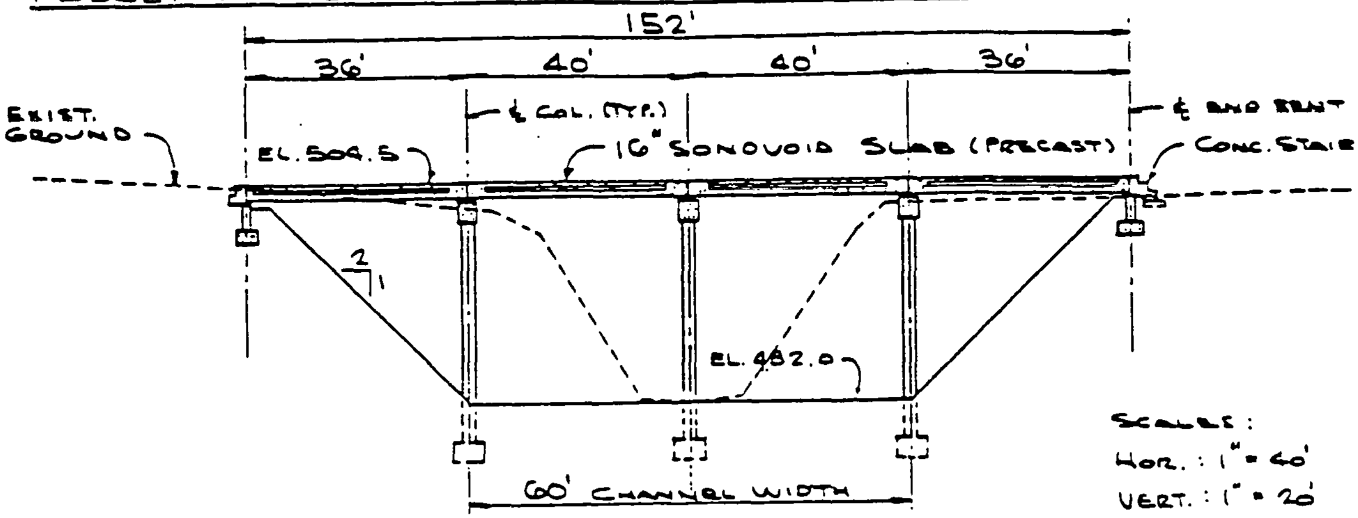
PLAN
Not to Scale

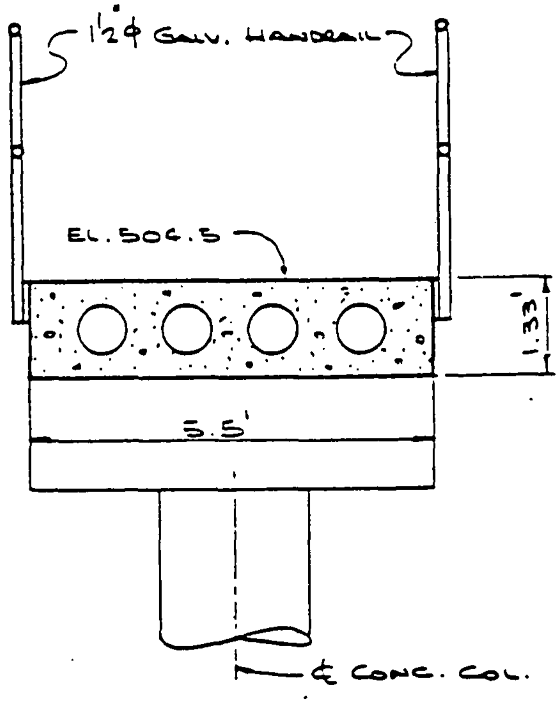


SECTION C-C
Not to Scale

PROJECT		COMPUTED BY	DATE
Coldwater Creek Study	Page 30 of __	Stohl	12 APR 1983
SUBJECT	MEASURE	CHECKED BY	DATE
Lower Coldwater - 10 Year Plan -	C-5		

Pedestrian Bridge (St. Ferdinand Park)





Typical Section
Thru Slab
Scale: 3/8" = 1'-0"

COLDWATER CREEK, MISSOURI

FEASIBILITY REPORT

APPENDIX D

RECREATION

COLDWATER CREEK RECREATION APPENDIX

COLDWATER CREEK RECREATION APPENDIX

1. Recreation Objective

The authorizing resolutions directed the Corps of Engineers to study recreation in relation to flood control in the Coldwater Creek Basin. Regulations of the Corps of Engineers directs that this study should evaluate the existing recreation and, where possible, improve and increase the quality and quantity of recreation opportunities within the study area. As directed by Public Law 89.72, all Corps of Engineer studies, where applicable, must evaluate the opportunities for recreation.

2. Inventory of Existing Facilities in the Coldwater Creek Basin

The study of existing recreation areas within the Coldwater Creek Basin has been examined in three segments to conform to the opportunities afforded by the project lands of the various flood control proposals. Recreation features of all plans will be established on project lands. All discussions of the proposed recreation plans are limited to the Recreation Market Areas (RMA) for the plans presented. See Plate 1 following.

a. Recreation Plan 1 (Rec Plan 1). There are three cities that lie in RMA of Rec Plan 1.

(1) Berkeley has 61.4 acres of parks in the area. These lands lie in 2 parks.

(2) Florissant has ten parks within the designated RMA. The acreage within the area totals 119.3 acres.

(3) The City of Hazelwood maintains eight separate parks in the RMA and has 72.3 acres of parkland in use.

b. Recreation Plan 2 (Rec Plan 2). In the RMA of Rec Plan 2, there are four cities.

(1) Breckenridge Hills has 3.3 acres in two parks.

(2) The City of Edmondson has one park with 3.4 acres that at present is undeveloped.

(3) St. Ann maintains three developed parks in the assigned area with 77.4 acres. Principal developments are the St. Ann Golf Course and St. Ann Park, which are contiguous developments and are in the flood plain.

(4) The citizens of Woodson Terrace have two parks with 16.8 acres.

c. Recreation Plan 3 (Rec Plan 3). Within the RMA of Rec Plan 3, neither St. Louis County nor Florissant maintain parks at the present time.

