

Fuller
Mossbarger
Scott &
May



E N G I N E E R S



Technical Memo #3

PMP Modeling for Buckeye Lake

Prepared for

Ohio Department of Natural Resources
Division of Engineering

November 29, 2000

Technical Memorandum #3

PMP Modeling for Buckeye Lake

Date: November 28, 2000

To: Mark Ogden Division of Water, ODNR
Jerry Reed Division of Engineering, ODNR

From: Richard R. Noss FMSM
Susan K. Coyle FMSM

RE: South Fork Licking River Watershed Initiative
Probable Maximum Precipitation Modeling

DEC - 4 2000

Executive Summary

The Buckeye Lake Watershed's response to the Probable Maximum Precipitation (PMP) was modeled by Dodson Lindblom Associates (DLA) prior to the design of the Sellers Point Spillway (late 1980's). As part of the South Fork Licking River Watershed Initiative Project (SFLR) the DLA modeling results were re-generated and compared with PMP modeling performed for the SFLR watershed study. Although there are numerous differences in the way the models were specified and in the rainfall patterns used, the calculated peak water elevations for the PMP in Buckeye Lake are very similar – at or slightly above elevation 896.5 feet (NGVD). Both models incorporated all watersheds directly tributary to Buckeye Lake and the Kirkersville Reservoir Feeder. Both models accounted for overflows from the Feeder to the South Fork Licking River when flows exceeded the capacity of the Feeder channel. Unlike the DLA study, the SFLR study also modeled the South Fork Licking River so that river flood elevations could be estimated as well. This memo describes the PMP modeling of Buckeye Lake.

Introduction

This memorandum and the appended supporting materials summarize hydrologic modeling of the Buckeye Lake Watershed's response to the Probable Maximum Precipitation (PMP). The PMP for Buckeye Lake has been modeled twice, the first time by Dodson Lindblom Associates (DLA) prior to the design of the Sellers Point Spillway (late 1980's) and more recently for the South Fork Licking River Watershed Initiative Project (SFLR) by Fuller, Mossbarger, Scott and May Engineers. As part of the SFLR analysis of the PMP, the original DLA PMP modeling results using HEC-1 were regenerated, and the DLA HEC-1 input file was imported into HEC-HMS (HMS), the hydrologic model being used for the SFLR project. The DLA HEC-1 model was converted to the HEC-HMS (DLA/HMS) model so that a comparison of the of the DLA

and SFLR assessments of the PMP impacts could be made using the same output display capabilities.

Both PMP models are premised on two important assumptions. First, both models assume that the Buckeye Lake Dam is high enough to contain the calculated lake levels. * (There is no over-topping of the dam.) Second, both models assume that the discharge from the Sellers Point Spillway depends only on the head on the spillway.* In fact, the flooding of the South Fork Licking River due to the PMP rainfall is estimated to exceed the crest of the Sellers Point Spillway, which would decrease the amount of water that could be discharged from the lake. Consequently, the peak lake elevation would be higher than the models indicate (assuming the dam is high enough to contain the lake - i.e., assumption one).

The SFLR and DLA PMP models are discussed in Appendix A. Differences between the two models are discussed in the Appendix B.

Summary of DLA HEC-1 and HMS Model Results

The DLA HEC-1 model input file was imported to HEC-HMS. The output from the DLA/HMS model was compared with the output generated from running the input file in HEC-1. The results from HEC-1 and HEC-HMS are virtually identical. It was concluded that the DLA/HMS model accurately recreates the DLA HEC-1 modeling and can be used in comparisons between the PMP modeling performed by DLA and the PMP modeling performed for the current South Fork Licking River Watershed Initiative Project.

Summary of SFLR HMS Modeling

The SFLR Project modeled the PMP with a hydrologic model of the entire South Fork Licking River Watershed. The National Weather Service procedure for generating the PMP used in the SFLR/HMS model put more rainfall over the areas near the Lake (26.7 inches) and less rainfall over outlying areas than the DLA/HMS model. Also, the bulk of the SFLR/HMS model rainfall occurs significantly earlier in the PMP than in the DLA/HMS model. Overall the average PMP rainfall in the SFLR model was 23.1 inches compared with the uniform 23.7-inch rainfall used in the DLA PMP model. The average curve number for calculating runoff in the SFLR model was 84.4 for watersheds immediately tributary to the lake, compared to the average curve number of 83.0 in the DLA model. The higher curve numbers in the SFLR model produce greater runoff from tributary watersheds.

As the lake level rises, less flow can enter the lake from the Kirkersville Feeder. The response of Buckeye Lake is almost entirely the result of rainfall directly onto the lake and runoff from the lake tributaries. Buckeye Lake receives more runoff from the Kirkersville Feeder in the DLA model.

PMP Simulation Results

The water surface elevations of Buckeye Lake during the PMP, as calculated by the DLA and SFLR models, are graphed in Exhibit 1. Except for the rising limb of the graph, the elevations are almost identical. The differing rainfall patterns account for the faster rise in the lake elevation in the SFLR PMP model. The inflow hydrographs to the lake, which are presented in Exhibit 2, show the timing of the peak runoff rates. The early peak of the SFLR rainfall accounts for the differing inflow hydrographs and for the difference in lake elevations during the early portion of the storm. The outflows from the Sellers Point Spillway are presented in Exhibit 3. Again, except for a small portion of the rising limb of the hydrograph, the two graphs are similar. The SFLR PMP spillway outflow hydrograph is higher because the lake reaches a slightly higher peak elevation.

Exhibit 4 summarizes some of the input and output data from the DLA and SFLR PMP models.

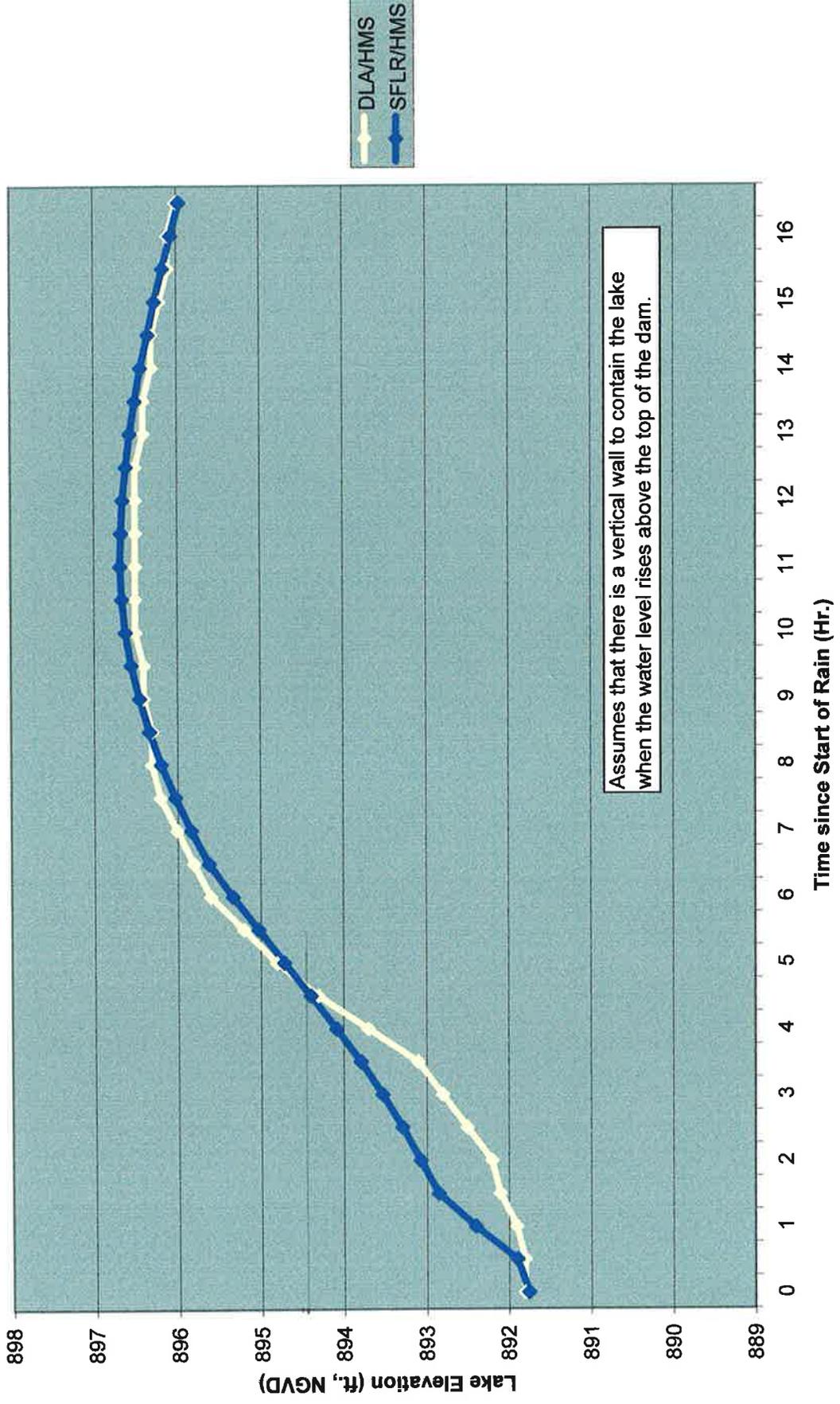
Summary

The peak lake elevations from the two PMP models are within two-tenths of a foot. The slightly higher lake elevation in the SFLR model is primarily due to the differing precipitation patterns. The SFLR/HMS PMP model used a precipitation distribution that placed greater rainfall amounts over Buckeye Lake and the closest subwatersheds than the DLA model and weighted most of the precipitation earlier during the storm. The different rainfall patterns are reflected in the inflow hydrographs to Buckeye Lake. Lake storage reduces the impact of the differences between the models, with the result that the peak lake elevations are essentially the same and peak outflows differ by less than ten percent.

