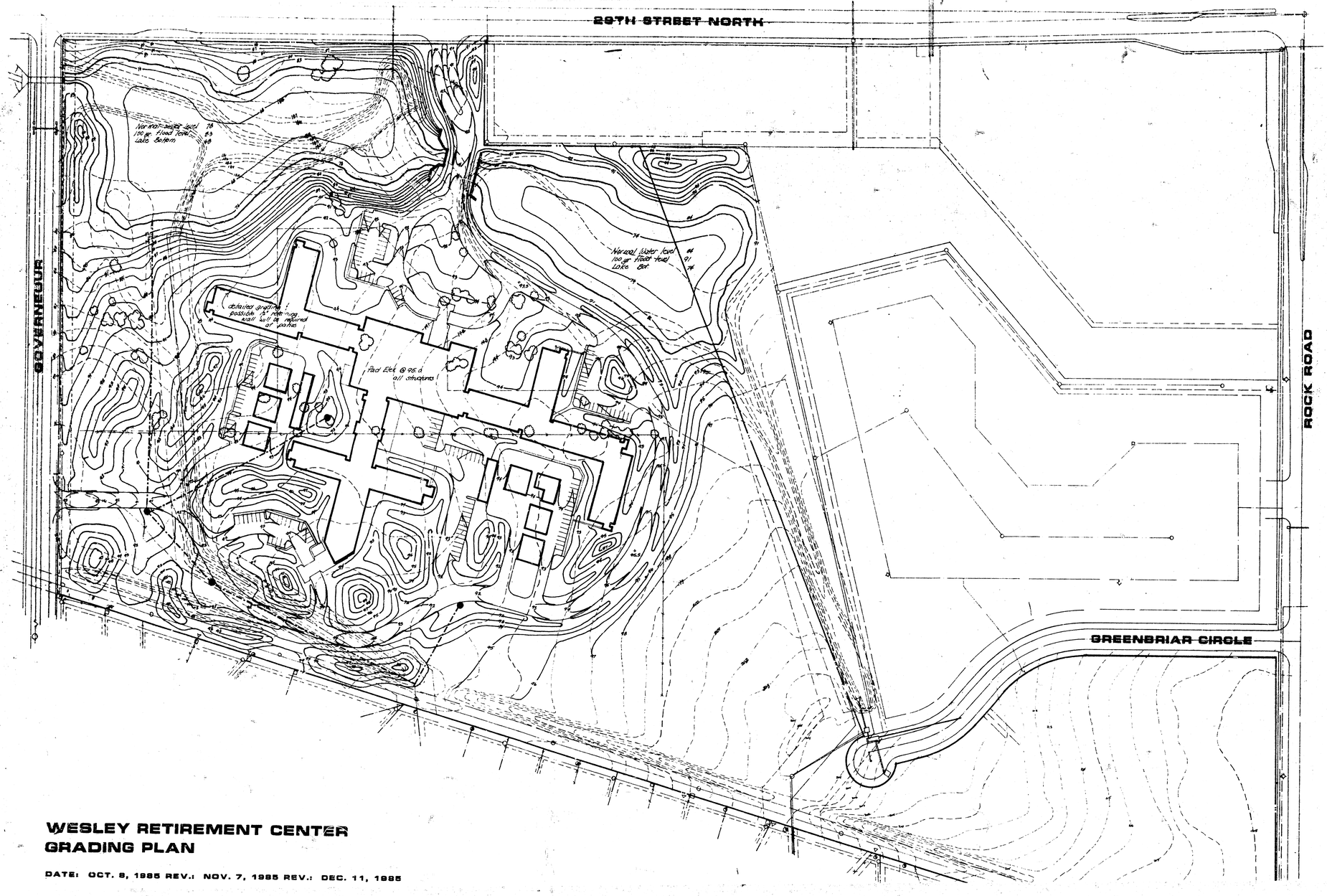

WESLEY RETIREMENT CENTER
GRADING PLAN

DATE: OCT. 8, 1985 REV.: NOV. 7, 1985 REV.: DEC. 11, 1985

HYDROLOGY AND HYDRAULIC
ANALYSIS
DETENTION RESERVOIRS "A" AND "B"

LARKSFIELD PLACE
IN
WICHITA, KANSAS

JANUARY 1986

MID - KANSAS ENGINEERING CONSULTANTS

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I. INTRODUCTION

A. PURPOSE: The purpose of this study is to evaluate the characteristics of the proposed detention reservoirs "A" and "B" in the Larksfield Place Addition. Since the proposed reservoirs are immediately upstream of the "Pepperwood" detention reservoir, a review of the potential downstream impact has also been included.

