BUCKEYE LAKE

SPILLWAY ADEQUACY

PREPARED FOR THE
SAVE THE LAKE COMMITTEE

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1.0 EXECUTIVE SUMMARY

Buckeye lake, about 2830 acres in size is located in the southern end of the South Fork Licking River (SFLR) watershed. The lake was created between 1825 and 1832 by constructing a dam and reservoir to supply water for the Ohio Canal. The 3 to 15 ft high embankment is about 4.1 miles long.

During average meteorological conditions the lake receives water from Honey creek, a few smaller unnamed streams and the Reservoir Feeder. The Reservoir Feeder is approximately six miles long and runs between the towns of Millersport and Kirkersville. Although the Feeder no longer intercepts the SLFR near Kirkersville, it intercepts about five streams that originally flowed into the lacustrine area traversed by the SFLR.

During extreme meteorological events the Feeder canal can only intercept a maximum flow of 2000 cubic feet per second (cfs) (see page 11 of Reference 1). Therefore, the runoff from the upper reaches of the Feeder's drainage area is diverted to the SFLR, inundating the low-lands downstream of Kirkersville.

In other words, with exception of the Feeder's maximum carrying capacity, all storm runoff generated by the drainage area located west of the lake during the probable maximum precipitation (PMP) will not reach the lake. Consequently; the effective area draining into Buckeye lake is 26.1 square miles and not 46.7 square miles as previously indicated. A 44 percent reduction of the drainage area available during average meteorological conditions.

Reduction of the lake's drainage area results in additional runoff and inundation levels along the lower reach of the SFLR. The SFLR reach located between Kirkersville and Hebron is about ten miles long and characterized by flat lowlands with poor storm drainage. The flood plain is undeveloped, frequently inundated and up to two miles wide. It is pointed out that the inundation levels are controlled (and increased) by a narrowing of the flood plain at Hebron where, the width is reduced to half mile.

Evaluation of the adequacy of the Buckeye lake spillway during the PMP requires the evaluation of both; the upstream and the downstream conditions. The upstream conditions to determine the probable maximum flood (PMF) inflow into the lake and, the downstream conditions to determine weather the spillway capacity is affected by submergence.

The **methodology** used to evaluate the adequacy of the Buckeye reservoir spillway includes the following conditions and analysis:

- The Buckeye lake is within the boundaries of the SFLR drainage area
- The drainage area contributing runoff to the lake during the PMP event is limited to the adjacent areas located north and south of the lake.
- The drainage area located west of the lake is diverted into the SFLR reach located downstream of the dam.
- The magnitude of the PMP storm corresponds to the precipitation intensity over the SFLR drainage area.
- The precipitation intensity of the PMP storm varies in accordance to predetermined isohyetal patters
- The downstream water levels are determined for the maximum PMF flows along the Kirkersville to Hebron reach.
- Hydrologic calculations include HEC-1and HEC-RAS

The main **differences** between this approach and the evaluations performed in the past are listed below. Additional differences in the assessment of the hydrologic parameters are listed in the table included in Appendix C.

- Reduction of the drainage area contributing runoff to the lake during the PMP event
- Incorporation of the lake's drainage area into the SFLR drainage area
- Determination of downstream water levels for the PMF flows

The **conclusions** are:

1. The existing dam crest varies between elevation 894.20 ft and 897.00 ft
2. The existing emergency spillway together with the gated outflow structure are inadequate to pass the runoff of the PMP storm without over-topping the existing dam crest. During the PMF, the total outflow is 34452 cfs and the lake surface will reach elevation 895.88 ft. (1.68 ft over the lowest point along the dam crest.)
3. The existing emergency spillway together with the gated outflow structure are adequate to pass the runoff of the PMP storm without overtopping the dam crest ,as long as the crest of the dam is raised to a uniform elevation equal to 896.5 feet..
4. If the dam is raised to a uniform elevation equal to 896.5 feet ,The PMF outflow will be 21012 cfs and the maximum water surface elevation in the lake will be 896.56 ft (No freeboard).
5. The magnitude of the PMF flow entering the lake is only 75 percent of the PMF flow indicated in the Dodson-Lindblom 1987 report
6. The maximum water levels due to the PMF over the SFLR watershed do not submerge the crest of the spillway
7. The Buckeye Lake locality can experience wind speeds of 100 mph
8. The horizontal distance of open water over which the wind blow (effective fetch) varies between 8000 ft and 9200 ft.
9. The actual freeboard available at the Buckeye lake during normal operating conditions is 1.0 foot short of the normal freeboard recommended by US Bureau of Reclamation
10. The minimum USBR freeboard required during 50 mph winds is 3.0 feet.
11. Wave runup will overtop the embankment during 100 mph winds when the lake is at its normal operating water level (891.75 ft.). The amount of overtopping is 0.8 cfs per ft of embankment length.
12. Wave runup overtopping during 50 mph winds with 12 inch freeboard is 1.0 cfs per longitudinal feet of dam.
13. The wind tide (lake setup) during 100 mph winds will pile up the water at Millersport (the leeward end of the lake) about 10 inches.

To minimize the embankment failure risks associated with increasing the lake surface during the PMF to the unsafe pool levels identified in reference 23 (see excerpt included in Appendix E), it is **recommended** that a new flow control structure be constructed at Sellers Point.

The **recommended** flow control structure shall be able to accommodate the outflow of the PMF without significantly exceeding pool elevations above 892.00 ft during a long period or over-topping the existing dam crest.

The **recommended** flow control structure is shown in exhibit 22 and consists of four radial gates similar to the Amil gate installed at the existing gated outflow structure If this proposed structure is constructed, the existing dam crest will not be over-topped . The maximum PMF outflow will be 31121 cfs with a pool level of 894.08 ft.

2.0 PURPOSE

The purpose of this evaluation was to confirm the adequacy of the recently constructed spillway to pass the outflow of the PMF without overtopping the crest of the sheet piling and parapet extensions. The spillway adequacy was based on the evaluation of:

- The watershed characteristics
- Hydrologic analysis
- PMF routing
- Downstream water levels
- Wave runup
- Identification of remedial measures

3.0 WATERSHED CHARACTERISTICS

The Buckeye lake lies within the boundaries of the SFLR watershed that, is part of the Muskingum river system. The lake is located at the southern end of the watershed in Licking, Fairfield an Perry Counties. The general location of the lake is shown in exhibit 1. The lake's plan is shown in exhibit 2. The Dam Owner information is included in Appendix D.

The SFLR watershed considered in this evaluation covers an area of 117.4 square miles and is located between the SLFR source an the USGS gaging station near Hebron OH. The course of the SFLR is approximately 26 miles long and runs through two distinctive zones. The upper reach, upstream of Kirkersville, is characterized by gently sloping areas with undulating hills and a relatively narrow flood plain. The lower reach, located between Kirkersville and Hebron, is about 10 miles long and is characterized by flat low lands up to two miles wide with poor storm drainage. The flood plain is undeveloped and frequently inundated. Inundation levels along the lower reach are influenced by a narrowing of the flood plain at Hebron where, the flood plain width is reduced to half a mile.

Approximately 15 percent of the watershed is wooded, 25 percent is brush and the balance is agricultural lands and meadows. The predominant soils found within the confines of the basin are hydrologic C groups (Centerburg-Benington-Pewano and Amanda associations) interspersed with type B (Oakley-Stonelick-Shoals associations) and D (Montgomery and Benington) soils. Most of the soils found along the upper reach of the SFLR are moderately well drain and slowly permeable silt and clay loams. Soils along the lower reach are poorly drain, slowly permeable silt loams. The soils were identified using references 2, 3 and 4.

The SFLR watershed was subdivided into 11 sub-basins. The surface area of the Buckeye Lake (4.2 sq., mi.) was proportionally distributed among the Harbor, Honey and Walnut sub-basins. The boundaries, location an identification of the 11 sub-basins are shown in exhibit 2. The surface areas of the sub-basins are:

Sub - Basin Name	Drainage Area Square Miles	Impervious Percent
Jersey	16.6	
Pataskala	13.2	
Harrison	16.7	
Kirkersville	9.3	
Watergate	9.6	
Lakeside	7.8	10
Liberty	11.0	
Walnut	9.7	10
Honey	9.5	16
Harbor	6.9	23
Hebron	7.1	5
TOTAL	**117.4**	

During average meteorological conditions the lake receives water from Honey creek, a few smaller unnamed streams and the Reservoir Feeder canal. The Reservoir Feeder is approximately six miles long and runs between the towns of Millersport and Kirkersville. Although the Feeder no longer intercepts the SLFR near Kirkersville, it intercepts about five streams that originally flowed into the lacustrine area traversed by the SFLR.

During extreme meteorological events the Feeder can only intercept a maximum flow of 2000 cubic feet per second (cfs) (see page 11 of Reference 1). Further, due to inundation of the lowlands located downstream of Kirkersville, the runoff of the upper reaches of the Feeder's drainage area is diverted into the SFLR.

4.0 HYDROLOGY

4.1 Introduction

The hydrologic evaluation presented in this report pertains to present hydrologic conditions; it does not consider the potential effects of future hydrologic changes due to uncertain conditions such as urbanization, forest fires and other modifications within the watershed.

The Buckeye Lake Dam is formed by an earthen embankment, an emergency spillway and a main spillway.

The earthen embankment is about 4 miles long with crest elevations, that vary between elevation 494.2 ft and 497.0 ft. About 2650 ft are between elevation 494.2 ft and 495.0 ft.; 14680 ft between elevation 495.0 ft and 496.0 ft and 3670 ft between elevation 496.0 ft and 497.0 ft. The maximum height of the embankment is 15 feet

The emergency spillway is a 472 feet long ogee crest emergency spillway at elevation 892.2 feet. The main spillway is 33.5 ft wide provided with an Amil gate. The gate's crest is at 891.75 ft. Photographs of this facilities are shown on exhibits 20 and 21. Additional details are provided in appendix D.

The Ohio Department of Natural Resources plans to raise the height of the embankment to and uniform elevation of 896.50 ft by adding shoreline protection structures. The proposed additions consist of sheet piling walls, concrete parapets and slopped riprap Sheet piling walls are 10494 feet long, concrete parapets are 8430 feet long and the slopped riprap zone 1219 feet. Typical cross sections of the proposed embankment protection are shown in exhibits 4, 5 and 6.

The Buckeye Lake Dam is classified as a Class 1 (high hazard potential) structure by the Division of Water Standards of the Ohio Department of Natural Resources (ODNR) and, in accordance with Section 1501:21-13-02 and 03 of Chapter 13 (Reference 12) it should be able to pass a minimum design flood equal to the PMF without endangering the safety of the Dam. As a minimum, the spillway should be able to pass the peak outflow rate of the PMF after routing the PMF flood through the lake.

The PMF is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonable possible in the area. The PMF is derived from the PMP.

The transformation of the PMP to the PMF requires the:

- estimation of retention losses
- derivation of unit Hydrographs
- convolution of rainfall excess and unit hydrograph
- Flood routing through the river channel and the reservoir (lake)

4,2 Retention Losses

The precipitation retention losses were calculated assuming an uniform rainfall abstraction rate which, is dependent on the prevalent hydrologic soil type, land use, and topography. Calculations were performed in accordance to US Soil Conservation Service (SCS) methods included in reference 16.

Antecedent or subsequent floods were not considered. It was assumed that the meteorological conditions prevalent before the PMF were average.

4.3 Unit Hydrograph

The unit hydrograph is the hydrograph resulting from one unit of rainfall excess over a specified duration. To account for natural variations across the SFLR watershed, unit Hydrographs were derived for each sub-basin with uniform but distinct rainfall intensities and basin characteristics. The unit Hydrographs were determined using a combination of the Snyder and the SCS methods. The lag time needed to calculate the Hydrographs were estimated using both; the Snyder coefficients (Cp=4.1 and Cp=0.55) determined by DLA (Reference 1) and the curve numbers (CN) of the SCS method (Reference 16). The lag time used in the determination of the PMF Hydrographs was the lower of the lag times calculated with these two methods. The lag times are:

Sub - Basin Name	**SCS Curve Number**	**Lag Time SCS** Hours	**Lag Time Snyder** Hours	**Lag Time Selected** Hours
Jersey	75	14.17	12.18	12.2
Pataskala	75	11.62	9.8	9.8
Harrison	76	8.86	9.32	8.9
Kirkersville	77	8.22	11.93	8.2
Watergate	78	6.32	9.03	6.3
Lakeside	80	9.01	10.45	9.0
Liberty	80	12.55	11.12	11.2
Walnut	82	2.47	5.96	2.5
Honey	81	5.48	7.68	5.5
Harbor	82	2.39	4.28	2.4
Hebron	83	11.36	10.11	10.1

4.4 Probable Maximum Precipitation

In computing the PMF, the most important element is the PMP. PMP was defined by the American Meteorological Society in 1959 as "*the theoretical greatest depth of precipitation for a given duration that is physically possible over a particular drainage area for a certain time of year*".

The maximum intensity of the "all seasons" PMP over the SFLR watershed was determined in accordance with NOAA HR 51 (Reference 17) and occurs during August. PMP intensities vary monthly. The lowest PMP occurs during February when the

precipitation intensities are about 30 percent of the August PMP. Maximum PMP intensities from 6 to 72 hour duration over the SFLR watershed are shown in exhibit 7

The following table shows the PMP intensities for up to 24 hour duration for:

a) The SFLR drainage area (117.3 square miles)
b) The area normally draining into the lake that includes the contributions from the feeder canal (46.7 square miles)
c) The effective area draining into the lake during PMF conditions (26.1 sq. mi.)

Duration Hours	**SFLR** Inches	**Lake with Feeder canal** Inches	**Lake without Feeder canal** Inches
0 to 6	20.0	22.5	24.0
0 to 12	24.0	26.0	27.5
0 to 24	25.5	28.0	30.0

4.5 Probable Maximum Flood

In order to maximize the magnitude of the Lake's PMF inflow hydrograph, a PMP of 20 inches with a duration of 6 hours was selected. The hourly rainfall distribution selected corresponds to a type II distribution (Reference 16) and is shown in exhibit 8

To avoid unrealistic high PMF flows resulting from the use of the PMP intensities applied uniformly over the entire drainage area , the PMP intensities were corrected to reflect their temporal and spatial distribution and, the orientation of the isohyetal storm pattern. The intensities and orientation patterns of the postulated PMP storm were determined in accordance with NOAA HR 52 (Reference 18)

The following three scenarios were considered in the assessment of the effects that the PMP storm direction and location would have on the PMF:

- Maximum PMF peak inflow into Buckeye lake
- Homogeneous distribution throughout the watershed
- Maximum PMF outflow at the USGS gaging station near Hebron

The maximum PMF inflow into Buckeye lake was determined by placing the storm over the center of the lake. The major storm axis was oriented along the N 10° E direction that, corresponds to the track followed by past storms (Reference 18). The superposition of this PMP storm pattern over the center of the lake drainage area is shown in exhibit 9.

Since the magnitude of the lake's outflow during the PMF depends on the maximum allowable water surface elevation, it was necessary to evaluate this scenario for three different conditions namely:

- Existing outflow facilities with the dam crest reconstructed to elevation 896.5 ft.
- Existing outflow facilities with the existing dam crest elevations
- Existing outflow facilities with the existing dam crest elevations and a new gated outflow structure at Sellers Point.

The homogeneous distribution of the PMP was evaluates to determine the sensitivity of the storm location to both; the PMF inflow into the lake a the PMF outflow at gaging station near Hebron. This second scenario placed the PMP over the center of the SFLR watershed with its major axis along the historical storm track orientation of N 10° E. The superimposition of this storm pattern over the SFLR watershed is shown in exhibit 10.

The maximum PMF outflow at the gaging station near Hebron was evaluated to determine the maximum water elevations and the extent of flooding downstream of the Buckeye Lake Dam. This scenario placed the center of the PMP storm over the center of the SFLR watershed with its major axis oriented along the maximum longitudinal watershed dimension which runs along N 70° W. The superimposition of this storm pattern over the SFLR watershed is shown in exhibit 11.

The isohyetal distributions of each storm scenario were converted into an uniform rainfall over each sub-basin. The accumulated 6 hour precipitation over each sub-basin is:

Sub - Basin	**Maximum PMF Inflow into lake**	**Homogeneous PMP Distribution**	**Maximum PMF Outflow at Hebron**
Name	Inches	Inches	Inches
Jersey	7.0	11.7	19.5
Pataskala	7.0	11.6	19.8
Harrison	8.0	22.0	22.5
Kirkersville	14.0	22.8	23.0
Watergate	11.0	22.5	22.4
Lakeside	18.0	21.7	22.0
Liberty	16.0	22.3	22.3
Walnut	23.0	14.3	20.3
Honey	22.0	10.0.	18.8
Harbor	23.0	11.4	18.8

Convolution and Flood Routing

The integration of the incremental rainfall excesses with the unit Hydrographs and PMF routing through river channels and the Buckeye Lake Reservoir was accomplished using the 1990 version of HEC-1 (Reference 19).These version features improved hydrologic capabilities not available in earlier versions such as ogee spillway discharges, Muskingum-Cunge flood routing, reservoir releases over time and improved numerical solution of kinematic wave equation. The software used in the calculations was the GEOHEC-1 package distributed by Boss International of Madison, Wisconsin.

The topological tree used in HEC-1 is shown in exhibit 12. As shown, this topological tree diverts the outflow of the Liberty sub-basin directly into the SFLR because:

a), During extreme meteorological conditions the Feeder canal can only intercept a maximum flow of 2000 cubic feet per second (see page 11 of Reference 1)

b) .Due to the inundation of the lowlands located downstream of Kirkersville the runoff of the upper reaches of the Feeder's drainage area is diverted into the SFLR

The PMF inflow and outflow hydrographs with storm intensities equal to 100 , 75 and 50 percent of the PMP were determined for each postulated scenario.. Copies of the HEC-1 printouts of the data input and of the output summary are included in appendix A. The PMF inflow and outflow hydrographs are shown in exhibits 13, 14 and 15. Neither a complete copy of the HEC-1 calculations nor a floppy disc have been included; however they are available on request. Significant results for the PMF are:

- **Maximum PMF peak inflow into Buckeye lake**

Parameter	Units	**Dam crest reconstructed to elevation 896.5 ft.** 100 % PMF	**Existing dam crest elevations** 100 % PMF	**New gated outflow at Sellers Point** 100 % PMF
Buckeye lake Inflow	cfs	47804	47804	47804
Buckeye lake Outflow	cfs	21590	34074	32068
Maximum lake level	ft	896.37	895.85	893.96
Freeboard	ft	0.13	- 1.65	0.24
PMF outflow Hebron	cfs	56631	60375	64428

- **Homogeneous distribution throughout the watershed**

Parameter	Units	100 % PMF
Buckeye lake Inflow	cfs	24348
Buckeye lake Outflow	cfs	10961
Maximum lake level	ft	894.08
Freeboard	ft	2.42
PMF outflow Hebron	cfs	75168

- **Maximum PMF outflow at the USGS gaging station near Hebron**

Parameter	Units	100 % PMF
Buckeye lake Inflow	cfs	40320
Buckeye lake Outflow	cfs	18018
Maximum lake level	ft	895.72
Freeboard	ft	0.78
PMF outflow Hebron	cfs	91838

Flood Frequency

Determination of flood flows with return intervals of 10,25, 50, 100 and 500 years were based on a statistical evaluation of the SFLR hydrologic records for the USGS gaging station located near Hebron OH. The statistical evaluation was based on 36 years of record; 1940 through 1948 and 1959 through 1994. The maximum flood of record was 5880 cfs during 1959. Flood flows were calculated for both, the SFLR at Hebron and the inflow into Buckeye lake. The Buckeye lake flood inflows were determined using a direct correlation of the contributing drainage areas during average hydrologic conditions.

The return period or recurrence interval of any frequency, for example the 100-year flood, does not indicate that after its occurrence there are 99 years of immunity. The recurrence interval is simply the reciprocal of the annual probability that the event will be equaled or exceeded in that year. Note that if a longer interval period is used the true probability changes as shown in the table below. There is a 39 percent chance of having the 100-year or greater intensity in only 50 years but, there is only a 63 percent probability of having the 100 year or greater intensity in 100 years. Other probabilities for different periods of time are also shown. The frequency, probability and magnitude of peak flood flow to be expected at Hebron and the peak inflows into Buckeye lake are as follows:

Return Interval Years	**Gag. Sta. Hebron** cfs	**Buckeye lake inflow** cfs	**Exceedance Probability 10 YEAR** %	**Exceedance Probability 50 YEAR** %	**Exceedance Probability 100 YEAR** %
10	3700	1480	65	99	100
25	3420	1720	33	87	98
50	4910	1960	18	64	87
100	5510	2200	10	39	63
500	6720	2680	5	22	39

5.0 DOWNSTREAM FLOODING

Since the Buckeye water levels were predicated on free weir discharge conditions, it was deemed necessary to ascertain that the flooding levels downstream of the dam would not submerge the spillway.

Backwater analysis run with this purpose included the SFLR reach between the gaging station near Hebron, where the flood plain is narrow and restricts the flood flows and, the town of Kirkersville, where the flood plain is more than two miles wide.

Flooding levels downstream of the dam were computed using the combined discharge of the SFLR and the spillway outflow. Backwater calculations were performed for the three postulated storm scenarios (see Section 4) using HEC-RAS software. HEC-RAS (Reference 20) is the latest River Systems Analysis program issued during 1995 by the US Corps of engineers to replace HEC-2. **Although the calculations do not include the backwater effects of man-made obstructions such the bridges on US Highway 40, it is evident that water surface elevations downstream of Buckeye Lake Dam will be below the crest of the spillway (891.75 ft).** The extent of flooding between Hebron and Kirkersville during the PMF is shown in exhibit 16 .Close examination of this exhibit indicates that the upper third of the feeder canal is submerged and intercepts the local runoff.. Significant results are:

PMP Scenario	**100 % PMF** Downstream level ft	**75 % PMF** Downstream level ft
Maximum PMF lake inflow	888.83	887.84
Homogeneous distribution	887.07	—
Maximum Outflow at Hebron	888.24	887.14

Pertinent printouts of the HEC-RAS calculations and graphs for each of the postulated scenarios are included in appendix B. They include:

- Backwater calculation results
- Graphs of water profiles
- Three-dimensional views of the channel reach between the lake spillway and the junction with SFLR
- Three-dimensional views of the SFLR course between the Gaging Station near Hebron and Kirkersville.

Neither a complete copy of the HEC-RAS calculations nor a floppy disc have been included; however they are available on request.

6.0 FREEBOARD ADEQUACY

6.1 Freeboard

Freeboard is the vertical distance between the crest of the embankment a the reservoir water surface. The US Bureau of Reclamation (USBR) (Reference 13) differentiates between normal an minimum freeboards. Normal freeboard is the difference between the crest of the dam and the normal reservoir water level. Minimum freeboard is the difference between the crest of the dam and the maximum reservoir water level during the design flood. The normal freeboard shall:

- Meet the requirements for long time storage
- Be sufficient to prevent seepage through core
- Be sufficient to prevent overtopping of the embankment by abnormal or severe wave action that may result from 100 mph sustained winds from a critical direction

The minimum freeboard shall be able to prevent overtopping of the embankment by wave action during the inflow design flood (PMF) and a sustained wind of 50 mph.

The following factors were considered in the assessment of the freeboard adequacy:

- Wind characteristics
- Height of the wind tide (lake setup)
- Height of waves generated by winds
- Wave runup and overtopping of the dam crest

6.2 Buckeye Lake Dam Data

Significant dimensions are taken from Reference 1. Effective fetch lengths were determined using data from Reference 7 and are shown in exhibits 16, 17 and 18.

• Dam crest elevation	896.5	ft
• Spillway crest elevation	891.75	ft
• Normal freeboard	4.75	ft
• Normal operation water depth (average)	10	ft
• Maximum water depth (average)	15	ft
• Upstream dam face (typical throughout)	Vertical sheet piling and parapets	
• Upstream dam face (selected locations)	Rubble at 2 H: 1V slopes	
• Effective fetch "A" in the S 82° E direction	1.69	miles
• Effective fetch "B" in the S 45° E direction	1.40	miles
• Effective fetch "C" in the S 10° W direction	1.53	miles
• Effective fetch "D" in the N 75° E direction	1.75	miles
• Effective fetch "E" in the S 45° W direction	1.73	miles

6.3 Wind Characteristics

The characteristics of the winds that may be prevalent throughout the Buckeye Lake region are based on information taken from References 10, 21 and 22. They are:

1. Annual average wind speed in Columbus OH	8.3	mph
2. March average wind speed in Columbus OH	12.5	mph
3. Fastest recorded wind speed in Cleveland	68	mph
4. Maximum recorded wind peak gust in Ohio	102	mph
5. Agnes wind speeds	42	mph
6. 50 year recurrence winds at Mentor OH	70	mph
7. 100 year recurrence winds at Mentor OH	74	mph
8. Wind exposure needed for full wave action at 100 mph	15	minutes
9. Wind exposure needed for full wave action at 50 mph	20	minutes

6.4 Wind Effects

The effects of sustained winds blowing over the Buckeye lake were evaluated using procedures developed by the USCOE and the US Navy (References 14 and 15). The results of the analysis are presented in the following table:

Wind speed	mph	100	100	75	50	50	50	50
Lake Level	feet	891.75	895.5	891.75	893.0	893.5	894.5	895.5
available freebrd	ft	4.75	1.0	4.75	3.5	3.0	2.0	1.0
BUREC freebrd	ft	5.6	5.6	5.1	4.6	4.6	4.6	4.6
Applicability	*	1	1		2	2	2	2
Wave height	ft	4.0	4.0	3.2	2.7	2.7	2.7	2.7
Wave period	sec	4.1	4.1	3.7	3.2	3.2	3.2	3.2
Wave length	ft	86	86	70	52	52	52	52
Overtopping flow	cfs/ft	0.78	6.0	0.03	0.08	0.32	0.87	1.0

* 1 = Long time storage
2 = Inflow design flood

Evaluation of the wind effects over the Buckeye indicate that:

1. The Buckeye locality can experience wind speeds of 100 mph
2. The actual freeboard (4.75 feet) available at the Buckeye lake during normal operating conditions corresponds to the minimum free board of 4.6 ft during the inflow design flood recommended by USBR (Reference 13). The actual freeboard is 1.0 foot short of the normal freeboard of 5.6 ft during long time storage recommended by USBR.
3. The actual freeboard (4.75 feet) available at the Buckeye lake during normal operating conditions is inadequate to prevent overtopping of the dam crest when the wind speed exceeds 75 mph.

4. Water spillage due to wave runup overtopping during 100 mph winds at the lake's normal operating water level (891.75) is 0.8 cfs per ft of dam crest
5. The minimum USBR freeboard required during 50 mph winds is 3.0 ft. Overtopping spillage when the water surface is at elevation 595.5 (12 inch freeboard) is 1.0 cfs per ft.
7. The wind tide (lake setup) during 100 mph winds will pile up the water at Millersport (the leeward end of the lake) about 10 inches.

7.0 CONCLUSIONS

The conclusions of this evaluation are:

1. The existing dam crest varies between elevation 894.20 ft and 897.00 ft
2. The existing emergency spillway together with the gated outflow structure are inadequate to pass the runoff of the PMP storm without over-topping the existing dam crest. During the PMF, the total outflow is 34452 cfs and the lake surface will reach elevation 895.88 ft. (1.68 ft over the lowest point along the dam crest.)
3. The existing emergency spillway together with the gated outflow structure are adequate to pass the runoff of the PMP storm without overtopping the dam crest ,as long as the crest of the dam is raised to a uniform elevation equal to 896.5 feet..
4. If the dam is raised to a uniform elevation equal to 896.5 feet ,The PMF outflow will be 21012 cfs and the maximum water surface elevation in the lake will be 896.56 ft (No freeboard).
5. The magnitude of the PMF flow entering the lake is only 75 percent of the PMF flow indicated in the Dodson-Lindblom 1987 report
6. The maximum water levels due to the PMF over the SFLR watershed do not submerge the crest of the spillway
7. The Buckeye Lake locality can experience wind speeds of 100 mph
8. The horizontal distance of open water over which the wind blow (effective fetch) varies between 8000 ft and 9200 ft.
9. The actual freeboard available at the Buckeye lake during normal operating conditions is 1.0 foot short of the normal freeboard recommended by US Bureau of Reclamation
10. The minimum USBR freeboard required during 50 mph winds is 3.0 feet.
11. Wave runup will overtop the embankment during 100 mph winds when the lake is at its normal operating water level (891.75 ft.). The amount of overtopping is 0.8 cfs per ft of embankment length.
12. Wave runup overtopping during 50 mph winds with 12 inch freeboard is 1.0 cfs per longitudinal feet of dam.
13. The wind tide (lake setup) during 100 mph winds will pile up the water at Millersport (the leeward end of the lake) about 10 inches.

8.0 RECOMMENDATIONS

To minimize the embankment failure risks associated with increasing the lake surface during the PMF to the unsafe pool levels identified in reference 23 (see excerpt included in Appendix E), it is **recommended** that a new flow control structure be constructed at Sellers Point.

The **recommended** flow control structure shall be able to accommodate the outflow of the PMF without significantly exceeding pool elevations above 892.00 ft during a long period or over-topping the existing dam crest.

The **recommended** flow control structure is shown in exhibit 22 and consists of four radial gates similar to the Amil gate installed at the existing gated outflow structure If this proposed structure is constructed, the existing dam crest will not be over-topped during the PMF. The PMF peak outflow will be 31121 cfs with a maximum pool level of 894.08 ft.

9.0 REFERENCES

1. Buckeye Lake Dam - Spillway Adequacy, Embankment Stability and Seepage Study -Dodson Lindblom Associates -August 1987
2. Soil Survey of Licking County OH - US Dept. of Agriculture SCS
3. Soil Survey of Perry County OH - US Dept. of Agriculture SCS
4. Soil Survey of Fairfield County OH - US Dept. of Agriculture SCS
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6. USGS quadrangle Maps - 1:100000 - Newark and Lancaster. OH.
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8. USGS Water Data Report - Water Resources Data OHIO - Water Years.
9. Federal Emergency Management Agency - Flood insurance Studies for the Villages of Buckeye Lake, Kirkersville and Millersport.
10. Estuary and Coastline Hydrodynamics - A. T. Ippen - Mc Graw Hill.
11. Ohio Dam Safety Law - ORC 1521 ODNR
12. Ohio Laws and Administration Rules ODNR - Chapter 13 Section a501:21-13-02 and 03. (Design Storm and Flood for Dam)
13. Design Of Small Dams - US Bureau of Reclamation.
14. Shore Protection Manual - Coastal Engineering Research Center - US Corps of Engineers.
15. Coastal Protection - Design Manual 26.2 - Department of the Navy.
16. Urban Hydrology for Small Watersheds (Technical Release 55) - US Dept. of Agriculture SCS
17. NOAA HR 51 - Probable Maximum Precipitation Estimates United States East of the 105 Meridian. US Weather Service.
18. NOAA HR 52. Application of Probable Maximum Precipitation Estimates United States East of the 105 Meridian. US Department of the Army.
19. Flood Hydrograph Package HEC-1 September 1990 - Hydrologic Engineering Center. US Corps of Engineers
20. HEC-RAS River Analysis System. July 1995. Hydrologic Engineering Center. US Corps of Engineers
21. Effect of Geographic Location on Cooling Pond Requirements and Performance - E. L. Thackson and F. L. Parker. - Vanderbilt University
22. Section 2.3 - Safety Analysis Report - Perry Nuclear Power Plant
23. Buckeye Lake Dam Review of Embankment Stability - W. S. Gardner - 1996

10.0 APPENDICES

Appendix A - HEC-1 Input and Summary Printouts

Appendix B - HEC-RAS Printouts and Graphs

Appendix C - Comparison of Hydrologic Assessments

Appendix D - Owner Information

Appendix E - Excerpt from Embankment Stability Review

Appendix A - HEC-1 Input and Summary Printouts

First Scenario

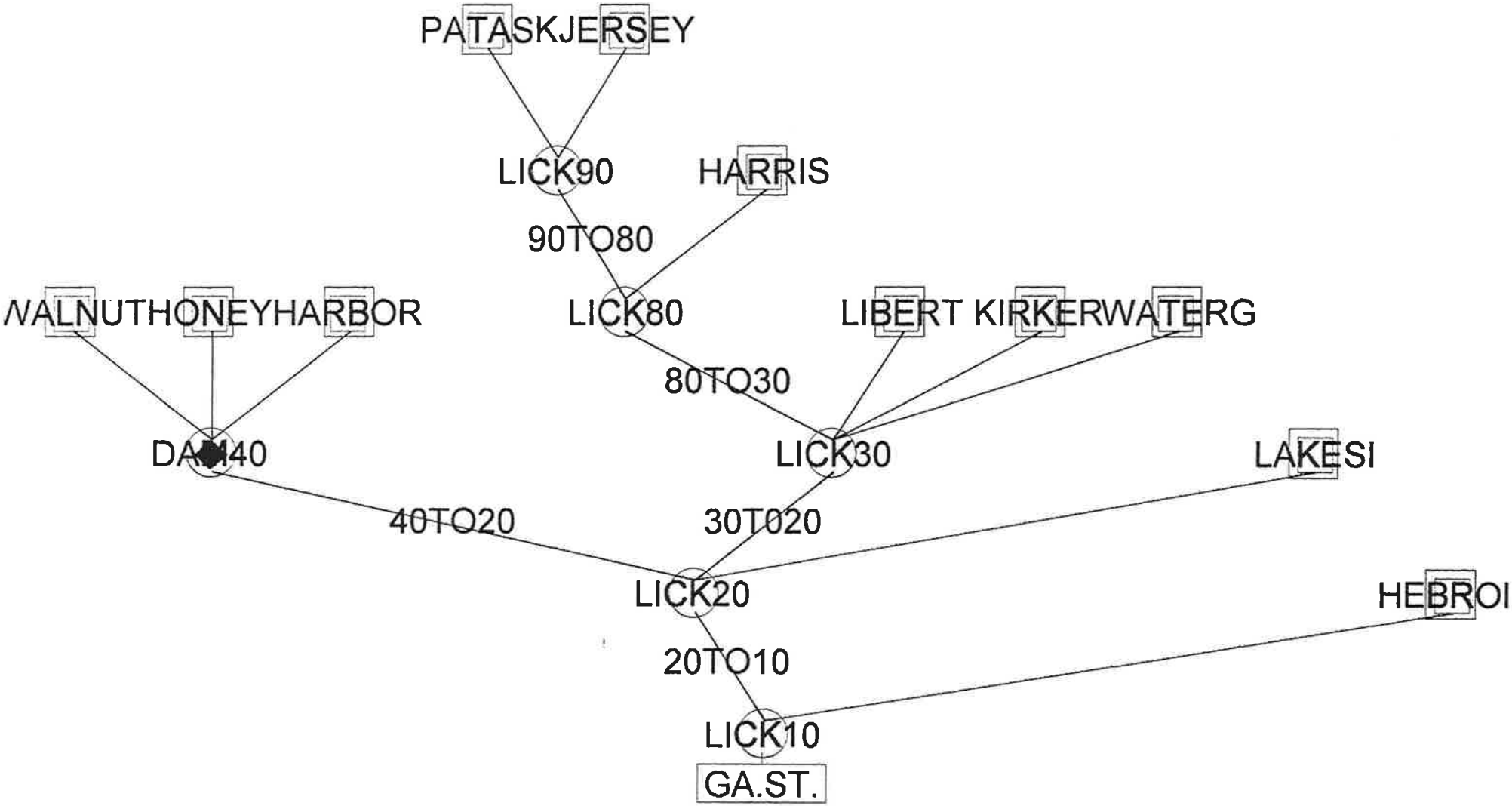
Maximum PMF peak inflow into Buckeye lake

Second Scenario

Homogeneous distribution throughout the watershed

Third Scenario

Maximum PMF outflow at the USGS gaging station near Hebron


PATASKJERSEY
LICK90
HARRIS
90TO80
WALNUTHONEYHARBOR
LICK80
LIBERT KIRKERWATERG
80TO30
DAM40
LICK30
LAKESI
40TO20
30TO20
LICK20
HEBROI
20TO10
LICK10
GA.ST.