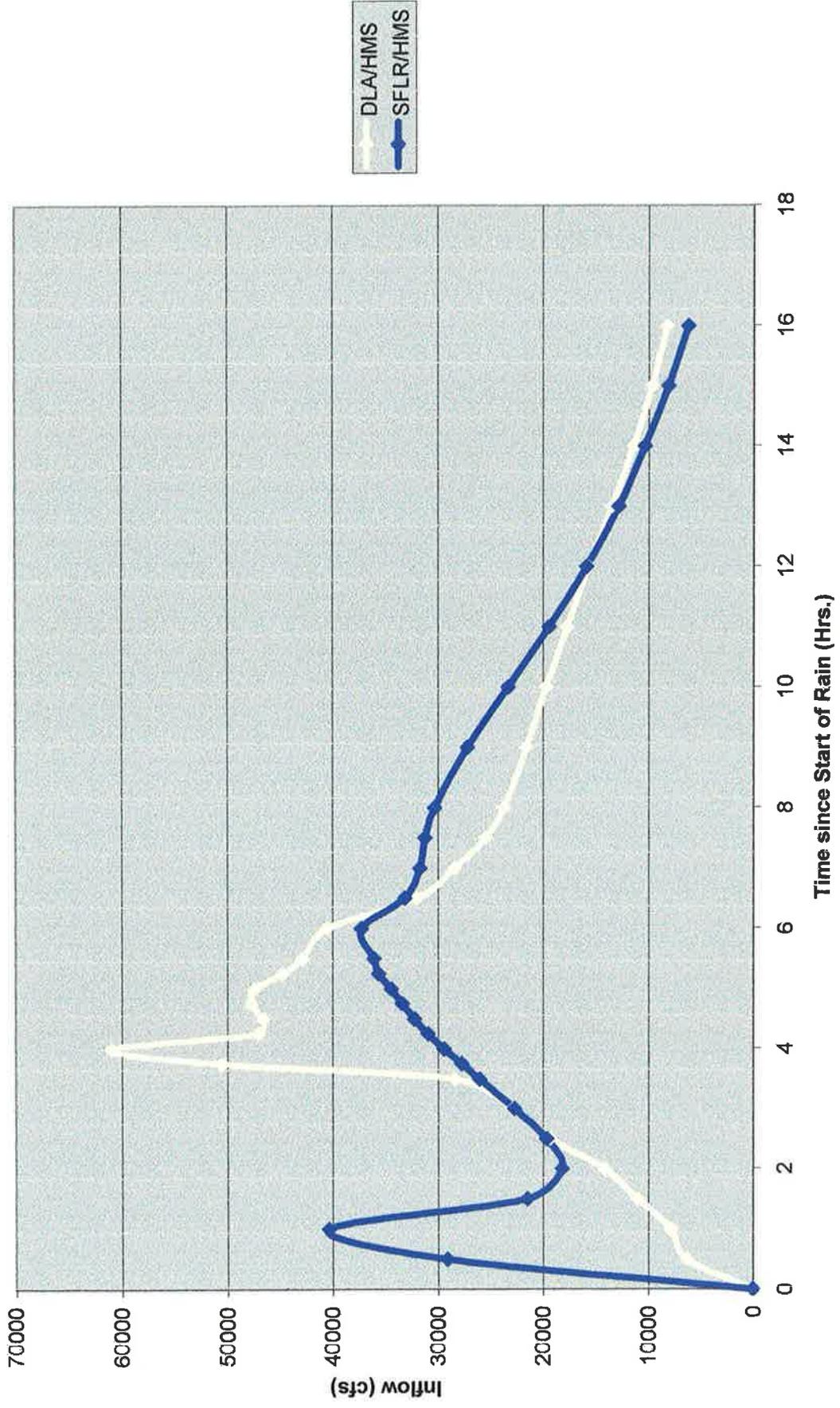
How are Inflow hydrograph dependent upon the lake elevations?

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Buckeye Lake Elevation during 6-Hour PMP



Inflow to Buckeye Lake during 6-Hour PMP



Buckeye Lake PMP Outflow from Sellers Point Spillway

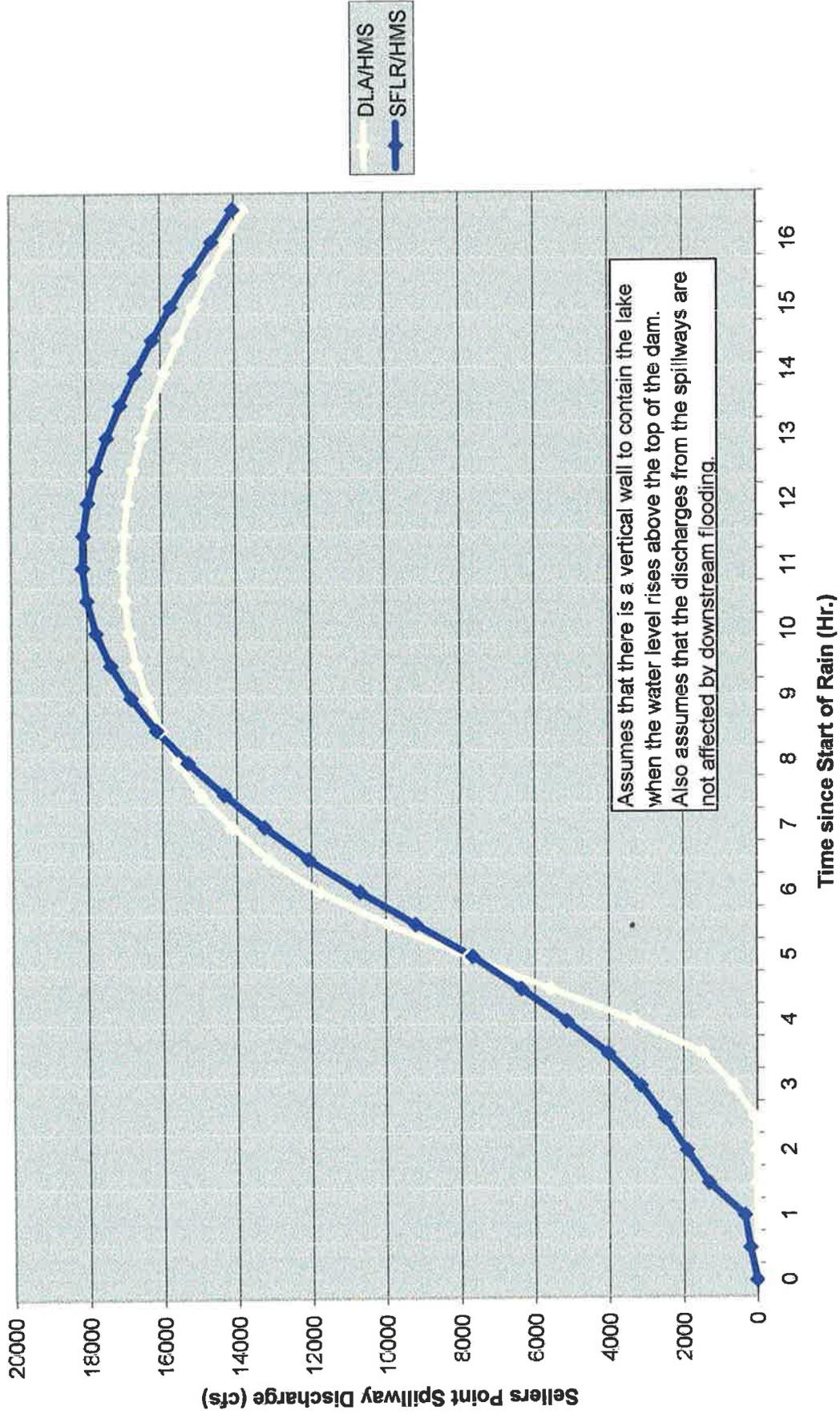


Exhibit 4

Comparison of DLA and SFLR Models of the 6-Hour PMP for Buckeye Lake

Description	SFLR PMP Model	DLA PMP Model *
Peak Lake Elevation (NGVD) and Time (hrs.) after Start of Rain	896.68' at 11:12	896.5' at 10:45
Peak Storage in the Lake above elev. 891.75'	16,272 acre-ft	15,209 acre-ft
Peak Outflow and time	18,716 cfs @ 11:12	17,621 cfs @ 10:45
Peak Inflow and time	41,043 cfs @ 1:06	60,952 cfs @ 4:00
Total Inflow Volume (over entire lake watershed)	13.81 in.	14.43 in.
Average Precipitation over the Lake & Feeder watersheds	23.1 in. (ranged from 26.7 to 20.8)	23.7 in.
Precipitation Pattern	varied over watershed and varied intra-storm as prescribed by NWS HR-52	constant over watershed; used intra-storm pattern similar to SCS Type II
Starting Lake Elevation (NGVD)	891.75'	891.75'
Reservoir Feeder Subwatershed	16.54 sq.mi.	16.74 sq.mi.
Buckeye Lake Tributaries (excl. Feeder)	22.53 sq.mi.	23.09 sq.mi.
Buckeye Lake Area	4.63 sq. mi.	4.31 sq.mi.
Total Buckeye Lake Watershed	43.7 sq.mi.	44.14 sq.mi.
Average Curve Number	84.4	83.0
Runoff from Kirkersville Feeder (volume from Feeder watershed)	1.39 in.	3.11 in.
(normalized to entire lake watershed)	0.53 in.	1.18 in.
Assumed Capacity of Kirkersville Feeder (remainder of Feeder watershed runoff diverted to the South Fork Licking River)	1000 cfs	2000 cfs

* DLA used HEC-1 to model the PMP. DLA's HEC-1 input file was entered into HEC-HMS and modeled with both HEC-1 and HMS. The DLA HMS model results are virtually identical to the DLA HEC-1 model results. The DLA HMS model results are referenced here because the format of the HMS results is clearer and some additional information is reported by HMS.

Appendix A

Descriptions of the Hydrologic Models

The following section describes the DLA HEC-1 modeling and provides graphs of modeling results to illustrate how closely the DLA/HMS PMP results reproduce the DLA HEC-1 PMP results. This comparison gives confidence that DLA's modeling results as reproduced with the DLA/HMS model can be used in lieu of the output from the HEC-1 model. The SFLR/HMS PMP modeling is described following the discussion of the DLA modeling.

DLA PMP Modeling

The Original HEC-1 Model

- * Dodson Lindblom Associates (DLA) modeled the Buckeye Lake watershed with HEC-1 to develop hydrographs of runoff into the lake for storms ranging from a 2-year recurrence interval storm (1.9 inches in 6 hours) to the probable maximum precipitation (PMP) (23.6 inches in 6 hours). Releases from the lake were based on the combined flow through the Amil Gate and the Sellers Point Spillway (with a starting lake elevation of 891.75 feet (NGVD)). The DLA HEC-1 input file modeling the PMP was imported into the Corps of Engineers' Hydrologic Modeling System, HEC-HMS (referred to below as DLA/HMS). DLA's PMP modeling results using the two models are discussed in the following paragraphs.

