Letter of Map Revision

White Lake
City of Reno, Nevada

Prepared for:
City of Reno, NV
July, 2009

PROFESSIONAL ENGINEER-STATE OF NEVADA
MARK E. FOREST
Exp: 6/30/11
CIVIL
No. 8022

7/8/09

HDR

9805 Double R Boulevard, Suite 101
Reno, NV 89521
(775)337-4700

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Background and Purpose

In June 2006 the Regional Planning Commission for the City of Reno Nevada adopted amendments to its master plan including modifications to an Annexation Settlement Agreement (ASA) between Washoe County, City of Reno and City of Sparks. One result of this Regional Plan modification is a change to the boundaries of the Metropolitan Service Area (MSA) boundary (also known as the Truckee Meadows Service Area) and the Spheres of Influence for the Cities of Reno and Sparks. The current ASA adds requirements for facility plans to cover water supply, sanitary sewer, flood management, transportation, police, parks, and schools.

One area included in the expanded MSA is a small suburban community known as Cold Springs. Approximately 18 miles north east of Reno, Cold Springs borders an approximately 1.8 square mile desert playa lake known as White Lake. The lake is bounded to the west by US 395 (Figure 1). Most significant flooding events in this area have historically been rain on snow events. White Lake receives runoff from a 29.3 square mile watershed which includes portions of Peavine Mountain, the Cold Springs Valley and Peterson Mountain. The lake is in a closed basin and the only form of discharge is evaporation and evapotranspiration. Due to highly clay soils and high groundwater table in the area it is assumed that infiltration does not significantly affect the water balance.

Because flood management is included in the facility planning for the ASA, a revision to the existing approximate Zone A floodplain boundary for White Lake is needed to provide a better floodplain management tool. The purpose of this report is to present the results of a detailed floodplain analysis for the White Lake within Washoe County, Nevada that is intended to provide the technical justification for a Letter of Map Revision (LOMR). The basis of the LOMR is technically superior methods (detailed study to replace an approximate study) and better topographic data. The existing Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) show an approximate Zone A for the lake in this study. The existing mapping is based on the USGS 7.5 minute quadrangle sheets. Urban planning efforts by the City of Reno have created the need for Base Flood Elevations (BFE) and a more refined floodplain for White Lake. This study is being funded by the City of Reno to aid in flood management planning for the floodplain area.

White Lake is a hydrologically closed system and therefore methods for determining peak flood inundation limits differ from a standard approach. A hydrologic analysis entitled *Hydrologic Analysis of Silver Lake and Lemmon Valley Playas* was conducted for FEMA in 1987 (FEMA contract #EMW-86-C-2239). Both Silver Lake and Lemmon Valley Playa are hydrologically and geographically similar to White Lake. For this reason a similar methodology was used in this study to determine the 100-year peak runoff and resulting water surface elevations. Specific hydrologic methods are discussed further in Chapter 3.

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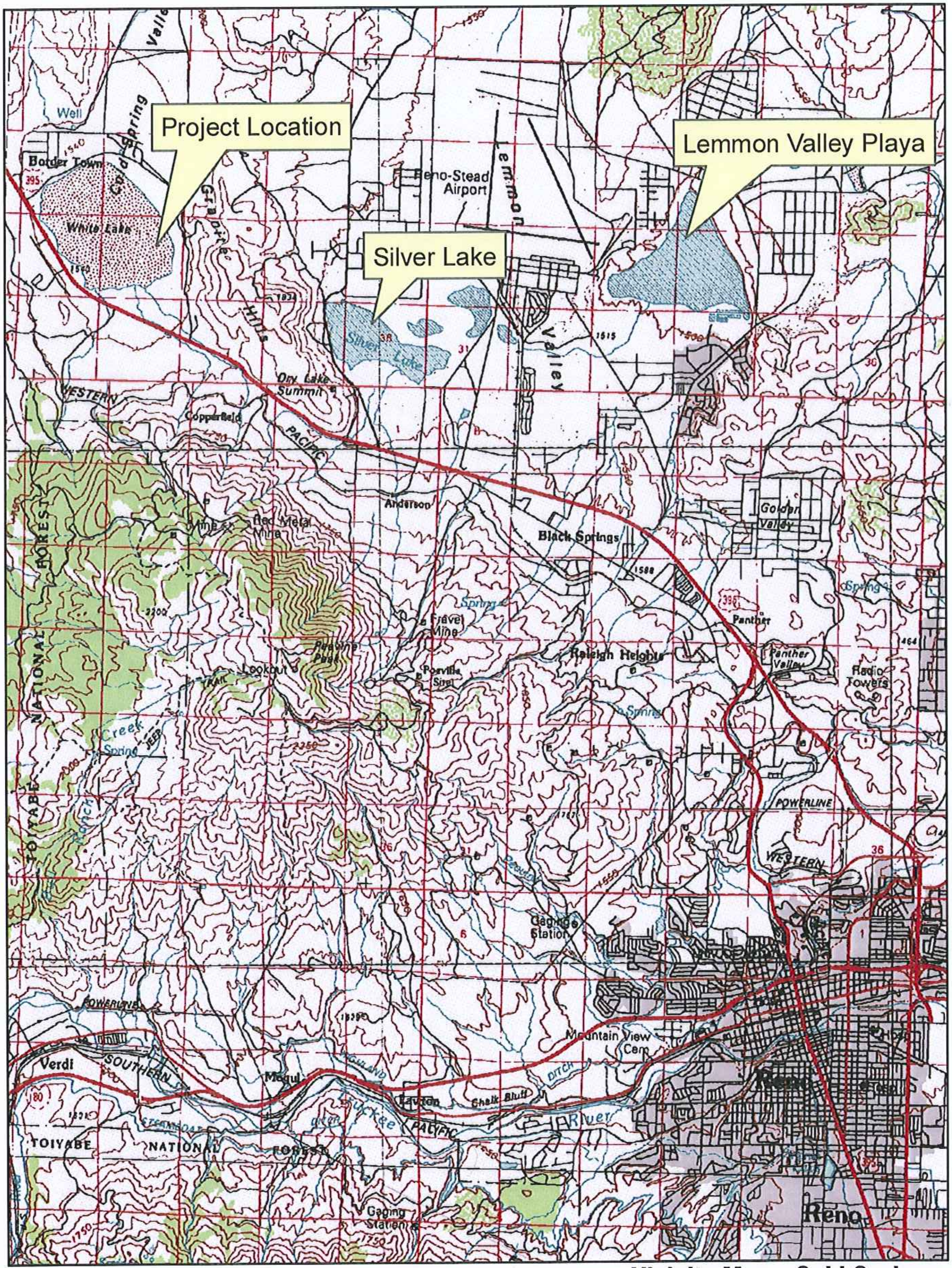

Vicinity Map - Cold Springs

FIGURE 1

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Chapter 1 - Existing Data

There are several existing studies and data that are relevant to this project. The information most relevant to the project is described below with a discussion regarding the relevance of each.

FEMA Flood Insurance Study

The Federal Emergency Management Agency (FEMA) prepares floodplain maps for the most significant flooding hazards in the communities that participate in the National Flood Insurance Program (NFIP). As a condition of participation in the NFIP, the community must adopt a floodplain ordinance which enforces the minimum requirements of the NFIP. Washoe County entered the regular program of the NFIP on August 1, 1984 after adopting a floodplain management ordinance that met the requirements of 44 CFR Parts 60 to 65. At that time a set of Flood Insurance Rate Maps (FIRM) were published. The first set of FIRMs published in 1984 showed an approximate 100-year floodplain analysis for White Lake that was based on USGS 7.5 minute topographic maps. The current FEMA FIRMs for the project area have an effective date of September 30, 1994. Copies of the current FIRM is provided in Appendix A for White Lake.

Topographic Mapping

Topographic mapping has been prepared for Washoe County and the Cities of Reno and Sparks at a 2' contour interval. This data is from 2002 and 2006. The reason for the mixed data sets is that a portion of the lake was not updated in 2006 so 2002 data was obtained. The 2004 data did not meet National Mapping Accuracy Standards so the 2002 data was used for the northwest portions of the lake (Figure 2). A visual inspection of ½ foot resolution aerial photos from both years indicates that there was no change in the study area which might affect topography. The mapping has been prepared using NAD 83 State Plane (feet) Nevada West FIPS 2703 Coordinates. The Washoe County mapping was used as the basis for the work map. The data was provided by Washoe County as point and breakline data as well as finished contours. Metadata is provided in Appendix F. Processing of this data is discussed in Chapter 3 Hydrology.

Topographic Surveys

Topographic surveys of the lake bottom were provided by Washoe County Department of Water Resources. These surveys were used to supplement the Washoe County topography below the water line in White Lake (Figure 2).

Figure 2: Topographic Data Used in TIN Creation.

Previous Studies

There were no relevant previous studies identified for the White Lake Watershed.

Similar Studies

Hydrologic Analysis of Silver Lake and Lemmon Valley Playas, (Nimbus, December 1987). This report is a FEMA re-study for the Reno/Sparks area which includes hydrologic and hydraulic analysis to determine 100-year runoff volumes and lake levels. The study utilizes precipitation and water level data collected during a 1986 flood to calibrate hydrologic models for determination of the regulatory floodplain for both lakes. This report is reproduced in Appendix E.

North Valleys Flood Control Hydrologic Analysis and Mitigation Options City of Reno and Washoe County Nevada Volumes I and II, (Quad Knopf, March 2007). This report is a detailed hydrologic report to determine the 100-year water surface elevations for Silver Lake and Swan (Lemmon) Lake Playas.

Chapter 2 - Hydrology

100-Year Peak Flow Estimates

Hydrologic Method

Because historic lake level data does not exist for White Lake a statistical analysis of lake level recurrence intervals was impossible. A hydrologic analysis using a rainfall runoff model such as the US Army Corps of Engineers' HEC-1 was therefore necessary to determine watershed runoff for the 100-year event. As stated above, the study area is similar to two desert lakes studied for FEMA in 1987 (Appendix E). For that reason a hydrologic analysis methodology outlined in the 1987 report was followed in this study.

A common procedure used to determine peak flow runoff within HEC-1 is the SCS Curve Number Method. This method uses 100-year, 24 hour precipitation with basin curve numbers to develop a peak flow estimate. This method was developed for basins with active stream channel runoff and 24 hour storm events where a simple peak flow value is used in conjunction with a hydraulics model for determining flood water surface elevations. Because White Lake is a closed basin system and the only form of "runoff" is evaporation, a peak flow method like the SCS curve number over predicts storm volume as discovered with observed data in the 1987 Nimbus study.

The 1986 storm event lasted 9 days and produced substantial flooding in the Reno/Sparks area. Detailed rainfall and lake level information was available for both Lemmon Valley Playa and Silver Lake. Using this information, a thorough calibration effort was undertaken in the 1987 FEMA re-study with HEC-1. Several methods for estimating runoff volumes were compared to observed data. The SCS Curve Number Method was used for the 1987 study and was found to over estimate observed runoff volumes by an average of 201% and water surface elevations by

2.3 feet. Another method incorporated into the HEC-1 model to determine storm runoff volume is an initial and constant loss rate method. This was found to be the most accurate method for calibration to the 1986 storm. For this reason a constant and initial loss rate methodology was used in conjunction with detailed topographic data to determine water surface elevations in White Lake using a computed stage-storage curve.

In addition to inaccuracies in predicting storm volume, the SCS curve number method was developed for short duration storms of 24 hours. From 1955 to 1986 a number of storms on the east side of the Sierra Nevada near Reno, NV ranged in duration from 3 - 9 days (Nimbus, 1987). For this reason a 100-year 10-day intensity and duration of precipitation was chosen as a conservative estimate of runoff volumes for the 100-year event.

It is possible that there could be back to back storms or some amount of water already stored in the lake when the 100-year storm occurs. Because there is no information on White Lake Playa, the 1986 flooding data collected for Silver Lake and Lemmon Valley Playas outlined in the 1987 Nimbus report was used to determine what a reasonable carryover storage storm event would be. Based on the 1987 FIS for Silver Lake and Lemmon Valley Playa in the same area, a 25-year 24-hour event modeled with the initial and constant loss rate method was used as a reasonable estimate of carryover storage conditions in Silver Lake and Lemmon Valley Playas (Nimbus 1987). This report is included in Appendix E. This event and modeling methodology was therefore used to estimate carryover storage for White Lake as well.

In summary, because it is a peak flow method based on 24-hour data the SCS curve number method was shown to overestimate flood runoff volumes for closed basin lakes near Reno, NV (Nimbus, 1987). This conclusion was based on lake level data collected during the 1986 flood event in Reno, Nevada and subsequent calibration efforts Silver Lake and Lemmon Valley Playas. For these reasons an initial and constant loss rate runoff method was used to determine base flood elevations in White Lake Playa. The 1987 study also found that the 25-year 24-hour storm most closely estimated carryover storage in the lake. The basic procedure therefore was to calculate the 25-year 24-hour runoff volume and then use that volume as initial storage for a 100-year 10-day runoff calculation.

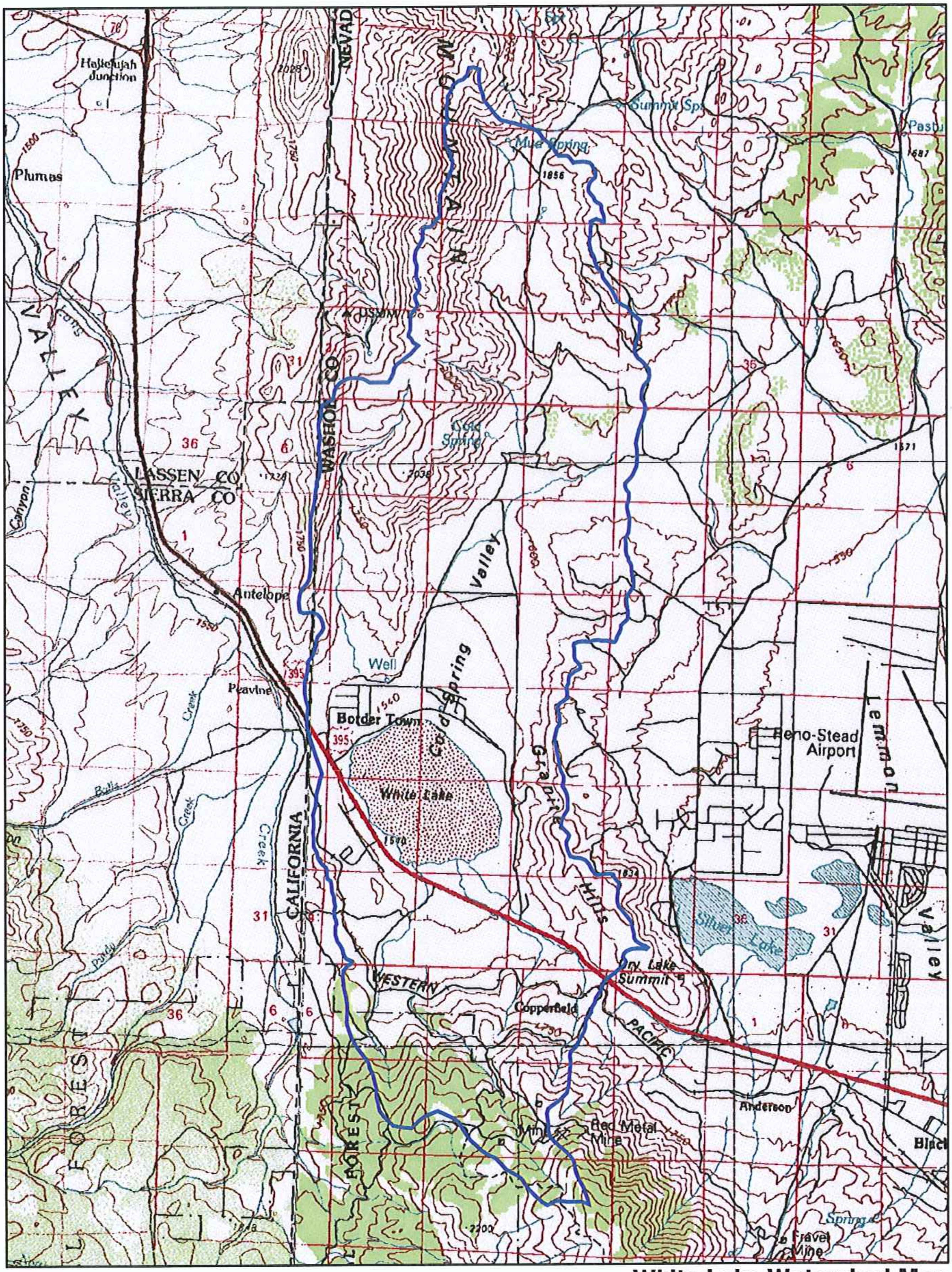
Input Parameters

Because the initial and constant loss rate method was chosen for hydrologic runoff calculations, input parameters were limited to precipitation, basin area, initial and constant loss rates (assumed to be 0.3 and 0.1 respectively), percent impervious and lag time. The methodology for determining each of these parameters is outlined below.

The first step in estimating the 100-year runoff volume from the White Lake watershed was to delineate a watershed boundary. The detailed 2-ft topography described in Chapter 1 in combination with USGS topographic maps were used to delineate a watershed boundary using GIS capabilities (Figure 3). The watershed area was determined to be 18,725 acres.

Because the analysis used initial and constant loss rates for pervious area runoff modeling it was necessary to estimate watershed percent impervious. For the existing conditions impervious condition, recent aerial photos and GIS capabilities were used to delineate developed areas. Average lot sizes were measured and the appropriate average percent impervious was assigned for each area. Average percent impervious values were taken from Natural Resource Conservation Service Technical Release 55. Existing impervious cover was estimated to be 9%.

For an advisory future condition impervious cover HDR acquired Planned Land Use from the City of Reno and Washoe County for the white lake watershed. Using GIS capabilities impervious percentages were assigned to each parcel according to averages outlined in Natural Resource Conservation Service Technical Release 55 (Figure 4). Playa areas were assumed to be 100% impervious because it is already water. The acres of impervious land cover were then calculated for the entire watershed. Planned land use impervious cover was estimated to be 27%



White Lake Watershed Map

FIGURE 3

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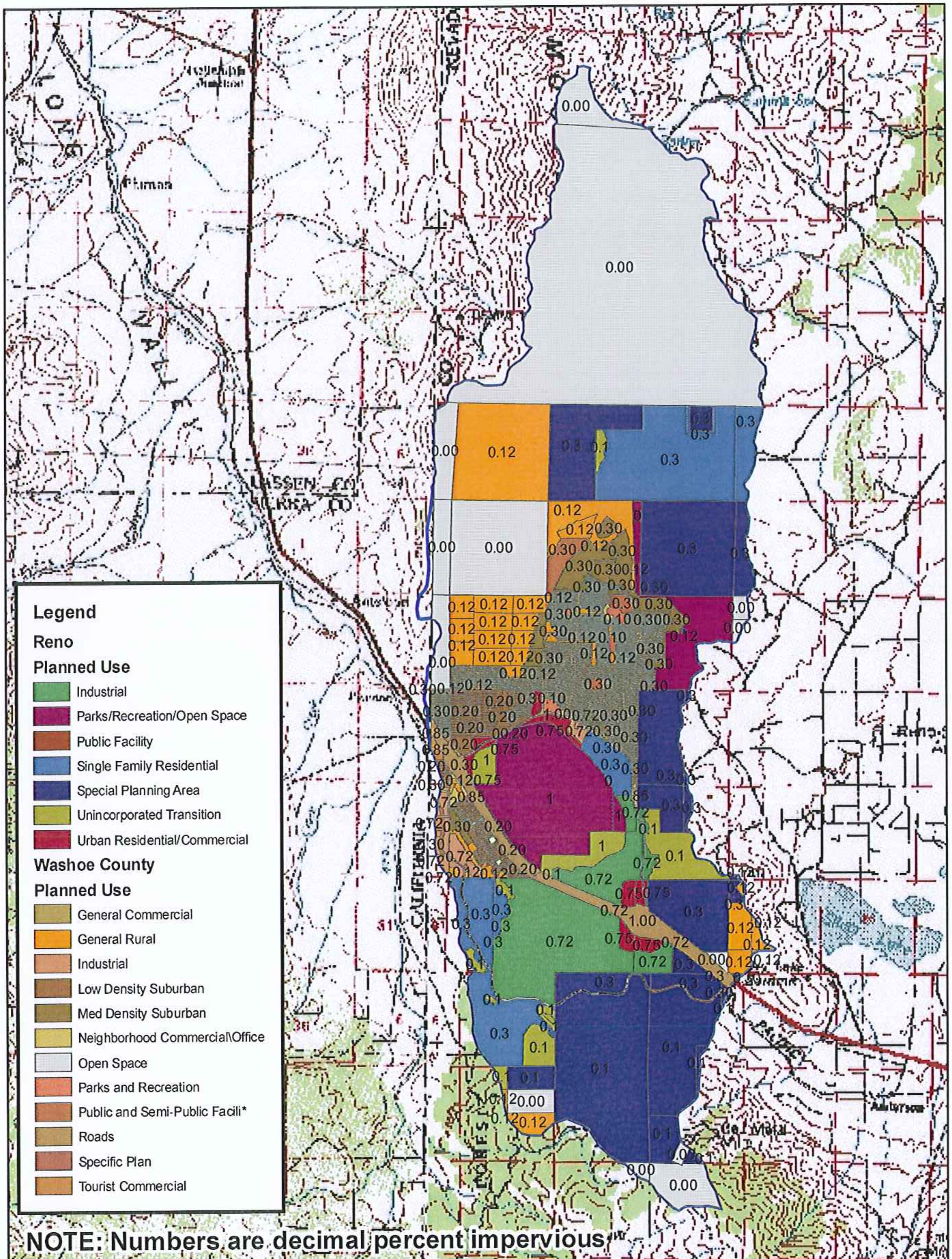


White Lake Impervious Area Map
FIGURE 4

In addition to watershed area and impervious cover, HEC-1 modeling requires precipitation frequency estimates, initial and constant loss rates and lag time estimates to calculate runoff volume.

NOAA Atlas 14 precipitation values for both the 100-yr 10-day and the 25-yr 24-hr depth values were used in this model.

For loss rates, the Sacramento District US Army Corps of Engineers (USACE) prepared a hydrology report for the Truckee River basin in 1980 in which initial and constant loss rates of 0.3 and 0.1 respectively were adopted for general rain, probable maximum and standard project flood events. In addition to the USACE report, the 1987 Nimbus study modeled the 1986 flood event using various initial and constant loss rates. Results were not sensitive to the initial loss rate so a value of 0.3 was accepted. This value was chosen in this study as well. For constant loss rates the values which returned the most accurate water surface elevations for the 100-year storm were 0.073 for Lemmon Valley Playa and 0.14 for Silver Lake (Nimbus, 1987). A value of 0.1 was chosen for constant loss rates as a good amalgam of these values and identical to that used by the USACE.

Because the Study Site is in Washoe County jurisdiction, Lag Time for both the 100-year and 25-year events was estimated using a method outlined in the Draft Truckee Meadows Regional Drainage Manual (2008). The Soil Conservation Service (SCS) Unit Hydrograph transform method was used with the following Lag Time equation used for basins larger than one square mile (equation 710, pg 709):

$$T_{LAG} = 22.1K_n\left(\frac{LL_c}{S^{0.5}}\right)^{0.33}$$

Where:

K_n = Roughness factor for the basin channels

L = Length of longest water course (miles)

L_c = Length along longest water course measured upstream to a point opposite the centroid of the basin (miles)

S = representative (average) slope of the longest water course (feet per mile)

The basin Lag Time was estimated to be 1.36 hours (backup calculation in Appendix C).

HEC-1 models were run using the above parameters and for both the 100-year 10-day and 25-year 24-hour storm events to estimate runoff volumes.

Table 1 is a summary of input parameters for hydrologic modeling.

Table 1: Input parameters for hydrologic models.

Parameter	Value	Units
Initial Loss Rate	0.3	in
Constant Loss Rate	0.1	in/hr
Lag Time	1.36	hr
Basin Area	29.3	mi^2
Existing Condition Impervious	9	%
Advisory Condition Impervious	27	%

Water Surface Elevations

The first step in determining the aerial extent of flooding for the 100-year 10-day event was to use a detailed digital terrain model (DTM) to develop an accurate elevation-storage relationship for use in the HEC-1 hydrologic model. Washoe County digital topographic data from 2002 and 2006 in the form of spot elevations, 3D breaklines and field survey points were integrated together and used to create a DTM in the form of a GIS layer known as a Triangular Irregular Network (TIN) (Figure 2). HEC-GeoRAS utilities within the GIS system were used to create a stage-volume or elevation-storage relationship in feet and acre-feet. This relationship was input into the HEC-1 model for the 100-year 10-day event as a series of Reservoir Storage cards (SV and SE cards). The total runoff volume from the 25-year 24-hour model was used as initial storage for the 100-year 10-day HEC-1 model. HEC-1 used the initial volume and the input elevation-storage curve to determine flood elevations. HEC-1 models are provided in Appendix D.

Impacts of Sediment Transport

Because this analysis was for a closed basin lake sediment transport was not considered to be significant enough to warrant consideration.