First Scenario

Maximum PMF peak inflow into Buckeye lake

Existing outflow facilities with the dam crest reconstructed to elevation 896.5 ft.

Existing outflow facilities with the existing dam crest elevations

Existing outflow facilities with the existing dam crest elevations and a new gated outflow structure at Sellers Point.

Existing outflow facilities
with the dam crest
reconstructed to elevation 896.5 ft.

```
1*************************************
*                                   *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)*
*            MAY   1991             *
*          VERSION 4.0.1E           *
*                                   *
*  RUN DATE  ********  TIME  ******** *
*                                   *
*************************************
```

```
*************************************
*                                   *
*    U.S. ARMY CORPS OF ENGINEERS   *
*   HYDROLOGIC ENGINEERING CENTER   *
*          609 SECOND STREET        *
*       DAVIS, CALIFORNIA 95616     *
*          (916) 551-1748           *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX          X
X    X  X      X     X        XX
X    X  X      X              X
XXXXXXX  XXXX   X       XXXXX  X
X    X  X      X              X
X    X  X      X     X        X
X    X  XXXXXXX  XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
1                                          HEC-1 INPUT                                                    PAGE  1

        LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

           1          ID                                   PMF OVER LAKE , 472  FT WEIR, ONE AMIL GATE
           2          ID
           3          ID
                      *DIAGRAM
*** LIST ***
           4          IT      30  1AUG96    1200      80
           5          IO       4
           6          JD                0
           7          PH      10                0    0.87    1.87    3.45   15.56   18.72      20
           8          JR    PREC        1    0.75     0.5       0       0       0

           9          KK  WALNUT
          10          KO       1        2        0       0      22
          11          BA     9.7
          12          BF      10        0      1.3
          13          PB      23
          14          IN      15  1AUG96        0
                      * HOURLY PRECIPITATIO
          15          PC       0   0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
          16          PC  1.7877   2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
          17          PC  3.5177   2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
          18          IS    0.42       82      10
          19          UD     2.5

          20          KK   HONEY
          21          KO       1        2        0       0      22
          22          BA     9.5
          23          BF      10        0      1.3
          24          PB      22
          25          IN      15  1AUG96        0
                      * HOURLY PRECIPITATIO
          26          PC       0   0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
          27          PC  1.7877   2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
          28          PC  3.5177   2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
          29          IS   0.469       81      16
          30          UD     5.4

          31          KK  HARBOR
          32          KO       1        2        0       0      22
          33          BA     6.9
          34          BF      10        0      1.3
          35          PB      23
          36          IN      15  1AUG96        0
                      * HOURLY PRECIPITATIO
          37          PC       0   0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
          38          PC  1.7877   2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
          39          PC  3.5177   2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
          40          IS    0.42       82      23
          41          UD     2.4
1                                          HEC-1 INPUT                                                    PAGE  2

        LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

          42          KK   DAM40   CNAME  40TO20
          43          KO       0       0       0       1      22
          44          HC       3

          45          KK   DAM40
                      * RESERVOIR STORAGE
          46          KO       0       0       0       1      22
          47          RS       1    ELEV  891.75       0
                      * DAM40 SURFACE AREA
          48          SA    2758    2800    2925    3093    3260    3427    3762    4096
                      * DAM40 ELEVATION
          49          SE     892  892.25     893 893.875  894.75 895.625   896.5 897.375  898.25 899.125
          50          SE     900
          51          SS   892.2     472     3.3     1.5
          52          SL     886     340     0.7     0.5
          53          ST   896.5   21700     2.3     1.5

          54          KK  40TO20   CNAME   DAM40
          55          KO       0       0       0       1      22
          56          RK    6560  0.0009    0.06            TRAP      80       1

          57          KK  PATASK
          58          KO       1        2        0       0      22
          59          BA    13.2
          60          BF      10        0      1.3
          61          PB       7
          62          IN      15  1AUG96        0
                      * HOURLY PRECIPITATIO
          63          PC       0   0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
          64          PC  1.7877   2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
          65          PC  3.5177   2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
          66          IS   0.667       75       0
```

```
 67          UD     9.8

 68          KK  JERSEY
 69          KO       1       2       0       0      22
 70          BA    16.6
 71          BF      10       0     1.3
 72          PB       7
 73          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
 74          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
 75          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
 76          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
 77          LS   0.667      75       0
 78          UD    12.2

 79          KK  LICK90   CNAME  90TO80
 80          KO       0       0       0       1      22
 81          HC       2
1                                          HEC-1 INPUT                                                    PAGE  3
LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 82          KK  90TO80   CNAME  LICK90
 83          KO       0       0       0       1      22
 84          RK    6560  0.0009    0.06            TRAP      80       1

 85          KK  HARRIS
 86          KO       1       2       0       0      22
 87          BA    16.7
 88          BF      10       0     1.3
 89          PB       8
 90          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
 91          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
 92          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
 93          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
 94          LS   0.632      76       0
 95          UD     8.9

 96          KK  LICK80   CNAME  80TO30
 97          KO       0       0       0       1      22
 98          HC       2

 99          KK  80TO30   CNAME  LICK80
100          KO       0       0       0       1      22
101          RK    6560  0.0009    0.06            TRAP      80       1

102          KK  LIBERT
103          KO       0       0       0       0      22
104          BA      11
105          BF      10       0     1.3
106          PB      16
107          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
108          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
109          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
110          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
111          LS     0.5      80       0
112          UD    11.2

113          KK  KIRKER
114          KO       1       2       0       0      22
115          BA     9.3
116          BF      10       0     1.3
117          PB      14
118          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
119          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
120          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
121          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
122          LS   0.597      77       0
123          UD     8.2
1                                          HEC-1 INPUT                                                    PAGE  4
LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

124          KK  WATERG
125          KO       1       2       0       0      22
126          BA     9.6
127          BF      10       0     1.3
128          PB      11
129          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
130          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
131          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
132          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
133          LS   0.564      78       0
134          UD     6.3

135          KK  LICK30   CNAME  30TO20
136          KO       0       0       0       1      22
137          HC       4

138          KK  30TO20   CNAME  LICK30
139          KO       0       0       0       1      22
140          RK    6560  0.0009    0.06            TRAP      80       1

141          KK  LAKESI
142          KO       1       2       0       0      22
143          BA     7.8
144          BF      10       0     1.3
145          PB      18
146          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
147          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
148          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
149          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
150          LS     0.5      80      10
151          UD       9

152          KK  LICK20   CNAME  20TO10
153          KO       0       0       0       1      22
154          HC       3

155          KK  20TO10   CNAME  LICK20
156          KO       0       0       0       1      22
157          RK    6560  0.0009    0.06            TRAP      80       1

158          KK  HEBRON
159          KO       3       2    1000       0      22
160          BA     7.1
161          BF      10       0     1.3
```

```
162          PB      22
163          IN      15  1AUG96        0
             * HOURLY PRECIPITATIO
164          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
165          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
166          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
167          LS    0.41      83       5
168          UD    10.1
```



```
LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

169          KK  LICK10   CNAME  GA.ST.
170          KO       0       0       0       1      22
171          HC       2

172          KK  GA.ST.   CNAME  LICK10
173          KO       0       0       0       1      22
174          RK    6560  0.0009    0.06            TRAP      80       1
175          ZZ
```

1

```
            SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE     (V) ROUTING          (---->) DIVERSION OR PUMP FLOW
  NO.     (.) CONNECTOR        (<----) RETURN OF DIVERTED OR PUMPED FLOW

   9      WALNUT
                .
  20            .       HONEY
                .           .
  31            .           .       HARBOR
                .           .           .
  42       DAM40.......................
                V
                V
  45       DAM40
                V
                V
  54      40TO20
                .
  57            .       PATASK
                .           .
  68            .           .       JERSEY
                .           .           .
  79            .       LICK90............
                .           V
                .           V
  82            .       90TO80
                .           .
  85            .           .       HARRIS
                .           .           .
  96            .       LICK80............
                .           V
                .           V
  99            .       80TO30
                .           .
 102            .           .       LIBERT
                .           .           .
 113            .           .           .       KIRKER
                .           .           .           .
 124            .           .           .           .       WATERG
                .           .           .           .           .
 135            .       LICK30.................................
                .           V
                .           V
 138            .       30TO20
                .           .
 141            .           .       LAKESI
                .           .           .
 152      LICK20.......................
                V
                V
 155      20TO10
                .
 158            .       HEBRON
                .           .
 169      LICK10............
                V
                V
 172      GA.ST.
```

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
1****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*            MAY   1991                *
*          VERSION 4.0.1E              *
*                                      *
*  RUN DATE  ########  TIME  ########  *
*                                      *
****************************************
```

```
*************************************
*                                   *
*     U.S. ARMY CORPS OF ENGINEERS  *
*   HYDROLOGIC ENGINEERING CENTER   *
*         609 SECOND STREET         *
*       DAVIS, CALIFORNIA 95616     *
*          (916) 551-1748           *
*                                   *
*************************************
```

PMF OVER LAKE , 472 FT WEIR, ONE AMIL GATE

```
  5 10        OUTPUT CONTROL VARIABLES
                  IPRNT          4  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
```

```
21900  63.   O
21930  64.   O
22000  65.   O
22030  66.   O
22100  67.  O
22130  68.  O
22200  69.  O
22230  70.  O
22300  71. O
22330  72. O
30000  73. O
30030  74. O
30100  75. O
30130  76. O
30200  77.O
30230  78.O
30300  79.O
30330  80.O
1
```

*** ***

```
            **************
            *            *
169 KK      *   LICK10   *        CNAME  GA.ST.
            *            *
            **************

170 KO          OUTPUT CONTROL VARIABLES
                      IPRNT          4  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE
                      IPNCH          1  PUNCH COMPUTED HYDROGRAPH
                       IOUT         22  SAVE HYDROGRAPH ON THIS UNIT
                      ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                      ISAV2         80  LAST ORDINATE PUNCHED OR SAVED
                     TIMINT      0.500  TIME INTERVAL IN HOURS

171 HC          HYDROGRAPH COMBINATION
                      ICOMP          2  NUMBER OF HYDROGRAPHS TO COMBINE
                                                                  ***
```

*** ***

```
            **************
            *            *
172 KK      *   GA.ST.   *        CNAME  LICK10
            *            *
            **************

173 KO          OUTPUT CONTROL VARIABLES
                      IPRNT          4  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE
                      IPNCH          1  PUNCH COMPUTED HYDROGRAPH
                       IOUT         22  SAVE HYDROGRAPH ON THIS UNIT
                      ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                      ISAV2         80  LAST ORDINATE PUNCHED OR SAVED
                     TIMINT      0.500  TIME INTERVAL IN HOURS

                HYDROGRAPH ROUTING DATA

174 KK          KINEMATIC WAVE STREAM ROUTING
                          L       6560.  CHANNEL LENGTH
                          S      0.0009  SLOPE
                          N       0.060  CHANNEL ROUGHNESS COEFFICIENT
                         CA        0.00  CONTRIBUTING AREA
                      SHAPE        TRAP  CHANNEL SHAPE
                         WD       80.00  BOTTOM WIDTH OR DIAMETER
                          Z        1.00  SIDE SLOPE
                     NDXMIN           2  MINIMUM NUMBER OF DX INTERVALS
                                                                  ***
1

                PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                          FLOWS IN CUBIC FEET PER SECOND.  AREA IN SQUARE MILES
                                          TIME TO PEAK IN HOURS

                                                          RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN              RATIO 1  RATIO 2  RATIO 3
                                                          1.00     0.75     0.50

 HYDROGRAPH AT
+                WALNUT      9.70     1   FLOW        22251.   16281.   10306.
                                          TIME         9.00     9.00     9.00

 HYDROGRAPH AT
+                 HONEY      9.50     1   FLOW        14013.   10172.    6363.
                                          TIME        11.50    11.50    12.00

 HYDROGRAPH AT
+                HARBOR      6.90     1   FLOW        16180.   11836.    7532.
                                          TIME         8.50     8.50     9.00

  3 COMBINED AT
+                 DAM40     26.10     1   FLOW        47804.   34920.   22141.
                                          TIME         9.00     9.50     9.50

 ROUTED TO
+                 DAM40     26.10     1   FLOW        21012.   14622.    9266.
                                          TIME        13.00    13.50    13.50

                                     ** PEAK STAGES IN FEET **
                                     1   STAGE       896.56   895.37   894.03
                                          TIME        13.00    13.50    13.50

 ROUTED TO
+                 40TO20     26.10     1   FLOW        20959.   14614.    9260.
                                          TIME        13.50    13.50    13.50

 HYDROGRAPH AT
+                PATASK      13.20     1   FLOW         2519.    1612      792.
                                          TIME        16.50    16.50    17.00
```

```
 HYDROGRAPH AT
+                JERSEY     16.60     1  FLOW        2601.    1662.     816.
                                         TIME       18.50    18.50    19.00

  2 COMBINED AT
+                LICK90     29.80     1  FLOW        5019.    3212.    1581.
                                         TIME       17.50    18.00    18.00

 ROUTED TO
+                90TO80     29.80     1  FLOW        5015.    3212.    1578.
                                         TIME       18.00    18.00    18.00

 HYDROGRAPH AT
+                HARRIS     16.70     1  FLOW        4312.    2828.    1455.
                                         TIME       15.50    15.50    15.50

  2 COMBINED AT
+                LICK80     46.50     1  FLOW        9135.    5905.    2966.
                                         TIME       16.50    16.50    17.00

 ROUTED TO
+                80TO30     46.50     1  FLOW        9123.    5904.    2962.
                                         TIME       16.50    17.00    17.00

 HYDROGRAPH AT
+                LIBERT     11.00     1  FLOW        5993.    4243.    2527.
                                         TIME       17.50    17.50    17.50

 HYDROGRAPH AT
+                KIRKER      9.30     1  FLOW        5476.    3802.    2181.
                                         TIME       14.50    14.50    14.50

 HYDROGRAPH AT
+                WATERG      9.60     1  FLOW        5256.    3606.    2020.
                                         TIME       13.00    13.00    13.00

  4 COMBINED AT
+                LICK30     76.40     1  FLOW       23960.   16247.    8947.
                                         TIME       15.50    15.50    15.50

 ROUTED TO
+                30TO20     76.40     1  FLOW       23957.   16238.    8934.
                                         TIME       15.50    15.50    16.00

 HYDROGRAPH AT
+                LAKESI      7.80     1  FLOW        6009.    4304.    2628.
                                         TIME       15.00    15.00    15.50

  3 COMBINED AT
+                LICK20    110.30     1  FLOW       49576.   34654.   20529.
                                         TIME       14.50    15.00    15.00

 ROUTED TO
+                20TO10    110.30     1  FLOW       49542.   34645.   20511.
                                         TIME       15.00    15.00    15.00

 HYDROGRAPH AT
+                HEBRON      7.10     1  FLOW        6300.    4570.    2852.
                                         TIME       16.00    16.00    16.50

  2 COMBINED AT
+                LICK10    117.40     1  FLOW       55650.   39067.   23283.
                                         TIME       15.00    15.00    15.50

 ROUTED TO
+                GA.ST.    117.40     1  FLOW       55622.   39026.   23278.
1                                        TIME       15.00    15.00    15.50

                                   SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE ROUTING
                                       (FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)
                                                                   INTERPOLATED TO
                                                                 COMPUTATION INTERVAL
          ISTAQ    ELEMENT      DT       PEAK    TIME TO      VOLUME      DT       PEAK    TIME TO      VOLUME
                                                   PEAK                                              PEAK
                                (MIN)     (CFS)     (MIN)      (IN)    (MIN)     (CFS)     (MIN)       (IN)

        FOR PLAN = 1  RATIO= 1.00
          40TO20  MANE          3.32  21004.87    789.54     21.60    30.00  20958.86    810.00      21.48

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2995E+05 EXCESS=0.0000E+00 OUTFLOW=0.3007E+05 BASIN STORAGE=-.1301E+03 PERCENT ERROR=   0.0

        FOR PLAN = 1  RATIO= 0.75
          40TO20  MANE          3.72  14620.40    816.08     16.46    30.00  14614.20    810.00      16.34

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2283E+05 EXCESS=0.0000E+00 OUTFLOW=0.2291E+05 BASIN STORAGE=-.7997E+02 PERCENT ERROR=   0.0

        FOR PLAN = 1  RATIO= 0.50
          40TO20  MANE          4.47   9264.59    816.91     11.63    30.00   9260.06    810.00      11.45

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1608E+05 EXCESS=0.0000E+00 OUTFLOW=0.1618E+05 BASIN STORAGE=-.8047E+02 PERCENT ERROR=  -0.1

        FOR PLAN = 1  RATIO= 1.00
          90TO80  MANE          5.66   5018.43   1063.44      4.01    30.00   5015.00   1080.00       4.01

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.6396E+04 EXCESS=0.0000E+00 OUTFLOW=0.6374E+04 BASIN STORAGE=0.1775E+02 PERCENT ERROR=   0.1

        FOR PLAN = 1  RATIO= 0.75
          90TO80  MANE          6.68   3212.00   1092.55      2.56    30.00   3211.62   1080.00       2.56

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.4090E+04 EXCESS=0.0000E+00 OUTFLOW=0.4076E+04 BASIN STORAGE=0.1220E+02 PERCENT ERROR=   0.0

        FOR PLAN = 1  RATIO= 0.50
          90TO80  MANE          8.03   1580.84   1096.93      1.26    30.00   1578.11   1080.00       1.26

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2008E+04 EXCESS=0.0000E+00 OUTFLOW=0.2001E+04 BASIN STORAGE=0.5771E+01 PERCENT ERROR=   0.0

        FOR PLAN = 1  RATIO= 1.00
          80TO30  MANE          4.52   9134.24   1000.03      4.40    30.00   9122.55    990.00       4.40
```

Dam Crest Reconstructed To 896.5

```
CONTINUITY SUMMARY

        FOR PLAN
          80TO30

CONTINUITY SUMMARY (

        FOR PLAN -
          80TO30  M

CONTINUITY SUMMARY (AC

        FOR PLAN - 1
          30TO20  MAN

CONTINUITY SUMMARY (AC-F

        FOR PLAN - 1  R
          30TO20  MANE

CONTINUITY SUMMARY (AC-FT)                                                                                    0.0

        FOR PLAN - 1  RAT
          30TO20  MANE                                                  --.29    960.00        2.57

CONTINUITY SUMMARY (AC-FT) -                  - 0.0000E+00 OUTFLOW=0.1049E+05 BASIN STORAGE=0.1243E+02 PERCENT ERROR=   0.0

        FOR PLAN - 1  RATIO= 1.00
          20TO10  MANE        2.36  49575.76    874.75     10.96     30.00  49542.02    900.00       10.96

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.6444E+05 EXCESS=0.0000E+00 OUTFLOW=0.6448E+05 BASIN STORAGE=-.7952E+02 PERCENT ERROR=   0.1

        FOR PLAN - 1  RATIO= 0.75
          20TO10  MANE        2.83  34650.56    904.11      7.89     30.00  34645.08    900.00        7.89

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.4640E+05 EXCESS=0.0000E+00 OUTFLOW=0.4644E+05 BASIN STORAGE=-.9394E+02 PERCENT ERROR=   0.1

        FOR PLAN - 1  RATIO= 0.50
          20TO10  MANE        3.34  20526.70    907.31      4.98     30.00  20511.18    900.00        4.98

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2924E+05 EXCESS=0.0000E+00 OUTFLOW=0.2929E+05 BASIN STORAGE=-.1006E+03 PERCENT ERROR=   0.2

        FOR PLAN - 1  RATIO= 1.00
          GA.ST.  MANE        2.36  55642.19    903.52     11.48     30.00  55622.24    900.00       11.48

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.7186E+05 EXCESS=0.0000E+00 OUTFLOW=0.7190E+05 BASIN STORAGE=-.8225E+02 PERCENT ERROR=   0.1

        FOR PLAN - 1  RATIO= 0.75
          GA.ST.  MANE        2.58  39064.86    906.04      8.28     30.00  39025.74    900.00        8.28

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.5179E+05 EXCESS=0.0000E+00 OUTFLOW=0.5183E+05 BASIN STORAGE=-.8964E+02 PERCENT ERROR=   0.1

        FOR PLAN - 1  RATIO= 0.50
          GA.ST.  MANE        3.16  23281.08    934.19      5.22     30.00  23278.47    930.00        5.22

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3262E+05 EXCESS=0.0000E+00 OUTFLOW=0.3266E+05 BASIN STORAGE=-.9702E+02 PERCENT ERROR=   0.2

1                    SUMMARY OF DAM OVERTOPPING/BREACH ANALYSIS FOR STATION    DAM40
                (PEAKS SHOWN ARE FOR INTERNAL TIME STEP USED  DURING BREACH FORMATION)

    PLAN  1 ..............                  INITIAL VALUE     SPILLWAY CREST     TOP OF DAM
                                ELEVATION       891.75            892.20            896.50
                                STORAGE           0.               555.            14322.
                                OUTFLOW        4577.              4753.            20074.

                  RATIO     MAXIMUM     MAXIMUM     MAXIMUM     MAXIMUM     DURATION     TIME OF     TIME OF
                    OF     RESERVOIR     DEPTH      STORAGE     OUTFLOW     OVER TOP   MAX OUTFLOW   FAILURE
                   PMF      W.S.ELEV    OVER DAM     AC-FT        CFS        HOURS       HOURS       HOURS

                  1.00       896.56       0.06      14532.      21012.       2.00       13.00        0.00
                  0.75       895.37       0.00      10302.      14622.       0.00       13.50        0.00
                  0.50       894.03       0.00       5957.       9266.       0.00       13.50        0.00

***     1 ERROR(S) DETECTED BY HEC-1 ***
```

Existing outflow facilities
with the existing dam crest elevations

```
1*************************************
*                                   *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)*
*            MAY   1991             *
*          VERSION 4.0.1E           *
*                                   *
*  RUN DATE  !!!!!!!!  TIME  !!!!!!!!*
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
*   HYDROLOGIC ENGINEERING CENTER   *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*        (916) 551-1748             *
*                                   *
*************************************
```

```
X     X  XXXXXXX  XXXXX          X
X     X  X        X    X        XX
X     X  X        X             X
XXXXXXX  XXXX     X       XXXXX X
X     X  X        X             X
X     X  X        X    X        X
X     X  XXXXXXX  XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
1                                          HEC-1 INPUT                                                    PAGE  1

        LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

           1          ID                                     PMF OVER LAKE , 472  FT WEIR, ONE ANIL GAT
           2          ID
           3          ID
                      *DIAGRAM
*** LIST ***
           4          IT      30  1AUG96    1200      80
           5          IO       4
           6          JD                0
           7          PH      10                0    0.87    1.87    3.45   15.56   18.72      20
           8          JR    PREC        1    0.75     0.5       0       0       0

           9          KK  WALNUT
          10          KO       1        2       0       0      22
          11          BA     9.7
          12          BF      10        0     1.3
          13          PB      23
          14          IN      15  1AUG96       0
                      * HOURLY PRECIPITATIO
          15          PC       0   0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
          16          PC  1.7877   2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
          17          PC  3.5177   2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
          18          LS    0.42       82      10
          19          UD     2.5

          20          KK   HONEY
          21          KO       1        2       0       0      22
          22          BA     9.5
          23          BF      10        0     1.3
          24          PB      22
          25          IN      15  1AUG96       0
                      * HOURLY PRECIPITATIO
          26          PC       0   0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
          27          PC  1.7877   2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
          28          PC  3.5177   2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
          29          LS   0.469       81      16
          30          UD     5.4

          31          KK  HARBOR
          32          KO       1        2       0       0      22
          33          BA     6.9
          34          BF      10        0     1.3
          35          PB      23
          36          IN      15  1AUG96       0
                      * HOURLY PRECIPITATIO
          37          PC       0   0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
          38          PC  1.7877   2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
          39          PC  3.5177   2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
          40          LS    0.42       82      23
          41          UD     2.4
1                                          HEC-1 INPUT                                                    PAGE  2

        LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

          42          KK   DAM40   CNAME  40TO20
          43          KO       0       0       0       1      22
          44          HC       3

          45          KK   DAM40
                      * RESERVOIR STORAGE
          46          KO       0       0       0       1      22
          47          RS       1    ELEV  891.75       0
                      * DAM40 SURFACE AREA
          48          SA    2758    2800    2925    3093    3260    3427    3762    4096
                      * DAM40 ELEVATION
          49          SE     892  892.25     893 893.875  894.75 895.625   896.5 897.375  898.25 899.125
          50          SE     900
                      * Slopped Dam Crest Flow
          51          SQ    3464    3540    3598    3880    4842    6161    7722    9137   10959   15141
          52          SQ   17123   21816   27804   35108   53539   88956  103823
                      * Water Level crest o
          53          SE  891.75     892  892.25   892.5     893   893.5     894    894.4   894.8   895.1
          54          SE   895.3   895.5   895.7   895.9  896.25  896.75     897

          55          KK  40TO20   CNAME   DAM40
          56          KO       0       0       0       1      22
          57          RK    6560  0.0009    0.06            TRAP      80       1

          58          KK  PATASK
          59          KO       1        2       0       0      22
          60          BA    13.2
          61          BF      10        0     1.3
          62          PB       7
          63          IN      15  1AUG96       0
                      * HOURLY PRECIPITATIO
          64          PC       0   0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
```

```
 65          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
 66          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
 67          LS   0.667      75       0
 68          UD     9.8

 69          KK  JERSEY
 70          KO       1       2       0       0      22
 71          BA    16.6
 72          BF      10       0     1.3
 73          PB       7
 74          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
 75          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
 76          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
 77          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
 78          LS   0.667      75       0
 79          UD    12.2
1                                          HEC-1 INPUT                                          PAGE  3

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 80          KK  LICK90   CNAME  90TO80
 81          KO       0       0       0       1      22
 82          HC       2

 83          KK  90TO80   CNAME  LICK90
 84          KO       0       0       0       1      22
 85          RK    6560  0.0009    0.06            TRAP      80       1

 86          KK  HARRIS
 87          KO       1       2       0       0      22
 88          BA    16.7
 89          BF      10       0     1.3
 90          PB       8
 91          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
 92          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
 93          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
 94          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
 95          LS   0.632      76       0
 96          UD     8.9

 97          KK  LICK80   CNAME  80TO30
 98          KO       0       0       0       1      22
 99          HC       2

100          KK  80TO30   CNAME  LICK80
101          KO       0       0       0       1      22
102          RK    6560  0.0009    0.06            TRAP      80       1

103          KK  LIBERT
104          KO       0       0       0       0      22
105          BA      11
106          BF      10       0     1.3
107          PB      16
108          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
109          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
110          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
111          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
112          LS     0.5      80       0
113          UD    11.2

114          KK  KIRKER
115          KO       1       2       0       0      22
116          BA     9.3
117          BF      10       0     1.3
118          PB      14
119          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
120          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
121          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
122          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
123          LS   0.597      77       0
124          UD     8.2
1                                          HEC-1 INPUT                                          PAGE  4

LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

125          KK  WATERG
126          KO       1       2       0       0      22
127          BA     9.6
128          BF      10       0     1.3
129          PB      11
130          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
131          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
132          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
133          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
134          LS   0.564      78       0
135          UD     6.3

136          KK  LICK30   CNAME  30TO20
137          KO       0       0       0       1      22
138          HC       4

139          KK  30TO20   CNAME  LICK30
140          KO       0       0       0       1      22
141          RK    6560  0.0009    0.06            TRAP      80       1

142          KK  LAKESI
143          KO       1       2       0       0      22
144          BA     7.8
145          BF      10       0     1.3
146          PB      18
147          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
148          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
149          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
150          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
151          LS     0.5      80      10
152          UD       9

153          KK  LICK20   CNAME  20TO10
154          KO       0       0       0       1      22
155          HC       3

156          KK  20TO10   CNAME  LICK20
157          KO       0       0       0       1      22
158          RK    6560  0.0009    0.06            TRAP      80       1

159          KK  HEBRON
```

```
 160          KO      3       2    1000       0      22
 161          BA    7.1
 162          BF     10       0     1.3
 163          PB     22
 164          IN     15  1AUG96       0
              * HOURLY PRECIPITATIO
 165          PC      0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
 166          PC 1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
 167          PC 3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
 168          LS   0.41      83       5
 169          UD   10.1
1                                          HEC-1 INPUT                                          PAGE  5

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 170          KK  LICK10   CNAME  GA.ST.
 171          KO       0       0       0       1      22
 172          HC       2

 173          KK  GA.ST.   CNAME  LICK10
 174          KO       0       0       0       1      22
 175          RK    6560  0.0009    0.06            TRAP      80       1
 176          ZZ
1
              SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE     (V) ROUTING          (---->) DIVERSION OR PUMP FLOW

 NO.      (.) CONNECTOR        (<----) RETURN OF DIVERTED OR PUMPED FLOW

   9      WALNUT
                .
  20              .      HONEY
                  .        .
  31              .        .      HARBOR
                  .        .        .
  42       DAM40.........................
              V
              V
  45       DAM40
              V
              V
  55      40TO20
                .
  58              .      PATASK
                  .        .
  69              .        .      JERSEY
                  .        .        .
  80              .      LICK90............
                  .        V        .
                  .        V        .
  83              .      90TO80
                  .        .        .
  86              .        .      HARRIS
                  .        .        .
  97              .      LICK80............
                  .        V        .
                  .        V        .
 100              .      80TO30
                  .        .        .
 103              .        .      LIBERT
                  .        .        .
 114              .        .        .      KIRKER
                  .        .        .        .
 125              .        .        .        .      WATERG
                  .        .        .        .        .
 136              .      LICK30.......................................
                  .        V        .        .        .
                  .        V        .        .        .
 139              .      30TO20
                  .        .        .        .        .
 142              .        .      LAKESI     .        .
                  .        .        .        .        .
 153      LICK20........................
              V
              V
 156      20TO10
                .
 159              .      HEBRON
                  .        .
 170      LICK10............
              V
              V
 173      GA.ST.
(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*************************************
*                                   *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)*
*            MAY   1991             *
*          VERSION 4.0.1E           *
*                                   *
*  RUN DATE  ########  TIME  ########*
*                                   *
*************************************

*************************************
*                                   *
*    U.S. ARMY CORPS OF ENGINEERS   *
*    HYDROLOGIC ENGINEERING CENTER  *
*          609 SECOND STREET        *
*       DAVIS, CALIFORNIA 95616     *
*          (916) 551-1748           *
*                                   *
*************************************

                                   PMF OVER LAKE . 472  FT WEIR, ONE AMIL GAT

  5 IO          OUTPUT CONTROL VARIABLES
                     IPRNT          4  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
```

```
171 KO          OUTPUT CONTROL VARIABLES
                      IPRNT          4  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE
                      IPNCH          1  PUNCH COMPUTED HYDROGRAPH
                       IOUT         22  SAVE HYDROGRAPH ON THIS UNIT
                      ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                      ISAV2         80  LAST ORDINATE PUNCHED OR SAVED
                     TIMINT      0.500  TIME INTERVAL IN HOURS

172 HC          HYDROGRAPH COMBINATION
                      ICOMP          2  NUMBER OF HYDROGRAPHS TO COMBINE
                                                                   ***

*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

            **************
            *            *
173 KK      *   GA.ST.   *        CNAME  LICK10
            *            *
            **************

174 KO          OUTPUT CONTROL VARIABLES
                      IPRNT          4  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE
                      IPNCH          1  PUNCH COMPUTED HYDROGRAPH
                       IOUT         22  SAVE HYDROGRAPH ON THIS UNIT
                      ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                      ISAV2         80  LAST ORDINATE PUNCHED OR SAVED
                     TIMINT      0.500  TIME INTERVAL IN HOURS

                HYDROGRAPH ROUTING DATA

175 RK          KINEMATIC WAVE STREAM ROUTING
                          L      6560.  CHANNEL LENGTH
                          S     0.0009  SLOPE
                          N      0.060  CHANNEL ROUGHNESS COEFFICIENT
                         CA       0.00  CONTRIBUTING AREA
                      SHAPE       TRAP  CHANNEL SHAPE
                         WD      80.00  BOTTOM WIDTH OR DIAMETER
                          Z       1.00  SIDE SLOPE
                     NDXMIN          2  MINIMUM NUMBER OF DX INTERVALS
                                                                   ***
1

                PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                              FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS

                                                          RATIOS APPLIED TO PRECIPITATION
 OPERATION       STATION     AREA    PLAN            RATIO 1  RATIO 2  RATIO 3
                                                       1.00     0.75     0.50

 HYDROGRAPH AT
+                WALNUT      9.70     1   FLOW       22251.   16281.   10306.
                                          TIME        9.00     9.00     9.00

 HYDROGRAPH AT
+                 HONEY      9.50     1   FLOW       14013.   10172.    6363.
                                          TIME       11.50    11.50    12.00

 HYDROGRAPH AT
+                HARBOR      6.90     1   FLOW       16180.   11836.    7532.
                                          TIME        8.50     8.50     9.00

  3 COMBINED AT
+                ·DAM40     26.10     1   FLOW       47804.   34920.   22141.
                                          TIME        9.00     9.50     9.50

 ROUTED TO
+                 DAM40     26.10     1   FLOW       34452.   18082.    8567.
                                          TIME       11.50    12.50    13.50

                                     ** PEAK STAGES IN FEET **
                                     1   STAGE      895.88   895.34   894.24
                                          TIME       11.50    12.50    13.50