3. Recreation Demand

The population for the combined Recreation Plans are displayed in Table 1 below and are projected for the life of the project. Historical populations are displayed in the Economic Evaluation of Coldwater Creek.

The area within Rec Plan 1 and 2 are served with diverse recreation opportunities, although needs for additional facilities do exist. Table 2 details the deficiencies that can be considered for improvement by the Flood Control Plans studied.

3.1 The Recreation Market Areas

Plate 1 displays the RMA's of each Rec Plan. Boundaries for the RMA were established to reasonable limits for the recreation use as well as alternate transportation routes for travel to parks, schools, churches, public facilities, and locations of employment.

McDonnell-Douglas Corporation provided statistics* regarding the domiciles of their employees. These figures show that 11.64% of the 35,000 employees live in Illinois. Employees from Missouri who reside outside St. Louis City and County make up 30.84% of the total work force.

Applying this information to the total estimate employees (1990)** within the Coldwater Creek Basin, 9,969 people are Illinois residents and 26,415 employees live outside the City and County of St. Louis. These employees add significantly to the total number of people who can participate in recreation pursuits within the Coldwater Creek Basin. These numbers represent a substantial regional demand for the recreation equation in the RMA.

Many of the employers have located near or adjacent to the creek, therefore the facilities will be readily available for noontime and after work use. Shift schedules are common from many plants in the area, so recreation demand can occur at varying intervals throughout the day.

4. Future Recreation Resources Without Project.

Most of the cities within the basin have Master Plans or Development Plans that identify deficiencies or desires for additional recreation development. All Government Agencies have indicated that funding is now programmed on annual or a biannual basis. Due to the present economic and taxing problems, long term goals and programs are severely restricted. Agencies have indicated an interest in increasing recreation opportunities when additional lands and funds are available.

* These statistics are on file in LMSPD-E.
** See Economics Supporting Documentation, APPENDIX, Page 22, Table 8.

5. Recreation Opportunities.

Details of deficiencies for the various Recreation Plans were obtained from "Recreation Spaces - Community Places - 1982-2000 - by St. Louis County Parks & Recreation Department. The selected features displayed in Table 2 were chosen because they could be accommodated on the project lands required for flood control in the plans developed. The recreation features include hiking and biking trails in all RMA's and picnicking in Rec Plan 1. This Plan provided two small parcels of land suitable for picnic shelter development.

6. Summary of Recreation Plans

6.1 Recreation Points

Before evaluating recreation opportunities associated with the flood control plans, points for general recreation were evaluated as directed by the Economic & Environmental Principles & Guidelines for Water and Related Land Resources Implementation Studies. Based on knowledge of the quality of the existing recreation facilities in the study area and comparison with other local recreation developments, point assignments were selected as follows:

TABLE I
POPULATIONS FOR RECREATION MARKET AREAS (RMA)

RECREATION PLAN 1*													
CITIES	1990	*** 1995	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2094
Berkeley (10%)	1,692	1,721	1,750	1,793	1,837	1,882	1,901	1,920	1,939	1,959	1,978	2,001	2,022
Florissant (66%)	38,309	38,968	39,627	40,597	41,592	42,612	43,037	43,468	43,903	44,342	44,785	45,228	45,450
Hazelwood	13,559	13,792	14,026	14,369	14,721	15,082	15,233	15,385	15,539	15,695	15,851	16,007	16,090
	53,560	54,481	55,403	56,759	58,150	59,676	60,171	60,773	61,381	61,999	62,614	63,242	63,562
RECREATION PLAN 2*													
CITIES													
Breckenridge Hills 65%	4,787	5,505	6,224	6,286	6,348	6,411	6,475	6,539	6,604	6,670	6,736	6,803	6,837
Edmunson 90%	1,307	1,347	1,377	1,475	1,559	1,575	1,592	1,609	1,626	1,643	1,660	1,678	1,696
Overland 10%	2,550	2,932	3,315	3,348	3,381	3,414	3,468	3,536	3,571	3,606	3,642	3,678	3,696
St. Ann 50%	6,798	7,012	7,226	7,660	8,119	8,205	8,291	8,358	8,446	8,535	8,625	8,716	8,762
Woodson Terrace 40%	1,930	1,992	2,052	2,175	2,305	2,324	2,353	2,378	2,403	2,428	2.453	2.480	2.402
	17,372	18,788	20,205	20,944	21,712	21,934	22,179	22,420	22,650	22,882	23,116	23,354	23,483
RECREATION PLAN 3**													
RMA As Detailed On Map	12,880	13,265	13,650	13,794	13,940	14,087	14,236	14,386	14,548	14,702	14,857	15,014	15,093

* Populations Based on OBERS by LMSPD-E
** Populations Provided by St. Louis Co. Planning Commission 3/5/86
*** Assumed to be the Base Year of Recreation Use

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CRITERIA	JUDGMENT FACTORS	TOTAL POSSIBLE POINTS	SELECTED POINTS
Recreation Experience	Several general activities.	30	10
Availability of Opportunity	Several within 1 hour, few within 30 minutes.	18	3
Carrying Capacity	Adequate facilities to conduct without deterioration of the Resource or Activity Experience.	14	7
Accessibility	Good access, good roads to site.	18	14
Environmental Quality	Average aesthetic quality, factors exist that lower quality to a minor degree.	20	6
	TOTALS	100	30

The conversion of total points to dollar values is displayed on TABLE VIII-3-1 of Economic & Environmental Principals & Guidelines, dated March 10, 1983, with the price level updated to October 1985. The conversion resulted in a $2.60 value for a recreation visitor occasion.

6.2 Components of Recreation Plans

a. Rec Plan 1. This plan provides 5.97 miles of trails for hiking and biking use. Included are two picnic shelters for a total of 16 picnic tables. Seven fords and 4'0" high chain link fencing are included in the Recreation Plan.

b. Rec Plan 2. The recreation features of this plan will provide 1.75 miles of hiking and biking trails. A ford and a 4'0" chain link fence through residential areas complete the Recreation Plan.

c. Rec Plan 3. The recreation corridor for this segment will provide 1.97 miles that will be developed for hiking and biking use. The residential areas will be fenced with a 4'0" chain link fence.