Chapter 3 - Results

Existing Condition

In order to determine carryover or initial storage for the existing conditions in White Lake Watershed as described in Chapter 2, an HEC-1 model was run for the 25-year, 24-hour event with an impervious cover of 9% and initial and constant loss rates of 0.3 and 0.1 respectively. The total 25-year, 24-hour runoff volume was 2470 acre-feet. This volume was used as the carryover or initial storage for the 100-year, 10-day model which yielded an independent runoff volume 5116 acre-feet. Cumulative volume used in determining flood elevation was 7586 acre-feet which represents the carryover volume from the 25-year event (2470) plus the runoff volume from the 100-year event (5116). A resulting base flood elevation stage of 5037.7 feet for White Lake was then selected from the elevation-storage curve and extracted from the detailed TIN. An existing conditions BFE of 5038 was used in conjunction with contour lines developed from the terrain model to delineate the Zone AE Special Flood Hazard Area (Figure 6).

Advisory Build-out Condition

In addition to the existing conditions Special Flood Hazard Area and BFE the City of Reno analyzed potential future conditions "advisory" Special Flood Hazard Area and BFE. This advisory BFE would be based a full watershed build-out or Planned Land Use condition in which 27% of the watershed was assumed to be impervious as described in Chapter 2 and potential future wetland enhancements/water storage in White Lake using reclaimed water in the Playa.

In order to determine carryover or initial storage for the advisory condition in White Lake Watershed as described in Chapter 2, an HEC-1 model was run for the 25-year, 24-hour event with an impervious cover of 27% and initial and constant loss rates for pervious areas of 0.3 and 0.1 respectively. The total 25-year, 24-hour runoff volume was 2927 acre-feet. This volume was used as the carryover or initial storage for the 100-year, 10-day model which yielded a runoff volume of 10809 acre-feet.

For the advisory build out condition it is the intention of the City of Reno to add volume to White Lake for wetland enhancement and water storage. The estimated discharge to the lake is approximately 3 million gallon per day or 4.6 cfs. Because this is a closed basin system the only outflow assumed is evaporation. Evaporation varies significantly depending on time of the year and water surface elevation/area. In order to determine that maximum potential storage volume in the lake from the discharge a mass balance was performed for an annual evaporation series. The basic computation was as follows:

$$\text{Inflow} - \text{Outflow} = \text{Change in Storage}$$

Inflow was assumed to be constant at 4.6 cfs (3MGD). Outflow was variable based on a monthly evaporation depth in ft times the area of the pond at a given elevation. In order to model the evaporation rates and mass balance for an annual series. A series of elevation/area/discharge (evaporation) curves were developed for each month of the year. Evaporation rates from Lemmon Valley Playa were used to estimate outflow (Table 2). An HEC-HMS model was used with elevation/area/discharge curves and constant inflow to estimate the change in storage on a yearly basis. Each month was run with a specific discharge curve and the ending elevation/storage from the previous month as a start condition. The model was run successively each month until the assumed January starting elevation matched the ending December elevation. The maximum storage volume for an annual series was then used as additional storage due to the City of Reno's discharge. The maximum storage in the lake occurred in February and was 818 ac-ft. This volume was added to carryover storage for the advisory elevation HEC-1 modeling.

Table 2: Monthly evaporation rates

Month	(in/month)
January	1.565
February	1.84
March	3.678
April	4.659
May	7.44
June	9.055
July	13.518
August	9.394
September	6.323
October	4.184
November	2.133
December	1.332

Table 3: Carryover volumes for discharge storage analysis

Month	Volume(ac-ft)	Elevation (ft)
January*	690.5	5031.8
February	818.3	5031.9
March	785.1	5031.9
April	699.1	5031.8
May	429.7	5031.5
June	159.8	5031.1
July	51.9	5030.8
August	78.4	5030.9
Septembe	116.8	5031.0
October	187.3	5031.2
November	358.7	5031.4
December	548.3	**5031.6**
*Assumed starting WS elevation 5031.6 ft		

Cumulative volume used in determining advisory flood elevation was 11643 acre-feet which represents the carryover volume from the 25-year event (2927) plus the runoff volume from the 100-year event (7898) plus the wetland enhancement/storage volume (818). A resulting base flood elevation stage of 5040.6 feet for White Lake was then selected from the elevation-storage curve and extracted from the detailed TIN(Figure 6).

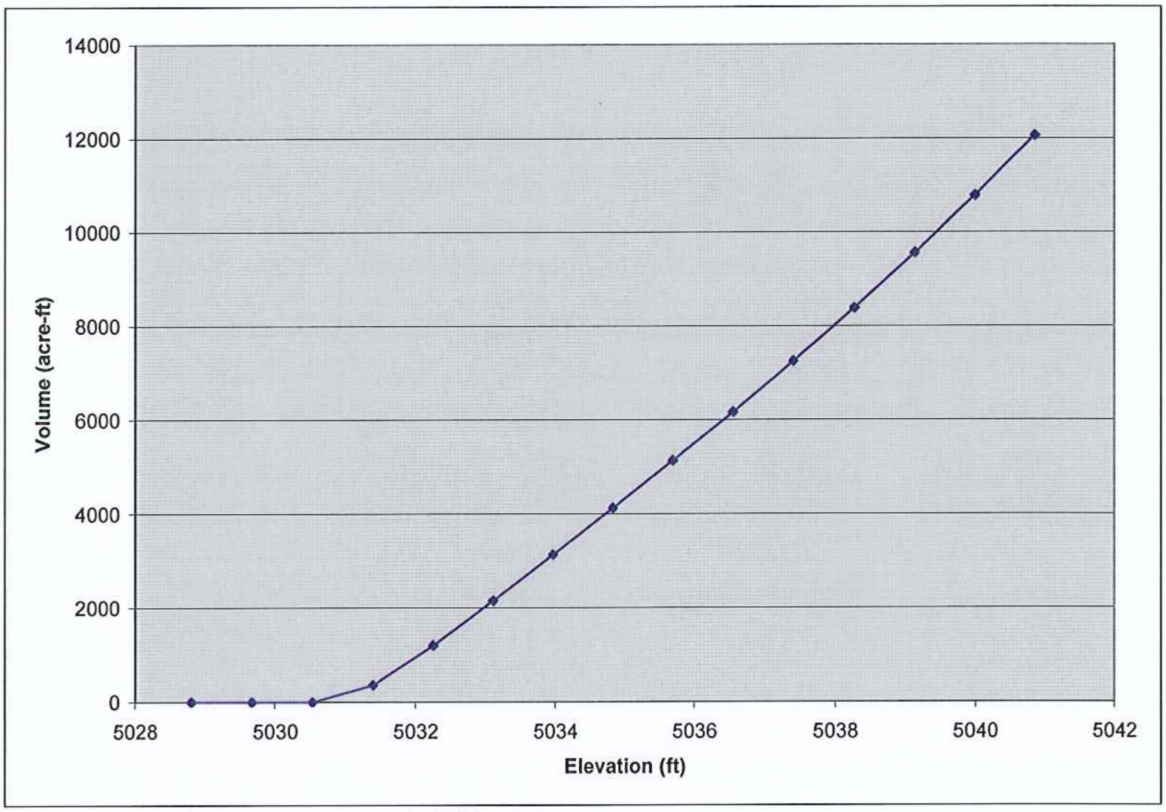
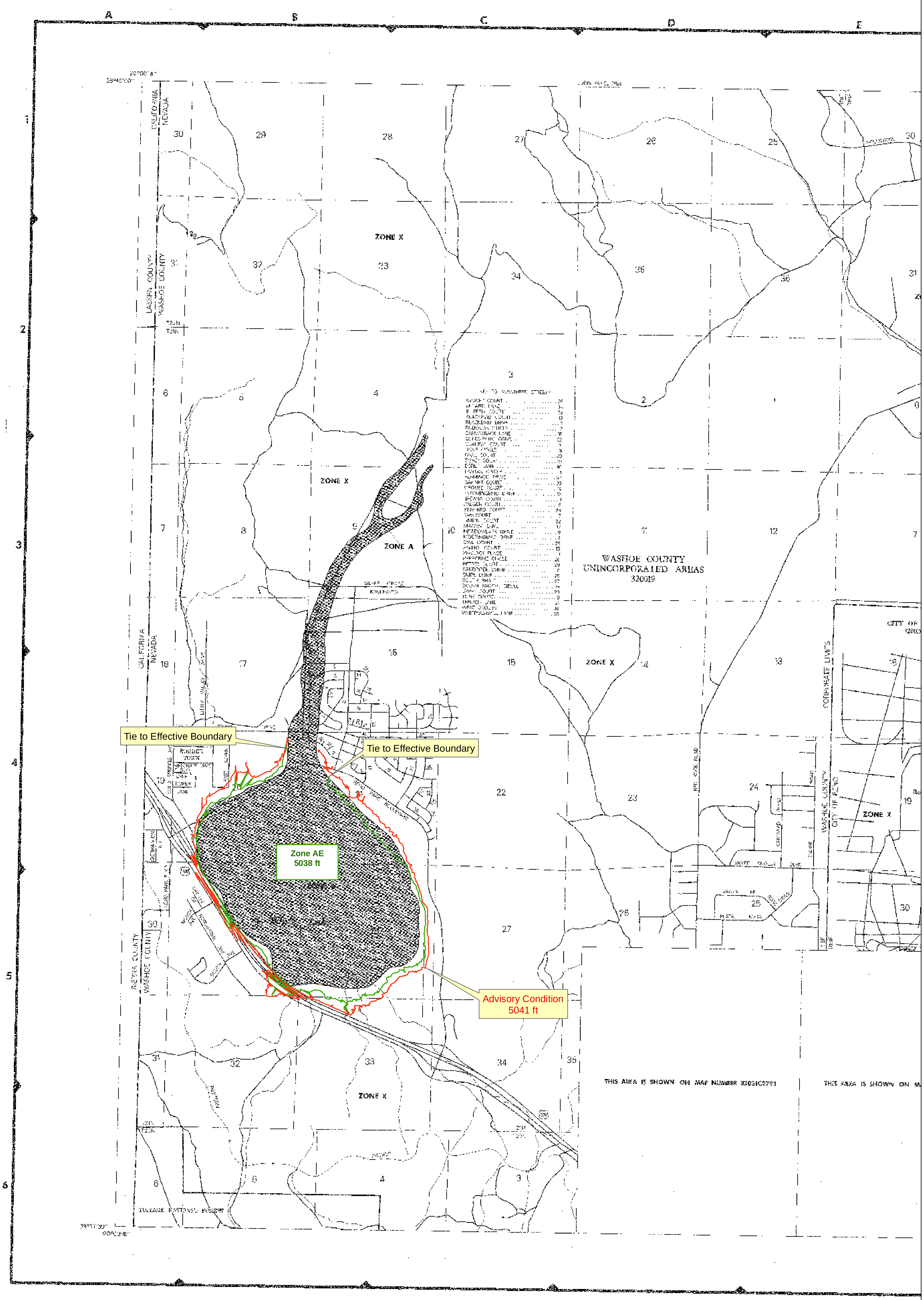


Figure 5: Elevation-storage Curve for White Lake.



BASE MAP IS EFFECTIVE FIRM. MAP COORDINATE SYSTEM IS NAD 83 STATE PLANE (FEET) NEVADA WEST FIPS 2703 AND VERTICAL DATUM IS NAVD88. EFFECTIVE FIRM VERTICAL DATUM IS NGVD 29. SCALE IS SAME AS EFFECTIVE FIRM 1 INCH = 2000 FEET

NGVD29 + 3.71 ft = NAVD88

Flood Insurance Rate Map
Panel 32031C2800E
September 30, 1994

HDR Engineering, Inc.
9805 Double R Blvd
Suite 101
Reno, NV 89521
(775)337-4700

White Lake LOMR

Project: White Lake LOMR

Annotated FIRM

2,000 0 2,000 Feet

DATE 06/08

SCALE 1 inch equals 2,000 feet

Figure 6

HDR

HDR Engineering, Inc.
9805 Double R Boulevard
Suite 101
Reno, NV 89521
(775) 337-4700

White Lake LOMR

Project: White Lake LOMR

Work Map

500 0 500 Feet

DATE 12/22/08

SCALE 1 inch equals 500 feet

Figure 7

Chapter 4 - Conclusions and Recommendations

In Summary an existing conditions BFE of 5038 and an advisory build-out flood elevation of 5041 was used for mapping purposes. Figure 6 is the Annotated FIRM and Figure 7 the Work Map. The analysis summarized in this report was for lake levels only. There were no changes to riverine Zone A boundaries north of the lake. Lake floodplain boundaries were tied in at reasonable points.

The data in this report provides the results of a hydrologic analysis of White Lake for support of a LOMR to replace the existing approximate study for this reach. The inclusion of a more refined Special Flood Hazard Area and Base Flood Elevations provides a more accurate tool for floodplain management in this area.

Attached, in Appendix B are the MT-2 forms, and the hydrologic model input and output.

Figure 6 is an Annotated FIRM showing the location of the existing Zone A boundary and the proposed revised Zone AE and BFEs. As can be seen in this Annotated FIRM the revised floodplain does change the approximate Zone A boundary slightly.

The basis of this revision is better topographical data and superior hydrologic methods.

Review Fees and Forms

Attached to this report are the completed MT-2 forms by the community officials and requestor.

Based on the Current Fee Schedule for Mitigation Products, there is no fee for this request. The LOMR is based solely on submission of more detailed data.

References

Draft Truckee Meadows Regional Drainage Manual, October 2008

Federal Emergency Management Agency, *Flood Insurance Study, Washoe County and Unincorporated Areas*, June 1, 2001.

Federal Emergency Management Agency, *Flood Insurance Rate Maps*, September 1994.

Nimbus Engineers, *Hydrologic Analysis of Silver Lake and Lemmon Valley Playas Located in City of Reno, Nevada and Washoe County Nevada*, December 1987.

Quad Knopf, *North Valleys Flood Control Hydrologic Analysis and Mitigation Options City of Reno and Washoe County Nevada Volumes I and II*, March 2007.

U.S. Army Corps of Engineers, Sacramento District, Truckee River, California and Nevada Hydrology, February 1980.

WRC Nevada, Swan lake Flood Impact Analysis, Reno, NV. January, 2004

Appendix A

FEMA Flood Insurance Rate Maps

APPROXIMATE SCALE IN FEET

2000 0 2000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

WASHOE COUNTY, NEVADA AND INCORPORATED AREAS

PANEL 2800 OF 3350

(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
RENO, CITY OF	320020	2800	E
WASHOE COUNTY, UNINCORPORATED AREAS	320019	2800	E

MAP NUMBER 32031C2800 E

EFFECTIVE DATE: SEPTEMBER 30, 1994

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

Appendix B

MT-2 Forms

FEDERAL EMERGENCY MANAGEMENT AGENCY **OVERVIEW & CONCURRENCE FORM**	*O.M.B No. 3067-0148* *Expires September 30, 2005*

PAPERWORK BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 1 hour per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless a valid OMB control number appears in the upper right corner of this form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, SW, Washington DC 20472, Paperwork Reduction Project (3067-0148). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

A. REQUESTED RESPONSE FROM FEMA

This request is for a (check one):

☐ CLOMR: A letter from FEMA commenting on whether a proposed project, if built as proposed, would justify a map revision, or proposed hydrology changes (See 44 CFR Ch. 1, Parts 60, 65 & 72).

☒ LOMR: A letter from FEMA officially revising the current NFIP map to show the changes to floodplains, regulatory floodway or flood elevations. (See Parts 60 & 65 of the NFIP Regulations.)

B. OVERVIEW

1. The NFIP map panel(s) affected for all impacted communities is (are):

Community No.	Community Name	State	Map No.	Panel No.	Effective Date
320020	City of Reno	NV	32031C	2800E	9/30/94
320019	Unincorporated Areas of Washoe County	NV	32031C	2800E	9/30/94

2. Flooding Source: White Lake, Nevada

3. Project Name/Identifier: Letter of Map Revision, White Lake, NV

4. FEMA zone designations affected: A (choices: A, AH, AO, A1-A30, A99, AE, AR, V, V1-V30, VE, B, C, D, X)

5. Basis for Request and Type of Revision:

a. The basis for this revision request is (check all that apply)

☐ Physical Change ☒ Improved Methodology/Data

☐ Regulatory Floodway Revision ☐ Other (Attach Description)

Note: A photograph and narrative description of the area of concern is not required, but is very helpful during review.

b. The area of revision encompasses the following types of flooding and structures (check all that apply)

Types of Flooding:	☐ Riverine	☐ Coastal	☐ Shallow Flooding (e.g., Zones AO and AH)
	☐ Alluvial fan	☒ Lakes	☐ Other (Attach Description)
Structures:	☐ Channelization	☐ Levee/Floodwall	☐ Bridge/Culvert
	☐ Dam	☐ Fill	☐ Other, Attach Description

C. REVIEW FEE

Has the review fee for the appropriate request category been included?	☒ Yes ☐ No, Attach Explanation	Fee amount: $0

Please see the FEMA Web site at http://www.fema.gov/plan/prevent/fhm/frm_fees.shtm **for Fee Amounts and Exemptions.**

D. SIGNATURE

All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: Neil Mann, Public Works Director	Company: City of Reno, Nevada	
Mailing Address: P.O. Box 1900 Reno, NV 89505	Daytime Telephone No.: (775) 334-2683 (Attn: Kerri Lanza) E-Mail Address: willams-lanza@ci.reno.nv.us	Fax No.: (775) 334-2490
Signature of Requester (required):		Date:

As the community official responsible for floodplain management, I hereby acknowledge that we have received and reviewed this Letter of Map Revision (LOMR) or conditional LOMR request. Based upon the community's review, we find the completed or proposed project meets or is designed to meet all of the community floodplain management requirements, including the requirement that no fill be placed in the regulatory floodway, and that all necessary Federal, State, and local permits have been, or in the case of a conditional LOMR, will be obtained. In addition, we have determined that the land and any existing or proposed structures to be removed from the SFHA are or will be reasonably safe from flooding as defined in 44CFR 65.2(c), and that we have available upon request by FEMA, all analyses and documentation used to make this determination.

Community Official's Name and Title: Neil Mann, Public Works Director		Telephone No.: (775) 334-2683 (Attn: Kerri Lanza)
Community Name: City of Reno, NV	Community Official's Signature (required):	Date:

CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR

This certification is to be signed and sealed by a licensed land surveyor, registered professional engineer, or architect authorized by law to certify elevation information. All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Certifier's Name: Mark Forest, PE	License No.: 8022, Nevada	Expiration Date: 6/31/09
Company Name: HDR Engineering Inc.	Telephone No.: (775) 337-4710	Fax No.: (775) 337-4774
Signature:		Date:

Ensure the forms that are appropriate to your revision request are included in your submittal.

Form Name and (Number)	Required if ...
☒ Riverine Hydrology and Hydraulics Form (Form 2)	New or revised discharges or water-surface elevations
☐ Riverine Structures Form (Form 3)	Channel is modified, addition/revision of bridge/culverts, addition/revision of levee/floodwall, addition/revision of dam
☐ Coastal Analysis Form (Form 4)	New or revised coastal elevations
☐ Coastal Structures Form (Form 5)	Addition/revision of coastal structure
☐ Alluvial Fan Flooding Form (Form 6)	Flood control measures on alluvial fans

PROFESSIONAL ENGINEER STATE OF NEVADA
MARK E. FOREST
Exp: 6/30/09
CIVIL
No. 8022
Seal (Optional)

2/8/09

FEDERAL EMERGENCY MANAGEMENT AGENCY

RIVERINE HYDROLOGY & HYDRAULICS FORM

O.M.B No. 3067-0148
Expires September 30, 2005

PAPERWORK REDUCTION ACT

Flooding Source: White Lake, Nevada
Note: Fill out one form for each flooding source studied

A. HYDROLOGY

1. Reason for New Hydrologic Analysis (check all that apply)

☐ Not revised (skip to section 2) ☒ No existing analysis ☒ Improved data
☐ Alternative methodology ☐ Proposed Conditions (CLOMR) ☐ Changed physical condition of watershed

2. Comparison of Representative 1%-Annual-Chance Discharges

Location	Drainage Area (Sq. Mi.)	FIS (cfs)	Revised (cfs)
White Lake	29.3	None	NA (Volume Estimate)

3. Methodology for New Hydrologic Analysis (check all that apply)

☐ Statistical Analysis of Gage Records ☒ Precipitation/Runoff Model HEC-1 [TR-20, HEC-1, HEC-HMS etc.]
☐ Regional Regression Equations ☐ Other (please attach description)

Please enclose all relevant models in digital format, maps, computations (including computation of parameters) and documentation to support the new analysis. The document, "Numerical Models Accepted by FEMA for NFIP Usage" lists the models accepted by FEMA. This document can be found at: http://www.fema.gov/plan/prevent/fhm/en_modl.shtm.

4. Review/Approval of Analysis

If your community requires a regional, state, or federal agency to review the hydrologic analysis, please attach evidence of approval/review.

5. Impacts of Sediment Transport on Hydrology

Was sediment transport considered? ☐ Yes ☒ No If yes, then fill out Section F (Sediment Transport) of Form 3. If No, then attach your explanation for why sediment transport was not considered.

B. HYDRAULICS

1. <u>Reach to be Revised</u>

	Description	Cross Section	Water-Surface Elevations (ft.) Effective	Proposed/Revised
Downstream Limit				
Upstream Limit				

2. <u>Hydraulic Method Used</u>

Hydraulic Analysis None [HEC-2 , HEC-RAS, Other (Attach description)]

B. HYDRAULICS (CONTINUED)

3. Pre-Submittal Review of Hydraulic Models

FEMA has developed two review programs, CHECK-2 and CHECK-RAS, to aid in the review of HEC-2 and HEC-RAS hydraulic models, respectively. These review programs verify that the hydraulic estimates and assumptions in the model data are in accordance with NFIP requirements, and that the data are comparable with the assumptions and limitations of HEC-2/HEC-RAS. CHECK-2 and CHECK-RAS identify areas of potential error or concern. These tools do not replace engineering judgment. CHECK-2 and CHECK-RAS can be downloaded from http://www.fema.gov/plan/prevent/fhm/frm_soft.shtm. We recommend that you review your HEC-2 and HEC-RAS models with CHECK-2 and CHECK-RAS. If you disagree with a message, please attach an explanation of why the message is not valid in this case. Review of your submittal and resolution of valid modeling discrepancies will result in reduced review time.

HEC-2/HEC-RAS models reviewed with CHECK-2/CHECK-RAS? ☐ Yes ☒ No

4. Models Submitted

Duplicate Effective Model*	Natural File Name:	Floodway File Name:
Corrected Effective Model*	Natural File Name:	Floodway File Name:
Existing or Pre-Project Conditions Model	Natural File Name:	Floodway File Name:
Revised or Post-Project Conditions Model	Natural File Name:	Floodway File Name:
Other - (attach description)	Natural File Name:	Floodway File Name:

*Not required for revisions to approximate 1%-annual-chance floodplains (Zone A) – for details, refer to the corresponding section of the instructions.

The document "Numerical Models Accepted by FEMA for NFIP Usage" lists the models accepted by FEMA. This document can be found at: http://www.fema.gov/plan/prevent/fhm/en_modl.shtm.

C. MAPPING REQUIREMENTS

A **certified topographic map** must be submitted showing the following information (where applicable): the boundaries of the effective, existing, and proposed conditions 1%-annual-chance floodplain (for approximate Zone A revisions) or the boundaries of the 1%- and 0.2%-annual-chance floodplains and regulatory floodway (for detailed Zone AE, AO, and AH revisions); location and alignment of all cross sections with stationing control indicated; stream, road, and other alignments (e.g., dams, levees, etc.); current community easements and boundaries; boundaries of the requester's property; certification of a registered professional engineer registered in the subject State; location and description of reference marks; and the referenced vertical datum (NGVD, NAVD, etc.).

Note that the boundaries of the existing or proposed conditions floodplains and regulatory floodway to be shown on the revised FIRM and/or FBFM must tie-in with the effective floodplain and regulatory floodway boundaries. Please attach **a copy of the effective FIRM and/or FBFM,** annotated to show the boundaries of the revised 1%- and 0.2%-annual-chance floodplains and regulatory floodway that tie-in with the boundaries of the effective 1%- and 0.2%-annual-chance floodplain and regulatory floodway at the upstream and downstream limits of the area of revision.

D. COMMON REGULATORY REQUIREMENTS

1. For CLOMR requests, do Base Flood Elevations (BFEs) increase? ☐ Yes ☐ No

For CLOMR requests, if either of the following is true, please submit evidence of compliance with Section 65.12 of the NFIP regulations:

- The proposed project encroaches upon a regulatory floodway and would result in increases above 0.00 foot.
- The proposed project encroaches upon a SFHA with BFEs established and would result in increases above 1.00 foot.

2. Does the request involve the placement or proposed placement of fill? ☐ Yes ☒ No

If Yes, the community must be able to certify that the area to be removed from the special flood hazard area, to include any structures or proposed structures, meets all of the standards of the local floodplain ordinances, and is reasonably safe from flooding in accordance with the NFIP regulations set forth at 44 CFR 60.3(a)(3), 65.5(a)(4), and 65.6(a)(14). Please see the MT-2 instructions for more information.

