DAM FAILURE FLOODPLAIN INFORMATION for the YAMPA RIVER downstream of STAGECOACH RESERVOIR

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1.0 Introduction

The Upper Yampa Water Conservancy District completed construction of Stagecoach dam in 1988. One of its purposes is the generation of hydroelectric power.

Section 12.20(a) of the Federal Energy Regulatory Commission (FERC) regulations requires that every applicant for a license for hydropower generation must develop and file an Emergency Action Plan (EAP) with the Regional Director unless granted a written exemption. An important element of such a plan is the preparation of dam failure inundation maps which are required for all high and significant hazard dams.

The purpose of this report is to document the investigation on the extent of flooding that would result should the dam fail for some reason. This is not intended to reflect upon the integrity of the dam.

The flood boundaries, depths, and travel times shown in this report will be essential in developing an effective Emergency Action Plan for use by local governments in the area. The potentially impacted communities are listed below:

City of Steamboat Springs

Routt County - including the unincorporated areas of Milner and Mt. Harris

Town of Hayden

City of Craig

Moffat County - including the unincorporated areas of Juniper Hot Springs, Maybell, and Sunbeam

This revised analysis incorporates review comments on the Emergency Action Plan made by FERC in a letter dated November 30, 1988 concerning the assumed size of the breach in Stagecoach dam.

2.0 Flood Hydrology

Flood hydrology for the Yampa River has been previously conducted by the Sacramento District of the Army Corps of Engineers for Steamboat Springs and Craig and by the U.S. Bureau of Reclamation for Hayden. A summary of available flood hydrology developed by these agencies is shown in Table 1.

Table 1, Yampa River Flood Hydrology

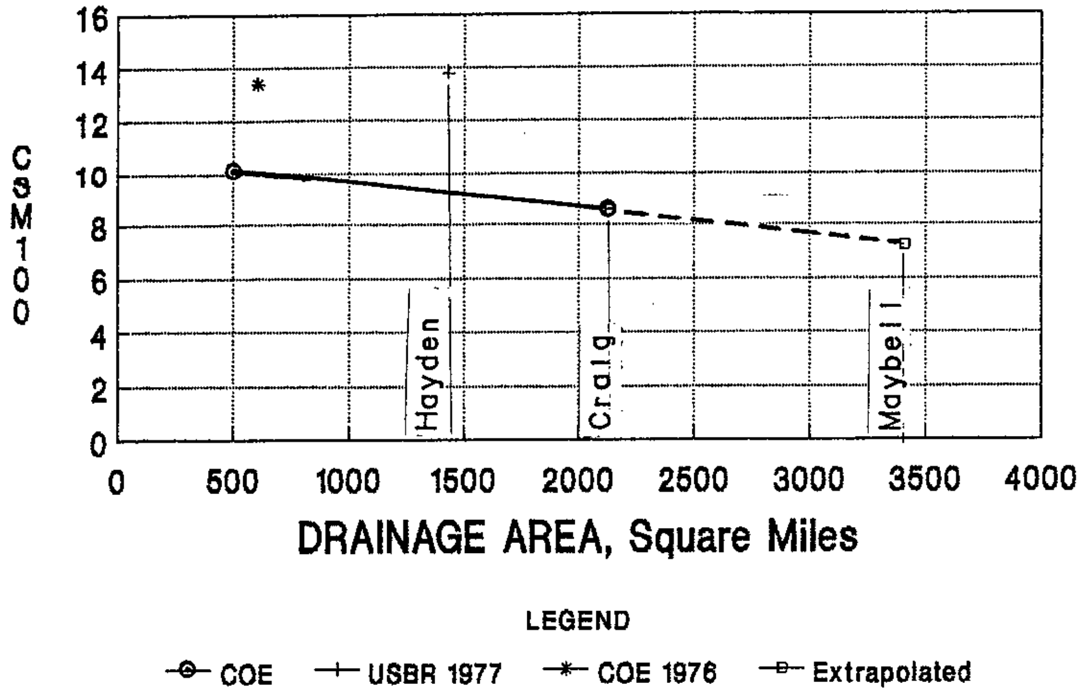
Location	Drainage Area	Peak Discharges, cfs Q10	Q50	Q100	Q500
Agate Creek[1]	493	2,670	4,000	5,000	12,890
Steamboat Springs[1]	604	5,300	6,570	8,000	20,000
Near Hayden[2]	1,430	12,333	16,912	19,131	24,914
Below Craig[3]	2,131	12,000	15,800	18,300	29,000
Near Maybell[4]	3,410			24,550	

[1] U.S. Army Corps of Engineers, Sacramento District, February 1976
[2] U.S. Bureau of Reclamation, December 1977
[3] U.S. Army Corps of Engineers, Sacramento District, November 1977
[4] Estimated from previous studies and trend in runoff per square mile

Extrapolating the Corp's peak discharges for Agate Creek (unit runoff of 10.1 cfs per square mile) and Craig (unit runoff of 8.6 cfs per square mile), we get a 100-year unit runoff at Maybell of 7.2 cfs per square mile. Multiplying this by the drainage area of 3,410 square miles, we get an estimated 100-year peak discharge at Maybell of 24,552 cfs.

The 100-year flood peak discharge is significant since routing of the dam failure flood is generally terminated when the dam failure flood peak discharge has attenuated to a magnitude equal or less than the 100-year flood. The depth of flooding at Steamboat Springs, Hayden and Craig for the 100-year flood varies between 8 and 12 feet above the lowest point in the channel. Flood damages from the 100-year flood or less are expected to be mitigated by local governments through land use planning and zoning regulations.

UNIT RUNOFF vs BASIN AREA
Yampa River, Colorado



Dam failure floods are significantly larger than floods caused by natural precipitation. For example, the flood on Fall River at Estes Park, Colorado, which resulted from the failure of Lawn Lake dam on July 15, 1982 had a peak discharge almost ten times that of the previously estimated 100-year flood and flood depths in Estes Park were over 2 1/2 times the estimated depth of the 500-year flood.

3.0 Stagecoach Dam

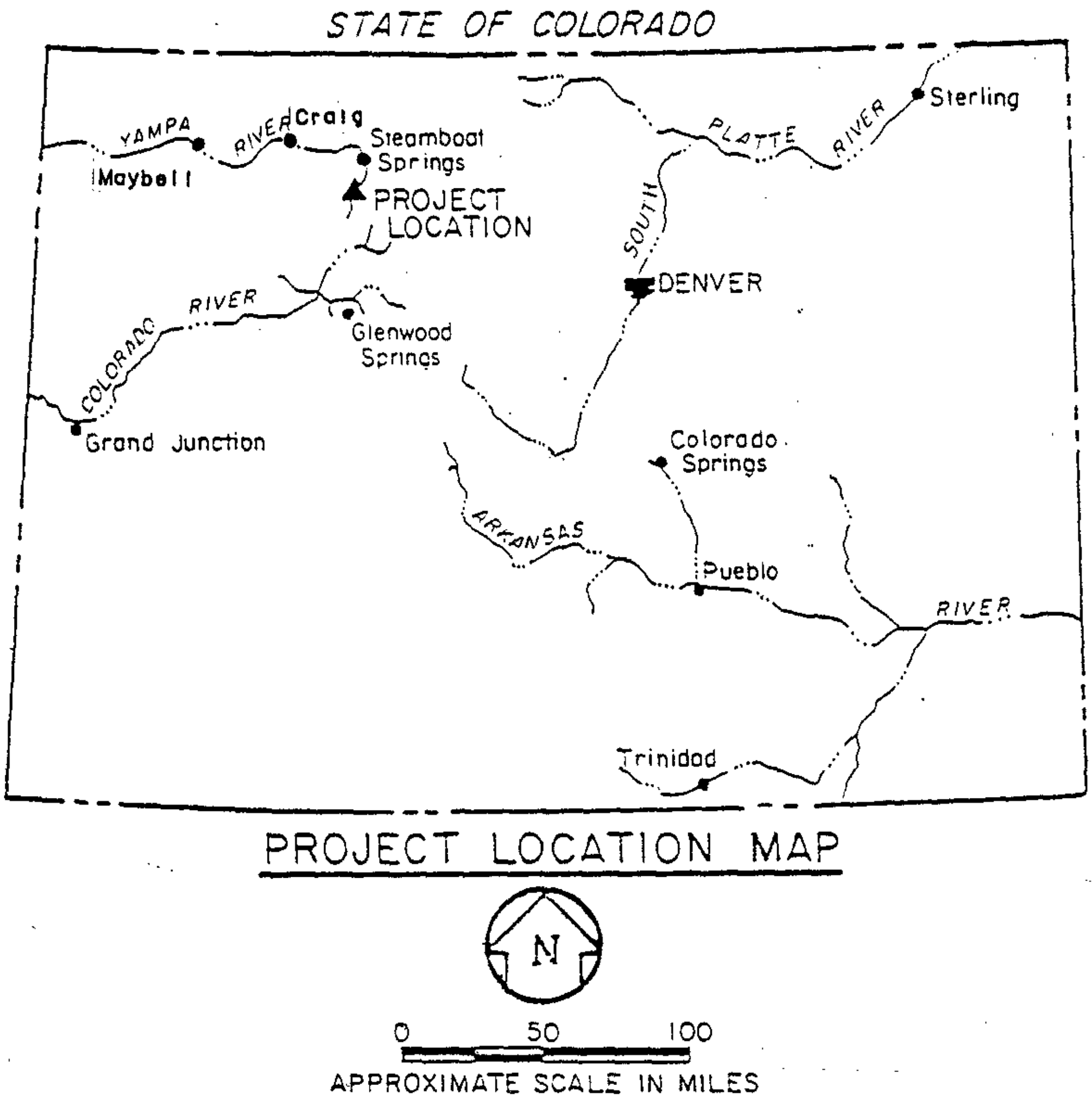
Stagecoach dam is a 135 foot high roller compacted concrete (RCC) gravity dam constructed on the Yampa River in Routt County, Colorado in 1988. The dam is located in the SW1/4 of Section 29, T4N, R84W, 6th Principal Meridian, at a point approximately 16.3 river miles upstream from the City of Steamboat Springs.

It has a normal operating volume of 33,275 acre-feet and a normal surface area of 775 acres. There is 10 feet of freeboard between the elevation of the 50 foot wide central overflow spillway and the top of the dam. The crest is 24 feet wide and 362 feet long. The upstream face of the dam is vertical and the downstream face is on a slope of 0.8 horizontal to 1.0 vertical. The outlet works is controlled by a 36 inch diameter jet flow gate valve which has a maximum release of about 450 cfs at normal operating volume.

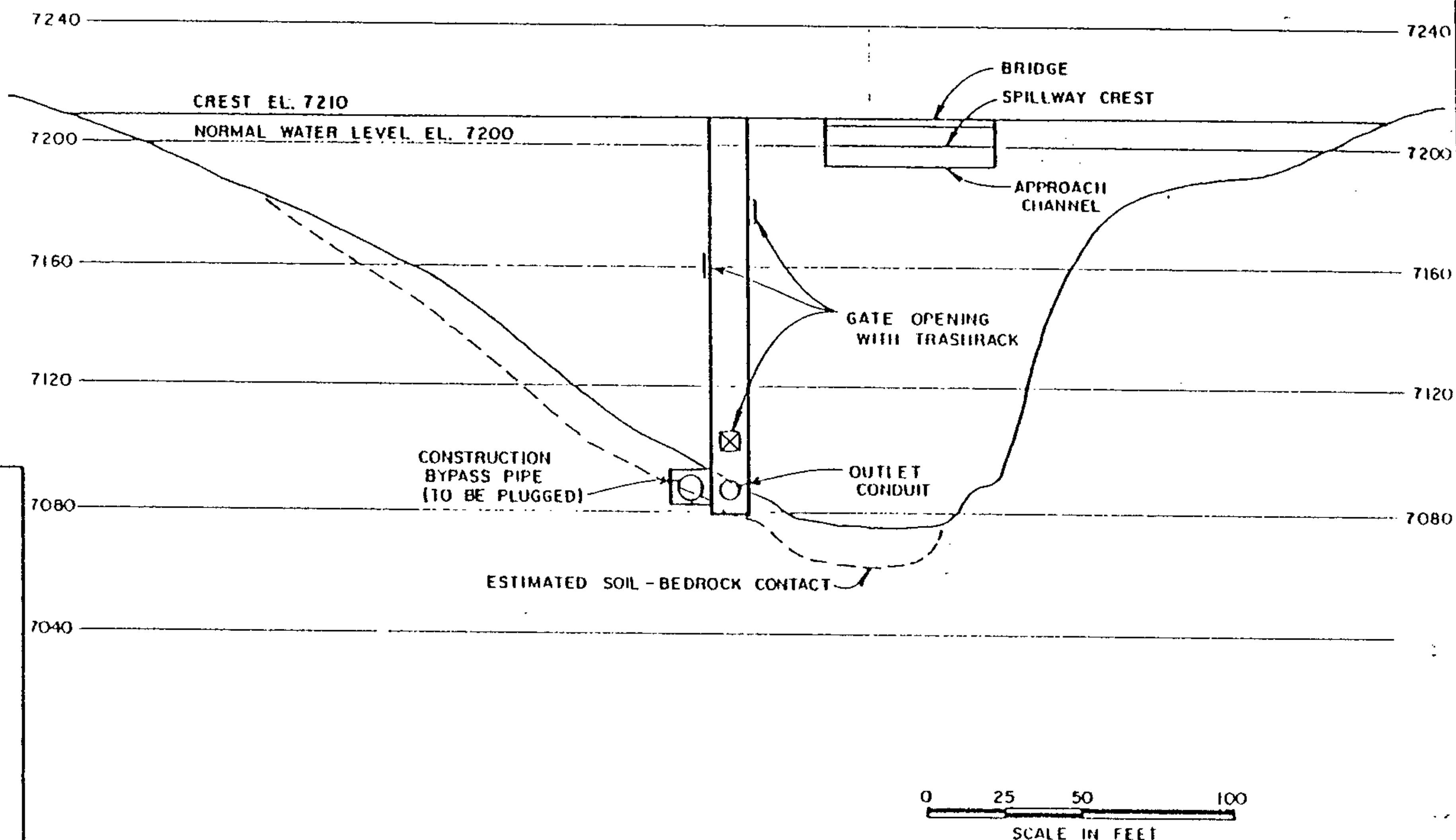
For purposes of this investigation, Stagecoach dam will be assumed to fail "in the dry" under the following conditions:

Water level -	at the crest of the emergency spillway, elevation 7200.
Surface Area -	normal operating surface area, or 775 acres
Reservoir Volume -	normal operation capacity, 33,275 acre-feet
Time of breach -	15 minutes

The slope of the channel downstream from Stagecoach dam varies from about 80 feet per mile immediately below the dam to about 25 feet per mile in Lake Catamount a few miles downstream. Manning's roughness coefficient will be assumed to be 0.08 in the three mile long canyon just below the dam and 0.04 elsewhere.



