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This section is continued on page 2.

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RECORD OF REVISIONS

9. No.	10. Reason For Revision	11. Total # of Pgs.	12. Last Pg. #	13. Originator (Print/Sign/Date)	14. Checker (Print/Sign/Date)	15. EGS (Print/Sign/Date)	16. Approved/Accepted (Print/Sign/Date)
00A	Issued for License Application.	30 plus 74 pages of attachments	Attachment F, page 2	Shane Hsieh 9/19/07 Phillip Mineart 9/19/07 See note on page 2, Block 8	Jeanne Hudson Jeanne Hud 9/19/07 Thomas MacDonald Thomas MacDonald 9/19/07 See note on page 2, Block 8	JAMES P. DOCKERY J. P. Dockery 9/21/07	R.S. RAJAGOPAL 9/21/07

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8. Notes/Comments

Several authors prepared this calculation. The originators and checkers of the various sections are shown below. For attachments containing computer program output, the originator and checker (other than the originator) of the attachment also performed and checked the computer runs and files.

Section(s)	Originator	Checker
Cover, Disclaimer, Table of Contents, Acronyms, Abbreviations, Section 1, and Section 2	Phillip Mineart	Jeanne Hudson
Section 3	Phillip Mineart	Thomas MacDonald
Section 4 and Section 5	Phillip Mineart	Jeanne Hudson
Section 6.1.1 and Section 6.1.2	Shane Hsieh	Jeanne Hudson
Sections 6.1.3, 6.1.4, 6.1.5, 6.1.6, 6.2, and 6.3	Phillip Mineart	Thomas MacDonald
Section 7.1	Phillip Mineart	Jeanne Hudson
Section 7.2, Attachment A, and Attachment D	Shane Hsieh	Jeanne Hudson
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DISCLAIMER

The calculations contained in this document were developed by URS Corporation and are intended solely for the use of Bechtel SAIC Company, LLC in its work for the Yucca Mountain Project.

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FIGURES

TABLES

ACRONYMS

COE	U.S. Army Corps of Engineers
CRWMS	Civilian Radioactive Waste Management System
CSCI	Computer Software Configuration Item
DOE	U.S. Department of Energy
DTN	Data Tracking Number
ESF	Exploratory Studies Facility
EIS	Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
HEC	Hydrologic Engineering Center
HEC-RAS	Hydrologic Engineering Center, River Analysis System
HMR	Hydrometeorological Report
ITS	Important to Safety
ITWI	Important to Waste Isolation
M&O	Management and Operating Contractor
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
QARD	Quality Assurance Requirements and Description
SCS	Soil Conservation Service
STN	Software Tracking Number
TDMS	Technical Data Management System
TIN	Triangulated Irregular Network
URS	URS Corporation
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
YMP	Yucca Mountain Project

ABBREVIATIONS

cfs	cubic feet per second
ft	feet
ft^2	square feet
ft/s	feet per second
FY	Fiscal Year
mi	miles

1 PURPOSE

The purpose of this calculation is to demonstrate that the drainage features depicted in Attachment A of this calculation will adequately protect the Geologic Repository Operations Area (GROA) nuclear facilities from flooding associated with the Probable Maximum Precipitation (PMP) event. Flood control features (e.g., dikes and channels) are non-ITS and non-ITWI.

2 REFERENCES

2.1 PROCEDURES/DIRECTIVES

2.1.1 EG-PRO-3DP-G04B-00037 Rev. 9, Calculations and Analyses. ENG.20070717.0004

2.1.2 IT-PRO-0011, Rev. 7, Software Management. DOC. 20070905.0007.

2.2 DESIGN INPUTS

2.2.1 BSC (Bechtel SAIC Company) 2006. *Project Design Criteria Document.* 000-3DR-MGR0-00100-000-006. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061201.0005.

2.2.2 Borup, H.J. and Bagley, D.G. 1976. *Soil Survey of Meadow Valley Area, Nevada-Utah, Parts of Lincoln County, Nevada and Iron County, Utah.* [Washington, D.C.]: U.S. Department of Agriculture. TIC: 242941.

2.2.3 Brunner, G.W. 1997. *HEC-RAS River Analysis System Hydraulic Reference Manual.* Version 2.0. Davis, California: U.S. Army Corps of Engineers, Hydrologic Engineering Center. TIC: 243256

2.2.4 HEC-1 V. 4.0. 1999. Windows 95-DOS Emulation. CSCI: 30078-V4.0-. DIRS 158052

2.2.5 HECRAS V. 2.1. 1999. Windows 95-DOS Emulation. CSCI: 30079-V2.1-. DIRS 158053

2.2.6 BSC (Bechtel SAIC Company) 2002. *Preliminary Hydrologic Engineering Studies for the North Portal Pad and Vicinity.* ANL-EBS-MD-000060 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021028.0123.

2.2.7 BSC (Bechtel SAIC Company) 2004. *Hydrologic Engineering Studies for the North Portal Pad and Vicinity.* 000-00C-CD04-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20040504.0005.