The Buckeye Lake Watershed includes several small streams along the south and east/northeast sides and the land adjacent to the lake. In addition, the Kirkersville Feeder Canal was constructed in the late 1820's to intercept the flow of several streams between Kirkersville and Millersport and divert their flow to augment Buckeye Lake. A schematic drawing of the subwatersheds and other hydrologic elements for the corresponding HMS model is provided in Figure A-1. In this schematic representation of the watershed, all of the runoff from tributaries to the lake, including the Kirkersville Feeder, is combined into a single runoff hydrograph at Junction 13. The rain that falls directly on the lake is converted into a hydrograph in the LAKE watershed. The runoff hydrograph at Junction 13 and the LAKE hydrograph are combined at Junction 14. The combined hydrograph at Junction 14 is used to calculate the storage and elevation of the lake during the storm and the discharge over the spillway(s) in the Dam element.

The Kirkersville Feeder is modeled with eight diversion points along its length to account for overflows (to the east) when flows exceeded channel capacity. The first seven of the eight diversion points limit flows continuing in the channel to 400 cfs. In the "real world", flow in excess of Feeder capacity overflows to the South Fork Licking River, but since the river was not modeled with HEC-1, the diversion points in the model just remove flow from the Feeder. No further accounting of the diverted flows is made. At the last diversion point, immediately upstream from the lake, 2000 cfs is allowed to pass to the

lake. These capacity limits are consistent with the results of HEC-2 modeling of Kirkersville Feeder capacity presented in the 1987 DLA report, which is the basis for the frequently-cited figure that the maximum discharge from the Feeder to the lake is 2000 cfs. Note, however, that only the largest storms (>> 100-yr) produce enough rainfall between the seventh and eighth diversion points to achieve the 2000 cfs discharge rate. (It should also be noted that the 2000 cfs capacity discharge was computed using a constant lake elevation of 893.0 feet; at higher lake levels the effective capacity of the Feeder would be reduced.)

The technical appendix to the DLA 1987 report on the Buckeye Lake Dam provides the physical data, assumptions, and calculations for the hydrologic modeling of the Buckeye Lake Watershed. DLA developed SCS curve numbers to estimate direct runoff and used Snyder's unit hydrograph procedure to calculate the runoff hydrographs from the 17 sub-basins with defined stream systems. Runoff hydrographs for the other 16 sub-basins were calculated with the SCS unit hydrograph method. Channel flows were routed by the Muskingum-Cunge 8-Point method.

The HEC-1 input file used by DLA was obtained from the ODNR Division of Water for the SFLR project and run with HEC-1 to produce the HEC-1 output that would have been produced during DLA's work. The HEC-1 input file was also imported into HEC-HMS so that the advantages of the better output presentation and additional information available from HMS could be obtained. The next section describes the conversion to HEC-HMS and compares the HMS results with the HEC-1 results.

HEC-HMS Model of DLA's PMP Runoff Hydrograph to Buckeye Lake

DLA's HEC-1 input file was imported into HMS. Hand coding was used as necessary to complete the conversion. The information imported to HEC-HMS included: late 1980's watershed conditions, channel routing by Muskingum-Cunge 8-Point (with DLA's surveyed cross-section data), and DLA's 6-hour Probable Maximum Precipitation (PMP).

DLA developed the 6-hour PMP from the "State of Ohio PMP vs. Latitude and Depth-Area Relationships for Dam Safety Analysis" (DLA 1987 Report). To do this, the 72-hour PMP (10 sq. mi.) for latitude 39.92°, 38.0 inches, was converted to a 6-hour PMP for a 44.14 sq. mi. drainage area. The 23.6 inches of rain was distributed over the 6-hour duration in 30-minute increments according to the default rainfall distribution in HEC-1 using Tables 3.1 and 3.2 of the HEC-1 Users Manual. The rainfall was uniform over the entire Buckeye Lake Watershed (including the Feeder). The resulting rainfall hyetograph is presented as Figure A-2. For the purposes of this simulation, the beginning of the storm was set at 12:00 noon. Note that almost one-fourth of the total rainfall occurs at the midpoint of the storm in the half-hour between 15:30 and 16:00.

The runoff hydrograph to the lake results from the combination of the "hydrograph" of rain falling directly on the lake and a cumulative hydrograph of the runoff from all land tributary to the lake. In Figure A-3, the two contributing hydrographs (lighter lines) and the combined runoff hydrograph to the lake are shown (DLA/HMS output). The earlier of the two smaller hydrographs is the rain falling directly on the lake. Rainfall directly to the lake produces the equivalent of a runoff hydrograph with a peak discharge of 36,644 cfs at 16:00. This input, combined with the rising limb of the runoff hydrograph of the watershed tributary to the lake, including the Kirkersville Feeder, produces a 62,000 cfs

peak inflow. The rainfall input to the lake decreases dramatically after 16:00, but the runoff from the tributary watersheds is still increasing. The result is a second peak discharge to the lake of 47,000 cfs an hour after the first peak. These double peaks match the DLA HEC-1 modeling results very closely. The hydrograph to Buckeye Lake computed with DLA/HMS is compared to the hydrograph computed by DLA's HEC-1 model in Figure A-4. The peak inflow hydrograph values from the DLA HEC-1 model and the DLA/HMS model are given in Table A-1.

**Table A-1
Combined 6-hour PMP Hydrograph to Buckeye Lake**

Characteristic	DLA HEC-1	DLA/HMS
Peak inflow (cfs)	62,494	60,952
Time of peak inflow	16:00	16:00
Secondary peak inflow (cfs)	46,431	47,452
Time of secondary peak inflow	17:00	17:00
Peak outflow (cfs)	17,604	17,621
Time of peak outflow	23:00	23:00
Peak lake elevation (feet, NGVD)	896.5	896.5

The peak discharge to the lake from the Kirkersville Feeder was 2000 cfs. This runoff occurred from 20:00 to 23:45, more than three hours after the peak of the overall runoff hydrograph to the lake.

Overflows from the Feeder were significant. Over the entire length of the channel, approximately 85 percent of the runoff generated in watersheds tributary to the Feeder was diverted to the South Fork. At the diversion points midway along the Feeder, most of the flow diversions began about three hours after the start of the rain and the longest lasted for more than a day. The peak overflow from the feeder (approximately 15,000 cfs based on the HMS results), occurred at about 22:00, 10 hours after the start of the rain.

The combined input hydrograph is routed through Buckeye Lake and discharged through a single spillway representing the combined discharges of Sellers Point and the Amil Gate. In the DLA/HMS modeling, the maximum water level in Buckeye Lake, elevation 896.5 feet, occurred eleven hours after the start of the storm. The peak discharge from the spillways was 17,621 cfs. The corresponding DLA HEC-1 values were 896.5 feet elevation, 11 hours after the start of the storm, and 17,604 cfs, respectively. The discharge hydrographs calculated by the two models are presented in Figure A-5. The data on peak outflow values are included in Table A-1.

SFLR PMP Modeling

The SFLR Project modeled the PMP with a hydrologic model of the entire South Fork Licking River Watershed that was developed and calibrated for flood events such as the

100-year (one percent chance) flood and smaller. Routing parameters and diversion tables were extrapolated to handle the increased flows resulting from the PMP. Although the model provided results for the entire watershed, only the results for the immediate vicinity of Buckeye Lake and the lake itself were reviewed.

A schematic drawing of the subwatersheds and other hydrologic elements in the vicinity of Buckeye Lake is provided in Figure A-6. In this schematic representation of the watershed, the runoff from tributaries to the lake is combined with the inflow from the Kirkersville Feeder at Junction 165. The rain that falls directly on the lake is converted into a hydrograph in watershed 9S, which is combined with the runoff from the lake tributaries prior to Junction 165. The outflow from junction 165 is the inflow to Buckeye Lake (9S) where the storage and elevation of the lake are calculated and the discharge over the spillway(s) is computed. The combined outflow from Buckeye Lake is split between the Sellers Point Spillway and the Amil Gate at the Spillways diversion node.

The Kirkersville Feeder is modeled with five diversion points along its length to account for overflows (to the east) when flows exceed channel capacity. The diversion relationships were based on the capacity of the Feeder channel, as evaluated with HEC-RAS simulations using cross sections cut from the GIS Digital Elevation Model. Because the entire South Fork Licking River watershed is modeled, flow in excess of Feeder capacity overflows to channels that lead to the South Fork between Kirkersville and the Sellers Point Spillway, and the diverted flows become part of the hydrograph in the river upstream its confluence with the Sellers Point Spillway channel. At the last diversion point, immediately upstream from the lake, 1000 cfs is allowed to pass to the lake. The capacity limit of this last section of the Feeder is lower than the capacity used by DLA. As the lake level rises, the discharge capacity of the Feeder is reduced. However, HMS cannot model a varying diversion rate. The constant 1000 cfs value is a compromise between the higher discharge rate of the Feeder early in the storm and the lower discharge capacity to the lake later in the storm.