6.3 Values of Rec Plans Added to (Flood Control) Plans

a. Rec Plan 1 and Rec Plan 2 are combined in (Flood Control) Plan 1 and will yield $274,758 average annual benefits for recreation.

b. (Flood Control) Plan 2 adds all the components of Rec Plans 1, 2, and 3 for a total of $340,418 average annual recreation benefits.

c. (Flood Control) Plan 3 combines Rec Plans 1 and 2 for a to[illegible] $274,758 average annual benefits.

6.4 Recreation Objective Fulfillment

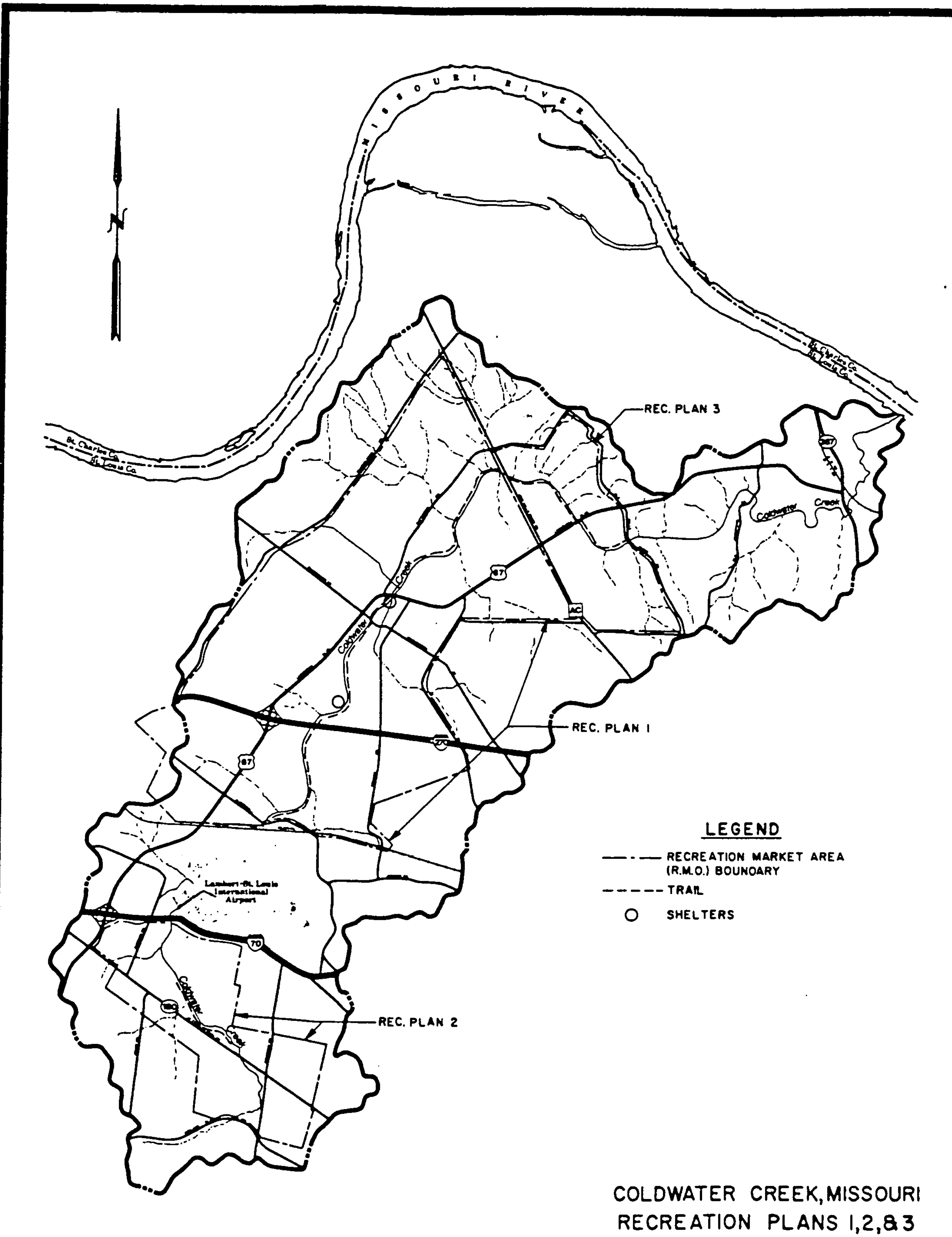
The stated objective of the recreation components was to increas[illegible] quantity and quality of recreation opportunities within the study area[illegible] Table 2 provides a summary of existing recreation facilities, a comparis[illegible] existing and proposed facilities, the unmet needs, and the visitor occ[illegible] that will be generated by selected recreation features. Table 2 also [illegible] the Average Annual Benefits and the Benefit/Cost Ratio of each recreati[illegible]

TABLE 2
COMPARISON OF RECREATION PLANS 1, 2, & 3

EVALUATION OF EXISTING & PROPOSED RECREATION FEATURES IN RMA

	Features Recreation	Existing Features	Present Unmet Needs	Features In Rec Plan	Remaining Unmet Needs	Visitor Occasions/ Rec Features	Total Benefits By Rec Plan	Benefit/ Cost Ratio (Oct 1985 Price Level)	Benefits By Plan **	Benefit/ Cost Ratio (Oct 1985 Price Level)
REC PLAN 1		*								
	Hiking Trails	1.8M	-22.0M	5.97M	-16.03M	30,142				
	Biking Trails	1.8M	-45.1M	5.97M	-39.13M	44,863				
	Picnic Tables	150	-20	16	-4	6,075				
						81,080	X $2.60 = $210,808	4.19		
REC PLAN 2										
	Hiking Trails	0	-16.1M	1.75M	-14.35M	9,445				
	Biking Trails	0	-32.5M	1.75M	-30.75M	15,151				
						24,596	X $2.60 = $63,950	5.20		
REC PLAN 3										
	Hiking Trail	0	-20.1M	1.97M	-18.13M	10,161				
	Biking Trail	0	-26.7M	1.97M	-24.73M	15,093				
						26,254	X $2.60 = $65,660	5.53		
PLAN 1	Combines REC PLAN 1 & 2								$274,758	4.39
PLAN 2	Combines REC PLAN 1, 2, & 3								$340,418	4.57
PLAN 3	Combines Rec Plan 1 & 2								$274,758	4.39