PROJECT LOCATION MAP

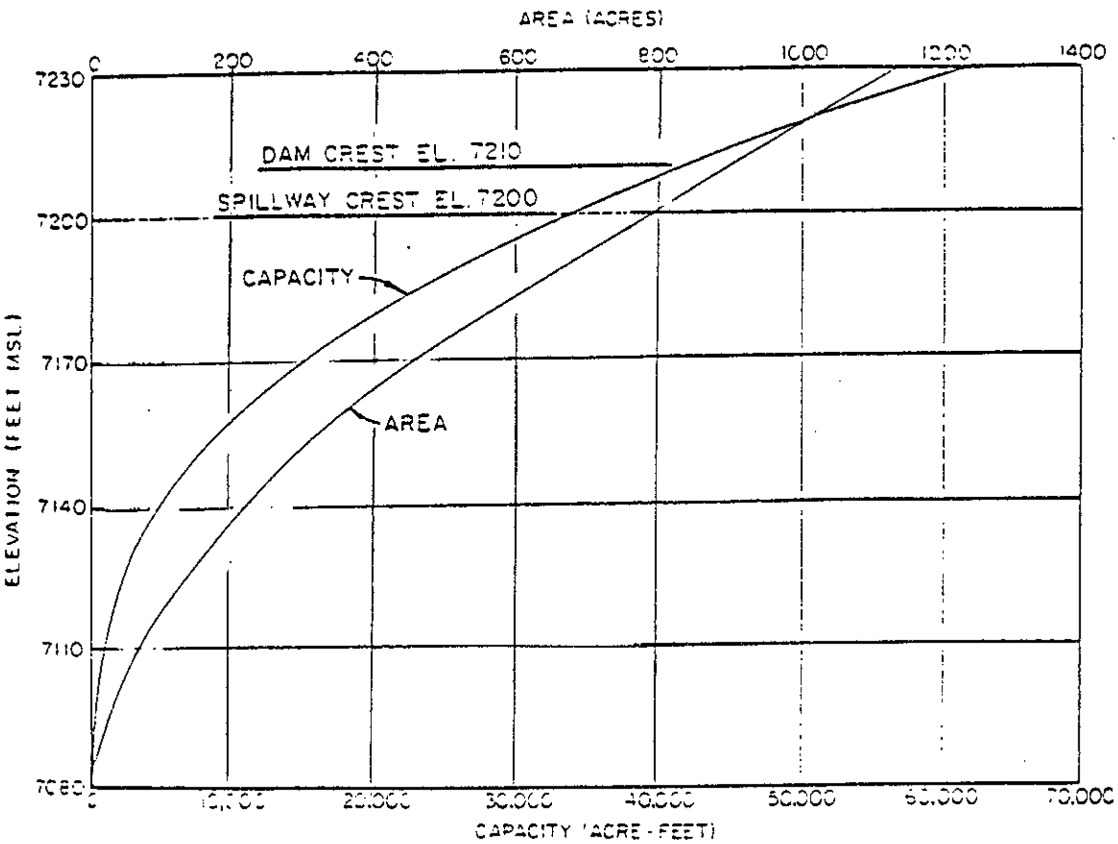


PROFILE ALONG AXIS OF DAM

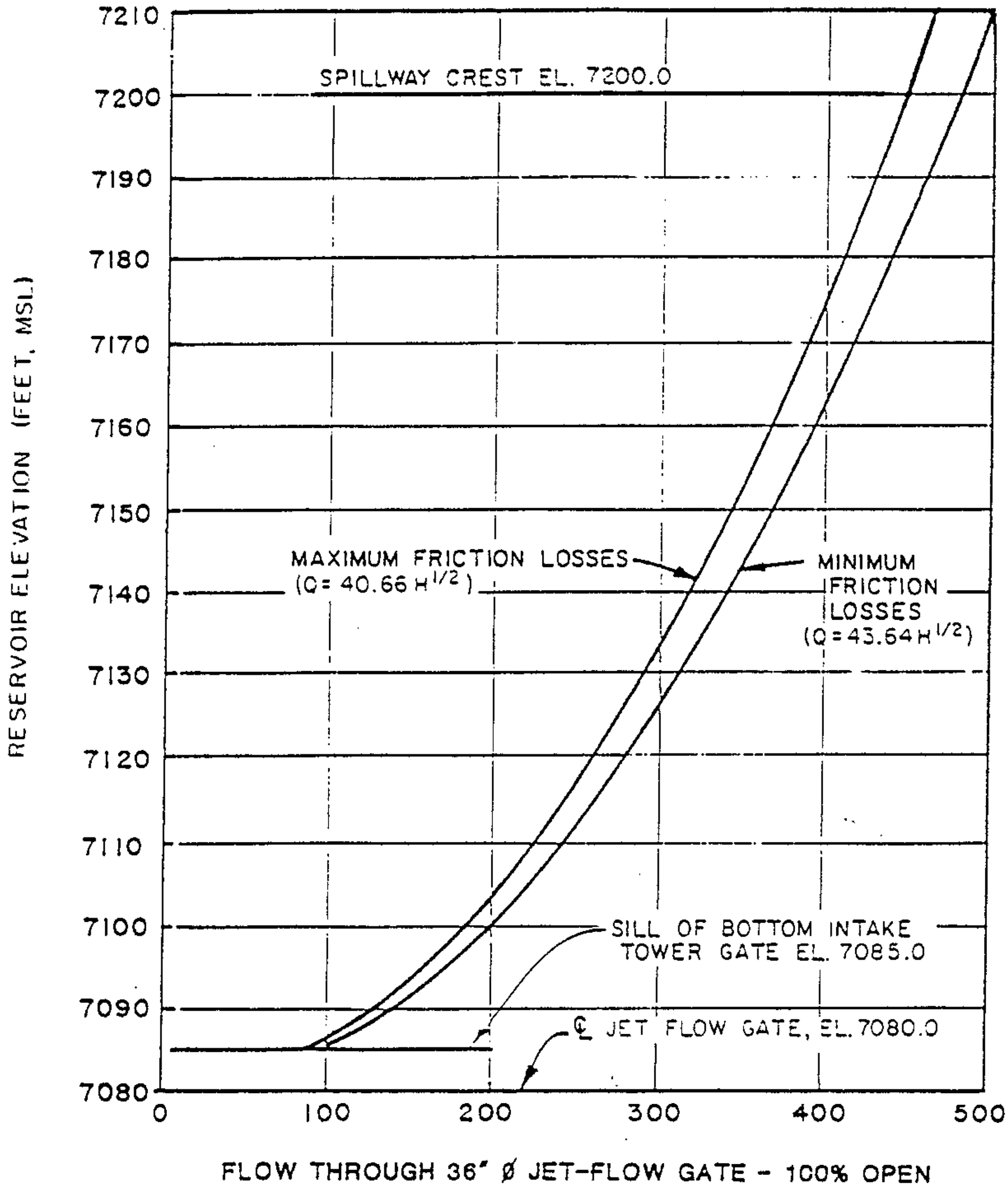
STAGECOACH RESERVOIR ON THE YAMPA RIVER

AREA-CAPACITY TABLE

ELEVATION	SURFACE AREA (ACRES)	AVERAGE SURFACE AREA (ACRES)	INCREMENTAL VOLUME (AC/FT)	CUMULATIVE VOLUME (AC/FT)
7080	0			
7090	15	7.5	75	75
7100	35	25.0	250	325
7110	70	52.5	525	850
7120	110	90.0	900	1750
7130	160	135.0	1350	3100
7140	215	187.5	1875	4975
7150	285	250.0	2500	7575
7160	360	322.5	3225	10,700
7170	450	405.0	4050	14,750
7180	565	507.5	5075	[illegible]
7190	675	620.0	6200	26,025
7200	775	725.0	7250	33,275
7210	910	[illegible]	[illegible]	[illegible]
7220	1030	970.0	9700	51,40[illegible]
7230	1140	1085.0	10,850	62.250



AREA-CAPACITY CURVES



JET FLOW GATE DISCHARGE RATING CURVE

4.0 Lake Catamount Dam

Lake Catamount dam is a 57 foot high zoned earthfill embankment constructed on the Yampa River in Routt County in 1978. It is located in the NW1/4 of Section 27, T4N, R84W, 6th Principal Meridian, about 6.8 miles downstream of Stagecoach dam and about 10.5 miles upstream of Steamboat Springs.

It has a normal operating capacity of 7,422 acre-feet and a normal surface area of 563 acres. There is 15 feet of freeboard between the main ogee and auxillary roller gate channel spillways, elevation 6900, and the top of the dam. The roller gate has never been installed and flow through the roller gate channel is controlled by inserting steel stop logs.

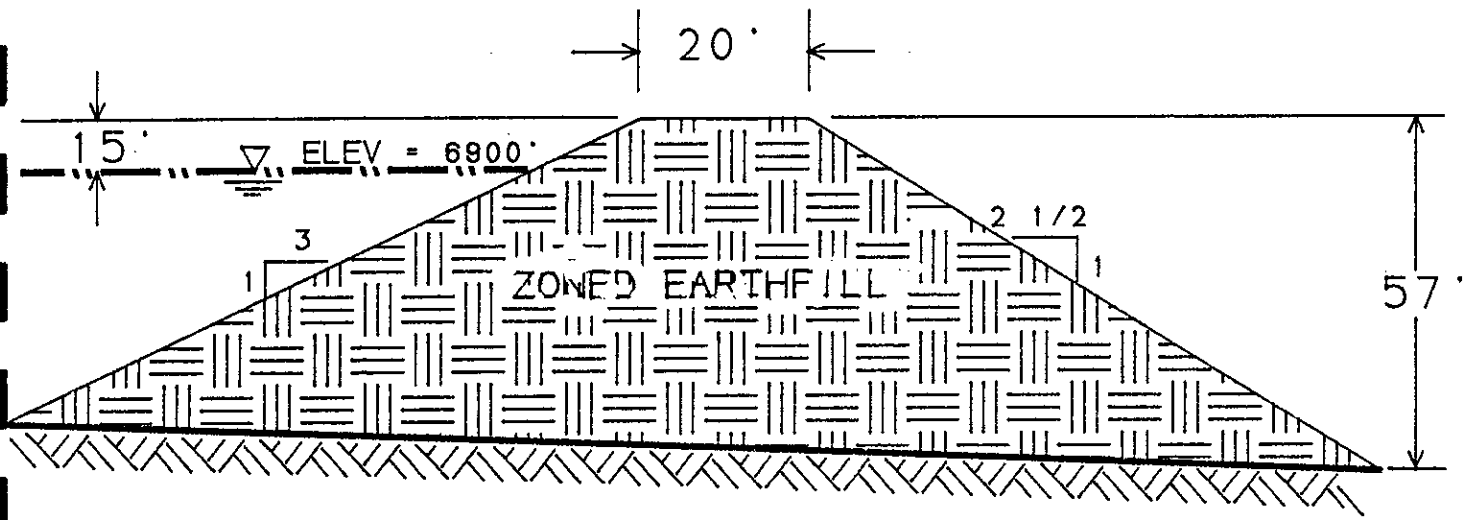
The discharge capacity of the ogee spillway is 26,000 cfs with the water at the top of the dam. The discharge capacity of the auxillary roller gate channel spillway is 4,900 cfs with the water at the top of the dam and the elevation of the top of the stop logs at 6900 feet.

The crest of the dam is 20 feet wide by 400 feet long. The embankments slope 3 horizontal to 1 vertical on the upstream side and 2 1/2 horizontal to 1 vertical on the downstream side.

Lake Catamount dam will be assumed to fail due to overtopping by the dam failure flood coming from Stagecoach reservoir. The following assumptions will be used:

Water level -	at the crest of the dam, elevation 6915
Surface Area -	983 acres
Reservoir Volume -	normal operation capacity plus freeboard storage, or 18900 acre-feet
Time of breach -	to be determined

The slope of the Yampa River channel downstream from Lake Catamount dam varies from about 22 feet per mile immediately below the dam to about 10 feet per mile at Craig. A Manning's roughness coefficient of 0.40 was assumed for all reaches downstream of Catamount dam.



LAKE CATAMOUNT DAM

NOT TO SCALE

5.0 Available Mapping

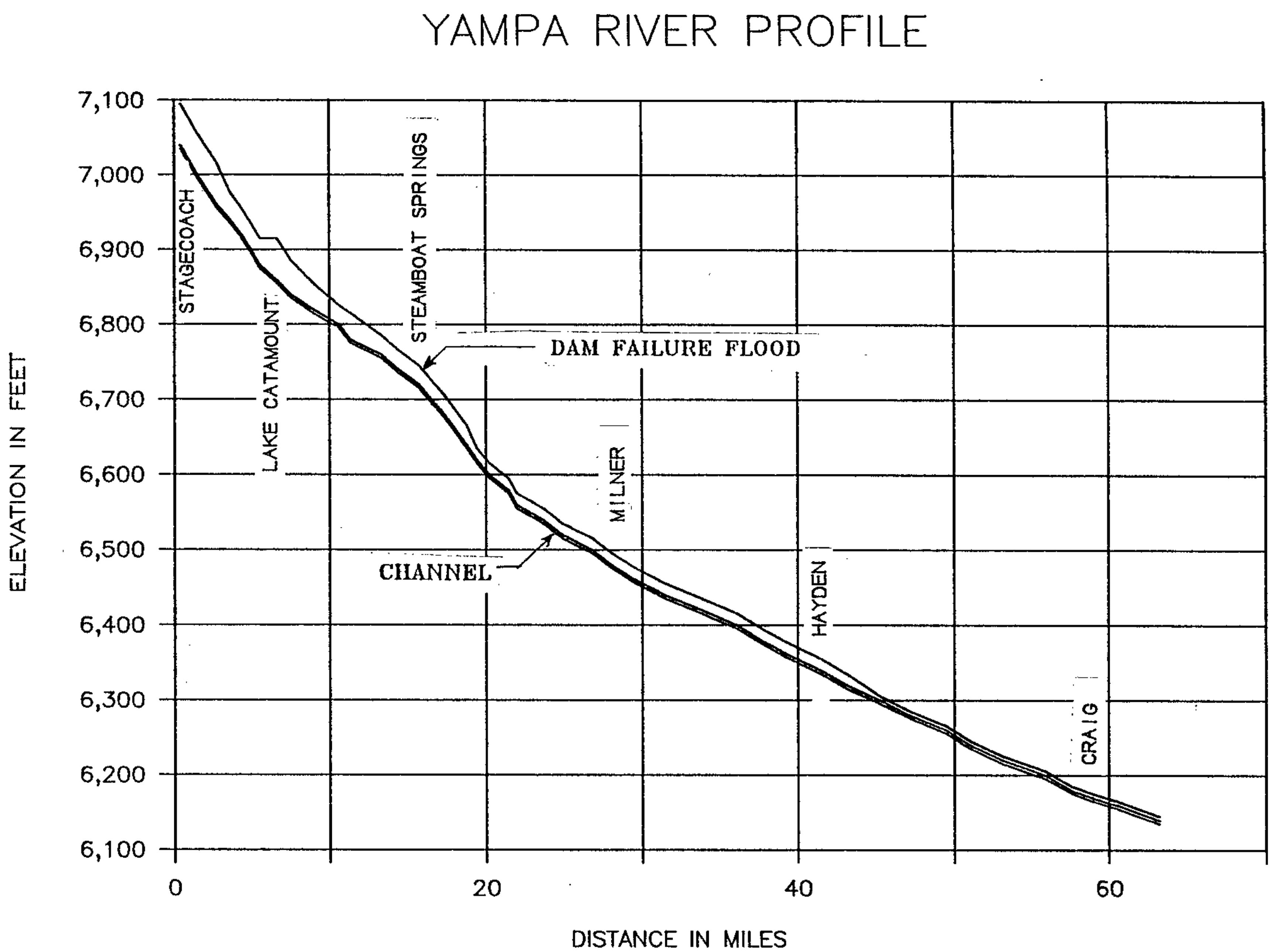
Previously published floodplain information reports prepared by the Sacramento District Army Corps of Engineers for Steamboat Springs (February 1976) and Craig (November 1977) include detailed mapping. Topographic maps with a contour interval of 2.0 feet are available for approximately 4.5 miles in the vicinity of Steamboat Springs and about 2.4 miles in the vicinity of Craig.

The following U.S.G.S. quadrangle maps, scale 1 inch equals 2,000 feet, are available for the entire study reach:

- Blacktail Mountain
- Steamboat Springs
- Rocky Creek
- Mad Creek
- Cow Creek
- Milner
- Mt. Harris
- Rocky Spring Gulch
- Hayden
- Ralph White Lake
- Craig
- Castor Gulch
- Round Bottom
- Horse Gulch
- Juniper Hot Springs

These topographic maps for the areas upstream of Craig have 40 foot contour intervals with supplemental contours at 20 feet in the river valley. The areas downstream of Craig are shown with 20 foot contour intervals and 10 foot supplemental contours in the valley.

The dam failure inundation maps in this report are shown with U.S.G.S. maps as a base. In addition, the flood boundary in the vicinity of Steamboat Springs has also been shown on a 2.0 foot contour map.



YAMPA RIVER PROFILE
7,100
7,000
6,900
6,800
6,700
6,600
6,500
6,400
6,300
6,200
6,100
ELEVATION IN FEET
0
20
40
60
DISTANCE IN MILES
STAGECOACH
LAKE CATAMOUNT
STEAMBOAT SPRINGS
MILNER
HAYDEN
CRAIG
DAM FAILURE FLOOD
CHANNEL

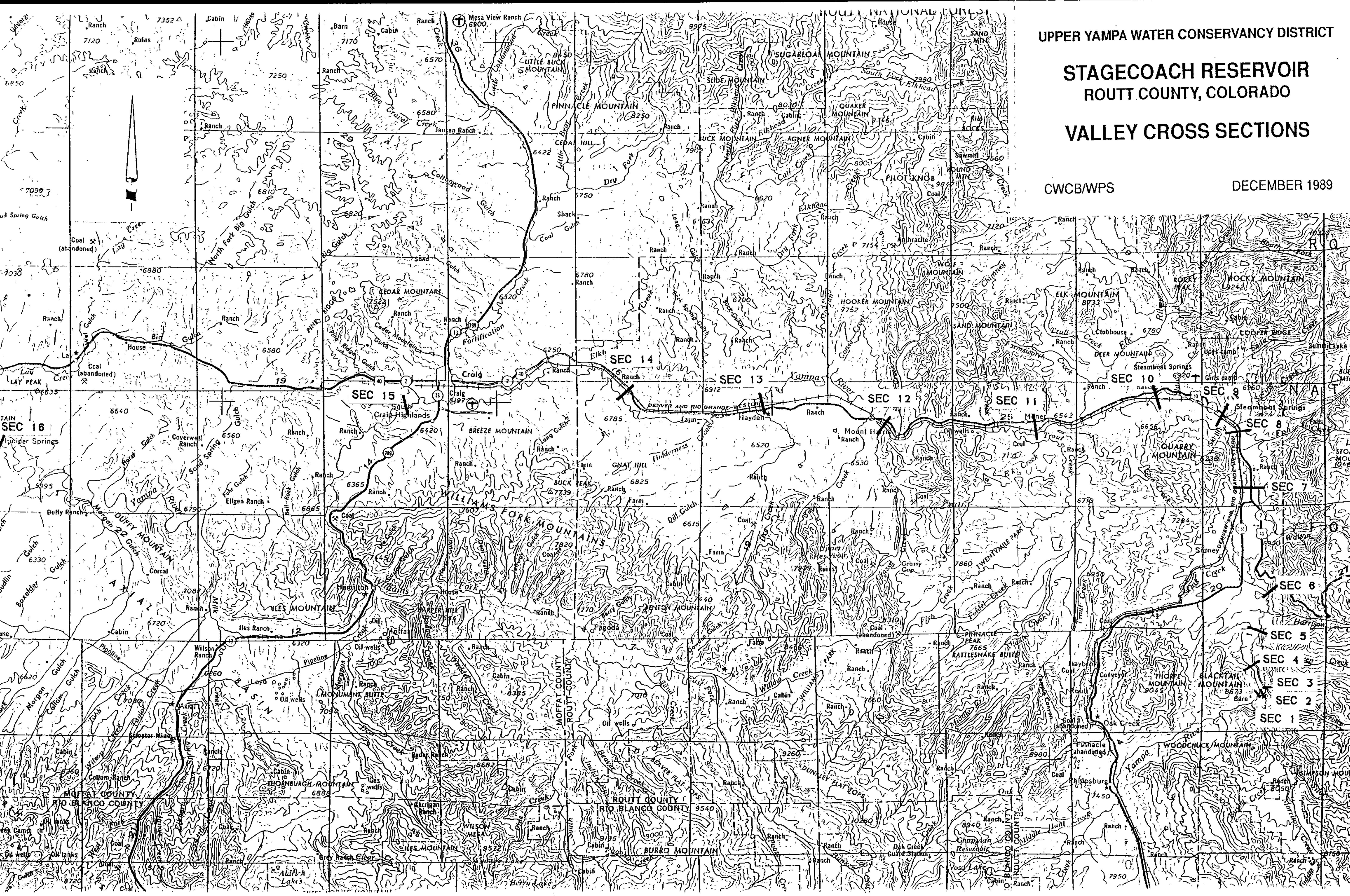
13

6.0 Valley Cross Sections

A field survey was conducted in May 1985 by Woodward-Clyde Consultants for the three mile stream reach in the canyon immediately downstream of Stagecoach dam. This survey includes eight cross sections, four of which were used in this investigation.

Cross section data has been developed for floodplain information reports and flood insurance studies prepared for Routt County, Steamboat Springs, Moffat County, Hayden, and Craig. This cross section data is quite detailed but is in a format for input with computer program HEC-2. Most of this data is either in use by FEMA contractors or in FEMA archives and is currently inaccessible.

Since the flows used in this investigation are quite large, it was possible to develop satisfactory cross sections directly from the U.S.G.S quad maps. Twelve additional valley cross sections were derived from these maps.


UPPER YAMPA WATER CONSERVANCY DISTRICT
STAGECOACH RESERVOIR
ROUTT COUNTY, COLORADO
VALLEY CROSS SECTIONS
CWCB/WPS
DECEMBER 1989
SEC 1
SEC 2
SEC 3
SEC 4
SEC 5
SEC 6
SEC 7
SEC 8
SEC 9
SEC 10
SEC 11
SEC 12
SEC 13
SEC 14
SEC 15
SEC 16
Craig
Hayden
Milner
Steamboat Springs
Yampa River
WILLIAMS FORK MOUNTAINS
MOFFAT COUNTY
ROUTT COUNTY
RIO BLANCO COUNTY
Oak Creek
Phippsburg
DENVER AND RIO GRANDE WESTERN

7.0 Colorado DWR Model

The Colorado Division of Water Resources (DWR), also known as the Office of the State Engineer, has developed a procedure to prepare dam failure flood inundation maps below each of the 238 high hazard dams in the state. This procedure is based on an empirical dam breach algorithm, a recognized flood routing technique, and an approximate mapping method.

The DWR procedure for dam-failure flood mapping consists of the following steps:

1. Using an empirical formula derived from regression analysis of actual dam failures considering physical dimensions of the dam and the reservoir as well as the relative erosiveness of the embankment soils, compute the peak discharge and base time of a triangular shaped hydrograph at the dam site due to failure of the dam.

2. Using the method of successive averages, route the dam failure hydrograph downstream to typical trapezoidal shaped valley cross sections by calculating the depth of flow, average velocity, and travel time.