The proposed detention reservoirs "A" and "B" will essentially provide for no net increase or adverse downstream impact from development of the contributing drainage basin. Design of the detention reservoirs "A" and "B" will be so configured as to meet necessary National Dam Safety Requirements, if applicable.

B. SCOPE: The scope of the study included the following major tasks;

1. Review of previous hydrology data for reservoirs "A" and "B" as well as the Pepperwood detention reservoir.
2. Determine applicable detention reservoir control structures for reservoirs "A" and "B".
3. Determine the maximum water surface elevations, through the use of reservoir routing procedures, for the 100 year - 6 Hour design storm.
4. Develop recommendations for final project design criteria.

C. BACKGROUND: The original hydrology and hydraulic criteria for the proposed detention reservoirs "A" and "B" were developed as part of the "Hydrology and Hydraulic Analysis for Pepperwood Detention Reservoir - August 1979". To adequately determine the design criteria for the Pepperwood facility, estimates were made concerning the potential upstream development surrounding reservoir sites "A" and "B". Detailed analyses were carried out with hydrograph generation, hydrograph addition and routings. This original hydrograph development has been utilized in the current analysis for reservoirs "A" and "B". The original hydrology analysis yielded the hydrograph and routing data as shown on the next pages; (calculations assumed reservoirs "A" and "B" combined - These calculations were included in the original Pepperwood Report).

INFLOW HYDROGRAPH
TO RESERVOIRS "A" AND "B"

TIME HRS	Q CFS
0.25	0.0
0.50	0.0
0.75	0.0
1.00	2.1
1.25	16.5
1.50	41.9
1.75	65.8
2.00	89.3
2.25	215.4
2.50	401.0
2.75	506.4
3.00	**540.5**
3.25	421.5
3.50	247.4
3.75	190.1
4.00	190.1
4.25	160.0
4.50	120.4
4.75	108.0
5.00	108.1
5.25	100.3
5.50	90.3
5.75	87.3
6.00	87.3
6.25	53.0
6.50	12.1
6.75	0.0

Peak inflow of 541 cfs @ Time 3.0 Hrs.

Based on an approximate available combined flood storage in reservoirs "A" and "B" the routing of the preceeding inflow hydrograph yielded:

RESERVOIR "A" AND "B"
ROUTING TABLE

TIME INTERVAL HRS.	Q-IN CFS	Q-OUT CFS	STORAGE AC.FT.	ELEV. FT.
0.00	0.00	0.00	0.00	181.00
0.25	0.00	0.00	0.00	181.00
0.50	0.00	0.00	0.00	181.00
0.75	0.00	0.00	0.00	181.00
1.00	2.11	0.00	0.04	181.00
1.25	16.53	0.00	0.38	181.05
1.50	41.98	0.00	1.25	181.19
1.75	65.86	0.00	2.61	181.39
2.00	89.36	0.00	4.45	181.67
2.25	215.41	0.00	8.91	182.31
2.50	401.09	7.21	17.18	183.48
2.75	506.42	51.41	27.15	184.91
3.00	**540.50**	155.79	36.27	186.02
3.25	421.55	**298.37**	**39.58**	**186.42**
3.50	247.48	258.81	38.66	186.31
3.75	190.19	213.62	37.61	186.18
4.00	190.16	195.23	37.18	186.13
4.25	160.07	168.75	36.57	186.06
4.50	120.49	142.69	35.80	185.97
4.75	108.07	135.40	35.14	185.89
5.00	108.19	129.63	34.61	185.82
5.25	100.38	123.44	34.05	185.76
5.50	90.31	116.51	33.41	185.68
5.75	87.38	110.44	32.86	185.61
6.00	87.31	105.60	32.42	185.56
6.25	53.09	94.70	31.42	185.44
6.50	12.10	77.80	29.88	185.25
6.75	0.00	77.80	29.88	185.25

The peak flow of 541 cfs was reduced to 298 cfs and retarded approximately 15 minutes. Overall storage needs were approximately 40 AFT.