3. For LOMR requests, is the regulatory floodway being revised? ☐ Yes ☒ No

If Yes, attach evidence of regulatory floodway revision notification. As per Paragraph 65.7(b)(1) of the NFIP Regulations, notification is required for requests involving revisions to the regulatory floodway. (Not required for revisions to approximate 1%-annual-chance floodplains [studied Zone A designation] unless a regulatory floodway is being added. Elements and examples of regulatory floodway revision notification can be found in the MT-2 Form 2 Instructions.)

4. For LOMR requests, does this request require property owner notification and acceptance of BFE increases? ☒ Yes ☐ No

If Yes, please attach proof of property owner notification and acceptance (if available). Elements of and examples of property owner notification can be found in the MT-2 Form 2 Instructions.

{Date}

Dennis Charley
16105 Highway 395 North
Reno, NV 89508-8021

Re: Notification of widening and/narrowing of 1% (100-year) annual chance floodplain and establishment of Base Flood Elevations

Dear Property Owner

The Flood Insurance Rate Map (FIRM) for a community depicts land which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

City of Reno, NV is applying for a Letter of Map Revision (LOMR) from the Federal Emergency Management Agency (DHS-FEMA) to revise FIRM 32031C2800 E along White Lake near the Cold Springs area in Reno, NV. City of Reno, NV is proposing to revise the FIRM to reflect a more accurate analysis and better topographic data.

The Letter of Map Revision will result in:

1. Establishment of Base (1% annual chance) Flood Elevations (BFEs). Currently, the flooding along White Lake is based on an approximate study.

2. Widening and narrowing of the 1% annual chance floodplain with the maximum widening of approximately 600 feet along the southern shore of White Lake and the maximum narrowing of approximately 440 feet along the eastern shore of White Lake.

This letter is to inform you of the establishment of Base Flood Elevations and revision of the 1% annual chance floodplain on your property at 16105 Highway 395 North.

If you have any questions or concerns about the proposed changes to the FIRM or its effect on your property, you may contact Kerri Lanza at (775) 334-2683

Sincerely,

Neil Mann
City of Reno Public Works Director

{Date}

H&N Properties LLC
225 West Moana Lane
Reno, NV 89509-4905

Re: Notification of widening and/narrowing of 1% (100-year) annual chance floodplain and establishment of Base Flood Elevations

Dear Property Owner

The Flood Insurance Rate Map (FIRM) for a community depicts land which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

City of Reno, NV is applying for a Letter of Map Revision (LOMR) from the Federal Emergency Management Agency (DHS-FEMA) to revise FIRM 32031C2800 E along White Lake near the Cold Springs area in Reno, NV. City of Reno, NV is proposing to revise the FIRM to reflect a more accurate analysis and better topographic data.

The Letter of Map Revision will result in:

1. Establishment of Base (1% annual chance) Flood Elevations (BFEs). Currently, the flooding along White Lake is based on an approximate study.

2. Widening and narrowing of the 1% annual chance floodplain with the maximum widening of approximately 600 feet along the southern shore of White Lake and the maximum narrowing of approximately 440 feet along the eastern shore of White Lake.

This letter is to inform you of the establishment of Base Flood Elevations and revision of the 1% annual chance floodplain on your property(s) at Village Parkway.

If you have any questions or concerns about the proposed changes to the FIRM or its effect on your property, you may contact Kerri Lanza at (775) 334-2683

Sincerely,

Neil Mann
City of Reno Public Works Director

{Date}

Lake Hills Association
C/O Benchmark Association Services
4690 Longley Lane Suite 1
Reno, NV 89502

Re: Notification of widening and/narrowing of 1% (100-year) annual chance floodplain and establishment of Base Flood Elevations

Dear Property Owner

The Flood Insurance Rate Map (FIRM) for a community depicts land which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

City of Reno, NV is applying for a Letter of Map Revision (LOMR) from the Federal Emergency Management Agency (DHS-FEMA) to revise FIRM 32031C2800 E along White Lake near the Cold Springs area in Reno, NV. City of Reno, NV is proposing to revise the FIRM to reflect a more accurate analysis and better topographic data.

The Letter of Map Revision will result in:

1. Establishment of Base (1% annual chance) Flood Elevations (BFEs). Currently, the flooding along White Lake is based on an approximate study.

2. Widening and narrowing of the 1% annual chance floodplain with the maximum widening of approximately 600 feet along the southern shore of White Lake and the maximum narrowing of approximately 440 feet along the eastern shore of White Lake.

This letter is to inform you of the establishment of Base Flood Elevations and revision of the 1% annual chance floodplain on your property(s) at <u>Glen Lakes Court, Diamond Peak Drive and White Lake Parkway</u>.

If you have any questions or concerns about the proposed changes to the FIRM or its effect on your property, you may contact Kerri Lanza at (775) 334-2683

Sincerely,

Neil Mann
City of Reno Public Works Director

{Date}

Jack Lehman
17005 North US 395 Highway
Reno, NV 89508-8047

Re: Notification of widening and/narrowing of 1% (100-year) annual chance floodplain and establishment of Base Flood Elevations

Dear Property Owner

The Flood Insurance Rate Map (FIRM) for a community depicts land which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

City of Reno, NV is applying for a Letter of Map Revision (LOMR) from the Federal Emergency Management Agency (DHS-FEMA) to revise FIRM 32031C2800 E along White Lake near the Cold Springs area in Reno, NV. City of Reno, NV is proposing to revise the FIRM to reflect a more accurate analysis and better topographic data.

The Letter of Map Revision will result in:

1. Establishment of Base (1% annual chance) Flood Elevations (BFEs). Currently, the flooding along White Lake is based on an approximate study.

2. Widening and narrowing of the 1% annual chance floodplain with the maximum widening of approximately 600 feet along the southern shore of White Lake and the maximum narrowing of approximately 440 feet along the eastern shore of White Lake.

This letter is to inform you of the establishment of Base Flood Elevations and revision of the 1% annual chance floodplain on your property(s) at 17005 North US 395 Highway.

If you have any questions or concerns about the proposed changes to the FIRM or its effect on your property, you may contact Kerri Lanza at (775) 334-2683

Sincerely,

Neil Mann
City of Reno Public Works Director

{Date}

Lifestyle Homes TND LLC
PO Box 7548
Reno, NV 89510-7548

Re: Notification of widening and/narrowing of 1% (100-year) annual chance floodplain and establishment of Base Flood Elevations

Dear Property Owner

The Flood Insurance Rate Map (FIRM) for a community depicts land which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

City of Reno, NV is applying for a Letter of Map Revision (LOMR) from the Federal Emergency Management Agency (DHS-FEMA) to revise FIRM 32031C2800 E along White Lake near the Cold Springs area in Reno, NV. City of Reno, NV is proposing to revise the FIRM to reflect a more accurate analysis and better topographic data.

The Letter of Map Revision will result in:

1. Establishment of Base (1% annual chance) Flood Elevations (BFEs). Currently, the flooding along White Lake is based on an approximate study.

2. Widening and narrowing of the 1% annual chance floodplain with the maximum widening of approximately 600 feet along the southern shore of White Lake and the maximum narrowing of approximately 440 feet along the eastern shore of White Lake.

This letter is to inform you of the establishment of Base Flood Elevations and revision of the 1% annual chance floodplain on your property(s) at White Lake Parkway, Reno Park Boulevard, Village Parkway and Reno Corporate Drive.

If you have any questions or concerns about the proposed changes to the FIRM or its effect on your property, you may contact Kerri Lanza at (775) 334-2683

Sincerely,

Neil Mann
City of Reno Public Works Director

{Date}

Timothy McDonald
3680 Grant Drive, Suite C-1-A
Reno, NV 89509-5350

Re: Notification of widening and/narrowing of 1% (100-year) annual chance floodplain and establishment of Base Flood Elevations

Dear Property Owner

The Flood Insurance Rate Map (FIRM) for a community depicts land which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

City of Reno, NV is applying for a Letter of Map Revision (LOMR) from the Federal Emergency Management Agency (DHS-FEMA) to revise FIRM 32031C2800 E along White Lake near the Cold Springs area in Reno, NV. City of Reno, NV is proposing to revise the FIRM to reflect a more accurate analysis and better topographic data.

The Letter of Map Revision will result in:

1. Establishment of Base (1% annual chance) Flood Elevations (BFEs). Currently, the flooding along White Lake is based on an approximate study.

2. Widening and narrowing of the 1% annual chance floodplain with the maximum widening of approximately 600 feet along the southern shore of White Lake and the maximum narrowing of approximately 440 feet along the eastern shore of White Lake.

This letter is to inform you of the establishment of Base Flood Elevations and revision of the 1% annual chance floodplain on your property at Village Parkway.

If you have any questions or concerns about the proposed changes to the FIRM or its effect on your property, you may contact Kerri Lanza at (775) 334-2683

Sincerely,

Neil Mann
City of Reno Public Works Director

{Date}

Georgia Murphy
PO Box 727
Homedale, ID 83629

Re: Notification of widening and/narrowing of 1% (100-year) annual chance floodplain and establishment of Base Flood Elevations

Dear Property Owner

The Flood Insurance Rate Map (FIRM) for a community depicts land which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

City of Reno, NV is applying for a Letter of Map Revision (LOMR) from the Federal Emergency Management Agency (DHS-FEMA) to revise FIRM 32031C2800 E along White Lake near the Cold Springs area in Reno, NV. City of Reno, NV is proposing to revise the FIRM to reflect a more accurate analysis and better topographic data.

The Letter of Map Revision will result in:

1. Establishment of Base (1% annual chance) Flood Elevations (BFEs). Currently, the flooding along White Lake is based on an approximate study.

2. Widening and narrowing of the 1% annual chance floodplain with the maximum widening of approximately 600 feet along the southern shore of White Lake and the maximum narrowing of approximately 440 feet along the eastern shore of White Lake.

This letter is to inform you of the establishment of Base Flood Elevations and revision of the 1% annual chance floodplain on your property(s) at 17620 East Aspen Circle.

If you have any questions or concerns about the proposed changes to the FIRM or its effect on your property, you may contact Kerri Lanza at (775) 334-2683

Sincerely,

Neil Mann
City of Reno Public Works Director

{Date}

Roy Wannamaker, Cold Springs Ranches
926 East 22nd St.
National City, CA 91950

Re: Notification of widening and/narrowing of 1% (100-year) annual chance floodplain and establishment of Base Flood Elevations

Dear Property Owner

The Flood Insurance Rate Map (FIRM) for a community depicts land which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

City of Reno, NV is applying for a Letter of Map Revision (LOMR) from the Federal Emergency Management Agency (DHS-FEMA) to revise FIRM 32031C2800 E along White Lake near the Cold Springs area in Reno, NV. City of Reno, NV is proposing to revise the FIRM to reflect a more accurate analysis and better topographic data.

The Letter of Map Revision will result in:

1. Establishment of Base (1% annual chance) Flood Elevations (BFEs). Currently, the flooding along White Lake is based on an approximate study.

2. Widening and narrowing of the 1% annual chance floodplain with the maximum widening of approximately 600 feet along the southern shore of White Lake and the maximum narrowing of approximately 440 feet along the eastern shore of White Lake.

This letter is to inform you of the establishment of Base Flood Elevations and revision of the 1% annual chance floodplain on your property(s) at Village Parkway.

If you have any questions or concerns about the proposed changes to the FIRM or its effect on your property, you may contact Kerri Lanza at (775) 334-2683

Sincerely,

Neil Mann
City of Reno Public Works Director

Appendix C

Back-up Lag Calculation

Project:	ECO:LOGIC City of Reno Master Plan	Computed:	MLB	Date:	12/14/2008
Subject:	White Lake Hydrology	Checked:		Date:	
Task:	Calculate Lag by Washoe County Method	Page:		of:	
Job #:		No:			

Truckee Meadows Regional Drainage Manual Section 705.3 Lag Equation for SCS Unit Hydrograph Method

$$T_{lag} = 22.1K_n(LL_C / S^{0.5})^{0.33}$$

Where:

Kn = Roughness factor for the basin from table 703 = 0.09

L = Length of the longest water course = 7.84 miles

Lc = Length of the longets water course to the centroid = 0.75 miles

S = Slope of the longest water course = 349 ft/mile

Tlag = 1.36 hr | 81 min

Slope Calculation

	Length (mi)	Elevation(ft)	Slope (ft/mi)
Section 1	0.96	1411	1469.79167
Section 2	3.92	1185	302.295918
Section 3	2.96	140	47.2972973
Composite			349

Appendix D

HEC-1 Hydrologic Modeling

```
1*****************************************               ****************************************
 *                                       *               *                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *               *   U.S. ARMY CORPS OF ENGINEERS       *
 *              JUN   1998               *               *   HYDROLOGIC ENGINEERING CENTER      *
 *            VERSION 4.1                *               *         609 SECOND STREET            *
 *                                       *               *      DAVIS, CALIFORNIA 95616         *
 * RUN DATE   05JUN09  TIME  14:43:21    *               *          (916) 756-1104              *
 *                                       *               *                                      *
 *****************************************               ****************************************



                              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

                      *DIAGRAM
            1         ID     WHITE LAKE LOMR, WASHOE COUNTY & CITY OF RENO, NEVADA
            2         ID     BY HDR INC., RENO, NEVADA (FILE WL25YR_NOAA) JUNE 2009
            3         ID     NOAA ATLAS 14 PRECIPITATION VALUES, 25 YEAR, 24 HOUR EXISTING CONDITIONS
            4         IT      5                      300
            5         IO      3
                      *

            6         KK      WL
            7         KM       RUNOFF FROM ENTIRE WHITE LAKE WATERSHED USING CALIBRATED LOSS RATES
            8         PH      1      30     .31     .59    0.98    1.13    1.27    1.78    2.67    3.83
            9         BA     29.3
           10         LU     0.30    0.10      9
           11         UD     1.36
                      *
           12         ZZ
1
             SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE      (V) ROUTING           (--->) DIVERSION OR PUMP FLOW

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

   6        WL

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```


```
1*****************************************               ****************************************
 *                                       *               *                                      *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *               *   U.S. ARMY CORPS OF ENGINEERS       *
 *              JUN   1998               *               *   HYDROLOGIC ENGINEERING CENTER      *
 *            VERSION 4.1                *               *         609 SECOND STREET            *
 *                                       *               *      DAVIS, CALIFORNIA 95616         *
 * RUN DATE   05JUN09  TIME  14:43:21    *               *          (916) 756-1104              *
 *                                       *               *                                      *
 *****************************************               ****************************************
```


```
                       WHITE LAKE LOMR, WASHOE COUNTY & CITY OF RENO, NEVADA
                       BY HDR INC., RENO, NEVADA (FILE WL25YR_NOAA) JUNE 2009
                       NOAA ATLAS 14 PRECIPITATION VALUES, 25 YEAR, 24 HOUR EXISTING CONDITIONS

   5 IO          OUTPUT CONTROL VARIABLES
                      IPRNT            3  PRINT CONTROL
                      IPLOT            0  PLOT CONTROL
                      QSCAL           0.  HYDROGRAPH PLOT SCALE

     IT          HYDROGRAPH TIME DATA
                       NMIN            5  MINUTES IN COMPUTATION INTERVAL
                      IDATE       1    0  STARTING DATE
                      ITIME         0000  STARTING TIME
                         NQ          300  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE       2    0  ENDING DATE
                     NDTIME         0055  ENDING TIME
                      ICENT           19  CENTURY MARK

                 COMPUTATION INTERVAL      .08 HOURS
                      TOTAL TIME BASE    24.92 HOURS

         ENGLISH UNITS
             DRAINAGE AREA         SQUARE MILES
             PRECIPITATION DEPTH   INCHES
             LENGTH, ELEVATION     FEET
             FLOW                  CUBIC FEET PER SECOND
             STORAGE VOLUME        ACRE-FEET
             SURFACE AREA          ACRES
```

```
           TEMPERATURE          DEGREES FAHRENHEIT

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

              **************
              *            *
   6 KK       *     WL     *
              *            *
              **************
                         RUNOFF FROM ENTIRE WHITE LAKE WATERSHED USING CALIBRATED LOSS RATES

            SUBBASIN RUNOFF DATA

   9 BA       SUBBASIN CHARACTERISTICS
                 TAREA      29.30  SUBBASIN AREA

              PRECIPITATION DATA

   8 PH                           DEPTHS FOR   1-PERCENT HYPOTHETICAL STORM
              ..... HYDRO-35 ......   ............... TP-40 ...............   ........... TP-49 ...........
              5-MIN  15-MIN  60-MIN    2-HR    3-HR    6-HR   12-HR   24-HR   2-DAY   4-DAY   7-DAY  10-DAY
                .31     .59     .98    1.13    1.27    1.78    2.67    3.83     .00     .00     .00     .00

                                                   STORM AREA =    30.00

  10 LU       UNIFORM LOSS RATE
                 STRTL        .30  INITIAL LOSS
                 CNSTL        .10  UNIFORM LOSS RATE
                 RTIMP       9.00  PERCENT IMPERVIOUS AREA

  11 UD       SCS DIMENSIONLESS UNITGRAPH
                 TLAG        1.36  LAG

                                                             ***

                                                        UNIT HYDROGRAPH
                                                  84 END-OF-PERIOD ORDINATES
         180.      437.      857.     1353.     1894.     2606.     3392.     4352.     5419.     6560.
        7537.     8430.     9090.     9587.     9948.    10049.    10088.    10028.     9818.     9458.
        9049.     8620.     8140.     7605.     7005.     6312.     5602.     5002.     4475.     4054.
        3678.     3320.     3020.     2749.     2530.     2310.     2091.     1911.     1731.     1551.
        1409.     1289.     1168.     1056.      966.      876.      786.      718.      652.      586.
         531.      486.      441.      398.      365.      332.      299.      273.      249.      225.
         204.      186.      168.      150.      138.      126.      114.      106.       99.       91.
          84.       77.       70.       63.       55.       49.       43.       37.       31.       25.
          19.       13.        7.        1.

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

                 HYDROGRAPH AT STATION       WL

   TOTAL RAINFALL =    3.71, TOTAL LOSS =    2.12, TOTAL EXCESS =    1.59

  PEAK FLOW     TIME                       MAXIMUM AVERAGE FLOW
                                  6-HR        24-HR        72-HR      24.92-HR
+   (CFS)       (HR)
                        (CFS)
+   8192.      13.42               3529.       1245.        1199.        1199.
                      (INCHES)     1.120       1.580        1.580        1.580
                      (AC-FT)      1750.       2469.        2470.        2470.

                   CUMULATIVE AREA =    29.30 SQ MI

1
                                                  RUNOFF SUMMARY
                                           FLOW IN CUBIC FEET PER SECOND
                                        TIME IN HOURS,  AREA IN SQUARE MILES

                                              PEAK    TIME OF     AVERAGE FLOW FOR MAXIMUM PERIOD      BASIN     MAXIMUM     TIME OF
           OPERATION        STATION          FLOW      PEAK                                            AREA       STAGE     MAX STAGE
+                                                                6-HOUR      24-HOUR      72-HOUR

           HYDROGRAPH AT
+                              WL            8192.    13.42      3529.       1245.        1199.      29.30


*** NORMAL END OF HEC-1 ***
```

```
1*****************************************
 *                                       *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
 *             JUN  1998                 *
 *           VERSION 4.1                 *
 *                                       *
 * RUN DATE   05JUN09  TIME  14:50:43    *
 *                                       *
 *****************************************

 *****************************************
 *                                       *
 *    U.S. ARMY CORPS OF ENGINEERS       *
 *    HYDROLOGIC ENGINEERING CENTER      *
 *          609 SECOND STREET            *
 *        DAVIS, CALIFORNIA 95616        *
 *            (916) 756-1104             *
 *                                       *
 *****************************************


                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

             *DIAGRAM
     1       ID   WHITE LAKE LOMR, WASHOE COUNTY & CITY OF RENO, NEVADA
     2       ID   BY HDR INC., RENO, NEVADA (FILE WL25YRP_NOAA) JUNE 2009
     3       ID   NOAA ATLAS 14 PRECIPITATION VALUES, 25 YEAR, 24 HOUR ADVISORY CONDITIONS
     4       IT      5                 300
     5       IO      3
             *

     6       KK     WL
     7       KM      RUNOFF FROM ENTIRE WHITE LAKE WATERSHED USING CALIBRATED LOSS RATES
     8       PH      1      30     .31     .59    0.98    1.13    1.27    1.78    2.67    3.83
     9       BA   29.3
    10       LU   0.30    0.10      27
    11       UD   1.36
             *
    12       ZZ
1
           SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE     (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

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

   6        WL

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
```



```
1*****************************************
 *                                       *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
 *             JUN  1998                 *
 *           VERSION 4.1                 *
 *                                       *
 * RUN DATE   05JUN09  TIME  14:50:43    *
 *                                       *
 *****************************************

 *****************************************
 *                                       *
 *    U.S. ARMY CORPS OF ENGINEERS       *
 *    HYDROLOGIC ENGINEERING CENTER      *
 *          609 SECOND STREET            *
 *        DAVIS, CALIFORNIA 95616        *
 *            (916) 756-1104             *
 *                                       *
 *****************************************
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                 WHITE LAKE LOMR, WASHOE COUNTY & CITY OF RENO, NEVADA
                 BY HDR INC., RENO, NEVADA (FILE WL25YRP_NOAA) JUNE 2009
                 NOAA ATLAS 14 PRECIPITATION VALUES, 25 YEAR, 24 HOUR ADVISORY CONDITIONS

   5 IO        OUTPUT CONTROL VARIABLES
                     IPRNT          3  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
                     QSCAL         0.  HYDROGRAPH PLOT SCALE

     IT        HYDROGRAPH TIME DATA
                      NMIN          5  MINUTES IN COMPUTATION INTERVAL
                     IDATE      1   0  STARTING DATE
                     ITIME       0000  STARTING TIME
                        NQ        300  NUMBER OF HYDROGRAPH ORDINATES
                    NDDATE      2   0  ENDING DATE
                    NDTIME       0055  ENDING TIME
                     ICENT         19  CENTURY MARK

               COMPUTATION INTERVAL     .08 HOURS
                    TOTAL TIME BASE   24.92 HOURS

       ENGLISH UNITS
           DRAINAGE AREA          SQUARE MILES
           PRECIPITATION DEPTH    INCHES
           LENGTH, ELEVATION      FEET
           FLOW                   CUBIC FEET PER SECOND
           STORAGE VOLUME         ACRE-FEET
           SURFACE AREA           ACRES
```

```
         TEMPERATURE          DEGREES FAHRENHEIT

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

           **************
           *            *
   6 KK    *      WL    *
           *            *
           **************
                          RUNOFF FROM ENTIRE WHITE LAKE WATERSHED USING CALIBRATED LOSS RATES

          SUBBASIN RUNOFF DATA

   9 BA    SUBBASIN CHARACTERISTICS
              TAREA      29.30  SUBBASIN AREA

           PRECIPITATION DATA

   8 PH                       DEPTHS FOR   1-PERCENT HYPOTHETICAL STORM
           ..... HYDRO-35 ......   .............. TP-40 ..............   .......... TP-49 ..........
           5-MIN  15-MIN  60-MIN    2-HR    3-HR    6-HR   12-HR   24-HR   2-DAY   4-DAY   7-DAY  10-DAY
             .31     .59     .98    1.13    1.27    1.78    2.67    3.83     .00     .00     .00     .00

                                               STORM AREA =    30.00

  10 LU    UNIFORM LOSS RATE
              STRTL        .30  INITIAL LOSS
              CNSTL        .10  UNIFORM LOSS RATE
              RTIMP      27.00  PERCENT IMPERVIOUS AREA

  11 UD    SCS DIMENSIONLESS UNITGRAPH
              TLAG        1.36  LAG

                                                   ***

                                              UNIT HYDROGRAPH
                                           84 END-OF-PERIOD ORDINATES
         180.      437.      857.     1353.     1894.     2606.     3392.     4352.     5419.     6560.
        7537.     8430.     9090.     9587.     9948.    10049.    10088.    10028.     9818.     9458.
        9049.     8620.     8140.     7605.     7005.     6312.     5602.     5002.     4475.     4054.
        3678.     3320.     3020.     2749.     2530.     2310.     2091.     1911.     1731.     1551.
        1409.     1289.     1168.     1056.      966.      876.      786.      718.      652.      586.
         531.      486.      441.      398.      365.      332.      299.      273.      249.      225.
         204.      186.      168.      150.      138.      126.      114.      106.       99.       91.
          84.       77.       70.       63.       55.       49.       43.       37.       31.       25.
          19.       13.        7.        1.

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

                    HYDROGRAPH AT STATION       WL

    TOTAL RAINFALL =    3.71, TOTAL LOSS =    1.70, TOTAL EXCESS =    2.01

   PEAK FLOW     TIME                        MAXIMUM AVERAGE FLOW
                                     6-HR        24-HR        72-HR        24.92-HR
+   (CFS)        (HR)
                            (CFS)
+   8533.       13.42                3870.       1564.        1507.        1507.
                          (INCHES)   1.228       1.985        1.985        1.985
                           (AC-FT)   1919.       3101.        3103.        3103.