2.2.8 Bullard, K.L. 1992. *Nevada Test Site Probable Maximum Flood Study, Part of U.S. Geological Survey Flood Potential and Debris Hazard Study, Yucca Mountain Site for U.S. Department of Energy, Office of Civilian Radioactive Waste Management.* Denver, Colorado: U.S. Department of Interior, Bureau of Reclamation. ACC: MOL.20010730.0396.

2.2.9 Candland, D.M. 1980. *Soil Survey of Big Smokey Valley Area, Nevada, Part of Nye County.* [Washington, D.C.]: U.S. Department of Agriculture. TIC: 242947.

2.2.10 Chow, V.T. 1959. *Open-Channel Hydraulics.* New York, New York: McGraw-Hill. TIC: 233922.

2.2.11 Christensen, R.C. and Spahr, N.E. 1980. *Flood Potential of Topapah Wash and Tributaries, Eastern Part of Jackass Flats, Nevada Test Site, Southern Nevada.* Open-File Report 80-963. Lakewood, Colorado: U.S. Geological Survey. TIC: 203211.

2.2.12 Costa, J. E. 1997. "Hydraulic Modeling for Lahar Hazards at Cascades Volcanoes." *Environmental & Engineering Geoscience, III,* (1), 21-30. [College Station, Texas]: Geologic Society of America. TIC: 243277.

2.2.13 Cudworth, A.G., Jr. 1992. *Flood Hydrology Manual, A Water Resources Technical Publication.* 3rd Edition. Denver, Colorado: U.S. Department of the Interior, Bureau of Reclamation. TIC: 248285.

2.2.14 Duncan, W.; Huntley, C.; Hokenstrom, J.; Cudworth, A.; McDaniel, T.; Blair, H.; Bartlett, S.; Hatcher, R.; Boggs, H.; Hennig, C.; Rhone, T.; Gersch, W.; Yocom, L.; Warren, H.; Achterberg, D.; Trieste, D.; Strand, R.; Pemberton, E.; Simmonds, R.; Hart, J.; Wright, R.; and Restad, R. 1987. *Design of Small Dams.* 3rd Edition. Denver, Colorado: U.S. Department of the Interior, Bureau of Reclamation. TIC: 242958.

2.2.15 FEMA (Federal Emergency Management Agency) 2001. "Hydraulic Models Accepted by FEMA for NFIP Usage." [Washington, D.C.]: Federal Emergency Management Agency. Accessed November 27, 2001. TIC: 251302. http://www.fema.gov/mit/tsd/en_hydra.htm

2.2.16 Hansen, E.M.; Schwarz, F.K.; and Riedel, J.T. 1977. *Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages.* Hydrometeorological Report No. 49. Silver Spring, Maryland: U.S. Department of Commerce, National Oceanic and Atmospheric Administration. TIC: 220224.

2.2.17 MO0002SPATOP00.001. Topographic Grid Data. Submittal date: 02/24/2000.

2.2.18 MO9906COV98462.000. Coverage: TOPO2FTS. Submittal date: 06/07/1999.

2.2.19 McKeown, M. 1992. *Soil and Rock Geotechnical Investigations, Field and Laboratory Studies, North Ramp Surface Facility, Exploratory Studies Facility, Yucca Mountain*

Project, Nevada. TM 3610-92-35. Denver, Colorado: U.S. Department of the Interior, Bureau of Reclamation. ACC: NNA.19930607.0020. Submittal date: 12/4/1992.

2.2.20 Software Code: ArcGIS Desktop 9.1. 2005. Windows XP, STN: 11205-9.1-00.

2.2.21 Simons, D.B. and Senturk, F. 1992. *Sediment Transport Technology, Water and Sediment Dynamics*. Littleton, Colorado: Water Resources Publications. TIC: 244762.

2.2.22 Squires, R.R. and Young, R.L. 1984. *Flood Potential of Fortymile Wash and its Principal Southwestern Tributaries, Nevada Test Site, Southern Nevada.* Water-Resources Investigations Report 83-4001. Carson City, Nevada: U.S. Geological Survey. ACC: NNA.19890511.0110.

2.2.23 U.S. Army Corps of Engineers. 1990. *HEC-1, Computer Program, User's Manual.* CPD-1A, Version: 4.0. Davis, California: U.S. Army Corps of Engineers. TIC: 243325.

2.2.24 GS950308312213.004. Cumulative Infiltration and Surface Flux Rates Conducted in Fortymile Wash and Near UE-25 UZN#7. Submittal date: 03/27/1995.

2.2.25 GS960908312212.009. Cumulative Infiltration and surface Flux Rates Calculated on Raw Millivolt Readings for FY95. Submittal date: 09/12/1996.

2.2.26 Software Code: ARCINFO. V7.2.1. SGI, Irix 6.5. 10033-7.2.1-00.

2.2.27 CRWMS M&O 2000. User's Manual for ARC/INFO 7.2.1. SDN: 10033-UM-7.2.1-00. Las Vegas, Nevada: CRWMS M&O. ACC MOL.20020129.0112.

2.2.28 BSC (Bechtel SAIC Company) 2006. *Basis of Design for the TAD Canister-Based Repository Design Concept.* 000-3DR-MGR0-00300-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20061023.0002.