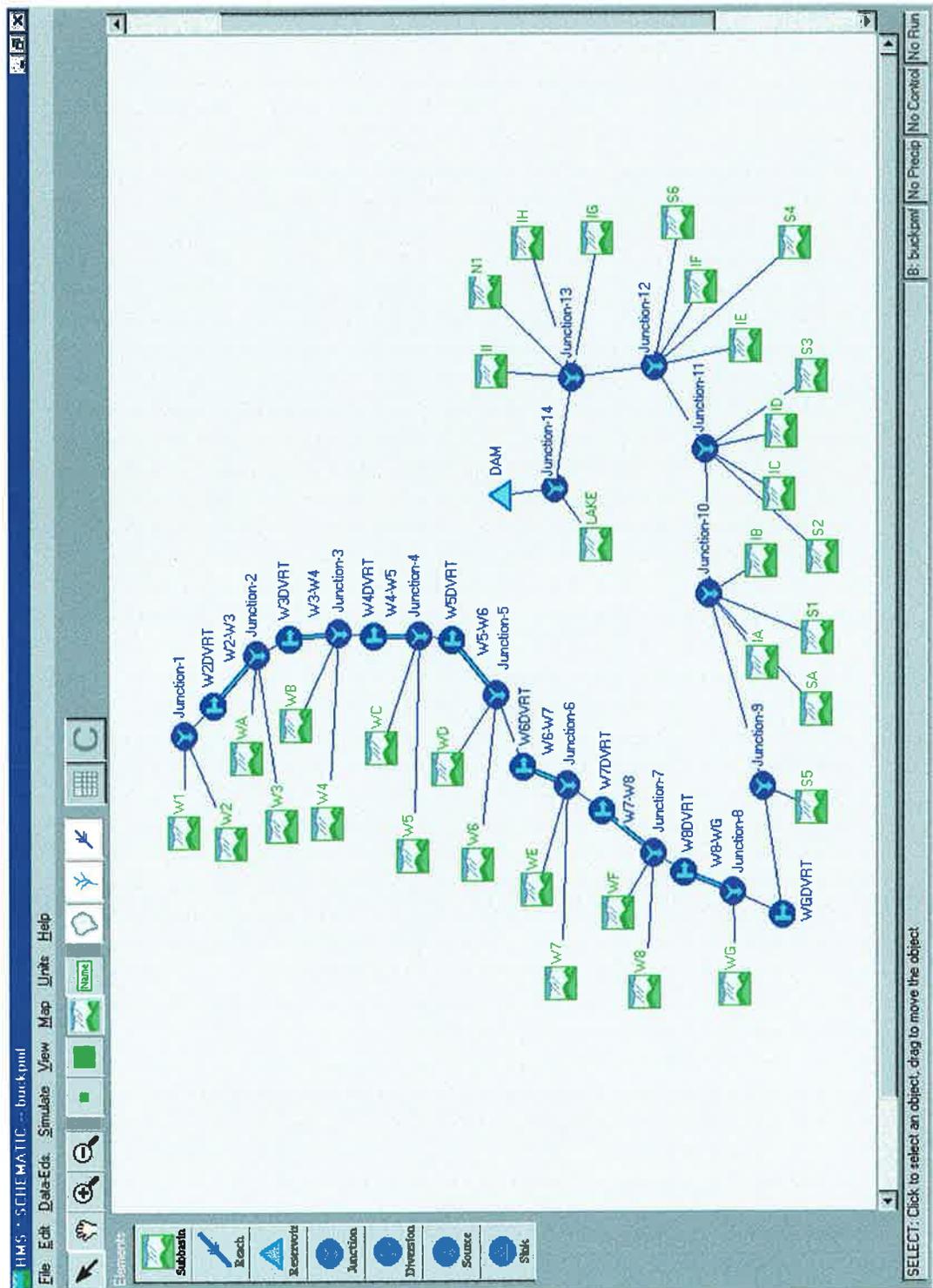
The basic modeling structure for the SFLR/HMS model was adapted from the NRCS (SCS) watershed model prepared in the late 1970's. Curve numbers were updated to reflect 1999 development. Runoff hydrographs were computed using SCS unit hydrographs. Channel routing was performed by the Modified Puls method where overbank flow and storage was judged to be important. Other channels were routed with the Muskingum method. Modified Puls relationships for the Kirkersville Feeder and South Fork mainstem channels were computed using the respective HEC-RAS models.

The SFLR/HMS model was calibrated primarily with the July 26-28, 1997 storm. Storm events in June 1990 and April 1998 were also used. Curve numbers were modified (across the board) to match runoff volumes computed from Buckeye Lake and USGS gage data. Routing coefficients were used to match the hydrographs at the USGS gage at Ridgely Tract Road and the timing of lake level increases at Buckeye Lake.

The PMP rainfall was calculated according to National Weather Service Publications HR-51 and HR-52. The rainfall volume for each half-hour of the PMP is graphed in Figure A-7. The hourly rainfall intensities are distributed over the subwatersheds as a series of concentric ellipses. Each succeeding elliptical ring, being farther from the epicenter of the PMP, is associated with a smaller total rainfall volume. The innermost ellipse ("ellipse A"), which was centered over Buckeye Lake at the Sellers Point Spillway, received 26.7 inches of rain in six hours. The total rainfall amount was distributed over

the six hours according to the procedure given in HR-52. The resulting intra-storm distribution was strongly front-weighted; 14.1 of the 26.7 inches of rain in ellipse A occur in the first hour.

The SFLR/HMS model has an area-weighted average curve number of 84.4 for the overall Buckeye Lake watershed (compared to 83.0 in the DLA/HMS model).



Schematic of Buckeye Lake Watershed including Kirkersville Feeder
 From HEC-HMS model reproducing the conditions modeled by Dodson-Lindblom Associates with HEC-1

DLA 6-Hour PMP

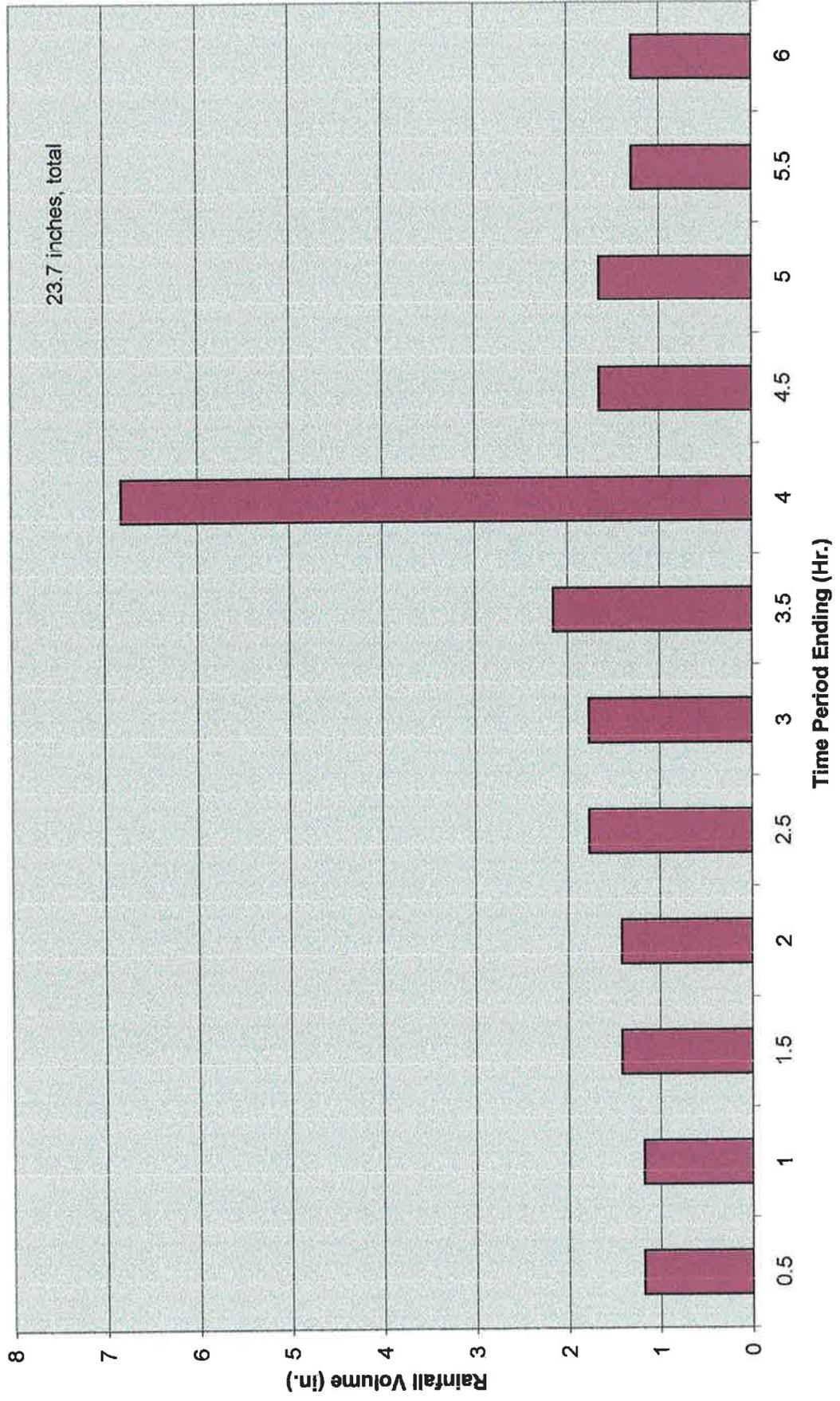
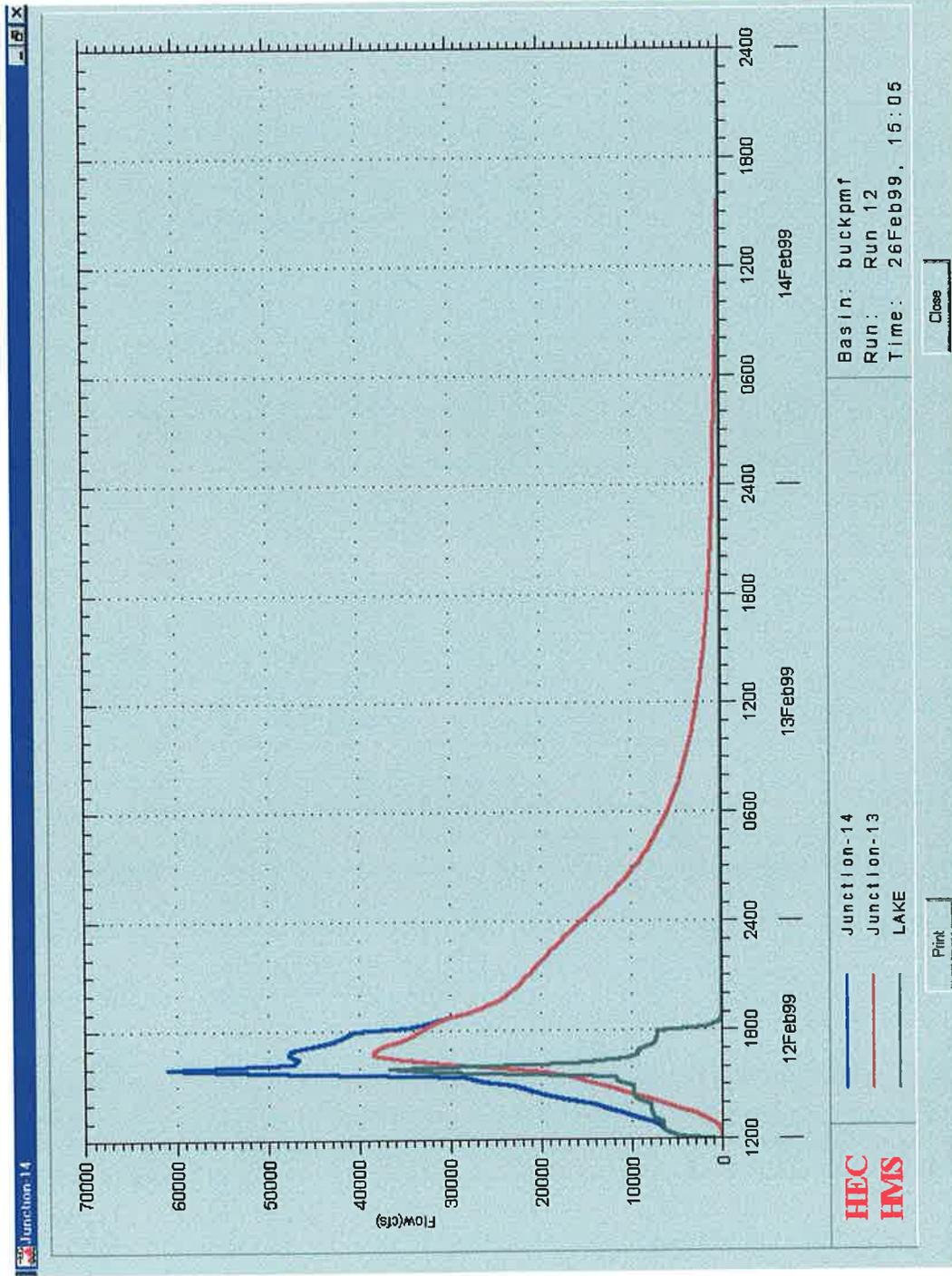


Figure A-2



DLA/HMS Model

6-hr. PMP Buckeye Lake Inflow Hydrographs

LAKE is the hydrograph from rainfall directly on the lake. (early hydrograph)

Junction 13 is runoff from all tributary watersheds and the Kirkersville Feeder.