 ROUTED TO
+                40TO20     26.10     1   FLOW       34335.   17958.    8561.
                                          TIME       11.50    13.00    14.00

 HYDROGRAPH AT
+                PATASK     13.20     1   FLOW        2519.    1612.     792.
                                          TIME       16.50    16.50    17.00

 HYDROGRAPH AT
+                JERSEY     16.60     1   FLOW        2601.    1662.     816.
                                          TIME       18.50    18.50    19.00

  2 COMBINED AT
+                LICK90     29.80     1   FLOW        5019.    3212.    1581.
                                          TIME       17.50    18.00    18.00

 ROUTED TO
+                90TO80     29.80     1   FLOW        5015.    3212.    1578.
                                          TIME       18.00    18.00    18.00

 HYDROGRAPH AT
+                HARRIS     16.70     1   FLOW        4312.    2828.    1455.
                                          TIME       15.50    15.50    15.50

  2 COMBINED AT
+                LICK80     46.50     1   FLOW        9135.    5905.    2966.
                                          TIME       16.50    16.50    17.00

 ROUTED TO
+                80TO30     46.50     1   FLOW        9123.    5904.    2962.
                                          TIME       16.50    17.00    17.00

 HYDROGRAPH AT
+                LIBERT     11.00     1   FLOW        5993.    4243.    2527.
                                          TIME       17.50    17.50    17.50

 HYDROGRAPH AT
```

```
+                KIRKER      9.30     1   FLOW        5476.    3802.    2181.
                                             TIME       14.50    14.50    14.50

 HYDROGRAPH AT
+                WATERG      9.60     1   FLOW        5256.    3606.    2020.
                                             TIME       13.00    13.00    13.00

  4 COMBINED AT
+                LICK30     76.40     1   FLOW       23960.   16247.    8947.
                                             TIME       15.50    15.50    15.50

 ROUTED TO
+                30TO20     76.40     1   FLOW       23957.   16238.    8934.
                                             TIME       15.50    15.50    16.00

 HYDROGRAPH AT
+                LAKESI      7.80     1   FLOW        6009.    4304.    2628.
                                             TIME       15.00    15.00    15.50

  3 COMBINED AT
+                LICK20    110.30     1   FLOW       56109.   36472.   19909.
                                             TIME       12.50    14.00    15.00

 ROUTED TO
+                20TO10    110.30     1   FLOW       56106.   36436.   19885.
                                             TIME       12.50    14.00    15.00

 HYDROGRAPH AT
+                HEBRON      7.10     1   FLOW        6300.    4570.    2852.
                                             TIME       16.00    16.00    16.50

  2 COMBINED AT
+                LICK10    117.40     1   FLOW       60744.   40711.   22683.
                                             TIME       12.50    14.50    15.50

 ROUTED TO
+                GA.ST.    117.40     1   FLOW       60650.   40685.   22673.
                                             TIME       12.50    14.50    15.50
1
                                        SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE ROUTING
                                           (FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)
                                                                          INTERPOLATED TO
                                                                          COMPUTATION INTERVAL
          ISTAQ    ELEMENT      DT        PEAK    TIME TO      VOLUME      DT        PEAK    TIME TO      VOLUME
                                                    PEAK                                              PEAK
                               (MIN)      (CFS)     (MIN)      (IN)     (MIN)      (CFS)     (MIN)       (IN)
        FOR PLAN = 1  RATIO= 1.00
          40TO20  MANE         2.75   34440.37    695.26     20.67     30.00   34334.96    690.00      20.67

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2866E+05 EXCESS=0.0000E+00 OUTFLOW=0.2877E+05 BASIN STORAGE=-.1457E+03 PERCENT ERROR=   0.1

        FOR PLAN = 1  RATIO= 0.75
          40TO20  MANE         3.44   18070.04    759.04     15.09     30.00   17957.80    780.00      15.08

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2089E+05 EXCESS=0.0000E+00 OUTFLOW=0.2100E+05 BASIN STORAGE=-.1479E+03 PERCENT ERROR=   0.2

        FOR PLAN = 1  RATIO= 0.50
          40TO20  MANE         4.69    8566.19    819.05      9.56     30.00    8560.92    840.00       9.56

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1319E+05 EXCESS=0.0000E+00 OUTFLOW=0.1331E+05 BASIN STORAGE=-.1493E+03 PERCENT ERROR=   0.2

        FOR PLAN = 1  RATIO= 1.00
          90TO80  MANE         5.66    5018.43   1063.44      4.01     30.00    5015.00   1080.00       4.01

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.6396E+04 EXCESS=0.0000E+00 OUTFLOW=0.6374E+04 BASIN STORAGE=0.1775E+02 PERCENT ERROR=   0.1

        FOR PLAN = 1  RATIO= 0.75
          90TO80  MANE         6.60    3212.00   1092.55      2.56     30.00    3211.62   1080.00       2.56

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.4090E+04 EXCESS=0.0000E+00 OUTFLOW=0.4076E+04 BASIN STORAGE=0.1220E+02 PERCENT ERROR=   0.0

        FOR PLAN = 1  RATIO= 0.50
          90TO80  MANE         8.83    1580.84   1096.93      1.26     30.00    1578.11   1080.00       1.26

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2008E+04 EXCESS=0.0000E+00 OUTFLOW=0.2001E+04 BASIN STORAGE=0.5771E+01 PERCENT ERROR=   0.0

        FOR PLAN = 1  RATIO= 1.00
          80TO30  MANE         4.52    9134.24   1000.03      4.40     30.00    9122.55    990.00       4.40

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1093E+05 EXCESS=0.0000E+00 OUTFLOW=0.1091E+05 BASIN STORAGE=0.2049E+02 PERCENT ERROR=   0.0

        FOR PLAN = 1  RATIO= 0.75
          80TO30  MANE         5.28    5904.71   1001.59      2.84     30.00    5903.86   1020.00       2.84

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.7061E+04 EXCESS=0.0000E+00 OUTFLOW=0.7048E+04 BASIN STORAGE=0.1385E+02 PERCENT ERROR=   0.0

        FOR PLAN = 1  RATIO= 0.50
          80TO30  MANE         6.92    2965.44   1034.81      1.42     30.00    2961.84   1020.00       1.42

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3536E+04 EXCESS=0.0000E+00 OUTFLOW=0.3527E+04 BASIN STORAGE=0.6816E+01 PERCENT ERROR=   0.1

        FOR PLAN = 1  RATIO= 1.00
          30TO20  MANE         3.08   23959.17    935.75      6.90     30.00   23956.75    930.00       6.90

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2814E+05 EXCESS=0.0000E+00 OUTFLOW=0.2811E+05 BASIN STORAGE=0.3186E+02 PERCENT ERROR=   0.0

        FOR PLAN = 1  RATIO= 0.75
          30TO20  MANE         3.57   16245.36    935.99      4.67     30.00   16238.29    930.00       4.67

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1907E+05 EXCESS=0.0000E+00 OUTFLOW=0.1905E+05 BASIN STORAGE=0.2279E+02 PERCENT ERROR=   0.0
```

```
FOR PLAN = 1  RATIO= 0.50
  30TO20  MANE        4.58   8946.61    940.27      2.57     30.00   8934.29    960.00        2.57

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1050E+06 EXCESS=0.0000E+00 OUTFLOW=0.1049E+05 BASIN STORAGE=0.1243E+02 PERCENT ERROR=   0.0

FOR PLAN = 1  RATIO= 1.00
  20TO10  MANE        2.31  56106.63    751.08     10.77     30.00  56105.95    750.00       10.77

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.6330E+05 EXCESS=0.0000E+00 OUTFLOW=0.6337E+05 BASIN STORAGE=-.1013E+03 PERCENT ERROR=   0.1

FOR PLAN = 1  RATIO= 0.75
  20TO10  MANE        2.62  36468.62    846.83      7.60     30.00  36436.57    840.00        7.60

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.4464E+05 EXCESS=0.0000E+00 OUTFLOW=0.4471E+05 BASIN STORAGE=-.1117E+03 PERCENT ERROR=   0.1

FOR PLAN = 1  RATIO= 0.50
  20TO10  MANE        3.34  19908.80    906.71      4.53     30.00  19885.06    900.00        4.53

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2659E+05 EXCESS=0.0000E+00 OUTFLOW=0.2668E+05 BASIN STORAGE=-.1237E+03 PERCENT ERROR=   0.2

FOR PLAN = 1  RATIO= 1.00
  GA.ST.  MANE        2.21  60739.33    754.86     11.31     30.00  60650.46    750.00       11.31

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.7076E+05 EXCESS=0.0000E+00 OUTFLOW=0.7081E+05 BASIN STORAGE=-.9199E+02 PERCENT ERROR=   0.1

FOR PLAN = 1  RATIO= 0.75
  GA.ST.  MANE        2.56  40709.46    874.88      8.01     30.00  40685.16    870.00        8.01

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.5007E+05 EXCESS=0.0000E+00 OUTFLOW=0.5012E+05 BASIN STORAGE=-.1052E+03 PERCENT ERROR=   0.1

FOR PLAN = 1  RATIO= 0.50
  GA.ST.  MANE        3.24  22680.54    935.08      4.81     30.00  22673.29    930.00        4.80

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3001E+05 EXCESS=0.0000E+00 OUTFLOW=0.3009E+05 BASIN STORAGE=-.1189E+03 PERCENT ERROR=   0.1


***    1 ERROR(S) DETECTED BY HEC-1 ***
```

**Existing outflow facilities
with the existing dam crest elevations
and a new gated outflow structure at
Sellers Point.**

```
1*************************************
*                                   *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)*
*            MAY   1991             *
*          VERSION 4.0.1E           *
*                                   *
* RUN DATE  ########  TIME  ########*
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
*   HYDROLOGIC ENGINEERING CENTER   *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*          (916) 551-1748           *
*                                   *
*************************************
```

```
X     X  XXXXXXX  XXXXX          X
X     X  X       X     X        XX
X     X  X       X              X
XXXXXXX  XXXX    X        XXXXX X
X     X  X       X              X
X     X  X       X     X        X
X     X  XXXXXXX  XXXXX          XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
1                                          HEC-1 INPUT                                                    PAGE  1

          LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

            1           ID                                     PMF OVER LAKE . 472  FT WEIR, ONE AMIL GAT
            2           ID
            3           ID
                        *DIAGRAM
*** LIST ***
            4           IT      30  1AUG96    1200      00
            5           IO       4
            6           JD                 0
            7           PH      10                0    0.87    1.87    3.45   15.56   18.72      20
            8           JR    PREC        1    0.75     0.5       0       0       0

            9           KK  WALNUT
           10           KO       1        2        0       0      22
           11           BA     9.7
           12           BF      10        0      1.3
           13           PB      23
           14           IN      15  1AUG96        0
                        * HOURLY PRECIPITATIO
           15           PC       0   0.2175    0.435   0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
           16           PC  1.7877   2.1913   2.9987    4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
           17           PC  3.5177   2.7175    2.265   1.8125    1.36    1.02    0.68    0.34       0
           18           LS    0.42       82       10
           19           UD     2.5

           20           KK   HONEY
           21           KO       1        2        0       0      22
           22           BA     9.5
           23           BF      10        0      1.3
           24           PB      22
           25           IN      15  1AUG96        0
                        * HOURLY PRECIPITATIO
           26           PC       0   0.2175    0.435   0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
           27           PC  1.7877   2.1913   2.9987    4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
           28           PC  3.5177   2.7175    2.265   1.8125    1.36    1.02    0.68    0.34       0
           29           LS   0.469       81       16
           30           UD     5.4

           31           KK  HARBOR
           32           KO       1        2        0       0      22
           33           BA     6.9
           34           BF      10        0      1.3
           35           PB      23
           36           IN      15  1AUG96        0
                        * HOURLY PRECIPITATIO
           37           PC       0   0.2175    0.435   0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
           38           PC  1.7877   2.1913   2.9987    4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
           39           PC  3.5177   2.7175    2.265   1.8125    1.36    1.02    0.68    0.34       0
           40           LS    0.42       82       23
           41           UD     2.4
1                                          HEC-1 INPUT                                                    PAGE  2

          LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

           42           KK   DAM40   CNAME  40TO20
           43           KO       0        0        0       1      22
           44           HC       3

           45           KK   DAM40
                        * RESERVOIR STORAGE
           46           KO       0        0        0       1      22
           47           RS       1     ELEV  891.75       0
                        * DAM40 SURFACE AREA
           48           SA    2758     2800     2925    3093    3260    3427    3762    4096
                        * DAM40 ELEVATION
           49           SE     892   892.25      893 893.875  894.75 895.625   896.5 897.375  898.25 899.125
           50           SE     900
           51           SS   892.2      472      3.3     1.5
           52           SL     886    1700      0.7     0.5
           53           ST   896.5   21700      2.3     1.5

           54           KK  40TO20   CNAME   DAM40
           55           KO       0        0        0       1      22
           56           RK    6560   0.0009     0.06            TRAP      80       1

           57           KK  PATASK
           58           KO       1        2        0       0      22
           59           BA    13.2
           60           BF      10        0      1.3
           61           PB       7
           62           IN      15  1AUG96        0
                        * HOURLY PRECIPITATIO
           63           PC       0   0.2175    0.435   0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
           64           PC  1.7877   2.1913   2.9987    4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
           65           PC  3.5177   2.7175    2.265   1.8125    1.36    1.02    0.68    0.34       0
           66           LS   0.667       75        0
```

```
 67          UD     9.8

 68          KK  JERSEY
 69          KO       1       2       0       0      22
 70          BA    16.6
 71          BF      10       0     1.3
 72          PB       7
 73          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
 74          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
 75          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
 76          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
 77          LS   0.667      75       0
 78          UD    12.2

 79          KK  LICK90   CNAME  90TO80
 80          KO       0       0       0       1      22
 81          HC       2
1                                          HEC-1 INPUT                                                    PAGE  3
LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 82          KK  90TO80   CNAME  LICK90
 83          KO       0       0       0       1      22
 84          RK    6560  0.0009    0.06            TRAP      80       1

 85          KK  HARRIS
 86          KO       1       2       0       0      22
 87          BA    16.7
 88          BF      10       0     1.3
 89          PB       8
 90          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
 91          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
 92          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
 93          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
 94          LS   0.632      76       0
 95          UD     8.9

 96          KK  LICK80   CNAME  80TO30
 97          KO       0       0       0       1      22
 98          HC       2

 99          KK  80TO30   CNAME  LICK80
100          KO       0       0       0       1      22
101          RK    6560  0.0009    0.06            TRAP      80       1

102          KK  LIBERT
103          KO       0       0       0       0      22
104          BA      11
105          BF      10       0     1.3
106          PB      16
107          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
108          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
109          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
110          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
111          LS     0.5      80       0
112          UD    11.2

113          KK  KIRKER
114          KO       1       2       0       0      22
115          BA     9.3
116          BF      10       0     1.3
117          PB      14
118          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
119          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
120          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
121          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
122          LS   0.597      77       0
123          UD     8.2
1                                          HEC-1 INPUT                                                    PAGE  4
LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

124          KK  WATERG
125          KO       1       2       0       0      22
126          BA     9.6
127          BF      10       0     1.3
128          PB      11
129          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
130          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
131          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
132          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
133          LS   0.564      78       0
134          UD     6.3

135          KK  LICK30   CNAME  30TO20
136          KO       0       0       0       1      22
137          HC       4

138          KK  30TO20   CNAME  LICK30
139          KO       0       0       0       1      22
140          RK    6560  0.0009    0.06            TRAP      80       1

141          KK  LAKESI
142          KO       1       2       0       0      22
143          BA     7.8
144          BF      10       0     1.3
145          PB      18
146          IN      15  1AUG96       0
             * HOURLY PRECIPITATIO
147          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
148          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
149          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
150          LS     0.5      80      10
151          UD       9

152          KK  LICK20   CNAME  20TO10
153          KO       0       0       0       1      22
154          HC       3

155          KK  20TO10   CNAME  LICK20
156          KO       0       0       0       1      22
157          RK    6560  0.0009    0.06            TRAP      80       1

158          KK  HEBRON
159          KO       3       2    1000       0      22
160          BA     7.1
161          BF      10       0     1.3
```

```
 162          PB      22
 163          IN      15  1AUG96       0
              * HOURLY PRECIPITATIO
 164          PC       0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
 165          PC  1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
 166          PC  3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
 167          IS    0.41      83       5
 168          UD    10.1
1                                          HEC-1 INPUT                                          PAGE  5
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 169          KK  LICK10   CNAME  GA.ST.
 170          KO       0       0       0       1      22
 171          HC       2

 172          KK  GA.ST.   CNAME  LICK10
 173          KO       0       0       0       1      22
 174          RK    6560  0.0009    0.06            TRAP      80       1
 175          ZZ
1
            SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE     (V) ROUTING          (---->) DIVERSION OR PUMP FLOW

 NO.      (.) CONNECTOR        (<----) RETURN OF DIVERTED OR PUMPED FLOW

   9      WALNUT
            .
  20        .       HONEY
            .          .
  31        .          .       HARBOR
            .          .          .
  42      DAM40.......................
            V
            V
  45      DAM40
            V
            V
  54      40TO20
            .
  57        .       PATASK
            .          .
  68        .          .       JERSEY
            .          .          .
  79        .       LICK90............
            .          V
            .          V
  82        .       90TO80
            .          .
  85        .          .       HARRIS
            .          .          .
  96        .       LICK80............
            .          V
            .          V
  99        .       80TO30
            .          .
 102        .          .       LIBERT
            .          .          .
 113        .          .          .       KIRKER
            .          .          .          .
 124        .          .          .          .       WATERG
            .          .          .          .          .
 135        .       LICK30.......................................
            .          V
            .          V
 138        .       30TO20
            .          .
 141        .          .       LAKESI
            .          .          .
 152      LICK20.......................
            V
            V
 155      20TO10
            .
 158        .       HEBRON
            .          .
 169      LICK10............
            V
            V
 172      GA.ST.
(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*************************************
*                                   *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)*
*            MAY  1991              *
*          VERSION 4.0.1E           *
*                                   *
*  RUN DATE  ########  TIME  ########*
*                                   *
*************************************

*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
*   HYDROLOGIC ENGINEERING CENTER   *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*        (916) 551-1748             *
*                                   *
*************************************

                                   PMF OVER LAKE , 472  FT WEIR, ONE AMIL GAT

  5 IO          OUTPUT CONTROL VARIABLES
                     IPRNT          4  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
                     QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT            HYDROGRAPH TIME DATA
```

```
 22300  71.0
 22330  72.0
 30000  73.0
 30030  74.0
 30100  75.0
 30130  76.0
 30200  77.0
 30230  78.0
 30300  79.0
 30330  80.0
1

*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

            **************
            *            *
169 KK      *   LICK10   *        CNAME  GA.ST.
            *            *
            **************

170 KO          OUTPUT CONTROL VARIABLES
                      IPRNT          4  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE
                      IPNCH          1  PUNCH COMPUTED HYDROGRAPH
                       IOUT         22  SAVE HYDROGRAPH ON THIS UNIT
                      ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                      ISAV2         80  LAST ORDINATE PUNCHED OR SAVED
                     TIMINT      0.500  TIME INTERVAL IN HOURS

171 HC          HYDROGRAPH COMBINATION
                      ICOMP          2  NUMBER OF HYDROGRAPHS TO COMBINE
                                                                  ***

*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

            **************
            *            *
172 KK      *   GA.ST.   *        CNAME  LICK10
            *            *
            **************

173 KO          OUTPUT CONTROL VARIABLES
                      IPRNT          4  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE
                      IPNCH          1  PUNCH COMPUTED HYDROGRAPH
                       IOUT         22  SAVE HYDROGRAPH ON THIS UNIT
                      ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                      ISAV2         80  LAST ORDINATE PUNCHED OR SAVED
                     TIMINT      0.500  TIME INTERVAL IN HOURS

                HYDROGRAPH ROUTING DATA

174 RK          KINEMATIC WAVE STREAM ROUTING
                          L       6560.  CHANNEL LENGTH
                          S     0.0009  SLOPE
                          N      0.060  CHANNEL ROUGHNESS COEFFICIENT
                         CA       0.00  CONTRIBUTING AREA
                      SHAPE       TRAP  CHANNEL SHAPE
                         WD      80.00  BOTTOM WIDTH OR DIAMETER
                          Z       1.00  SIDE SLOPE
                     NDXMIN          2  MINIMUM NUMBER OF DX INTERVALS
                                                                  ***
1

                PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                              FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS

                                                                  RATIOS APPLIED TO PRECIPITATION
 OPERATION        STATION      AREA     PLAN              RATIO 1  RATIO 2  RATIO 3
                                                             1.00     0.75     0.50

 HYDROGRAPH AT
+                 WALNUT       9.70      1   FLOW         22251.   16281.   10306.
                                               TIME          9.00     9.00     9.00

 HYDROGRAPH AT
+                  HONEY       9.50      1   FLOW         14013.   10172.    6363.
                                               TIME         11.50    11.50    12.00

 HYDROGRAPH AT
+                 HARBOR       6.90      1   FLOW         16180.   11836.    7532.
                                               TIME          8.50     8.50     9.00

  3 COMBINED AT
+                  DAM40      26.10      1   FLOW         47804.   34920.   22141.
                                               TIME          9.00     9.50     9.50

 ROUTED TO
+                  DAM40      26.10      1   FLOW         31121.   25805.   23433.
                                               TIME         11.50    11.50     7.00

                                          ** PEAK STAGES IN FEET **
                                          1   STAGE        894.08   892.85   892.03
                                               TIME         11.50    11.50     7.00

 ROUTED TO
+                 40TO20      26.10      1   FLOW         31116.   25802.   23389.
                                               TIME         12.00    11.50     7.50

 HYDROGRAPH AT
+                 PATASK      13.20      1   FLOW          2519.    1612.     792.
                                               TIME         16.50    16.50    17.00

 HYDROGRAPH AT
+                 JERSEY      16.60      1   FLOW          2601.    1662.     816.
                                               TIME         18.50    18.50    19.00

  2 COMBINED AT
+                 LICK90      29.80      1   FLOW          5019.    3212.    1581.
                                               TIME         17.50    18.00    18.00
```

```
 ROUTED TO
+                90TO80     29.80    1   FLOW        5015.    3212.    1578.
                                         TIME        18.00    18.00    18.00

 HYDROGRAPH AT
+                HARRIS     16.70    1   FLOW        4312.    2828.    1455.
                                         TIME        15.50    15.50    15.50

  2 COMBINED AT
+                LICK80     46.50    1   FLOW        9135.    5905.    2966.
                                         TIME        16.50    16.50    17.00

 ROUTED TO
+                80TO30     46.50    1   FLOW        9123.    5904.    2962.
                                         TIME        16.50    17.00    17.00

 HYDROGRAPH AT
+                LIBERT     11.00    1   FLOW        5993.    4243.    2527.
                                         TIME        17.50    17.50    17.50

 HYDROGRAPH AT
+                KIRKER      9.30    1   FLOW        5476.    3802.    2181.
                                         TIME        14.50    14.50    14.50

 HYDROGRAPH AT
+                WATERG      9.60    1   FLOW        5256.    3606.    2020.
                                         TIME        13.00    13.00    13.00

  4 COMBINED AT
+                LICK30     76.40    1   FLOW       23960.   16247.    8947.
                                         TIME        15.50    15.50    15.50

 ROUTED TO
+                30TO20     76.40    1   FLOW       23957.   16238.    8934.
                                         TIME        15.50    15.50    16.00

 HYDROGRAPH AT
+                LAKESI      7.80    1   FLOW        6009.    4304.    2628.
                                         TIME        15.00    15.00    15.50

  3 COMBINED AT
+                LICK20    110.30    1   FLOW       58088.   43910.   32480.
                                         TIME        14.00    14.50    12.50

 ROUTED TO
+                20TO10    110.30    1   FLOW       58034.   43902.   32328.
                                         TIME        14.00    15.00    12.50

 HYDROGRAPH AT
+                HEBRON      7.10    1   FLOW        6300.    4570.    2852.
                                         TIME        16.00    16.00    16.50

  2 COMBINED AT
+                LICK10    117.40    1   FLOW       63959.   48324.   34380.
                                         TIME        14.50    15.00    12.50

 ROUTED TO
+                GA.ST.    117.40    1   FLOW       63927.   48301.   34192.
                                         TIME        14.50    15.00    12.50
1
                                    SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE ROUTING
                                        (FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)
                                                                    INTERPOLATED TO
                                                                  COMPUTATION INTERVAL
          ISTAQ    ELEMENT      DT        PEAK    TIME TO     VOLUME      DT       PEAK    TIME TO     VOLUME
                                                     PEAK                                     PEAK
                               (MIN)      (CFS)     (MIN)      (IN)     (MIN)     (CFS)     (MIN)       (IN)
        FOR PLAN = 1  RATIO= 1.00
          40TO20  MANE          2.90  31120.54    696.30     38.37     30.00  31116.06    720.00      39.92

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.5309E+05 EXCESS=0.0000E+00 OUTFLOW=0.5340E+05 BASIN STORAGE=-.1920E+03 PERCENT ERROR=  -0.2

        FOR PLAN = 1  RATIO= 0.75
          40TO20  MANE          3.09  25803.96    695.41     34.62     30.00  25801.50    690.00      36.17

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.4767E+05 EXCESS=0.0000E+00 OUTFLOW=0.4818E+05 BASIN STORAGE=-.3695E+03 PERCENT ERROR=  -0.3

        FOR PLAN = 1  RATIO= 0.50
          40TO20  MANE          3.10  23426.86    429.32     31.53     30.00  23388.80    450.00      33.36

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.4346E+05 EXCESS=0.0000E+00 OUTFLOW=0.4389E+05 BASIN STORAGE=-.1663E+03 PERCENT ERROR=  -0.6

        FOR PLAN = 1  RATIO= 1.00
          90TO80  MANE          5.66   5018.43   1063.44      4.01     30.00   5015.00   1080.00       4.01

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.6396E+04 EXCESS=0.0000E+00 OUTFLOW=0.6374E+04 BASIN STORAGE=0.1775E+02 PERCENT ERROR=   0.1

        FOR PLAN = 1  RATIO= 0.75
          90TO80  MANE          6.68   3212.00   1092.55      2.56     30.00   3211.62   1080.00       2.56

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.4090E+04 EXCESS=0.0000E+00 OUTFLOW=0.4076E+04 BASIN STORAGE=0.1220E+02 PERCENT ERROR=   0.0

        FOR PLAN = 1  RATIO= 0.50
          90TO80  MANE          8.83   1580.84   1096.93      1.26     30.00   1578.11   1080.00       1.26

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2008E+04 EXCESS=0.0000E+00 OUTFLOW=0.2001E+04 BASIN STORAGE=0.5771E+01 PERCENT ERROR=   0.0

        FOR PLAN = 1  RATIO= 1.00
          80TO30  MANE          4.52   9134.24   1000.03      4.40     30.00   9122.55    990.00       4.40

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1093E+05 EXCESS=0.0000E+00 OUTFLOW=0.1091E+05 BASIN STORAGE=0.2049E+02 PERCENT ERROR=   0.0

        FOR PLAN = 1  RATIO= 0.75
          80TO30  MANE          5.28   5904.71   1001.59      2.84     30.00   5903.86   1020.00       2.84

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.7061E+04 EXCESS=0.0000E+00 OUTFLOW=0.7048E+04 BASIN STORAGE=0.1305E+02 PERCENT ERROR=   0.0
```

```
FOR PLAN = 1  RATIO= 0.50
  80TO30  MANE        6.92   2965.44   1034.81      1.42     30.00   2961.84   1020.00        1.42

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3536E+04 EXCESS=0.0000E+00 OUTFLOW=0.3527E+04 BASIN STORAGE=0.6816E+01 PERCENT ERROR=   0.1

FOR PLAN = 1  RATIO= 1.00
  30TO20  MANE        3.08  23959.17    935.75      6.90     30.00  23956.75    930.00        6.90

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2814E+05 EXCESS=0.0000E+00 OUTFLOW=0.2811E+05 BASIN STORAGE=0.3186E+02 PERCENT ERROR=   0.0

FOR PLAN = 1  RATIO= 0.75
  30TO20  MANE        3.57  16245.36    935.99      4.67     30.00  16238.29    930.00        4.67

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1907E+05 EXCESS=0.0000E+00 OUTFLOW=0.1905E+05 BASIN STORAGE=0.2279E+02 PERCENT ERROR=   0.0

FOR PLAN = 1  RATIO= 0.50
  30TO20  MANE        4.58   8946.61    940.27      2.57     30.00   8934.29    960.00        2.57

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1050E+05 EXCESS=0.0000E+00 OUTFLOW=0.1049E+05 BASIN STORAGE=0.1243E+02 PERCENT ERROR=   0.0

FOR PLAN = 1  RATIO= 1.00
  20TO10  MANE        2.32  58085.18    845.64     15.33     30.00  58034.49    840.00       15.39

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.9010E+05 EXCESS=0.0000E+00 OUTFLOW=0.9020E+05 BASIN STORAGE=-.2057E+03 PERCENT ERROR=   0.1

FOR PLAN = 1  RATIO= 0.75
  20TO10  MANE        2.48  43909.53    876.85     12.62     30.00  43901.54    900.00       12.67

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.7400E+05 EXCESS=0.0000E+00 OUTFLOW=0.7421E+05 BASIN STORAGE=-.3027E+03 PERCENT ERROR=   0.1

FOR PLAN = 1  RATIO= 0.50
  20TO10  MANE        2.87  32402.47    752.96     10.17     30.00  32327.87    750.00       10.25

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.5973E+05 EXCESS=0.0000E+00 OUTFLOW=0.5985E+05 BASIN STORAGE=-.2131E+03 PERCENT ERROR=   0.2

FOR PLAN = 1  RATIO= 1.00
  GA.ST.  MANE        2.27  63949.77    873.38     15.66     30.00  63927.27    870.00       15.67

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.9795E+05 EXCESS=0.0000E+00 OUTFLOW=0.9804E+05 BASIN STORAGE=-.2235E+03 PERCENT ERROR=   0.1

FOR PLAN = 1  RATIO= 0.75
  GA.ST.  MANE        2.41  48306.12    902.74     12.78     30.00  48301.22    900.00       12.79

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.7986E+05 EXCESS=0.0000E+00 OUTFLOW=0.8001E+05 BASIN STORAGE=-.2760E+03 PERCENT ERROR=   0.2

FOR PLAN = 1  RATIO= 0.50
  GA.ST.  MANE        2.71  34348.21    755.05     10.19     30.00  34192.06    750.00       10.20

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.6366E+05 EXCESS=0.0000E+00 OUTFLOW=0.6378E+05 BASIN STORAGE=-.2437E+03 PERCENT ERROR=   0.2

1                    SUMMARY OF DAM OVERTOPPING/BREACH ANALYSIS FOR STATION    DAM40
              (PEAKS SHOWN ARE FOR INTERNAL TIME STEP USED  DURING BREACH FORMATION)

PLAN  1 ..............                  INITIAL VALUE     SPILLWAY CREST     TOP OF DAM
                          ELEVATION          891.75            892.20            896.50
                          STORAGE                0.               555.           14322.
                          OUTFLOW            22885.             23764.           44814.