2.2.29 SNF29041993001.002. Percolation Test Data, ESF Muck Storage Area. Submittal date: 12/21/1994.

2.2.30 CRWMS M&O 2000. *Validation Test Report for ARC/INFO.* SDN: 10033-VTR-7.2.1-00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20020129.0113.

2.2.31 DOE (U.S. Department of Energy) 2005. *Software Validation Report for: ArcGIS Desktop 9.1.* Document Id: 11205-SVR-9.1-00-WINXP. Las Vegas, Nevada: U.S. Department of Energy, Office of Repository Development. ACC: MOL.20051212.0430.

2.2.32 Regulatory Guide 1.59, Revision 2. 1977. Design Basis Floods for Nuclear Power Plants. Washington, D. C.: U. S. Nuclear Regulatory Commission. TIC: 2708.

2.2.33 Regulatory Guide 1.102, Revision 1. 1976. Flood Protection for Nuclear Power Plants. Washington, D. C.: U. S. Nuclear Regulatory Commission. TIC: 3697.

2.2.34 CRWMS M&O 1999. *Software Qualification Report for HEC-1 V4.0.* CSCI: 30078 V4.0 DI: 30078-2003, Rev. 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990521.0220.

2.2.35 CRWMS M&O 1999. *Software Qualification Report HEC-RAS V2.1.* CSCI: 30079 V2.1 DI: 30079-2003, Rev. 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990521.0221.

2.3 DESIGN CONSTRAINTS

None.

2.4 DESIGN OUTPUTS

None.

3 ASSUMPTIONS

3.1 ASSUMPTIONS REQUIRING VERIFICATION

None.

3.2 ASSUMPTIONS NOT REQUIRING VERIFICATION

3.2.1 Homogeneity of Watershed Properties

Watershed sub-area properties are assumed to be spatially uniform within each sub-area boundary during the entire duration of the storm.

Rationale: Since the relative size of the sub-areas is very small, significant variations in hydrologic properties within the sub-areas is unlikely. However, a sensitivity analysis for variations in soil types was performed in Section 6.2.4 of Reference 2.2.6. This calculation demonstrates that the effects of minor soil variations are small. Therefore, verification of this assumption is not required.

3.2.2 Initial Abstraction

Initial rainfall abstraction for any given watershed can vary over a relatively wide range depending on antecedent moisture conditions, season, and other factors. It was assumed that an initial rainfall abstraction (rainfall loss) of 1 inch would occur prior to rainfall runoff from the watershed to account for interception (wetting), depression storage, and rainfall required to saturate the uppermost layer of soil.

Rationale: Justification for this assumption is provided in Section 6.1.4.

3.2.3 Aging Pad Infiltration

For purposes of determining input parameters into the U.S. Army Corps of Engineers' HEC-1 computer model, it was conservatively assumed that the Aging Pads area shown on Attachment A is impervious to rainfall infiltration.

Rationale: The most conservative condition is assumed. Therefore, this is a bounding assumption that does not require verification.

3.2.4 Infiltration Rate

For all areas outside of the Aging Pads, a conservatively low rainfall infiltration rate of 1.5 inches per hour was assumed in the analysis.

Rationale:

Justification for this assumption is provided in Section 6.1.4.

3.2.5 Manning's Roughness Coefficient

A conservatively high Manning's n roughness coefficient of 0.09 was assumed for the HEC-1 and HEC-RAS computer calculations to provide conservatively high flow depths at project facilities.

Rationale: Justification for the assumed Manning's roughness coefficients is provided in Section 6.1.4.

3.2.6 Boundary Conditions

It was assumed that flows at upstream boundaries of the man-made channels around the Aging Pad and North Portal Facilities areas are at normal depth as determined by channel slopes and discharge. Flow was also assumed to be at normal depth at the downstream outlet of the channel system. The water surface elevation calculated by the HEC-RAS model in Segment 3 at its junction with Segment 2 was used as the downstream boundary of Segment 2. The water surface elevation calculated by the HEC-RAS model in Segment 2 at its junction with Segment 1 was used as the downstream boundary of Segment 1. See Figure 6-1 or 7-1 for definitions of Segments 1, 2, and 3.

Rationale: Upstream and downstream boundary conditions are dependent upon channel geometry and channel entrance and exit conditions at the boundaries, which are not in the scope of this analysis.

3.2.7 Fixed Bed Model

For the purpose of calculating PMF water surface elevations, it is assumed that channel sizes and locations, as defined by the current topography, will not change during the PMF event, i.e., a fixed bed model such as HEC-RAS can be used in the analyses.

Rationale: Flood channel design is not in the scope of this analysis. Sufficient watershed and sediment data are not available to predict possible changes in channel geometry and location during an extreme flood event such as the PMF. For purposes of the modeling, runoff has been directed toward the dike system. Should peak flows exceed the capacity of formed flow paths, water surface elevations adjacent to the dikes would be lower due to the overflow into adjacent channels farther away from the facilities.

3.2.8 Structural Integrity of the Dike System

It is assumed that structural failure of the dike system due to erosion or other factors will not occur.