This data was added to the addditional drainage area upstream of the Pepperwood detention reservoir to provide a composite inflow hydrograph to the Pepperwood facility. This composite hydrograph has been provided below for further reference later in this report;

COMPOSITE INFLOW
HYDROGRAPH - PEPPERWOOD DETENTION RESERVOIR

TIME INTERVAL HRS.	INFLOW HYDROGRAPH TO PEPPERWOOD RESERVOIR * CFS	OUTFLOW HYDROGRAPH FROM RESERVOIRS "A" and "B" CFS	COMPOSITE INFLOW HYDROGRAPH TO PEPPERWOOD RESERVOIR CFS
0.25	13.2	0.00	13.2
0.50	26.4	0.00	26.4
0.75	18.50	0.00	18.5
1.00	11.6	0.00	11.6
1.25	13.4	0.00	13.4
1.50	32.0	0.00	32.0
1.75	61.2	0.00	61.2
2.00	91.0	0.00	91.0
2.25	186.0	0.00	186.0
2.50	360.0	7.21	367.3
2.75	534.6	51.41	586.0
3.00	**670.5**	155.79	826.3
3.25	654.2	**298.37**	**952.6**
3.50	508.7	258.81	767.5
3.75	374.6	213.62	588.2
4.00	286.7	195.23	481.9
4.25	242.2	168.75	411.0
4.50	204.7	142.69	347.4
4.75	173.4	135.40	308.8
5.00	153.5	129.63	283.1
5.25	143.0	123.44	266.4
5.50	133.6	116.51	250.1
5.75	125.7	110.44	236.1
6.00	11.0	105.60	216.6
6.25	75.2	94.70	169.9
6.50	36.4	77.80	114.1
6.75	12.2	77.80	90.0

*From Area other than that contributing to "A" and "B"

With the routed effect of reservoirs "A" and "B", the above composite hydrograph indicates that the peak flow has been shifted in time to 3.25 Hrs. The composite inflow hydrograph was utilized for the design of the Pepperwood facility.

SECTION II
DESIGN METHODOLOGY

A. DESIGN CRITERIA: The following criteria were utilized in the development of the detention reservoirs:

1. The net increase in peak runoff due to development for the 100 year 6 hour storm event would be essentially zero for the contributing drainage basin.
2. Reservoirs "A" and "B" would be sized to provide less than 30 AFT of accumulated storage.
3. Outlet configurations would be developed to provide adequate storage and to retard flows thereby insuring downstream impact at or below the level originally envisioned in the Pepperwood Report.

B. HYDROLOGY COMPUTATION METHODS: Runoff volumes and peak flows were calculated through the use of SCS (Soil Conservation Service) procedures.

Runoff volumes were determined through the use of SCS Hydrologic Soil Groupings and appropriate runoff curve numbers (CN) for the drainage basin under consideration. Runoff volume was also distributed over the storm duration in accordance with SCS recommendations.

Time of concentration was determined by basin characteristics and through the use of Kirpich Nomograph where;

$$Tc = \left(\frac{11.9\,L^3}{H}\right)^{.385}$$

Tc = Time of Concentration (Hrs)
L = Length of Basin (miles)
H = Elevation Difference in Basin (feet)

Unit hydrographs were developed and summed for the 100 year 6 hour storm. Computer calculations utilizing SCS Soil Group Numbers, CN, Tc, drainage basin areas, etc. were performed to develop hydrographs and to provide the inflow hydrographs for routing purposes. The following general formula was utilized in the computations:

$$Qp = \frac{484\,AR}{Tp}$$

where A = Area in square miles
R = Total runoff in inches (1 inch for unit hydrograph)
Tp = Time in hours from start of rise to peak rate

The relationship of Tp to storm duration and time of concentration was established through the relationship of Tp = D/2 + 0.6 Tc. Therefore the formula for peak flow took the form of:

where D = Duration of storm event (or storm segment for unit hydrograph)
Tc = Time of concentration

The inflow hydrographs were routed through the detention reservoir by use of a computer model.

Individual elevation/discharge curves were developed for several types of outlet structures for both reservoirs "A" and "B". These curves were utilized with the calculated hydrographs to determine design water surfaces.