* Miles
** Benefits are Average Annual



COLDWATER CREEK, MISSOURI
RECREATION PLANS 1,2,&3

PLATE 1

COLDWATER CREEK, MISSOURI

FEASIBILITY REPORT

APPENDIX E

REAL ESTATE

TABLE 1
REAL ESTATE COSTS OF PLANS
OCTOBER 1985 PRICE LEVEL

	Plan 1	Plan 2	Plan 3
Measure CS-1	$ 0	-	-
Measure C-9	-	$624,000	-
Measure C-5	2,896,000	2,896,000	$2,896,000
Measure C-20	405,000	405,000	405,000
Measure L-7	5,000	5,000	5,000
Measure L-8	10,000	10,000	10,000
Measure R-1	0	0	0
Measure R-2	0	0	0
Measure R-3	-	0	-
Total	$3,316,000	$3,940,000	$3,316,000

TABLE 2
UPDATE OF REAL ESTATE COSTS
FOR MEASURES INCLUDED IN PLAN 1, 2 OR 3
OCTOBER 1985 PRICE LEVEL

	Update to October 1985 Price Level ($1,000)	Original Appraisals			
		Source	Lands & Dam. ($1,000)	Acquis. & PL ($1,000)	Total ($1,000)
Measure CS-1 ($0)	0	Paragraph 7 of C-5 text	0	0	0
Measure C-9 ($624,000)	(1) Increase Lands & Damages total by 10 percent	Channel Row			
		Map 7-H-2	49	37	86
	437 x 1.1 = 481	Map 6-H-3	120	29	149
		Map 6-H-4	8	14	22
	(2) Add updated Lands & Damages to same Acquisition & PL 91-646 to get total October 1985 Real Estate Cost	Map 6-H-1	35	41	76
		Subtotal	212	121	333
		Disposal Areas			
	481 + 143 = 624				
		Map 7-H-2	126	5	131
		Map 6-H-4	99	17	116
		Subtotal	225	22	247
		Total	437	143	580
Measure C-5 ($2,896,000)	(1) Increase Lands and Damages total by 10 percent	Channel Row			
		Map 6-J-2	36	36	72
	1,771 x 1.1 = 1,948	Map 6-J-3	69	40	109
		Map 7-J-2	93	106	199
		Map 7-J-1	59	76	135
		Map 7-J-4	114	126	240

TABLE 2 (Continued)
UPDATE OF REAL ESTATE COSTS
FOR MEASURES INCLUDED IN PLAN 1, 2 OR 3
OCTOBER 1985 PRICE LEVEL

	Update to October 1985 Price Level ($1,000)
Measure C-5 (continued)	(2) Add updated Lands & Damages to same Acquisition & PL 91-646 to get total October 1985 Real Estate Cost 1,948 + 948 = 2,896

	Original Appraisals		
Source	Lands & Dam. ($1,000)	Acquis & PL ($1,000)	Total ($1,000)
Map 8-J-1	8	10	18
Map 8-K-2	259	40	299
Map 8-K-3	244	66	310
Map 9-K-2	67	50	117
Map 9-K-1	12	50	62
Map 9-K-4	531	70	601
Map 10-K-1	71	20	91
Map 10-K-4	83	10	93
Map 10-L-3	26	10	36
Subtotal	1,672	710	2,382
Disposal Areas			
Disposal Area 1	0	10	10
Disposal Area 2	0	6	6
Disposal Area 3	4	6	10
Disposal Area 4	0	0	0
Disposal Area 5	0	6	6
Disposal Area 6	0	6	6
Disposal Area 7	0	6	6
Disposal Area 8	0	6	6
Disposal Area 9	0	10	10
Disposal Area 10	0	10	10
Disposal Area 11	0	6	6
Disposal Area 12	0	46	46
Disposal Area 13	0	30	30
Disposal Area 14	0	26	26
Disposal Area 15	0	6	6
Disposal Area 16	0	6	6
Disposal Area 17	0	16	16

TABLE 2 (Continued)
UPDATE OF REAL ESTATE COSTS
FOR MEASURES INCLUDED IN PLAN 1, 2 OR 3
OCTOBER 1985 PRICE LEVEL

	Update to October 1985 Price Level ($1,000)	Original Appraisals Source	Lands & Dam. ($1,000)	Acquis & PL ($1,000)	Total ($1,000)
Measure C-5 (continued)		Disposal Area 18	0	6	6
		Disposal Area 19	0	6	6
		Disposal Area 20	0	6	6
		Disposal Area 21	15	6	21
		Disposal Area 22	56	6	62
		Disposal Area 23	24	0	24
		Disposal Area 24	0	6	6
		Subtotal	99	238	337
		Total	1,771	948	2,719
Measure C-20 ($405,000)	(1) Increase Lands & Damages total by 10 percent	Channel Row			
	55 x 1.1 = 61	Measure C-11 (Plan C-4, Reach CC-9A)	11	10	21
	(2) Add updated Lands & Damages to same Acquisition & PL 91-646 to get total October 1985 Real Estate Cost	Measure C-12A[1]	0	0	0
		Measure C-12 (Plan C-4, Reach CC-9B)	0	0	0
	61 + 344 = 405	Measure C-13 (Plan C-4, Reach CC-10A)	44	56	100
		Measure C-16 (Plan C-4, Reach CC-10B)	0	278	278
		Total	55	344	399
		Disposal Areas[2]			0

TABLE 2 (Continued)
UPDATE OF REAL ESTATE COSTS
FOR MEASURES INCLUDED IN PLAN 1, 2 OR 3
OCTOBER 1985 PRICE LEVEL

	Update to October 1985 Price Level ($1,000)	Original Appraisals: Source	Lands & Dam. ($1,000)	Acquis & PL ($1,000)	Total ($1,000)
Measure L-7 ($5,000)	(1) Increase Lands & Damages total by 10 percent 0 x 1.1 = 0 (2) Add updated Lands & Damages to same Acquisition & PL 91-646 to get total October 1985 Real Estate Cost 0 + 5 = 5	Non-Structural Levee #2-WB, without borrow areas, Map 8-K-2	0	5	5
Measure L-8 ($10,000)	(1) Increase Lands & Damages total by 10 percent 0 x 1.1 = 0 (2) Add updated Lands & Damages to same Acquisition & PL 91-646 to get total October 1985 Real Estate Cost 0 + 10 = 10	Plan C-5 & N-3 Map 9-K-2	0	10 3/	10 3/
Measure R-1 4/ ($0)	0		0	0	0
Measure R-2 4/ ($0)	0		0	0	0