Rationale: Structural design for the dike system is not in the scope of this analysis.

3.2.9 Flow Bulking Factor

In this study, it was conservatively assumed that flows will be bulked by 10% to account for sediment, debris, and air entrainment in the flowing water.

Rationale: Hydraulic equations and computer models do not account for entrainment of sediment, debris, and air bulking and must be separately accounted for by the investigator. Data are not available to estimate the amount of flow bulking at the project site during a PMF event. Justification for this assumption is provided in Section 6.1.4.

3.2.10 Detention Basin Design

As shown in Attachment A, runoff from the North Portal Facilities area will be detained on site and/or collected in detention ponds located at the southern and eastern boundaries of the North Portal Facilities area. It is assumed that detailed design will ensure that releases from the detention ponds through their outlet works will be controlled such that outflows will have no significant effect on peak flows in the downstream channel.

Rationale: The outlet works and detention storage volume for the detention ponds are not in the scope of this calculation.

4 METHODOLOGY

4.1 QUALITY ASSURANCE

This calculation was prepared in accordance with EG-PRO-3DP-G04B-00037, Calculations and Analyses (Ref. 2.1.1). The flood control structures have not been classified in the Basis of Design (Ref. 2.2.28). However, it is not anticipated that this system will perform any functions important to safety or important to waste isolation. Therefore, the approved version is designated as QA:N/A.

4.2 USE OF SOFTWARE

Software listed in Table 4-1 is qualified and was obtained from Software Configuration Management. The software was appropriate for the applications described in this report and the software was used within its range of validation as required by IT-PRO-0011 (Ref. 2.1.2). The computer used to run HEC-1 and HEC-RAS software is located in the URS office in Oakland, California. The computer was a Toshiba Satellite Pro with serial number 97244164. The computers used to run ArcGIS V.9.1 are also located in the URS office in Oakland, California. The computer types and identifiers are as follows: Hewlett-Packard hpxw4400 workstation, w021xp060928 and w021xp060917; and Hewlett Packard hp workstation xw6000, w021xp-8004. The computer used to run ArcINFO V.7.2.1 is located in the Yucca Mountain Las Vegas Office, Nevada. The BSC property tag number of this computer is 700810.

Table 4-1. Software Usage

Reference	Name	STN/CSCI Identifier	CPU Operating Platform	CPU Operating System
Ref. 2.2.4, Ref. 2.2.34	HEC-1 Version 4.0	30078-V4.0	PC	Windows 95-DOS Emulation
Ref. 2.2.5, Ref. 2.2.35	HEC-RAS Version 2.1	30079-V2.1	PC	Windows 95-DOS Emulation
Ref. 2.2.26, Ref. 2.2.30	ArcINFO V.7.2.1	STN 10033-7.2.1-00	SGI	IRIX 6.5
Ref. 2.2.20, 2.2.31	ArcGIS Desktop V.9.1	STN 11205-9.1-00	PC	Windows XP

4.2.1 Probable Maximum Flood Calculation

The HEC-1 computer software, Version 4.0 (Ref. 2.2.34, 2.2.4, 2.2.23) was used to perform the rainfall-runoff simulations using PMP amounts. This is the same software used in the previous studies (Ref. 2.2.6, 2.2.7).

4.2.2 Flood Inundation Calculation

The U.S. Army Corps of Engineers, Hydrologic Engineering Center, River Analysis System software (HEC-RAS), Version 2.1 (Ref. 2.2.35, 2.2.3, 2.2.5), was used for the flood inundation analysis. This program is designed for flood inundation studies and flood risk analysis. This software performs standard backwater computations to predict water surface elevations under steady gradually varied flow conditions. HEC-RAS is one of the FEMA nationally accepted computer programs that can be used to estimate flood elevations (Ref. 2.2.15). This is the same software used in the previous studies (Ref. 2.2.6 and 2.2.7).

4.2.3 Generation of Digital Terrain

A composite Triangulated Irregular Network (TIN) comprising two datasets (DTN #s MO0002SPATOP00.001 (Ref. 2.2.17) and MO9906COV98462.000 (Ref. 2.2.18)) was generated using ArcINFO V.7.2.1 (Ref. 2.2.26, 2.2.27) to produce a topographic representation of the project area. The dataset MO9906COV98462.000 (Ref. 2.2.18) contains 2-foot contour data encompassing the North Portal Facilities and vicinity, whereas the dataset MO0002SPATOP00.001 (Ref. 2.2.17) consists of an output gridded (100-foot spacing) surface that covers the entire watershed. The 2 datasets have overlapping information and the goal was to use the best available data for the region analyzed. The 2-foot contours from DTN MO9906COV98462.000 (Ref. 2.2.18) were the preferred data as they have the best vertical resolution available. The 2-foot contours were clipped to the extent of the study area. The gridded elevation points from DTN MO0002SPATOP00.001 (Ref. 2.2.17) were then clipped to the same extent, and points overlapping the area where 2-foot contours existed were eliminated.