The following references were utilized for the computations:

1. Design of Small Dams - 1974, Bureau of Reclamation.
2. Probable Maximum Precipitation Estimates, U.S. East of 105th Meridian. HR No. 51, U.S. Dept. of Commerce.
3. Earth Dams and Reservoirs, TR 60 U.S. Dept. of Agriculture. SCS.
4. SCS National Engineering Handbook, Section 4.
5. Determination of Peak Discharge From Rainfall Data for Urbanized Basins, Wichita, Kansas, U.S.G.S. Open File Report 78-974.

III. COMPUTATIONS

A. DRAINAGE AREA: The total drainage area served by reservoirs "A" and "B" is 233 Acres or 0.36 square miles.

B. HYDROGRAPHS: As previously discussed, computations for the drainage area served by reservoirs "A" and "B" are provided in the original Pepperwood Report. In addition, pertinent hydrograph data has been provided in Sec. I of this report. Routed hydrographs, water surface data, and downstream impacts will be discussed in following sections.

C. DETENTION RESERVOIRS "A" and "B": The following general characteristics were utilized in the development of data necessary to provide hydrograph routings:

1. Reservoir "A" outlet structure: An 8 x 4 Reinforced Concrete Box Structure (RCB) was utilized to provide discharge control for reservoir "A". The RCB also will serve as a roadway crossing between reservoirs "A" and "B". The RCB characteristics were;

Length = 70 ft.
Width = 8 ft.
Height = 4 ft.
Slope = .0071 ft./ft.
N = .013
Tailwater Depth = 0 ft.

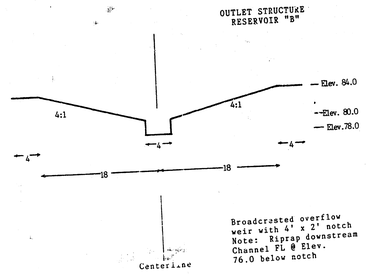
Wingwalls @ 30°
Upper entrance not rounded
Upstream fl @ 184.00

2. Reservoir "B" outlet structure: A combination broadcrested weir with a low flow notch (see figure below) was utilized to provide discharge control for reservoir "B". The weir characteristics were;

Notch - Rectangular/Contracted
Width = 4 ft.
Height = 2 ft.

Broadcrested Weir
Width = Varies with depth
Slope = 4:1
Height = 4 ft.

Flows were combined between the notch and weir to yield a composite discharge versus elevation relationship.



3. Reservoir routing tables; The following routing tables were utilized for the determination of water surface elevation for reservoirs "A" and "B".

RESERVOIR "A"

ELEVATION	STORAGE IN AFT*	DISCHARGE Q, CFS
184 (Normal Pool)	0.0	0
185	5.4	18
186	8.8	50
187	11.6	126
188	14.0	190
189	16.2	244
190	18.6	292
191	21.4	340
192	25.1	386

RESERVOIR "B"

ELEVATION	STORAGE IN AFT*	DISCHARGE Q, CFS
178.0 (Normal Pool)	0.0	0
178.5	5.0	5
179.0	7.4	13
179.5	9.6	23
180.0	11.6	34
180.5	13.4	40
181.0	15.0	56
181.5	16.4	84
182.0	18.0	125
182.5	19.6	181
183.0	21.5	253
183.5	23.6	343
184.0	26.5	451

*STORAGE ABOVE NORMAL POOL

4. Reservoir routing results: Complete routing tables relating inflow, outflow, storage and water surface elevations have been provided in the appendix. The routing table for Reservoir "A" indicates a decrease in peak flow from 541 cfs to 377 cfs with the peak flow detained approximately 24 minutes. A maximum water surface elevation of 191.7 - 191.8 would provide approximately 24.5 AFT of flood storage. These flows are based on the use of the 8' x 4' RCB outlet structure. The outflow hydrograph shown in the routing table was utilized as the inflow hydrograph for reservoir "B".

The routing table for Reservoir "B" indicates a decrease in peak flow from 377 cfs to 316 cfs with the peak flow detained approximately 24 additional minutes. A maximum water surface of 183.4 would yield a flood storage of 23 AFT. The outflow hydrograph from this routing table would be the inflow hydrograph to the Pepperwood detention facility (in combination with other contributing drainage areas). These results were obtained with the 4 foot notch and broadcrested weir configuration.