3. Draw the flood inundation zone on U.S.G.S. quadrangle maps using flood depths calculated at the typical sections.

A computer program, called HAZARD2.BAS, has been created to make the computations in steps 1 and 2 for dams with with earth embankments. A simplified method for calculating the peak flow for concrete and masonry dams was developed by applying the weir equation in the standard form:

$$Q = CLh^{3/2}$$

where
- C = discharge coefficient
- L = length of the weir
- h = depth of flow over the weir

Assuming the dam fails abruptly forming a rectangular breach which has a width of one half the length of the dam crest (LC) and a depth which is the full heigth of the dam (H) less the freeboard (FB), and a discharge coefficient of 3.0, the above equation becomes:

$$Q_p = \{3.0\}\ \{(LC)/2\}\ \{(1.00)(H-FB)\}^{3/2}$$
$$= 1.50\ (LC)\ (H-FB)^{3/2}$$

Substituting the values for Stagecoach dam we have:

$$Q_p = 1.50\ (362)\ (135-10)^{1.5}$$
$$= 758{,}866 \text{ cfs}$$

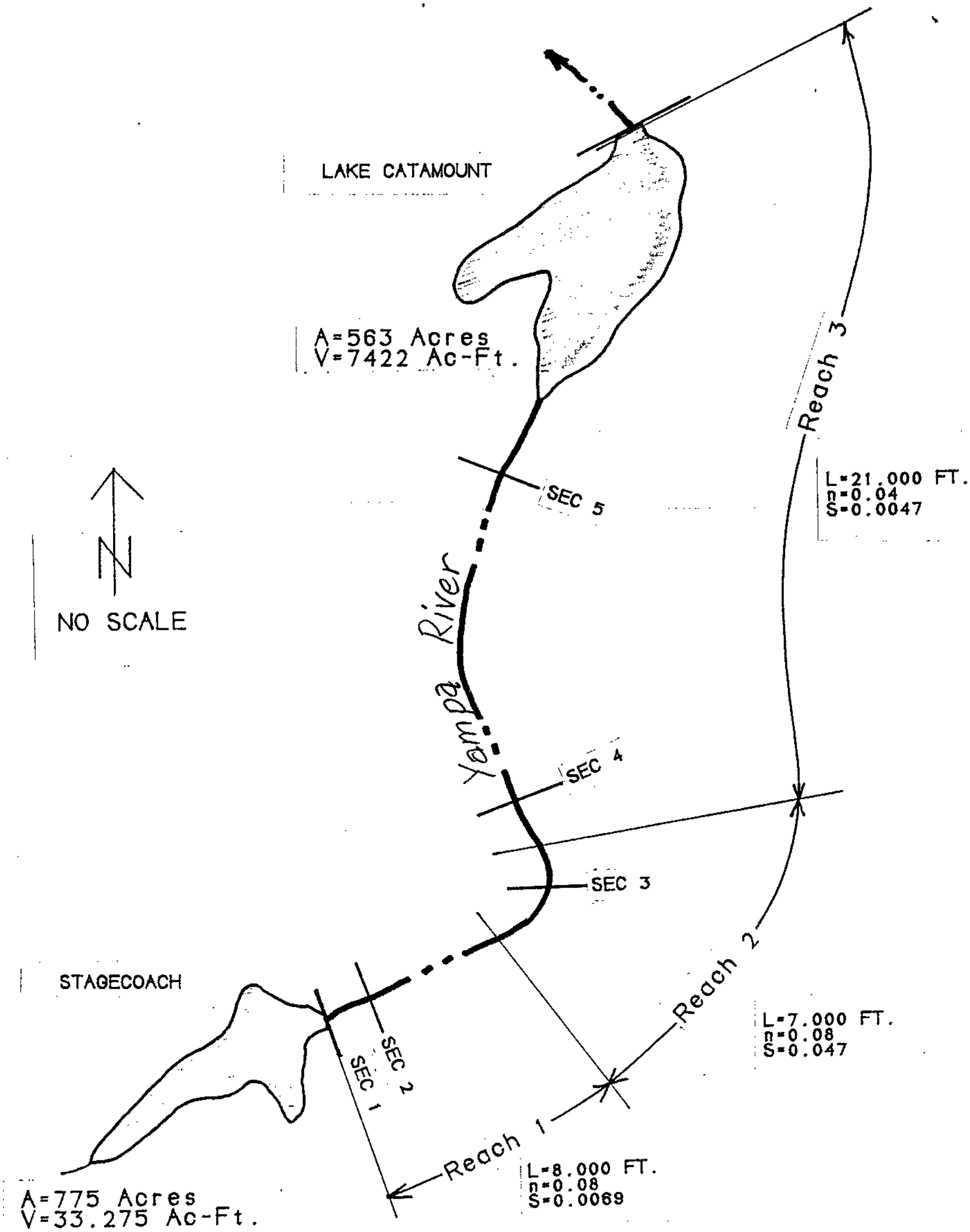
The outlet works in both Stagecoach dam (450 cfs maximum) and Lake Catamount dam (480 cfs maximum) were assumed to be closed at the time of failure.

The volume of water in Stagecoach reservoir available for flooding is the normal operating volume less any volume that remains in the reservoir below the level of the breach. Since the depth of the breach at Stagecoach dam was taken as the full heigth of the dam (H) less the freeboard (FB), or

$$(1.00)(H-FB)$$
$$= (135 - 10)$$
$$= 125 \text{ feet.}$$

This is at elevation 7,075 feet above mean sea level, and corresponds to a total available volume of 33,275 acre-feet.

For the DWR model, the Yampa River between Stagecoach dam and Lake Catamount dam was divided into three stream reaches. The stream reaches are shown in the following schematic diagrams, and the trapezoidal valley cross section data used to typify each reach is shown in Table 2.



REACH DIAGRAM No 1

Table 2, Valley Cross Section Input Data for DWR Model

Cross Section	River Mile	Distance	Bottom Width	Slope Left	Slope Right	Reach Length	Channel Slope	Manning's n
2	0.4	2300	200	3.0	2.0	8000	.0069	.08
3	1.8	9500	220	3.0	2.5	7000	.0047	.08
5	4.8	25400	1800	2.6	1.6	21000	.0047	.04
7	13.0	68800	4580	2.5	2.5	38000	.0041	.04
8	16.3	86000	1000	3.5	3.3	13000	.0035	.04
9	17.4	91700	100	7.5	3.1	10000	.0044	.04
10	20.8	109800	2000	3.0	3.0	40000	.0029	.04
11	27.2	143700	3000	1.2	1.3	50000	.0017	.04
12	36.0	189800	850	1.7	1.7	20000	.0025	.04
13	42.8	225700	1200	85.0	11.0	30000	.0031	.04
14	50.2	265200	2000	4.0	2.0	50000	.0020	.04
15	61.7	326000	2250	2.5	8.2	50000	.0021	.04
16	100.0	528000	2000	4.0	4.0	300000	.0015	.04

Using these parameters, the routed peak discharge at the end of Reach 3 as the flood enters Lake Catamount, was computed at 474,291 cfs. Assuming a triangular shaped hydrograph, the base time is estimated at

$$t_b = 2\ V\ /\ q_p$$
$$= 2\ (33{,}275)(43{,}560)/(474{,}291)(3{,}600)$$
$$= 1.70 \text{ hours.}$$

The freeboard storage volume in Lake Catamount is calculated as the difference between the volume with the water in the reservoir at the top of the dam and the volume when the water is at the elevation of the spillway, or

$$V_{fs} = 18{,}900 - 7{,}422$$
$$= 11{,}478 \text{ acre feet.}$$

Assuming the shape of the inflow triangular hydrograph is a right triangle, it can be determined by solving two equations simultaneously that the time to fill the freeboard storage space is approximately

$$t_f = 0.33 \text{ hours.}$$

Using similar triangles, the flow into Lake Catamount at failure is estimated at about

$$q_f = (q_p)(t_b - t_f)/(t_b)$$
$$= (474{,}291)(1.70 - 0.33) / 1.70$$
$$= 382{,}223 \text{ cfs.}$$

The flow through the spillways at failure is estimated at

$$q_s = 26{,}000 + 4{,}900$$
$$= 30{,}900 \text{ cfs.}$$

The volume of water that flows through the spillways at Lake Catamount while the freeboard storage space is being filled is estimated at

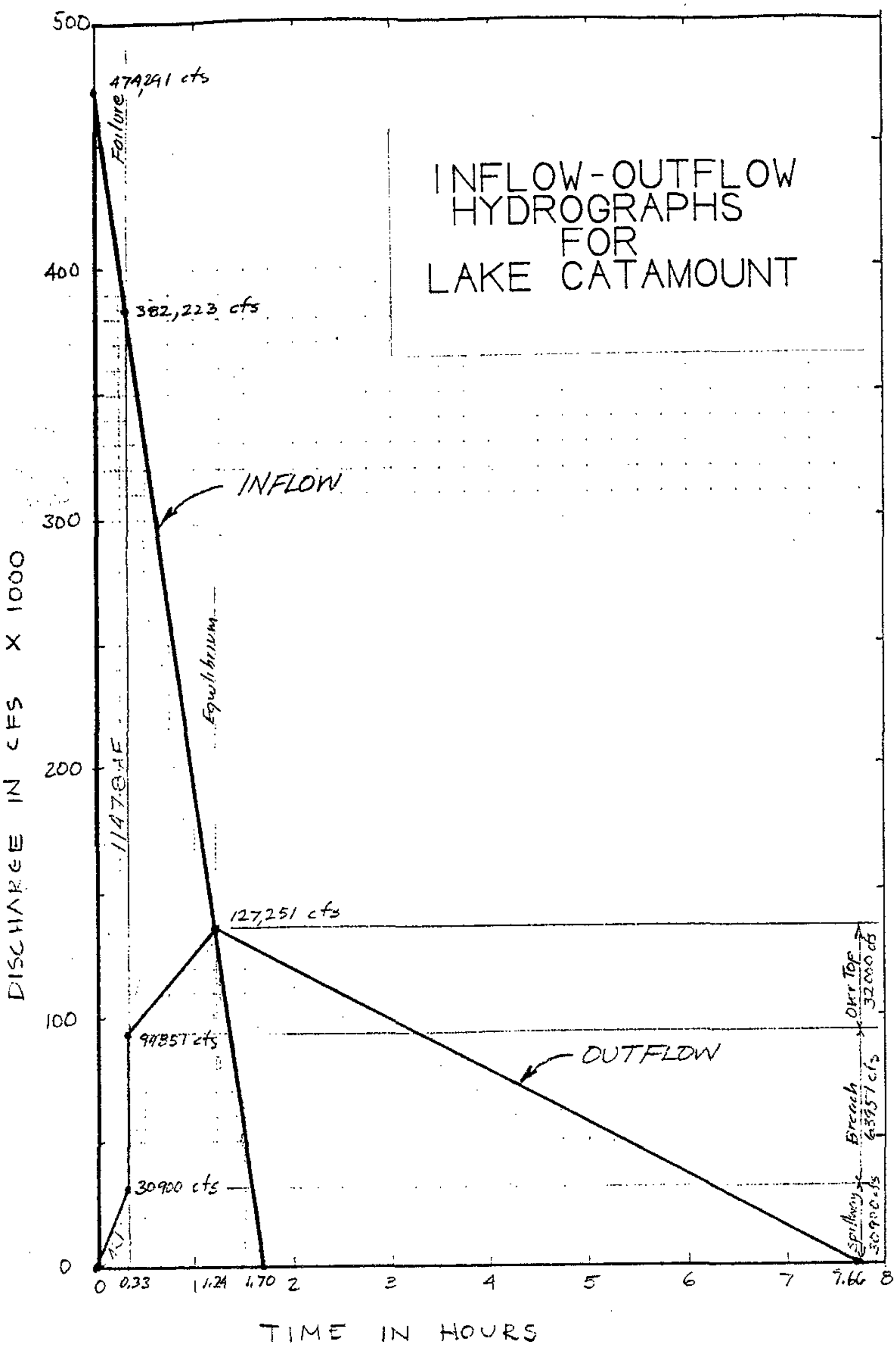
$$V_s = 1/2\ (30{,}900)\ (0.33)\ (3{,}600/43{,}560)$$
$$= 421 \text{ acre feet.}$$

Based on the geometry of the dam and the volume and the surface area of the reservoir, the peak flow through the breach was calculated by computer program HAZARD2.BAS at 63,951 cfs. The sum of the discharge through the breach and through the spillways is

63,951 + 30,900 = 94,851 cfs.

Since the rate of flow into the reservoir at the time the flood water reaches the level of the crest of the dam is greater than the rate of flow out of the reservoir, the water will continue to rise and start flowing over the top of the dam. This rise will continue until equilibrium is reached, or when the rate of flow into the reservoir equals the rate of flow out of the reservoir.

The maximum discharge over the top of the dam was estimated by simultaneously solving three independent equations. These equations are based on an estimate of the additional volume in the reservoir during overflow assuming an average surface area of 1200 acres, the slope of the inflow hydrograph, and the equation for flow over a broad crested wier. The peak rate of flow over the top of the dam is estimated at 32,400 cfs which will occur at a depth of 9.0 feet at approximately 0.91 hours after water begins to flow over the dam.



INFLOW-OUTFLOW HYDROGRAPHS FOR LAKE CATAMOUNT
474,291 cfs
Failure
382,223 cfs
INFLOW
Equilibrium
1147 A.F.
127,251 cfs
99857 cfs
OUTFLOW
30900 cfs
Ovr Top 32000 cfs
Breach 63357 cfs
Spillway 30900 cfs
DISCHARGE IN CFS X 1000
500
400
300
200
100
0
0 0.33 1.24 1.70 2 3 4 5 6 7 7.66 8
TIME IN HOURS

The additional discharge to be added to the computed flow through the breach is therefore

30,900 + 32,400 = 63,300 cfs.

The additional volume to pass through Lake Catamount coming from Stagecoach reservoir was estimated by subtracting the volume of the flood that fills the freeboard storage space in Lake Catamount plus the volume that escapes through the spillways from the total volume coming from Stagecoach, or

$$
\begin{aligned}
V_a &= 33{,}275 - \{(18{,}900 - 7{,}422) + 421\} \\
&= 33{,}275 - \{\ 11{,}487 + 421\ \} \\
&= 21{,}376 \text{ acre-feet}
\end{aligned}
$$

Using these parameters, the dam failure hydrograph at Lake Catamount was computed to have the following characteristics:

$$
\begin{aligned}
V_t &= 40{,}276 \text{ acre feet} \\
q_p &= 127{,}251 \text{ cfs} \\
t_b &= 7.66 \text{ hours}
\end{aligned}
$$

The Yampa River downstream of Lake Catamount dam to Sunbeam in unincorporated Moffat County was divided into ten stream reaches. The stream reaches were shown in the schematic diagrams, and the trapezoidal valley cross section data used to typify each reach was shown in Table 2.

The results of the DWR model analysis are summarized in Table 3. Since the routed peak discharge at the end of reach 13 was approximately equal to the estimated peak discharge of the 100-year flood, the analysis was not continued beyond this point.

Table 3, Results of DWR Model

Reach	Peak Discharge	Average Velocity	Flood Depth	Base Time	Travel Time	Cumulative Travel Time
1	758,866	21.8	84.7	1.27	0.15	0.15
2	632,388	17.7	80.9	1.27	0.13	0.28
3	632,388	17.9	19.2	-	0.39	0.67
	474,291				0.33	1.00
4	127,251	6.2	4.2	10.21	1.70	2.70
5	95,438	9.7	9.6	10.21	0.37	3.07
6	95,438	15.7	25.7	10.21	0.23	3.30
7	95,438	7.1	6.7	11.67	1.57	4.87
8	83,508	4.9	5.7	15.56	2.85	7.72
9	62,631	8.0	9.1	16.24	0.70	8.42
10	60,021	6.3	6.4	16.94	1.33	9.75
11	57,521	5.2	5.5	19.37	2.69	12.44
12	50,331	4.8	4.7	22.13	2.92	15.36
13	44,039	4.3	5.1	-	19.61	34.97
	24,837					

8.0 NWS Dambreak Model

The Simplified Dam-Break Model, version 7/88, was also used in this investigation. This model is an interactive program developed by the National Weather Service which computes the maximum discharge, maximum depth, and times of occurrence of flooding at selected cross sections downstream of a breached dam.

The input data for Stagecoach Dam was as follows:

TYPE OF DAM (IDAM)	CONCRETE GRAVITY		
DAM BREACH ELEVATION (HDE)	7200.00	FT	
FINAL BREACH ELEVATION (BME)	7075.00	FT	
VOLUME OF RESERVOIR (VOL)	33275.00	ACRE-FT	
SURFACE AREA OF RESERVOIR (SA)	775.00	ACRES	
FINAL BREACH WIDTH (BW)	181.00	FT	
TIME OF DAM FAILURE (TFM)	15.00	MINUTES	
NON-BREACH FLOW (QO)	.00	CFS	
DEAD STORAGE EQUIV. MANN. N (CMS)	.30		

The input data for Lake Catamount dam was as follows:

TYPE OF DAM (IDAM)	EARTH		
DAM BREACH ELEVATION (HDE)	6915.00	FT	
FINAL BREACH ELEVATION (BME)	6858.00	FT	
VOLUME OF RESERVOIR (VOL)	18900.00	ACRE-FT	
SURFACE AREA OF RESERVOIR (SA)	983.00	ACRES	
FINAL BREACH WIDTH (BW)	171.00	FT	*
TIME OF DAM FAILURE (TFM)	5.70	MINUTES	*
NON-BREACH FLOW (QO)	30900.00	CFS	
DEAD STORAGE EQUIV. MANN. N (CMS)	.30		

* an asterisk means that this parameter was computed by the program.