                    CUMULATIVE AREA =    29.30 SQ MI

1
                                                   RUNOFF SUMMARY
                                            FLOW IN CUBIC FEET PER SECOND
                                         TIME IN HOURS,  AREA IN SQUARE MILES

                                          PEAK   TIME OF     AVERAGE FLOW FOR MAXIMUM PERIOD      BASIN    MAXIMUM    TIME OF
            OPERATION        STATION      FLOW     PEAK                                           AREA     STAGE    MAX STAGE
+                                                            6-HOUR      24-HOUR      72-HOUR

            HYDROGRAPH AT
+                              WL        8533.   13.42       3870.       1564.        1507.       29.30

*** NORMAL END OF HEC-1 ***
```

```
1*****************************************                    *****************************************
*                                       *                    *                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                    *   U.S. ARMY CORPS OF ENGINEERS        *
*             JUN  1998                 *                    *   HYDROLOGIC ENGINEERING CENTER       *
*           VERSION 4.1                 *                    *         609 SECOND STREET             *
*                                       *                    *       DAVIS, CALIFORNIA 95616         *
*  RUN DATE   05JUN09  TIME  15:00:07   *                    *          (916) 756-1104               *
*                                       *                    *                                       *
*****************************************                    *****************************************


                     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

                      *DIAGRAM
           1          ID    WHITE LAKE LOMR, WASHOE COUNTY & CITY OF RENO, NEVADA
           2          ID    BY HDR INC., RENO, NEVADA (FILE WL100YR_NOAA.DAT) JUNE 2009
           3          ID    NOAA ATLAS 14 PRECIPITATION VALUES, 100 YEAR, 10 DAY EXISTING CONDITIONS
           4          IT      20                          720
           5          IO       3
                      *

           6          KK      WL
           7          KM       100 YR 10 DAY RUNOFF FROM ENTIRE WHITE LAKE WATERSHED USING LOSS RATES
           8          PH       1      30     .47      .9    1.49    1.59    1.69    2.17    3.32    4.95
           9          PH    6.71    9.03   11.07   12.46
          10          BA    29.3
          11          LU    0.30    0.10       9
          12          UD    1.36
                      *

          13          KK   WL+25
          14          KM   100 YR 10 DAY RUNOFF FROM WHITE LAKE PLUS 25 YR 24 HR INITIAL VOLUME
          15          RS       1    STOR    2470       0
          16          SV       0   0.003    0.05   362.3  1204.5  2157.4  3133.5  4123.9  5132.5  6169.7
          17          SV  7250.9  8383.2  9563.3 10792.7
          18          SQ       0       0       0       0       0       0       0       0       0       0
          19          SQ       0       0       0       0
          20          SE  5028.8  5029.7  5030.5  5031.4  5032.3  5033.1  5034.0  5034.8  5035.7  5036.6
          21          SE  5037.4  5038.3  5039.1  5040.0
          22          ZZ
1
            SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE     (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

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

   6           WL
                V
                V
  13        WL+25

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                    *****************************************
*                                       *                    *                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                    *   U.S. ARMY CORPS OF ENGINEERS        *
*             JUN  1998                 *                    *   HYDROLOGIC ENGINEERING CENTER       *
*           VERSION 4.1                 *                    *         609 SECOND STREET             *
*                                       *                    *       DAVIS, CALIFORNIA 95616         *
*  RUN DATE   05JUN09  TIME  15:00:07   *                    *          (916) 756-1104               *
*                                       *                    *                                       *
*****************************************                    *****************************************


                   WHITE LAKE LOMR, WASHOE COUNTY & CITY OF RENO, NEVADA
                   BY HDR INC., RENO, NEVADA (FILE WL100YR_NOAA.DAT) JUNE 2009
                   NOAA ATLAS 14 PRECIPITATION VALUES, 100 YEAR, 10 DAY EXISTING CONDITIONS

   5 IO         OUTPUT CONTROL VARIABLES
                      IPRNT          3  PRINT CONTROL
                      IPLOT          0  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE

     IT         HYDROGRAPH TIME DATA
                       NMIN         20  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1   0  STARTING DATE
                      ITIME       0000  STARTING TIME
                         NQ        720  NUMBER OF HYDROGRAPH ORDINATES
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```
          NDDATE     10    0  ENDING DATE
          NDTIME       2340  ENDING TIME
          ICENT          19  CENTURY MARK

       COMPUTATION INTERVAL     .33 HOURS
             TOTAL TIME BASE  239.67 HOURS

 ENGLISH UNITS
       DRAINAGE AREA            SQUARE MILES
       PRECIPITATION DEPTH      INCHES
       LENGTH, ELEVATION        FEET
       FLOW                     CUBIC FEET PER SECOND
       STORAGE VOLUME           ACRE-FEET
       SURFACE AREA             ACRES
       TEMPERATURE              DEGREES FAHRENHEIT

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

              **************
              *            *
   6 KK       *     WL     *
              *            *
              **************
                        100 YR 10 DAY RUNOFF FROM ENTIRE WHITE LAKE WATERSHED USING LOSS RATES

                SUBBASIN RUNOFF DATA

  10 BA           SUBBASIN CHARACTERISTICS
                        TAREA      29.30  SUBBASIN AREA

                  PRECIPITATION DATA

   8 PH                                   DEPTHS FOR   1-PERCENT HYPOTHETICAL STORM
                  ..... HYDRO-35 ......   ............... TP-40 ...............  ........... TP-49 ...........
                  5-MIN  15-MIN  60-MIN    2-HR    3-HR    6-HR   12-HR   24-HR   2-DAY   4-DAY   7-DAY  10-DAY
                    .47     .90    1.49    1.59    1.69    2.17    3.32    4.95    6.71    9.03   11.07   12.46

                                                      STORM AREA =    30.00

  11 LU           UNIFORM LOSS RATE
                        STRTL        .30  INITIAL LOSS
                        CNSTL        .10  UNIFORM LOSS RATE
                        RTIMP       9.00  PERCENT IMPERVIOUS AREA

  12 UD           SCS DIMENSIONLESS UNITGRAPH
                        TLAG        1.36  LAG

                                                              ***

                                                        UNIT HYDROGRAPH
                                                   22 END-OF-PERIOD ORDINATES
             1080.     3417.     6932.     9026.     9182.     7895.     5986.     3960.     2757.     1974.
             1359.      964.      674.      470.      332.      234.      164.      115.       85.       61.
               38.       18.

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

                      HYDROGRAPH AT STATION       WL

     TOTAL RAINFALL =    12.26, TOTAL LOSS =     8.98, TOTAL EXCESS =     3.28

   PEAK FLOW      TIME                          MAXIMUM AVERAGE FLOW
                                          6-HR         24-HR         72-HR       239.67-HR
 +   (CFS)        (HR)
                                (CFS)
 +   11314.      121.33                  4888.         2038.          755.          258.
                             (INCHES)    1.551         2.587         2.876         3.274
                              (AC-FT)    2424.         4043.         4495.         5116.

                      CUMULATIVE AREA =     29.30 SQ MI

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

              **************
              *            *
  13 KK       *   WL+25    *
              *            *
              **************
                     100 YR 10 DAY RUNOFF FROM WHITE LAKE PLUS 25 YR 24 HR INITIAL VOLUME

                HYDROGRAPH ROUTING DATA

  15 RS           STORAGE ROUTING
                        NSTPS          1  NUMBER OF SUBREACHES
                        ITYP        STOR  TYPE OF INITIAL CONDITION
                        RSVRIC   2470.00  INITIAL CONDITION
                        X            .00  WORKING R AND D COEFFICIENT

  16 SV           STORAGE         .0        .0        .1     362.3    1204.5    2157.4    3133.5    4123.9    5132.5    6169.7
                              7250.9    8383.2    9563.3   10792.7

  18 SQ          DISCHARGE         0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
                                   0.        0.        0.        0.

  20 SE          ELEVATION    5028.80   5029.70   5030.50   5031.40   5032.30   5033.10   5034.00   5034.80   5035.70   5036.60
                              5037.40   5038.30   5039.10   5040.00

                                                              ***
```

```
                 NMIN        20  MINUTES IN COMPUTATION INTERVAL
                IDATE     1   0  STARTING DATE
                ITIME      0000  STARTING TIME
                   NQ      2000  NUMBER OF HYDROGRAPH ORDINATES
               NDDATE    28   0  ENDING DATE
               NDTIME      1820  ENDING TIME
                ICENT        19  CENTURY MARK

          COMPUTATION INTERVAL      .33 HOURS
               TOTAL TIME BASE   666.33 HOURS

      ENGLISH UNITS
           DRAINAGE AREA          SQUARE MILES
           PRECIPITATION DEPTH    INCHES
           LENGTH, ELEVATION      FEET
           FLOW                   CUBIC FEET PER SECOND
           STORAGE VOLUME         ACRE-FEET
           SURFACE AREA           ACRES
           TEMPERATURE            DEGREES FAHRENHEIT


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

           **************
           *            *
   7 KK    *      WL    *
           *            *
           **************
                         100 YR 10 DAY RUNOFF FROM ENTIRE WHITE LAKE WATERSHED USING LOSS RATES

             SUBBASIN RUNOFF DATA

  11 BA        SUBBASIN CHARACTERISTICS
                     TAREA        29.30  SUBBASIN AREA

               PRECIPITATION DATA

   9 PH                                   DEPTHS FOR   1-PERCENT HYPOTHETICAL STORM
               ..... HYDRO-35 ......   ............... TP-40 ...............   ........... TP-49 ...........
               5-MIN  15-MIN  60-MIN    2-HR    3-HR    6-HR   12-HR   24-HR   2-DAY   4-DAY   7-DAY  10-DAY
                 .47     .90    1.49    1.59    1.69    2.17    3.32    4.95    6.71    9.03   11.07   12.46

                                                       STORM AREA =    30.00

  12 LU        UNIFORM LOSS RATE
                     STRTL          .30  INITIAL LOSS
                     CNSTL          .10  UNIFORM LOSS RATE
                     RTIMP        27.00  PERCENT IMPERVIOUS AREA

  13 UD        SCS DIMENSIONLESS UNITGRAPH
                     TLAG          1.36  LAG

                                                                      ***

                                                            UNIT HYDROGRAPH
                                                      22 END-OF-PERIOD ORDINATES
        1080.     3417.     6932.     9026.     9182.     7895.     5986.     3960.     2757.     1974.
        1359.      964.      674.      470.      332.      234.      164.      115.       85.       61.
          38.       18.

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

                        HYDROGRAPH AT STATION        WL

    TOTAL RAINFALL =    12.26, TOTAL LOSS =     7.21, TOTAL EXCESS =     5.05

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                    6-HR          24-HR          72-HR       666.33-HR
+    (CFS)      (HR)
                           (CFS)
+   11654.    121.67                5228.          2377.          1012.           143.
                        (INCHES)    1.659          3.017          3.852          5.054
                         (AC-FT)    2592.          4715.          6019.          7898.

                       CUMULATIVE AREA =    29.30 SQ MI


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

           **************
           *            *
  14 KK    *    WL+25   *
           *            *
           **************
                     100 YR 10 DAY RUNOFF FROM WHITE LAKE
                     PLUS 25 YR 24 HR INITIAL VOLUME (3103 AC-FT)
                     3MGD ANALYSIS ADDED TO STORAGE FOR EFFLUENT DISCHERGE (818 AC-FT)

             HYDROGRAPH ROUTING DATA

  18 RS        STORAGE ROUTING
                     NSTPS            1  NUMBER OF SUBREACHES
                      ITYP         STOR  TYPE OF INITIAL CONDITION
                    RSVRIC      3921.00  INITIAL CONDITION
                         X          .00  WORKING R AND D COEFFICIENT

  19 SV         STORAGE              .0        .0        .1     362.3    1204.5    2157.4    3133.5    4123.9    5132.5    6169.7
                                 7250.9    8383.2    9563.3   10792.7   12066.0   13382.8   14742.5   16146.5

  21 SQ        DISCHARGE             0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
                                     0.        0.        0.        0.        0.        0.        0.        0.
```

```
 23 SE          ELEVATION     5028.80   5029.70   5030.50   5031.40   5032.30   5033.10   5034.00   5034.80   5035.70   5036.60
                              5037.40   5038.30   5039.10   5040.00   5040.90   5041.70   5042.60   5043.40
                                                           ***

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

                   HYDROGRAPH AT STATION     WL+25

    PEAK FLOW      TIME                        MAXIMUM AVERAGE FLOW
                                       6-HR       24-HR       72-HR     666.33-HR
 +    (CFS)        (HR)
                              (CFS)
 +       0.         .00                  0.          0.          0.          0.
                            (INCHES)   .000        .000        .000        .000
                            (AC-FT)      0.          0.          0.          0.

  PEAK STORAGE     TIME                      MAXIMUM AVERAGE STORAGE
                                       6-HR       24-HR       72-HR     666.33-HR
 +  (AC-FT)        (HR)
     11819.      247.00               11819.      11819.      11819.      10375.

    PEAK STAGE     TIME                        MAXIMUM AVERAGE STAGE
                                       6-HR       24-HR       72-HR     666.33-HR
 +   (FEET)        (HR)
    5040.73      245.67              5040.72     5040.72     5040.75     5039.59

                             CUMULATIVE AREA =      29.30 SQ MI

1
                                              RUNOFF SUMMARY
                                         FLOW IN CUBIC FEET PER SECOND
                                      TIME IN HOURS,  AREA IN SQUARE MILES

                                            PEAK    TIME OF       AVERAGE FLOW FOR MAXIMUM PERIOD        BASIN    MAXIMUM     TIME OF
              OPERATION        STATION      FLOW     PEAK                                                AREA     STAGE     MAX STAGE
 +                                                                6-HOUR      24-HOUR      72-HOUR

              HYDROGRAPH AT
 +                                  WL     11654.   121.67          5228.        2377.        1012.      29.30

              ROUTED TO
 +                               WL+25        0.      .00             0.           0.           0.      29.30
 +                                                                                                               5040.73      245.67