TABLE 2 (Continued)
UPDATE OF REAL ESTATE COSTS
FOR MEASURES INCLUDED IN PLAN 1, 2 OR 3
OCTOBER 1985 PRICE LEVEL

	Update to October 1985 Price Level ($1,000)	Original Appraisals			
		Source	Lands & Dam. ($1,000)	Acquis & PL ($1,000)	Total ($1,000)
Measure R-3 4/ ($0)	0		0	0	0

1/ Real estate cost for Measure C-12A is zero because this short segment of channel widening is within the existing Metropolitan St. Louis Sewer District right-of-way.

2/ For the channel widening segments in Measure C-20, the engineering assumption was made that excavated material would be taken by private and public interests and that no disposal areas would be needed.

3/ The engineering decision was made to shift the alignment of this small levee so that only 2 ownerships would be affected.

4/ The recreation measures would be constructed on flood control project lands.

COLDWATER CREEK, MISSOURI

FEASIBILITY REPORT

APPENDIX F

COST ESTIMATE

TABLE 1
COLDWATER CREEK
DETAILED COST ESTIMATES BY MEASURE
OCTOBER 1985 PRICE LEVEL

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	MEASURE CS-1				
09.	Channels and Canals				($125,000)
	Light Clearing	12	Acre	$1,000.00	$12,000
	Heavy Clearing and Snagging	25	Acre	3,500.00	87,500
				Subtotal	$99,500
				Contingencies	25,500
		TOTAL CHANNELS AND CANALS			$125,000
30.	ENGINEERING AND DESIGN	Sum	Job		14,000
31.	SUPERVISION AND ADMINISTRATION	Sum	Job		11,000
		TOTAL FOR MEASURE CS-1			$150,000
	MEASURE C-5				
01.	Lands and Damages	Sum	Job		$2,896,000
02.	Relocations				($92,000)
	Sewer Alterations	Sum	Job		30,400
	Utility Alterations	Sum	Job		10,100
	Footbridge-Mile 9.83	Sum	Job		23,000
	Footbridge-Mile 11.63	Sum	Job		10,000
				Subtotal	$73,500
				Contingencies	18,500
		TOTAL RELOCATIONS			$92,000
09.	Channels and Canals				($8,162,000)
	Excavation	750,000	Cy	$5.00	$3,750,000
	Clearing	25	Acre	1,000.00	25,000
	Seeding	185	Acre	1,000.00	185,000
	Riprap	43,000	Ton	20.00	860,000
	Bedding Material	22,000	Ton	18.00	396,000
	Ground Stabilizing Fabric	6,000	SY	9.00	54,000
	Concrete Channel Lining	Sum	Job		1,220,000
	Radiological Monitoring	Sum	Job		100,000
	Trees	Sum	Job		30,000
				Subtotal	$6,620,000
				Contingencies	1,542,000
		TOTAL CHANNELS AND CANALS			$8,162,000

TABLE 1 (Continued)
COLDWATER CREEK
DETAILED COST ESTIMATES BY MEASURE
OCTOBER 1985 PRICE LEVEL

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	MEASURE C-5 (Continued)				
30.	ENGINEERING AND DESIGN				$1,000,000
31.	SUPERVISION AND ADMINISTRATION				750,000
		TOTAL FOR MEASURE C-5			$12,900,000
	MEASURE C-9				
01.	Lands and Damages	Sum	Job		$624,000
02.	Relocations				($82,000)
	Sewer Alterations	Sum	Job		16,000
	Utility Alterations	Sum	Job		50,000
			Subtotal		$66,000
			Contingencies		16,000
		TOTAL RELOCATIONS			$82,000
09.	Channels and Canals				($1,893,000)
	Excavation	70,800	CY	5.00	$354,000
	Clearing	5	Acre	1,000.00	5,000
	Seeding	24	Acre	1,000.00	24,000
	Riprap	10,400	Ton	20.00	208,000
	Bedding Material	5,200	Ton	18.00	93,600
	Tunnels (8 ft. dia. 5 each)	Sum	Job		650,000
	Concrete Channel Lining	Sum	Job		158,000
	Trees	Sum	Job		10,000
			Subtotal		$1,502,600
			Contingencies		390,400
		TOTAL CHANNELS AND CANALS			$1,893,000
30.	ENGINEERING AND DESIGN	Sum	Job		232,000
31.	SUPERVISION AND ADMINISTRATION	Sum	Job		169,000
		TOTAL FOR MEASURE C-9			$3,000,000

TABLE 1 (Continued)
COLDWATER CREEK
DETAILED COST ESTIMATES BY MEASURE
OCTOBER 1985 PRICE LEVEL

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	MEASURE C-20				
01.	Lands and Damages	Sum	Job		$405,000
02.	Relocations	--			($406,000)
	Sewer Alterations	Sum	Job		245,000
	Utility Alterations	Sum	Job		45,000
	Footbridge - Mile 15.80	Sum	Job		15,000
	Footbridge - Mile 17.15	Sum	Job		10,000
	Footbridge - Mile 17.80	Sum	Job		10,000
			Subtotal		$325,000
			Contingencies		81,000
		TOTAL RELOCATIONS			$406,000
09.	Channels and Canals				($1,503,000)
	Excavation	100,000	Cy	5.00	$500,000
	Clearing	15	Acre	1,000.00	15,000
	Seeding	6	Acre	1,000.00	6,000
	Riprap	15,000	Ton	20.00	300,000
	Bedding Material	7,500	Ton	18.00	135,000
	Concrete Channel Lining	Sum	Job		225,000
	Trees	Sum	Job		10,000
			Subtotal		$1,191,000
			Contingencies		312,000
		TOTAL CHANNELS AND CANALS			$1,503,000
30.	ENGINEERING AND DESIGN	Sum	Job		216,000
31.	SUPERVISION AND ADMINISTRATION	Sum	Job		170,000
		TOTAL FOR MEASURE C-20			$2,700,000
	MEASURE L-7				
01.	Lands and Damages	Sum	Job		5,000