Table 4, STAGECOACH DAM FAILURE ANALYSIS - VALLEY CROSS SECTION INPUT DATA FOR NWS MODEL

Section	Station	Miles	Elev	Width	Left	Right	Dist	Slope	ft/mi	n	Depth
1	0	0.00	7200	350	200	150	0	0.0152	80.3	0.08	10.0
Stagecoach			7160	210	150	60				0.08	
			7120	145	100	45				0.08	
			7080	55	30	25				0.08	
			7075	20	10	10				0.08	
2	2300	0.44	7100	175	100	75	2300	0.0069	36.7	0.08	10.0
			7080	121	56	65				0.08	
			7070	85	25	60				0.08	
			7050	62	22	40				0.08	
			7040	20	10	10				0.08	
3	9500	1.80	7040	221	75	146	7200	0.0047	24.8	0.08	10.0
			7020	152	55	97				0.08	
			7010	123	50	73				0.08	
			7000	92	44	48				0.08	
			6990	20	10	10				0.08	
4	18000	3.41	7000	1295	215	1080	8500	0.0054	28.5	0.08	10.0
			6980	1223	193	1030				0.08	
			6960	1126	156	970				0.08	
			6955	104	50	54				0.08	
			6950	20	10	10				0.08	
5	25400	4.81	7040	2300	350	1950	7400	0.0047	24.9	0.04	10.0
			7000	2140	1850	290				0.04	
			6960	1990	1750	240				0.04	
			6920	1800	1640	160				0.04	
			6910	30	15	15				0.04	
6	36000	6.82	7000	750	350	400	10600	0.0030	16.1	0.04	10.0
Catamount		0.00	6960	580	280	300				0.04	
			6920	400	200	200				0.04	
			6880	250	100	150				0.04	
			6860	30	15	15				0.04	
7	68800	13.03	6880	5400	500	4900	32800	0.0041	21.5	0.04	10.0
(2)		6.21	6840	5150	450	4700				0.04	
			6800	4950	350	4600				0.04	
			6780	4850	300	4550				0.04	
			6760	30	15	15				0.04	
8	86000	16.29	6800	1660	950	710	17200	0.0035	18.5	0.04	10.0
(3)		9.47	6760	1410	760	650				0.04	
			6720	1100	600	500				0.04	
			6700	1000	550	450				0.04	
			6690	30	15	15				0.04	
9	91700	17.37	6800	1700	400	1300	5700	0.0044	23.3	0.04	10.0
(4)		10.55	6760	950	300	650				0.04	
			6720	800	250	550				0.04	
			6680	100	50	50				0.04	
			6670	30	15	15				0.04	

10	109800	20.80	6680	3850	3100	750	18100	0.0029	15.6	0.04	10.0
(5)		13.98	6640	2800	2600	200				0.04	
			6620	2650	2500	150				0.04	
			6600	160	60	100				0.04	
			6590	40	20	20				0.04	
11	143700	27.22	6600	6200	3200	3000	33900	0.0017	9.2	0.04	10.0
(6)		20.40	6560	3290	3010	280				0.04	
			6520	3140	2940	200				0.04	
			6500	3000	2900	100				0.04	
			6490	40	20	20				0.04	
12	189800	35.95	6520	1610	1400	210	46100	0.0025	13.2	0.04	10.0
(7)		29.13	6480	1050	850	200				0.04	
			6440	940	800	140				0.04	
			6420	850	750	100				0.04	
			6410	40	20	20				0.04	
13	225700	42.75	6400	4250	3650	600	35900	0.0031	16.5	0.04	10.0
(8)		35.93	6360	4080	3550	530				0.04	
			6340	3330	2950	380				0.04	
			6330	1200	1000	200				0.04	
			6320	40	20	20				0.04	
14	265200	50.23	6360	4750	2500	2250	39500	0.0020	10.4	0.04	10.0
(9)		43.41	6320	4200	2000	2200				0.04	
			6280	3200	1150	2050				0.04	
			6260	2750	1050	1700				0.04	
			6250	40	20	20				0.04	
15	326000	61.74	6240	3250	2600	650	60800	0.0021	11.0	0.04	10.0
(10)		54.92	6200	2890	2300	590				0.04	
			6160	2400	2250	150				0.04	
			6140	2250	2150	100				0.04	
			6130	40	20	20				0.04	
16	528000	100.00	5820	3250	2600	650	202000			0.04	10.0
(11)		93.18	5780	2890	2300	590				0.04	
			5740	2400	2250	150				0.04	
			5720	2250	2150	100				0.04	
			5710	40	20	20				0.04	

Table 5, Results of NWS Model

SECTION NO.	RVR MILE FROM DAM	MAX FLOW (CFS)	MAX DEPTH (FT)	TIME(HR) MAX DEPTH	TIME(HR) FLOOD	TIME(HR) DEFLOOD	FLOOD DEPTH(FT)
1	.00	277386.	74.71	.25	.00	2.86	10.00
2	.44	237501.	74.84	.27	.03	3.33	10.00
3	1.78	221319.	70.17	.37	.12	3.65	10.00
4	3.41	219106.	20.51	.54	.31	3.36	10.00
5	4.81	216915.	14.63	.64	.46	2.66	10.00
6	.00	153790.	39.79	.09	.00	.00	8.00
7	6.21	135384.	12.51	1.00	.91	4.57	8.00
8	9.47	110174.	14.89	1.74	.00	.00	8.00
9	10.55	82109.	30.60	1.98	.00	.00	8.00
10	13.98	81288.	20.43	2.38	.00	.00	8.00
11	20.40	80475.	9.56	3.44	3.37	7.22	8.00
12	29.13	70457.	15.69	5.58	.00	.00	8.00
13	35.93	69639.	13.32	6.83	.00	.00	8.00
14	43.41	67118.	10.13	8.45	8.36	15.00	8.00
15	54.92	54995.	9.92	11.43	11.33	20.05	8.00
16	93.18	37632.	8.50	21.96	21.87	38.39	8.00

9.0 Summary

Stagecoach dam was assumed to fail "in the dry" with the water at the elevation of the spillway crest. The dam failure flood would then travel approximately six miles downstream into Lake Catamount which is assumed to be full to the elevation of its two spillways. These spillways will begin to flow as soon as the flood wave arrives at the upstream end of Lake Catamount. When the water level in Lake Catamount reaches the top of the dam, the embankment was assumed to fail. At the same time, water will also begin to flow over the top of the dam.

The above scenario is an extremely remote event and this analysis is not intended to reflect upon the integrity of Stagecoach dam or Lake Catamount dam.

The resultant flood was routed through the Yampa River valley for a distance of approximately 115 miles through Routt and Moffat Counties. A total of 16 valley cross sections were used in the analysis.

The dam failure floodplain was drawn on USGS quad maps using flood depths from two dam failure computer models recognized in Colorado. These are the methods developed by the Colorado Division of Water Resources (DWR), also known as the State Engineer, and the National Weather Service (NWS).

The results of the two models varied greatly both in peak discharge, flood depths, and travel times. The differences in flood depth may be attributed to the difference in the way of representing the cross section. The DWR model is based on a trapezoidal cross section and the NWS model fits a mathematical curve through hypothetical coordinates. With this difference in mind, engineering judgement was used to arrive at a flood depth for mapping. The mapped depth is the vertical distance above the low flow shown in the channel on the USGS quad maps.

The travel times shown in Table 8 recommended for use in emergency action planning are based on the NWS model. The average speed of the flood downstream from Steamboat Springs decreases from about 5.4 miles per hour at Milner to about 4.8 miles per hour at Craig. The approximate travel times are starting from the time of failure of Stagecoach Dam.

Table 6, Comparison of Results for Flood Discharges

Location	DWR Model (cfs)	NWS Model (cfs)
Stagecoach Dam	758,866	277,386
Inlet to Lake Catamount	474,291	216,915
Lake Catamount Dam	127,251	153,790
Steamboat Springs	95,438	82,109
Craig	50,331	54,995
Sunbeam	24,837	37,632

Table 7, Comparison of Results for Flood Depths

Cross Section	River Mile	DWR Depth (ft)	NWS Depth (ft)	Mapped Depth (ft)
1	0.0	-	74.7	80
2	0.4	84.7	74.8	80
3	1.8	80.9	70.2	80
4	3.4	-	20.5	20
5	4.8	19.2	14.6	20
6	6.8	-	39.8	70
7	13.0	4.2	12.5	15
8	16.3	9.6	14.9	15
9	17.4	25.7	30.6	30
10	20.8	6.7	20.4	20
11	27.2	5.7	9.6	10
12	36.0	9.1	15.7	15
13	42.8	6.4	13.3	15
14	50.2	5.5	10.1	10
15	61.7	4.7	9.9	10
16	100.0	5.1	8.5	

Table 8, Flood Data for Emergency Action Plans

Location	River Miles	Approx Flood Depth (ft)	Approx Flood Elev. (ft)	Approx Time Flood (hours)
Stagecoach Dam	0	80	7155	0
Inlet to Lake Catamount	4.8	20	6925	1/2
Lake Catamount Dam	6.8	70	6925	1 1/2
Steamboat Springs	16.3	30	6720	3 1/4
Milner	27.2	10	6495	5
Mt. Harris	36.0	15	6420	7
Hayden	42.8	15	6340	8 1/4
Craig	61.7	10	6180	12 2/3
Juniper Hot Springs	100.0			23 1/4
Maybell	109.0			25
Sunbeam	115.0			26 1/4

The enclosed inundation maps show the area downstream from Stagecoach Dam which would be affected by a failure of that dam. Flood depths, flood elevations and travel times are noted on the maps at various locations.

Because of the method, procedures, and assumptions used to develop these inundation maps, the limits of flooding shown and the flood wave travel times are only approximations. They should be only be used as a guideline for establishing flood evacuation zones. Actual areas inundated will depend on actual failure conditions and may differ significantly from those shown on these maps.

Although such measures may be risky and insignificant depending on the amount of advanced warning, the outlet works for Lake Catamount should be opened as soon as possible after it is known that Stagecoach Dam has failed. A more effective measure, if possible, would be to remove the stop logs in the roller gate spillway channel. These measures are intended to release as much water as possible in Lake Catamount before it is overtopped. This could slightly lower the risk of overtopping and might result in slightly lower peak discharges downstream.

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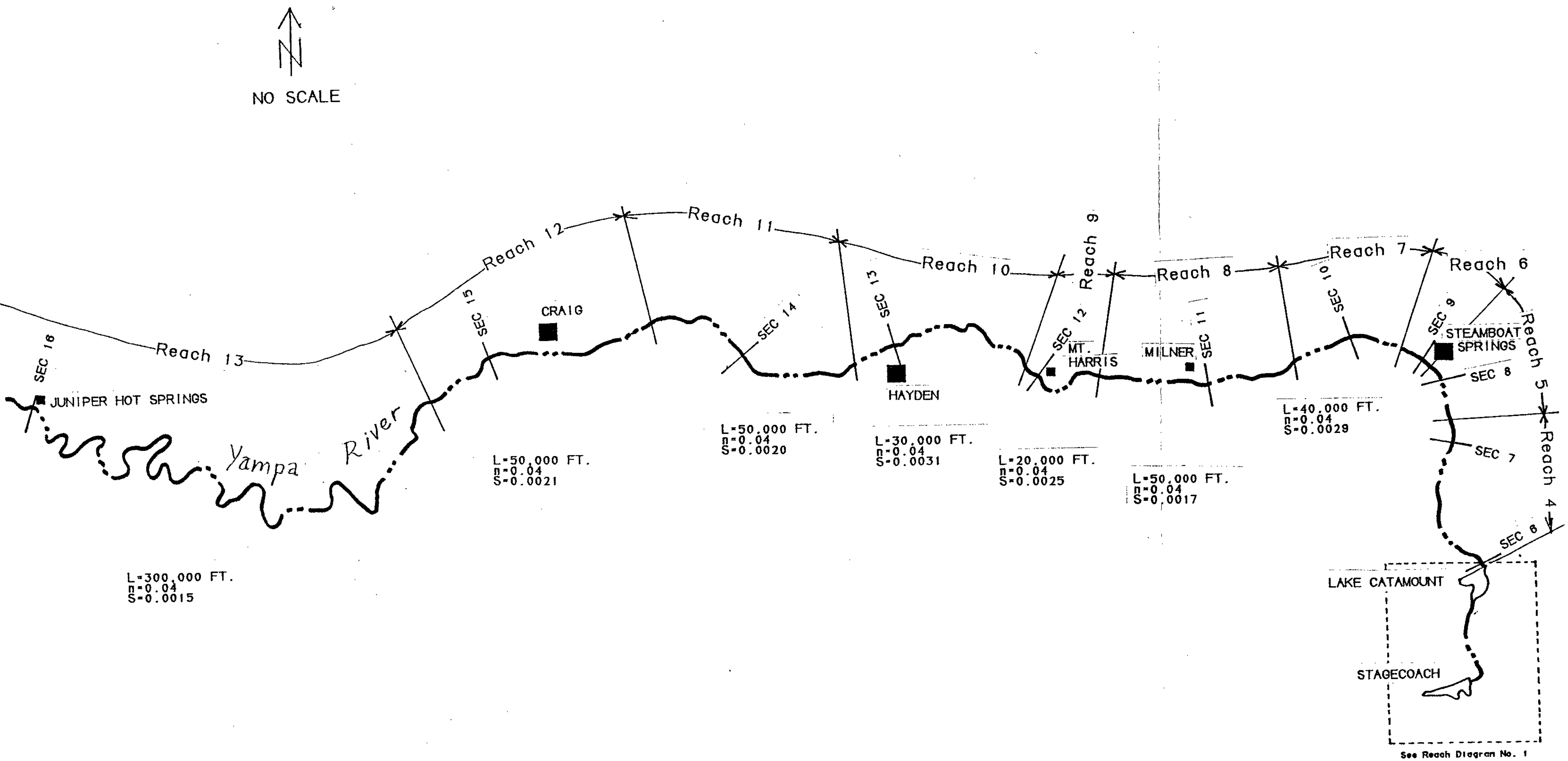
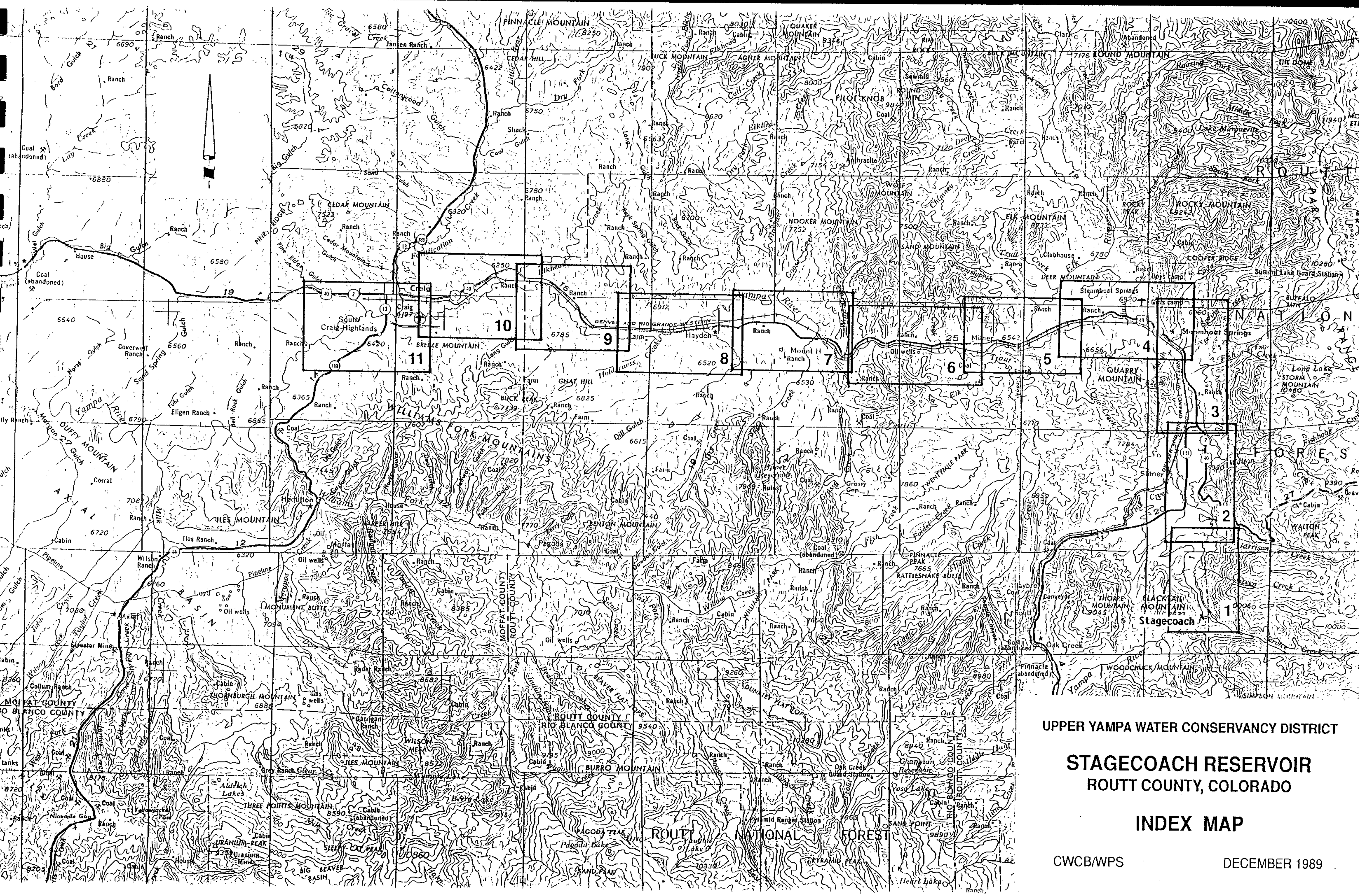
Inundation Maps



REACH DIAGRAM No 2



UPPER YAMPA WATER CONSERVANCY DISTRICT

STAGECOACH RESERVOIR
ROUTT COUNTY, COLORADO

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DECEMBER 1989

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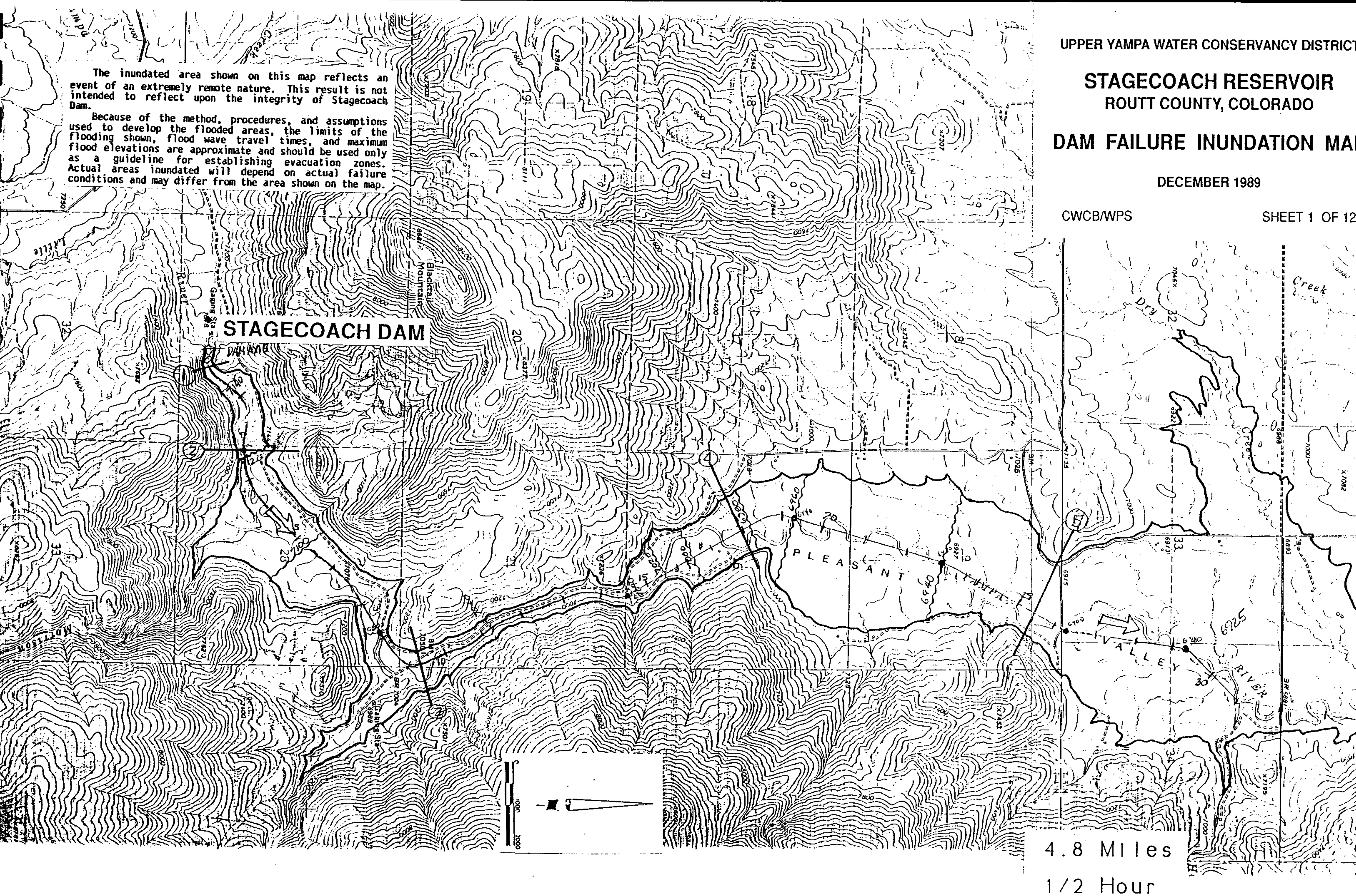
The inundated area shown on this map reflects an event of an extremely remote nature. This result is not intended to reflect upon the integrity of Stagecoach Dam.

Because of the method, procedures, and assumptions used to develop the flooded areas, the limits of the flooding shown, flood wave travel times, and maximum flood elevations are approximate and should be used only as a guideline for establishing evacuation zones. Actual areas inundated will depend on actual failure conditions and may differ from the area shown on the map.