 *** NORMAL END OF HEC-1 ***
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Appendix E

Storage Analysis Backup Calculations

				January	February	March	April	May	June	July	August	September	October	November	December
			EVAP RATES(ft)	0.13	0.15	0.31	0.39	0.62	0.75	1.13	0.78	0.53	0.35	0.18	0.11
Elevation	Area (ft^2)	Area (ac)		Evap (ft^3)	Evap (ft^3)	Evap (ft^3)	Evap (ft^3)	Evap (ft^3)	Evap (ft^3)	Evap (ft^3)	Evap (ft^3)	Evap (ft^3)	Evap (ft^3)	Evap (ft^3)	Evap (ft^3)
5028.814	0.0	0.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5029.197	94.4	0.0		12.31	14.47	28.93	36.65	58.53	71.23	106.34	73.90	49.74	32.91	16.78	10.48
5029.579	311.9	0.0		40.68	47.82	95.60	121.10	193.38	235.35	351.36	244.17	164.35	108.75	55.44	34.62
5029.961	1151.5	0.0		150.17	176.56	352.93	447.07	713.93	868.90	1297.16	901.43	606.74	401.49	204.68	127.82
5030.344	3905.9	0.1		509.39	598.90	1197.16	1516.47	2421.66	2947.33	4400.00	3057.67	2058.08	1361.86	694.27	433.55
5030.726	5602433.0	128.6		730650.64	859039.73	1717145.71	2175144.61	3473508.46	4227502.57	6311140.77	4385771.30	2952015.32	1953381.64	995832.47	621870.06
5031.108	26456418.0	607.4		3450357.85	4056650.76	8108892.12	10271704.29	16402979.16	19963572.08	29803154.88	20710965.89	13940327.58	9224471.08	4702628.30	2936662.40
5031.490	37417824.0	859.0		4879907.88	5737399.68	11468563.06	14527470.17	23199050.88	28234866.36	42151178.74	29291919.89	19716075.10	13046347.97	6651018.22	4153378.46
5031.873	44154772.0	1013.7		5758518.18	6770398.37	13533437.62	17143090.23	27375958.64	33318455.04	49740350.66	34565827.35	23265885.28	15395297.17	7848510.72	4901179.69
5032.255	47338260.0	1086.7		6173698.08	7258533.20	14509176.69	18379079.45	29349721.20	35720662.03	53326549.89	37057967.87	24943318.17	16505273.32	8414375.72	5254546.86
5032.637	48208172.0	1106.7		6287149.10	7391919.71	14775804.72	18716822.78	29889066.64	36377083.12	54306505.76	37738963.98	25401689.30	16808582.64	8569002.57	5351107.09
5033.020	48861360.0	1121.7		6372335.70	7492075.20	14976006.84	18970423.02	30294043.20	36869967.90	55042322.04	38250301.32	25745864.94	17036327.52	8685106.74	5423610.96
5033.402	49331708.0	1132.5		6433676.92	7564195.23	15120168.50	19153035.63	30585658.96	37224884.66	55572169.06	38618505.41	25993699.14	17200322.19	8768711.10	5475819.59
5033.784	49651456.0	1139.8		6475377.39	7613223.25	15218171.26	19277177.79	30783902.72	37466161.17	55932365.18	38868814.81	26162179.69	17311807.66	8825546.30	5511311.62
5034.167	49955372.0	1146.8		6515013.10	7659823.71	15311321.52	19395173.18	30972330.64	37695491.12	56274726.56	39106730.38	26322318.10	17417773.04	8879567.37	5545046.29
5034.549	50276820.0	1154.2		6556935.28	7709112.40	15409845.33	19519975.37	31171628.40	37938050.43	56636837.73	39358370.59	26491694.41	17529851.24	8936704.76	5580727.02
5034.931	50650376.0	1162.8		6605653.20	7766390.99	15524340.24	19665008.48	31403233.12	38219929.56	57057648.56	39650802.68	26688527.29	17660097.77	9003104.33	5622191.74
5035.313	51124908.0	1173.7		6667540.09	7839152.56	15669784.30	19849245.53	31697442.96	38578003.50	57592208.86	40022282.15	26938566.11	17825551.26	9087452.40	5674864.79
5035.696	51746696.0	1187.9		6748631.60	7934493.39	15860362.32	20090654.72	32082951.52	39047194.36	58292653.04	40509038.52	27266196.57	18042348.01	9197975.21	5743883.26
5036.078	52397016.0	1202.9		6833444.17	8034209.12	16059685.40	20343141.46	32486149.92	39537914.99	59025238.52	41018130.69	27608861.01	18269092.91	9313569.59	5816068.78
5036.460	53243760.0	1222.3		6943873.70	8164043.20	16319212.44	20671889.82	33011131.20	40176853.90	59979095.64	41680990.12	28055024.54	18564324.32	9464078.34	5910057.36
5036.842	54351260.0	1247.7		7088310.16	8333859.87	16658661.19	21101876.70	33697781.20	41012554.94	61226694.39	42547978.04	28638584.75	18950472.65	9660936.47	6032989.86
5037.225	55455556.0	1273.1		7232328.76	8503185.25	16997127.91	21530619.62	34382444.72	41845838.30	62470683.83	43412457.76	29220456.72	19335503.86	9857225.08	6155566.72
5037.607	56663784.0	1300.8		7389901.83	8688446.88	17367449.80	21999714.14	35131546.08	42757547.01	63831752.68	44358298.91	29857092.19	19756772.69	10071987.61	6289680.02
5037.989	57779360.0	1326.4		7535391.53	8859501.87	17709373.84	22432836.52	35823203.20	43599342.07	65088449.04	45231608.99	30444907.77	20145736.65	10270281.24	6413508.96
5038.372	58823776.0	1350.4		7671600.79	9019645.65	18029487.34	22838331.03	36470741.12	44387440.97	66264983.66	46049212.65	30995227.97	20509889.90	10455926.18	6529439.14
5038.754	59882904.0	1374.7		7809728.73	9182045.28	18354110.08	23249537.48	37127400.48	45186641.31	67458091.36	46878333.35	31553300.17	20879172.53	10644186.19	6647002.34
5039.136	61042852.0	1401.4		7961005.28	9359903.97	18709634.14	23699887.29	37846568.24	46061918.74	68764772.78	47786379.31	32164496.10	21283607.73	10850366.94	6775756.57
5039.519	62162296.0	1427.0		8106999.44	9531552.05	19052743.72	24134511.42	38540623.52	46906632.52	70025826.44	48662717.39	32754349.80	21673920.54	11049348.11	6900014.86
5039.901	63186496.0	1450.6		8240572.19	9688596.05	19366661.02	24532157.07	39175627.52	47679476.77	71179587.74	49464495.29	33294017.85	22031024.94	11231399.66	7013701.06
5040.283	64122424.0	1472.0		8362632.80	9832105.01	19653522.96	24895531.12	39755902.88	48385712.44	72233910.64	50197170.92	33787173.91	22357351.83	11397760.87	7117589.06
5040.666	65095708.0	1494.4		8489565.25	9981341.89	19951834.50	25273408.63	40359338.96	49120136.33	73330315.06	50959090.08	34300013.47	22696703.52	11570762.10	7225623.59
5041.047	66095212.0	1517.3		8619917.23	10134599.17	20258182.48	25661466.06	40979031.44	49874345.39	74456256.32	51741535.13	34826668.79	23045197.25	11748423.93	7336568.53
5041.430	67053068.0	1539.3		8744837.62	10281470.43	20551765.34	26033353.65	41572902.16	50597127.56	75535281.10	52491376.73	35331379.08	23379169.71	11918682.84	7442890.55
5041.812	68017200.0	1561.5		8870576.50	10429304.00	20847271.80	26407677.90	42170664.00	51324645.50	76621375.80	53246131.40	35839396.30	23715330.40	12090057.30	7549909.20
5042.194	68980704.0	1583.6		8996233.48	10577041.28	21142585.78	26781758.33	42768036.48	52051689.56	77706763.06	54000394.45	36347082.62	24051272.13	12261320.14	7656858.14
5042.577	69983408.0	1606.6		9127002.79	10730789.23	21449914.55	27171058.16	43389712.96	52808313.29	78836309.11	54785344.56	36875424.07	24400881.59	12439550.77	7768158.29
5042.959	70975008.0	1629.4		9256323.96	10882834.56	21753839.95	27556046.86	44004504.96	53556558.12	79953346.51	55561602.10	37397914.63	24746619.46	12615807.67	7878225.89
5043.341	72020912.0	1653.4		9392727.27	11043206.51	22074409.53	27962119.08	44652965.44	54345779.85	81131557.37	56380370.61	37949018.88	25111291.32	12801717.11	7994321.23
5043.724	73065232.0	1677.3		9528924.01	11203335.57	22394493.61	28367576.32	45300443.84	55133806.31	82307983.85	57197899.12	38499288.49	25475410.89	12987344.99	8110240.75
5044.106	73923320.0	1697.0		9640832.98	11334909.07	22657497.58	28700728.99	45832458.40	55781305.22	83274619.98	57869639.01	38951429.36	25774597.57	13139870.13	8205488.52
5044.488	74770624.0	1716.5		9751335.55	11464829.01	22917196.26	29029694.77	46357786.88	56420666.69	84229107.94	58532936.82	39397887.96	26070024.23	13290478.42	8299539.26
5044.871	75562960.0	1734.7		9854669.37	11586320.53	23160047.24	29337319.22	46849035.20	57018550.23	85121674.44	59153203.85	39815383.01	26346285.39	13431316.14	8387488.56
5045.253	76251976.0	1750.5		9944528.54	11691969.65	23371230.64	29604829.68	47276225.12	57538470.22	85897850.96	59692588.55	40178437.02	26586522.30	13553788.73	8463969.34
5045.635	76821016.0	1763.6		10018740.84	11779222.45	23545641.40	29825759.46	47629029.92	57967858.32	86538874.52	60138052.03	40478273.68	26784927.58	13654935.59	8527132.78
5046.017	77274528.0	1774.0		10077886.36	11848760.96	23684642.83	30001835.50	47910207.36	58310070.92	87049755.79	60493076.34	40717236.71	26943052.10	13735547.35	8577472.61
5046.399	77636536.0	1782.3		10125098.24	11904268.85	23795598.28	30142385.10	48134652.32	58583236.12	87457557.80	60776468.27	40907984.76	27069272.22	13799894.27	8617655.50
5046.782	77960264.0	1789.7		10167317.76	11953907.15	23894820.92	30268072.50	48335363.68	58827515.88	87822237.40	61029893.33	41078562.44	27182145.38	13857436.93	8653589.30
5047.164	78214480.0	1795.6		10200471.77	11992886.93	23972738.12	30366771.86	48492977.60	59019343.03	88108611.72	61228902.09	41212513.09	27270782.03	13902623.82	8681807.28
5047.546	78450184.0	1801.0		10231211.50	12029028.21	24044981.40	30458283.94	48639114.08	59197201.34	88374132.28	61413419.04	41336709.45	27352964.15	13944520.21	8707970.42
5047.929	78655440.0	1805.7		10257980.30	12060500.80	24107892.36	30537974.58	48766372.80	59352084.10	88605353.16	61574100.28	41444862.26	27424530.08	13981004.46	8730753.84
5048.311	78808608.0	1809.2		10277955.96	12083986.56	24154838.35	30597442.06	48861336.96	59467662.12	88777896.91	61694005.30	41525569.03	27477934.66	14008230.07	8747755.49
5048.693	78935280.0	1812.1		10294476.10	12103409.60	24193663.32	30646622.46	48939873.60	59563246.70	88920592.92	61793168.36	41592314.62	27522100.96	14030746.02	8761816.08
5049.076	79049912.0	1814.7		10309426.02	12120986.51	24228798.03	30691128.33	49010945.44	59649746.10	89049725.87	61882906.11	41652716.13	27562069.32	14051121.86	8774540.23
5049.458	79130464.0	1816.6		10319931.35	12133337.81	24253487.22	30722402.65	49060887.68	59710529.29	89140467.70	61945964.90	41695160.32	27590155.11	14065439.98	8783481.50
5049.840	79197080.0	1818.1		10328619.18	12143552.27	24273905.02	30748266.31	49102189.60	59760796.62	89215510.62	61998114.13	41730261.40	27613381.69	14077260.97	8790875.88
5050.223	79269512.0	1819.8		10338065.52	12154658.51	24296105.43	30776388.03	49147097.44	59815452.60	89297105.27	62054816.31	41768427.03	27638636.52	14090155.76	8798915.83
5050.604	79320208.0	1820.9		10344677.13	12162431.89	24311643.75	30796070.76	49178528.96	59853706.95	89354214.31	62094502.83	41795139.60	27656312.52	14099166.97	8804543.09
5050.987	79365912.0	1822.0		10350637.69	12169439.84	24325652.03	30813815.33	49206865.44	59888194.43	89405699.87	62130281.44	41819221.80	27672247.98	14107290.86	8809616.23
5051.369	79416152.0	1823.1		10357189.82	12177143.31	24341050.59	30833321.01	49238014.24	59926104.70	89462295.23	62169610.99	41845694.09	27689765.00	14116221.02	8815192.87
5051.751	79459040.0	1824.1		10362783.13	12183719.47	24354195.76	30849972.28	49264604.80	59958467.27	89510608.56	62203185.15	41868292.49	27704718.61	14123844.36	8819953.44
5052.134	79494736.0	1824.9		10367438.49	12189192.85	24365136.58	30863831.25	49286736.32	59985402.87	89550820.10	62231129.17	41887101.31	27717164.62	14130189.32	8823915.70
5052.516	79531536.0	1825.8		10372237.82	12194835.52	24376415.78	30878118.85	49309552.32	60013171.54	89592275.30	62259937.43	41906491.84	27729995.55	14136730.52	8828000.50
5052.898	79566856.0	1826.6		10376844.14	12200251.25	24387241.36	30891831.84	49331450.72	60039823.42	89632063.28	62287587.11	41925102.54	27742310.46	14143008.65	8831921.02
5053.281	79604800.0	1827.5		10381792.67	12206069.33	24398871.20	30906563.60	49354976.00	60068455.33	89674807.20	62317290.93	41945095.87	27755540.27	14149753.20	8836132.80
5053.663	79646592.0	1828.4		10387243.04	12212477.44	24411680.45	30922789.34	49380887.04	60099990.88	89721885.89	62350007.10	41967116.77	27770111.74	14157181.73	8840771.71
5054.045	79682336.0	1829.3		10391904.65	12217958.19	24422635.98	30936666.95	49403048.32	60126962.71	89762151.50	62377988.70	41985950.88	27782574.49	14163535.22	8844739.30
5054.428	79713416.0	1830.0		10395958.00	12222723.79	24432162.00	30948733.76	49422317.92	60150415.16	89797163.12	62402319.16	42002327.45	27793411.05	14169059.69	8848189.18
5054.810	79745616.0	1830.7		10400157.42	12227661.12	24442031.30	30961235.41	49442281.92	60174712.74	89833436.42	62427526.39	42019294.16	27804638.11	14174783.24	8851763.38
5055.192	79777320.0	1831.4		10404292.15	12232522.40	24451748.58	30973544.49	49461938.40	60198636.05	89869150.98	62452345.34	42035999.53	27815692.24	14180418.63	8855282.52
5055.574	79803184.0	1832.0		10407665.25	12236488.21	24459675.90	30983586.19	49477974.08	60218152.59	89898286.78	62472592.54	42049627.70	27824710.15	14185015.96	8858153.42
5055.957	79824864.0	1832.5		10410492.68	12239812.48	24466320.82	30992003.45	49491415.68	60234511.96	89922709.30	62489564.37	42061051.26	27832269.25	14188869.58	8860559.90
5056.339	79843224.0	1832.9		10412887.13	12242627.68	24471948.16	30999131.72	49502798.88	60248366.11	89943391.84	62503937.19	42070725.45	27838670.77	14192133.07	8862597.86
5056.721	79859056.0	1833.3		10414951.89	12245055.25	24476800.66	31005278.49	49512614.72	60260312.67	89961226.58	62516331.01	42079067.59	27844190.86	14194947.20	8864355.22
5057.104	79873656.0	1833.6		10416855.97	12247293.92	24481275.56	31010946.94	49521666.72	60271329.59	89977673.48	62527760.37	42086760.57	27849281.39	14197542.35	8865975.82
5057.486	79887616.0	1834.0		10418676.59	12249434.45	24485554.30	31016366.91	49530321.92	60281863.57	89993399.42	62538688.73	42094116.33	27854148.78	14200023.74	8867525.38
5057.868	79901176.0	1834.3		10420445.04	12251513.65	24489710.44	31021631.58	49538729.12	60292095.72	90008674.76	62549303.95	42101261.32	27858876.70	14202434.03	8869030.54
5058.250	79913880.0	1834.6		10422101.85	12253461.60	24493604.22	31026563.91	49546605.60	60301681.95	90022985.82	62559249.06	42107955.27	27863306.16	14204692.17	8870440.68
5058.633	79925952.0	1834.8		10423676.24	12255312.64	24497304.29	31031250.86	49554090.24	60310791.28	90036584.93	62568699.42	42114316.21	27867515.26	14206837.97	8871780.67
5059.015	79938768.0	1835.1		10425347.66	12257277.76	24501232.39	31036226.68	49562036.16	60320462.02	90051022.15	62578732.22	42121069.17	27871983.78	14209116.01	8873203.25
5059.397	79949864.0	1835.4		10426794.76	12258979.15	24504633.32	31040534.70	49568915.68	60328834.88	90063521.80	62587418.53	42126915.84	27875852.58	14211068.33	8874434.90
5059.780	79959872.0	1835.6		10428099.97	12260513.71	24507700.77	31044420.30	49575120.64	60336386.75	90074795.81	62595253.13	42132189.22	27879342.04	14212667.25	8875545.79
5060.162	79968456.0	1835.8		10429219.47	12261829.92	24510331.76	31047753.04	49580442.72	60342864.09	90084465.68	62601972.97	42136712.27	27882334.99	14214393.05	8876498.62
5060.544	79975760.0	1836.0		10430172.03	12262949.87	24512570.44	31050588.82	49584971.20	60348375.57	90092693.64	62607690.79	42140560.87	27884881.65	14215691.34	8877309.36
5060.926	79982088.0	1836.1		10430997.31	12263920.16	24514509.97	31053045.67	49588894.56	60353150.57	90099822.13	62612644.56	42143895.20	27887088.02	14216816.14	8878011.77
5061.309	79987592.0	1836.3		10431715.12	12264764.11	24516196.95	31055182.59	49592307.04	60357303.80	90106022.39	62616953.27	42146795.35	27889007.08	14217794.48	8878622.71
5061.691	79992024.0	1836.4		10432293.13	12265443.68	24517555.36	31056903.32	49595054.88	60360648.11	90111015.04	62620422.79	42149130.65	27890552.37	14218582.27	8879114.66
5062.073	79994968.0	1836.4		10432677.08	12265895.09	24518457.69	31058046.33	49596880.16	60362869.60	90114331.45	62622727.45	42150681.89	27891578.84	14219105.56	8879441.45
5062.456	79996336.0	1836.5		10432855.49	12266104.85	24518876.98	31058577.45	49597728.32	60363901.87	90115872.50	62623798.37	42151402.71	27892055.82	14219348.72	8879593.30
5062.838	79996840.0	1836.5		10432921.22	12266182.13	24519031.46	31058773.13	49598040.80	60364282.18	90116440.26	62624192.91	42151668.28	27892231.55	14219438.31	8879649.24
5063.220	79997336.0	1836.5		10432985.90	12266258.19	24519183.48	31058965.70	49598348.32	60364656.46	90116999.00	62624581.20	42151929.63	27892404.49	14219526.47	8879704.30
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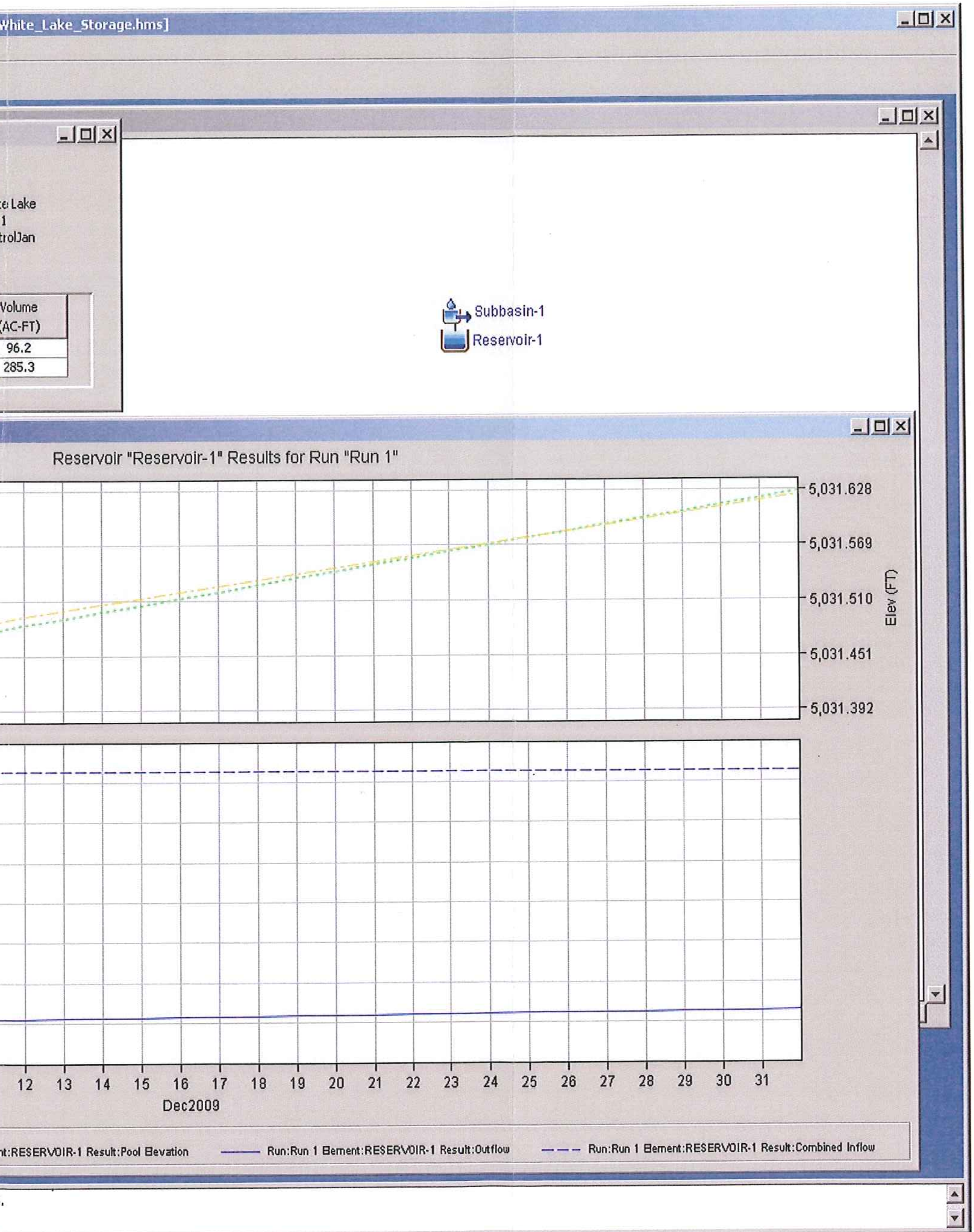
5063.985	79998336.0	1836.5		10433116.32	12266411.52	24519489.98	31059353.95	49598968.32	60365411.04	90118125.50	62625364.03	42152456.54	27892753.15	14219704.22	8879815.30
5064.367	79998992.0	1836.5		10433201.87	12266512.11	24519691.05	31059608.64	49599375.04	60365906.05	90118864.49	62625877.57	42152802.20	27892981.88	14219820.83	8879888.11
5064.749	79999992.0	1836.5		10433332.29	12266665.44	24519997.55	31059996.89	49599995.04	60366660.63	90119990.99	62626660.40	42153329.12	27893330.54	14219998.58	8879999.11
5065.131	80001200.0	1836.6		10433489.83	12266850.67	24520367.80	31060465.90	49600744.00	60367572.17	90121351.80	62627606.07	42153965.63	27893751.73	14220213.30	8880133.20
5065.514	80002568.0	1836.6		10433668.24	12267060.43	24520787.09	31060997.03	49601592.16	60368604.44	90122892.85	62628676.98	42154686.46	27894228.71	14220456.46	8880265.05
5065.896	80004616.0	1836.7		10433935.34	12267374.45	24521414.80	31061792.16	49602861.92	60370149.82	90125199.92	62630280.23	42155765.58	27894942.78	14220820.49	8880512.38
5066.278	80007480.0	1836.7		10434308.85	12267813.60	24522292.62	31062904.11	49604637.60	60372310.95	90128426.22	62632522.26	42157274.67	27895941.36	14221329.57	8880830.28
5066.661	80010928.0	1836.8		10434758.53	12268342.29	24523349.43	31064242.80	49606775.36	60374912.75	90132310.39	62635221.47	42159091.48	27897143.56	14221942.45	8881213.01
5067.043	80011736.0	1836.8		10434863.90	12268466.19	24523597.08	31064556.50	49607276.32	60375522.46	90133220.60	62635854.00	42159517.23	27897425.29	14222086.07	8881302.70



White_Lake_Storage.hms]
e Lake
1
trolJan
Volume
(AC-FT)
96.2
285.3
Subbasin-1
Reservoir-1
Reservoir "Reservoir-1" Results for Run "Run 1"
5,031.628
5,031.569
5,031.510
5,031.451
5,031.392
Elev (FT)
12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Dec2009
nt:RESERVOIR-1 Result:Pool Elevation
Run:Run 1 Element:RESERVOIR-1 Result:Outflow
Run:Run 1 Element:RESERVOIR-1 Result:Combined Inflow

Appendix F

Hydrologic Analysis of Silver Lake and Lemmon Valley Playa, 1987

HYDROLOGIC ANALYSIS OF SILVER LAKE AND LEMMON VALLEY PLAYAS

See p.6 for support of isopleth idea

See p.15 - question accuracy of study with 5' contour maps

p.20 why this scenario

See appendix B Dept of Commerce letter re isopleths

p.14 - calibration appears

If Lemmon lake a little high but Silver is 2' higher than observed

LOCATED IN CITY OF RENO, NEVADA AND
WASHOE COUNTY, NEVADA

FOR:

FEDERAL EMERGENCY MANAGEMENT AGENCY
(CONTRACT #EMW-86-C-2239)
JULY 1987
REVISED DECEMBER 1987

NIMBUS JOB #8601

Nimbus Engineers
240 Linden St., Suite B • Reno, NV 89502
Mail: P.O. Box 10220 • Reno, NV 89510
(702) 689-8630

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1.0 - INTRODUCTION AND PURPOSE

This report is prepared in conjunction with a current Federal Emergency Management Agency (FEMA) flood insurance re-study for the Reno/Sparks Area. The re-study includes a hydrologic and hydraulic analysis for the Silver Lake and Lemmon Valley watersheds in order to determine 100 year water surface elevations for the major playas within these areas. The previous flood insurance study mapped these playas using approximate methods. Due to the increase in development immediately adjacent to these lakes, it has become necessary to determine regulatory flood elevations for the lake areas.

A brief version of this report that addressed the calibration procedure used in this study was sent to the U.S. Geological Survey, National Weather Service Forecast Office in Reno, the Corps of Engineers, The Soil Conservation Service, the Federal Emergency Management Agency, and local agencies for review. Comments were received from each of these agencies. This report was revised to address each of the comments received and include the analysis of the 100 year runoff volumes. The letters that were received in response to the original report are contained in Appendix A with a section that specifically addresses each comment.

During February 1986, a significant precipitation event occurred which allowed the collection of valuable data for evaluating the hydrologic characteristics of these watersheds. This report presents the results of Nimbus Engineers calibration of the HEC-1 hydrologic models using the available data from the February 1986 event. This calibration was used to determine reasonable initial and constant loss rates to be used in the hydrologic models that will determine the runoff volumes from a 100 year, 10 day event.

Both the Lemmon Valley and Silver Lake Playas are terminal lakes within closed basins. Closed basin lakes present a unique and difficult regulatory problem for western flood plain managers. The only outflow from most of these lakes is evaporation, as is the case with the playas evaluated in this study. When flooding occurs from lake level fluctuations, the period of inundation can be weeks or months. This results in substantially higher damages to structures and roadways than shorter duration riverine flooding. Because of this fact; considerable care must be taken in determining an accurate level for the desired recurrence interval to be used for management purposes.

Due to insufficient historical lake level data for the playas evaluated in this study, the level for a 100 year recurrence interval must be established with a hydrologic model and tested with a variety of potential types and patterns of storms. This report presents the method used to calibrate the hydrologic model used and the rainfall patterns and distributions that were used to determine the potential lake level.

2.0 - PHYSICAL DESCRIPTION OF STUDY AREA

The two watersheds evaluated in this report are shown on Figure 1. These basins are located in southern Washoe County just north of the Reno area. Most of the area is within unincorporated Washoe County, Nevada with some portions incorporated into the City of Reno. Elevations within the watershed range from a maximum of 8266 feet to a minimum of 4906. Vegetation types in the watershed vary from sparse Pinon in the upper elevations to sage/grass in the majority of the watershed. Large portions of these watersheds consist of gently sloping alluvial material with a poorly defined drainage pattern. Most of the runoff within the watershed occurs as shallow sheet flow and braided flow. The primary drainages are so poorly defined that many of the major drainages are not readily discernable from the ground. Aerial photos provide a better reference for identification of the drainage patterns than field inspection. Both watersheds in the study area are closed basins draining to playas. The only losses from these playas are evaporation and infiltration.

The Silver Lake watershed is 53.8 square miles in size. The watershed is long and narrow with the playa located in the southern extreme of the watershed. The Lemmon Valley watershed is 43.02 square miles in size with the playa being centrally located within the basin.

3.0 - HISTORICAL DATA

Peak lake levels in the playas have not been recorded in the past since the lakes did not threaten any structures until recent encroachments have resulted in damage to structures. The only information on lake levels prior to 1983 only exists in a few photos with uncertain dates and indistinguishable shorelines.

In 1982 the Desert Research Institute (DRI) installed a staff gauge in Silver Lake to monitor lake level fluctuations. The purpose of their study was to determine the surface and groundwater contributions to the lake throughout the year for water supply studies. The staff gauge was destroyed by vandals soon after it was installed and has not been re-established.

Beginning in 1985, Pyramid Engineers and Land Surveyors began monitoring the lake level of Silver Lake and the two adjacent playas to the northeast, with periodic surveys of the water surface elevations.

During the flooding of February 1986, the Washoe County Utility Department began monitoring the water surface elevations of Lemmon Valley playa. The lake had risen to the point that it was inundating the sewage treatment plant at the southeast corner of the playa. The flooding of the playa resulted in closure of the plant and temporary discharge of raw sewage into the playa.

3.1 - 4 DAY STORM OF DECEMBER 1955

The 1955 storm was used by the Corps of Engineers in their analysis of the Truckee River Basin (Ref 25). The Corps developed an isohyetal map of the December 21-25, 1955 event for the Truckee River Basin. This map suggests that the precipitation totals within the study area was 1.2 to 1.4 times greater than the totals at Reno-Cannon International Airport. This event consisted of a 4-5 day rainfall on an existing snowpack that caused significant runoff on many of the major watercourses such as the Truckee River.

3.2 - 3 DAY STORM OF FEBRUARY 1963

The Corps of Engineers also prepared a isohyetal map of the January 30 to February 1, 1963 event, for their use in the Truckee River analysis (Ref 25). This event produced one of the highest recorded discharges on the Truckee River. The storm was a 3 day rainfall event. The Corps considered the snowpack to be light enough to be considered insignificant to the peak runoff response in the Truckee River.

Precipitation totals in the study area during the 1963 event appear to have been 1.6 to 2.3 times greater than the totals at the Reno airport gauge.

3.3 - WINTER OF 1982 - 1983

Unusually wet conditions existed before and during the winter of 1982 and 1983. Many of the terminal lakes and sinks in Nevada experienced higher than average runoff volumes and lake levels. The peak elevation of Silver Lake during 1983 was estimated by the Desert Research Institute as 4962.5.

3.4 - 9 DAY STORM OF FEBRUARY 1986

A significant amount of flooding occurred in the Reno/Sparks area during February 1986. The flooding was caused by a large warm Pacific storm that began February 12th and extended through February 20th. Daily precipitation totals for the storm were collected at 14 sites in and around the Reno area. Three of these gauges are located within the study area; two in the southern portion of the Silver Lake watershed and one in the northern portion of the Lemmon Valley watershed. The only recording rain gauge in the area was the National Weather Service gauge at the Reno-Cannon International Airport. Hourly totals of the rainfall which occurred at Cannon International Airport are graphed and shown in Figure 2.

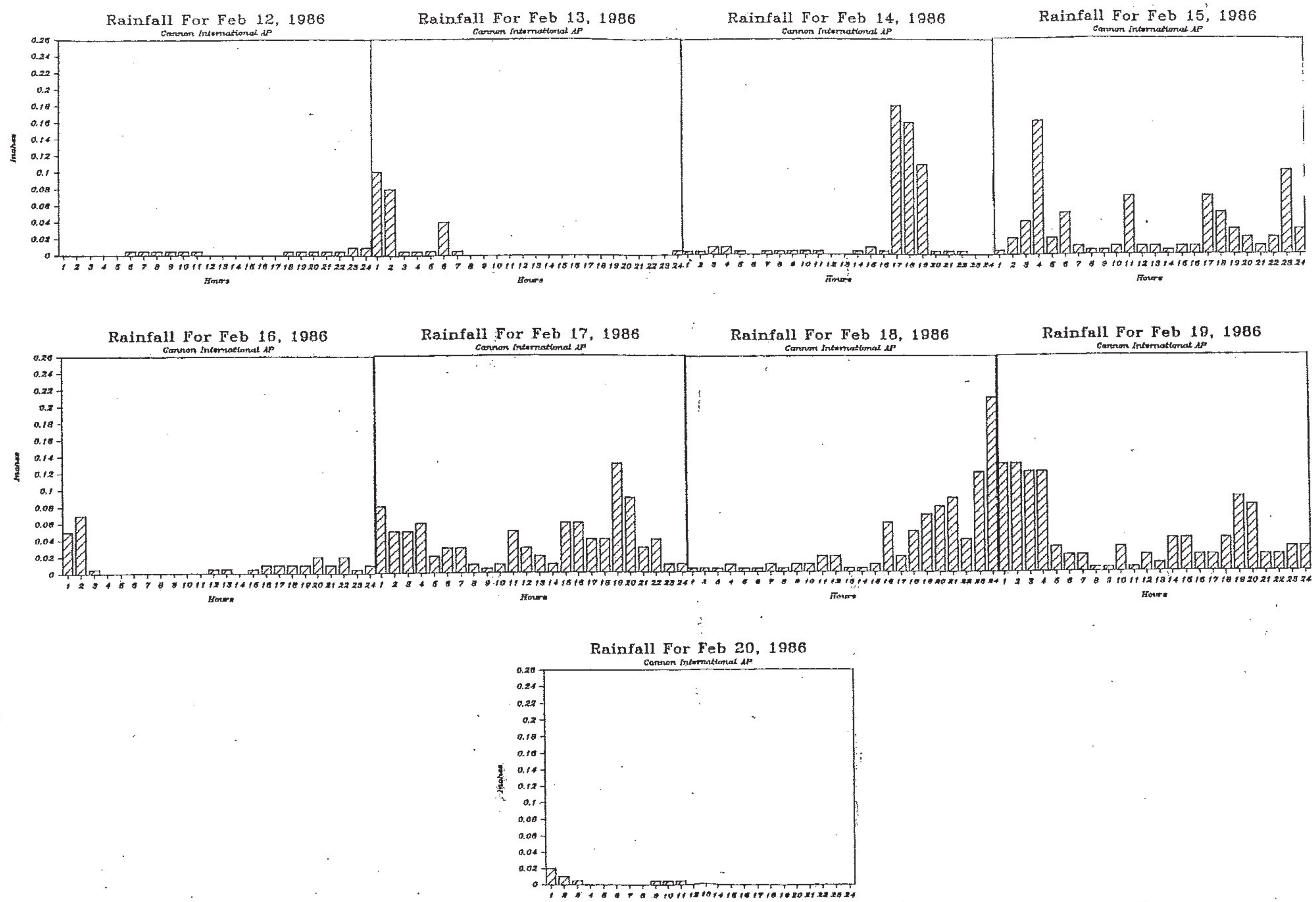

FIGURE 2

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Analysis of the rainfall data collected during that event was done by Washoe County Department of Comprehensive Planning (Ref. 4). Their analysis indicates that the rainfall totals vary consistently with elevation. This would suggest that the storm was large enough to have a relatively consistent spatial and temporal distribution over the area of interest. Rainfall totals at specific sites appeared to be dependant upon orographic effects. The National Weather Service Forecast Office at Reno, prepared a report on the February 1986 event which included a map of the 10 day precipitation totals for the Truckee River Basin (Ref. 28). Using the rainfall information from the 15 rain gauges, the NWS report, and the analysis by Washoe County, a reasonable Isohyetal Map was constructed for the area of interest. This map is included as Figure 3, as it was revised by NWS staff.