              RATIO      MAXIMUM      MAXIMUM      MAXIMUM      MAXIMUM     DURATION     TIME OF      TIME OF
               OF       RESERVOIR     DEPTH       STORAGE      OUTFLOW     OVER TOP    MAX OUTFLOW   FAILURE
               PMF       W.S.ELEV    OVER DAM      AC-FT        CFS         HOURS        HOURS       HOURS

              1.00       894.08        0.00        6097.       31121.       0.00        11.50        0.00
              0.75       892.85        0.00        2413.       25805.       0.00        11.50        0.00
              0.50       892.03        0.00          78.       23433.       0.00         7.00        0.00

***    1 ERROR(S) DETECTED BY HEC-1 ***
```

Second Scenario

Homogeneous distribution throughout the watershed

```
ID                          PMF DUE TO PMP STORM ALONG 190 DEGREE AXIS
ID                    PMP STORM OVER DRAINAGE AREA CENTER OF GRAVITY
ID
*DIAGRAM
*LISTING
IT    30  1AUG96    1200      80
IO     4
JD             0
PH    10                0    0.87    1.87    3.45   15.56   18.72      20
JR  PREC        1    0.75       0       0       0       0
KKWALNUT
KO     1        2       0       0      22
BA   9.7
BF    10        0     1.3
PB  14.3
IN    15  1AUG96        0
* HOURLY PRECIPITATIO
PC     0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
LS  0.42      82      10
UD   2.5
KK HONEY
KO     1        2       0       0      22
BA   9.5
BF    10        0     1.3
PB    10
IN    15  1AUG96        0
* HOURLY PRECIPITATIO
PC     0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
LS 0.469      81      16
UD   5.4
KKHARBOR
KO     1        2       0       0      22
BA   6.9
BF    10        0     1.3
PB  11.4
IN    15  1AUG96        0
* HOURLY PRECIPITATIO
PC     0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
LS  0.42      82      23
UD   2.4
KK DAM40   CNAME  40TO20
KO     0        0       0       1      22
HC     3
KK DAM40
* RESERVOIR STORAGE
KO     0        0       0       1      22
RS     1     ELEV     891       0
* DAM40 SURFACE AREA
SA  2758     2800    2925    3093    3260    3427    3762    4096
* DAM40 ELEVATION
SE   892   892.25     893 893.875  894.75 895.625   896.5 897.375  898.25 899.125
SE   900
SS891.75      472     3.3     1.5
SL   886      340     0.7     0.5
ST 896.5    21700       2     1.5
KK40TO20   CNAME   DAM40
KO     0        0       0       1      22
RK  6560   0.0009    0.06            TRAP      80       1
KKPATASK
KO     1        2       0       0      22
BA  13.2
BF    10        0     1.3
PB  11.6
IN    15  1AUG96        0
* HOURLY PRECIPITATIO
PC     0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
LS 0.667      75       0
UD   9.8
KKJERSEY
KO     1        2       0       0      22
BA  16.6
BF    10        0     1.3
PB  11.7
```

```
IN     15  1AUG96        0
* HOURLY PRECIPITATIO
PC      0  0.2175    0.435  0.6525  0.6343  0.7497    0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913   2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175    2.265  1.8125    1.36    1.02     0.68    0.34       0
LS 0.667      75        0
UD  12.2
KKLICK90    CNAME   90TO80
KO      0       0        0       1      22
HC      2
KK90TO80    CNAME   LICK90
KO      0       0        0       1      22
RK   6560  0.0009     0.06            TRAP      80       1
KKHARRIS
KO      1       2        0       0      22
BA   16.7
BF     10       0      1.3
PB     22
IN     15  1AUG96        0
* HOURLY PRECIPITATIO
PC      0  0.2175    0.435  0.6525  0.6343  0.7497    0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913   2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175    2.265  1.8125    1.36    1.02     0.68    0.34       0
LS 0.632      76        0
UD   8.9
KKLICK80    CNAME   80TO30
KO      0       0        0       1      22
HC      2
KK80TO30    CNAME   LICK80
KO      0       0        0       1      22
RK   6560  0.0009     0.06            TRAP      80       1
KKLIBERT
KO      0       0        0       0      22
BA     11
BF     10       0      1.3
PB   22.3
IN     15  1AUG96        0
* HOURLY PRECIPITATIO
PC      0  0.2175    0.435  0.6525  0.6343  0.7497    0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913   2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175    2.265  1.8125    1.36    1.02     0.68    0.34       0
LS    0.5      80        0
UD  11.2
KKKIRKER
KO      1       2        0       0      22
BA    9.3
BF     10       0      1.3
PB   22.8
IN     15  1AUG96        0
* HOURLY PRECIPITATIO
PC      0  0.2175    0.435  0.6525  0.6343  0.7497    0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913   2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175    2.265  1.8125    1.36    1.02     0.68    0.34       0
LS 0.597      77        0
UD    8.2
KKWATERG
KO      1       2        0       0      22
BA    9.6
BF     10       0      1.3
PB   22.5
IN     15  1AUG96        0
* HOURLY PRECIPITATIO
PC      0  0.2175    0.435  0.6525  0.6343  0.7497    0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913   2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175    2.265  1.8125    1.36    1.02     0.68    0.34       0
LS 0.564      78        0
UD    6.3
KKLICK30    CNAME   30T020
KO      0       0        0       1      22
HC      4
KK30T020    CNAME   LICK30
KO      0       0        0       1      22
RK   6560  0.0009     0.06            TRAP      80       1
KKLAKESI
KO      1       2        0       0      22
BA    7.8
BF     10       0      1.3
PB   21.7
IN     15  1AUG96        0
* HOURLY PRECIPITATIO
PC      0  0.2175    0.435  0.6525  0.6343  0.7497    0.935  1.0957  1.2687  1.4417
```

```
PC1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
LS   0.5      80      10
UD     9
KKLICK20   CNAME  20TO10
KO     0       0       0       1      22
HC     3
KK20TO10   CNAME  LICK20
KO     0       0       0       1      22
RK  6560  0.0009    0.06            TRAP      80       1
KKHEBRON
KO     3       2    1000       0      22
BA   7.1
BF    10       0     1.3
PB  18.1
IN    15  1AUG96       0
* HOURLY PRECIPITATIO
PC     0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
LS  0.41      83       5
UD  10.1
KKLICK10   CNAME  GA.ST.
KO     0       0       0       1      22
HC     2
KKGA.ST.   CNAME  LICK10
KO     0       0       0       1      22
RK  6560  0.0009    0.06            TRAP      80       1
ZZ
```

```
 174 RK          KINEMATIC WAVE STREAM ROUTING
                            L       6560.  CHANNEL LENGTH
                            S      0.0009  SLOPE
                            N       0.060  CHANNEL ROUGHNESS COEFFICIENT
                           CA        0.00  CONTRIBUTING AREA
                        SHAPE        TRAP  CHANNEL SHAPE
                           WD       80.00  BOTTOM WIDTH OR DIAMETER
                            Z        1.00  SIDE SLOPE
                       NDXMIN           2  MINIMUM NUMBER OF DX INTERVALS

                                                                  ***
1

                PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO
ECONOMIC COMPUTATIONS
                                   FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                              TIME TO PEAK IN HOURS

                                                                RATIOS APPLIED TO PRECIPITATION
 OPERATION        STATION      AREA     PLAN                 RATIO 1  RATIO 2
                                                                 1.00     0.75

 HYDROGRAPH AT
+                 WALNUT       9.70      1    FLOW            13215.    9503.
                                                TIME             9.00     9.00

 HYDROGRAPH AT
+                  HONEY       9.50      1    FLOW             5680.    3990.
                                                TIME            12.00    12.00

 HYDROGRAPH AT
+                 HARBOR       6.90      1    FLOW             7458.    5360.
                                                TIME             9.00     9.00

   3 COMBINED AT
+                  DAM40      26.10      1    FLOW            24348.   17429.
                                                TIME             9.00     9.50

 ROUTED TO
+                  DAM40      26.10      1    FLOW            10961.    8297.
                                                TIME            13.00    12.50

                                      ** PEAK STAGES IN FEET **
                                       1   STAGE            894.08   893.34
                                                TIME            13.00    12.50

 ROUTED TO
+                 40TO20      26.10      1    FLOW            10956.    8291.
                                                TIME            13.00    13.00

 HYDROGRAPH AT
+                 PATASK      13.20      1    FLOW             5092.    3449.
                                                TIME            16.00    16.00

 HYDROGRAPH AT
+                 JERSEY      16.60      1    FLOW             5314.    3603.
                                                TIME            18.50    18.50

   2 COMBINED AT
+                 LICK90      29.80      1    FLOW            10182.    6907.
                                                TIME            17.50    17.50

 ROUTED TO
+                 90TO80      29.80      1    FLOW            10179.    6902.
                                                TIME            17.50    17.50

 HYDROGRAPH AT
+                 HARRIS      16.70      1    FLOW            15548.   11053.
                                                TIME            15.00    15.00

   2 COMBINED AT
+                 LICK80      46.50      1    FLOW            25190.   17572.
                                                TIME            16.00    16.00

 ROUTED TO
+                 80TO30      46.50      1    FLOW            25171.   17553.
                                                TIME            16.00    16.00

 HYDROGRAPH AT
+                 LIBERT      11.00      1    FLOW             8776.    6312.
```

```
                                                TIME        17.50     17.50

 HYDROGRAPH AT
+                KIRKER      9.30      1   FLOW         9767.     6979.
                                             TIME        14.50     14.50

 HYDROGRAPH AT
+                WATERG      9.60      1   FLOW        12410.     8885.
                                             TIME        12.50     12.50

  4 COMBINED AT
+                LICK30     76.40      1   FLOW        52475.    37124.
                                             TIME        15.00     15.00

 ROUTED TO
+                30TO20     76.40      1   FLOW        52460.    37104.
                                             TIME        15.00     15.00

 HYDROGRAPH AT
+                LAKESI      7.80      1   FLOW         7419.     5354.
                                             TIME        15.00     15.00

  3 COMBINED AT
+                LICK20    110.30      1   FLOW        70303.    50346.
                                             TIME        15.00     15.00

 ROUTED TO
+                20TO10    110.30      1   FLOW        70297.    50331.
                                             TIME        15.00     15.00

 HYDROGRAPH AT
+                HEBRON      7.10      1   FLOW         5072.     3653.
                                             TIME        16.00     16.00

  2 COMBINED AT
+                LICK10    117.40      1   FLOW        75209.    53862.
                                             TIME        15.00     15.00

 ROUTED TO
+                GA.ST.    117.40      1   FLOW        75168.    53818.
                                             TIME        15.00     15.00
1
                                             SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE
ROUTING
                                                 (FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)

INTERPOLATED TO

COMPUTATION INTERVAL
            ISTAQ    ELEMENT       DT        PEAK    TIME TO     VOLUME       DT        PEAK
TIME TO     VOLUME                                     PEAK
PEAK
                                 (MIN)      (CFS)     (MIN)      (IN)     (MIN)      (CFS)
(MIN)       (IN)

           FOR PLAN = 1  RATIO= 1.00
             40TO20  MANE         4.29  10959.95    788.68     12.60     30.00  10956.27
780.00       12.41

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1744E+05 EXCESS=0.0000E+00 OUTFLOW=0.1754E+05 BASIN
STORAGE=-.7580E+02 PERCENT ERROR=  -0.2

           FOR PLAN = 1  RATIO= 0.75
             40TO20  MANE         4.63   8296.26    760.52     10.18     30.00   8290.65
780.00        9.93

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1403E+05 EXCESS=0.0000E+00 OUTFLOW=0.1417E+05 BASIN
STORAGE=-.5652E+02 PERCENT ERROR=  -0.6

           FOR PLAN = 1  RATIO= 1.00
             90TO80  MANE         4.32  10181.25   1057.61      8.16     30.00  10179.34
1050.00       8.16
```

```
 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1300E+05 EXCESS=0.0000E+00 OUTFLOW=0.1296E+05 BASIN
STORAGE=0.3009E+02 PERCENT ERROR=   0.0

           FOR PLAN = 1  RATIO= 0.75
             90TO80  MANE          5.11   6905.67   1061.86      5.53     30.00   6902.06
1050.00        5.53

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.8810E+04 EXCESS=0.0000E+00 OUTFLOW=0.8785E+04 BASIN
STORAGE=0.2261E+02 PERCENT ERROR=   0.0

           FOR PLAN = 1  RATIO= 1.00
             80TO30  MANE          3.07  25184.98    964.58     11.84     30.00  25171.42
960.00       11.84

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2942E+05 EXCESS=0.0000E+00 OUTFLOW=0.2937E+05 BASIN
STORAGE=0.3866E+02 PERCENT ERROR=   0.0

           FOR PLAN = 1  RATIO= 0.75
             80TO30  MANE          3.62  17571.15    967.08      8.24     30.00  17552.98
960.00        8.24

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2048E+05 EXCESS=0.0000E+00 OUTFLOW=0.2044E+05 BASIN
STORAGE=0.2969E+02 PERCENT ERROR=   0.0

           FOR PLAN = 1  RATIO= 1.00
             30TO20  MANE          2.36  52469.81    903.42     14.75     30.00  52459.74
900.00       14.75

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.6015E+05 EXCESS=0.0000E+00 OUTFLOW=0.6010E+05 BASIN
STORAGE=0.5205E+02 PERCENT ERROR=   0.0

           FOR PLAN = 1  RATIO= 0.75
             30TO20  MANE          2.72  37118.34    904.14     10.42     30.00  37104.00
900.00       10.42

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.4249E+05 EXCESS=0.0000E+00 OUTFLOW=0.4245E+05 BASIN
STORAGE=0.4002E+02 PERCENT ERROR=   0.0

           FOR PLAN = 1  RATIO= 1.00
             20TO10  MANE          2.18  70298.91    901.44     14.51     30.00  70296.74
900.00       14.50

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.8531E+05 EXCESS=0.0000E+00 OUTFLOW=0.8535E+05 BASIN
STORAGE=-.6563E+02 PERCENT ERROR=   0.0

           FOR PLAN = 1  RATIO= 0.75
             20TO10  MANE          2.34  50344.00    904.28     10.54     30.00  50331.22
900.00       10.54

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.6200E+05 EXCESS=0.0000E+00 OUTFLOW=0.6202E+05 BASIN
STORAGE=-.7356E+02 PERCENT ERROR=   0.1

           FOR PLAN = 1  RATIO= 1.00
             GA.ST.  MANE          2.03  75200.21    903.29     14.58     30.00  75168.08
900.00       14.58

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.9128E+05 EXCESS=0.0000E+00 OUTFLOW=0.9127E+05 BASIN
STORAGE=-.5957E+02 PERCENT ERROR=   0.1

           FOR PLAN = 1  RATIO= 0.75
             GA.ST.  MANE          2.28  53860.86    904.67     10.59     30.00  53817.87
900.00       10.59
```

Third Scenario

Maximum PMF outflow at the USGS gaging station near Hebron

```
ID                                BUCKEYE RESERVOIR  (SOUTH FORK LICKING RIVER DRAI
ID   MAXIMUM PMF DUE TO PMP STORM ALONG 120 DEGREE AXIS ( N 70 W)
ID                      PMP STORM OVER DRAINAGE AREA CENTER OF GRAVITY
*DIAGRAM
*LISTING
IT    30  1AUG96    1200      80
IO     4
JD             0
PH    10                0    0.87    1.87    3.45   15.56   18.72      20
JR  PREC        1    0.75       0       0       0       0
KKWALNUT
KO     1        2       0       0      22
BA   9.7
BF    10        0     1.3
PB  20.3
IN    15  1AUG96       0
* HOURLY PRECIPITATIO
PC     0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
LS  0.42      82      10
UD   2.5
KK HONEY
KO     1        2       0       0      22
BA   9.5
BF    10        0     1.3
PB  18.8
IN    15  1AUG96       0
* HOURLY PRECIPITATIO
PC     0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
LS 0.469      81      16
UD   5.4
KKHARBOR
KO     1        2       0       0      22
BA   6.9
BF    10        0     1.3
PB  18.8
IN    15  1AUG96       0
* HOURLY PRECIPITATIO
PC     0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
LS  0.42      82      23
UD   2.4
KK DAM40   CNAME  40TO20
KO     0        0       0       1      22
HC     3
KK DAM40
* RESERVOIR STORAGE
KO     0        0       0       1      22
RS     1     ELEV     891       0
* DAM40 SURFACE AREA
SA  2758     2800    2925    3093    3260    3427    3762    4096
* DAM40 ELEVATION
SE   892   892.25     893 893.875  894.75 895.625   896.5 897.375  898.25 899.125
SE   900
SS 891.8      472     3.3     1.5
SL   886      340     0.7     0.5
ST 896.5    21700       2     1.5
KK40TO20   CNAME   DAM40
KO     0        0       0       1      22
RK  6560   0.0009    0.06            TRAP      80       1
KKPATASK
KO     1        2       0       0      22
BA  13.2
BF    10        0     1.3
PB  19.8
IN    15  1AUG96       0
* HOURLY PRECIPITATIO
PC     0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
LS 0.667      75       0
UD   9.8
KKJERSEY
KO     1        2       0       0      22
BA  16.6
BF    10        0     1.3
PB  19.5
```

```
IN     15  1AUG96        0
* HOURLY PRECIPITATIO
PC      0  0.2175    0.435  0.6525  0.6343  0.7497    0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913   2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175    2.265  1.8125    1.36    1.02     0.68    0.34       0
LS 0.667      75        0
UD  12.2
KKLICK90   CNAME  90TO80
KO      0       0        0       1      22
HC      2
KK90TO80   CNAME  LICK90
KO      0       0        0       1      22
RK   6560  0.0009     0.06            TRAP      80       1
KKHARRIS
KO      1       2        0       0      22
BA   16.7
BF     10       0      1.3
PB   22.5
IN     15  1AUG96        0
* HOURLY PRECIPITATIO
PC      0  0.2175    0.435  0.6525  0.6343  0.7497    0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913   2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175    2.265  1.8125    1.36    1.02     0.68    0.34       0
LS 0.632      76        0
UD   8.9
KKLICK80   CNAME  80TO30
KO      0       0        0       1      22
HC      2
KK80TO30   CNAME  LICK80
KO      0       0        0       1      22
RK   6560  0.0009     0.06            TRAP      80       1
KKLIBERT
KO      0       0        0       0      22
BA     11
BF     10       0      1.3
PB   22.3
IN     15  1AUG96        0
* HOURLY PRECIPITATIO
PC      0  0.2175    0.435  0.6525  0.6343  0.7497    0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913   2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175    2.265  1.8125    1.36    1.02     0.68    0.34       0
LS    0.5      80        0
UD  11.2
KKKIRKER
KO      1       2        0       0      22
BA    9.3
BF     10       0      1.3
PB     23
IN     15  1AUG96        0
* HOURLY PRECIPITATIO
PC      0  0.2175    0.435  0.6525  0.6343  0.7497    0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913   2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175    2.265  1.8125    1.36    1.02     0.68    0.34       0
LS 0.597      77        0
UD   8.2
KKWATERG
KO      1       2        0       0      22
BA    9.6
BF     10       0      1.3
PB   22.4
IN     15  1AUG96        0
* HOURLY PRECIPITATIO
PC      0  0.2175    0.435  0.6525  0.6343  0.7497    0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913   2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175    2.265  1.8125    1.36    1.02     0.68    0.34       0
LS 0.564      78        0
UD    6.3
KKLICK30   CNAME  30TO20
KO      0       0        0       1      22
HC      4
KK30TO20   CNAME  LICK30
KO      0       0        0       1      22
RK   6560  0.0009     0.06            TRAP      80       1
KKLAKESI
KO      1       2        0       0      22
BA    7.8
BF     10       0      1.3
PB     22
IN     15  1AUG96        0
* HOURLY PRECIPITATIO
PC      0  0.2175    0.435  0.6525  0.6343  0.7497    0.935  1.0957  1.2687  1.4417
```

```
PC1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
LS   0.5      80      10
UD     9
KKLICK20   CNAME  20TO10
KO     0       0       0       1      22
HC     3
KK20TO10   CNAME  LICK20
KO     0       0       0       1      22
RK  6560  0.0009    0.06            TRAP      80       1
KKHEBRON
KO     3       2    1000       0      22
BA   7.1
BF    10       0     1.3
PB  20.4
IN    15  1AUG96       0
* HOURLY PRECIPITATIO
PC     0  0.2175   0.435  0.6525  0.6343  0.7497   0.935  1.0957  1.2687  1.4417
PC1.7877  2.1913  2.9987   4.205    6.84 10.4377 11.5333  10.726    7.64   5.405
PC3.5177  2.7175   2.265  1.8125    1.36    1.02    0.68    0.34       0
LS  0.41      83       5
UD  10.1
KKLICK10   CNAME  GA.ST.
KO     0       0       0       1      22
HC     2
KKGA.ST.   CNAME  LICK10
KO     0       0       0       1      22
RK  6560  0.0009    0.06            TRAP      80       1
ZZ
```

```
 174 RK          KINEMATIC WAVE STREAM ROUTING
                          L       6560.  CHANNEL LENGTH
                          S      0.0009  SLOPE
                          N       0.060  CHANNEL ROUGHNESS COEFFICIENT
                         CA        0.00  CONTRIBUTING AREA
                      SHAPE        TRAP  CHANNEL SHAPE
                         WD       80.00  BOTTOM WIDTH OR DIAMETER
                          Z        1.00  SIDE SLOPE
                     NDXMIN           2  MINIMUM NUMBER OF DX INTERVALS

                                                                  ***
1

                PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO
ECONOMIC COMPUTATIONS
                                  FLOWS IN CUBIC FEET PER SECOND,  AREA IN SQUARE MILES
                                                TIME TO PEAK IN HOURS

                                                                RATIOS APPLIED TO PRECIPITATION
 OPERATION        STATION     AREA    PLAN              RATIO 1  RATIO 2
                                                           1.00     0.75

 HYDROGRAPH AT
+                 WALNUT      9.70     1   FLOW         19449.   14176.
                                           TIME          9.00     9.00

 HYDROGRAPH AT
+                  HONEY      9.50     1   FLOW         11777.    8502.
                                           TIME         11.50    11.50

 HYDROGRAPH AT
+                 HARBOR      6.90     1   FLOW         13008.    9457.
                                           TIME          8.50     8.50

  3 COMBINED AT
+                  DAM40     26.10     1   FLOW         40320.   29366.
                                           TIME          9.00     9.50

 ROUTED TO
+                  DAM40     26.10     1   FLOW         18018.   13113.
                                           TIME         13.00    13.00

                                     ** PEAK STAGES IN FEET **
                                     1   STAGE        895.72   894.65
                                           TIME         13.00    13.00

 ROUTED TO
+                 40TO20     26.10     1   FLOW         17996.   13101.
                                           TIME         13.50    13.50

 HYDROGRAPH AT
+                 PATASK     13.20     1   FLOW          9902.    6980.
                                           TIME         16.00    16.00

 HYDROGRAPH AT
+                 JERSEY     16.60     1   FLOW         10031.    7066.
                                           TIME         18.50    18.50

  2 COMBINED AT
+                 LICK90     29.80     1   FLOW         19497.   13735.
                                           TIME         17.00    17.00

 ROUTED TO
+                 90TO80     29.80     1   FLOW         19478.   13732.
                                           TIME         17.50    17.50

 HYDROGRAPH AT
+                 HARRIS     16.70     1   FLOW         15959.   11358.
                                           TIME         15.00    15.00

  2 COMBINED AT
+                 LICK80     46.50     1   FLOW         34768.   24597.
                                           TIME         16.00    16.50

 ROUTED TO
+                 80TO30     46.50     1   FLOW         34741.   24596.
                                           TIME         16.50    16.50

 HYDROGRAPH AT
+                 LIBERT     11.00     1   FLOW          8776.    6312.
```

```
                                                TIME        17.50     17.50

 HYDROGRAPH AT
+                  KIRKER      9.30      1   FLOW        9866.     7052.
                                               TIME        14.50     14.50

 HYDROGRAPH AT
+                  WATERG      9.60      1   FLOW       12347.     8838.
                                               TIME        12.50     12.50

  4 COMBINED AT
+                  LICK30     76.40      1   FLOW       61592.    43800.
                                               TIME        15.00     15.50

 ROUTED TO
+                  30TO20     76.40      1   FLOW       61553.    43797.
                                               TIME        15.50     15.50

 HYDROGRAPH AT
+                  LAKESI      7.80      1   FLOW        7533.     5439.
                                               TIME        15.00     15.00

  3 COMBINED AT
+                  LICK20    110.30      1   FLOW       86328.    61784.
                                               TIME        15.00     15.00

 ROUTED TO
+                  20TO10    110.30      1   FLOW       86292.    61742.
                                               TIME        15.00     15.00

 HYDROGRAPH AT
+                  HEBRON      7.10      1   FLOW        5796.     4193.
                                               TIME        16.00     16.00

  2 COMBINED AT
+                  LICK10    117.40      1   FLOW       91908.    65798.
                                               TIME        15.00     15.00

 ROUTED TO
+                  GA.ST.    117.40      1   FLOW       91838.    65758.
                                               TIME        15.00     15.50
1
                                               SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE
ROUTING
                                                   (FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)

INTERPOLATED TO

COMPUTATION INTERVAL
            ISTAQ    ELEMENT       DT        PEAK     TIME TO      VOLUME       DT        PEAK
TIME TO     VOLUME
                                                        PEAK
PEAK

                                 (MIN)      (CFS)      (MIN)      (IN)      (MIN)      (CFS)
(MIN)       (IN)

           FOR PLAN = 1  RATIO= 1.00
             40TO20  MANE          3.49  18015.51    789.70      18.98      30.00  17995.77
810.00       18.82


 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2629E+05 EXCESS=0.0000E+00 OUTFLOW=0.2642E+05 BASIN
STORAGE=-.1169E+03 PERCENT ERROR=  -0.1


           FOR PLAN = 1  RATIO= 0.75
             40TO20  MANE          3.95  13112.71    787.93      14.69      30.00  13100.83
810.00       14.49


 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2031E+05 EXCESS=0.0000E+00 OUTFLOW=0.2044E+05 BASIN
STORAGE=-.1082E+03 PERCENT ERROR=  -0.1


           FOR PLAN = 1  RATIO= 1.00
             90TO80  MANE          3.37  19496.32   1026.69      15.63      30.00  19478.26
1050.00       15.62
```

```
 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2488E+05 EXCESS=0.0000E+00 OUTFLOW=0.2484E+05 BASIN
STORAGE=0.4661E+02 PERCENT ERROR=    0.0

            FOR PLAN = 1  RATIO= 0.75
              90TO80  MANE          3.92  13734.91    1029.05      11.00      30.00  13731.87
1050.00        11.00

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1753E+05 EXCESS=0.0000E+00 OUTFLOW=0.1748E+05 BASIN
STORAGE=0.3688E+02 PERCENT ERROR=    0.0

            FOR PLAN = 1  RATIO= 1.00
              80TO30  MANE          2.71  34767.66     965.99      16.80      30.00  34740.95
990.00         16.80

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.4172E+05 EXCESS=0.0000E+00 OUTFLOW=0.4166E+05 BASIN
STORAGE=0.5418E+02 PERCENT ERROR=    0.0

            FOR PLAN = 1  RATIO= 0.75
              80TO30  MANE          3.19  24595.94     994.12      11.88      30.00  24595.69
990.00         11.88

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.2950E+05 EXCESS=0.0000E+00 OUTFLOW=0.2946E+05 BASIN
STORAGE=0.4234E+02 PERCENT ERROR=    0.0

            FOR PLAN = 1  RATIO= 1.00
              30TO20  MANE          2.19  61589.07     905.87      17.77      30.00  61553.30
930.00         17.77

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.7248E+05 EXCESS=0.0000E+00 OUTFLOW=0.7241E+05 BASIN
STORAGE=0.6577E+02 PERCENT ERROR=    0.0

            FOR PLAN = 1  RATIO= 0.75
              30TO20  MANE          2.50  43798.75     933.40      12.64      30.00  43797.05
930.00         12.63

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.5153E+05 EXCESS=0.0000E+00 OUTFLOW=0.5149E+05 BASIN
STORAGE=0.5131E+02 PERCENT ERROR=    0.0

            FOR PLAN = 1  RATIO= 1.00
              20TO10  MANE          1.96  86317.83     904.45      18.13      30.00  86291.73
900.00         18.13

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1067E+06 EXCESS=0.0000E+00 OUTFLOW=0.1067E+06 BASIN
STORAGE=-.4432E+02 PERCENT ERROR=    0.0

            FOR PLAN = 1  RATIO= 0.75
              20TO10  MANE          2.20  61783.28     904.40      13.17      30.00  61741.70
900.00         13.17

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.7747E+05 EXCESS=0.0000E+00 OUTFLOW=0.7749E+05 BASIN
STORAGE=-.5604E+02 PERCENT ERROR=    0.0

            FOR PLAN = 1  RATIO= 1.00
              GA.ST.  MANE          1.88  91898.58     905.08      18.13      30.00  91838.42
900.00         18.12

 CONTINUITY SUMMARY (AC-FT) - INFLOW=0.1135E+06 EXCESS=0.0000E+00 OUTFLOW=0.1135E+06 BASIN
STORAGE=-.4893E+02 PERCENT ERROR=    0.0