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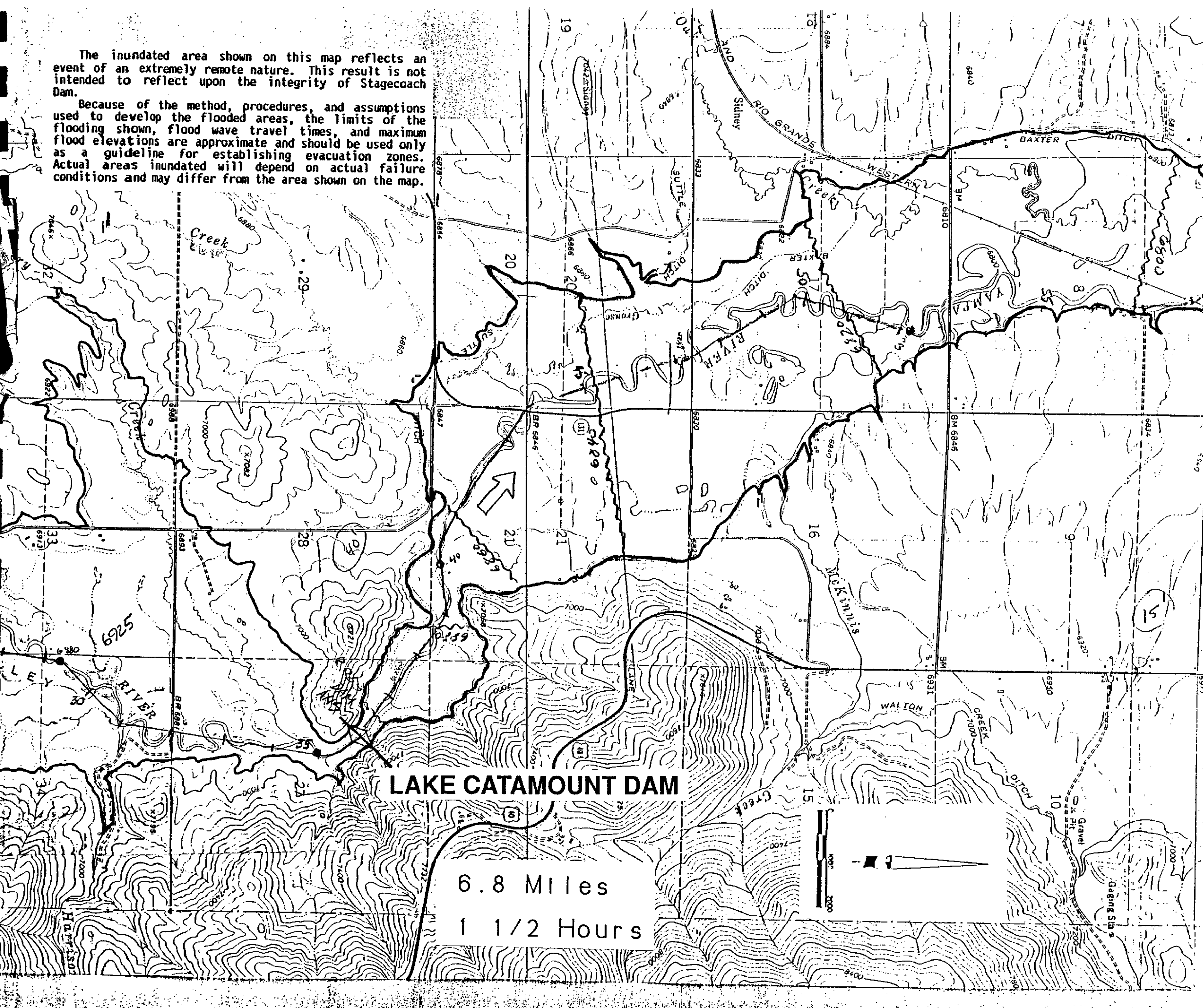

UPPER YAMPA WATER CONSERVANCY DISTRICT

STAGECOACH RESERVOIR

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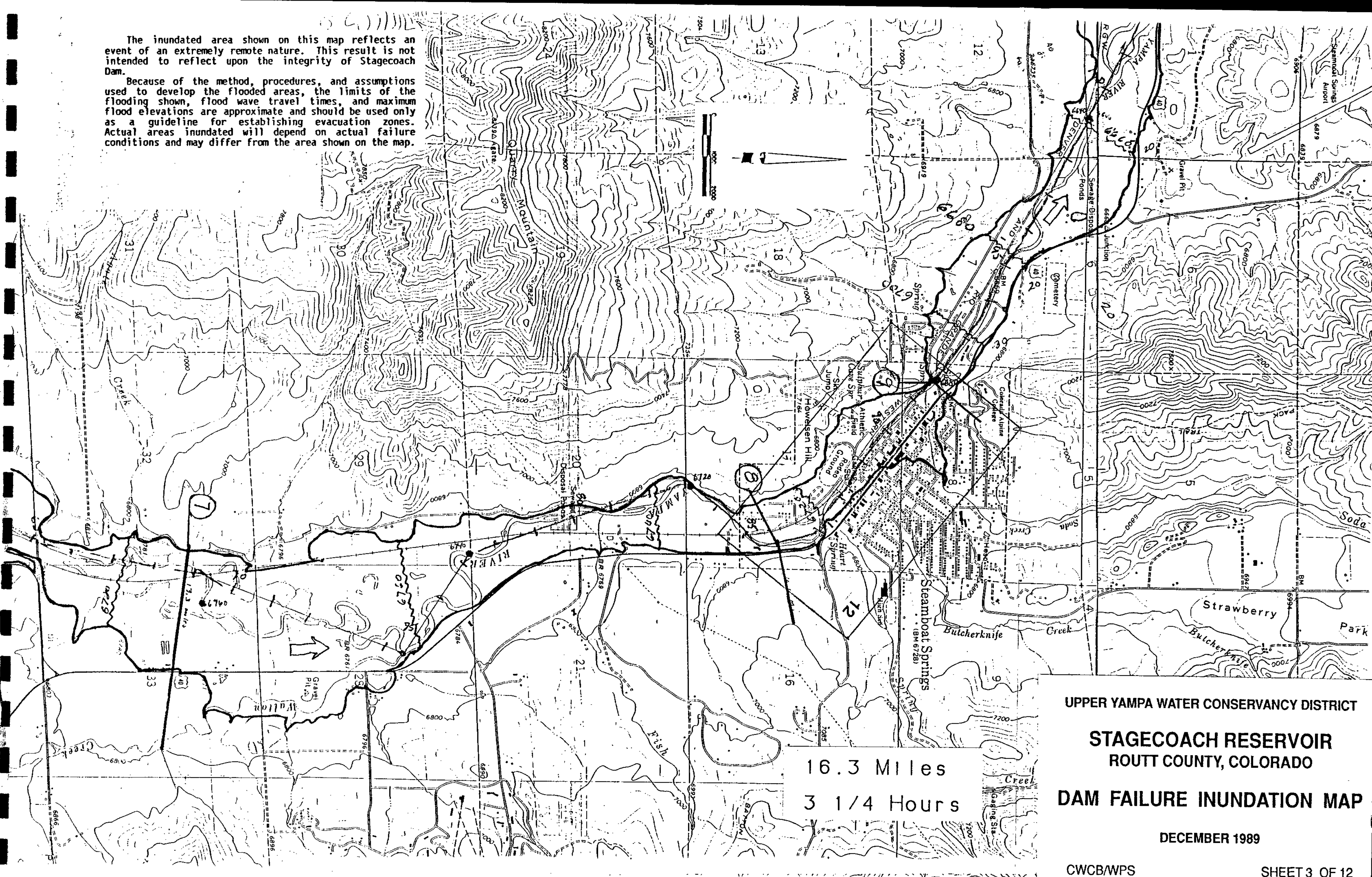

UPPER YAMPA WATER CONSERVANCY DISTRICT

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DAM FAILURE INUNDATION MAP

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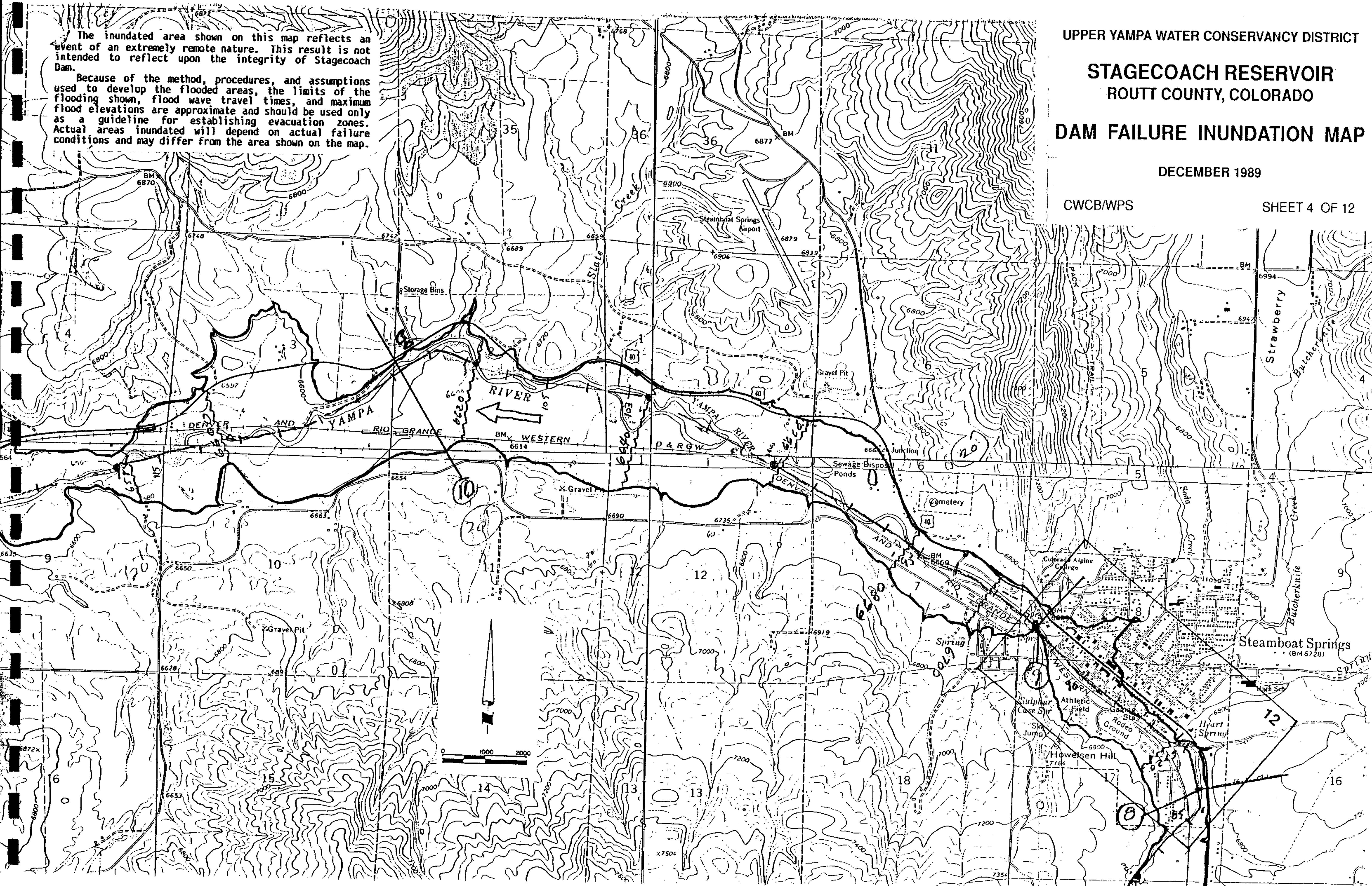

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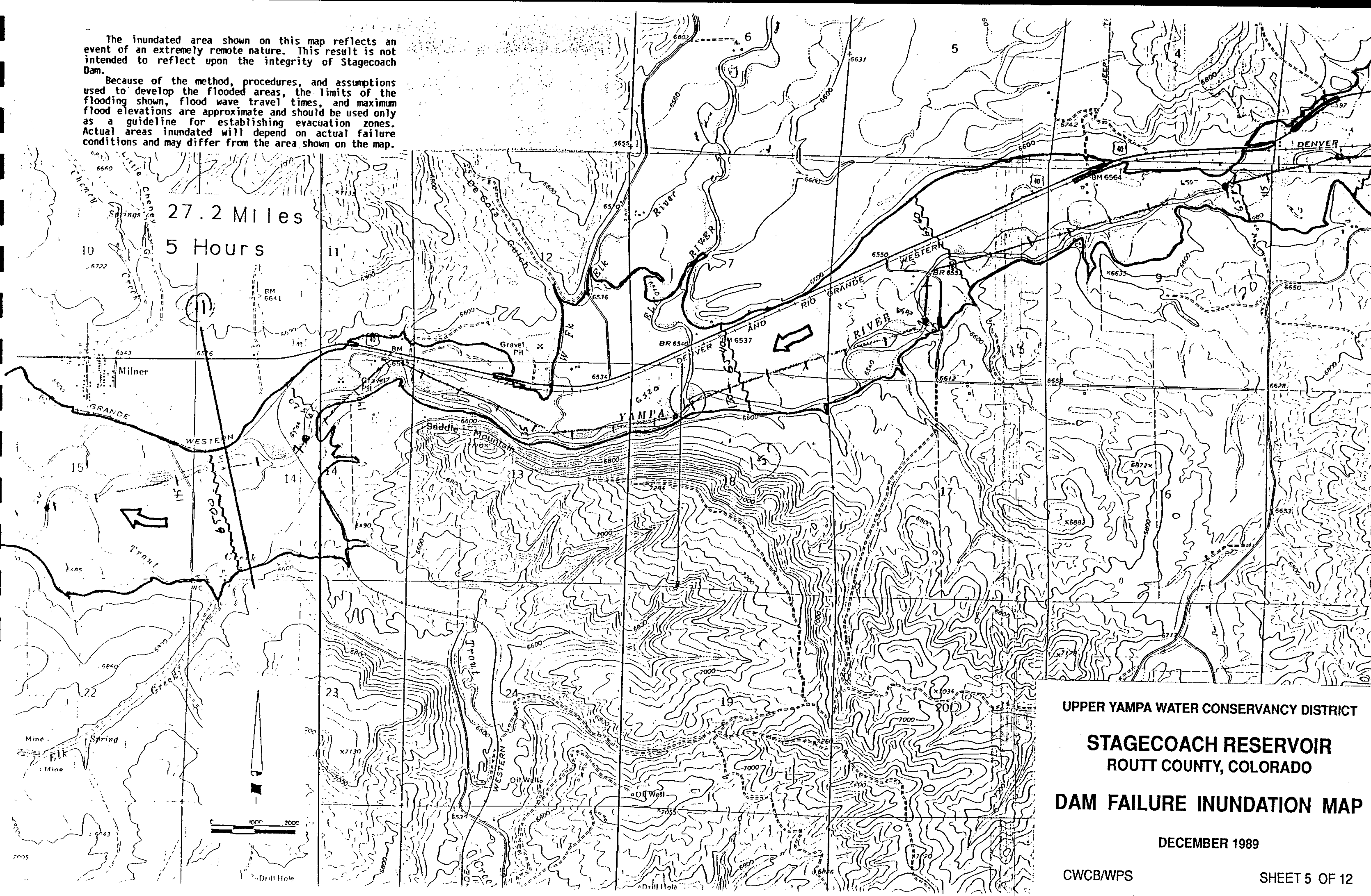

UPPER YAMPA WATER CONSERVANCY DISTRICT

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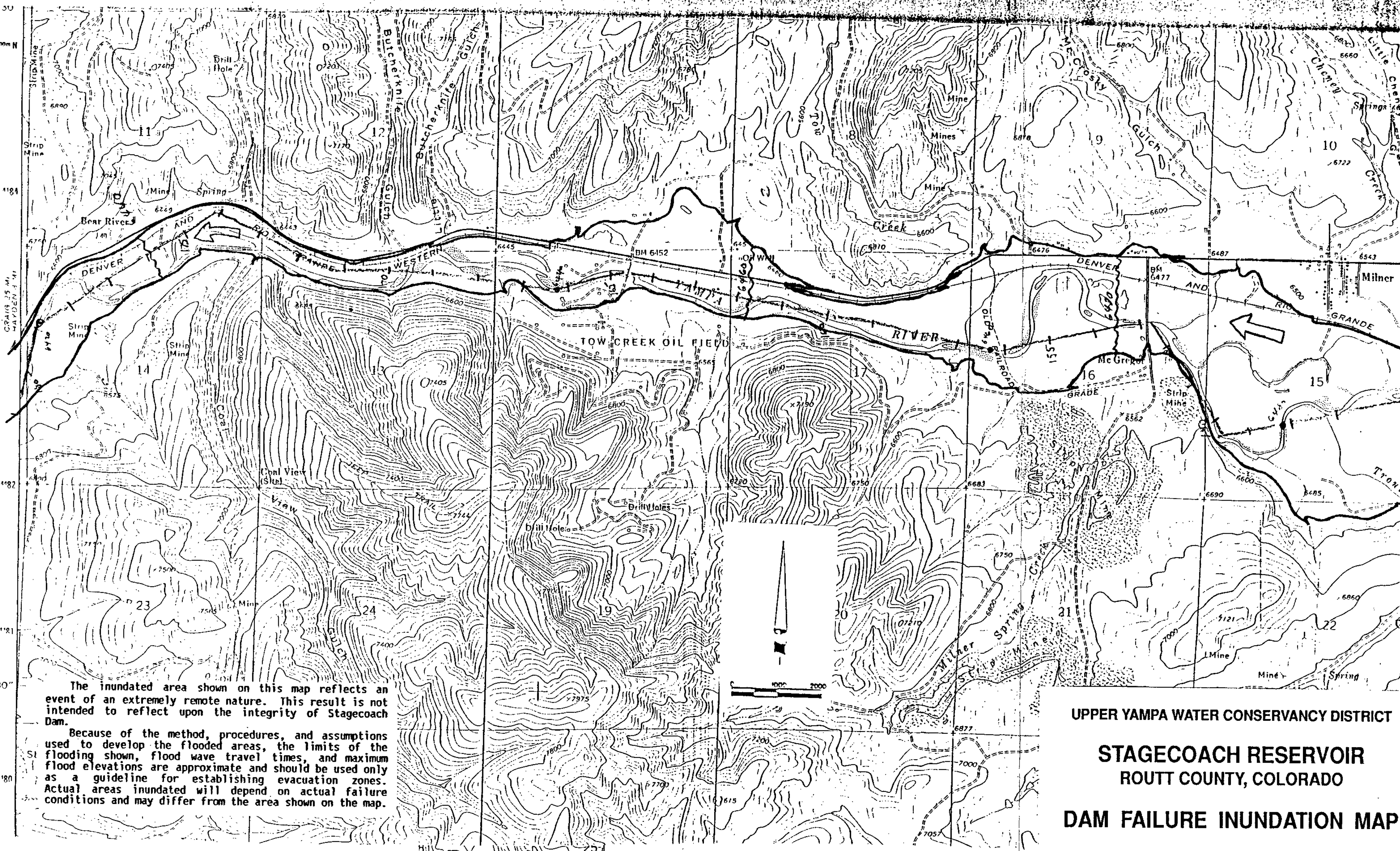