4.2.4 Geoprocessing and Displaying Results

ArcGIS V.9.1 (Ref. 2.2.20) was used to extract elevation data from the TIN described in Section 4.2.3 by querying information along user-defined section lines. ArcGIS V.9.1 was also used to calculate areas of watersheds defined as polygons, lengths of streams defined as lines, and present output from HEC-RAS graphically to show inundation boundaries. The solutions are documented in sufficient detail to allow an independent checker to reproduce or verify the results without recourse to the originator.

4.3 PMF CALCULATION METHOD

HEC-1 (Ref. 2.2.4), which was designed to simulate the surface runoff response of a watershed to precipitation, was used to calculate the Probable Maximum Flood (PMF). The program represents the watershed as an interconnected network of hydraulic and hydrologic components. A component may be a sub-area of the watershed, river channel, reservoir, or diversion. Each component is described by its physical characteristics and mathematical relations that describe the pertinent hydrologic and hydraulic processes. In the HEC-1 software, the study area is divided into drainage sub-areas with constant hydrologic properties. Separate hydrographs can be calculated for each sub-area. This method was necessary to provide information on flows at several key locations based on the proposed surface layout.

4.4 INUNDATION METHOD

The computational procedure used in HEC-RAS (Ref. 2.2.5) is based on solution of the one-dimensional energy equation. Energy losses consist of surface roughness and expansion/contraction losses. Energy loss by surface roughness is evaluated using Manning's equation and requires the user to define a roughness coefficient. The momentum equation is used in situations where flow is rapidly varied, such as hydraulic jumps and flow through bridges. A rigid channel boundary is used in the computations (i.e., channel cross section shapes do not change as a result of sediment deposition or scour). The HEC-RAS model uses input flows that are calculated by the HEC-1 model. Output from the model consists of water surface elevations at each user defined cross-section.

Three channel segments were analyzed using the HEC-RAS model. The channel segments are shown on Figure 7-1. Channel Segment 1 starts just north of the Aging Pads, follows the ditch and dike system towards the south and then continues south down the center of Midway Wash until it reaches Segment 2. Channel Segment 2 starts just north of the Aging Pads, and follows the ditch and dike system along the west side of the Aging Pad complex. At the southwest corner of the Aging Pad complex, Segment 2 turns east, passes through an opening in the dike, and flows east between the Aging Pads and the North Portal Facilities. At the northeast corner of the North Portal Facilities, Segment 2 turns south, follows the North Portal Loop eastern dike to its southern end, and then flows south away from the North Portal Facilities. Channel Segment 3 starts near the southwest corner of the North Portal Facilities, follows the North Portal Loop western dike to the southwest corner of the North Portal Facilities, turns toward the northeast, and flows under the H road through a series of culverts where it joins Segment 2 and flows out of Midway Valley. Assumption 3.2.6 was used to specify boundary conditions at the upstream and downstream ends of each Segment.

5 LIST OF ATTACHMENTS

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6 BODY OF CALCULATION

6.1 MODEL INPUTS

6.1.1 Topographic Data

A composite TIN was used to represent the topography of the project area. Generation of the TIN is described in Section 4.2.3. 10-foot contours were generated from the TIN using ArcGIS V.9.1 (Ref. 2.2.20) and were used in conjunction with the 2-foot contours from DTN M09906COV98462.000 (Ref. 2.2.18) to delineate the watershed and sub-areas and to determine channel flow paths. Elevations at the upstream and downstream ends of the flow paths defined for the HEC-1 model were also extracted from the TIN. Figure 6-1 shows sub-areas and drainage channels used in the HEC-1 model. A schematic of how the drainage system is represented in the HEC-1 model is provided in Attachment F. Elevation data from the TIN were also extracted at user-defined locations as input to the HEC-RAS models. The locations of extracted cross-sections are shown in Figure 7-1.

6.1.2 Layout Design

Preliminary layout sketches of the surface facilities, including the proposed North Portal Facilities, Aging Facilities, and dike and channel system, were used to define the extent of drainage sub-areas. A copy of the preliminary layout is provided in Attachment A. Project facilities are shown in the preliminary drawings as being protected by a ditch and dike system. The dimensions and elevations of the ditch and dike system were estimated from the drawings included in Attachment A. The dike system is included in the inundation study so that minimum elevations of the dikes could be estimated.

6.1.3 Precipitation

Section 4.2.10.2 of the Project Design Criteria (Ref 2.2.1) requires repository facilities to be protected from flooding utilizing the guidance from Regulatory Guide 1.102, "Flood Protection for Nuclear Power Plants" (Ref. 2.2.33), and Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants " (Ref. 2.2.32). These regulatory guides endorse National Oceanic and Atmospheric Administration (NOAA) methodology for determination of probable maximum precipitation (PMP). The PMP for the site was determined using procedures described in the National Oceanic and Atmospheric Administration's Hydrometeorological Report No. 49 (HMR 49) (Ref 2.2.16), which is considered to provide the best estimate of PMP potential (Ref. 2.2.13, p. 43). The HMR 49 method takes into account meteorological conditions and atmospheric processes in a region, moisture-maximized rains of record, and broad-scale terrain features among other factors to determine a theoretically maximum amount of precipitation for a region or a local watershed.