Junction 14 is the combined hydrograph that is routed to the dam.

Figure A-3

Buckeye Lake 6-Hour PMP Inflow Hydrographs

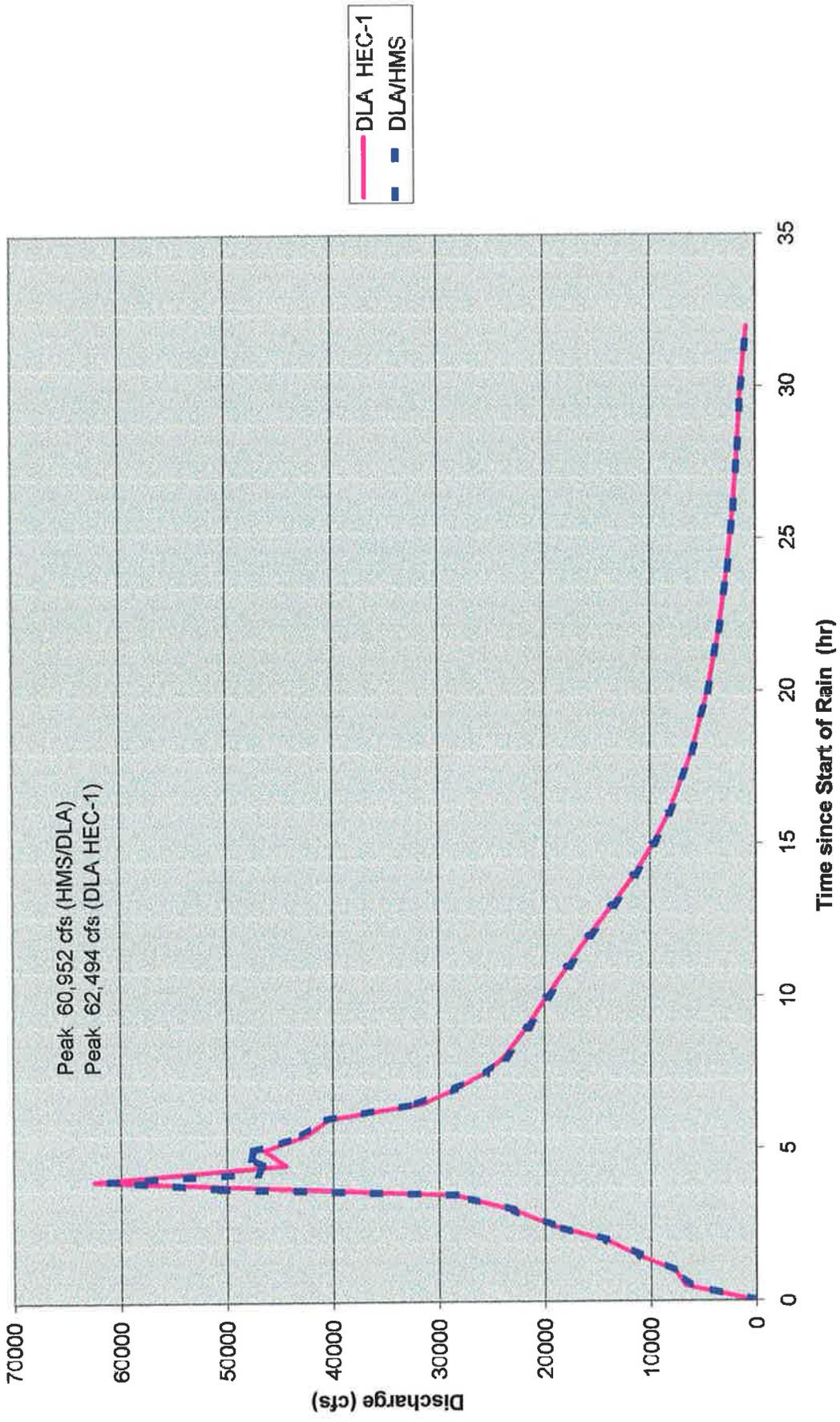


Figure A-4

Buckeye Lake 6-Hour PMP Outflow Hydrographs

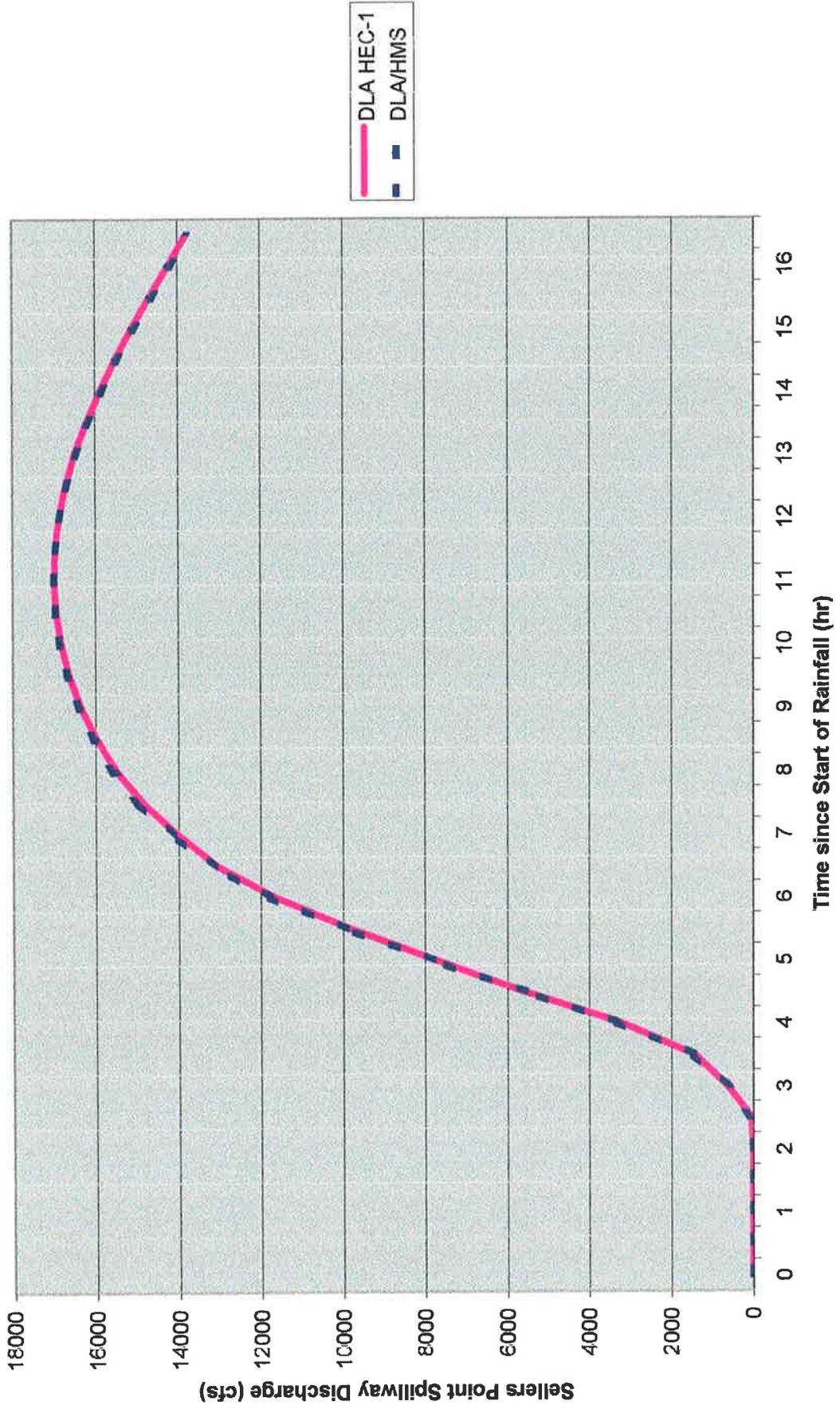
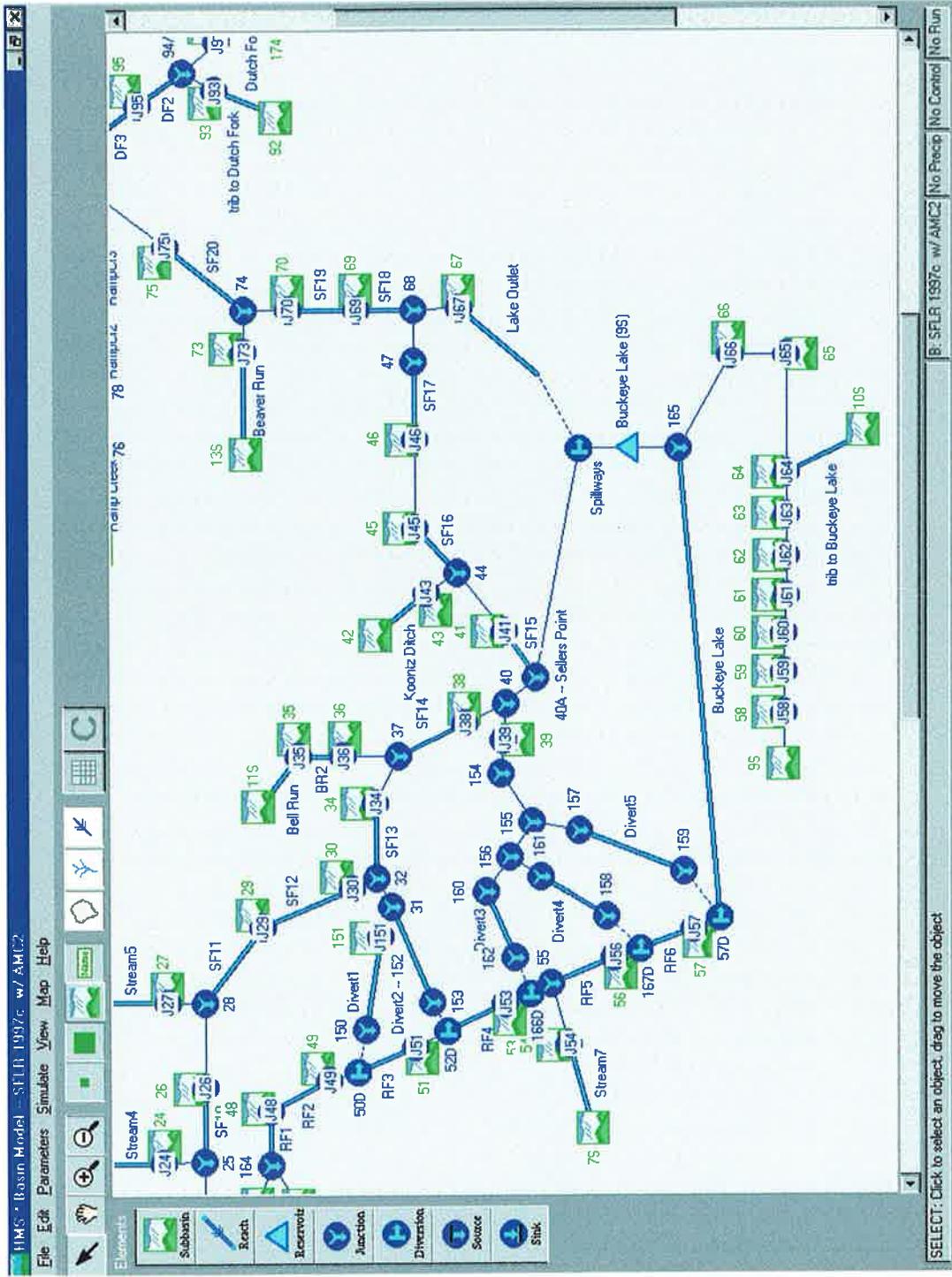