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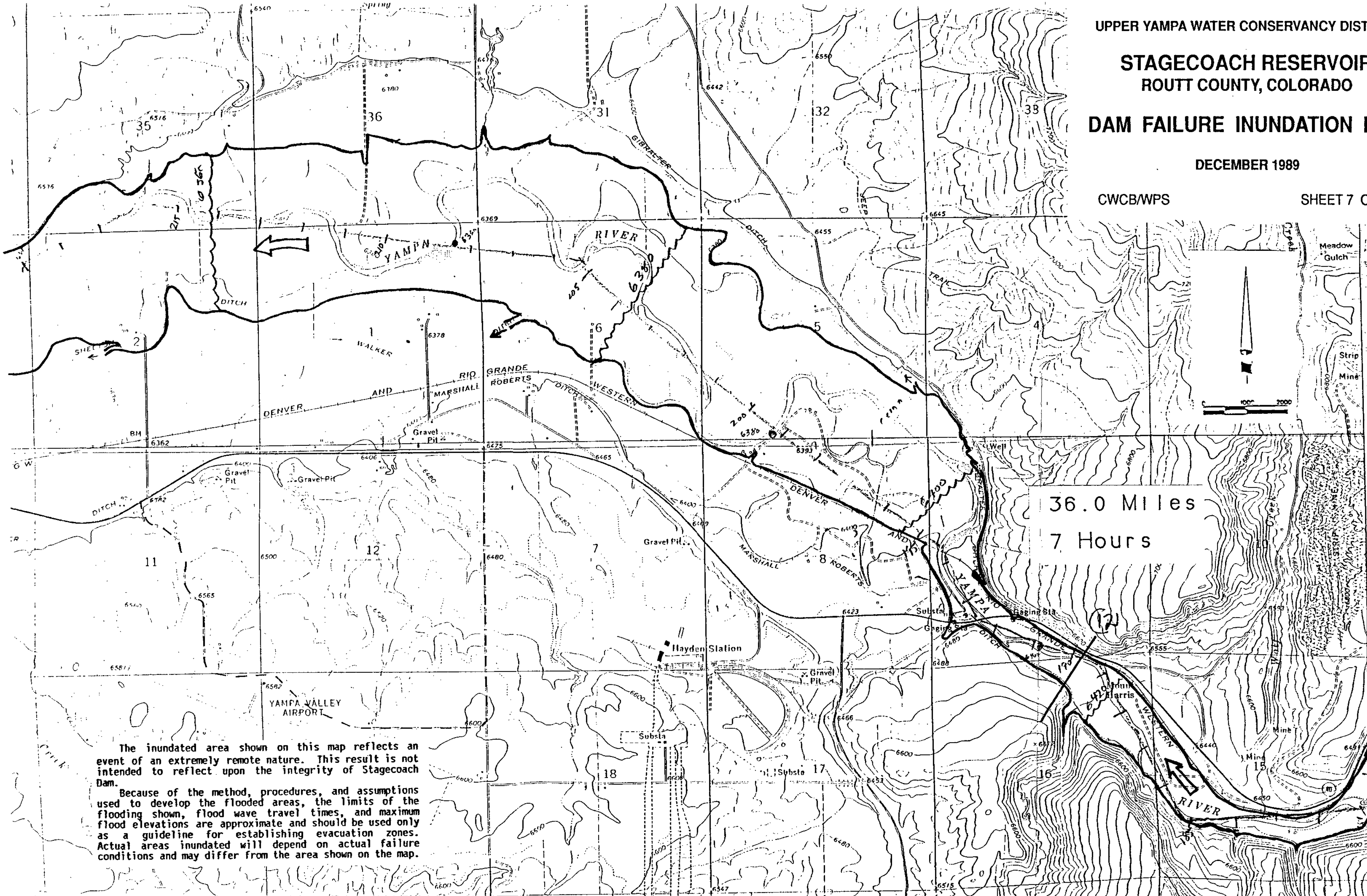

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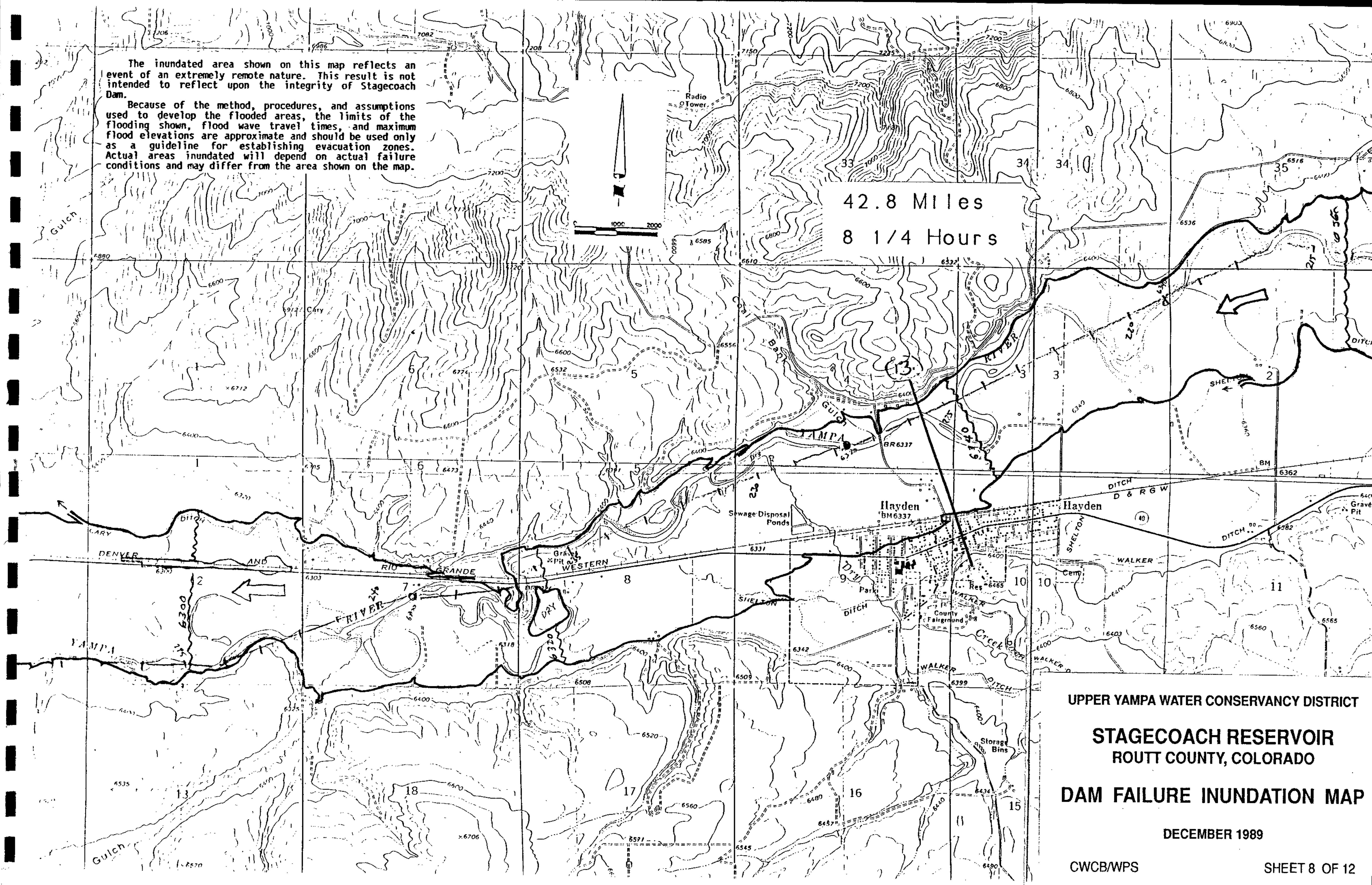

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STAGECOACH RESERVOIR
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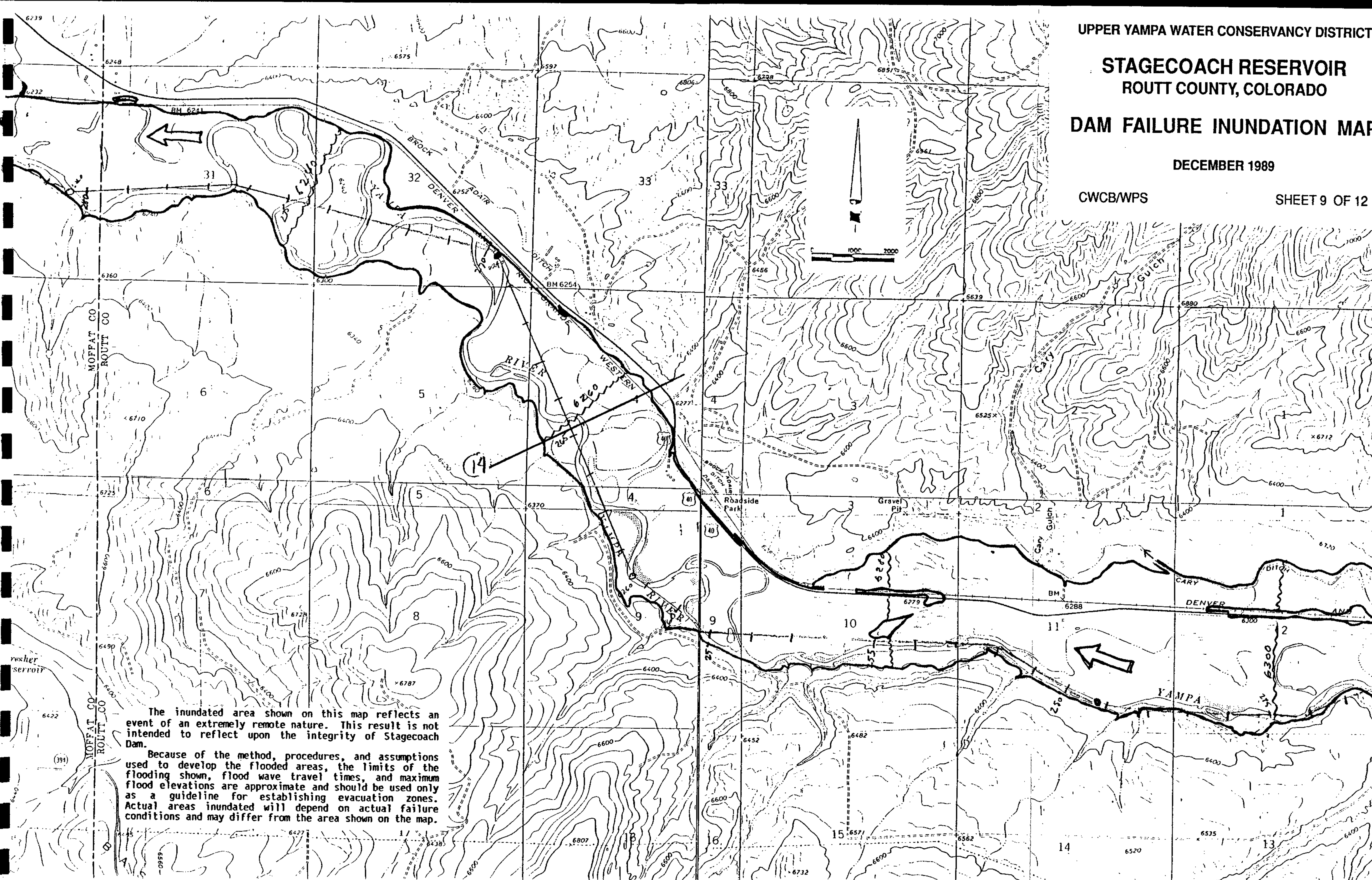

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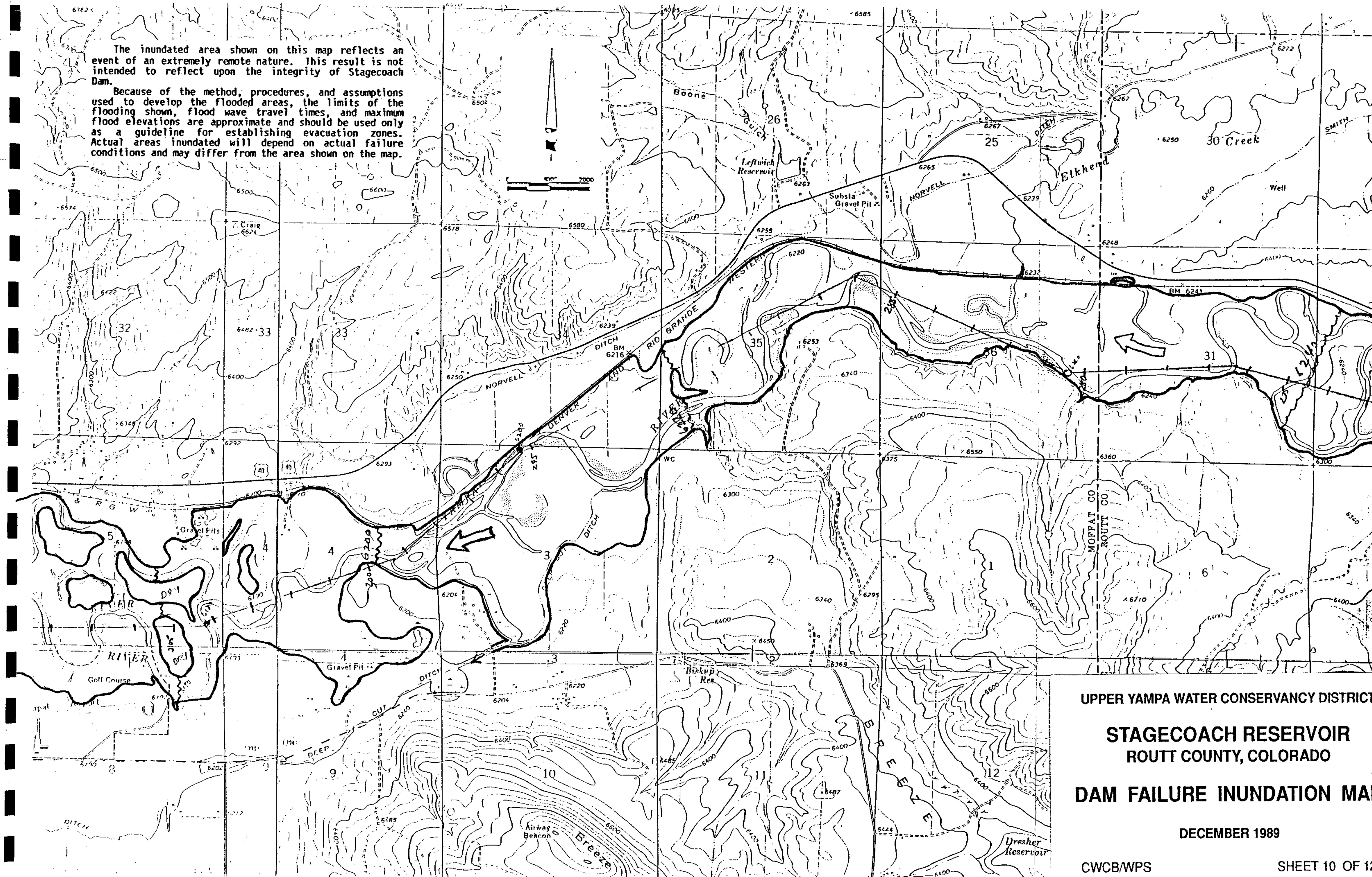

UPPER YAMPA WATER CONSERVANCY DISTRICT

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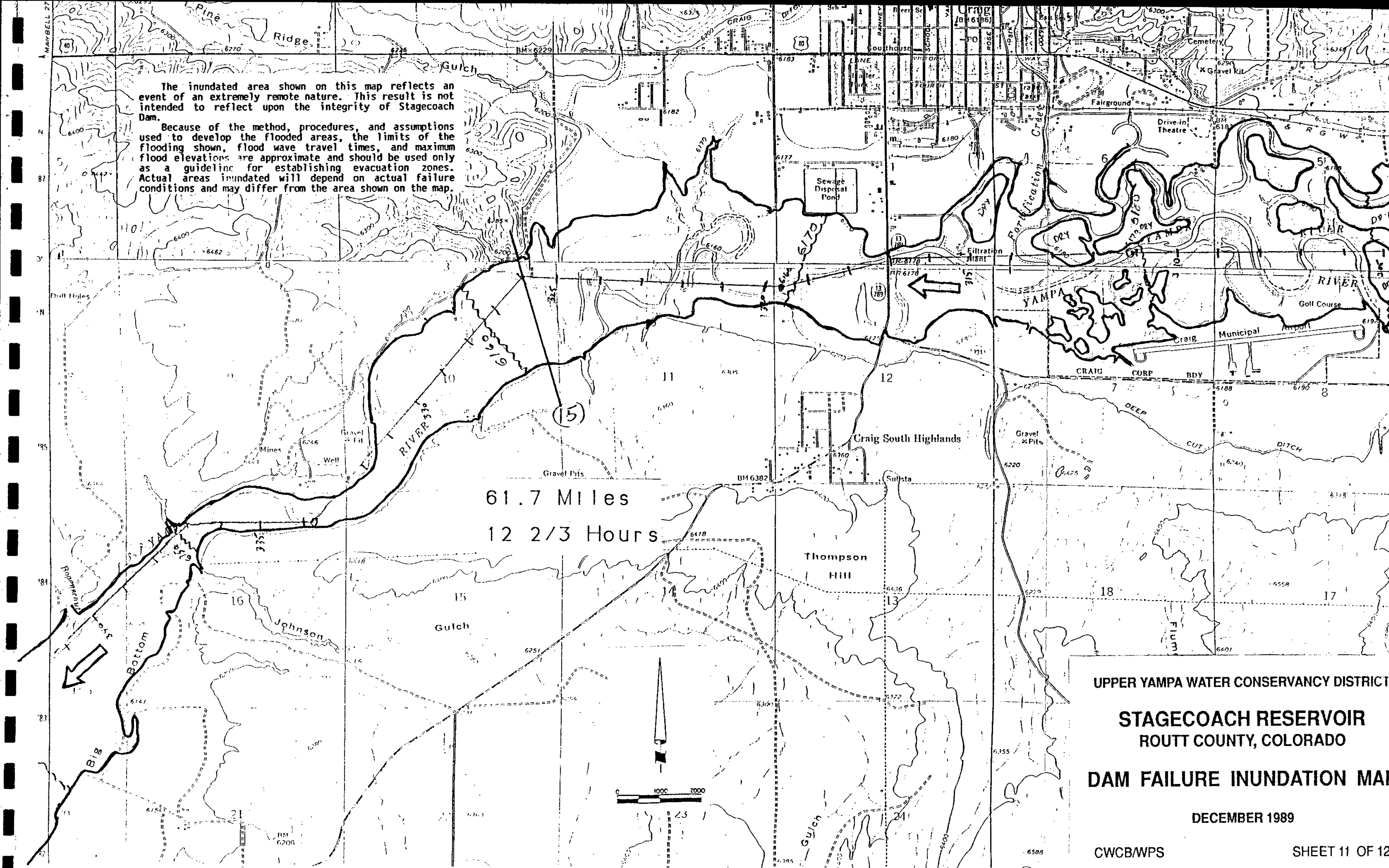

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UPPER YAMPA WATER CONSERVANCY DISTRICT