            FOR PLAN = 1  RATIO= 0.75
              GA.ST.  MANE          2.17  65795.74     905.35      13.16      30.00  65757.97
930.00         13.16
```

Appendix C - Comparison of Hydrologic Assessments

COMPARISON OF HYDROLOGIC ASSESSMENTS

TOPIC DESCRIPTION	THIS STUDY	DLA (1987)
• Buckeye lake drainage area (DA) classification	Sub-basin	Isolated
• Buckeye Lake DA considered as a sub-basin of the South Fork Licking River watershed	Yes	No
• South Fork Licking River watershed DA	117.4 Sq. Mi.	
• Number of sub-basins in SFLR watershed DA	11	
• DA adjacent to Buckeye Lake		
Reservoir Surface	4.2 Sq. Mi.	4.2 Sq. Mi
Harbor	5.8 Sq. Mi	
Honey	8.6 Sq. Mi	
Walnut	7.5 Sq. Mi	
Sub-total DA	26.1 Sq. Mi	27.4 Sq. Mi
• Feeder Canal DA upstream of Buckeye lake		
Watergate	11.0 Sq. Mi	
Liberty	9.6 Sq. Mi	
Sub-total DA	20.6 Sq. Mi	16.7 Sq. Mi
Total combined DA	46.7 Sq. Mi.	44.1 Sq. Mi.
• DLA assumed Feeder Canal contribution	Zero	2000 cfs
• Feeder Canal contribution used in computations	No	Unknown
• Probable Maximum Precipitation (PMP) over Buckeye Lake DA for six (6) hour duration	22.5 Inches	23.6 inches
• Six hour PMP over the watershed of the SFLR DA	20.0 Inches	
• Constant and uniform rainfall pattern	No	Yes
• Isohyetal rainfall distribution over drainage area	Yes	No
• PMP storm path orientation	Yes	No
• PMP storm transposition	Yes	No
• Probable Maximum Flood (PMF) inflow	47800 cfs	63000 cfs
• DA used to calculate the Lake's PMF inflow	26.1 sq. mi.	44.1 sq. mi.
• DA yield during the PMF	1831 cfs/sm.	1428 cfs/sm
• *Evaluation of downstream water levels considering the effects of the PMF over the SFLR DA	Yes	No
• Downstream water elevation during the PMF	889.0 ft	
• Determination of the PMF for other locations and along different storm paths	Yes	No
• Assessment of freeboard Adequacy	Yes	No

Appendix D - Owner Information

NAME: BUCKEYE LAKE DAM
RESERVOIR:

FILE NO: 9723-004
NATIONAL #: OH00474
PERMIT NO: N/A
CLASSIFICATION: I

OWNER INFORMATION

OWNER: ODNR, Division of Parks & Recreation
OWNER TYPE: PUBLIC, STATE
ADDRESS1: 1952 Belcher Drive
PARCEL NO:
ADDRESS2:
ADDRESS3:
CITY: Columbus
STATE: OH
ZIP: 43224
CONTACT PERSON:
TELEPHONE: 614/467-2690

LOCATION INFORMATION

COUNTY: LICKING
LATITUDE Deg: 39 Min: 55 Sec: 40
TOWNSHIP: UNION
LONGITUDE Deg: 82 Min: 29 Sec: 18
STREAM: TRIBUTARY TO SOUTH FORK LICKING RIVER
NEAREST AFFECTED COMMUNITY: BUCKEYE LAKE
COMMUNITY'S DISTANCE FROM DAM (miles): .10
USGS QUAD: THORNVILLE
USGS BASIN NO: 05040006

DESIGN/CONSTRUCTION INFORMATION

DESIGNED BY: STATE OF OHIO
CONSTRUCTED BY: STATE OF OHIO
COMPLETED: 1832 PLANS AVAILABLE: YES AT: ODNR, DIVISION OF WATER
FAILURE/INCIDENT/BREACH:

STRUCTURE INFORMATION

PURPOSE OF DAM: RECREATION, PUBLIC
TYPE OF IMPOUNDMENT: DAM AND SPILLWAY
TYPE OF STRUCTURE: EARTHFILL
DRAINAGE AREA (sq.miles): 44.10 or (acres): 28224

EMBANKMENT DATA

LENGTH (ft)	:21700	UPSTREAM SLOPE	: 1H:1V
MAX. HEIGHT (ft):	14.5	DOWNSTREAM SLOPE	: 2H:1V
TOP WIDTH (ft) :	3	VOLUME OF FILL (cu.yds.):	375000

SPILLWAY & OUTLET WORKS DATA
LAKE DRAIN: TWO 60-INCH DIAMETER CONCRETE PIPES
PRINCIPAL: 33.5-FT WEIR WITH AMIL GATE

EMERGENCY: 472-FT CONCRETE OGEE WEIR
MAXIMUM TOTAL SPILLWAY DISCHARGE (cfs): 20700
DESIGN FLOOD: PMF
FLOOD CAPACITY:

DAM & RESERVOIR DATA

	ELEVATION(ft-MSL)	AREA(acres)	STORAGE(acre-feet)
FOUNDATION (CUTOFF):			
STREAMBED :	879.9		
PRINCIPAL SPILLWAY :	891.8	2800.0	14000.0
EMERGENCY SPILLWAY :	892.2		
TOP OF DAM :	894.4	3030.0	20000.0

INSPECTION INFORMATION

LAST INSPECTION (mon/day/yr): 6/06/86
INSPECTOR:
PHASE I: 7/07/78
PRIOR INSPECTIONS:
OTHER SITE VISITS:

OPERATION INFORMATION/REMARKS:

EMERGENCY ACTION PLAN:
NPDP INCIDENT ID:
ANNUAL FEE: $ 74.00
LAST DATA ENTRY: 9/08/94

Appendix B - HEC-RAS Printouts and Graphs

First Scenario

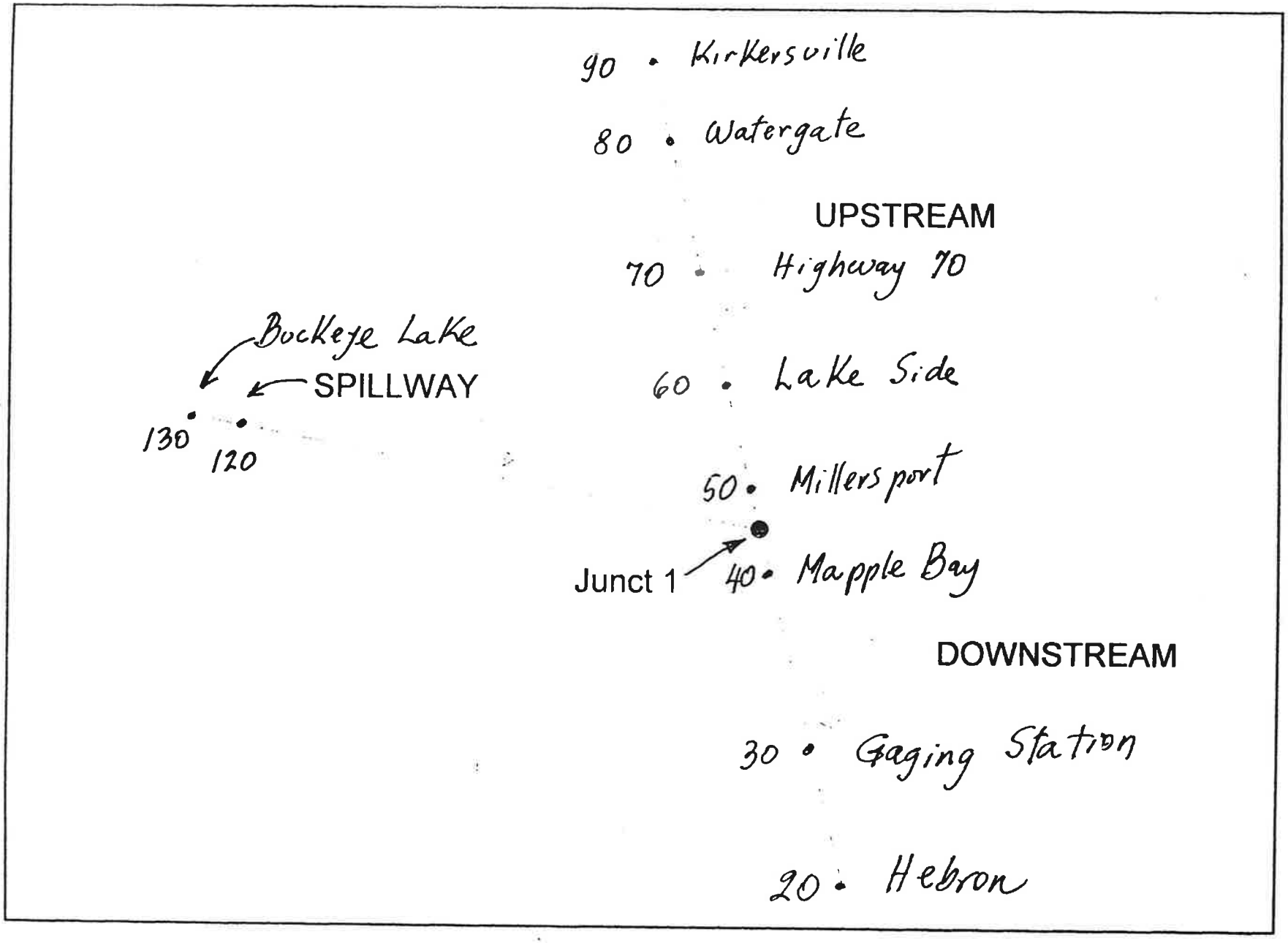
Maximum PMF peak inflow into Buckeye lake

Second Scenario

Homogeneous distribution throughout the watershed

Third Scenario

Maximum PMF outflow at the USGS gaging station near Hebron


90 Kirkersville
80 Watergate
UPSTREAM
70 Highway 70
Buckeye Lake
SPILLWAY
60 Lake Side
130
120
50 Millersport
Junct 1
40 Mapple Bay
DOWNSTREAM
30 Gaging Station
20 Hebron

First Scenario

Maximum PMF peak inflow into Buckeye lake

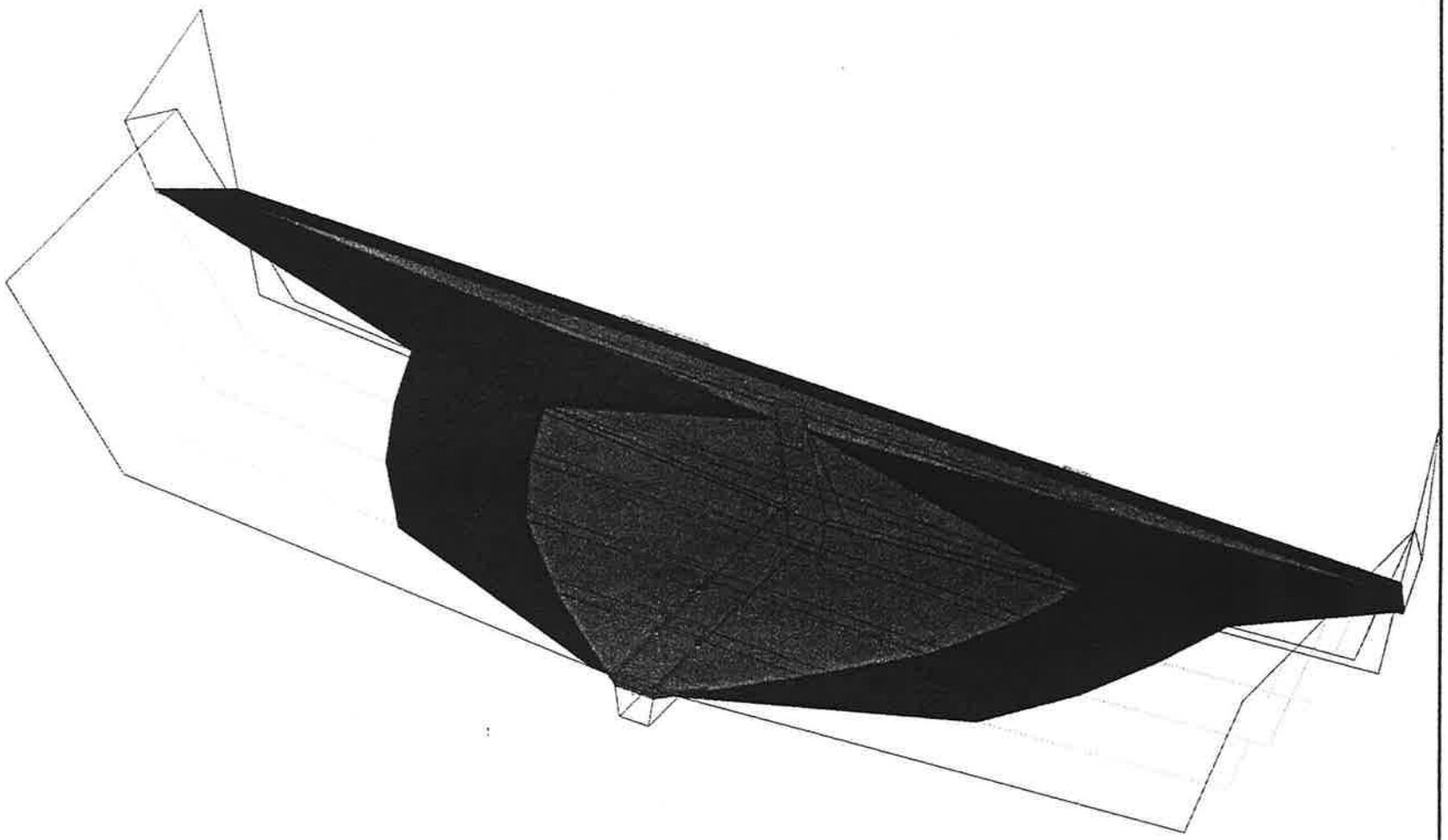
HEC RAS Plan: Plan 09

Reach	River Sta.	E.G. Elev (ft)	W.S. Elev (ft)	Vel Head (ft)	Frctn Loss (ft)	C & E Loss (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Top Width (ft)
DOWNSTREAM	20	881.27	880.39	0.88	0.00	0.00	3611.30	48071.57	5359.13	2153.13
DOWNSTREAM	20	878.24	877.55	0.69	0.00	0.00	1952.12	33652.13	2342.75	953.65
DOWNSTREAM	30	882.44	882.27	0.16	0.35	0.02	3672.17	50356.24	3013.59	3850.18
DOWNSTREAM	30	879.41	879.26	0.14	0.37	0.01	446.28	36008.64	1492.09	1401.44
DOWNSTREAM	40	885.00	884.90	0.10	0.65	0.00	5201.89	29500.09	17222.02	7176.06
DOWNSTREAM	40	883.38	883.26	0.12	1.12	0.01	1086.36	22290.05	10167.59	5979.69
UPSTREAM	50	885.01	885.00	0.01	0.01	0.01	3946.25	21290.79	225.96	9000.98
UPSTREAM	50	883.40	883.39	0.01	0.01	0.01	2831.68	17275.47	98.85	7678.60
UPSTREAM	60	885.31	885.30	0.01	0.06	0.00	1461.61	15232.85	7265.55	7984.39
UPSTREAM	60	883.78	883.77	0.01	0.08	0.00	685.33	11510.64	4051.03	7378.57
UPSTREAM	70	889.62	889.48	0.14	1.34	0.00	459.30	11555.81	6984.89	3119.76
UPSTREAM	70	888.92	888.82	0.10	1.31	0.00	199.13	7751.76	4849.11	2740.52
UPSTREAM	80	896.67	896.52	0.14	1.07	0.00	6.15	13993.86		1640.91
UPSTREAM	80	895.73	895.61	0.12	0.94	0.00		9354.00		1216.13
UPSTREAM	90	911.05	910.76	0.30	3.24	0.01		9135.00		1002.19
UPSTREAM	90	910.45	910.24	0.21	3.27	0.00		5908.00		932.02
SPILLWAY	110	886.31	885.23	1.08	1.02	0.29	28.10	26406.98	25.91	1509.04
SPILLWAY	110	884.38	883.80	0.58	0.86	0.14		13338.00		652.05