TABLE 1 (Continued)
COLDWATER CREEK
DETAILED COST ESTIMATES BY MEASURE
OCTOBER 1985 PRICE LEVEL

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	MEASURE L-7 (Continued)				
11.	Levees				($12,000)
	Embankment	2,000	Cy	3.00	6,000
	30-inch CMP with flapgate	40	LF	35.00	1,400
	Clearing	0.6	Acre	1,000.00	600
	Seeding	0.6	Acre	1,000.00	600
			Subtotal		$ 8,600
			Contingencies		3,400
		TOTAL LEVEES			$12,000
30.	ENGINEERING AND DESIGN	Sum	Job		$1,700
31.	SUPERVISION AND ADMINISTRATION	Sum	Job		1,300
		TOTAL FOR MEASURE L-7			$20,000
	MEASURE L-8				
01.	Lands and Damages	Sum	Job		$10,000
11.	Levees				($12,000)
	Embankment	2,200	Cy	3.00	6,600
	Ditch excavation	125	Cy	3.00	375
	Clearing	0.6	Acre	1,000.00	600
	Seeding	0.6	Acre	1,000.00	600
	30-inch CMP with flapgates	40	LF	35.00	1,400
			Subtotal		$9,575
			Contingencies		2,425
		TOTAL LEVEES			$12,000
30.	ENGINEERING AND DESIGN	Sum	Job		$1,700
31.	SUPERVISION AND ADMINISTRATION	Sum	Job		$1,300
		TOTAL FOR MEASURE L-8			$25,000
	FLOOD FORECASTING SYSTEM				
20.	Permanent Operating Equipment	Sum	Job		$28,000
			Subtotal		$28,000
			Contingencies		7,000
		TOTAL			$35,000

TABLE 1 (Continued)
COLDWATER CREEK
DETAILED COST ESTIMATES BY MEASURE
OCTOBER 1985 PRICE LEVEL

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	FLOOD FORECASTING SYSTEM (Continued)				
30.	ENGINEERING AND DESIGN	Sum	Job		$20,000
31.	SUPERVISION AND ADMINISTRATION	Sum	Job		$15,000
		TOTAL FLOOD FORECASTING SYSTEM			$70,000
	MEASURE R-1				
14.	Recreation				($475,000)
	Hiking Trail (6 miles)	Sum	Job		$200,000
	Culverts (I-270)	Sum	Job		6,000
	Fords	7	Each	2,500.00	17,500
	Shelter at R.M. 11.8	Sum	Job		30,000
	Shelter at R.M. 10.2	Sum	Job		47,000
	Fence, 4 ft. chain link	11,250	L.F.	7.00	78,750
			Subtotal		$379,250
			Contingencies		95,750
		TOTAL RECREATION			$475,000
30.	ENGINEERING AND DESIGN	Sum	Job		$57,000
31.	SUPERVISION AND ADMINISTRATION	Sum	Job		38,000
		TOTAL FOR MEASURE R-1			$570,000
	MEASURE R-2				
14.	Recreation				($64,000)
	Hiking Trail (1.2 miles)	Sum	Job		40,000
	Fence, 4 ft. chain link	1,200	L.F.	7.00	8,400
	Fords	1	Each	2,500.00	2,500
			Subtotal		$50,900
			Contingencies		13,100
		TOTAL RECREATION			$64,000
30.	ENGINEERING AND DESIGN	Sum	Job		$8,000
31.	SUPERVISION AND ADMINISTRATION	Sum	Job		$5,000
		TOTAL FOR MEASURE R-2			$77,000

TABLE 1 (Continued)
COLDWATER CREEK
DETAILED COST ESTIMATES BY MEASURE
OCTOBER 1985 PRICE LEVEL

Cost Acct. No.	Item	Quantity	Unit	Unit Price	Total Estimated Cost
	MEASURE R-3				
14.	Recreation				($110,000)
	Hiking Trail (2 miles)	Sum	Job		$70,000
	Fence, 4 ft. chain link	2,700	L.F.	7.00	18,900
			Subtotal		$88,900
			Contingencies		21,100
		TOTAL RECREATION			$110,000
30.	ENGINEERING AND DESIGN	Sum	Job		$15,000
31.	SUPERVISION AND ADMINISTRATION	Sum	Job		10,000
		TOTAL FOR MEASURE R-3			$135,000

TABLE 2
COLDWATER CREEK
COST ESTIMATES OF PLANS
OCTOBER 1985 PRICE LEVEL ($1,000)

COST ACCOUNT NUMBER	Structural Flood Control Measures						Nonstructural Flood Control Measures	Recreation Measures			
	CS-1	C-5	C-9	C-20	L-7	L-8	FLOOD FORECASTING SYSTEM	R-1	R-2	R-3	TOTAL
PLAN 1											
01 Lands and Damages		2,896.0		405.0	5.0	10.0					3,316.0
02 Relocations		92.0		406.0							498.0
09 Channels and Canals	125.0	8,162.0		1,503.0							9,790.0
11 Levees and Floodwalls					12.0	12.0					24.0
14 Recreation								475.0	64.0		539.0
20 Perm Operating Equip							35.0				35.0
30 Engineering and Design	14.0	1,000.0		216.0	1.7	1.7	20.0	57.0	8.0		1,318.4
31 Supervision and Admin	11.0	750.0		170.0	1.3	1.3	15.0	38.0	5.0		991.6
TOTAL	150.0	12,900.0	-	2,700.0	20.0	25.0	70.0	570.0	77.0	-	16,512.0
PLAN 2											
01 Lands and Damages		2,896.0	624.0	405.0	5.0	10.0					3,940.0
02 Relocations		92.0	82.0	406.0							580.0
09 Channels and Canals		8,162.0	1,893.0	1,503.0							11,558.0
11 Levees and Floodwalls					12.0	12.0					24.0
14 Recreation								475.0	64.0	110.0	649.0
20 Perm Operating Equip							35.0				35.0
30 Engineering and Design		1,000.0	232.0	216.0	1.7	1.7	20.0	57.0	8.0	15.0	1,551.4
31 Supervision and Admin		750.0	169.0	170.0	1.3	1.3	15.0	38.0	5.0	10.0	1,159.6
TOTAL	-	12,900.0	3,000.0	2,700.0	20.0	25.0	70.0	570.0	77.0	135.0	19,497.0
PLAN 3											
01 Lands and Damages		2,896.0		405.0	5.0	10.0					3,316.0
02 Relocations		92.0		406.0							498.0
09 Channels and Canals		8,162.0		1,503.0							9,665.0
11 Levees and Floodwalls					12.0	12.0					24.0
14 Recreation								475.0	64.0		539.0
20 Perm Operating Equip							35.0				35.0
30 Engineering and Design		1,000.0		216.0	1.7	1.7	20.0	57.0	8.0		1,304.4
31 Supervision and Admin		750.0		170.0	1.3	1.3	15.0	38.0	5.0		980.6
TOTAL	-	12,900.0	-	2,700.0	20.0	25.0	70.0	570.0	77.0	-	16,362.0