STAGECOACH RESERVOIR

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DAM FAILURE INUNDATION MAP

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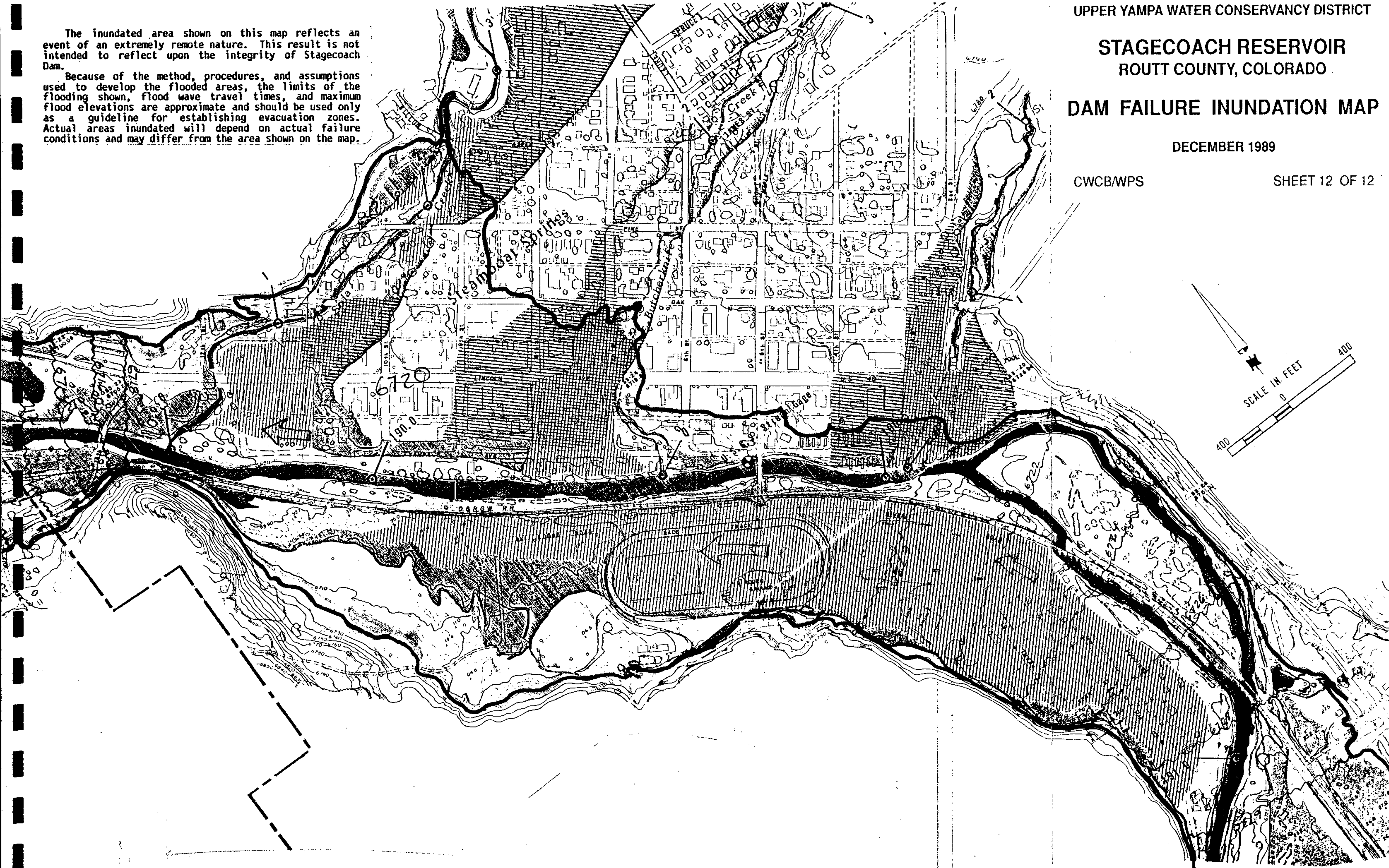

COMPUTER OUTPUTS

DAM BREAK FLOOD ROUTING PROCEDURE
BY COLORADO DIVISION OF WATER RESOURCES
VERSION DATED 11/22/88

DAM NAME: Stagecoach 12-20-1989

BEGIN ROUTING COMPUTATIONS WITH KNOWN HYDROGRAPH:

Peak Discharge, Q= 758866.00 cfs
Volume, V= 33275.00 acre-feet
Base Time, T= 1.06 hours

***************** REACH NO. 1 ************************

GEOMETRY FOR TRAPAZOIDAL SECTION:

Bottom Width, B= 200.00 feet
Channel Side Slopes: LEFT= 3.00:1 RIGHT= 2.00:1
Channel Bottom Slope, S=0.00690

CRITICAL DEPTH COMPUTATIONS:

Critical Depth= 59.43 feet
Critical Velocity= 36.6 ft/sec
Calculated n=0.032650
Assumed n=0.080000

RESULTS FROM MANNING'S EQUATION:

Q= 758934 cfs
D= 84.65 feet
Velocity= 21.78 ft/sec
Survival Factor (Depth x Velocity) = %1843.8

Assumed Velocity= 15.00 ft/sec
New Depth for above Velocity= 107.78 Feet
New Survival Factor (Depth x Velocity) = %1616.7

Length of Reach No. 1 = 8000 feet
Travel Time for Reach No. 1 = 0.15 hours

Number of Routing Steps = 2
Routed Q at End of Reach No. 1 ,QR= 632388 cfs
Base Time of Hydrograph at End of Reach No. 1 T= 1.27 hours

DAM NAME: Stagecoach 12-20-1989

***************** REACH NO. 2 ************************

GEOMETRY FOR TRAPAZOIDAL SECTION:

Bottom Width, B= 220.00 feet
Channel Side Slopes: LEFT= 3.00:1 RIGHT= 2.50:1
Channel Bottom Slope, S=0.00470

CRITICAL DEPTH COMPUTATIONS:

Critical Depth= 51.03 feet
Critical Velocity= 34.4 ft/sec
Calculated n=0.028743
Assumed n=0.080000

RESULTS FROM MANNING'S EQUATION:

Q= 632484 cfs
D= 80.94 feet
Velocity= 17.66 ft/sec
Survival Factor (Depth x Velocity) = %1429.1

Assumed Velocity= 15.00 ft/sec
New Depth for above Velocity= 90.13 Feet
New Survival Factor (Depth x Velocity) = %1351.9

Length of Reach No. 2 = 7000 feet
Travel Time for Reach No. 2 = 0.13 hours

Number of Routing Steps = 1
Routed Q at End of Reach No. 2 ,QR= 632388 cfs
Base Time of Hydrograph at End of Reach No. 2 T= 1.27 hours

DAM NAME: Stagecoach 12-20-1989

****************** REACH NO. 3 *************************

GEOMETRY FOR TRAPAZOIDAL SECTION:

Bottom Width, B= 1800.00 feet
Channel Side Slopes: LEFT= 2.60:1 RIGHT= 1.60:1
Channel Bottom Slope, S=0.00470

CRITICAL DEPTH COMPUTATIONS:

Critical Depth= 15.55 feet
Critical Velocity= 22.2 ft/sec
Calculated n=0.032907
Assumed n=0.040000

RESULTS FROM MANNING'S EQUATION:

Q= 632866 cfs
D= 19.18 feet
Velocity= 17.93 ft/sec
Survival Factor (Depth x Velocity) = 343.9

Assumed Velocity= 15.00 ft/sec
New Depth for above Velocity= 22.83 Feet
New Survival Factor (Depth x Velocity) = 342.5

Length of Reach No. 3 = 21000 feet
Travel Time for Reach No. 3 = 0.39 hours

Number of Routing Steps = 4
Routed Q at End of Reach No. 3 ,QR= 474291 cfs
QP= 474291 cfs D= 17.22 feet V= 15.0 ft/sec
Survival Factor (Depth x Velocity) = 258.3

DAM BREAK FLOOD ROUTING PROCEDURE
BY COLORADO DIVISION OF WATER RESOURCES
VERSION DATED 11/22/88

DAM NAME: Lake Catamount with Stagecoach 12-20-1989

GENERAL ASSUMPTIONS:

1. The water level is at the crest of the emergency spillway.
2. The dam fails at its maximum section.
3. Dam failure occurs under normal operating conditions.
4. The hydrograph at the dam site is triangular in shape.
5. Routed peak flows are based on method of successive averages.
6. Depth and velocity of flow are based on Manning's equation.
7. Channel is pre-wetted so loss of volume through absorption is negligible.
8. Valley cross section is trapazoidal and typical for the reach.

DAM AND RESERVOIR CHARACTERISTICS:

Maximum Height= 57.00 feet
Freeboard= 0.00 feet
Crest Width= 20.00 feet
Embankment Slopes: U/S= 3.00:1 D/S= 2.50:1
Crest Length= 400.0 feet

Reservoir Capacity= 18900.0 ac-ft
Surface Area= 983.0 acres

Crest Factor, K1= 1.07
Storage Intensity, K2= 0.252
Shape Factor, K3= 0.95
Erosiveness, K4= 1.00
K= 0.26

DAM FAILURE HYDROGRAPH CHARACTERISTICS:

T= 7.15 hours
QP= 63951 cfs

Additional Q= 63300 cfs
Total Q at Beginning of this Reach= 127251 cfs
Additional Volume= 21376.00 ac-ft.
Total Volume at Beginning of this Reach= 40276.00 ac-ft.
Base Time, T= 7.66 hours

DAM NAME: Lake Catamount with Stagecoach 12-20-1989

***************** REACH NO. 1 ************************

GEOMETRY FOR TRAPAZOIDAL SECTION:

Bottom Width, B= 4850.00 feet
Channel Side Slopes: LEFT= 2.50:1 RIGHT= 2.50:1
Channel Bottom Slope, S=0.00410

CRITICAL DEPTH COMPUTATIONS:

Critical Depth= 2.77 feet
Critical Velocity= 9.5 ft/sec
Calculated n=0.041043
Assumed n=0.040000

RESULTS FROM MANNING'S EQUATION:

Q= 127706 cfs
D= 4.23 feet
Velocity= 6.21 ft/sec
Survival Factor (Depth x Velocity) = 26.3
Length of Reach No. 1 = 38000 feet
Travel Time for Reach No. 1 = 1.70 hours

Number of Routing Steps = 3
Routed Q at End of Reach No. 1 ,QR= 95438 cfs
Base Time of Hydrograph at End of Reach No. 1 T= 10.21 hours

***************** REACH NO. 2 ************************

GEOMETRY FOR TRAPAZOIDAL SECTION:

Bottom Width, B= 1000.00 feet
Channel Side Slopes: LEFT= 3.50:1 RIGHT= 3.30:1
Channel Bottom Slope, S=0.00350

CRITICAL DEPTH COMPUTATIONS:

Critical Depth= 6.51 feet
Critical Velocity= 14.4 ft/sec
Calculated n=0.033826
Assumed n=0.040000

RESULTS FROM MANNING'S EQUATION:

Q= 95556 cfs
D= 9.56 feet
Velocity= 9.68 ft/sec
Survival Factor (Depth x Velocity) = 92.5
Length of Reach No. 2 = 13000 feet
Travel Time for Reach No. 2 = 0.37 hours

Number of Routing Steps = 0
Routed Q at End of Reach No. 2 ,QR= 95438 cfs
Base Time of Hydrograph at End of Reach No. 2 T= 10.21 hours

DAM NAME: Lake Catamount with Stagecoach 12-20-1989

***************** REACH NO. 3 ************************

GEOMETRY FOR TRAPAZOIDAL SECTION:

Bottom Width, B= 100.00 feet
Channel Side Slopes: LEFT= 7.50:1 RIGHT= 3.10:1
Channel Bottom Slope, S=0.00440

CRITICAL DEPTH COMPUTATIONS:

Critical Depth= 21.23 feet
Critical Velocity= 21.2 ft/sec
Calculated n=0.032644
Assumed n=0.040000

RESULTS FROM MANNING'S EQUATION:

Q= 95512 cfs
D= 25.74 feet
Velocity= 15.70 ft/sec
Survival Factor (Depth x Velocity) = 404.0

Assumed Velocity= 12.00 ft/sec
New Depth for above Velocity= 30.45 Feet
New Survival Factor (Depth x Velocity) = 365.4

Length of Reach No. 3 = 10000 feet
Travel Time for Reach No. 3 = 0.23 hours

Number of Routing Steps = 0
Routed Q at End of Reach No. 3 ,QR= 95438 cfs
Base Time of Hydrograph at End of Reach No. 3 T= 10.21 hours

DAM NAME: Lake Catamount with Stagecoach 12-20-1989

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***************** REACH NO.  4 ************************

GEOMETRY FOR TRAPAZOIDAL SECTION:

   Bottom Width, B= 2000.00 feet
   Channel Side Slopes: LEFT= 3.00:1  RIGHT= 3.00:1
   Channel Bottom Slope, S=0.00290

CRITICAL DEPTH COMPUTATIONS:

   Critical Depth=   4.12 feet
   Critical Velocity=  11.5 ft/sec
   Calculated n=0.033796
   Assumed n=0.040000

RESULTS FROM MANNING'S EQUATION:

   Q=  95532 cfs
   D=   6.70 feet
   Velocity=   7.06 ft/sec
   Survival Factor (Depth x Velocity) =  47.3
   Length of Reach No. 4  =  40000 feet
   Travel Time for Reach No. 4  =  1.57 hours

   Number of Routing Steps = 2
   Routed Q at End of Reach No. 4   ,QR=  83508 cfs
   Base Time of Hydrograph at End of Reach No.  4 T= 11.67 hours

***************** REACH NO.  5 ***********************

GEOMETRY FOR TRAPAZOIDAL SECTION:

   Bottom Width, B= 3000.00 feet
   Channel Side Slopes: LEFT= 1.20:1  RIGHT= 1.30:1
   Channel Bottom Slope, S=0.00170

CRITICAL DEPTH COMPUTATIONS:

   Critical Depth=   2.88 feet
   Critical Velocity=   9.7 ft/sec
   Assumed n=0.040000

RESULTS FROM MANNING'S EQUATION:

   Q=  83571 cfs
   D=   5.70 feet
   Velocity=   4.88 ft/sec
   Survival Factor (Depth x Velocity) =  27.8
   Length of Reach No. 5  =  50000 feet
   Travel Time for Reach No. 5  =  2.85 hours

   Number of Routing Steps = 3
   Routed Q at End of Reach No. 5   ,QR=  62631 cfs
   Base Time of Hydrograph at End of Reach No.  5 T= 15.56 hours
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DAM NAME: Lake Catamount with Stagecoach 12-20-1989

***************** REACH NO. 6 ************************

GEOMETRY FOR TRAPAZOIDAL SECTION:

Bottom Width, B= 850.00 feet
Channel Side Slopes: LEFT= 1.70:1 RIGHT= 1.70:1
Channel Bottom Slope, S=0.00250

CRITICAL DEPTH COMPUTATIONS:

Critical Depth= 5.50 feet
Critical Velocity= 13.3 ft/sec
Calculated n=0.030536
Assumed n=0.040000

RESULTS FROM MANNING'S EQUATION:

Q= 62666 cfs
D= 9.09 feet
Velocity= 7.97 ft/sec
Survival Factor (Depth x Velocity) = 72.4
Length of Reach No. 6 = 20000 feet
Travel Time for Reach No. 6 = 0.70 hours

Number of Routing Steps = 1
Routed Q at End of Reach No. 6 ,QR= 60021 cfs
Base Time of Hydrograph at End of Reach No. 6 T= 16.24 hours

***************** REACH NO. 7 ************************

GEOMETRY FOR TRAPAZOIDAL SECTION:

Bottom Width, B= 1200.00 feet
Channel Side Slopes: LEFT=85.00:1 RIGHT=11.00:1
Channel Bottom Slope, S=0.00310

CRITICAL DEPTH COMPUTATIONS:

Critical Depth= 4.03 feet
Critical Velocity= 10.7 ft/sec
Calculated n=0.035479
Assumed n=0.040000

RESULTS FROM MANNING'S EQUATION:

Q= 60095 cfs
D= 6.36 feet
Velocity= 6.28 ft/sec
Survival Factor (Depth x Velocity) = 39.9
Length of Reach No. 7 = 30000 feet
Travel Time for Reach No. 7 = 1.33 hours

Number of Routing Steps = 1
Routed Q at End of Reach No. 7 ,QR= 57521 cfs
Base Time of Hydrograph at End of Reach No. 7 T= 16.94 hours

DAM NAME: Lake Catamount with Stagecoach 12-20-1989

***************** REACH NO. 8 ************************

GEOMETRY FOR TRAPAZOIDAL SECTION:

Bottom Width, B= 2000.00 feet
Channel Side Slopes: LEFT= 4.00:1 RIGHT= 2.00:1
Channel Bottom Slope, S=0.00200

CRITICAL DEPTH COMPUTATIONS:

Critical Depth= 2.94 feet
Critical Velocity= 9.8 ft/sec
Calculated n=0.030964
Assumed n=0.040000

RESULTS FROM MANNING'S EQUATION:

Q= 57585 cfs
D= 5.53 feet
Velocity= 5.16 ft/sec
Survival Factor (Depth x Velocity) = 28.6
Length of Reach No. 8 = 50000 feet
Travel Time for Reach No. 8 = 2.69 hours

Number of Routing Steps = 2
Routed Q at End of Reach No. 8 ,QR= 50331 cfs
Base Time of Hydrograph at End of Reach No. 8 T= 19.37 hours

***************** REACH NO. 9 ************************

GEOMETRY FOR TRAPAZOIDAL SECTION:

Bottom Width, B= 2250.00 feet
Channel Side Slopes: LEFT= 2.50:1 RIGHT= 2.50:1
Channel Bottom Slope, S=0.00210

CRITICAL DEPTH COMPUTATIONS:

Critical Depth= 2.49 feet
Critical Velocity= 9.0 ft/sec
Calculated n=0.032384
Assumed n=0.040000

RESULTS FROM MANNING'S EQUATION:

Q= 50397 cfs
D= 4.69 feet
Velocity= 4.75 ft/sec
Survival Factor (Depth x Velocity) = 22.3
Length of Reach No. 9 = 50000 feet
Travel Time for Reach No. 9 = 2.92 hours

Number of Routing Steps = 2
Routed Q at End of Reach No. 9 ,QR= 44039 cfs
Base Time of Hydrograph at End of Reach No. 9 T= 22.13 hours

DAM NAME: Lake Catamount with Stagecoach 12-20-1989

****************** REACH NO. 10 ************************

GEOMETRY FOR TRAPAZOIDAL SECTION:

Bottom Width, B= 2000.00 feet
Channel Side Slopes: LEFT= 4.00:1 RIGHT= 4.00:1
Channel Bottom Slope, S=0.00150

CRITICAL DEPTH COMPUTATIONS:

Critical Depth= 2.46 feet
Critical Velocity= 8.9 ft/sec
Assumed n=0.040000

RESULTS FROM MANNING'S EQUATION:

Q= 44045 cfs
D= 5.13 feet
Velocity= 4.25 ft/sec
Survival Factor (Depth x Velocity) = 21.8
Length of Reach No. 10 = 300000 feet
Travel Time for Reach No. 10 = 19.61 hours

Number of Routing Steps =11
Routed Q at End of Reach No. 10 ,QR= 24837 cfs
QP= 24837 cfs D= 2.91 feet V= 4.2 ft/sec
Survival Factor (Depth x Velocity) = 12.3

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SIMPLIFIED DAMBREAK MODEL (SMPDBK) VERSION: 1/87
BY D.L. FREAD, J.M. LEWIS, & J.N. WETMORE - PHONE: (301) 427-7640
NWS HYDROLOGIC RESEARCH LAB, RM 530 8060 13TH ST, SILVER SPRING,MD 20910