Figure A-5



Schematic of Buckeye Lake Watershed (including adjacent section of the South Fork Licking River) used in SFLR/HMS modeling

SFLR 6-Hour PMP

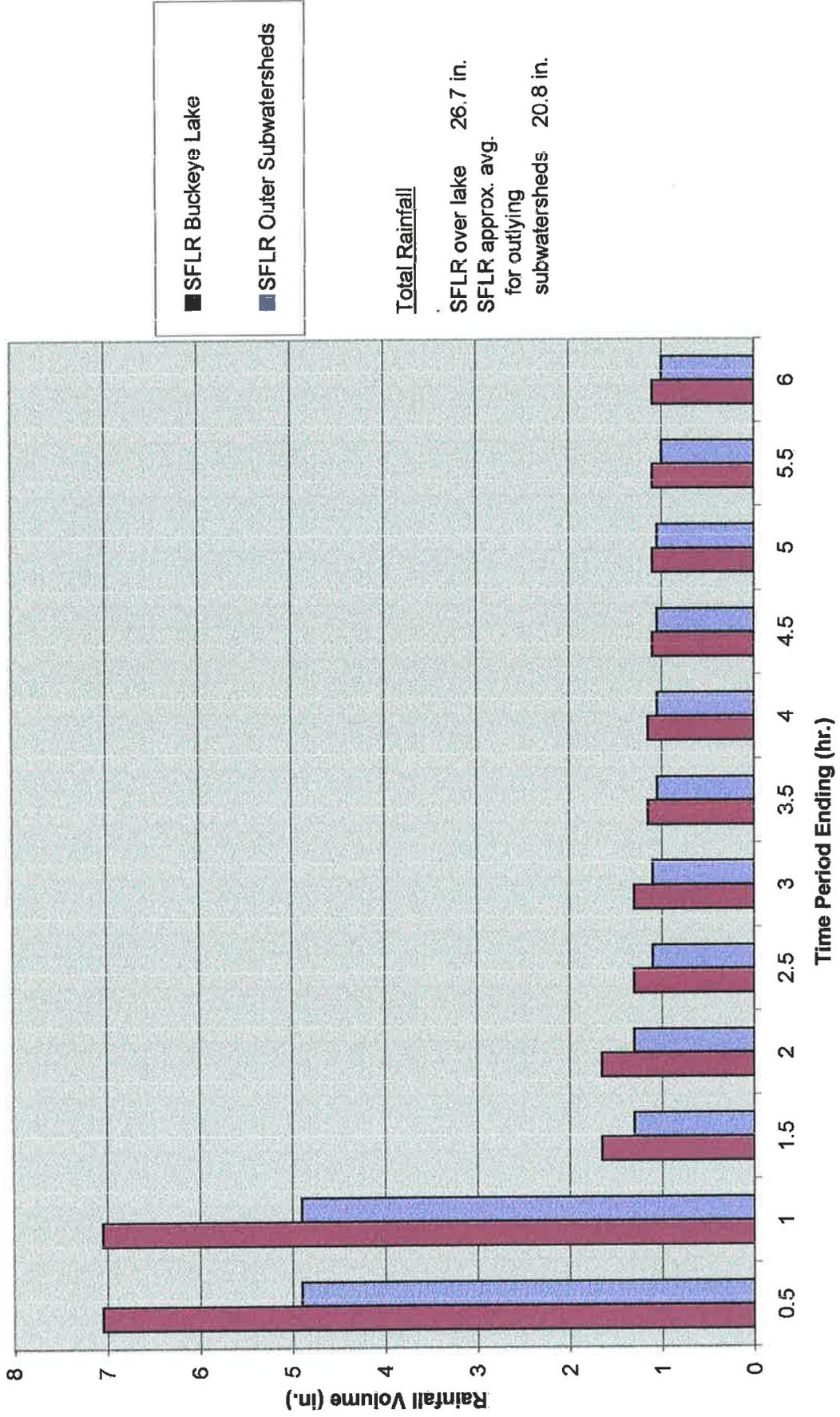


Figure A-7

Appendix B

Assumptions and Model Data

Differences between the Two PMP Models

Although the lake elevations and discharges from the spillways are quite similar (See Figures B-1 and B-2), there are numerous differences between the DLA and SFLR models. Some of the larger differences included:

- Precipitation
- Subwatershed curve numbers
- Buckeye Lake storage-elevation-outflow relationships

Smaller differences included:

- Diversions from the Kirkersville Feeder
- Subwatershed locations and sizes
- Routing
- Unit hydrograph generation

The model specifications and input data are discussed in the above order in the following sections:

Precipitation

Precipitation values were calculated according to National Weather Service Publications HR-51 and HR-52. ("Probable Maximum Precipitation Estimates, United States East of the 105th Meridian" and "Application of Probable Maximum Precipitation Estimates – United States East of the 105th Meridian," respectively) The hourly rainfall intensities are distributed over the subwatersheds as a series of concentric ellipses. (See Figure B-3.) Each succeeding elliptical ring, being farther from the epicenter of the PMP, is associated with a smaller total rainfall volume. The innermost ellipse ("ellipse A"), which was centered over Buckeye Lake at the Sellers Point Spillway, received 26.7 inches of rain in six hours. Kirkersville, the farthest portion of the Feeder watershed, was in ellipse J and received 12.6 inches of rain in 6 hours. The total rainfall amount was distributed over the six hours according to the procedure given in HR-52. The resulting intra-storm distribution was strongly front-weighted; 14.1 of the 26.7 inches of rain in ellipse A occur in the first hour. These rainfall distributions were implemented by coding rainfall gages A through J and then weighting the gages for each subwatershed according to which elliptical rings intersected the subwatershed and the approximate proportion of the subwatershed area in each ring.

In contrast, the DLA PMP used the Corps of Engineers default distribution, which is essentially a SCS Type-II distribution, with most of the rain occurring in the middle half-

hour of the storm duration (6.8 of the 23.7 inches occur between 3.5 and 4.0 hours of the PMP). Also, the DLA PMP uses the same rainfall distribution over the entire watershed. The SFLR/HMS model put more rainfall over the areas near the lake and less rainfall over outlying areas than the DLA/HMS model. Also, the bulk of the SFLR/HMS model rainfall occurs significantly earlier in the PMP than in the DLA/HMS model. The SFLR and DLA rainfall hyetographs are presented in Figure B-4. The resulting inflow hydrographs to Buckeye Lake were compared in Exhibit 2.

Subwatershed Curve Numbers

The volume of runoff from the subwatersheds during the PMP is determined by the curve numbers used. The SFLR/HMS model has an area-weighted curve number of 84.4 for the overall Buckeye Lake watershed. The DLA/HMS model has an area-weighted curve number of 83.0. Most of the difference in the curve numbers occurs in the subwatersheds surrounding Buckeye Lake. The differences in curve numbers for the Feeder watersheds are small. The SFLR/HMS model will generate slightly more runoff from a given precipitation amount (approximately 4% for a 7-inch rain), especially from the subwatersheds immediately adjacent to the Lake.

Buckeye Lake Storage-Elevation-Outflow Relationships

The SFLR/HMS model storage-elevation relationship for Buckeye Lake was developed from the area of Buckeye Lake measured at several elevations in the new Digital Elevation Model in the South Fork Licking River Watershed GIS. The volume in the SFLR/HMS model is about 4 percent greater than in the DLA/HMS model for elevations above 893.5. The elevation-discharge relationship in the SFLR model releases more flow than the DLA model, including at elevations where the only discharge would be via the Amil Gate. Figure B-5 graphs the two elevation-discharge relationships (combined discharge). Both models assume the Buckeye Lake Dam is high enough to contain the calculated volume and no downstream backwater interference.

Both models assume that the discharge from the Sellers Point Spillway is unaffected by the flood elevation of the South Fork Licking River. In fact, other estimates of the depth of flooding due to the PMP precipitation on the remainder of the South Fork Licking River watershed indicate that the river will rise above the spillway crest (892.2 feet) so that the spillway discharges used by the model are unrealistically high.

Diversions from the Kirkersville Feeder

The Kirkersville Feeder Watershed is almost 40 percent of the Buckeye Lake watershed, but almost all of the runoff generated in the Feeder watershed is diverted to the South Fork Licking River because the Feeder capacity is limited. Flow that overtops the Feeder's east bank continues to the South Fork Licking River. The diversion amounts and locations were determined by hydraulic analyses of the Feeder for the DLA and SFLR studies. The SFLR model diverts more water away from the upper reaches of the Feeder than the DLA model. The maximum capacity of the Feeder to Buckeye Lake is

higher in the DLA model (2000 cfs vs. 1000 cfs) because a lower lake elevation was used in the hydraulic analyses.

A quick sensitivity analysis was run on the assumed Feeder capacity to Buckeye Lake. For the PMP, the peak lake elevation rises by approximately 0.1 foot for every 1000 cfs increase in the flow to the lake.