HMR 49 (Ref. 2.2.16) provides procedures and data for estimating local thunderstorm PMP and general storm PMP. In general the local thunderstorm PMP is the more critical event for small watersheds and the general storm PMP is more critical for large watersheds. Evaluations of the two types of storms (thunderstorm versus general storm) are provided in the previous report (Ref. 2.2.6). The all-seasons local thunderstorm PMP was used for the analyses because it is the critical PMP event for the small watershed considered in these studies.

Using the watershed size and geographical location, the estimated 6-hour duration local storm PMP over the North Portal Facilities area (herein referred to as PMP-North Portal) was determined in the previous study (Ref. 2.2.6) to be 13.2 inches, which has a higher precipitation intensity than the general storm PMP and is therefore the more critical storm to use in the PMF determination. The temporal distribution of the total precipitation was provided in the previous report (Ref. 2.2.6) and was developed based on recommendations in HMR 49. The time series precipitation amounts used in these calculations are presented in the HEC-1 input and output files contained in Attachments B and C. The PMP-North Portal was applied to sub-areas SB1, SB2, SB3, SB4, SB5, SB6, SB13, and Aging1 in the HEC-1 model. These sub-areas are shown on Figure 6-1.

Since a local thunderstorm system affecting the South Portal area can be independent of one that occurs at the North Portal Facilities, a separate PMP value was developed for the tributary area south of the North Portal Facilities. Separate and independent PMP storms for the North and South Portal areas provide a more conservative estimate of the maximum flows at the two portals because the rainfall intensity is inversely related to the drainage area. With an area of 6.5 square miles, the local 6-hour PMP for the South Portal area was computed to be 12.9 inches and is presented in Attachment E. The PMP for the South Portal area was applied to sub-areas SB7, SB8, SB9, SB10, SB11, and SB12. The sub-areas designated as NPP1, NPP2, and NPP3 on Figure 6-1 were excluded from the HEC-1 analysis because of assumption 3.2.10, which assumes that the design of the detention ponds will result in controlling runoff from the North Portal Facilities area such that peak PMF flows would not be affected.

6.1.4 Sub-Area Properties

The unit hydrograph method was used to develop a runoff hydrograph for each sub-area. Two parameters, sub-area size and lag time, are needed to determine the unit hydrograph for each sub-area using the NRCS Dimensionless Unit Hydrograph (Ref. 2.2.23, pp. 23-24). Sub-area sizes were obtained from the topographic data using ArcGIS V.9.1 (Ref. 2.2.20) and are summarized in Table 6-1.

The lag time parameter is used to define the shape of the unit hydrograph and is defined as the time difference between the occurrence of the center of mass of excess rainfall and the peak of the unit hydrograph. There are several formulae available to calculate lag time. Five commonly used formulae were evaluated in the previous report (Ref 2.2.6, pp. 18-19, 35-37). In general, lag time values computed using the U.S. Bureau of Reclamation (USBR) empirical formula (Ref. 2.2.14, pp. 29-38) were the smallest and, therefore, most conservative (i.e., produce the largest peak flow). Based on this consideration, lag times were calculated using the USBR formula, which is presented below (Ref. 2.2.14, pp. 29-38), with the results tabulated in Table 6-1.

$$lag = C\left(\frac{L \cdot L_{ca}}{\sqrt{S}}\right)^{0.33} \text{ (hours)}$$

where

C = 1.1 (Ref. 2.2.6, p. 19, 35-37)
L = total channel length (mi)
L_{ca} = length along the flow path from the basin outlet to the point opposite the centroid of the basin area (mi)
S = slope of the channel (ft/mi)

Table 6-1. Properties of Sub-Areas Used in HEC-1 Model

Basin Name	Area (mi^2)	Total channel length (mi)	Length from centroid to outlet (mi)	Slope (ft/mi)	Lag time (hr)
Aging1	0.46	N/A	N/A	N/A	N/A
SB1	0.83	2.72	1.39	370	0.64
SB2	0.42	1.62	0.71	570	0.40
SB3	1.6	3.82	1.71	500	0.73
SB4	1.2	3.34	1.33	460	0.65
SB5	0.39	2.36	1.10	180	0.64
SB6	0.76	3.01	1.44	180	0.76
SB7	2.9	4.83	2.50	430	0.92
SB8	1.2	2.68	1.26	440	0.60
SB9	1.7	2.46	1.10	480	0.55
SB10	0.44	0.89	0.41	150	0.35
SB11	0.46	1.35	0.64	360	0.40
SB12	0.15	0.39	0.24	88	0.24
SB13	0.19	0.81	0.39	250	0.30

An initial rainfall abstraction, or rainfall loss, is a sub-area property used in these calculations. It was assumed that an initial rainfall abstraction of 1 inch would occur prior to rainfall runoff from the watershed to account for interception (wetting), depression storage, and rainfall required to saturate the uppermost layer of soil. This assumed 1-inch initial rainfall loss is consistent with a rainfall loss measured during a July 1985 storm event (Ref. 2.2.8, p.7) and, as shown by sensitivity analyses presented in the previous report (Ref. 2.2.6, pp. 36-37), is a small enough value that the calculation results are relatively insensitive to it and, therefore, this assumption does not require confirmation.