TABLE 3

NON-FEDERAL AND FEDERAL COST SHARING FOR PLANS 1, 2, AND 3
October 1985 Price Levels ($1,000)

		PLAN 1	PLAN 2	PLAN 3
1.	NON-FEDERAL COSTS			
a.	Structural Flood Control			
	01 Lands and Damages	$3,316.0	$3,940.0	$3,316.0
	02 Relocations	498.0	580.0	498.0
	30 Engr & Design for 02 (12% of 02)	60.0	70.0	60.0
	31 Supervision & Admin for 02 (9% of 02)	45.0	52.0	45.0
	Subtotal	3,919.0	4,642.0	3,919.0
	Cash Payment (5% of Non-Fed plus Fed Str Flood Control not Incl $145.0 Radiological Monitoring)	783.0	925.0	775.0
	Total Structural Flood Control	4,702.0	5,567.0	4,694.0
b.	Nonstructural Flood Control			
	20 Permanent Operating Equipment (25%)	9.0	9.0	9.0
	30 Engr & Design for 20 (25%)	5.0	5.0	5.0
	31 Supervision & Admin for 20 (25%)	4.0	4.0	4.0
	Total Nonstructural Flood Control	18.0	18.0	18.0
c.	Total Flood Control	4,720.0	5,585.0	4,712.0
d.	Recreation			
	14 Recreation Facilities (50%)	269.5	324.5	269.5
	30 Engr & Design for 14 (50%)	32.5	40.0	32.5
	31 Supervision & Admin for 14 (50%)	21.5	26.5	21.5
	Total recreation	323.5	391.0	323.5
e.	Total Flood Control plus Recreation	5,043.5	5,976.0	5,035.5
2.	FEDERAL COSTS			
a.	Structural Flood Control			
	09 Channels and Canals	9,790.0	11,558.0	9,665.0
	11 Levees and Floodwalls	24.0	24.0	24.0
	30 Engr & Design	1,173.4	1,381.4	1,159.4
	31 Supervision & Admin	888.6	1,039.6	877.6
	Subtotal	11,876.0	14,003.0	11,726.0
	Less Non-Federal Cash Payment	(783.0)	(925.0)	(775.0)
	Total Structural Flood Control	11,093.0	13,078.0	10,951.0
b.	Nonstructural Flood Control			
	20 Permanent Operating Equipment (75%)	26.0	26.0	26.0
	30 Engr & Design for 20 (75%)	15.0	15.0	15.0
	31 Supervision & Admin for 20 (75%)	11.0	11.0	11.0
	Total Nonstructural Flood Control	52.0	52.0	52.0
c.	Total Flood Control	11,145.0	13,130.0	11,003.0
d.	Recreation			
	14 Recreation Facilities (50%)	269.5	324.5	269.5
	30 Engr & Design for 14 (50%)	32.5	40.0	32.5
	31 Supervision & Admin for 14 (50%)	21.5	26.5	21.5
	Total Recreation	323.5	391.0	323.5
e.	Total Flood Control plus Recreation	11,468.5	13,521.0	11,326.5
3.	NON-FEDERAL PLUS FEDERAL COSTS			
a.	Structural Flood Control	15,795.0	18,645.0	15,645.0
b.	Nonstructural Flood Control	70.0	70.0	70.0
c.	Total Flood Control	15,865.0	18,715.0	15,715.0
d.	Recreation	647.0	782.0	647.0
e.	Total Flood Control Plus Recreation	$16,512.0	$19,497.0	$16,362.5

TABLE 4
ANNUAL OPERATION AND MAINTENANCE COSTS FOR PLANS 1, 2, AND 3
OCTOBER 1985 PRICE LEVEL

PLAN 1	PLAN 1	PLAN 2	PLAN 3
Measure CS-1	10,000	---	---
Measure C-9	---	9,700	---
Measure C-5	16,800	16,800	16,800
Measure C-20	7,200	7,200	7,200
Measure L-7	500	500	500
Measure L-8	500	500	500
Measure R-1	3,200	3,200	3,200
Measure R-2	600	600	600
Measure R-3	---	1,000	---
Flood Forecasting and Warning	500	500	500
TOTAL	$39,300	$40,000	$29,300

TABLE 5
25-YEAR REPLACEMENT COSTS FOR PLANS 1, 2, AND 3
OCTOBER 1985 PRICE LEVEL

	PLAN 1	PLAN 2	PLAN 3
Measure CS-1	0	---	---
Measure C-9	---	57,000	---
Measure C-5	614,100	614,100	614,100
Measure C-20	172,300	172,300	172,300
Measure L-7	3,800	3,800	3,800
Measure L-8	3,800	3,800	3,800
Measure R-1	23,000	23,000	23,000
Measure R-2	2,000	2,000	2,000
Measure R-3	---	2,000	---
Flood Forecasting and Warning	0	0	0
TOTAL	$819,000	$878,000	$819,000

TABLE 6

UPDATED COSTS OF RECOMMENDED PLAN (PLAN 2)
October 1986 Price Levels
(Update Factor = 1.03606)