Figure 4 is a rainfall mass curve from the event using the hourly totals from the National Weather Service gauge at the airport. This mass curve indicates that the highest intensity rainfall occurred between 2300 hours on February 18 and 400 hours on February 19th. Figure 5 shows the short duration precipitation that indicates that the intensities during the storm were low. The storm was a long duration and low intensity event that only produced high peak flows in the larger watercourses. Since the most significant portion of the total rainfall occurred at the end of the nine day period, the soils within the watershed were saturated during the key period.

Nimbus Engineers performed field inspections of the study area before, during, and after the February event. The Washoe County Utility Department took frequent water level measurements of the Lemmon Valley playa which recorded the lake's response to the runoff from the watershed. The graph prepared by Washoe County is included as Figure 6. Frequent lake level measurements that recorded Silver Lake's response to the event were also recorded by Pyramid Engineers. Their data has been plotted in the same format as the Lemmon Valley playa and is included as Figure 7. Both playas had minimal or no initial volume at the beginning of the event.

The precipitation data and lake levels are the only hard data collected. Watercourses were also inspected by Nimbus staff during and after the event to determine which areas of the watersheds contributed significantly to the watershed discharges.

4.0 - OTHER STUDIES

The original flood insurance study for Washoe County developed flood limits for these playas using approximate methods. Therefore this study does not provide useful information for this study.

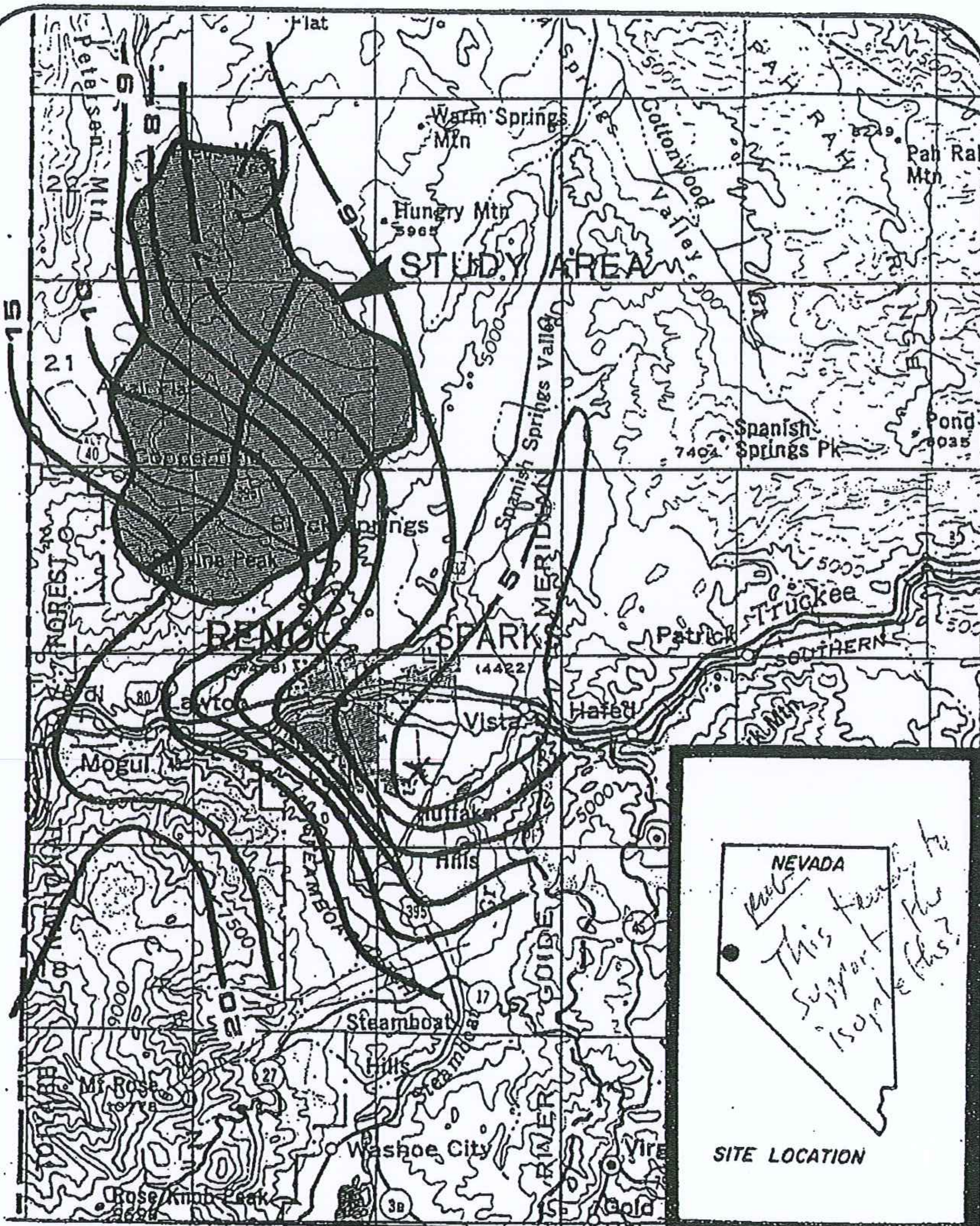

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FIGURE 3

ISOHYETAL MAP

FEBRUARY 12-20, 1986

RAINFALL MASS CURVE FOR FEB 13–19, 1986

CANNON INTERNATIONAL AIRPORT GAUGE

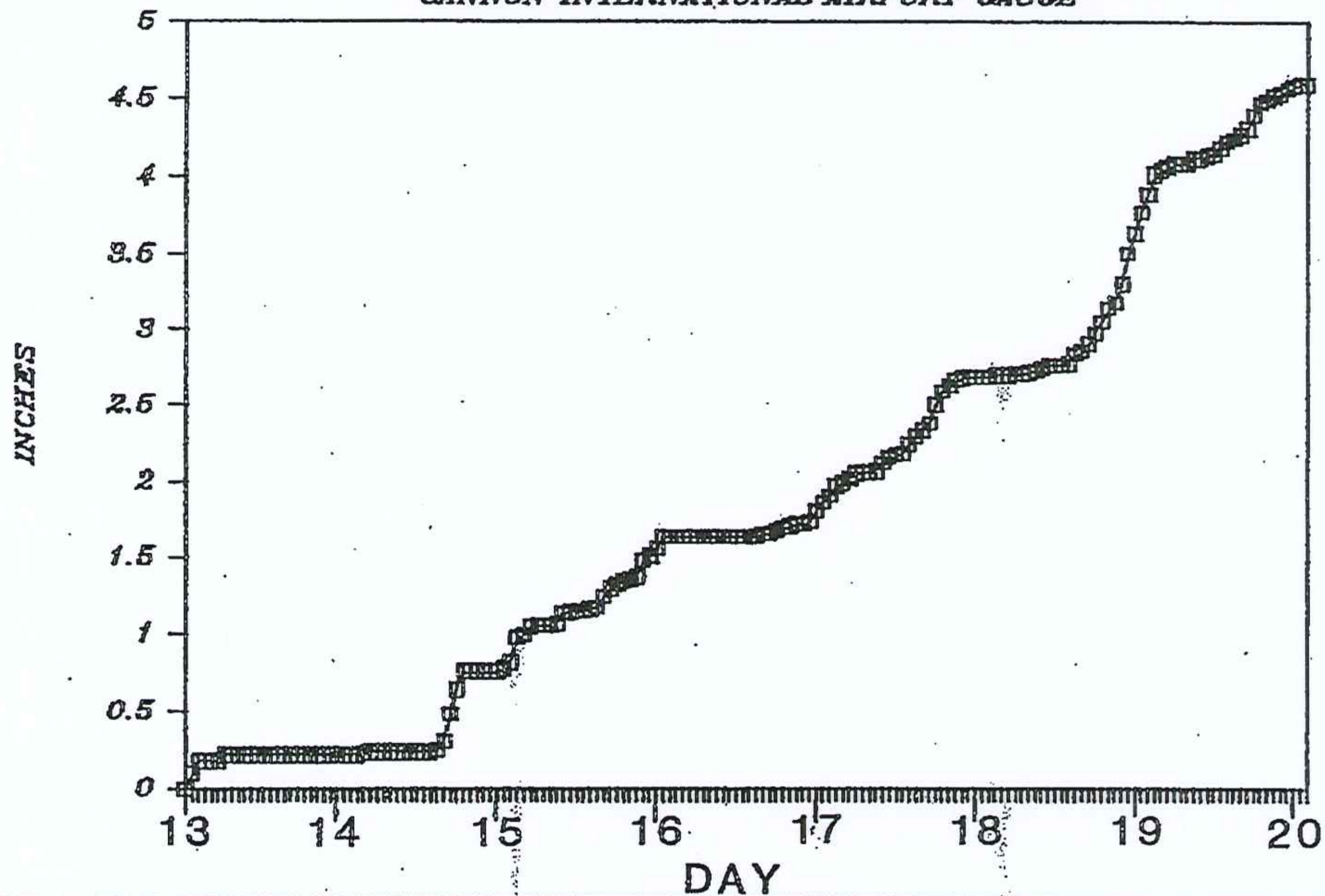

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FIGURE 4

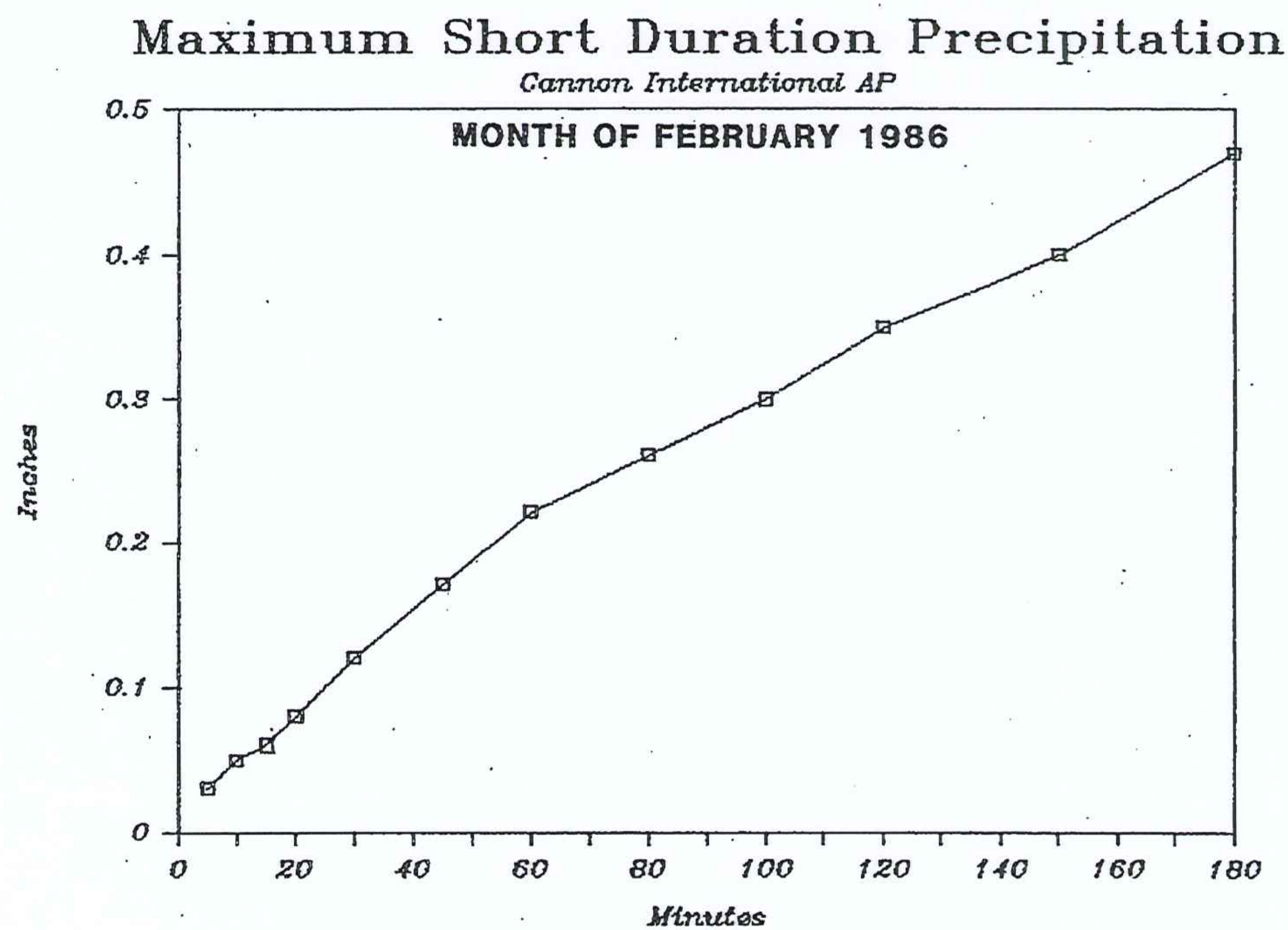

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FIGURE 5

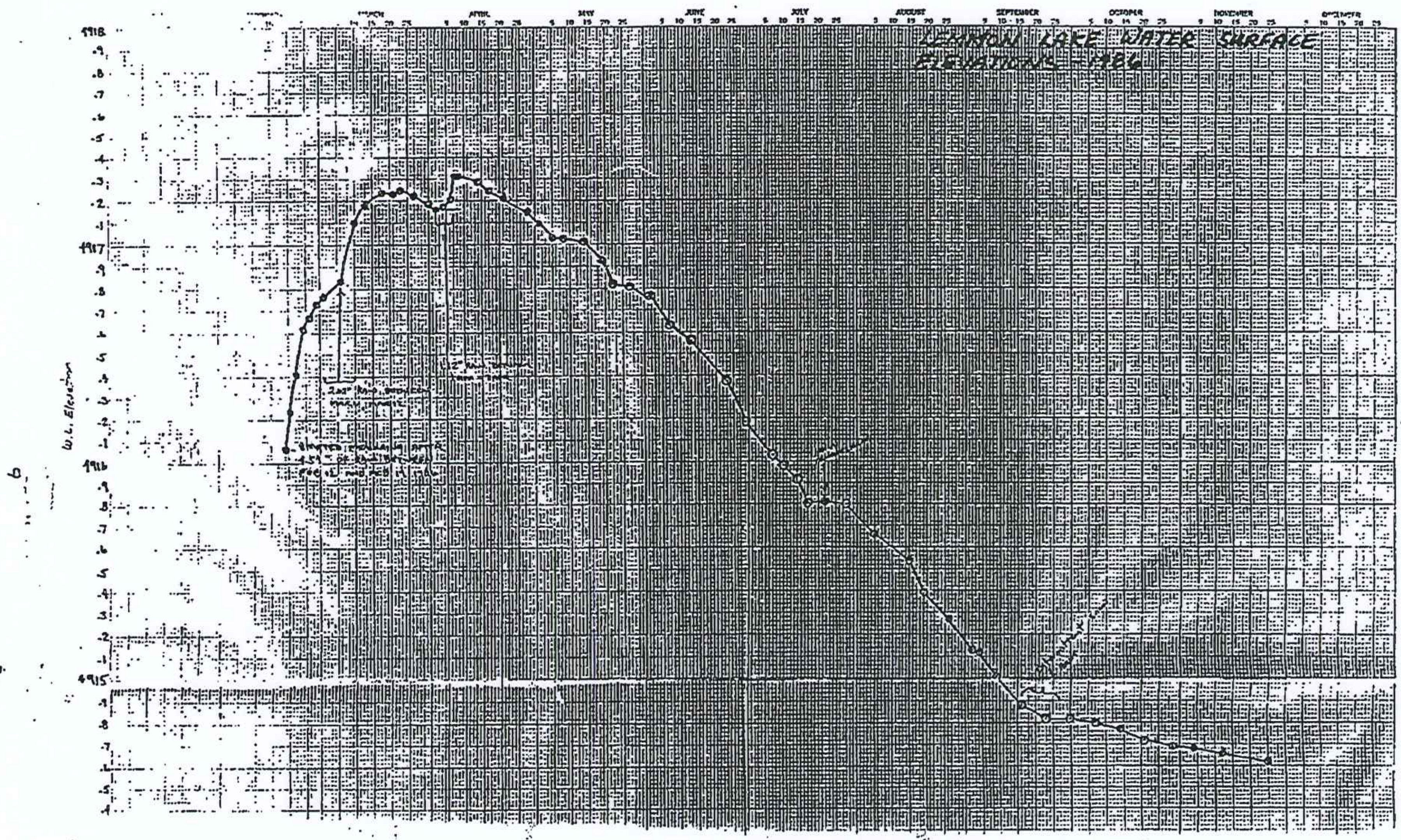
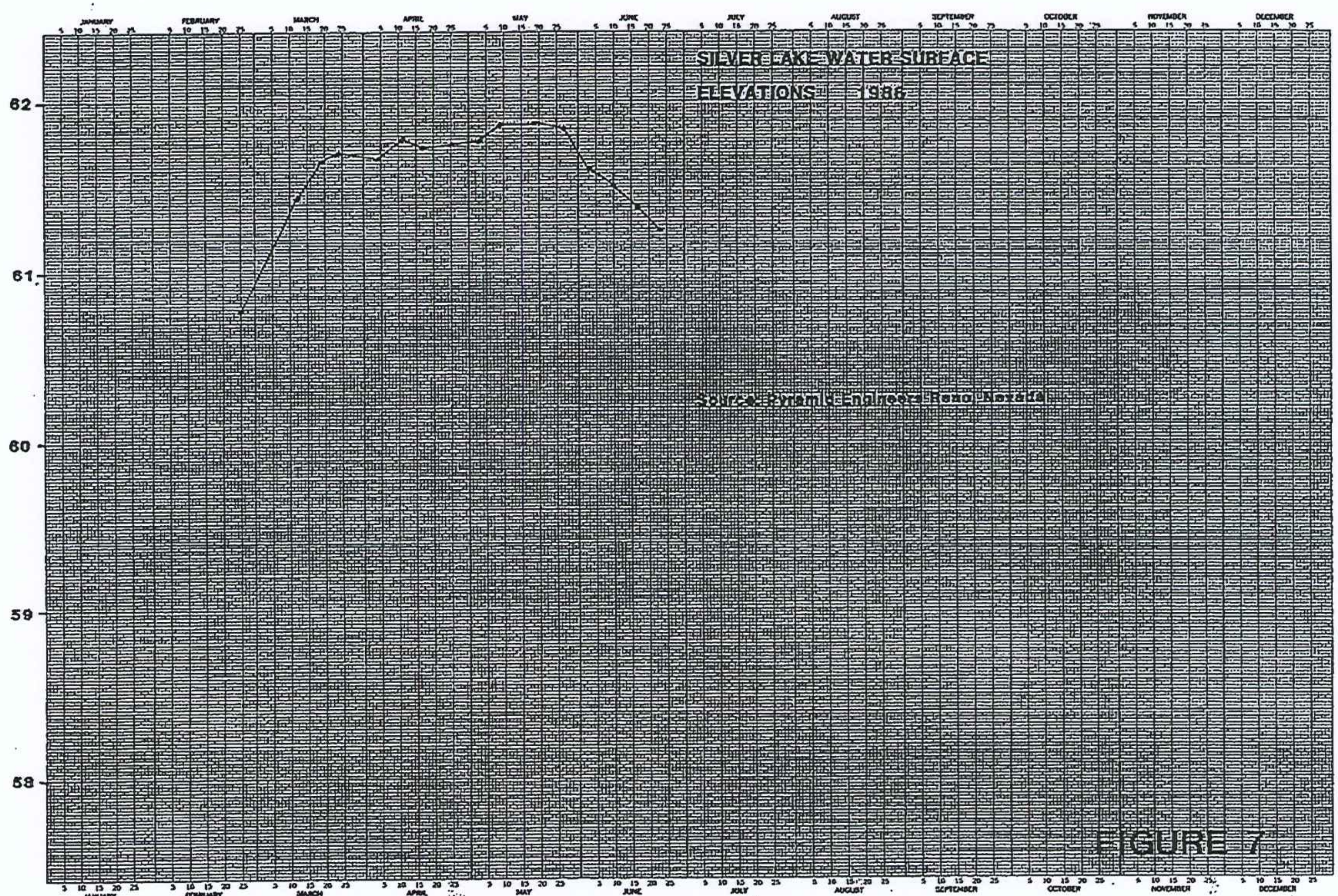

LEMMON LAKE WATER SURFACE
ELEVATIONS - 1986
W.L. Elevation
4918
4917
4916
4915
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

FIGURE 6



SILVER LAKE WATER SURFACE
ELEVATIONS 1986
Source: Pyramid Engineers Reno, Nevada
62
61
60
59
58
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

FIGURE 7

Reimer and Associates of Burlingame, California and Schaff & Wheeler Consulting Civil Engineers of San Jose, California submitted a request for Letter of Map Revision (LOMR) to the FEMA (Ref. 12 & 14), in 1985. This LOMR request included a hydrologic analysis of Silver Lake for the purpose of establishing a 100 year lake level. This level was needed for the design of a project that is proposed for a site at the northeast side of Silver Lake. The study used the curve number method of computing runoff volumes from the watershed. The rainfall used in the computations was derived from NOAA Atlas (Ref. 26) with a rainfall pattern distributed according to the pattern observed during the December 1955 to January 1956 event. The resulting water surface elevation from this analysis of Silver Lake was 4965.0.

Desert Research Institute has been performing studies of the Silver Lake Watershed for water harvesting studies. These studies, were performed to develop information on recharge and yield from smaller events and to determine information for average annual conditions. The studies were also isolated to small watersheds on Peavine Mountain. The information developed by DRI does not address extreme events.

5.0 - ALTERNATIVES FOR HYDROLOGIC ANALYSIS

Due to insufficient historical lake level data to perform a statistical analysis of lake level recurrence intervals, these levels must be estimated with hydrologic analysis. This study does not include calculation of water surface profiles, therefore peak discharge is not important to the study. Runoff volumes from the watershed for a given storm pattern or series of storm patterns is the desired result. The total runoff volume for the storm(s) deemed to be a reasonable estimate of a 100 year condition would then be translated into a lake level based on the calculated stage - discharge relationship for the lake of concern.

5.1 - SINGLE EVENT MODELS

5.1.1 - Curve Number Procedure

The most common method of calculating runoff volumes from a watershed is the SCS curve number method. This can be done using 24 hour daily rainfall information with 24 hour curve numbers and then summing the volumes for each day of the storm of interest. The curve number method can also be applied to a 10 day storm by reducing the 24 hour curve number to a 10 day curve number using

the procedure described in the SCS Technical Release No. 60 (TR-60).

5.1.1 - SCS Computer Program TR-20

The SCS computer program TR-20 develops a hydrograph for a watershed using the equations developed for the curve number procedure. The results using TR-20 should be very similar to the hand calculation method of the curve number procedure, in terms of runoff volume.

5.1.2 - Corps of Engineers Computer Program HEC-1

The Corps of Engineers Hydrologic Engineering Center developed a single event flood hydrograph package called HEC-1. HEC-1 is commonly used by engineers for developing hydrographs to be used in flood studies. HEC-1 allows the use of many methods of computing rainfall distributions, infiltration losses, routing methods, and hydrograph generation. One of the options includes the curve number method that is very similar to TR-20.

5.2 - CONTINUOUS EVENT MODELS

There are several continuous event models that will model long term runoff, and soil moisture accounting for a watershed. One example of this type of model is the Stanford Watershed Model. A continuous event model would likely produce the most accurate information for use in this type of study, but the data required to perform a continuous event simulation is extensive and is not available for the study area.

6.0 - MODEL CALIBRATION

The February 1986 event was very significant because it produced severe flooding in many parts of California and Nevada. During and after this event rainfall and lake level data was collected. There is sufficient information from this event to reasonably model the runoff response from the watershed as a single event simulation. Using this information, several of the methods described in Section 5 were tested for their ability to reproduce the results that were observed.