    C1         Stagecoach
    C2         Yampa
    C3         IBC= 1     ISH= 0     JNK= 0     IDAM=1
                  HDM      BME      VOL       SA    BW    TFM      QO
    C4          7200.00 7075.00  33275.     775. 181.0  15.0      0.
    C5         NS=  5     NCS= 5     CMS=.30
               X-S NO.   1
    C6- 1      D=     .00     FLD=   10.00
    C7-1       HS= 7075.00     BS=     20.     BSS=       0.      CM= .080
    C7-2       HS= 7080.00     BS=     55.     BSS=       0.      CM= .080
    C7-3       HS= 7120.00     BS=    145.     BSS=       0.      CM= .080
    C7-4       HS= 7160.00     BS=    210.     BSS=       0.      CM= .080
    C7-5       HS= 7200.00     BS=    350.     BSS=       0.      CM= .080
               X-S NO.   2
    C6- 2      D=     .44     FLD=   10.00
    C7-1       HS= 7040.00     BS=     20.     BSS=       0.      CM= .080
    C7-2       HS= 7050.00     BS=     62.     BSS=       0.      CM= .080
    C7-3       HS= 7070.00     BS=     85.     BSS=       0.      CM= .080
    C7-4       HS= 7080.00     BS=    121.     BSS=       0.      CM= .080
    C7-5       HS= 7100.00     BS=    175.     BSS=       0.      CM= .080
               X-S NO.   3
    C6- 3      D=    1.78     FLD=   10.00
    C7-1       HS= 6990.00     BS=     20.     BSS=       0.      CM= .080
    C7-2       HS= 7000.00     BS=     92.     BSS=       0.      CM= .080
    C7-3       HS= 7010.00     BS=    123.     BSS=       0.      CM= .080
    C7-4       HS= 7020.00     BS=    152.     BSS=       0.      CM= .080
    C7-5       HS= 7040.00     BS=    221.     BSS=       0.      CM= .080
               X-S NO.   4
    C6- 4      D=    3.41     FLD=   10.00
    C7-1       HS= 6950.00     BS=     20.     BSS=       0.      CM= .040
    C7-2       HS= 6955.00     BS=    104.     BSS=       0.      CM= .040
    C7-3       HS= 6960.00     BS=   1126.     BSS=       0.      CM= .040
    C7-4       HS= 6980.00     BS=   1223.     BSS=       0.      CM= .040
    C7-5       HS= 7000.00     BS=   1295.     BSS=       0.      CM= .040
               X-S NO.   5
    C6- 5      D=    4.81     FLD=   10.00
    C7-1       HS= 6910.00     BS=     30.     BSS=       0.      CM= .040
    C7-2       HS= 6920.00     BS=   1800.     BSS=       0.      CM= .040
    C7-3       HS= 6960.00     BS=   1990.     BSS=       0.      CM= .040
    C7-4       HS= 7000.00     BS=   2140.     BSS=       0.      CM= .040
    C7-5       HS= 7040.00     BS=   2300.     BSS=       0.      CM= .040


THE DATA FOR THIS DAM IS AS FOLLOWS:

TYPE OF DAM    (IDAM)              CONCRETE GRAVITY
DAM BREACH ELEVATION  (HDE)           7200.00 FT
FINAL BREACH ELEVATION  (BME)         7075.00 FT
VOLUME OF RESERVOIR  (VOL)           33275.00 ACRE-FT
SURFACE AREA OF RESERVOIR  (SA)        775.00 ACRES
FINAL BREACH WIDTH  (BW)                66.00 FT
TIME OF DAM FAILURE  (TFM)              15.00 MINUTES
NON-BREACH FLOW  (QO)                     .00 CFS
DEAD STORAGE EQUIV. MANN. N (CMS)         .30
```

CROSS SECTION NO. 1
FLOOD DEPTH (FLD) 10.00 FT

ELEV.(FT) (HS)	7075.0	7080.0	7120.0	7160.0	7200.0
TWIDTHS(FT) (BS)	20.0	55.0	145.0	210.0	350.0
INACTIVE TW(FT) (BSS)	.0	.0	.0	.0	.0
MANNING N (CM)	.080	.080	.080	.080	.080

CROSS SECTION NO. 2
REACH LENGTH (D) .44 MI
FLOOD DEPTH (FLD) 10.00 FT

ELEV.(FT) (HS)	7040.0	7050.0	7070.0	7080.0	7100.0
TWIDTHS(FT) (BS)	20.0	62.0	85.0	121.0	175.0
INACTIVE TW(FT) (BSS)	.0	.0	.0	.0	.0
MANNING N (CM)	.080	.080	.080	.080	.080

CROSS SECTION NO. 3
REACH LENGTH (D) 1.78 MI
FLOOD DEPTH (FLD) 10.00 FT

ELEV.(FT) (HS)	6990.0	7000.0	7010.0	7020.0	7040.0
TWIDTHS(FT) (BS)	20.0	92.0	123.0	152.0	221.0
INACTIVE TW(FT) (BSS)	.0	.0	.0	.0	.0
MANNING N (CM)	.080	.080	.080	.080	.080

CROSS SECTION NO. 4
REACH LENGTH (D) 3.41 MI
FLOOD DEPTH (FLD) 10.00 FT

ELEV.(FT) (HS)	6950.0	6955.0	6960.0	6980.0	7000.0
TWIDTHS(FT) (BS)	20.0	104.0	1126.0	1223.0	1295.0
INACTIVE TW(FT) (BSS)	.0	.0	.0	.0	.0
MANNING N (CM)	.040	.040	.040	.040	.040

CROSS SECTION NO. 5
REACH LENGTH (D) 4.81 MI
FLOOD DEPTH (FLD) 10.00 FT

ELEV.(FT) (HS)	6910.0	6920.0	6960.0	7000.0	7040.0
TWIDTHS(FT) (BS)	30.0	1800.0	1990.0	2140.0	2300.0
INACTIVE TW(FT) (BSS)	.0	.0	.0	.0	.0
MANNING N (CM)	.040	.040	.040	.040	.040

AN ASTERISK (*) BESIDE A PARAMETER IMPLIES THAT A DEFAULT VALUE WAS COMPUTED

SECTION NO.	RVR MILE FROM DAM	MAX FLOW (CFS)	MAX DEPTH (FT)	TIME(HR) MAX DEPTH	TIME(HR) FLOOD	TIME(HR) DEFLOOD	FLOOD DEPTH(FT)
********	********	********	********	********	********	********	********
1	.00	277386.	74.71	.25	.00	2.86	10.00
2	.44	237501.	74.84	.27	.03	3.33	10.00
3	1.78	221319.	70.17	.37	.12	3.65	10.00
4	3.41	219106.	20.51	.54	.31	3.36	10.00
5	4.81	216915.	14.63	.64	.46	2.66	10.00

ANALYSIS IS COMPLETE

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SIMPLIFIED DAMBREAK MODEL (SMPDBK) VERSION: 1/87
BY D.L. FREAD, J.M. LEWIS, & J.N. WETMORE - PHONE: (301) 427-7640
NWS HYDROLOGIC RESEARCH LAB, RM 530 8060 13TH ST, SILVER SPRING,MD 2091Q

     C1          Catamount
     C2          Yampa
     C3          IBC= 1       ISH= 0      JNK= 0       IDAM=0
                      HDM       BME      VOL         SA      BW    TFM      QO
     C4           6915.00 6858.00  18900.       983.      .0     .0 30900.
     C5          NS= 11      NCS= 5      CMS=.30
                 X-S NO.   1
     C6- 1       D=       .00      FLD=      8.00
     C7-1        HS= 6860.00       BS=       30.     BSS=         0.      CM= .040
     C7-2        HS= 6880.00       BS=      250.     BSS=         0.      CM= .040
     C7-3        HS= 6920.00       BS=      400.     BSS=         0.      CM= .040
     C7-4        HS= 6960.00       BS=      580.     BSS=         0.      CM= .040
     C7-5        HS= 7000.00       BS=      750.     BSS=         0.      CM= .040
                 X-S NO.   2
     C6- 2       D=      6.21      FLD=      8.00
     C7-1        HS= 6760.00       BS=       30.     BSS=         0.      CM= .040
     C7-2        HS= 6780.00       BS=     4850.     BSS=         0.      CM= .040
     C7-3        HS= 6800.00       BS=     4950.     BSS=         0.      CM= .040
     C7-4        HS= 6840.00       BS=     5150.     BSS=         0.      CM= .040
     C7-5        HS= 6880.00       BS=     5400.     BSS=         0.      CM= .040
                 X-S NO.   3
     C6- 3       D=      9.47      FLD=      8.00
     C7-1        HS= 6690.00       BS=       30.     BSS=         0.      CM= .040
     C7-2        HS= 6700.00       BS=     1000.     BSS=         0.      CM= .040
     C7-3        HS= 6720.00       BS=     1100.     BSS=         0.      CM= .040
     C7-4        HS= 6760.00       BS=     1410.     BSS=         0.      CM= .040
     C7-5        HS= 6800.00       BS=     1660.     BSS=         0.      CM= .040
                 X-S NO.   4
     C6- 4       D=     10.55      FLD=      8.00
     C7-1        HS= 6670.00       BS=       30.     BSS=         0.      CM= .040
     C7-2        HS= 6680.00       BS=      100.     BSS=         0.      CM= .040
     C7-3        HS= 6720.00       BS=      800.     BSS=         0.      CM= .040
     C7-4        HS= 6760.00       BS=      950.     BSS=         0.      CM= .040
     C7-5        HS= 6800.00       BS=     1700.     BSS=         0.      CM= .040
                 X-S NO.   5
     C6- 5       D=     13.98      FLD=      8.00
     C7-1        HS= 6590.00       BS=       40.     BSS=         0.      CM= .040
     C7-2        HS= 6600.00       BS=      160.     BSS=         0.      CM= .040
     C7-3        HS= 6620.00       BS=     2650.     BSS=         0.      CM= .040
     C7-4        HS= 6640.00       BS=     2800.     BSS=         0.      CM= .040
     C7-5        HS= 6680.00       BS=     3850.     BSS=         0.      CM= .040
                 X-S NO.   6
     C6- 6       D=     20.40      FLD=      8.00
     C7-1        HS= 6490.00       BS=       40.     BSS=         0.      CM= .040
     C7-2        HS= 6500.00       BS=     3000.     BSS=         0.      CM= .040
     C7-3        HS= 6520.00       BS=     3140.     BSS=         0.      CM= .040
     C7-4        HS= 6560.00       BS=     3290.     BSS=         0.      CM= .040
     C7-5        HS= 6600.00       BS=     6200.     BSS=         0.      CM= .040
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               X-S NO.   7
     C6- 7     D=    29.13      FLD=     8.00
     C7-1      HS= 6410.00       BS=      40.     BSS=        0.      CM= .040
     C7-2      HS= 6420.00       BS=     850.     BSS=        0.      CM= .040
     C7-3      HS= 6440.00       BS=     940.     BSS=        0.      CM= .040
     C7-4      HS= 6480.00       BS=    1050.     BSS=        0.      CM= .040
     C7-5      HS= 6520.00       BS=    1610.     BSS=        0.      CM= .040
               X-S NO.   8
     C6- 8     D=    35.93      FLD=     8.00
     C7-1      HS= 6320.00       BS=      40.     BSS=        0.      CM= .040
     C7-2      HS= 6330.00       BS=    1200.     BSS=        0.      CM= .040
     C7-3      HS= 6340.00       BS=    3330.     BSS=        0.      CM= .040
     C7-4      HS= 6360.00       BS=    4080.     BSS=        0.      CM= .040
     C7-5      HS= 6400.00       BS=    4250.     BSS=        0.      CM= .040
               X-S NO.   9
     C6- 9     D=    43.41      FLD=     8.00
     C7-1      HS= 6250.00       BS=      40.     BSS=        0.      CM= .040
     C7-2      HS= 6260.00       BS=    2750.     BSS=        0.      CM= .040
     C7-3      HS= 6280.00       BS=    3200.     BSS=        0.      CM= .040
     C7-4      HS= 6320.00       BS=    4200.     BSS=        0.      CM= .040
     C7-5      HS= 6360.00       BS=    4750.     BSS=        0.      CM= .040
               X-S NO.  10
     C6-10     D=    54.92      FLD=     8.00
     C7-1      HS= 6130.00       BS=      40.     BSS=        0.      CM= .040
     C7-2      HS= 6140.00       BS=    2250.     BSS=        0.      CM= .040
     C7-3      HS= 6160.00       BS=    2400.     BSS=        0.      CM= .040
     C7-4      HS= 6200.00       BS=    2890.     BSS=        0.      CM= .040
     C7-5      HS= 6240.00       BS=    3250.     BSS=        0.      CM= .040
               X-S NO.  11
     C6- 1     D=    93.18      FLD=     8.00
     C7-1      HS= 5710.00       BS=      40.     BSS=        0.      CM= .040
     C7-2      HS= 5720.00       BS=    2250.     BSS=        0.      CM= .040
     C7-3      HS= 5740.00       BS=    2400.     BSS=        0.      CM= .040
     C7-4      HS= 5780.00       BS=    2890.     BSS=        0.      CM= .040
     C7-5      HS= 5820.00       BS=    3250.     BSS=        0.      CM= .040

THE DATA FOR THIS DAM IS AS FOLLOWS:

TYPE OF DAM    (IDAM)                EARTH
DAM BREACH ELEVATION  (HDE)            6915.00 FT
FINAL BREACH ELEVATION  (BME)          6858.00 FT
VOLUME OF RESERVOIR  (VOL)            18900.00 ACRE-FT
SURFACE AREA OF RESERVOIR  (SA)          983.00 ACRES
FINAL BREACH WIDTH  (BW)                171.00 FT         *
TIME OF DAM FAILURE  (TFM)                5.70 MINUTES    *
NON-BREACH FLOW  (QO)                 30900.00 CFS
DEAD STORAGE EQUIV. MANN. N (CMS)          .30
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CROSS SECTION NO.  1
FLOOD DEPTH  (FLD)          8.00 FT

ELEV.(FT) (HS)            6860.0  6880.0  6920.0  6960.0  7000.0
TWIDTHS(FT) (BS)            30.0   250.0   400.0   580.0   750.0
INACTIVE TW(FT) (BSS)         .0      .0      .0      .0      .0
MANNING N (CM)              .040    .040    .040    .040    .040


CROSS SECTION NO.  2
REACH LENGTH  (D)           6.21 MI
FLOOD DEPTH  (FLD)          8.00 FT

ELEV.(FT) (HS)            6760.0  6780.0  6800.0  6840.0  6880.0
TWIDTHS(FT) (BS)            30.0  4850.0  4950.0  5150.0  5400.0
INACTIVE TW(FT) (BSS)         .0      .0      .0      .0      .0
MANNING N (CM)              .040    .040    .040    .040    .040


CROSS SECTION NO.  3
REACH LENGTH  (D)           9.47 MI
FLOOD DEPTH  (FLD)          8.00 FT

ELEV.(FT) (HS)            6690.0  6700.0  6720.0  6760.0  6800.0
TWIDTHS(FT) (BS)            30.0  1000.0  1100.0  1410.0  1660.0
INACTIVE TW(FT) (BSS)         .0      .0      .0      .0      .0
MANNING N (CM)              .040    .040    .040    .040    .040


CROSS SECTION NO.  4
REACH LENGTH  (D)          10.55 MI
FLOOD DEPTH  (FLD)          8.00 FT

ELEV.(FT) (HS)            6670.0  6680.0  6720.0  6760.0  6800.0
TWIDTHS(FT) (BS)            30.0   100.0   800.0   950.0  1700.0
INACTIVE TW(FT) (BSS)         .0      .0      .0      .0      .0
MANNING N (CM)              .040    .040    .040    .040    .040


CROSS SECTION NO.  5
REACH LENGTH  (D)          13.98 MI
FLOOD DEPTH  (FLD)          8.00 FT

ELEV.(FT) (HS)            6590.0  6600.0  6620.0  6640.0  6680.0
TWIDTHS(FT) (BS)            40.0   160.0  2650.0  2800.0  3850.0
INACTIVE TW(FT) (BSS)         .0      .0      .0      .0      .0
MANNING N (CM)              .040    .040    .040    .040    .040


CROSS SECTION NO.  6
REACH LENGTH  (D)          20.40 MI
FLOOD DEPTH  (FLD)          8.00 FT

ELEV.(FT) (HS)            6490.0  6500.0  6520.0  6560.0  6600.0
TWIDTHS(FT) (BS)            40.0  3000.0  3140.0  3290.0  6200.0
INACTIVE TW(FT) (BSS)         .0      .0      .0      .0      .0
MANNING N (CM)              .040    .040    .040    .040    .040
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CROSS SECTION NO. 7
REACH LENGTH (D) 29.13 MI
FLOOD DEPTH (FLD) 8.00 FT

ELEV.(FT) (HS)	6410.0	6420.0	6440.0	6480.0	6520.0
TWIDTHS(FT) (BS)	40.0	850.0	940.0	1050.0	1610.0
INACTIVE TW(FT) (BSS)	.0	.0	.0	.0	.0
MANNING N (CM)	.040	.040	.040	.040	.040

CROSS SECTION NO. 8
REACH LENGTH (D) 35.93 MI
FLOOD DEPTH (FLD) 8.00 FT

ELEV.(FT) (HS)	6320.0	6330.0	6340.0	6360.0	6400.0
TWIDTHS(FT) (BS)	40.0	1200.0	3330.0	4080.0	4250.0
INACTIVE TW(FT) (BSS)	.0	.0	.0	.0	.0
MANNING N (CM)	.040	.040	.040	.040	.040

CROSS SECTION NO. 9
REACH LENGTH (D) 43.41 MI
FLOOD DEPTH (FLD) 8.00 FT

ELEV.(FT) (HS)	6250.0	6260.0	6280.0	6320.0	6360.0
TWIDTHS(FT) (BS)	40.0	2750.0	3200.0	4200.0	4750.0
INACTIVE TW(FT) (BSS)	.0	.0	.0	.0	.0
MANNING N (CM)	.040	.040	.040	.040	.040

CROSS SECTION NO. 10
REACH LENGTH (D) 54.92 MI
FLOOD DEPTH (FLD) 8.00 FT

ELEV.(FT) (HS)	6130.0	6140.0	6160.0	6200.0	6240.0
TWIDTHS(FT) (BS)	40.0	2250.0	2400.0	2890.0	3250.0
INACTIVE TW(FT) (BSS)	.0	.0	.0	.0	.0
MANNING N (CM)	.040	.040	.040	.040	.040

CROSS SECTION NO. 11
REACH LENGTH (D) 93.18 MI
FLOOD DEPTH (FLD) 8.00 FT

ELEV.(FT) (HS)	5710.0	5720.0	5740.0	5780.0	5820.0
TWIDTHS(FT) (BS)	40.0	2250.0	2400.0	2890.0	3250.0
INACTIVE TW(FT) (BSS)	.0	.0	.0	.0	.0
MANNING N (CM)	.040	.040	.040	.040	.040

AN ASTERISK (*) BESIDE A PARAMETER IMPLIES THAT A DEFAULT VALUE WAS COMPUTED

SECTION NO.	RVR MILE FROM DAM	MAX FLOW (CFS)	MAX DEPTH (FT)	TIME(HR) MAX DEPTH	TIME(HR) FLOOD	TIME(HR) DEFLOOD	FLOOD DEPTH(FT)
********	********	********	********	********	********	********	********
1	.00	153790.	39.79	.09	.00	.00	8.00
2	6.21	135384.	12.51	1.00	.91	4.57	8.00
3	9.47	110174.	14.89	1.74	.00	.00	8.00
4	10.55	82109.	30.60	1.98	.00	.00	8.00
5	13.98	81288.	20.43	2.38	.00	.00	8.00
6	20.40	80475.	9.56	3.44	3.37	7.22	8.00
7	29.13	70457.	15.69	5.58	.00	.00	8.00
8	35.93	69639.	13.32	6.83	.00	.00	8.00
9	43.41	67118.	10.13	8.45	8.36	15.00	8.00
10	54.92	54995.	9.92	11.43	11.33	20.05	8.00
11	93.18	37632.	8.50	21.96	21.87	38.39	8.00

ITERATIVE SOLUTION FOR SUBMERGENCE EFFECT DID NOT CONVERGE;
THEREFORE, NO SUBMERGENCE IS ACCOUNTED FOR.

ANALYSIS IS COMPLETE