SPILLWAY	118	888.83	888.80	0.03	0.24	0.00		26461.00		13859.79
SPILLWAY	118	887.48	887.45	0.03	0.26	0.00		13338.00		9159.72
SPILLWAY	120	897.99	897.38	0.61	0.04	0.17	3642.68	19114.33	3703.99	21200.25
SPILLWAY	120	896.20	894.72	1.48	0.12	0.44		13338.00		460.00
SPILLWAY	130	898.06	898.06	0.00	0.00	0.06	8289.14	9882.72	8289.14	19746.02
SPILLWAY	130	896.35	896.35	0.00	0.00	0.15	3657.75	6022.50	3657.75	19648.48

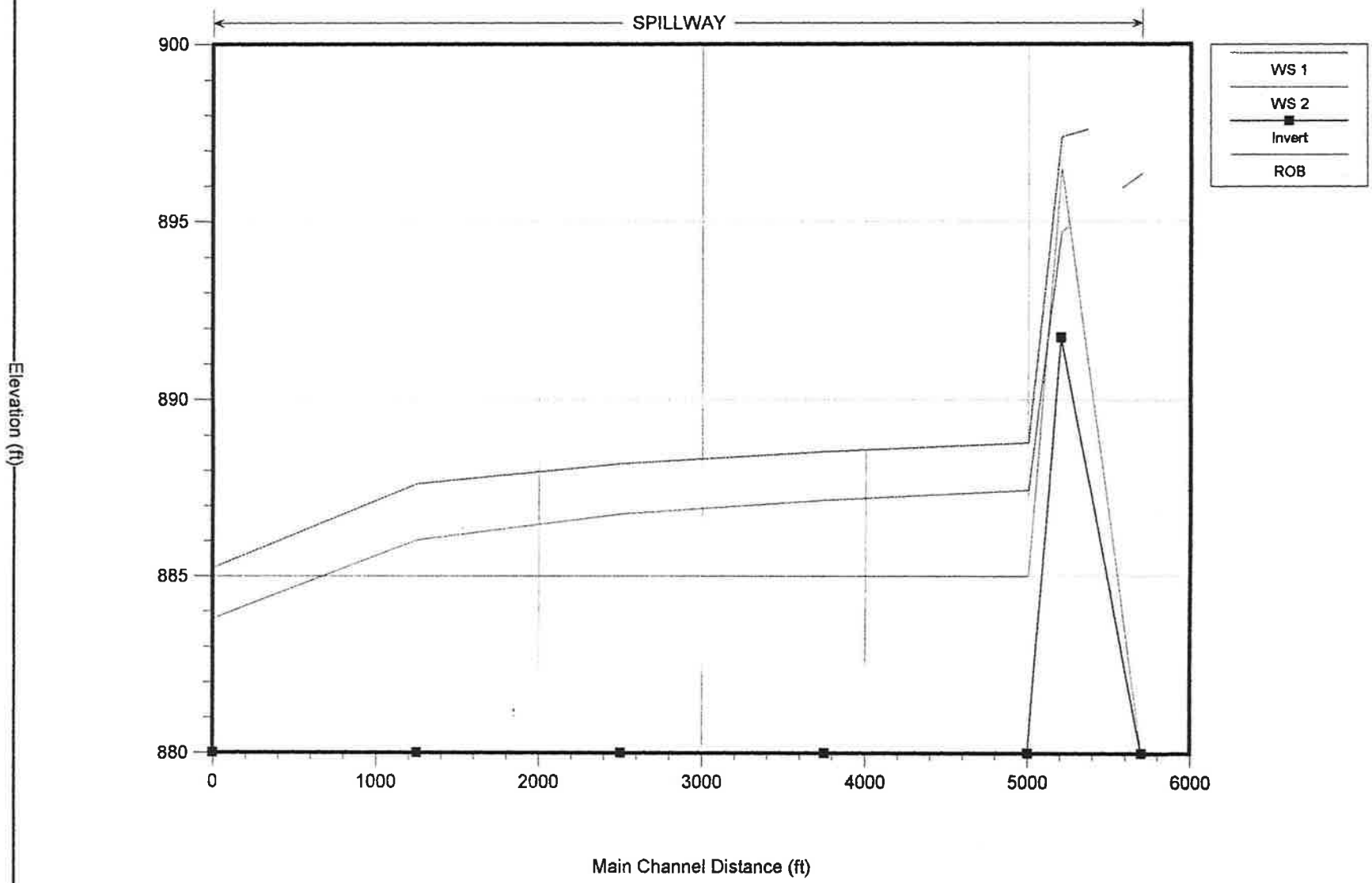
HEC RAS Plan: Plan 09

Reach	River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
DOWNSTREAM	20	57042.00	855.00	880.39	874.42	881.27	0.000750	8.14	10736.92	2153.13
DOWNSTREAM	20	37947.00	855.00	877.55	872.34	878.24	0.000750	7.06	6859.91	953.65
DOWNSTREAM	30	57042.00	856.00	882.27		882.44	0.000134	3.43	22846.86	3850.18
DOWNSTREAM	30	37947.00	856.00	879.26		879.41	0.000147	3.09	13523.61	1401.44
DOWNSTREAM	40	51924.00	878.00	884.90		885.00	0.000374	3.13	26262.51	7176.06
DOWNSTREAM	40	33544.00	878.00	883.26		883.38	0.000631	3.27	15125.00	5979.69
UPSTREAM	50	25463.00	876.00	885.00		885.01	0.000010	0.73	47043.95	9000.98
UPSTREAM	50	20206.00	876.00	883.39		883.40	0.000015	0.77	33902.29	7678.60
UPSTREAM	60	23960.00	878.00	885.30		885.31	0.000027	1.14	35658.70	7984.39
UPSTREAM	60	16247.00	878.00	883.77		883.78	0.000036	1.11	23894.09	7378.57
UPSTREAM	70	19000.00	885.00	889.48		889.62	0.000735	3.63	7995.96	3119.76
UPSTREAM	70	12800.00	885.00	888.82		888.92	0.000717	3.07	6063.76	2740.52
UPSTREAM	80	14000.00	890.00	896.52		896.67	0.000552	3.01	4671.22	1640.91
UPSTREAM	80	9354.00	890.00	895.61		895.73	0.000495	2.74	3413.02	1216.13
UPSTREAM	90	9135.00	906.00	910.76		911.05	0.001634	4.38	2119.94	1002.19
UPSTREAM	90	5908.00	906.00	910.24		910.45	0.001606	3.66	1617.26	932.02
SPILLWAY	110	26461.00	880.00	885.23	884.17	886.31	0.006459	8.35	3258.26	1509.04
SPILLWAY	110	13338.00	880.00	883.80		884.38	0.005111	6.09	2189.67	652.05
SPILLWAY	118	26461.00	880.00	888.80		888.83	0.000174	2.02	30688.38	13859.79
SPILLWAY	118	13338.00	880.00	887.45		887.48	0.000182	1.83	15053.55	9159.72
SPILLWAY	120	26461.00	891.75	897.38	897.38	897.99	0.000253	7.38	20042.15	21200.25
SPILLWAY	120	13338.00	891.75	894.72	894.72	896.20	0.001034	9.78	1363.94	460.00
SPILLWAY	130	26461.00	880.00	898.06		898.06	0.000000	0.10	302922.80	19746.02
SPILLWAY	130	13338.00	880.00	896.35		896.35	0.000000	0.06	269300.20	19648.48

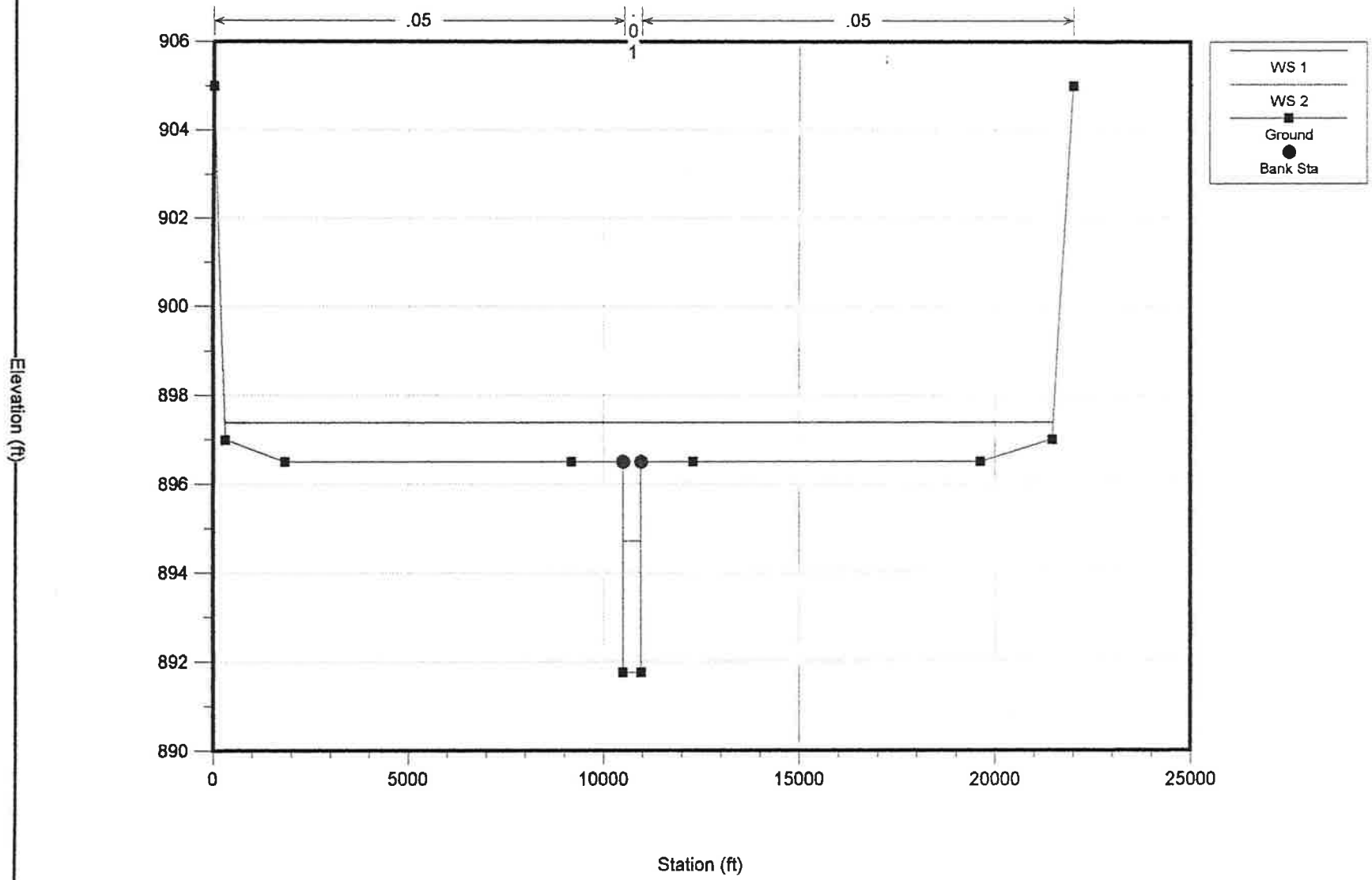
BUCKEYE LAKE RESTORATION Plan: Plan 09
Geom: SOUTH FORK LICKING RIVER Flow: BUCKEYE LAKE
Reach = SPILLWAY Riv Sta = 130 to 110 PF#: 1, 2



BUCKEYE LAKE RESTORATION Plan: Plan 09
Geom: SOUTH FORK LICKING RIVER Flow: BUCKEYE LAKE



BUCKEYE LAKE RESTORATION Plan: Plan 09
Geom: SOUTH FORK LICKING RIVER Flow: BUCKEYE LAKE
Reach = SPILLWAY NEW SPILLWAY - One mi. from confluence with SOUTH FORK LICKING RIVER Riv Sta = 120



Second Scenario

Homogeneous distribution throughout the watershed

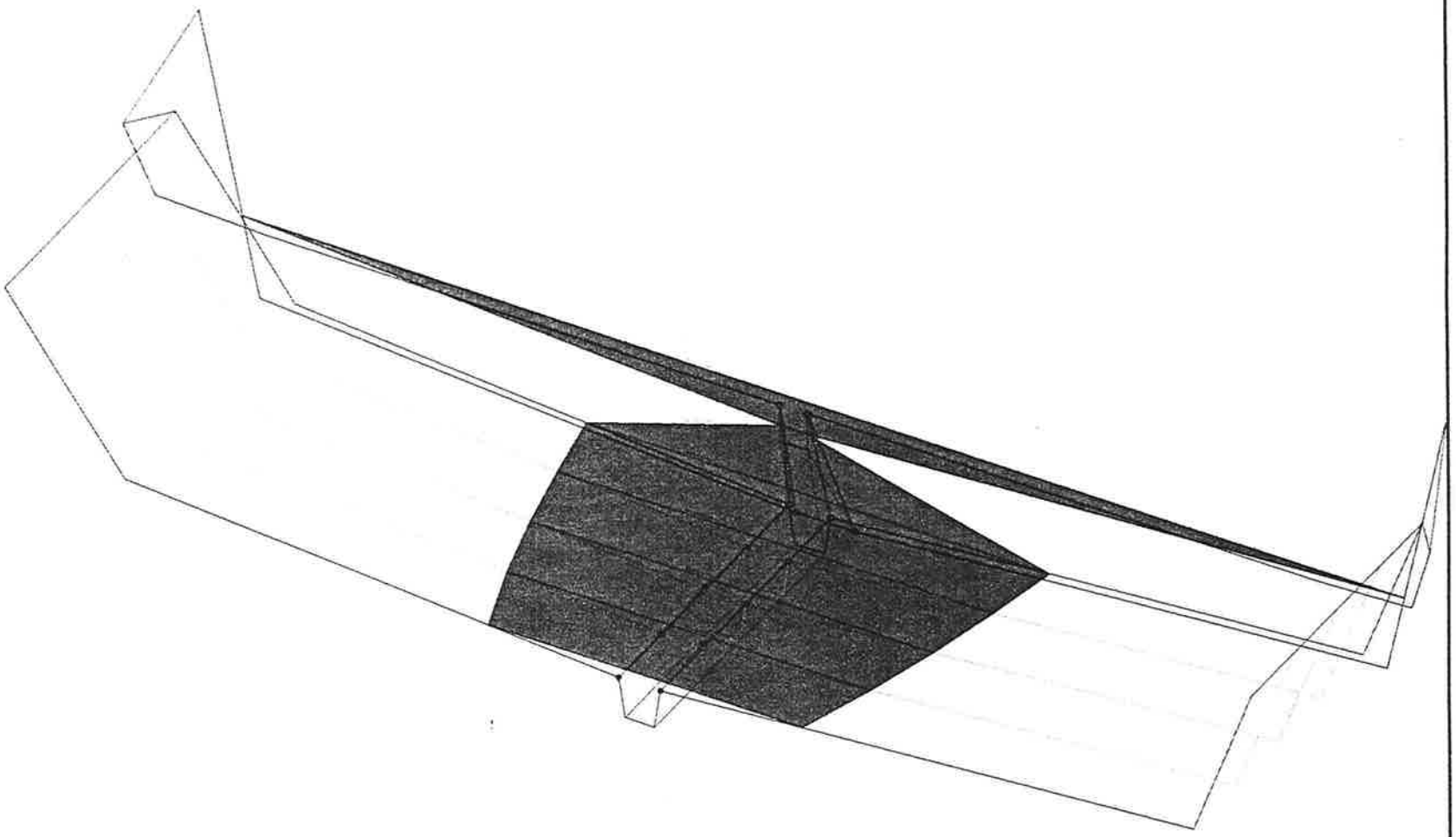
HEC-RAS Plan: Plan 07

Reach	River Sta.	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
		(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
DOWNSTREAM	20	882.79	881.87	0.92	0.00	0.00	8858.75	56333.01	7352.24	2352.38
DOWNSTREAM	30	884.05	883.87	0.18	0.36	0.02	8330.92	60022.27	4190.81	4143.29
DOWNSTREAM	40	886.29	886.20	0.09	0.49	0.01	10047.99	34869.45	22741.55	7480.50
UPSTREAM	50	886.31	886.29	0.03	0.02	0.01	10963.84	48000.61	713.55	9257.38
UPSTREAM	60	886.98	886.94	0.03	0.11	0.00	4208.00	30750.59	17516.41	8634.89
UPSTREAM	70	891.55	891.30	0.25	1.39	0.00	2041.70	25231.02	16107.28	4162.68
UPSTREAM	80	898.80	898.54	0.26	1.07	0.00	423.26	33800.63	61.11	2346.96
UPSTREAM	90	913.22	912.56	0.66	3.40	0.03	91.15	24966.27	132.59	1245.01
SPILLWAY	110	886.37	886.32	0.04	0.07	0.00	521.04	6889.45	480.51	5281.59
SPILLWAY	118	887.07	887.05	0.02	0.13	0.00		7891.00		7799.72
SPILLWAY	120	894.89	893.83	1.05	0.13	0.31		7891.00		460.00
SPILLWAY	130	894.99	894.99	0.00	0.00	0.11	1911.38	4068.24	1911.38	19570.93

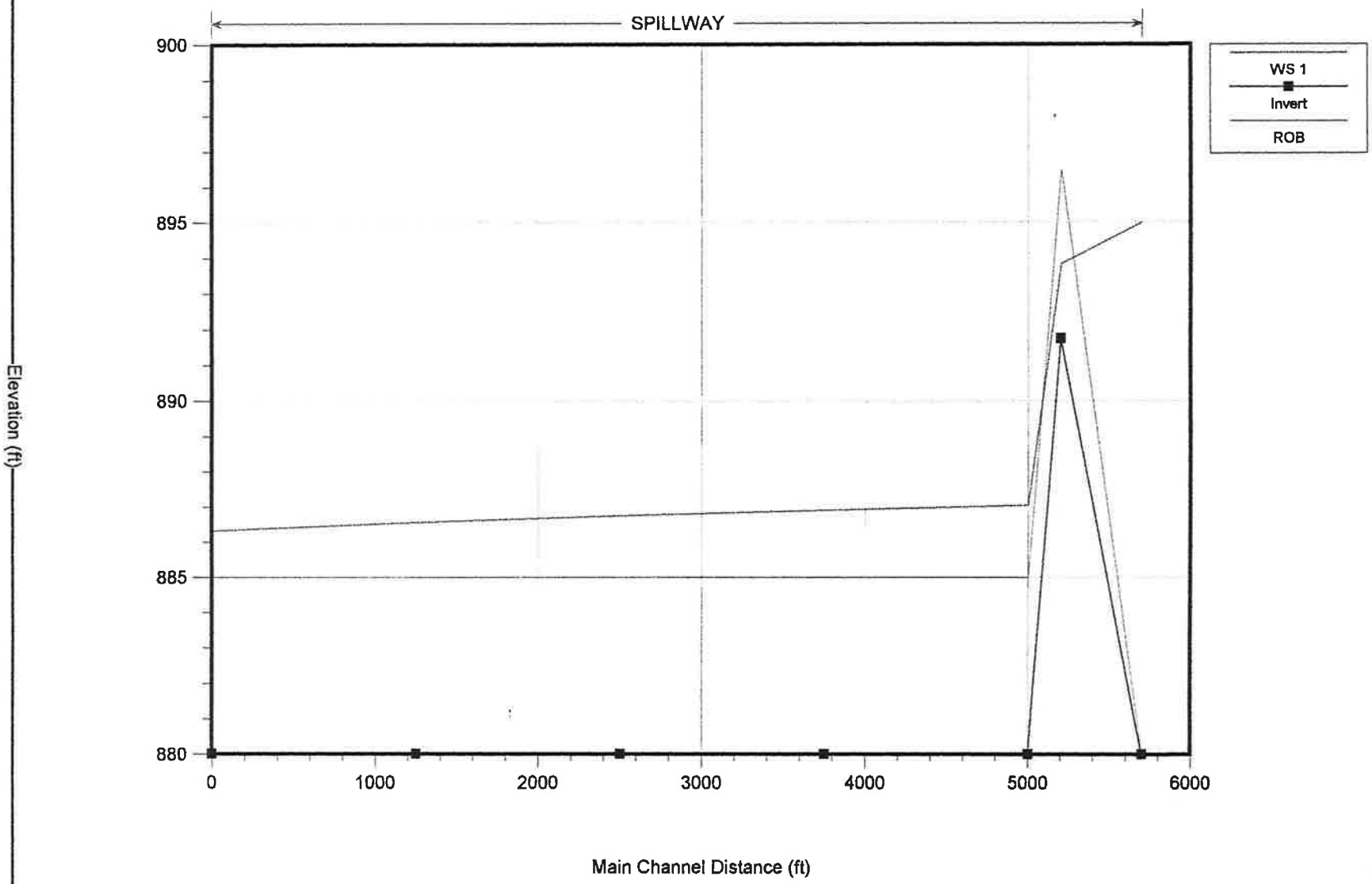
HEC-RAS Plan: Plan 09

Reach	River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
DOWNSTREAM	20	72544.00	855.00	881.87	875.88	882.79	0.000750	8.67	14061.74	2352.38
DOWNSTREAM	30	72544.00	856.00	883.87		884.05	0.000135	3.69	29236.90	4143.29
DOWNSTREAM	40	67659.00	878.00	886.20		886.29	0.000268	3.03	35824.07	7480.50
UPSTREAM	50	59678.00	876.00	886.29		886.31	0.000030	1.41	58747.95	9257.38
UPSTREAM	60	52475.00	878.00	886.94		886.98	0.000052	1.84	49324.16	8634.89
UPSTREAM	70	43380.00	885.00	891.30		891.55	0.000779	5.05	14599.01	4162.68
UPSTREAM	80	34285.00	890.00	898.54		898.80	0.000582	4.11	8806.55	2346.96
UPSTREAM	90	25190.00	906.00	912.56		913.22	0.001740	6.63	4140.97	1245.01
SPILLWAY	110	7891.00	880.00	886.32		886.37	0.000214	1.75	6960.28	5281.59
SPILLWAY	118	7891.00	880.00	887.05		887.07	0.000098	1.29	11720.46	7799.72
SPILLWAY	120	7891.00	891.75	893.83	893.83	894.89	0.001165	8.23	959.08	460.00
SPILLWAY	130	7891.00	880.00	894.99		894.99	0.000000	0.04	242685.10	18570.93

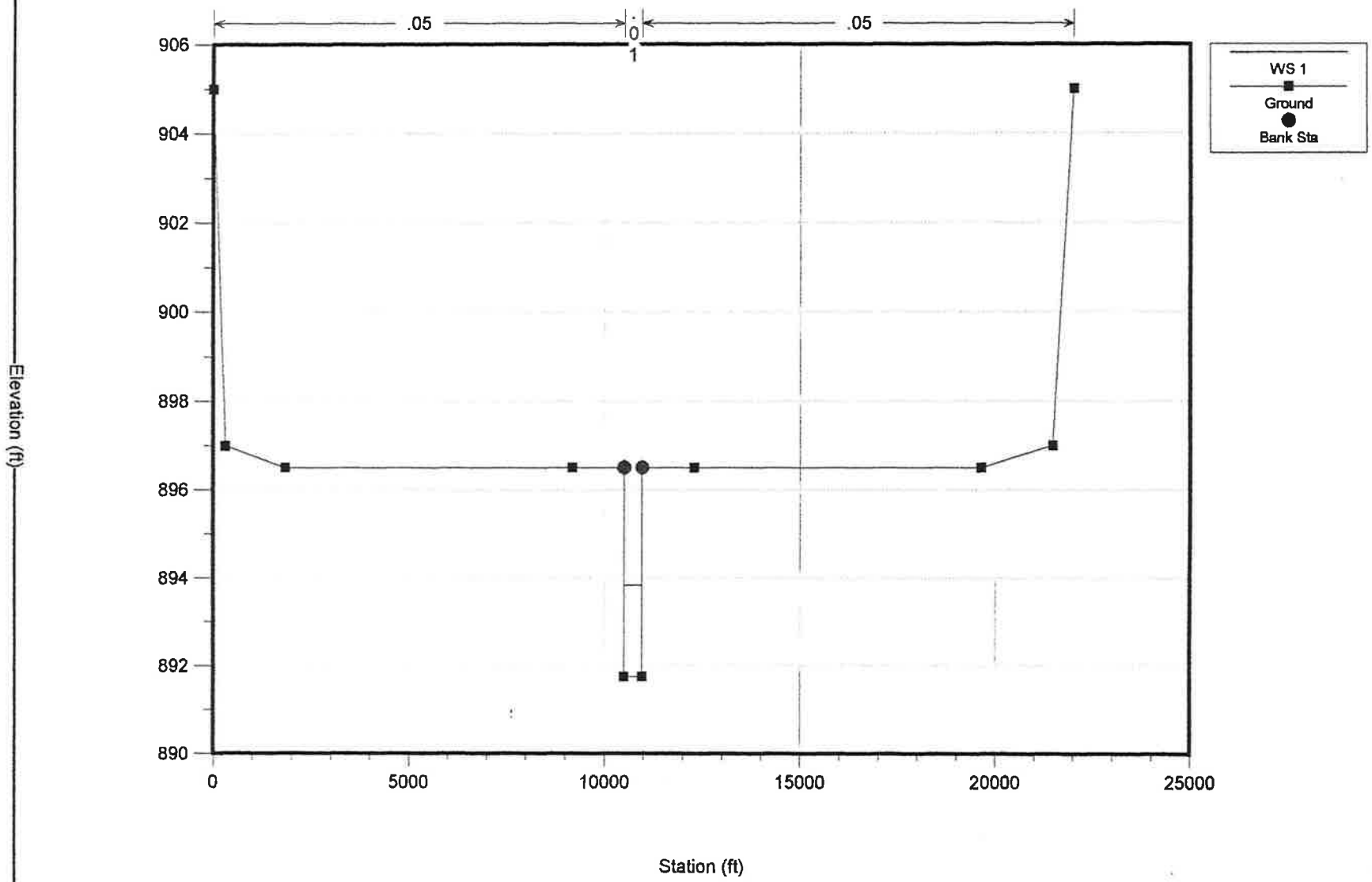
BUCKEYE LAKE RESTORATION Plan: Plan 09
Geom: SOUTH FORK LICKING RIVER Flow: buckeye lake
Reach = SPILLWAY Riv Sta = 130 to 110 PF#: 1



BUCKEYE LAKE RESTORATION Plan: Plan 09
Geom: SOUTH FORK LICKING RIVER Flow: buckeye lake



BUCKEYE LAKE RESTORATION Plan: Plan 09
Geom: SOUTH FORK LICKING RIVER Flow: buckeye lake
Reach = SPILLWAY NEW SPILLWAY - One mi. from confluence with SOUTH FORK LICKING RIVER Riv Sta = 120



Third Scenario

Maximum PMF outflow at the USGS gaging station near Hebron

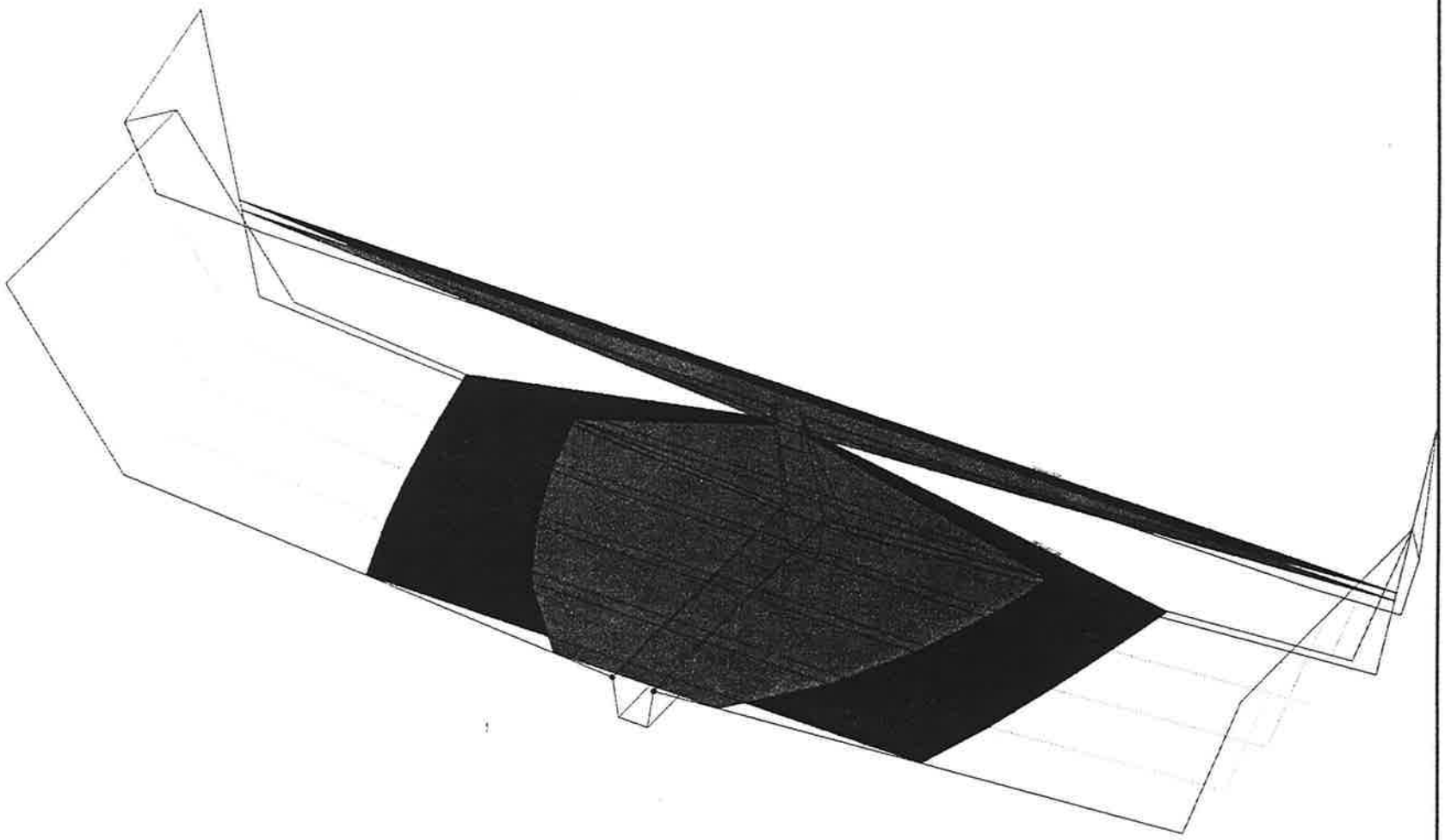
HEC-RAS Plan: Plan 05

Reach	River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)