A constant infiltration rate is also used in the calculations. Three double ring infiltrometer tests were conducted in the project vicinity that were used to estimate the constant infiltration rate used in these calculations. One test was conducted in Midway Wash at sampling location SA30 (MOL.19970513.0374, see ref 2.2.25, pp. 30-33), one was conducted in Pagany Wash at 32 cm below grade (MOL.19960112.0193, see ref 2.2.24), and one in 40 Mile Wash 200 feet south of H Road (MOL.19960112.0193, see ref. 2.2.24). A duplicate sample was collected at the 40 Mile Wash site. The infiltration rates after one hour varied from over 23 inches per hour (in/hr) at the 40 Mile Wash site, to 1.63 in/hr at the Pagany Wash site. The infiltration rate at the Midway Wash site was 5.58 in/hr.

A conservatively low rainfall infiltration rate of 1.5 inches per hour was assumed in the analysis. This is less than the lowest double infiltrometer test results and 0.3 inches per hour less than the 1.8 inches per hour infiltration rate estimated from percolation tests conducted at the ESF Muck Storage Area (Ref. 2.2.29, DTN#SNF29041993001.002). The assumed infiltration rate is consistent with hydrologic soil groups found in neighboring watersheds (Ref. 2.2.2, Table 8; Ref. 2.2.9, Tables 7 and 8) and soil particle size distributions found in Midway Valley (Ref. 2.2.19, DTN# GS921283114220.014). The influence of this assumed infiltration rate on the peak flood estimate was addressed through sensitivity analyses presented in the previous report (Ref. 2.2.6, pp. 36-37).

Bulking of flows by entrainment of sediment, debris, and air is another watershed sub-area characteristic that was considered in the studies. A review of literature regarding flow bulking suggests that bulking may not be a significant factor affecting PMF flows (Ref 2.2.6). This is because a PMF will have too much water for bulking to be significant. Bulking the PMF flow by 4 to 10 percent would be more than adequate. A bulking factor of 10 percent was assumed for the calculations, i.e., flows were increased by 10% to account for bulking and provide conservatism. Since the choice of this parameter is based primarily on literature, no confirmation is required.

6.1.5 Channel Properties

Manning's n roughness coefficient, which is used to calculate hydraulic losses of flows through a channel system, is needed for the HEC-1 and HEC-RAS models. Three different values for Manning's n, representing a lower limit, upper limit, and best estimate of PMF flow conditions, were considered for the analyses. The three different values for Manning's n that were considered are described below.

Clear Water Flow (Lower Limit)

Typically, a single value for Manning's n is used for the main channel, and a different coefficient is used for floodplains. Manning's n for clear flow conditions is based on typical values published in the literature (see Ref 2.2.10 pp. 101-123). A Manning's n value of 0.035 for the channel and a value of 0.05 for the floodplain would be appropriate based on ground cover and surface features shown in the project vicinity (Ref. 2.2.11, pp. 4-5; Ref. 2.2.22, pp. 6-10) and observed at the site in January 1999.

High Sediment Transport (Best Estimate)

During a PMF, the bed form is assumed to be continually changing and transporting large quantities of sediment, and may uproot plants and carry them and debris in the flow. This process will have the effect of increasing the effective roughness coefficient of the flow. Ref. 2.2.21 (pp. 197-371) lists Manning roughness coefficients for these forms and suggests increasing Manning's n by 0.02 to account for changing bed forms.

The degree of obstructions to the flow can also increase the Manning's n value. Obstructions include such things as debris deposits, exposed roots, floating vegetation that snag on downstream vegetation, and boulders. The Manning's n is increased by a value of 0.02 to account for obstructions during high sediment transport conditions, as recommended in Ref. 2.2.10 (pp. 101-123). Assuming a base roughness of 0.05 and adding values of 0.02 and 0.02 for bed forms and obstructions, respectively, results in a Manning's n value of 0.09 for high sediment transport conditions.

Mudflow (Upper Limit)

Under extreme sediment and debris transport conditions, a mudflow phenomenon may result in which the concentration of sediments in the water is greater than 20 percent by volume. Mudflows behave differently than clear water flow in that they have higher viscosity and internal shear stress. Calibration studies presented in the literature (Ref. 2.2.12, pp. 21-30) that simulated observed mudflows at several sites having field measurements indicated that the effective Manning's n roughness coefficient for mudflows ranged from 0.07 to 0.35. A conclusion of the calibration studies was that a Manning's n value of 0.16 provides the best fit when all data are considered.

Although it is expected that a significant amount of sediment and debris will be transported by the PMF, the amount of clear water runoff will be very large and it is unlikely that a mudflow condition will develop. On the other hand, it is likely that relatively large amounts of sediment will be transported by the runoff and a roughness that is higher than a clear water flow value of 0.035 is expected. Thus, a Manning's n roughness coefficient of 0.09 was assumed in the analyses. This assumed roughness will provide conservatively high estimates of water surface elevations without significantly underestimating peak discharges from the sub-areas since HEC-1 calculated peak flows from the sub-areas are not sensitive to assumed channel roughness. Higher Manning's n values would tend to decrease peak flows but would have no effect on the calculated lag time or time of concentration, which have a greater effect on the peak flows calculated by HEC-1. In HEC-RAS, the higher Manning's n values tend to increase water surface elevations. The results of a sensitivity analysis were provided in a previous study (Ref. 2.2.6, Section 6.3) for the three flow scenarios discussed above.