Subwatershed Locations and Sizes

The Feeder and Lake watersheds are divided into subwatersheds differently in the two models, but these differences do not influence the overall watershed behavior for a large event such as the PMP.

Routing

The SFLR/HMS model was developed with Modified Puls routing for the river and stream reaches where overbank flow and storage appeared to be significant. In calibrating the SFLR/HMS model to the July 26-28, 1997 storm, it was clear that significant attenuation of flood peaks occurs in these flat, broad floodplains. For the smaller watersheds tributary to the lake, the effects of channel routing are probably secondary to the impacts of the large amounts of runoff generated.

Unit Hydrograph Generation

DLA developed Snyder's unit hydrograph coefficients for the subwatersheds with defined stream systems. SCS unit hydrographs were used for the smaller watersheds. The SFLR model used SCS unit hydrographs for all watersheds. Snyder unit hydrographs generally provide a slower time to peak and smaller peak runoff than SCS hydrographs. The effect of these differences is probably secondary to the impacts of the large amounts of runoff generated.

Other Notes

- The models used the same starting elevation for Buckeye Lake.
- The SFLR model included the entire South Fork Licking River Watershed. The DLA model included only Buckeye Lake and its tributary watersheds, including the Kirkersville Feeder.
- Both models were run with the same time steps (6 minutes).
- Baseflow into Buckeye Lake and in the South Fork Licking River was not included in the models.

The cumulative effect of the differences is to produce a slightly faster rising lake level and spillway discharge in the SFLR PMP model. The difference in the rainfall patterns appears to be primarily responsible for the divergence. Despite the differences in the models, the response of Buckeye Lake to the PMP and the performance of the Sellers Point Spillway predicted by the models are very similar.

Buckeye Lake Elevation during 6-Hour PMP

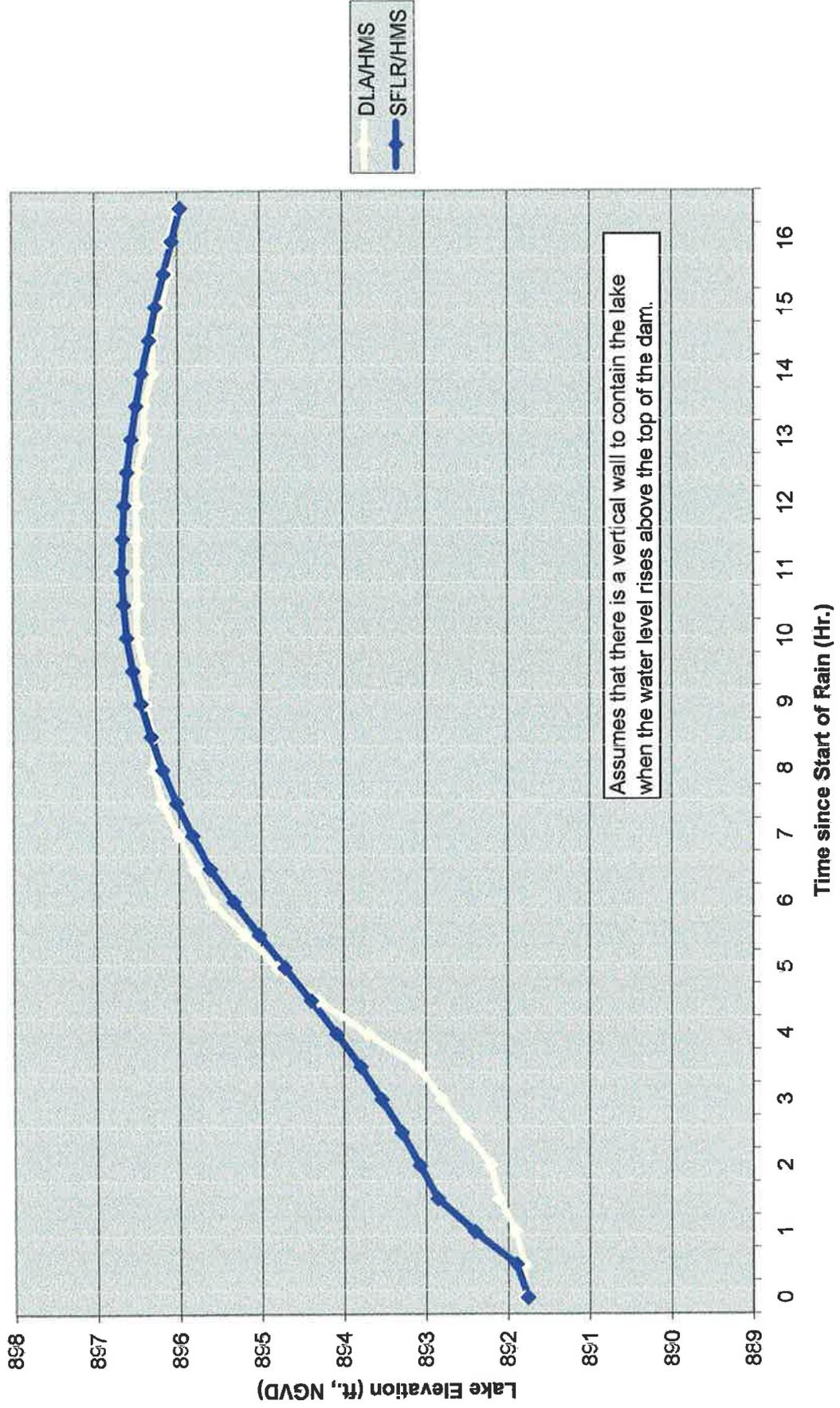
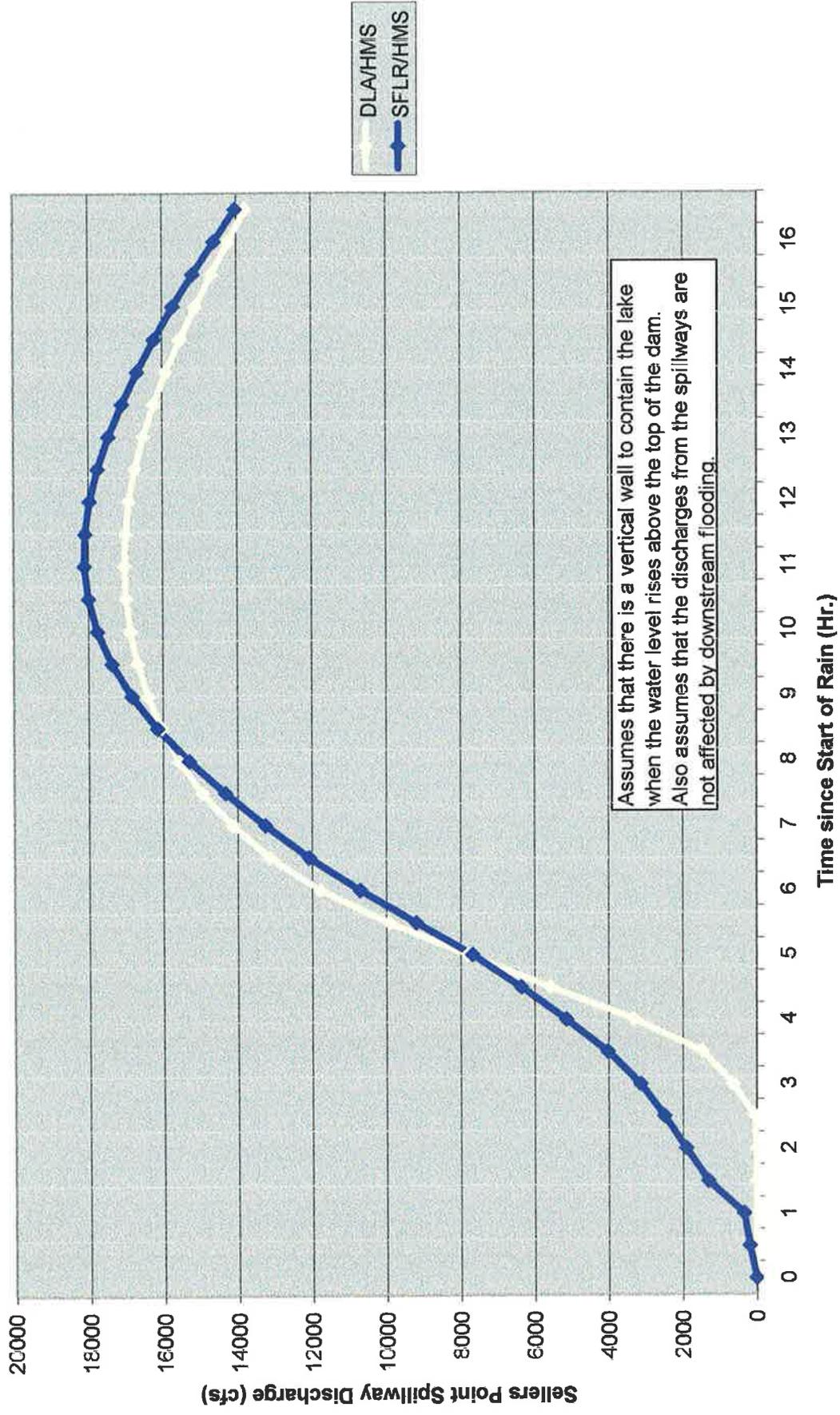
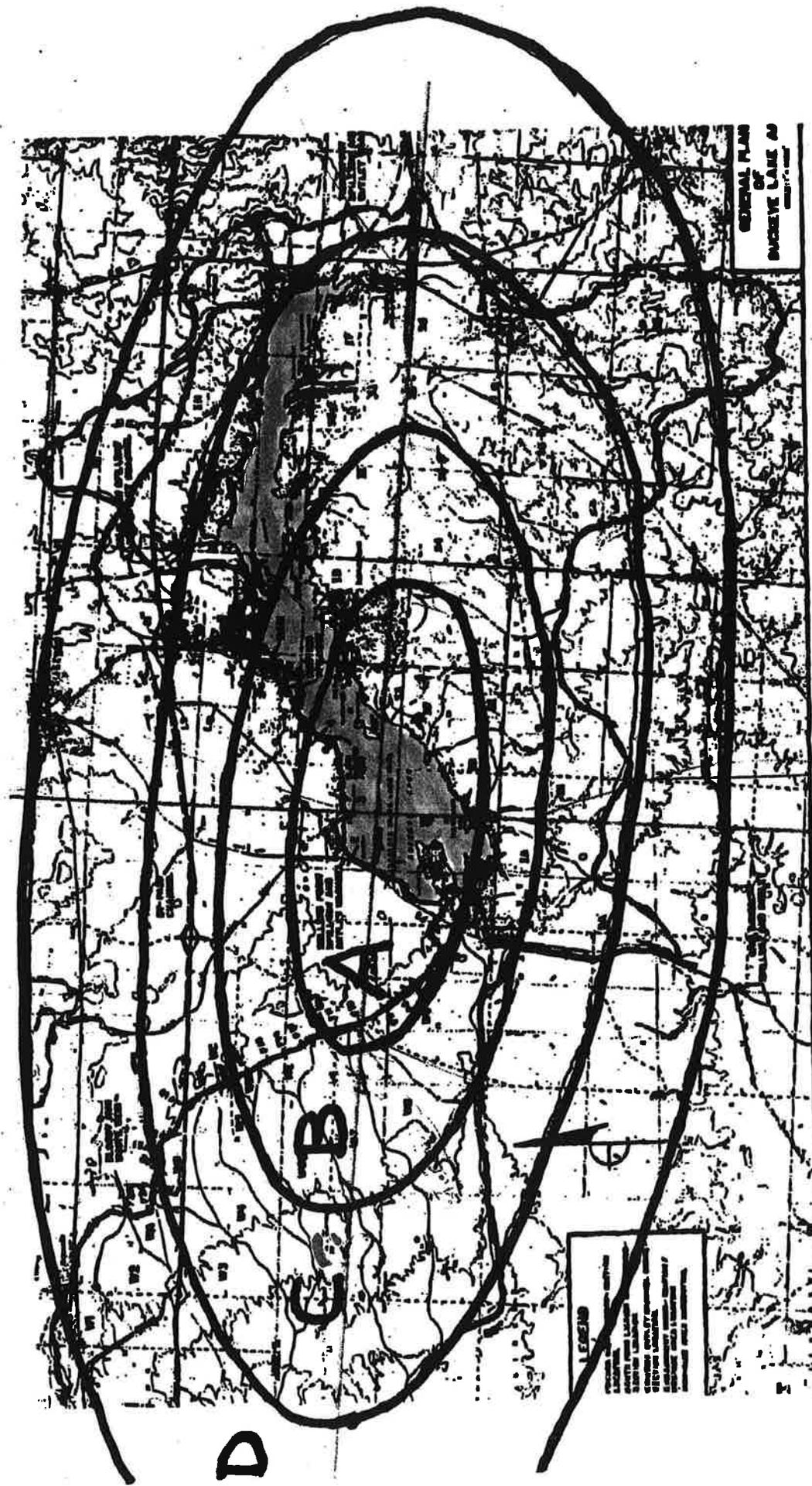