It should be noted, that the peak outflow from reservoir "B" of 316 cfs is slightly greater than the desired figure of 298 cfs as shown on page 3. However, if the outflow hyorograph of reservoir "B" is compared to the original composite hydrograph (see page 4) it is apparent that the reservoirs have retarded the flow sufficiently to actually decrease the composite inflow hydrograph peak to the Pepperwood facilities. Therefore, the slight difference of flow 316 cfs vs. 298 cfs is inconsequential. A new composite inflow hydrograph would have peak flows of;

REVISED COMPOSITE
INFLOW HYDROGRAPH
PEPPERWOOD DETENTION RESERVOIR

TIME INTERVAL HRS.	INFLOW HYDROGRAPH FROM AREAS OTHER THAN RES. A & B CFS	OUTFLOW HYDROGRAPH RES. B CFS	COMPOSITE INFLOW HYDROGRAPH TO PEPPERWOOD RES. CFS
3.00	670.5	43.9	705.4
3.25	654.2	126.0	780.2
3.50	508.7	252.0	760.7
3.75	374.6	310.0	684.6
4.00	286.7	310.4	597.1
4.25	242.2	280.0	522.2
4.50	204.7	244.0	448.7
4.75	173.4	208.0	381.4
5.00	153.5	175.4	328.9

The composite inflow hydrograph still has a peak flow at 3.25 hours, but it is reduced by approximately 18% from the original peak of 953 cfs shown on page 4.

5. Downstream condition (Governeour Road): An existing RCB structure lies immediately downstream from the proposed outlet of reservoir "B". This structure was analyzed for adequate capacity for the outflow of reservoir "B". The following characteristics were applied;

Length = 72 ft.
Height = 9 ft.
Width = 4 ft.
Slope = .00375 ft./ft.
N = .013
Tailwater Depth = 0 ft.

The analysis indicated that at a peak flow of 316 cfs, the RCB would require a headwater elevation of 80.34 or 6.54 ft with no inlet headwall and a headwater elevation of 79.47 or 5.67 ft. with inlet headwall in place. With a maximum water surface of 83.40 in reservoir "B", adequate driving head is available. Particular care should be paid to erosion protection and energy control downstream of the reservoir outlet and immediately upstream of the 9' x 4' RCB.

6. Recommendations: The data indicates that the storage volumes and outlet configurations utilized provide an actual improvement in flows to be Pepperwood detention facility. Therefore, the configurations as proposed would meet the basic criteria set forth earlier in the report.

IV. APPENDIX

A. HYDROGRAPHS AND ROUTING TABLES
RESERVOIRS "A" AND "B"
JAN. 1986

RESERVOIR "A"
ROUTING TABLE*

TIME HR.	INFLOW HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS	RESERVOIR WATER SURFACE ELEVATION	STORAGE ACRE-FT.
0.0	0.0	0.0	84.0	0.0
.2	0.0	0.0	84.0	0.0
.4	0.0	0.0	84.0	.01
.6	1.0	0.0	84.0	.11
.8	8.0	.3	84.0	.26
1.0	10.0	.7	84.0	.5
1.2	18.0	1.5	84.1	.89
1.4	28.0	2.6	84.1	1.48
1.6	44.0	4.4	84.2	2.55
1.8	80.0	7.5	84.4	3.89
2.0	96.0	11.8	84.7	6.0
2.2	160.0	18.2	85.0	10.37
2.4	360.0	58.9	86.1	15.03
2.6	464.0	187.0	88.0	19.21
2.8	532.0	283.6	89.8	22.63
3.0	541.0	345.3	91.1	24.48
3.2	460.0	373.9	91.7	24.11
3.4	320.0	376.6	91.8	22.21
3.6	224.0	356.9	91.4	19.99
3.8	192.0	325.3	90.7	17.9
4.0	164.0	288.3	89.9	16.07
4.2	144.0	250.3	89.1	14.58
4.4	128.0	213.0	88.4	13.42
4.6	116.0	181.9	87.9	12.55
4.8	108.0	156.8	87.5	11.89
5.0	100.0	137.8	87.2	11.37
5.2	94.0	123.1	87.0	10.99
5.4	90.0	111.8	86.8	10.69
5.6	86.0	103.1	86.7	10.42
5.8	80.0	95.8	86.6	10.15
6.0	72.0	88.5	86.5	9.83
6.2	60.0	80.2	86.4	9.42
6.4	44.0	69.8	86.3	8.87
6.6	20.0	55.9	86.1	8.17
6.8	0.0	45.8	85.9	7.49
7.0	0.0	39.2	85.7	6.91
7.2	0.0	33.6	85.5	6.42
7.4	0.0	28.7	85.3	6.0
7.6	0.0	24.6	85.2	5.64
7.8	0.0	21.0	85.1	