Since the purpose of this study is to determine the runoff volume to the playa areas, peak flows were not considered as being important in the selection of model parameters. For this reason, the two areas were lumped into two separate large watersheds and *basin wide averages were used in selecting the parameters for the model. The isohyetal map included as Figure 3 was used to determine basin average precipitation for each watershed. Lag times were estimated using both the curve number and Upland methods and average values were selected. Impervious cover was estimated including the lake surfaces, roads and residential/commercial areas.*

Observations made during and after the storm indicated that the upper elevations within the watersheds received a considerable amount of their precipitation as snowfall. Since snowfall would not contribute to the initial runoff response from the watershed, a certain amount of the watershed was excluded from the model. Based on the information presented in the NWS report and observations made in the field, the area above 5600 feet was selected as the area that received the bulk of it's precipitation as snowfall. This is probably a conservatively low level. If a higher level was selected, there would be a greater area of contributing watershed and the precipitation losses per unit area would need to be greater. The 5600 level is considered to be an appropriate and conservative estimate. This modification decreased the effective watershed area for Silver Lake from 53.8 square miles to 37 square miles, and for the Lemmon Valley playa from 43.02 square miles to 36 square miles.

The period of rainfall modeled was from 1100 hours on February 14 to the end of the storm. The modeling period does not include the first portion of the storm in order to concentrate the computational period to the end of the storm. This assumes that the rainfall that occurred prior to the 1100 hours on the 14th was lost as initial abstraction. Since the precipitation that occurred prior to this period was minimal, this assumption is not considered to be significant. Including this rainfall into the model would increase the runoff volume predicted and thus cause the predicted losses to be higher. Therefore, this is a conservative assumption.

6.1 - SCS CURVE NUMBER METHOD

Schaff and Wheeler estimated the 24 hour curve number for the Silver Lake watershed to be 82 (for AMC II). Based on the soil survey, vegetation types and the curve numbers presented in TR-55 for sage-grass conditions, this estimate appears to be reasonable. Based on Table 2-3 in TR-60, the corresponding 10 day curve number would be 68.

Imputing this 10 day curve number into the HEC-1 model for Silver Lake using the February 1986 storm data, yields a runoff volume of 9300 acre feet.

The curve number for Lemmon Valley playa was estimated to be 86 which translates into a 10 day curve number of 74. The runoff volume and corresponding lake level for Lemmon Valley playa is 10,200 acre feet and 4919.6 respectively.

As compared to the observed runoff volume, the SCS curve number method significantly over-predicted the runoff volumes for the watershed. For the Silver Lake watershed, the resulting volume predicted by the model with the reduced watershed area was over 2.6 times greater than the observed runoff volume of approximately 3600 acre-feet. In order to duplicate the observed runoff volume for this watershed, the curve number had to be adjusted to approximately 41.

Use of the 10 day curve number for Lemmon Lake watershed produced a runoff volume of 10,200 acre feet as compared to the observed runoff volume of 7100 acre-feet. In order to duplicate the observed runoff volume for this watershed, the curve number was adjusted to approximately 58.

TABLE 1

COMPARISON OF OBSERVED VOLUMES
WITH RESULTS FROM CURVE NUMBER METHOD

BASIN	OBSERVED VOLUME (AC-FT)	OBSERVED ELEVATION	* MODELED VOLUME (AC-FT)	MODELED ELEVATION
SILVER LAKE	3600	4961.7	9300	4967.9
LEMMON VALLEY	7100	4917.3	10,200	4919.6

* Using CNs of 68 and 74 for Silver Lake and Lemmon Valley respectively.

Because of the results of this analysis, the curve number method was determined to be inappropriate for this task. The curve number method appears to give reasonable results in terms of peak discharge values, but over-predicts the total volume under the hydrograph.

6.2 - INITIAL AND CONSTANT LOSS RATES

The Sacramento District of the Corps of Engineers prepared a hydrology report for the Truckee River basin in 1980 (Ref. 25). This report presents the results of their calibration of the initial and constant loss rates within that watershed during the 1955 and 1963 events. The results of their analysis indicated that an initial loss rate of 0.30 and constant loss rates of between 0.05 and 0.23 resulted in reasonable duplications of observed hydrographs for those events. They adopted a constant loss rate of 0.10 for general rain, probable maximum and standard project events.

Since our calibration model for this eight day event was not very sensitive to the initial loss rate, the value of 0.30 was chosen as a reasonable value. Each watershed model was then tested using varying constant loss rates to determine which constant loss rate would produce the observed runoff volume. The results of this analysis is presented in graphical form on Figures 8 and 10. Figures 9 and 11 are the stage-storage curves for these two major playas. The results indicate that the appropriate constant loss rates for the Silver Lake and Lemmon Valley watersheds are 0.14 and 0.072 respectively. These values are within the range of values observed by the Corps of Engineers for the adjacent watershed areas. These values are also very similar to the infiltration rates reported for the soils in the watersheds (Ref 21).

The stage-storage curves presented as Figures 9 and 11 were derived using References 5 and 7. Reference 7, is a topographic map of the Silver Lake area at a contour interval of 5 feet with frequent spot elevations. One foot contours were estimated and compared to the bathometric survey map in Reference 2. The areas under each contour were measured and compared to the information on the 7.5 min USGS quad. Once the stage area information was obtained, this information was input into the HEC-1 model and HEC-1 calculated. the storage volumes at each stage using the conic method.

1979 aerial photos of the Lemmon Valley playa were used to obtain spot elevations on a 100 foot grid of the playa area. This digital information was analyzed to obtain a stage-area relationship for the playa area. This information combined with the USGS quad, were utilized to obtain the final stage-area information that was input into the HEC-1 model.

Runoff volumes for Lemmon Valley playa are higher per unit area than for Silver Lake. As a result of the higher observed volumes, there is a lower calibrated loss rate for Lemmon Valley playa. The higher runoff potential for this basin is also observed in the greater percentage of soils in hydrologic soil groups C and D. This also results in a higher estimated curve number based on the soil survey and observed vegetation types and densities. Another factor that influences the runoff volumes is

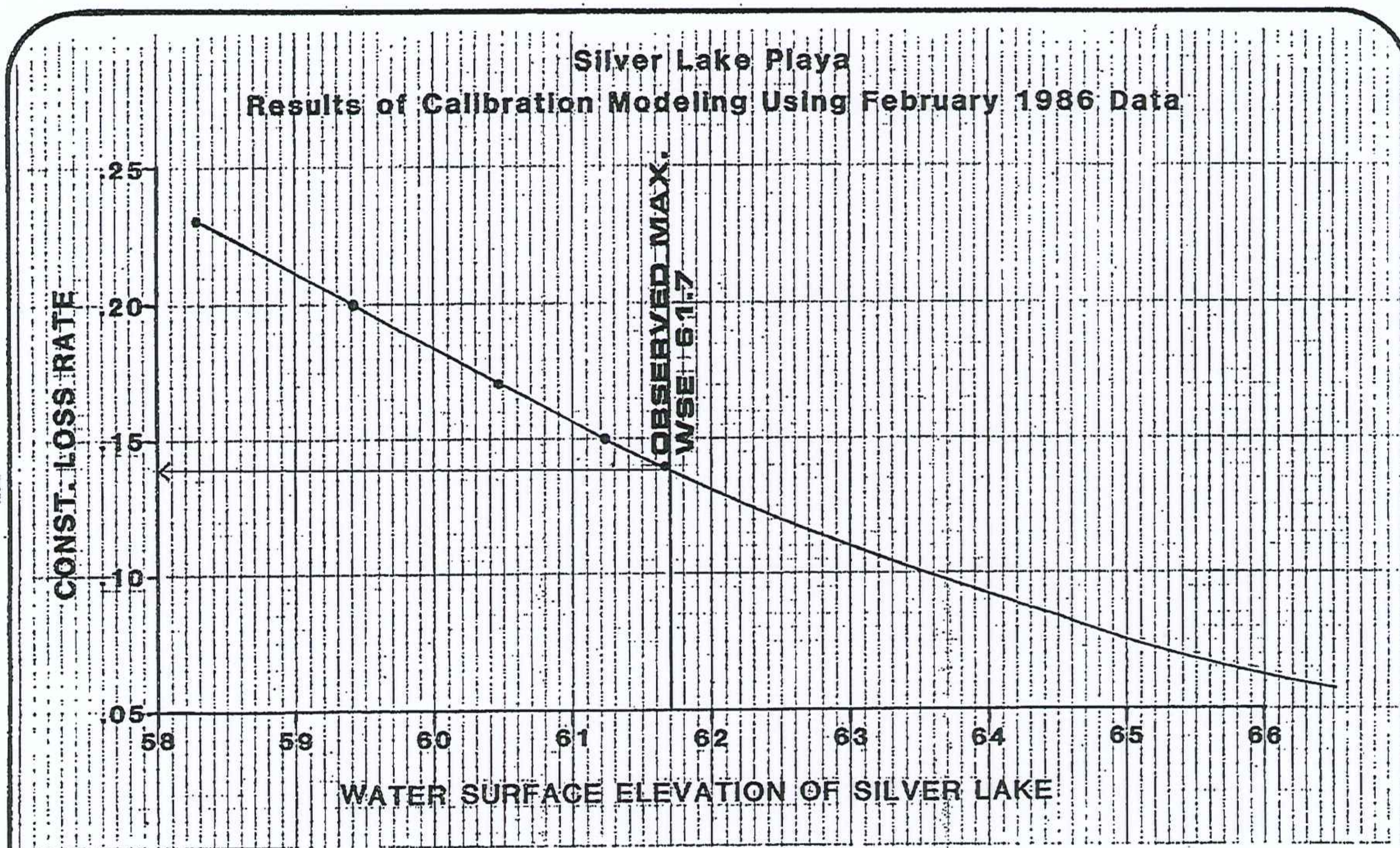


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FIGURE 8

SILVER LAKE PLAYA

STAGE–STORAGE RELATIONSHIP

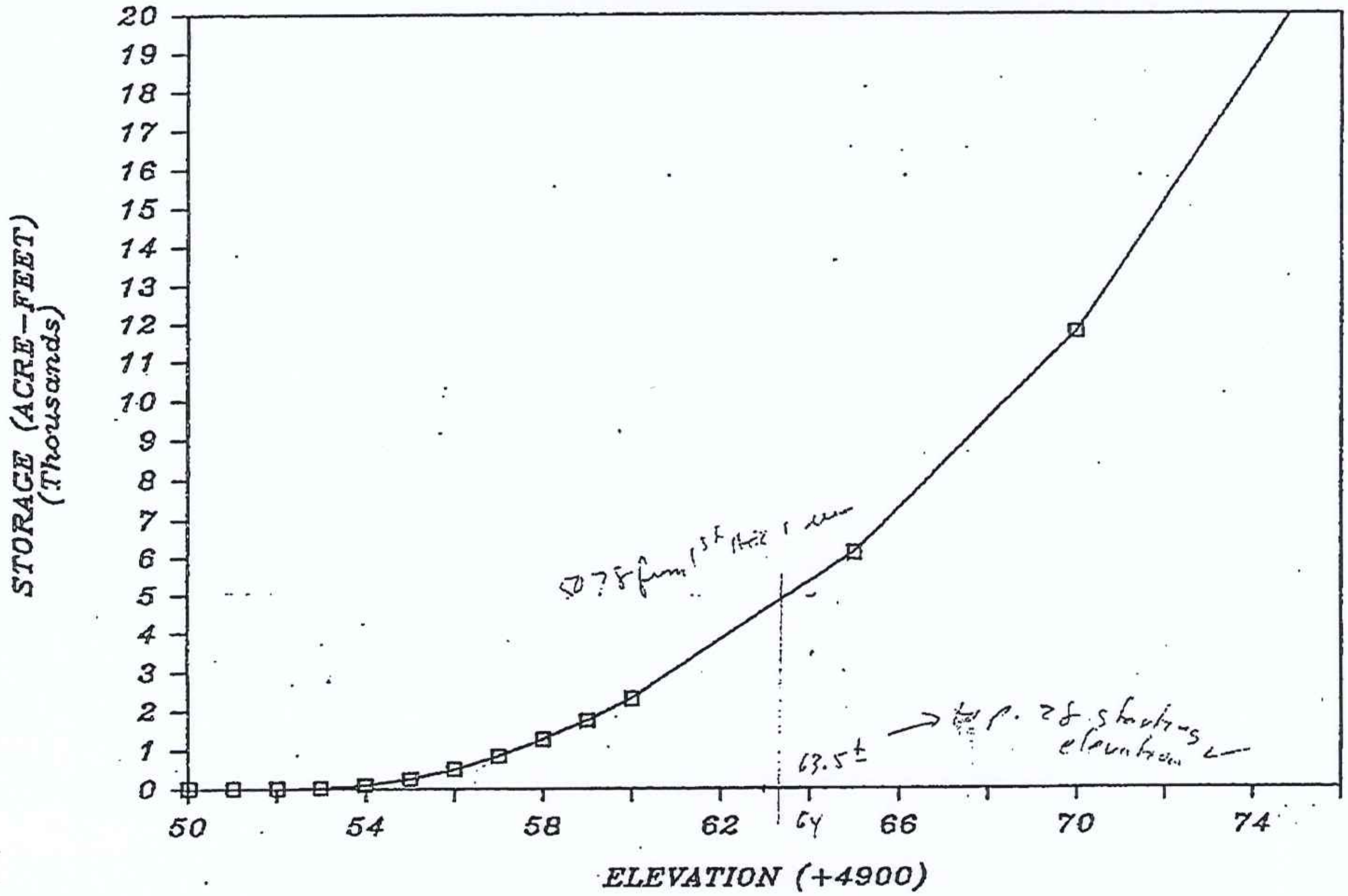

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FIGURE 9

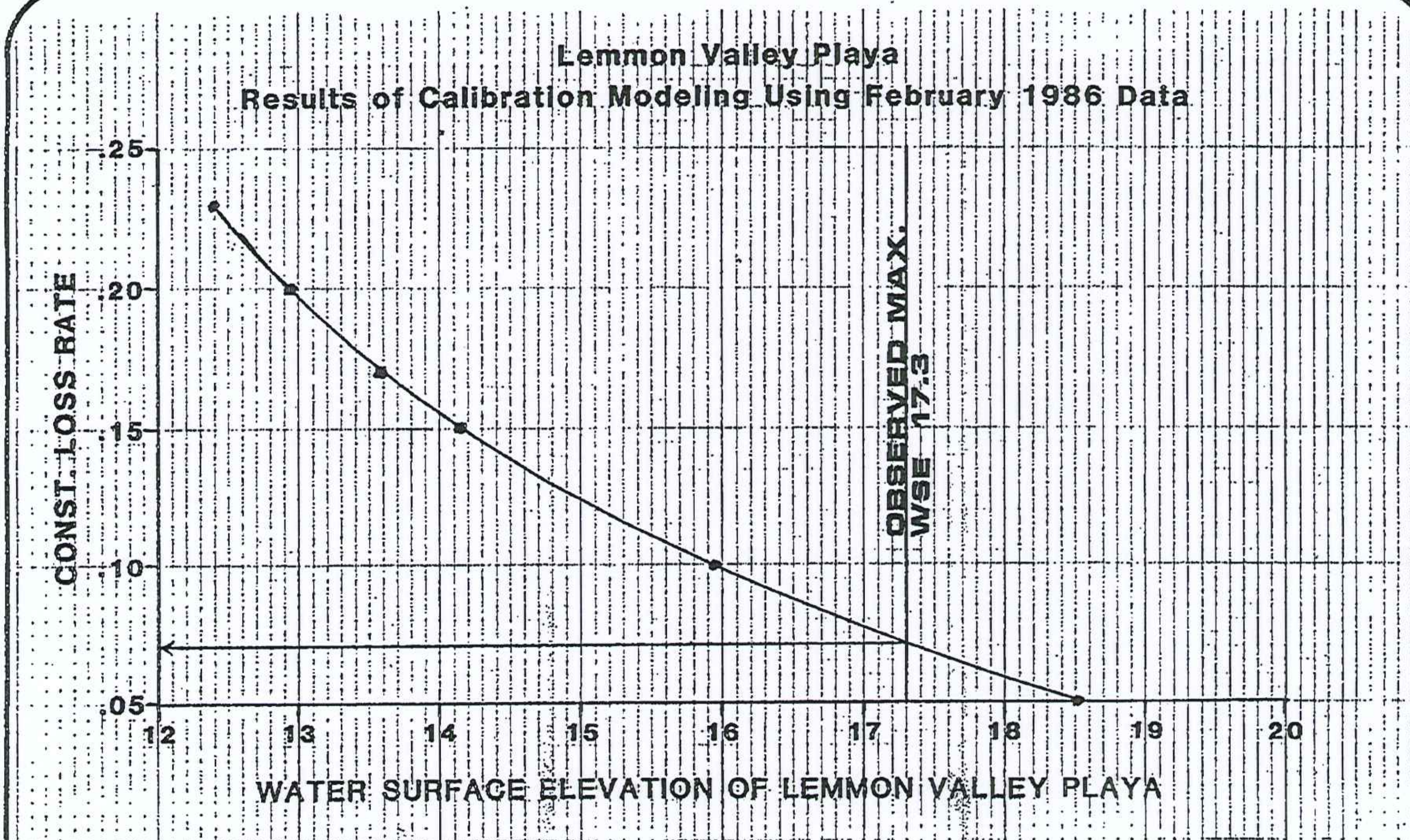

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FIGURE 10

LEMMON VALLEY PLAYA

STAGE–STORAGE RELATIONSHIP

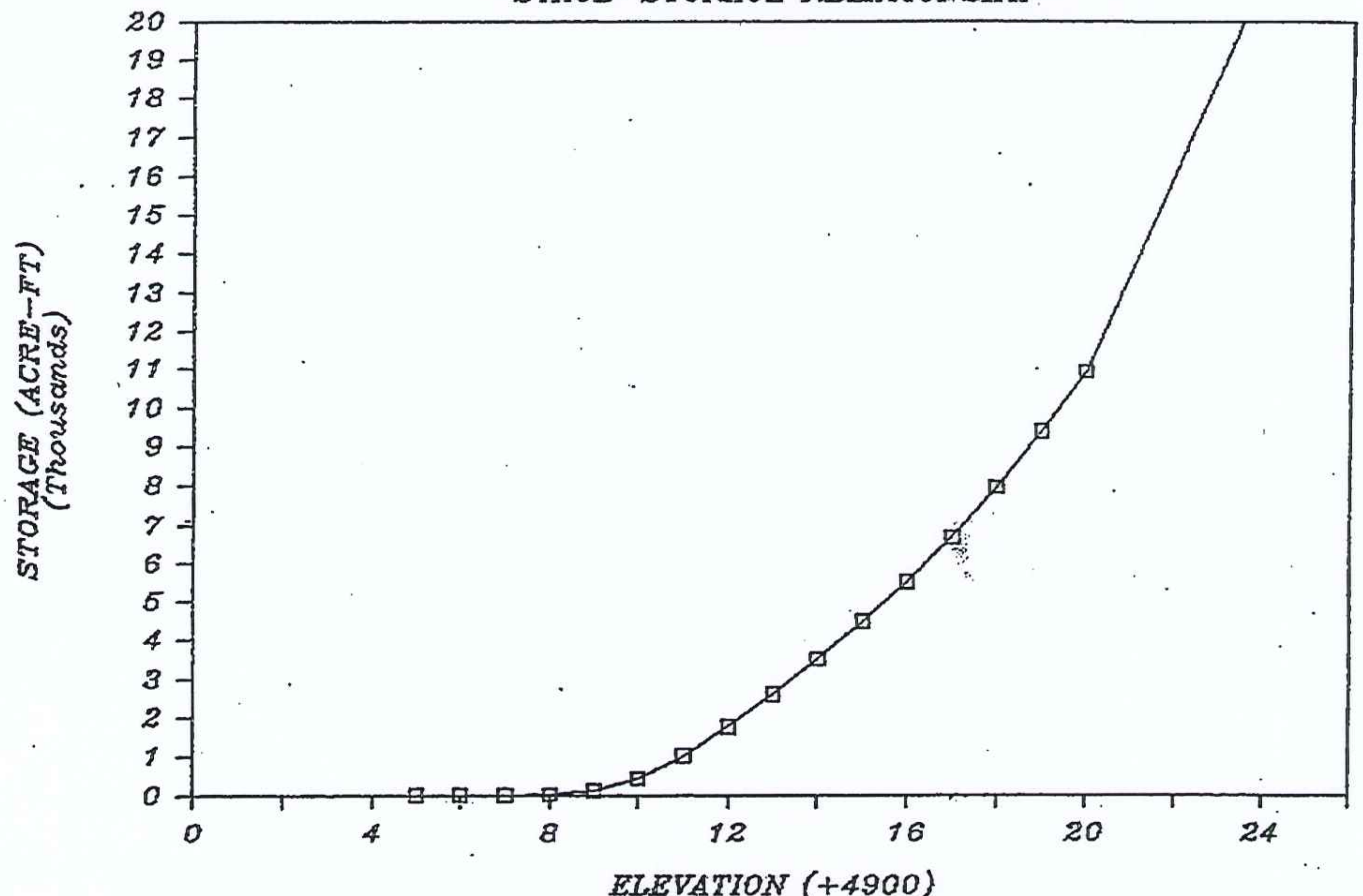

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FIGURE 11

channel infiltration losses. The Silver Lake watershed has longer channel reaches than Lemmon Valley because of the differences in watershed shape and location of the playa within the watershed. This higher potential for channel infiltration losses in the Silver Lake watershed results in higher constant loss rates than Lemmon Valley. These two factors provide a reasonable explanation for the differences noted between the constant loss rates obtained in the calibration analysis.

6.3 - RESULTS OF CALIBRATION MODELING

The SCS curve number method was deemed to be inappropriate for this analysis because of the excessive volumes of runoff predicted. The use of initial and constant loss rates were determined to be the most accurate means of duplicating the watershed characteristics observed during the February 1986 event, with the limited data available. The constant loss rate values determined by this analysis, are the result of a one event calibration attempt with limited data. Since the purpose of the calibration is to determine the loss rates to use in a 10 day, 100 year event, which is similar to the type of event experienced, the results are considered to be appropriate for use in the final analysis.

In order to get a final 100 year lake level for each of the playa areas, the model will need to incorporate an estimate of initial storage and possibly a smaller event that follows the 100 year event within the same year.

7.0 - STATISTICAL RAINFALL INFORMATION

Once the basic models were developed for the study area the next problem was identification of appropriate statistical rainfall information, storm pattern(s) and storm duration to be used for the study area. In the comments received from Washoe County Department of Comprehensive Planning, Leonard Crowe objected to the use of NOAA Atlas 2 for this study. In previous studies done by the Planning Department (Ref. 4), NOAA Atlas was found to under predict rainfall amounts near the eastern slopes of the Sierras.

During the course of this study several references were reviewed and data was compiled for gauges in the surrounding areas. The following sections provide a brief description of each reference and the method utilized in this study.

7.1 - NOAA ATLAS 2 AND TECHNICAL PAPER NO. 49

Prior to 1972, the NWS publications that provided statistical rainfall information for the entire United States was NWS Technical Paper No. 40. and 49. Technical Paper 40 provides information for durations of 5 minutes to 24 hours and Technical Paper 49 provides information for durations of 2 to 10 days. In the early 1970's, Technical Paper 40 was replaced with NOAA Atlas 2 for the western states. Technical Paper 40 is still used in the eastern states. Technical Paper 49 has not been replaced by the National Weather Service.

Each isopluvial line that passes through the study area in each of these references, also passes through Reno at the location of the Reno Airport. Therefore, each of these references suggests that the study area (at an average elevation of over 5000 feet) has similar rainfall statistics as the Reno Airport, which is at an elevation of 4411 feet. Past storms such as the 1955, 1963 and 1986 events suggest that this assumption is not correct (see sections 3.1 to 3.4). Appendix A contains two letters from Leonard Crowe that provide some additional storm by storm comparisons between the Reno Airport gauge and the Stead Gauge located in the study area. This analysis also suggests that the study area can receive up to twice the rainfall amount experienced in the Truckee Meadows from the same storm.

Since the use of accurate rainfall information is critical to this study, additional analysis was warranted. Table 2 identifies the rainfall values that would be obtained using NOAA Atlas 2.

TABLE 2
100 YEAR
PRECIPITATION DEPTH-DURATION INFORMATION
USING NOAA ATLAS 2

DURATION	DEPTH
5 MIN	0.35
1 HR	1.19
6 HR	1.70
12 HR	1.90
24 HR	2.62

7.2 - SCS TECHNICAL NOTE PO-6

Since the National Weather Service did not update Technical Paper 49 after NOAA Atlas was released, the SCS developed an alternative to Paper 49 with a short release known as Technical Note PO-6 - Hydrology. This reference describes a procedure for determining the 2 and 100 year, 10 day precipitation amounts from NOAA Atlas. Since this reference is based on NOAA Atlas 2, it also suggests that the study area and Reno Airport have similar statistics. The 100 year, 10 day total derived using this reference is 5.6 inches.

7.3 - NATIONAL WEATHER SERVICE FORECAST OFFICE IN RENO

On August 12, 1987, a letter was sent to the NWS office in Reno requesting their input on the problem of accurate information for the study area. The request letter and the response from Ron Olson are contained in Appendix B. This response contains several items of particular interest:

A. Ron Olson was in agreement with Leonard Crowe, that NOAA Atlas does not accurately represent the orographic and elevation differences that would be experienced in the study area.