Figure B-1

Buckeye Lake PMP Outflow from Sellers Point Spillway



Assumes that there is a vertical wall to contain the lake when the water level rises above the top of the dam. Also assumes that the discharges from the spillways are not affected by downstream flooding.



Elipses of Equal PMP Rainfall Intensity

Figure B-3

Buckeye Lake 6-Hour PMP Hyetographs

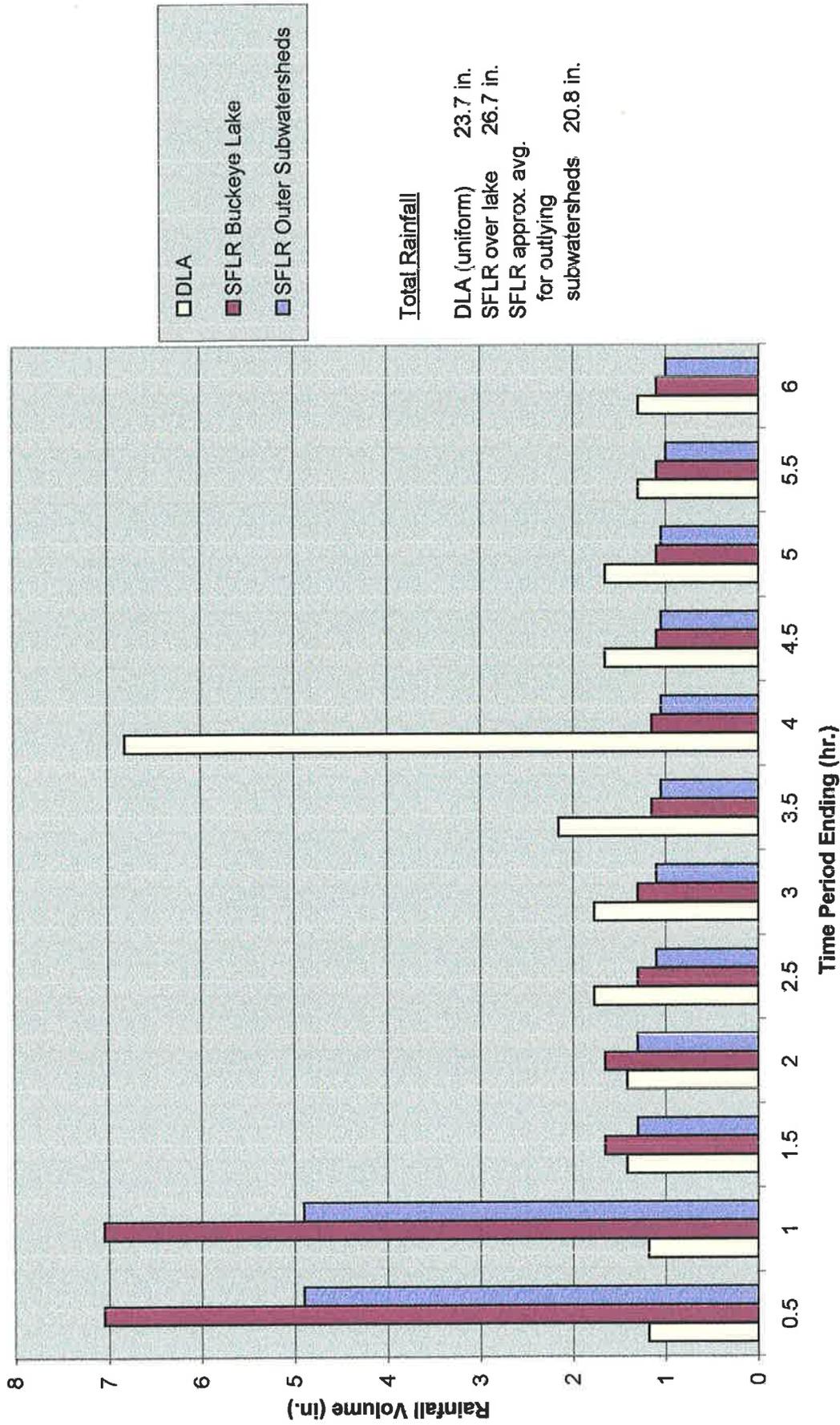


Figure B-4

Sellers Point and Amil Gate Combined Discharge Curve

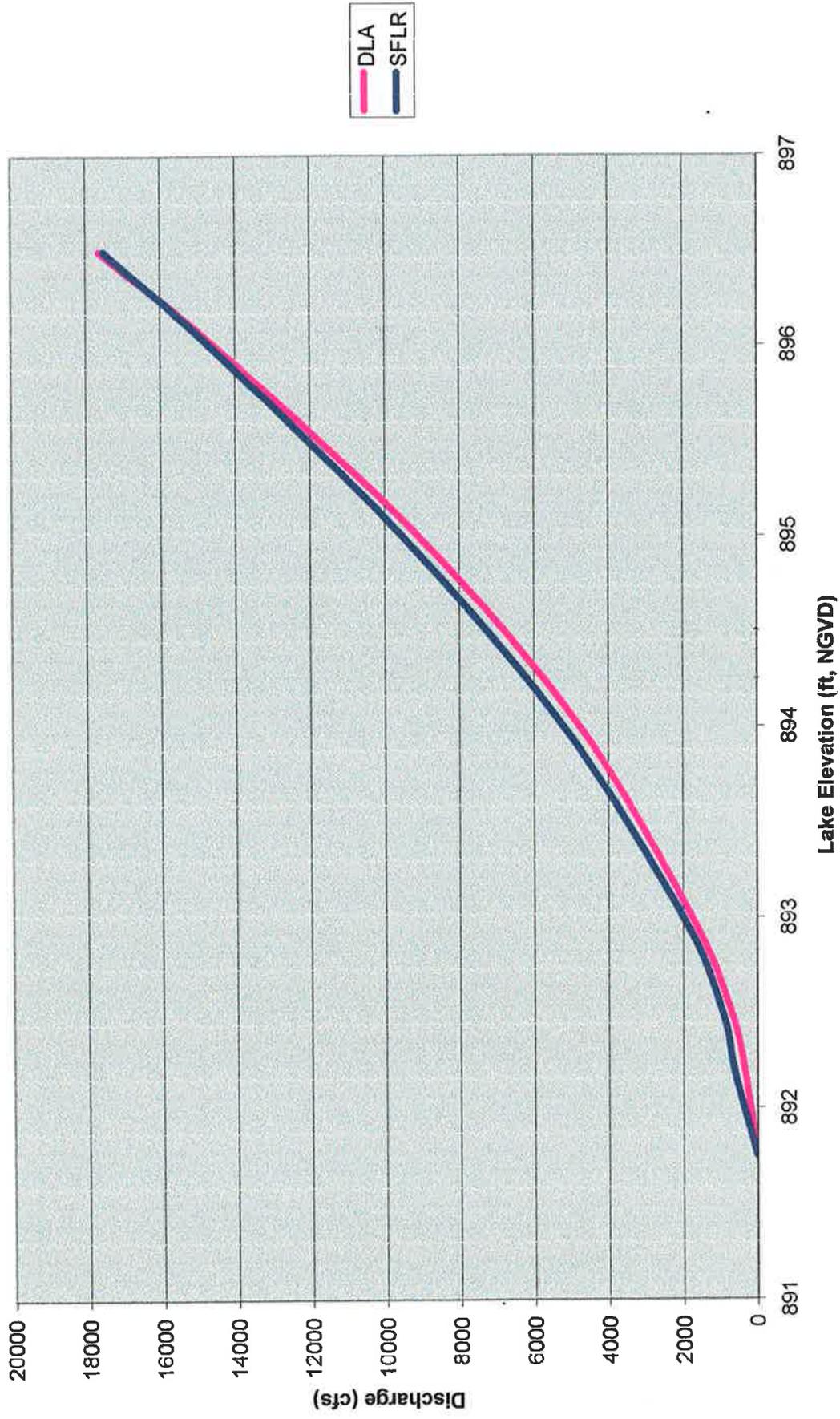


Figure B-5

Appendix C

SFLR/HMS PMP CD-ROM