* With 8' x 4' RCB Outlet

RESERVOIR "A"
ROUTING TABLE*

TIME HR.	INFLOW HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS	RESERVOIR WATER SURFACE ELEVATION	STORAGE ACRE-FT.
8.0	0.0	18.0	85.0	5.33
8.2	0.0	17.0	84.9	5.04
8.4	0.0	16.1	84.9	4.77
8.6	0.0	15.3	84.8	4.51
8.8	0.0	14.4	84.8	4.27
9.0	0.0	13.7	84.8	4.04
9.2	0.0	12.9	84.7	3.83
9.4	0.0	12.2	84.7	3.62
9.6	0.0	11.6	84.6	3.43
9.8	0.0	11.0	84.6	3.24
10.0	0.0	10.4	84.6	3.07

* With 8' x 4' RCB Outlet

RESERVOIR "B"
ROUTING TABLE*

TIME HR.	INFLOW HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS **	RESERVOIR WATER SURFACE ELEVATION	STORAGE ACRE-FT.
0.0	0.0	0.0	78.0	0.0
.2	0.0	0.0	78.0	0.0
.4	0.0	0.0	78.0	0.0
.6	0.0	0.0	78.0	0.0
.8	.3	0.0	78.0	0.0
1.0	.7	0.0	78.0	.01
1.2	1.5	0.0	78.0	.03
1.4	2.6	.1	78.0	.07
1.6	4.4	.1	78.0	.13
1.8	7.5	.2	78.0	.24
2.0	11.8	.4	78.0	.41
2.2	18.2	.6	78.1	.67
2.4	58.9	1.2	78.1	1.41
2.6	187.0	3.2	78.3	3.96
2.8	283.6	11.8	78.9	8.15
3.0	345.3	34.9	80.1	13.16
3.2	373.9	96.4	81.7	18.03
3.4	**376.6**	215.9	82.7	21.18
3.6	356.9	290.2	83.2	22.64
3.8	325.3	**316.0**	**83.4**	**23.01**
4.0	288.3	310.4	83.3	22.75
4.2	250.3	288.4	83.2	22.17
4.4	213.0	258.4	83.0	21.44
4.6	181.9	228.8	82.8	20.67
4.8	156.8	200.3	82.6	9.93
5.0	137.8	175.4	82.4	19.28
5.2	123.1	155.2	82.3	18.73
5.4	111.8	138.3	82.1	18.27
5.6	103.1	124.6	82.0	17.89
5.8	95.8	115.8	81.9	17.56
6.0	88.5	107.6	81.8	17.24
6.2	80.2	99.5	81.7	16.92
6.4	69.8	91.0	81.6	16.58
6.6	55.9	81.8	81.5	16.18
6.8	45.8	72.7	81.3	15.72
7.0	39.2	64.2	81.1	15.3
7.2	33.6	56.3	81.0	14.92
7.4	28.7	52.3	80.9	14.53
7.6	24.6	48.4	80.8	14.14
7.8	21.0	44.5	80.6	13.75

* With broadcrested weir and 4.0 ft. notch
** To Pepperwood detention reservoir downstream

RESERVOIR "B"
ROUTING TABLE*

TIME HR.	INFLOW HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS **	RESERVOIR WATER SURFACE ELEVATION	STORAGE ACRE-FT.
8.0	18.0	40.7	80.5	13.37
8.2	17.0	39.0	80.4	13.01
8.4	16.1	37.8	80.3	12.65
8.6	15.3	36.6	80.2	12.29
8.8	14.4	35.4	80.1	11.95
9.0	13.7	34.3	80.0	11.6
9.2	12.9	32.7	79.9	11.27
9.4	12.2	30.9	79.9	10.96
9.6	11.6	29.3	79.8	10.66
9.8	11.0	27.7	79.7	10.38
10.0	10.4	26.2	79.6	10.12

* With broadcrested weir and 4.0 ft. notch
** To Pepperwood detention reservoir downstream