DOWNSTREAM	20	89021.00	855.00	883.18	877.26	884.14	0.000751	9.14	17258.56	2529.19
DOWNSTREAM	20	63230.00	855.00	881.02	874.94	881.92	0.000750	8.37	12113.77	2237.79
DOWNSTREAM	30	89021.00	856.00	885.29		885.49	0.000137	3.93	35310.10	4402.86
DOWNSTREAM	30	63230.00	856.00	882.95		883.12	0.000134	3.54	25501.51	3974.57
DOWNSTREAM	40	83434.00	878.00	887.41		887.49	0.000212	2.99	45046.46	7762.84
DOWNSTREAM	40	59132.00	878.00	885.48		885.57	0.000323	3.09	30452.39	7311.03
UPSTREAM	50	68395.00	876.00	887.49		887.51	0.000024	1.37	70026.44	9497.93
UPSTREAM	50	49068.00	876.00	885.57		885.59	0.000028	1.29	52176.46	9114.31
UPSTREAM	60	61592.00	878.00	888.03		888.06	0.000044	1.83	58926.65	9109.34
UPSTREAM	60	43800.00	878.00	886.23		886.26	0.000052	1.74	43263.33	8352.64
UPSTREAM	70	53650.00	885.00	891.90		892.19	0.000779	5.45	17222.05	4510.54
UPSTREAM	70	37399.00	885.00	890.91		891.14	0.000775	4.78	13052.92	3943.29
UPSTREAM	80	45709.00	890.00	899.39		899.71	0.000572	4.57	10921.37	2616.05
UPSTREAM	80	30998.00	890.00	898.27		898.51	0.000586	3.96	8185.44	2261.85
UPSTREAM	90	37768.00	906.00	913.59		914.49	0.001787	7.80	5496.67	1384.23
UPSTREAM	90	24597.00	906.00	912.50		913.15	0.001737	6.56	4073.31	1237.66
SPILLWAY	110	15039.00	880.00	887.52		887.56	0.000212	1.99	15773.96	9427.93
SPILLWAY	110	10064.00	880.00	885.61		885.73	0.000689	2.87	4060.25	2797.67
SPILLWAY	118	15039.00	880.00	888.24		888.26	0.000098	1.45	23484.75	11926.63
SPILLWAY	118	10064.00	880.00	887.14		887.17	0.000144	1.58	12424.78	8106.14
SPILLWAY	120	15039.00	891.75	894.95	894.95	896.57	0.001018	10.21	1473.55	460.00
SPILLWAY	120	10064.00	891.75	894.20	894.20	895.44	0.001106	8.92	1128.07	460.00
SPILLWAY	130	15039.00	880.00	896.73		896.73	0.000000	0.06	276850.10	19670.43
SPILLWAY	130	10064.00	880.00	895.56		895.56	0.000000	0.04	253860.80	19603.53

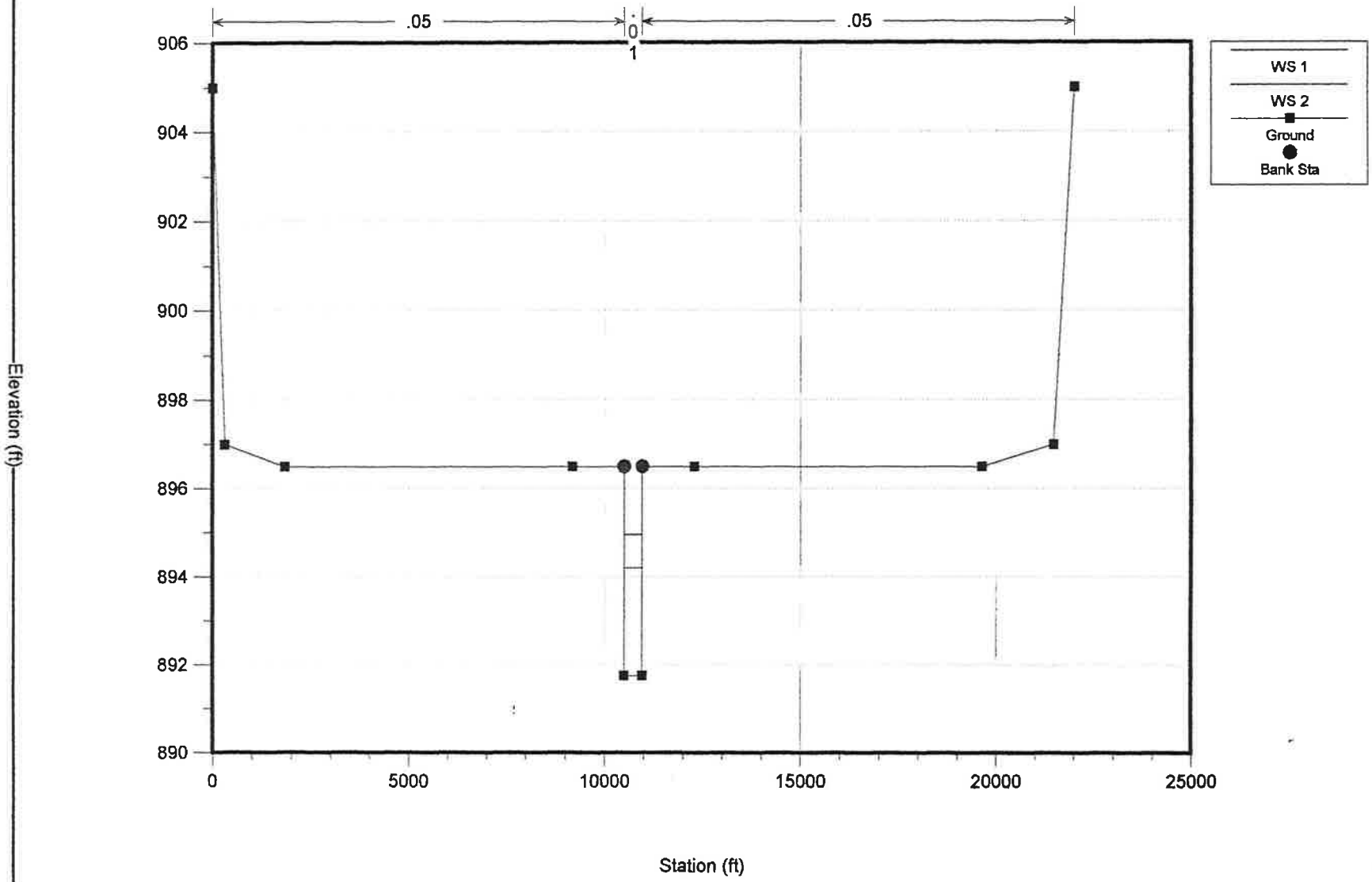
HEC-RAS Plan: Plan 05

Reach	River Sta.	E.G. Elev (ft)	W.S. Elev (ft)	Vel Head (ft)	Frctn Loss (ft)	C & E Loss (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Top Width (ft)
DOWNSTREAM	20	884 14	883 18	0 96	0 00	0 00	15066 21	64145.93	9808 87	2529 19
DOWNSTREAM	20	881 92	881 02	0 90	0 00	0 00	5604 86	51514 84	6110 30	2237.79
DOWNSTREAM	30	885 49	885 29	0 19	0 38	0 03	14016.79	69521 70	5482 51	4402 86
DOWNSTREAM	30	883 12	882 95	0 17	0 35	0 02	5424 20	54325.38	3480 42	3974 57
DOWNSTREAM	40	887 49	887 41	0 08	0 39	0 00	15068 88	40187 36	28177 76	7762 84
DOWNSTREAM	40	885 57	885 48	0 09	0 58	0 01	7318 37	32049.88	19763.75	7311.03
UPSTREAM	50	887 51	887 49	0 02	0 01	0 01	13954 37	53423.82	1016.81	9497.93
UPSTREAM	50	885 59	885 57	0 02	0 02	0 01	8281.76	40284.17	502.07	9114.31
UPSTREAM	60	888 06	888 03	0 03	0 09	0 00	5687.30	34594.41	21310.29	9109.34
UPSTREAM	60	886 26	886 23	0 03	0.11	0 00	3152.93	26508.27	14138.80	8352.64
UPSTREAM	70	892 19	891 90	0 29	1.36	0 00	2900.86	30522.77	20226.38	4510.54
UPSTREAM	70	891 14	890.91	0 23	1.40	0 00	1588 25	22032.86	13777.90	3943.29
UPSTREAM	80	899.71	899 39	0 32	1 05	0.00	907 99	44567.71	233.30	2616 05
UPSTREAM	80	898 51	898 27	0 24	1 07	0 00	314 87	30648.22	34.91	2261.85
UPSTREAM	90	914 49	913 59	0 90	3 48	0 04	334 35	36947.30	486 35	1384.23
UPSTREAM	90	913 15	912 50	0 65	3 39	0 03	84.70	24389.10	123.21	1237.66
SPILLWAY	110	887 56	887 52	0 04	0.06	0 00	2894.28	9475.55	2669.17	9427.93
SPILLWAY	110	885 73	885 61	0 13	0 15	0 01	116.43	9840.20	107.37	2797 67
SPILLWAY	118	888 26	888 24	0 02	0.13	0.00		15039.00		11926.63
SPILLWAY	118	887 17	887 14	0 03	0 20	0 00		10064 00		8106 14
SPILLWAY	120	896 57	894 95	1 62				15039.00		460.00
SPILLWAY	120	895 44	894 20	1 24	0 13	0 36		10064.00		460.00
SPILLWAY	130	896 73	896 73	0 00	0 00	0 16	4242.70	6553.59	4242 70	19670.43
SPILLWAY	130	895 56	895 56	0 00	0 00	0 12	2587 65	4888 69	2587.65	19603 53

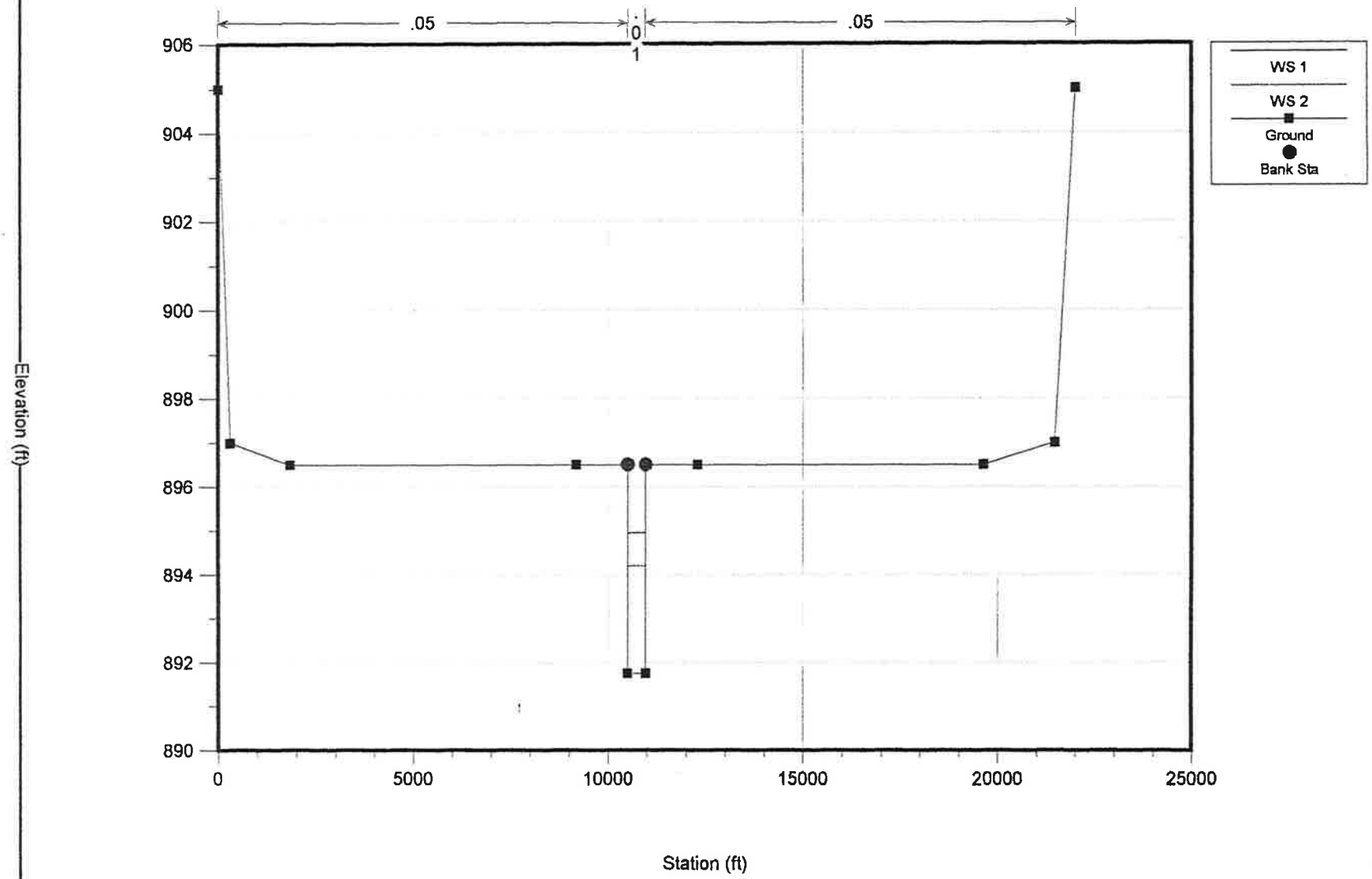
BUCKEYE LAKE RESTORATION Plan: SOUTH FORK LICKING RIVER DATA
Geom: SOUTH FORK LICKING RIVER Flow: SOUTH FORK LICKING RIVER
Reach = SPILLWAY Riv Sta = 130 to 110 PF#: 1, 2



BUCKEYE LAKE RESTORATION Plan: SOUTH FORK LICKING RIVER DATA
Geom: SOUTH FORK LICKING RIVER Flow: SOUTH FORK LICKING RIVER
Reach = SPILLWAY NEW SPILLWAY - One mi. from confluence with SOUTH FORK LICKING RIVER Riv Sta = 120



BUCKEYE LAKE RESTORATION Plan: SOUTH FORK LICKING RIVER DATA
Geom: SOUTH FORK LICKING RIVER Flow: SOUTH FORK LICKING RIVER
Reach = SPILLWAY NEW SPILLWAY - One mi. from confluence with SOUTH FORK LICKING RIVER Riv Sta = 120



Appendix E

Excerpt from Embankment Stability Review

BUCKEYE LAKE DAM
REVIEW OF EMBANKMENT STABILITY

Prepared For

BUCKEYE LAKE ASSOCIATION
Buckeye Lake, Ohio

Submitted By

W.S. GARDNER AND ASSOCIATES
Plymouth Meeting, Pennsylvania

Earth dams subject to seismicity may cause significant horizontal displacements of the embankment which may lead to a dam breach. The amount of displacement depends on the yield acceleration (k_y) and the maximum horizontal acceleration (A_{max}) of the earthquake. Following Hynes and Franklin (1984), the data required for the displacement analysis is the maximum horizontal acceleration (0.10 g) and the yield accelerations calculated previously. The displacement relationship, given by Figure 8, conservatively utilizes the mean + σ of the curve. The results of the displacement calculations are included in Table 4. As anticipated, the largest permanent embankment displacement is 34 cm which will likely fail the dam when the pool elevation is 896.5. A 21 cm displacement of the embankment with the pool at 895 would also likely be sufficient to fail the dam. With the pool at an elevation of 892, the embankment is stable and there is no displacement during the maximum earthquake.

8. CONCLUSIONS AND RECOMMENDATIONS

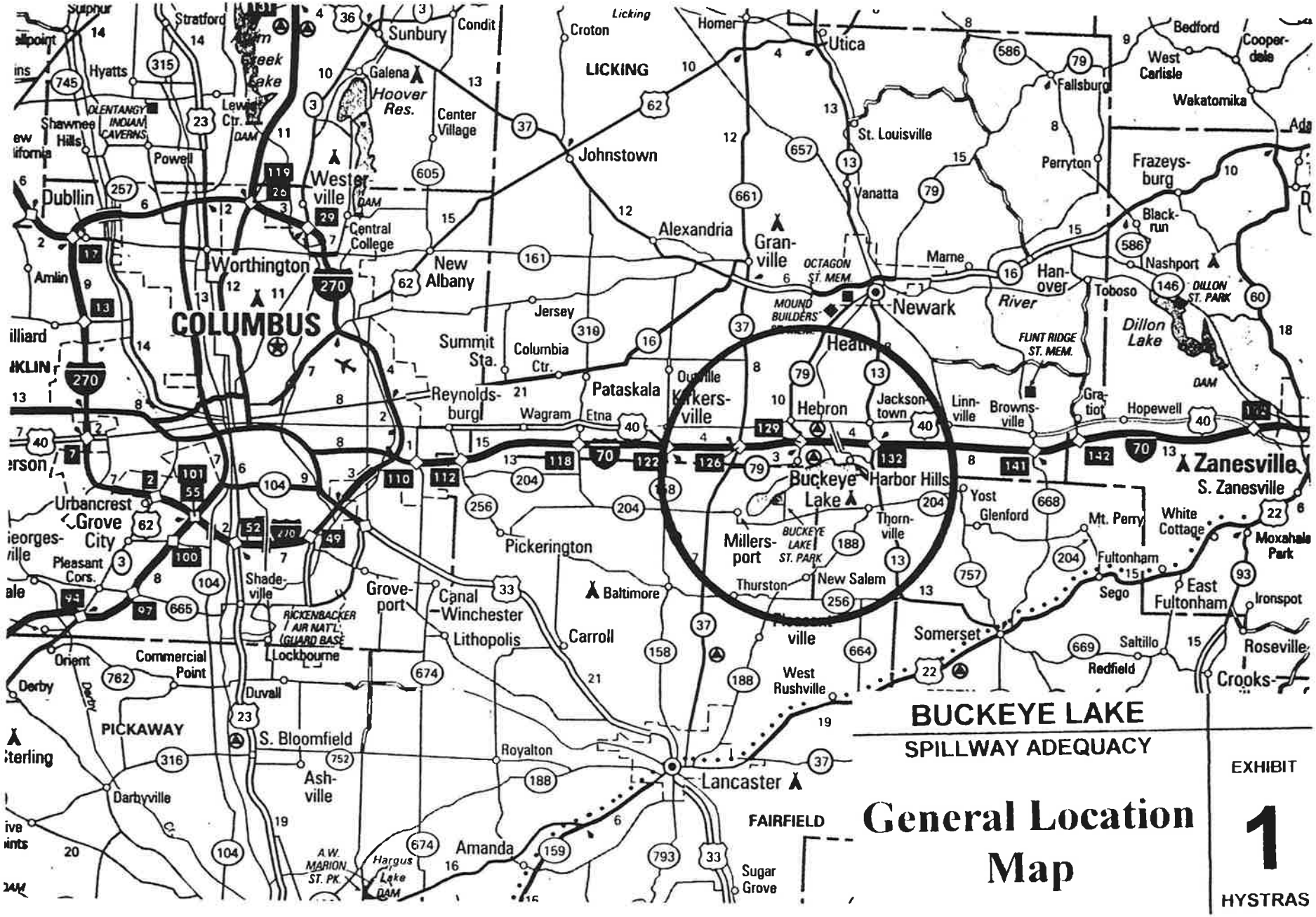