PROJECT FIRST COSTS

1.	NON-FEDERAL COSTS		
	a.	Structural Flood Control	
		01 Lands and Damages	$4,082,000
		02 Relocations	601,000
		30 Engr & Design for 02 (12% of 02)	72,000
		31 Supervision & Admin for 02 (9% of 02)	54,000
		Subtotal	4,809,000
		Cash Payment (5% of Non-Fed plus Fed Str Flood Control not incl $150,000 Radiological Monitoring)	958,000
		Total Structural Flood Control	5,767,000
	b.	Nonstructural Flood Control	
		20 Permanent Operating Equipment (25%)	9,000
		30 Engr & Design for 20 (25%)	5,000
		31 Supervision & Admin for 20 (25%)	4,000
		Total Nonstructural Flood Control	18,000
	c.	Total Flood Control	5,785,000
	d.	Recreation	
		14 Recreation Facilities (50%)	336,000
		30 Engr & Design for 14 (50%)	41,000
		31 Supervision & Admin for 14 (50%)	27,000
		Total Recreation	404,000
	e.	Total Flood Control Plus Recreation	6,189,000
2.	FEDERAL COSTS		
	a.	Structural Flood Control	
		09 Channels and Canals	11,975,000
		11 Levees and Floodwalls	25,000
		30 Engr & Design	1,431,000
		31 Supervision & Admin	1,077,000
		Subtotal	14,508,000
		Less Non-Federal Cash Payment	(958,000)
		Total Structural Flood Control	13,550,000
	b.	Nonstructural Flood Control	
		20 Permanent Operating Equipment (75%)	27,000
		30 Engr & Design for 20 (75%)	16,000
		31 Supervision & Admin for 20 (75%)	11,000
		Total Nonstructural Flood Control	54,000
	c.	Total Flood Control	13,604,000
	d.	Recreation	
		14 Recreation Facilities (50%)	336,000
		30 Engr & Design for 14 (50%)	41,000
		31 Supervision & Admin for 14 (50%)	27,000
		Total Recreation	404,000
	e.	Total Flood Control Plus Recreation	14,008,000

TABLE 6 (Continued)

UPDATED COSTS OF RECOMMENDED PLAN (PLAN 2)
October 1986 Price Levels
(Update Factor - 1.03606)

3. NON-FEDERAL PLUS FEDERAL COSTS	
a. Structural Flood Control	19,317,000
b. Nonstructural Flood Control	72,000
c. Total Flood Control	19,389,000
d. Recreation	808,000
e. Total Flood Control Plus Recreation	$20,197,000
ANNUAL OPERATION AND MAINTENANCE	
Measure C-9	10,000
Measure C-5	17,400
Measure C-20	7,500
Measure L-7	500
Measure L-8	500
Measure R-1	3,300
Measure R-2	600
Measure R-3	1,000
Flood Forecasting and Warning System	500
Total	$41,300
25-YEAR REPLACEMENT COSTS	
Measure C-9	59,100
Measure C-5	636,200
Measure C-20	178,500
Measure L-7	3,900
Measure L-8	3,900
Measure R-1	23,800
Measure R-2	2,100
Measure R-3	2,100
Flood Forecasting and Warning System	0
Total	$909,600

TABLE 4
ANNUAL OPERATION AND MAINTENANCE COSTS FOR PLANS 1, 2, AND 3
OCTOBER 1985 PRICE LEVEL

PLAN 1	PLAN 1	PLAN 2	PLAN 3
Measure CS-1	10,000	---	---
Measure C-9	---	9,700	---
Measure C-5	16,800	16,800	16,800
Measure C-20	7,200	7,200	7,200
Measure L-7	500	500	500
Measure L-8	500	500	500
Measure R-1	3,200	3,200	3,200
Measure R-2	600	600	600
Measure R-3	---	1,000	---
Flood Forecasting and Warning	500	500	500
TOTAL	$39,300	$40,000	$29,300

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TABLE 6

UPDATED COSTS OF RECOMMENDED PLAN (PLAN 2)
October 1986 Price Levels
(Update Factor = 1.03606)

PROJECT FIRST COSTS

1.	NON-FEDERAL COSTS	
a.	Structural Flood Control	
	01 Lands and Damages	$4,082,000
	02 Relocations	601,000
	30 Engr & Design for 02 (12% of 02)	72,000
	31 Supervision & Admin for 02 (9% of 02)	54,000
	Subtotal	4,809,000
	Cash Payment (5% of Non-Fed plus Fed Str Flood Control not incl $150,000 Radiological Monitoring)	958,000
	Total Structural Flood Control	5,767,000
b.	Nonstructural Flood Control	
	20 Permanent Operating Equipment (25%)	9,000
	30 Engr & Design for 20 (25%)	5,000
	31 Supervision & Admin for 20 (25%)	4,000
	Total Nonstructural Flood Control	18,000
c.	Total Flood Control	5,785,000
d.	Recreation	
	14 Recreation Facilities (50%)	336,000
	30 Engr & Design for 14 (50%)	41,000
	31 Supervision & Admin for 14 (50%)	27,000
	Total Recreation	404,000
e.	Total Flood Control Plus Recreation	6,189,000
2.	FEDERAL COSTS	
a.	Structural Flood Control	
	09 Channels and Canals	11,975,000
	11 Levees and Floodwalls	25,000
	30 Engr & Design	1,431,000
	31 Supervision & Admin	1,077,000
	Subtotal	14,508,000
	Less Non-Federal Cash Payment	(958,000)
	Total Structural Flood Control	13,550,000
b.	Nonstructural Flood Control	
	20 Permanent Operating Equipment (75%)	27,000
	30 Engr & Design for 20 (75%)	16,000
	31 Supervision & Admin for 20 (75%)	11,000
	Total Nonstructural Flood Control	54,000
c.	Total Flood Control	13,604,000
d.	Recreation	
	14 Recreation Facilities (50%)	336,000
	30 Engr & Design for 14 (50%)	41,000
	31 Supervision & Admin for 14 (50%)	27,000
	Total Recreation	404,000
e.	Total Flood Control Plus Recreation	14,008,000

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Formerly Utilized Sites Remedial Action Program (FUSRAP)

ADMINISTRATIVE RECORD

for the St. Louis Site, Missouri

U.S. Department of Energy

4.14-1073.2