B. Short duration totals do not tend to increase with elevation as much as the long duration precipitation values.

C. The February 1986 areal distribution pattern is reasonably representative of long duration, winter type of extreme events.

D. There is a very good possibility of having more than one sizable precipitation event within the watershed during the same season.

7.4 - CALIFORNIA DEPARTMENT OF WATER RESOURCES

The California Department of Water Resources published a report that contained a Log Pearson Type III analysis of each gauge in California and extreme eastern Nevada. There were not any gauges in the study area prior to 1981, but there are several gauges in the surrounding areas that provide very useful information.

The closest gauges that had analysis for both short and long duration events were selected for comparison purposes. Figure 12 is a map identifying the four sites selected. Figure 13 is a plot of the 100 year depth-duration information for four nearby

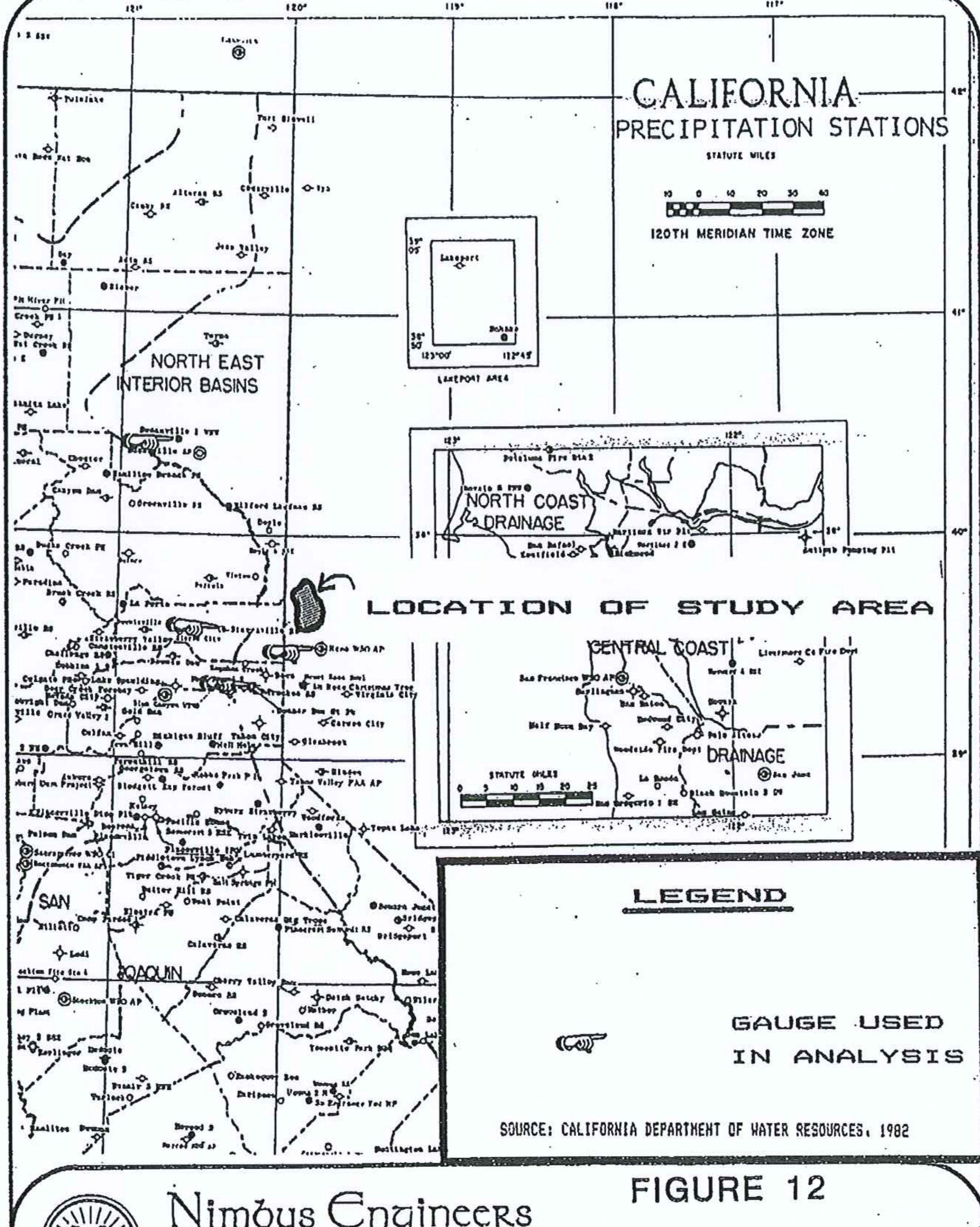

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FIGURE 12

LOCATION OF GAUGES USED IN COMPARISON OF RAINFALL STATISTICS

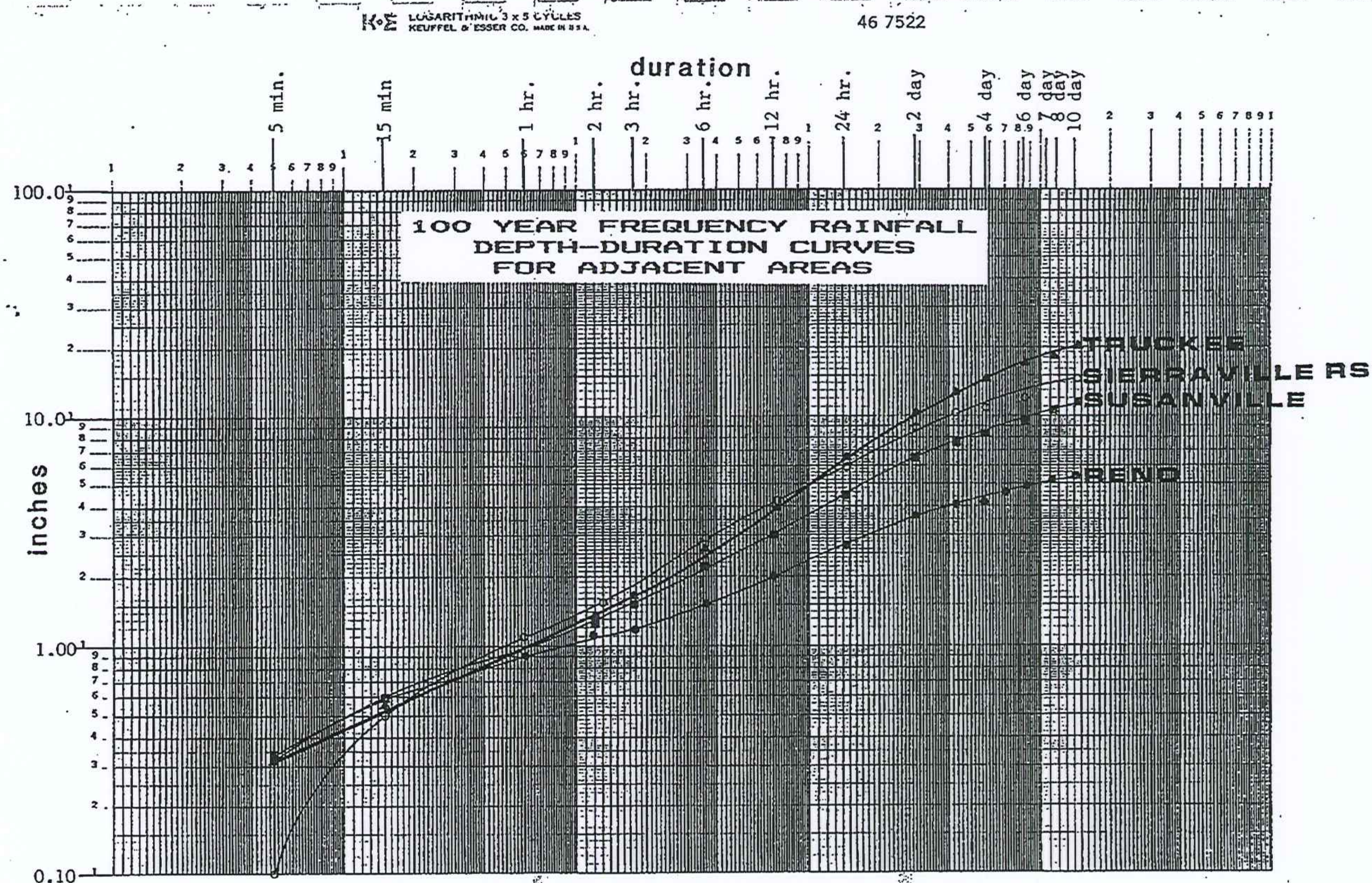

FIGURE 13

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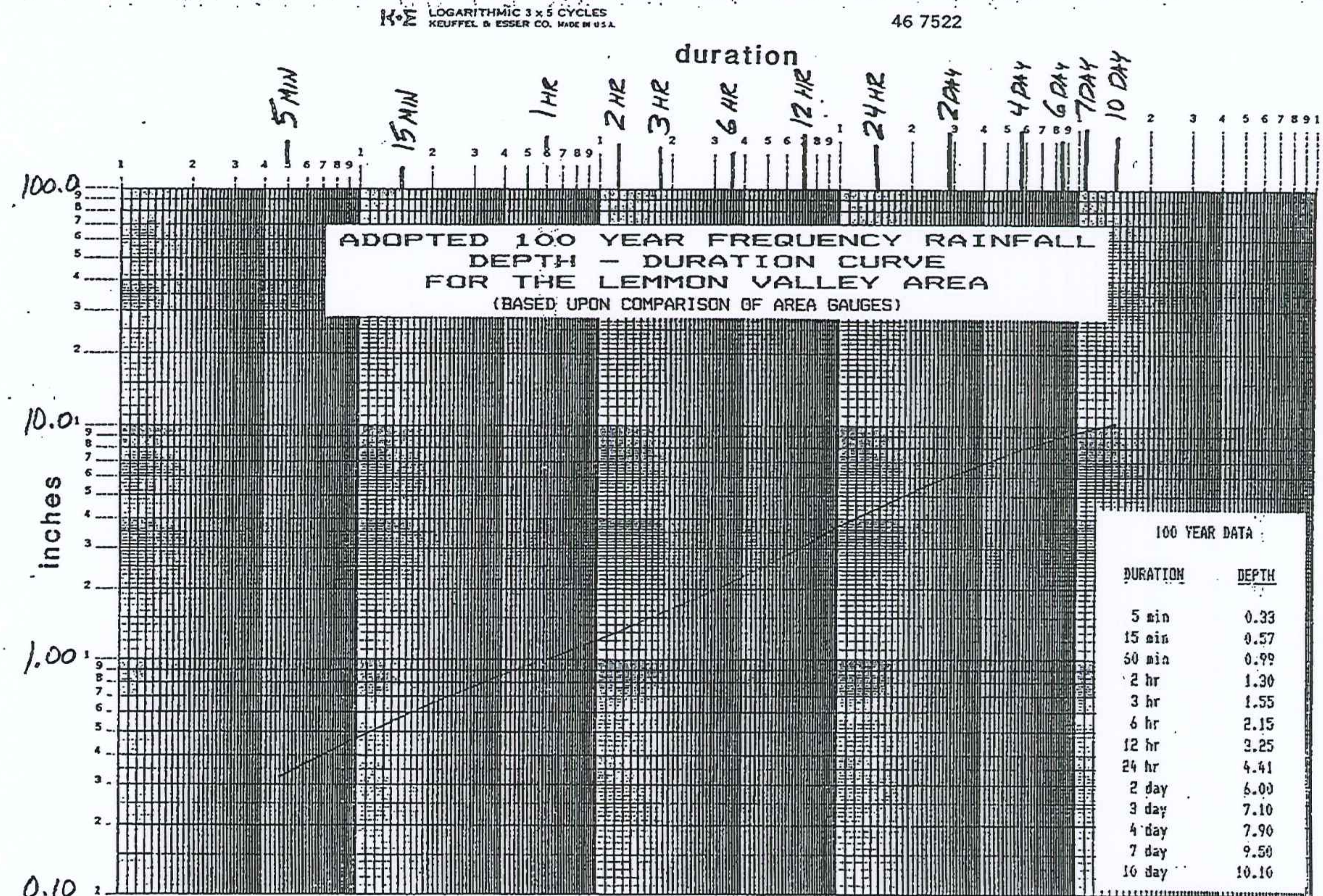

DURATION	DEPTH
5 min	0.33
15 min	0.57
60 min	0.99
2 hr	1.30
3 hr	1.55
6 hr	2.15
12 hr	3.25
24 hr	4.41
2 day	6.00
3 day	7.10
4 day	7.90
7 day	9.50
10 day	10.10

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FIGURE 14

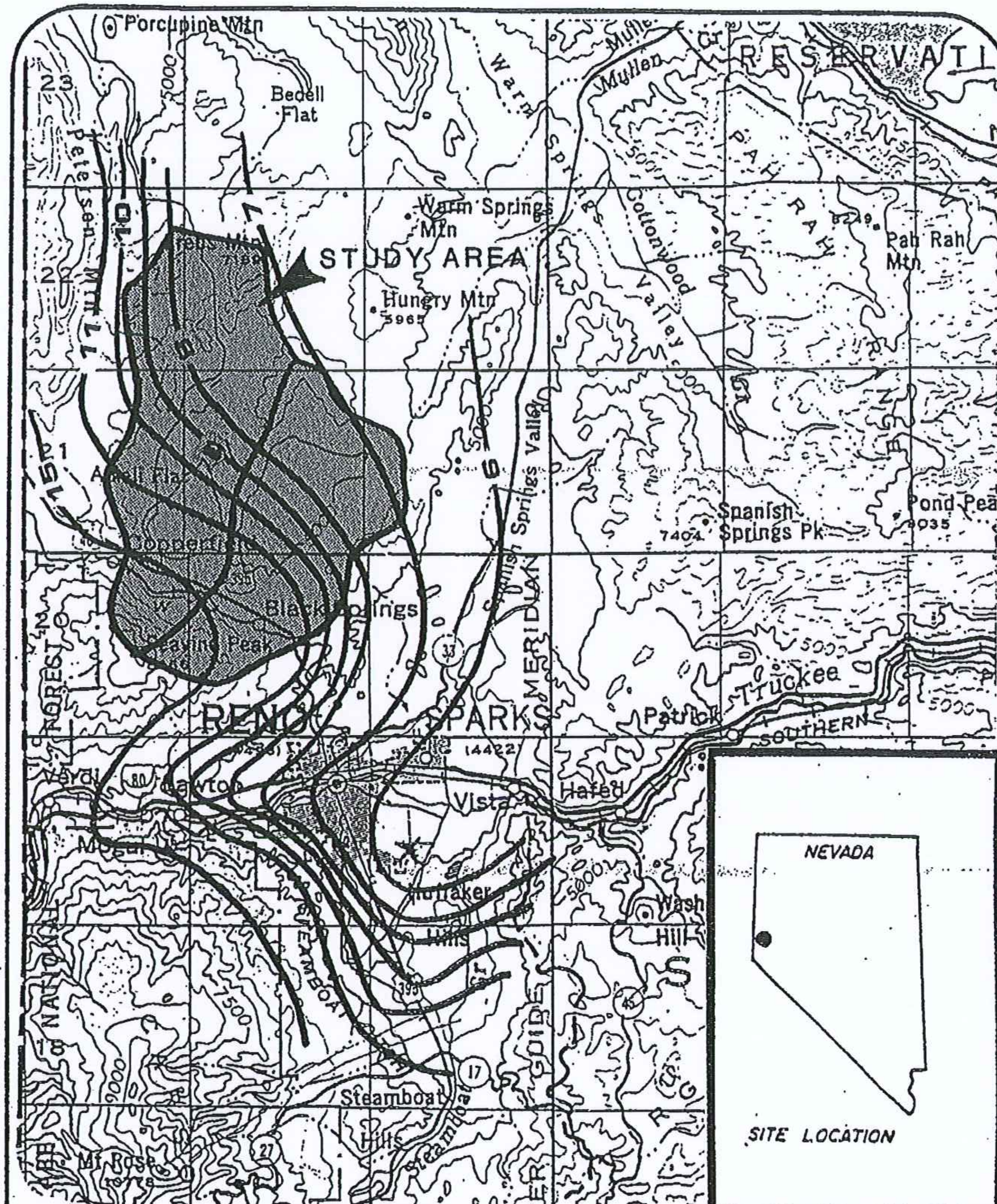

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FIGURE 15

100 YEAR, 10 DAY ISOPLETH MAP

BASED UPON FEBRUARY 1986 STORM PATTERN

gauges. This graph clearly confirms the comments by Ron Olson summarized in item B of section 7.3. The shorter duration totals do not increase with elevation. Only the long duration totals are increasing with higher elevations.

7.5 - SELECTION OF 100 YEAR, 10 DAY VALUES

Leonard Crowe suggested that a ratio of the February 1986 event totals be applied to the 10 day value for the Reno gauge to obtain a value for the study area. This approach was also discussed with Ron Olson at the NWS who agreed that in absence of more definitive data this approach would provide a more reasonable estimate than the other sources.

Based on a comparison of the similarities and differences of the four sites identified on Figures 12 and 13 and the precipitation pattern and ratios from the February 1986 event, a depth-duration curve was adopted for the study area and is included as Figure 14. Figure 15 is the adopted 100 year, 10 day isopleth map.

8.0 - 100 YEAR LAKE LEVEL ANALYSIS

A HEC-1 model was developed using the initial and constant loss rates that were determined from the calibration model and a hypothetical storm based on the values obtained from Figure 14. The final rainfall total input into the model is a basin wide average based on the aerial distribution from Figure 15. The results of this model should be a reasonable estimate of runoff volumes that would result from a 100 year, 10 day hypothetical storm.

This runoff volume alone would not be representative of a 100 year lake level since there could be some initial storage and the possibility of multiple events in the same season, as was indicated in the comments from the NWS summarized in section 7.3 D.. Each of the lakes was tested by incorporating initial storage in each lake that is representative of the volumes produced from 5 to 50 year, 24 hour events. Figure 16 is a graph of the results of this analysis. The HEC-1 model that produced the data for Figure 16 is contained in Appendix C.

The point on the curve that was considered a reasonable estimate of a 100 year lake level based on past events (see Appendix A) is identified on the graph by the heavy line. The resulting water surface elevations for Silver Lake and Lemmon Valley playa are 4966.5 and 4920.3 respectively.

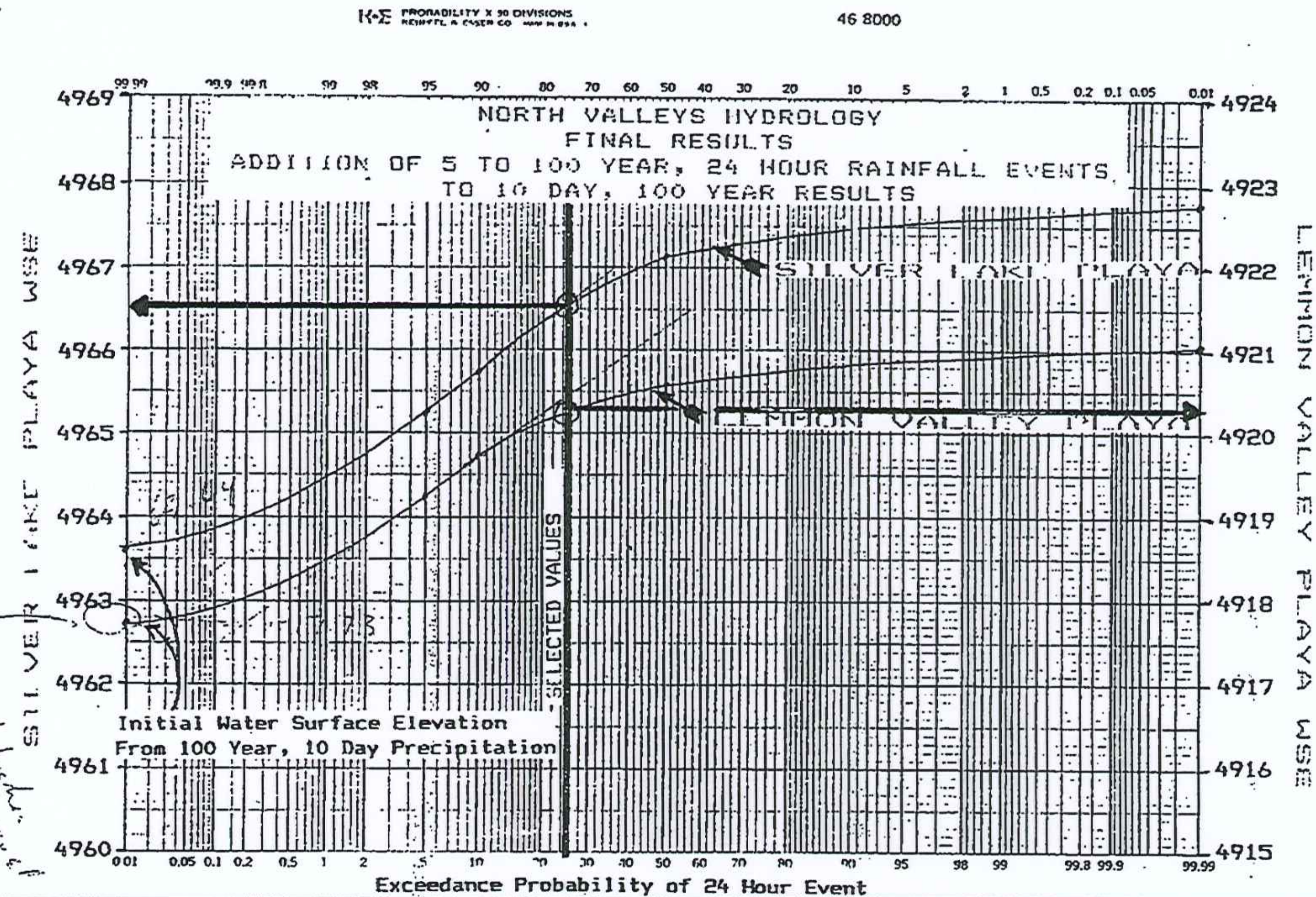

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FIGURE 16

8.1 - OTHER METHODS

Use of the SCS curve number method in this analysis results in a 100 year, 10 day volume and elevations of 17,551 acre feet and 4975.17 for Silver Lake and 16,226 acre feet and 4922.05 for Lemmon Lake. Adding an additional 25 year, 24 hour runoff volume results in elevations of 4977.60 and 4923.60 for Silver Lake and Lemmon Valley respectively. A water surface of 4977.60 in Silver Lake would result in over topping of the topographic divide between the two watersheds. These results are considered to be very unreasonable.

Rainfall on an existing snowpack could also be considered in determination of these lake levels. This possiblity was not evaluated in this analysis since there is a relatively small percentage of the total watershed areas above 7000 feet where a persistant snowpack is likely to exist. A large storm on a very heavy snowpack that extends down into the lowerer elevations is considered to be an event with a greater than one percent chance of occurrence.

9.0 - REFERENCES

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Appendix G

Elevation Metadata

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          <pubdate>May 2002</pubdate>
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          <cntorg>Washoe County GIS Program</cntorg>
          <cntvoice>775.328.3614</cntvoice>
          <cntfax>775.328.2356</cntfax>
          <cntemail>tlo@mail.co.washoe.nv.us</cntemail>
        </citeinfo>
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<cntorg>**Washoe County GIS Program**</cntorg>
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Washoe County
1001 East Ninth Street
PO Box 11130
Reno, NV 89520.0027

775.328.2350
Fax 775.328.2356

TECHNOLOGY SERVICES

June 17, 2009

Mitch Blum
HDR
9805 Double R Boulevard, Suite 101
Reno, NV 89521

Re: 2006 & 2007 contour data

The 2006 & 2007 2' contour data sets were created based on 0.5' pixel stereo aerial photo pairs and a set of high density survey-grade control points. The tiling scheme is based upon the 1-mile square sections from the U.S. Public Land Survey System. The end products of contours & spot elevations were required to meet the National Mapping Accuracy Standards (NMAS) at a scale of 1" = 100'. The tiles were edge matched, with the exception of few tile's edges where development had occurred between the 2006 and the 2007 aerial flights.

The data have been rigorously checked for both horizontal and vertical positional accuracy using survey-grade GPS field checks in a randomly distributed manner. Well over 90% of the horizontal positions of the checked data for both the 2006 & 2007 data were within the National Mapping Accuracy standard for 1"= 100' mapping scale.

The vertical accuracy for the 2006 & 2007 2' contour data, based on quality checking of 155 spot heights, resulted in 70% of the data within one half of the contour interval (< 1 foot). There were 47 points (30%) that exceeded a 1 foot vertical difference. However, the excessive errors are considered to be the contribution of the discrepancy between the horizontal positions of the field check locations and the map location of the spot heights points. Based on these results, we feel that the 2006 & 2007 2' contour data as a whole, meets the NMAS.

Thomas Lo

Thomas Lo

Washoe County GIS Manager
On behalf of the Washoe County Regional Basemap Committee