Based on review of the DLA report, observations at the dam site, and independent analysis, it is clear that Buckeye Lake Dam has some serious defects other than the extreme age of the dam. These deficiencies include: (1) a current inability to accommodate the PMF; (2) a leaky, uncompacted embankment; and (3) a potential instability of dam slopes if pool elevations significantly exceed about 892. At significantly higher pool elevations than 892, instability of the embankment is likely. In addition, seismic occurrences have the potential to induce rapid failures by large embankment displacements and/or progressive sliding downstream of the order predicted in Table 4.

In summary, analysis of Buckeye Lake Dam indicates that the embankment is unsafe at pool elevations much above 892. At this elevation, the factor of safety against failure is essentially 1.5 which meets conventional safety standards, and is strongly recommended. It is also prudent to provide the dam a freeboard of at least 3 ft. (to elevation 895) and is also a recommended safety provision. The plan by ODNR to construct a parapet wall around the dam to accommodate the PMF is unsafe as a temporary raise in the pool elevation to 896.5 would most likely induce an embankment failure. Consequently, it is recommended that the PMF be accommodated by other means, such as adding an additional spillway.

The recommendations of DLA concerning a staged removal over time of selected trees implanted in the embankment appear to be a reasonable procedure. Further, the width of the embankment may be deficient at some locations and should be investigated and remediated if verified.

11.0 EXHIBITS

1. General Location Map
2. Watershed Boundaries
3. Buckeye Lake Plan
4. Sheet Pile Protection
5. Parapet Extensions
6. Riprap Zones
7. PMP Depth and Duration Curves
8. PMP Precipitation Distribution
9. Storm Isohyets over Center of Lake
10. Storm Isohyets over Center of Drainage Area
11. Best Storm Isohyets fit over Center of Drainage Area
12. HEC-1 Topological Three
13. Hydrographs for PMP over Center of Lake
14. Hydrographs for PMP over Center of Drainage Area
15. Hydrographs for PMP Best Fit over Center of Drainage Area
16. Lower SFLR Reach Flooding
17. Effective Fetch- Locations A and B
18. Effective Fetch- Locations C and D
19. Effective Fetch- Location E
20. Photograph of the 1992 Emergency Spillway
21. Photograph of the Gated Outflow Structure



BUCKEYE LAKE

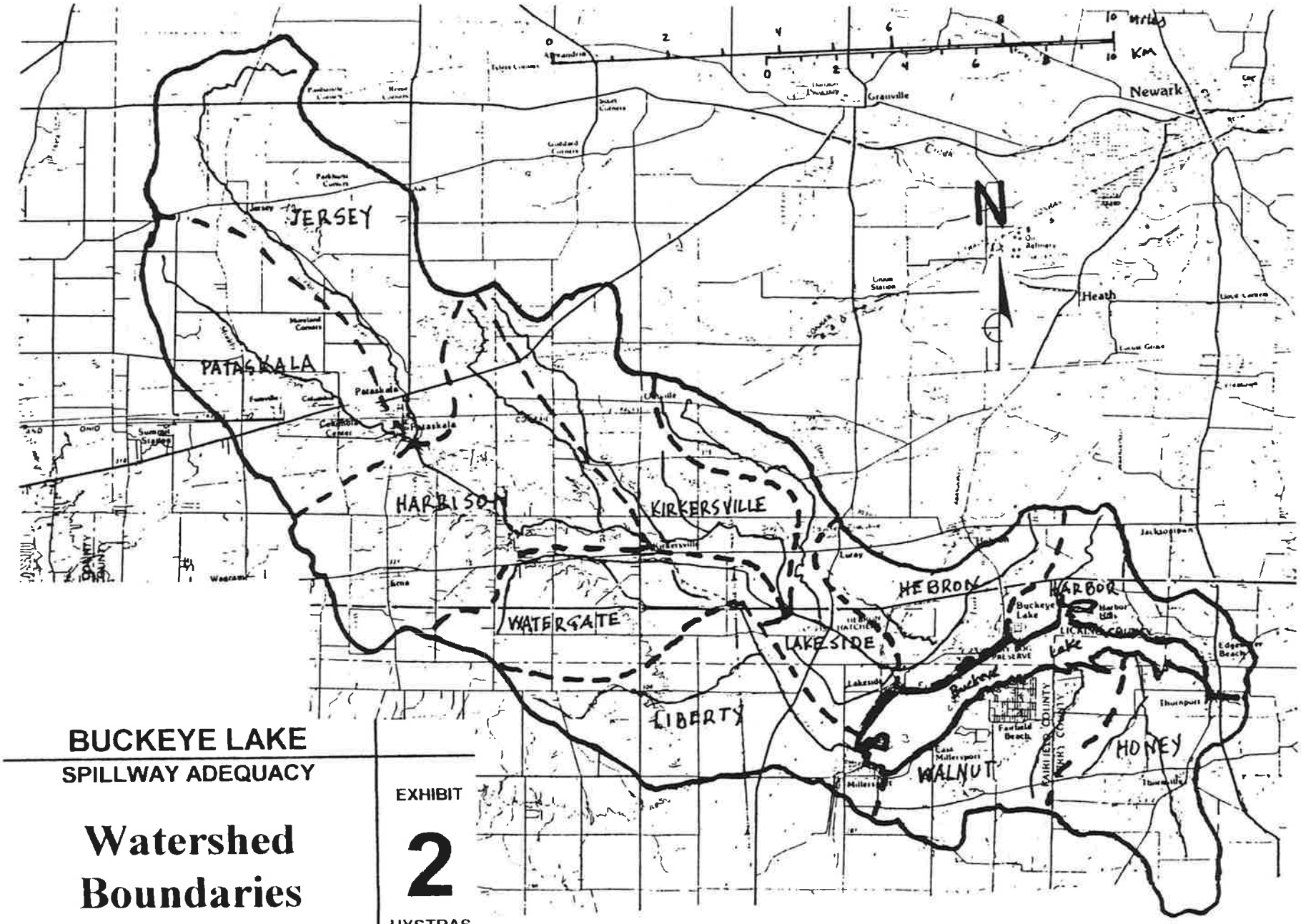
SPILLWAY ADEQUACY

General Location Map

EXHIBIT

1

HYSTRAS



BUCKEYE LAKE

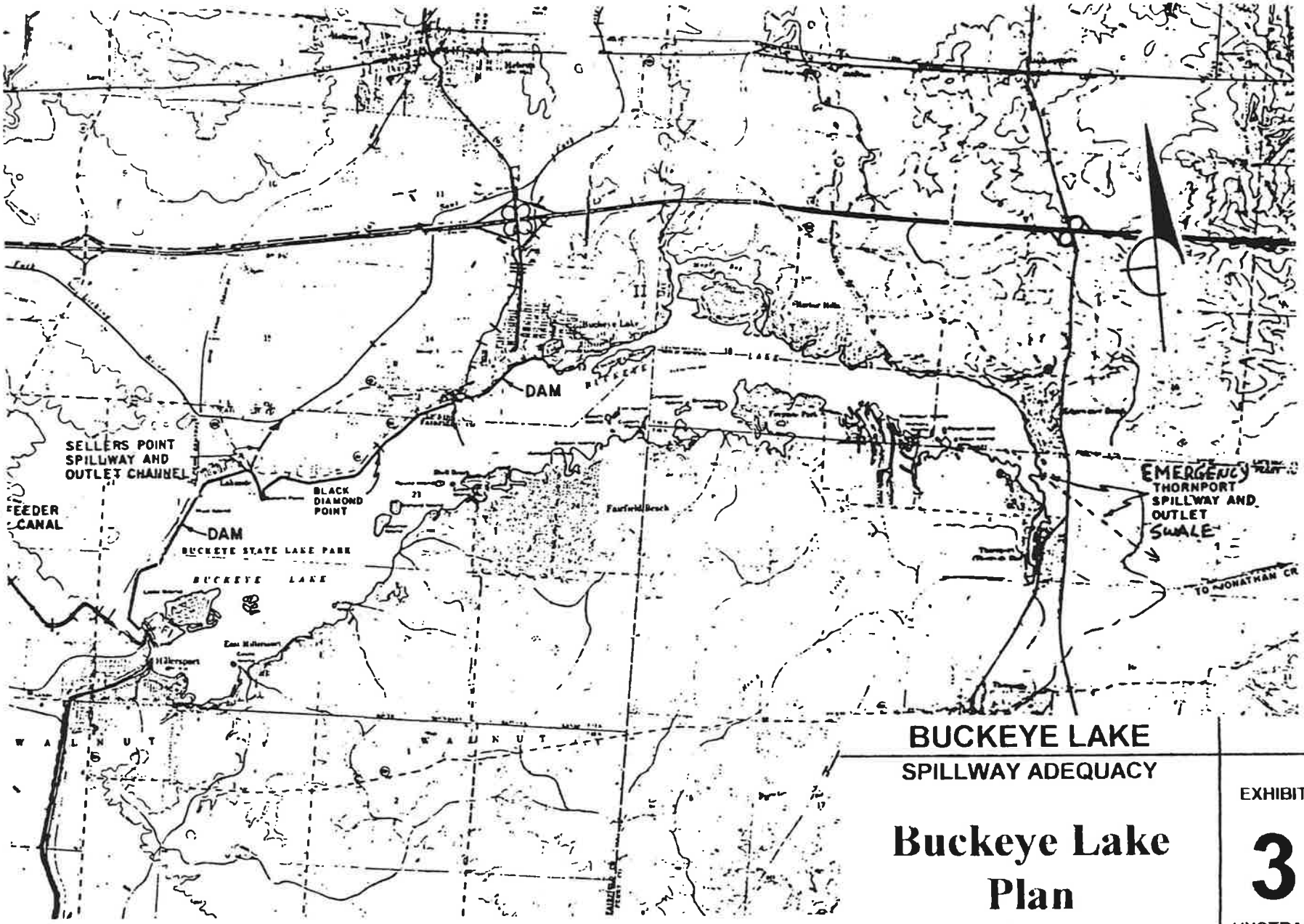
SPILLWAY ADEQUACY

Watershed Boundaries

EXHIBIT

2

HYSTRAS



BUCKEYE LAKE

SPILLWAY ADEQUACY

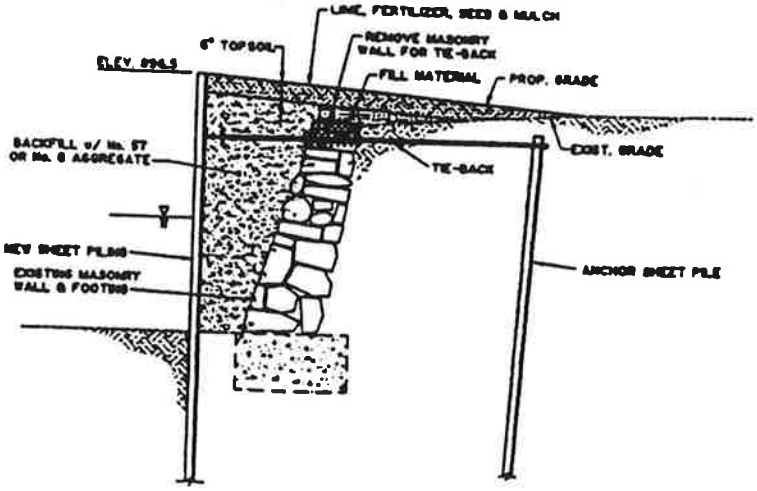
Buckeye Lake Plan

EXHIBIT

3

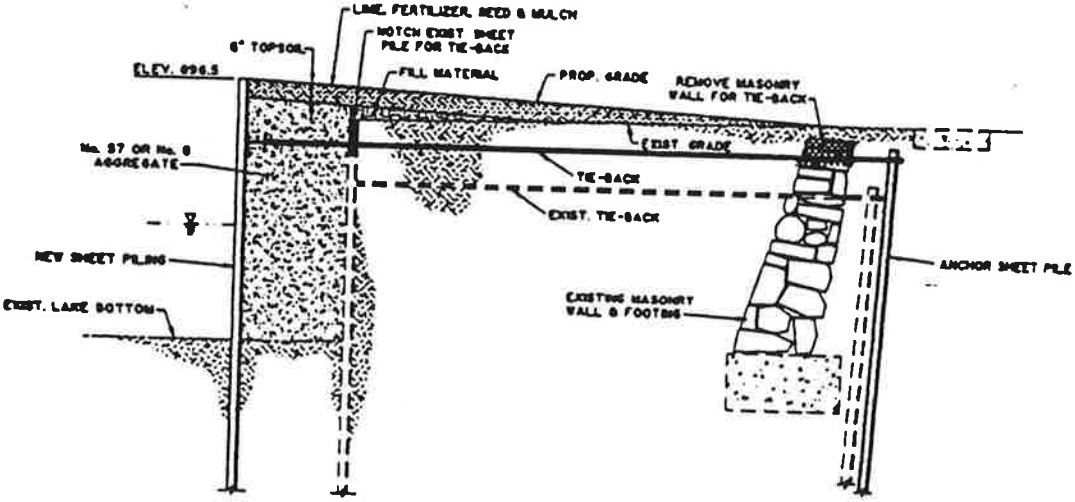
HYSTRAS

SHEET PILE SECTIONS



WEST BANK

STA. STA. 9+35 TO 66+97



BUCKEYE LAKE

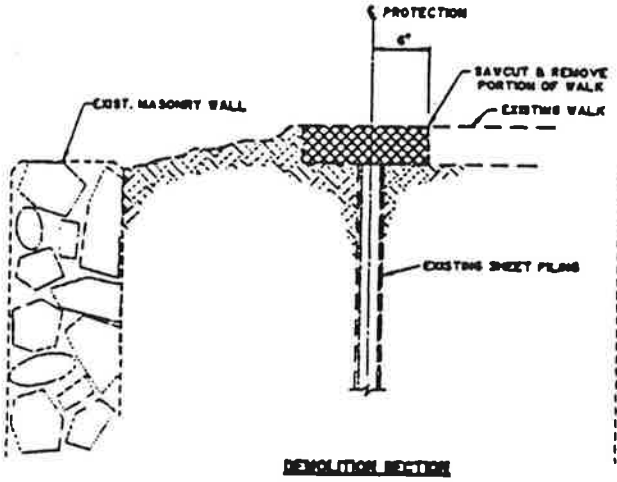
SPILLWAY ADEQUACY

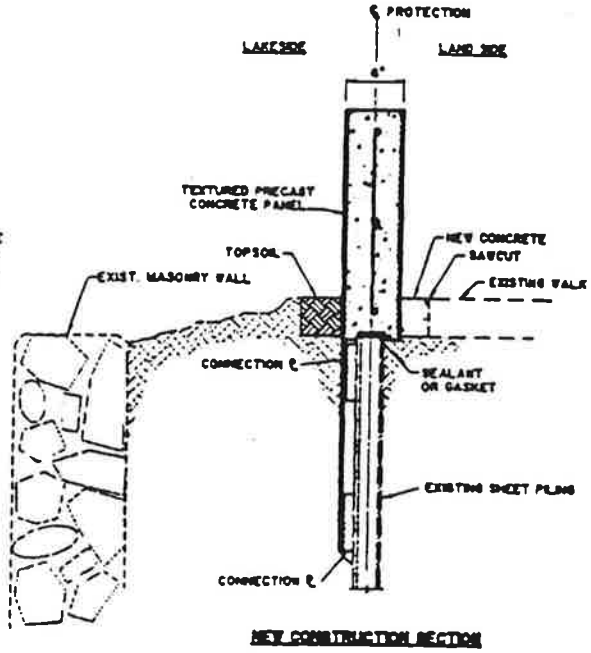
Sheet Pile Protection

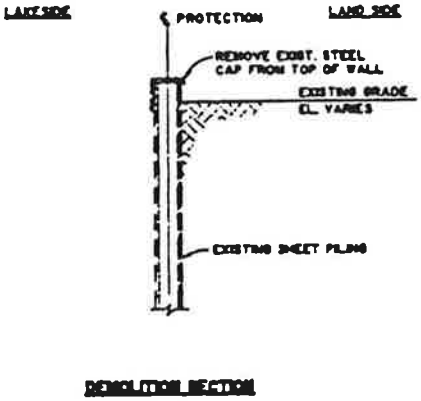
EXHIBIT

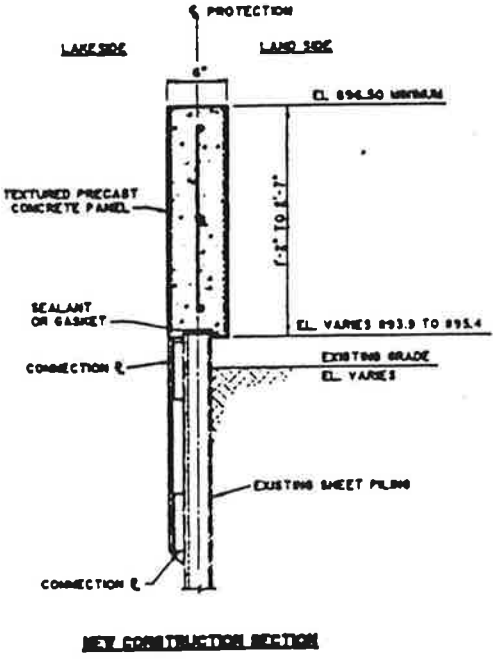
4

HYSTRAS









BUCKEYE LAKE

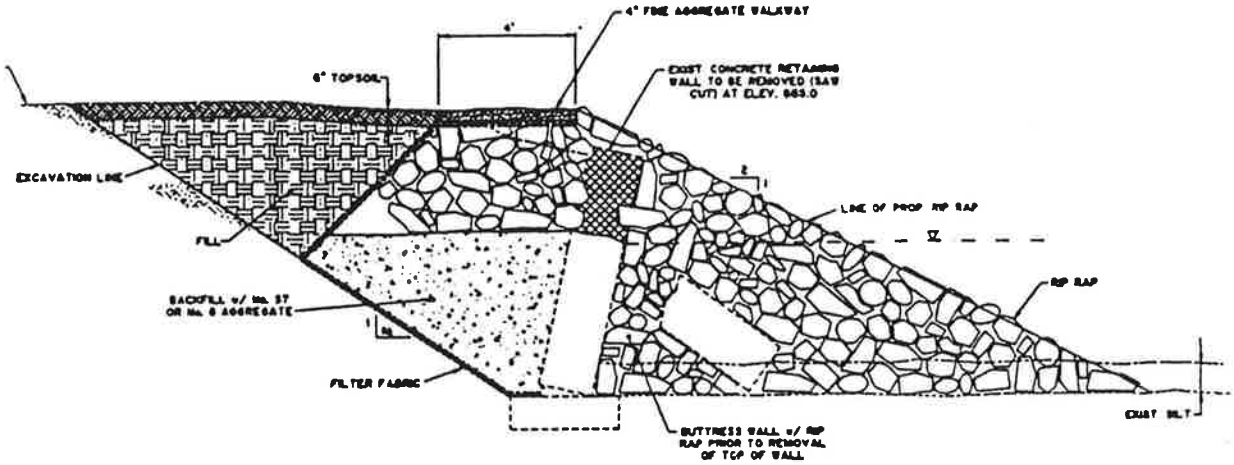
SPILLWAY ADEQUACY

Parapet Extensions

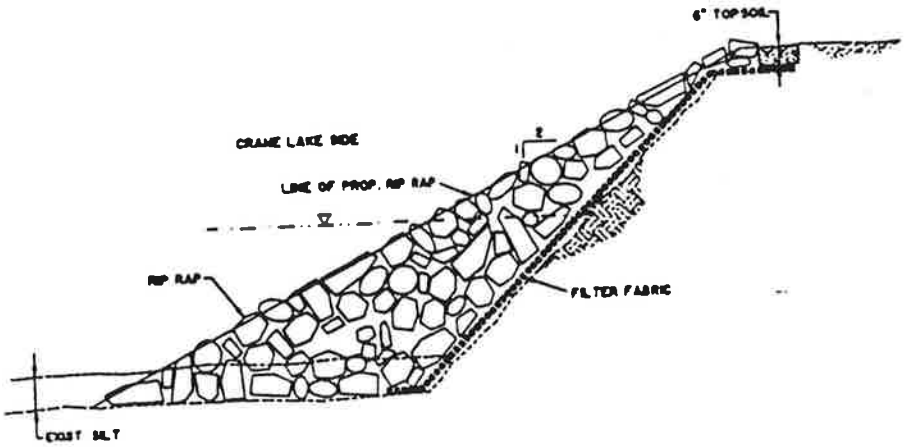
EXHIBIT

5

HYSTRAS



SHORE PROTECTION "A" SECTION



SHORE PROTECTION "B" SECTION

BUCKEYE LAKE

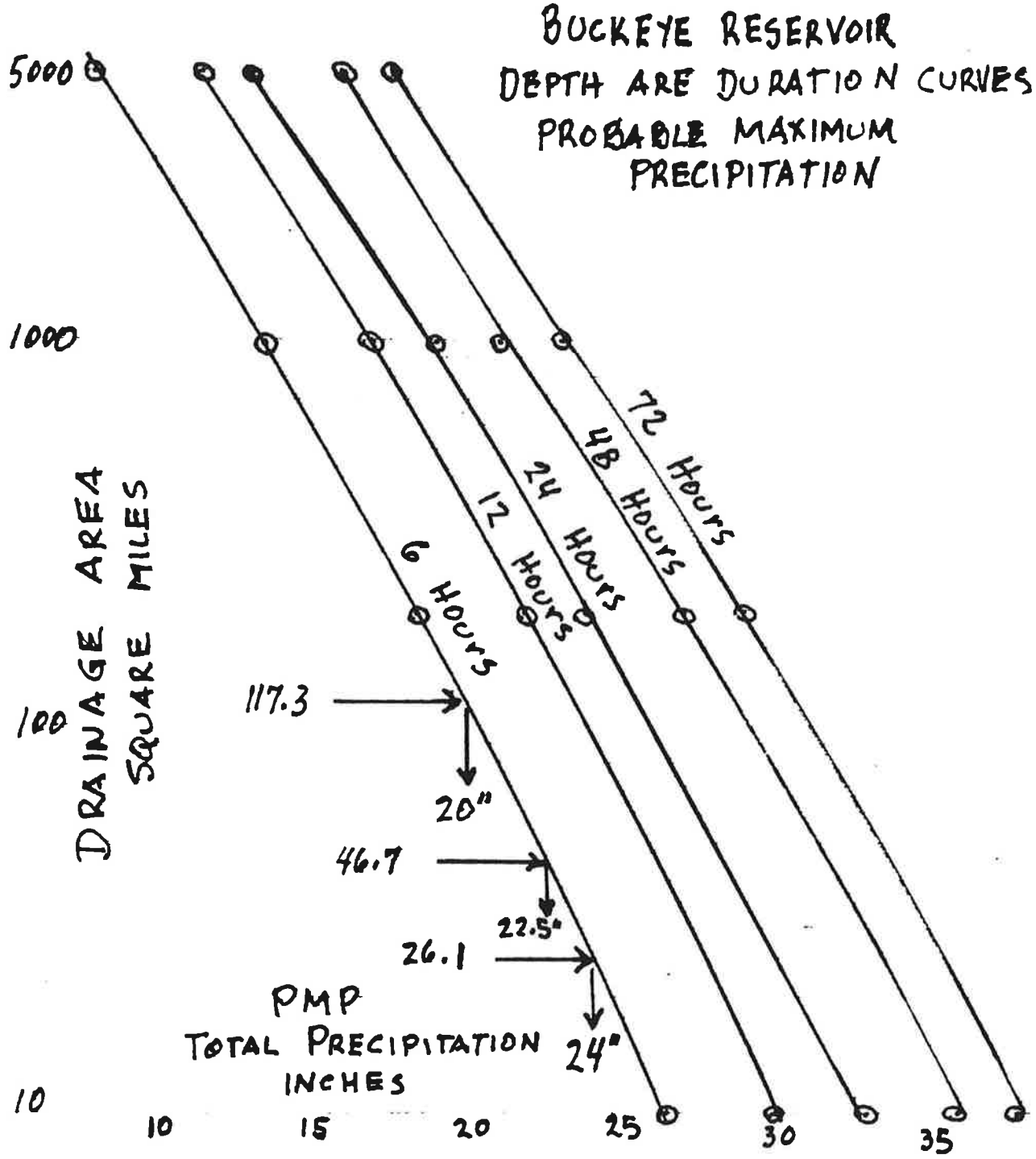
SPILLWAY ADEQUACY

Riprap Zones

EXHIBIT

6

HYSTRAS



BUCKEYE LAKE

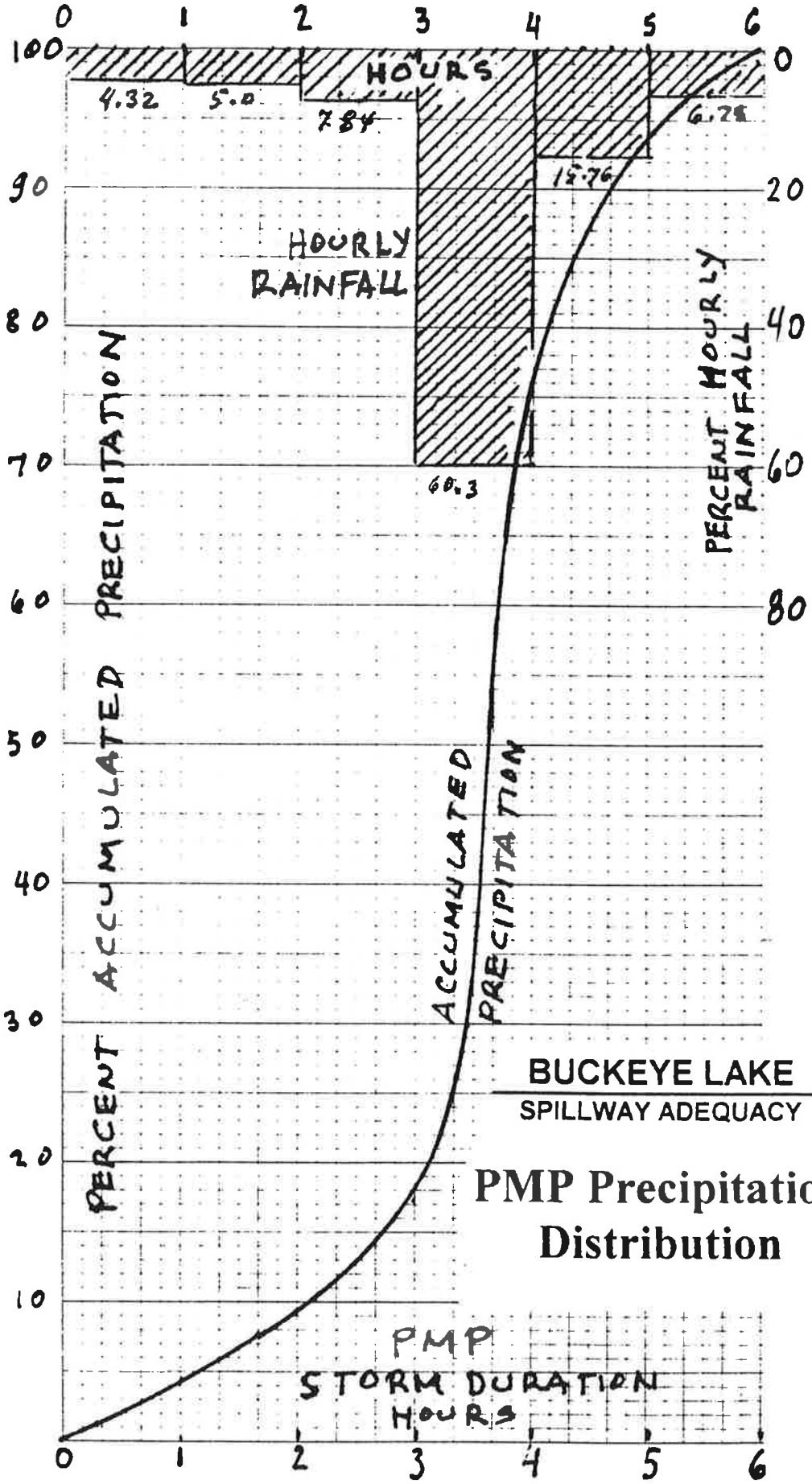
SPILLWAY ADEQUACY

PMP Depth and Duration Curves

EXHIBIT

7

HYSTRAS



BUCKEYE LAKE

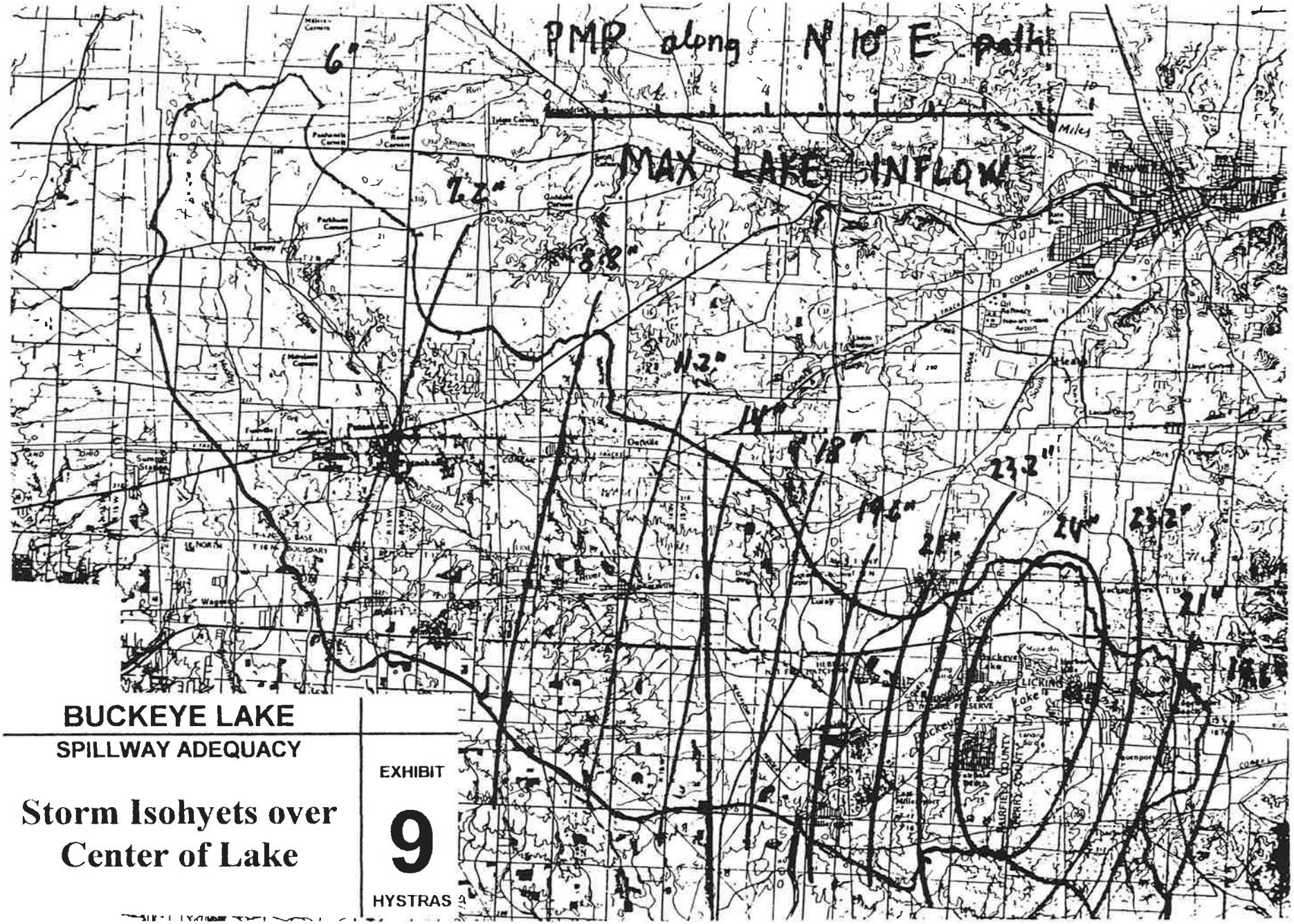
SPILLWAY ADEQUACY

PMP Precipitation Distribution

EXHIBIT

8

HYSTRAS



BUCKEYE LAKE

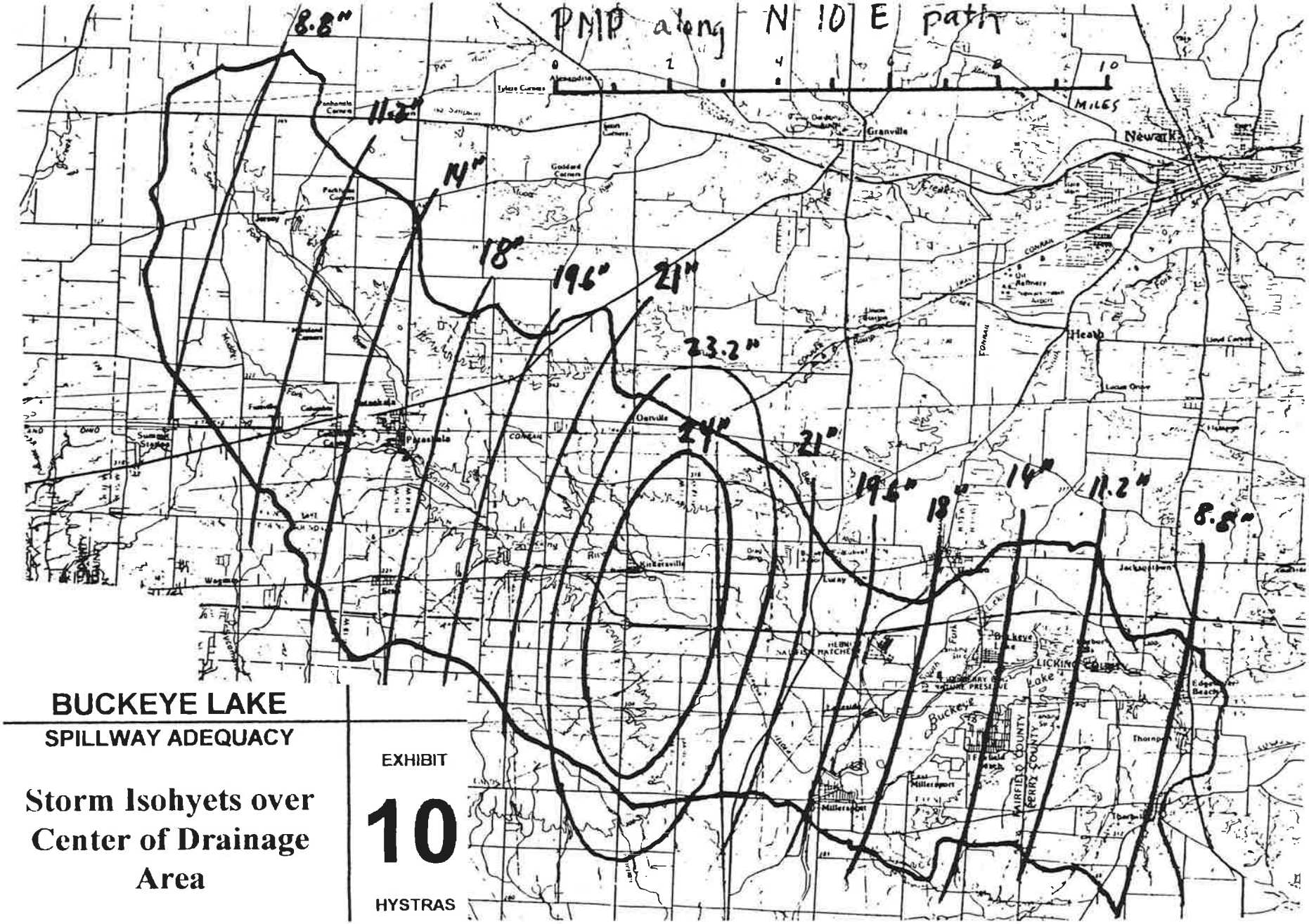
SPILLWAY ADEQUACY

Storm Isohyets over Center of Lake

EXHIBIT

9

HYSTRAS



BUCKEYE LAKE

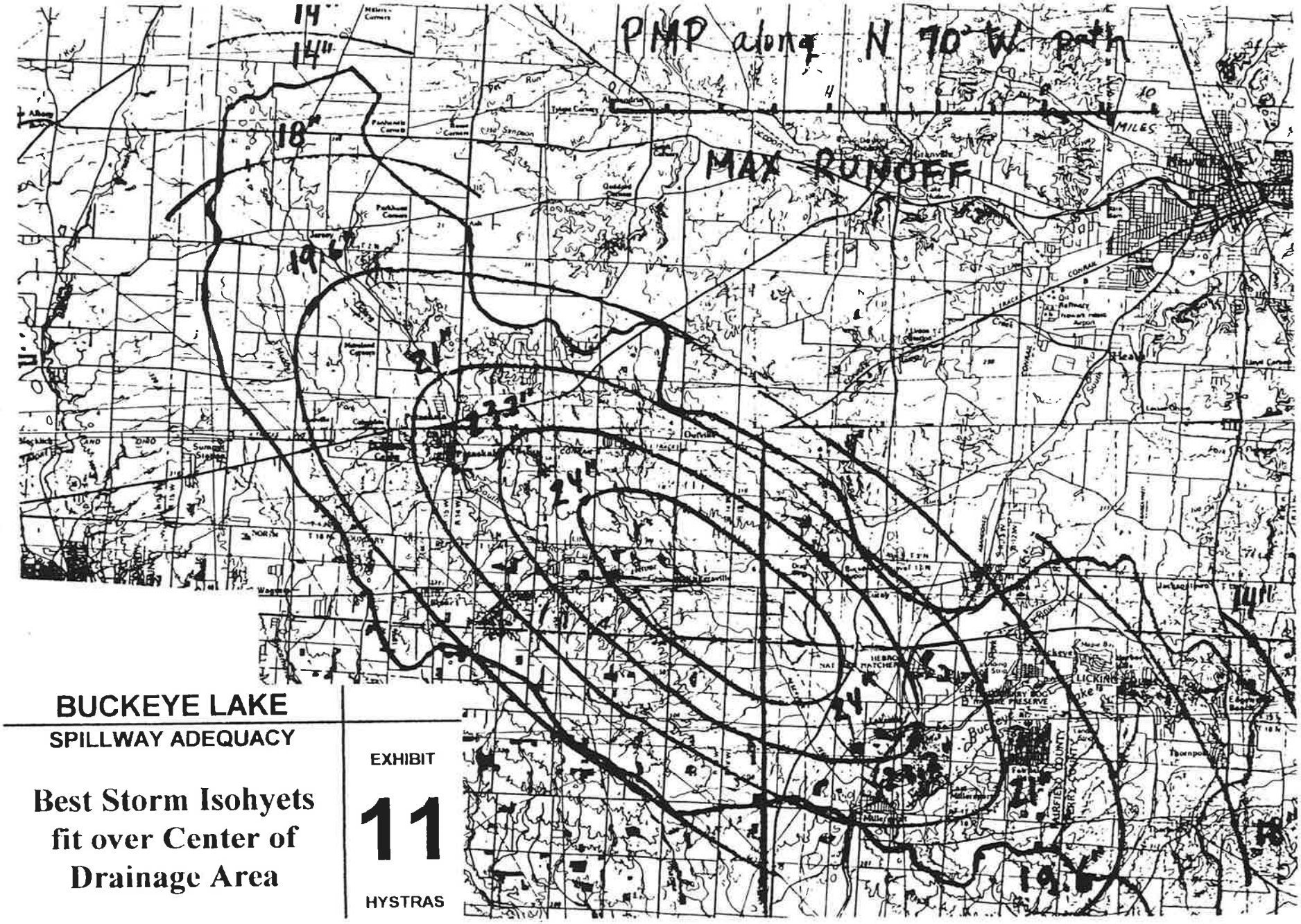
SPILLWAY ADEQUACY

Storm Isohyets over Center of Drainage Area

EXHIBIT

10

HYSTRAS



BUCKEYE LAKE

SPILLWAY ADEQUACY

Best Storm Isohyets fit over Center of Drainage Area

EXHIBIT

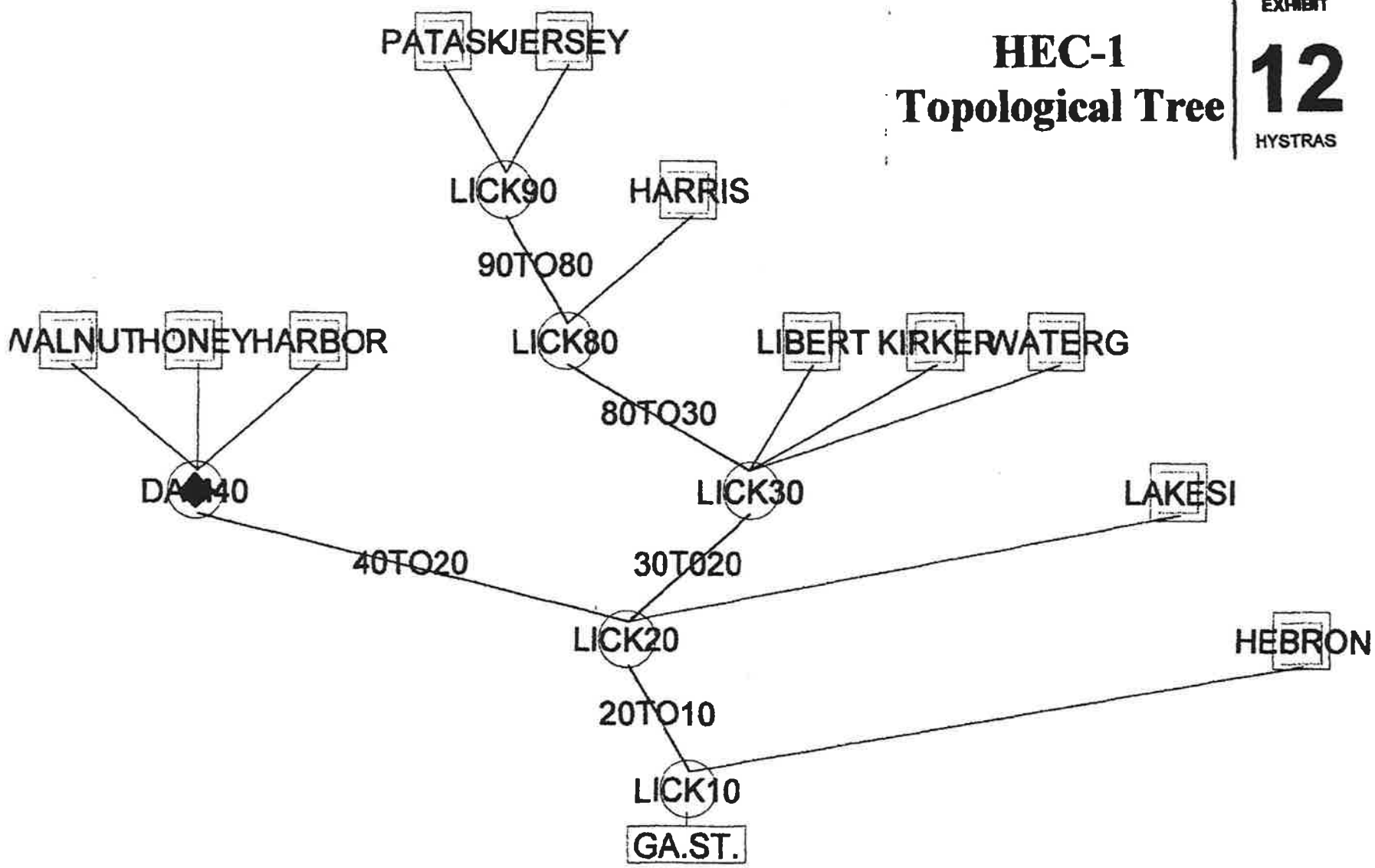
11

HYSTRAS

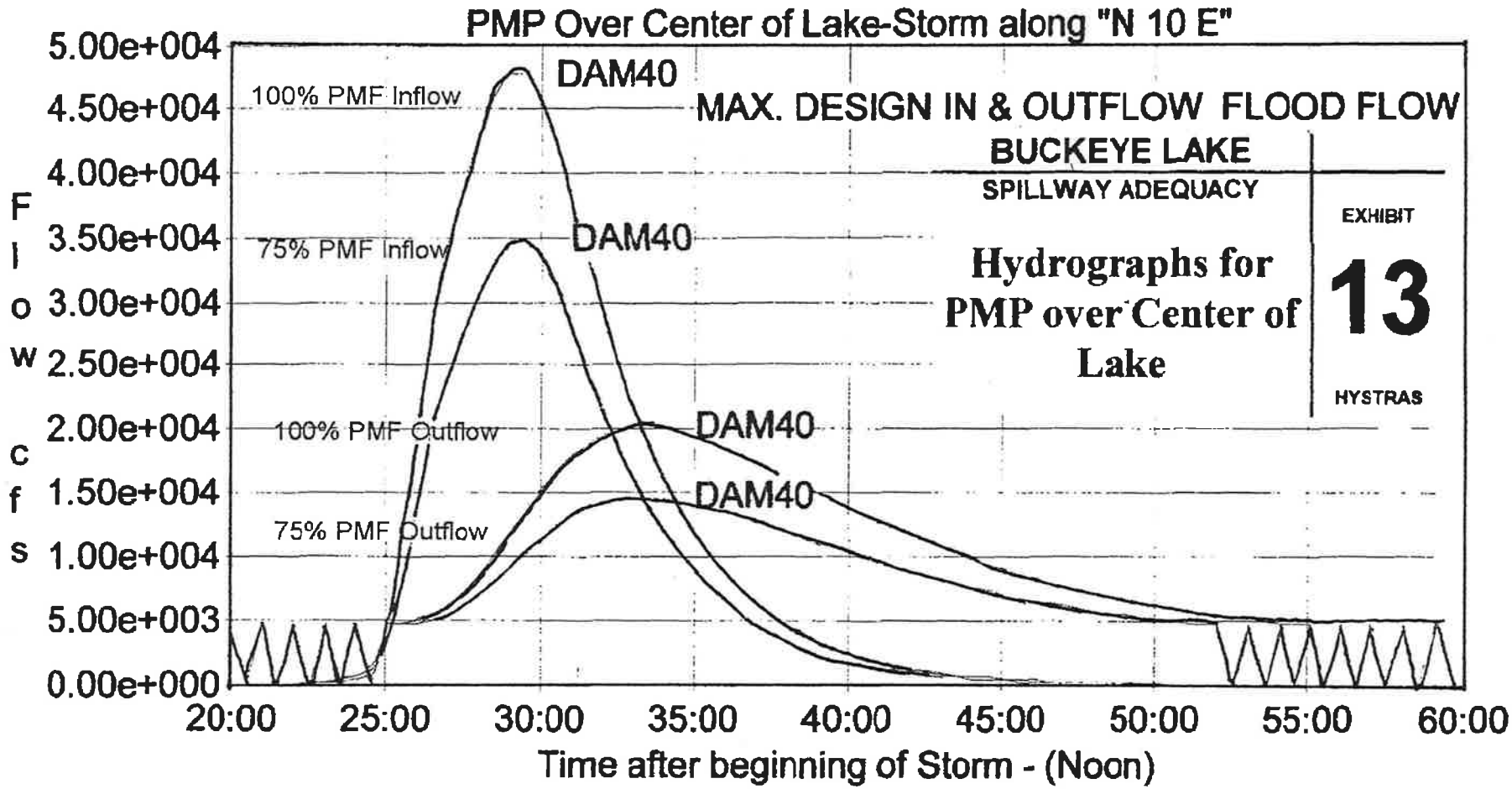
BUCKEYE LAKE
SPILLWAY ADEQUACY

HEC-1 Topological Tree

EXHIBIT **12** HYSTRAS

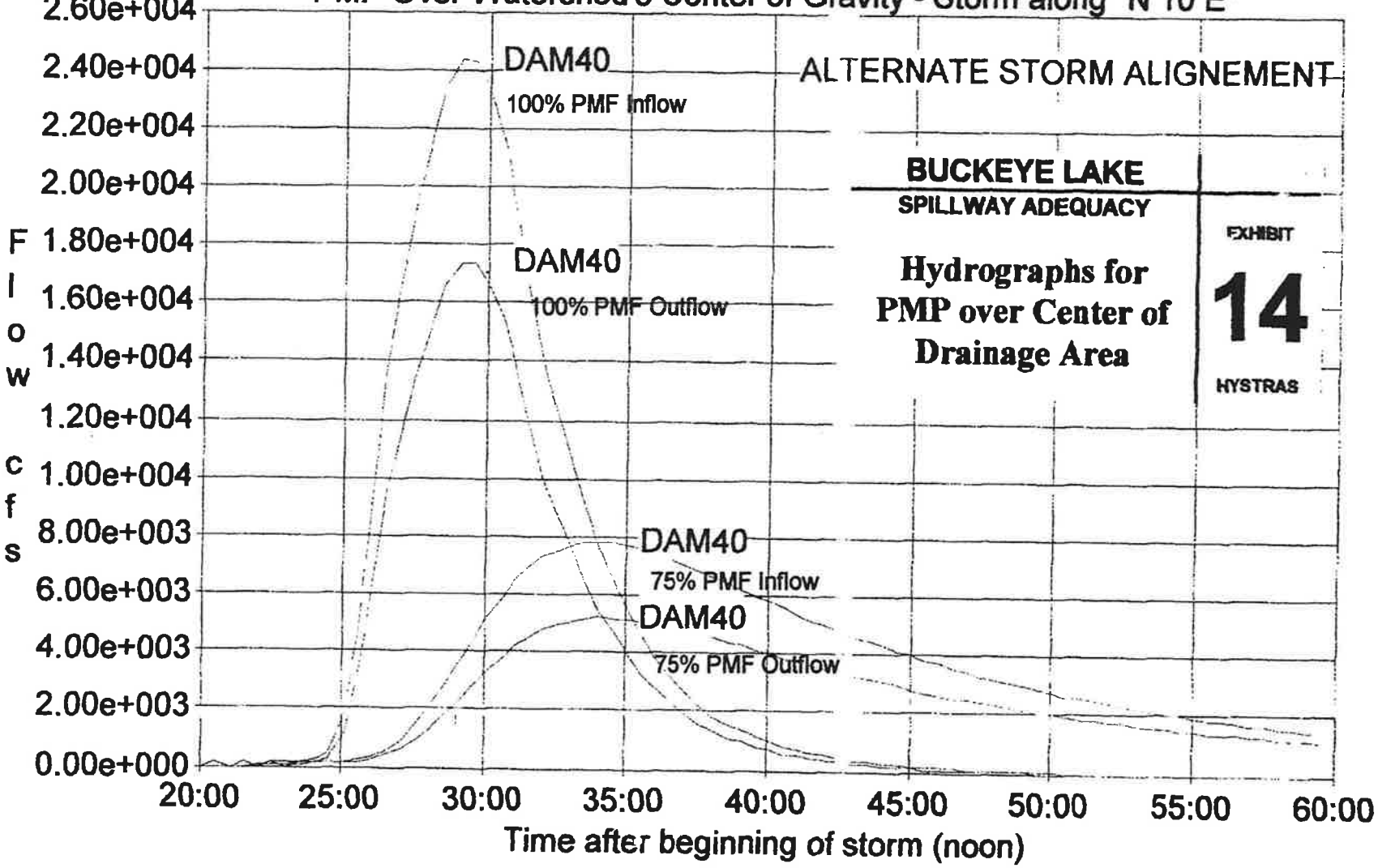


BUCKEYE LAKE - 100% & 75% PMF HYDROGRAPHS



BUCKEYE LAKE - 100 % PMF HYDROGRAPH

PMP Over Watershed's Center of Gravity - Storm along "N 10 E"



BUCKEYE LAKE

SPILLWAY ADEQUACY

Hydrographs for PMP over Center of Drainage Area

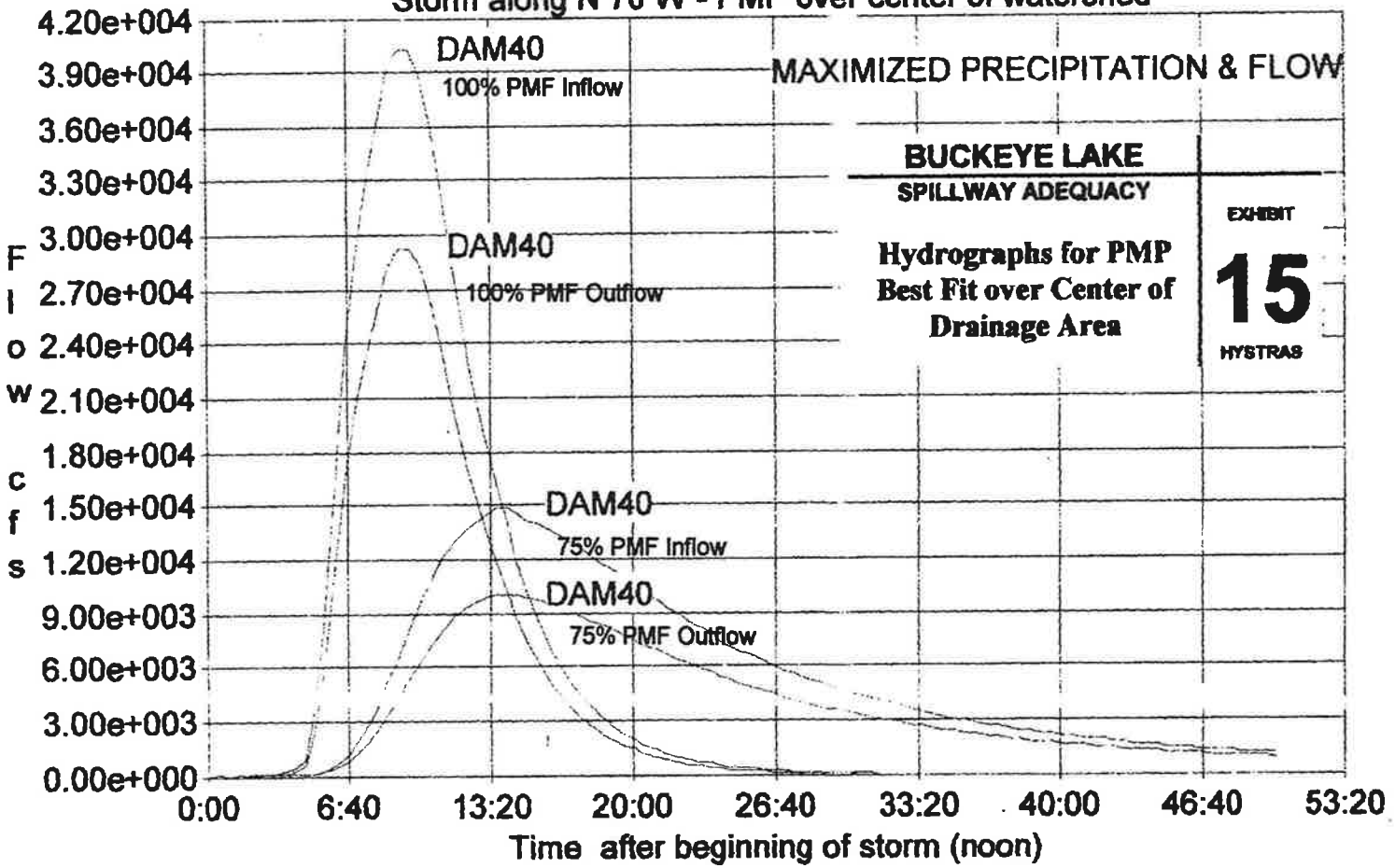
EXHIBIT

14

HYSTRAS

BUCKEYE LAKE- 100 % & 75 % PMF HYDROGRAPHS

Storm along N 70 W - PMP over center of watershed

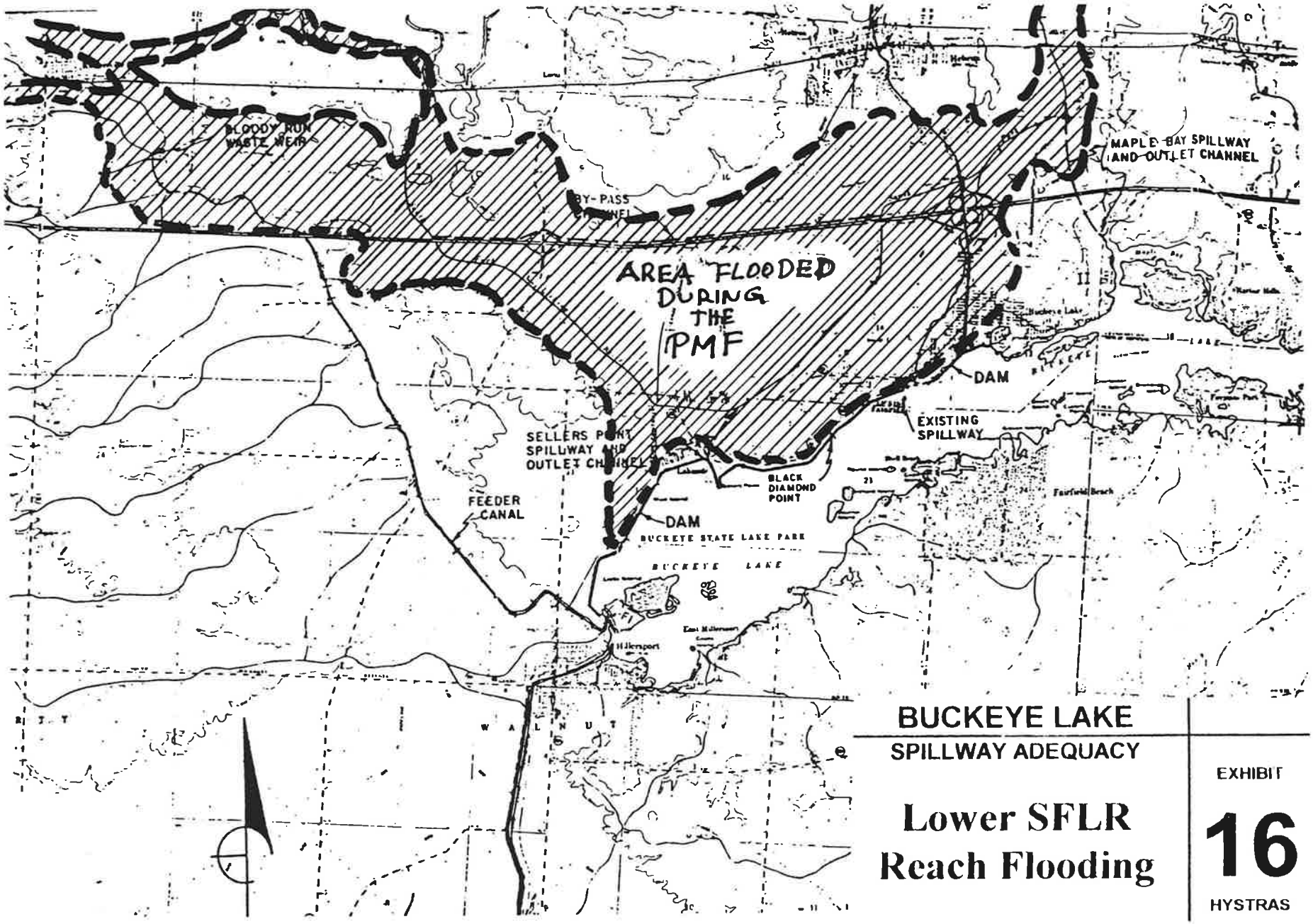


BUCKEYE LAKE

SPILLWAY ADEQUACY

Hydrographs for PMP Best Fit over Center of Drainage Area

EXHIBIT **15** HYSTRAS



BUCKEYE LAKE

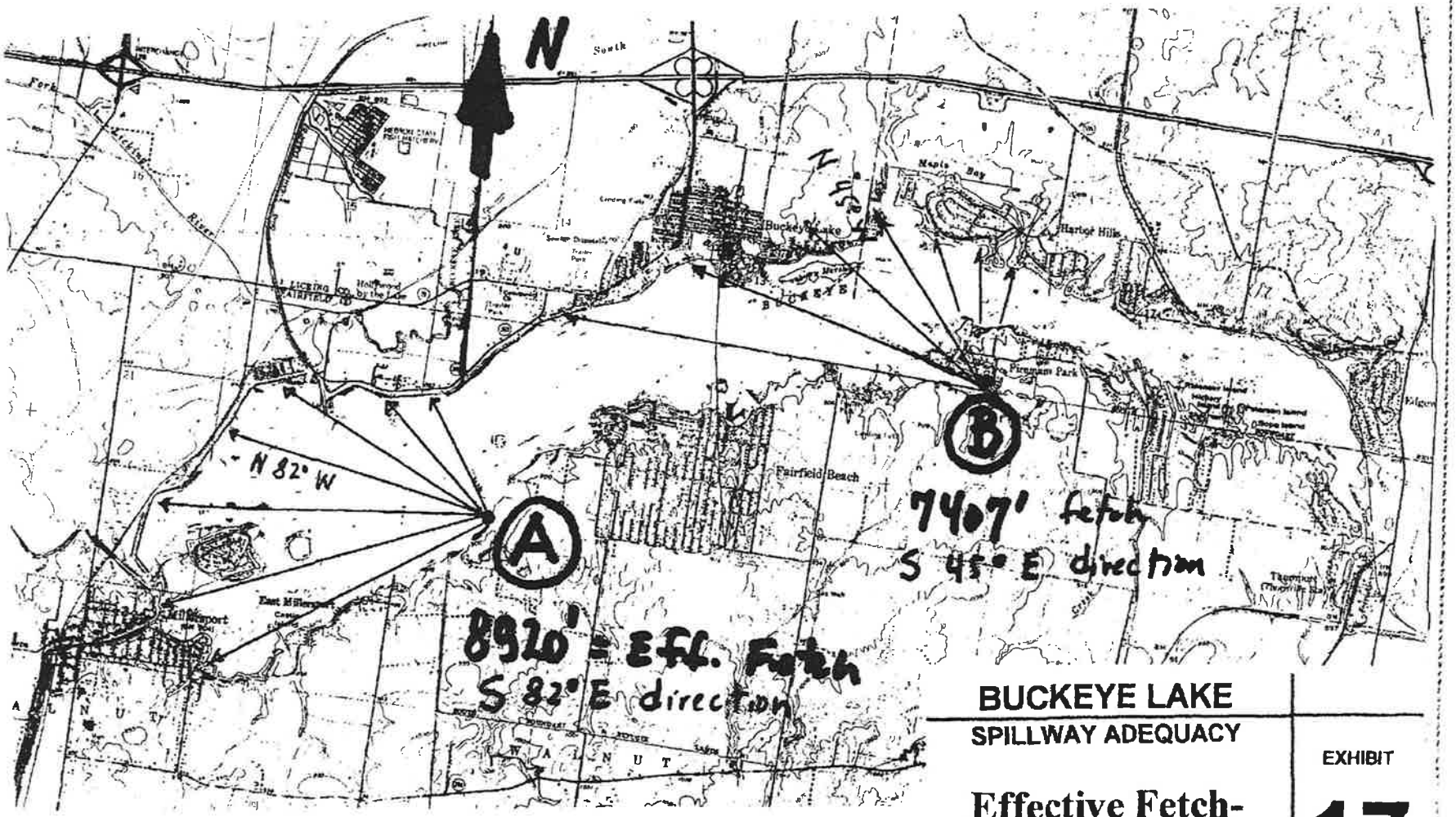
SPILLWAY ADEQUACY

Lower SFLR Reach Flooding

EXHIBIT

16

HYSTRAS



BUCKEYE LAKE

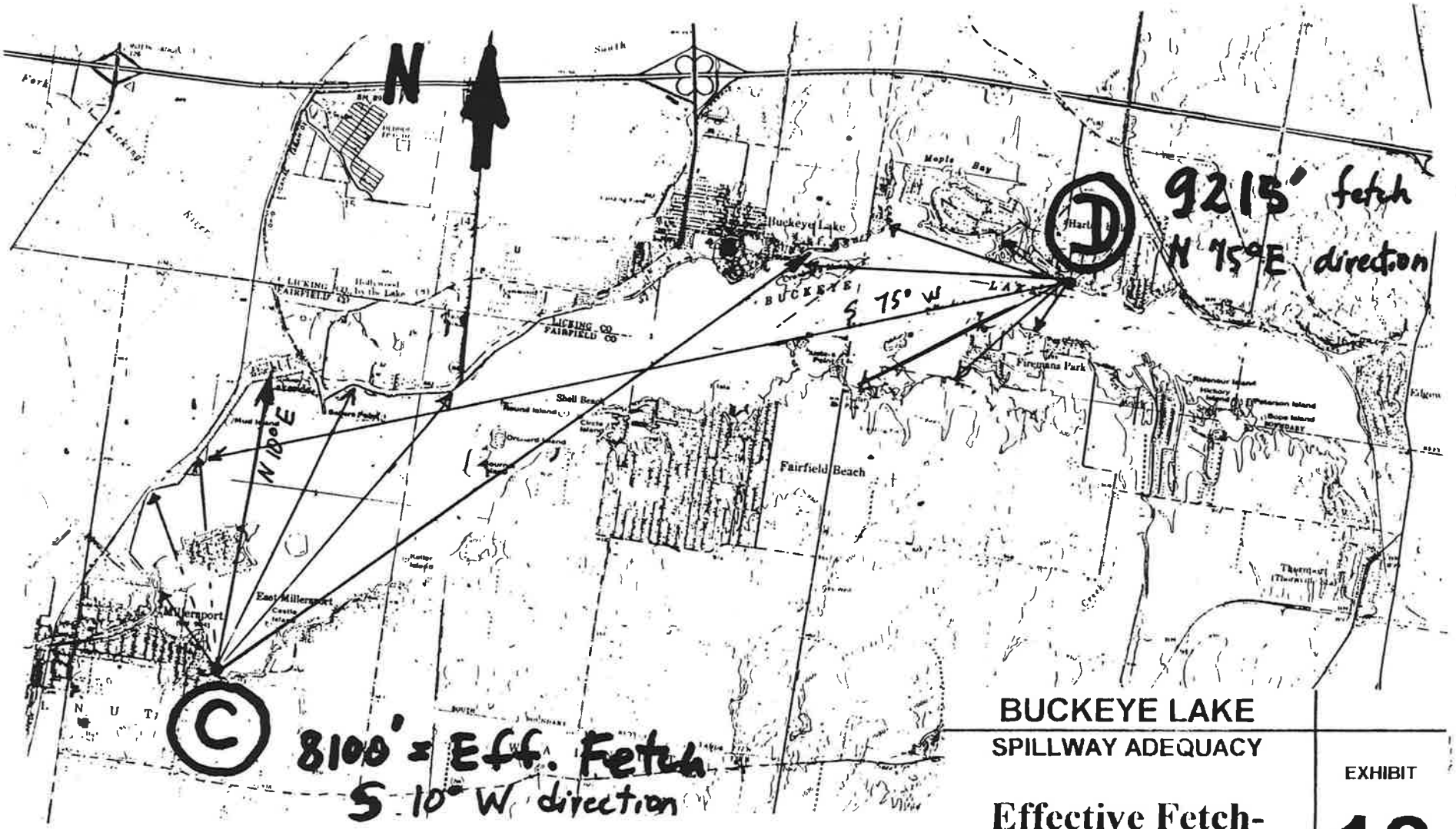
SPILLWAY ADEQUACY

Effective Fetch- Locations A and B

EXHIBIT

17

HYSTRAS



BUCKEYE LAKE

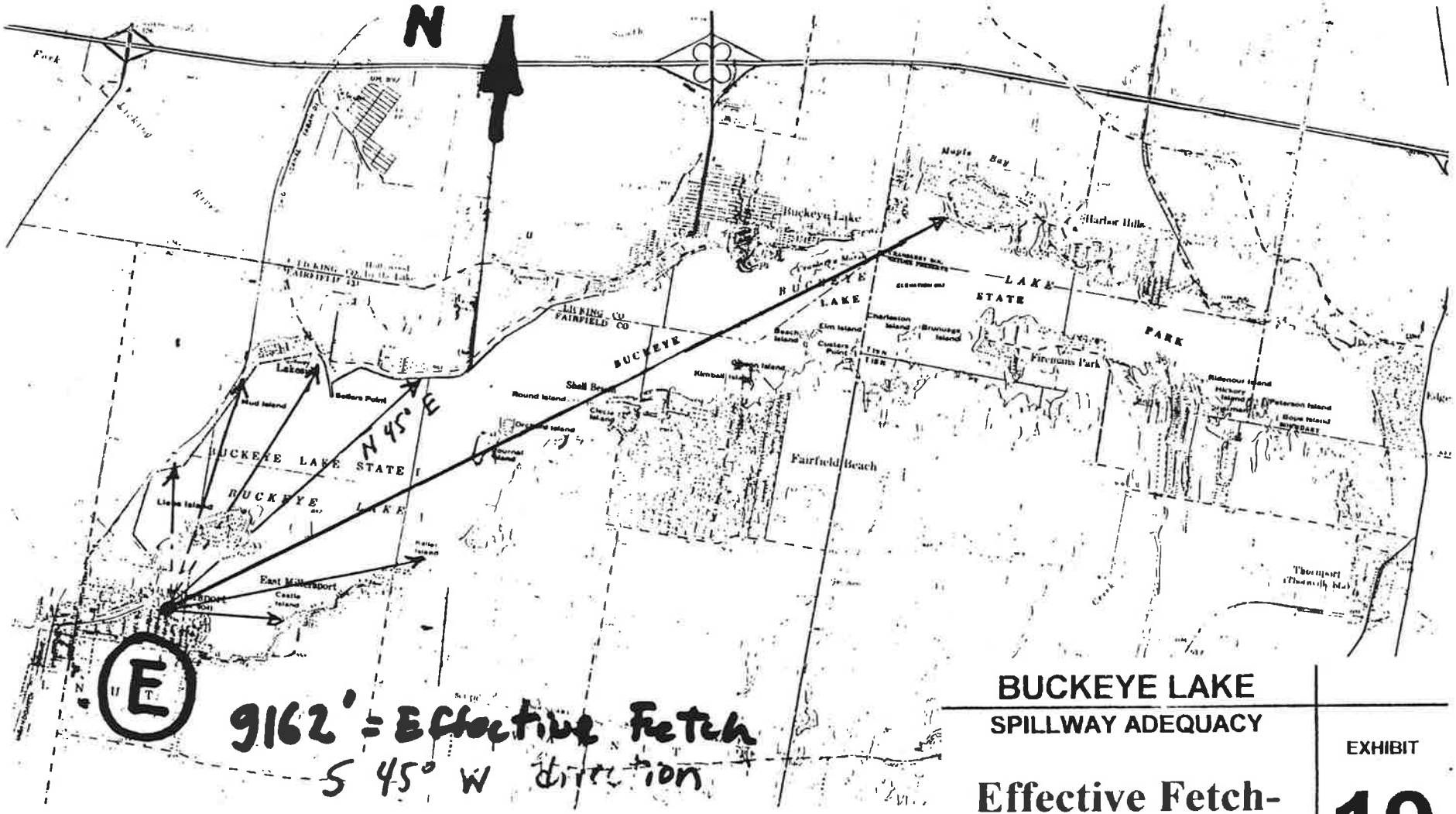
SPILLWAY ADEQUACY

Effective Fetch-Locations C and D

EXHIBIT

18

HYSTRAS



BUCKEYE LAKE

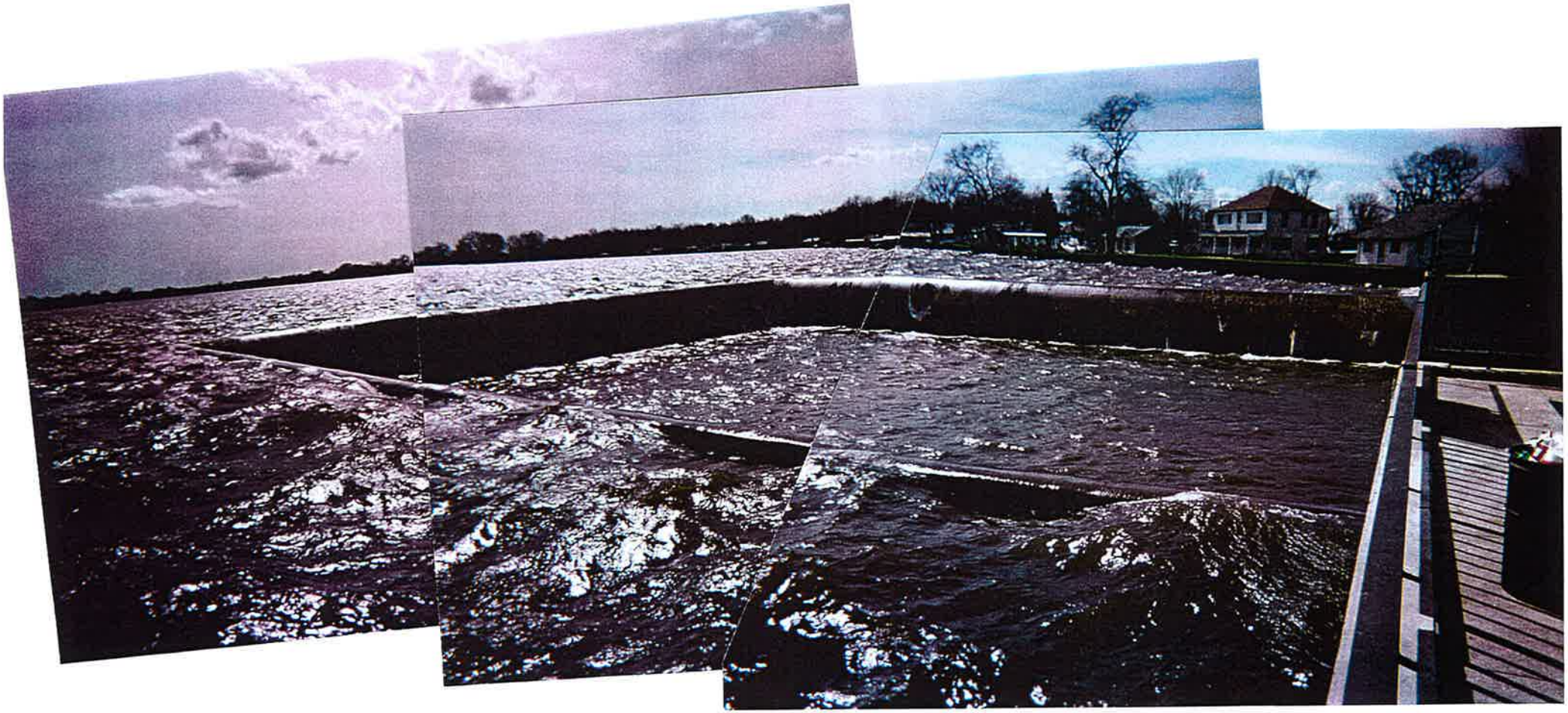
SPILLWAY ADEQUACY

Effective Fetch-Location E

EXHIBIT

19

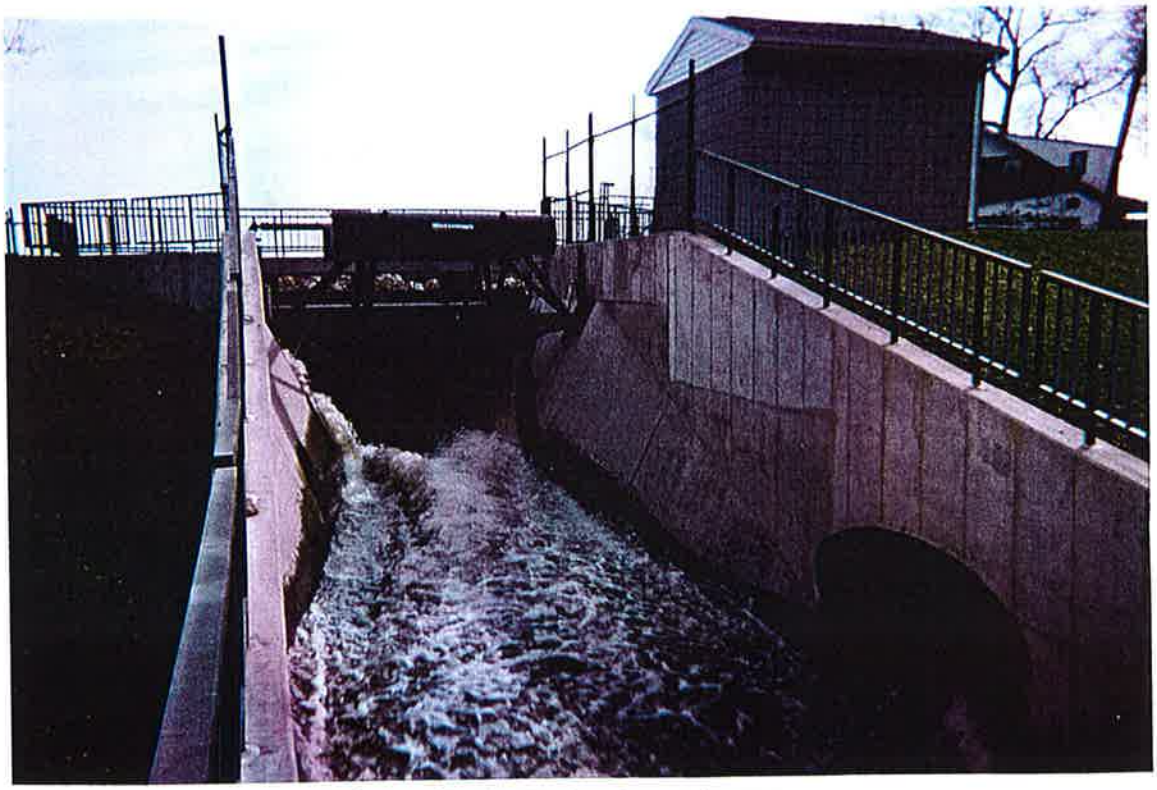
HYSTRAS



BUCKEYE LAKE

EXHIBIT 20

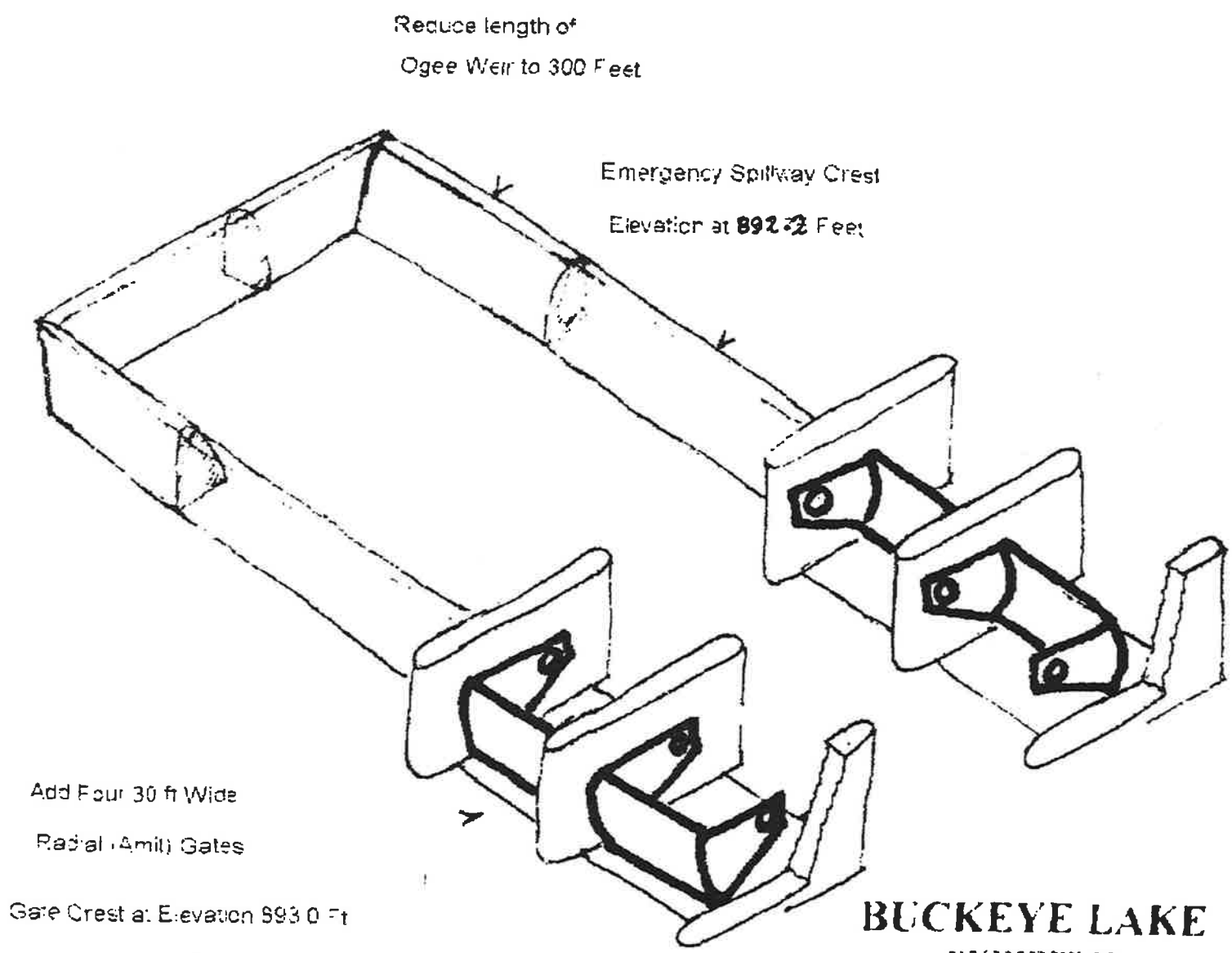
Photograph of the 1992 Spillway



BUCKEYE LAKE

EXHIBIT 21

Photograph of the Gated Outflow Structure



BUCKEYE LAKE

EXHIBIT 22

Proposed Gated Outflow Structure

at

Sellers Point