The Muskingum-Cunge method (Ref. 2.2.23, pp. 40-41) was used to perform HEC-1 hydrograph routing along the channels through the watershed network. Inputs for the HEC-1 model are presented in Table 6-2 and include the length, slope, and channel dimensions. Dimensions of the man-made channels were taken from the preliminary drawings included in Attachment A. Dimensions of the natural channels were based on the topographic data described in Section 4.2.3. In general the attenuation of peak flows is not sensitive to the assumed channel size.

To initiate the channel routing in HEC-RAS, a normal depth flow condition, based upon channel bed slopes, roughness and discharge were assumed at the boundaries of the man-made channel system around the Aging Pads and North Portal Facilities areas. Bed slopes at the upstream boundaries of channel Segments 1, 2, and 3 (see Section 4.4 and Figures 6-1 and 7-1 for Segment definition) were estimated from the topographic data described in Section 4.2.3 and are 0.044, 0.037, and 0.033, respectively. Flows at these upstream boundaries were obtained from the HEC-1 output. At the downstream outlet of the channel system, the combined flow in the channels and the 0.025 bed slope at the outlet were used to calculate normal depth flow for Segment 3. At the downstream boundaries of Segments 1 and 2, water surface elevations at the junctions of the channel segments were calculated by the HEC-RAS model using the flow downstream from the junction and the channel slope and geometry at the junction.

Table 6-2. Properties of Channels Used in HEC-1 Model

Channel Name[1]	Length (ft)	Slope (ft/ft)	Bottom Width (ft)	Side Slope (h:1)
SB1toCP1	2400	0.02	78	3
CP1toCP2	2600	0.02	68	3
CP2toCP3	3500	0.02	88	3
CP3toCP4	4100	0.03	30	4
CP4toCP9	3000	0.02	30	20
CP5toCP6	2000	0.03	30	20
CP6toCP7	2100	0.02	30	10
CP7toCP8	2000	0.02	30	4
CP8toCP9	1700	0.02	30	4
SB7toCP5	3200	0.04	30	20
SB9toCP6	4700	0.03	30	20

1. Channel name used in HEC-1 files, Attachment B.

6.1.6 Culvert Sizes

As shown in Attachment A, project facilities include a set of culverts that pass under the "H" road (H road culverts) located southeast of the North Portal Facilities area. As input to the HEC-RAS model and shown on the preliminary drawings in Attachment A, the H road culverts consist of eight 48–foot by 20-foot arch culverts. For later stages of design, other options, such as a bridge, could be used instead of the culverts to convey the PMF.

6.2 PROBABLE MAXIMUM FLOOD ANALYSIS

A rainfall-runoff simulation was performed using the HEC-1 computer software (Ref. 2.2.4) to determine PMF flows at pertinent locations in the vicinity of the North Portal and Aging Pad facilities. The study area encompasses Midway Valley Wash, Drillhole Wash, and Split Wash, and is bounded by Yucca Mountain to the west, and Fran Ridge and Alice Hill to the south and east. The area was divided into 17 sub-areas as presented in Figure 6-1 to provide information on flows near the surface facilities. The sub-area boundaries were modified from the previous report (Ref. 2.2.7) to reflect changes in design layout.

6.3 FLOOD INUNDATION ANALYSIS

Flood inundation calculations were performed for each channel Segment shown on Figure 6-1 and described in Section 4.4. Cross-sections for the HEC-RAS model (Ref. 2.2.5) for each Segment were cut from the TIN described in Section 6.1.1 using the ArcGIS software (Ref. 2.2.31, 2.2.20). Figure 7-1 shows the locations of the cross-sections.

7 RESULTS AND CONCLUSIONS

7.1 PROBABLE MAXIMUM FLOOD RESULTS

This calculation demonstrates that the designed drainage features, as depicted in Attachment A, are adequate to protect the GROA nuclear facilities from flooding associated with the Probable Maximum Precipitation (PMP) event. This conclusion is based on the peak discharges and flood inundation levels summarized below.

Table 7-1 summarizes peak discharges calculated by the HEC-1 computer software (Ref. 2.2.4) using the inputs and assumptions discussed in the preceding report sections. The complete HEC-1 inputs and results are included in Attachments B and C. In addition to the discharge for individual sub-areas, HEC-1 also calculated PMF discharges at flow concentration points where hydrographs from two or more sub-areas are combined before being routed downstream. The peak flow at a concentration point is not simply the sum of the peak flows from each contributing sub-area because the HEC-1 software routes the entire flood hydrograph downstream, and the time to reach peak flow varies between sub-areas. The locations of sub-areas and flow concentration points are shown on Figure 6-1. The HEC-1 schematic is included in Attachment F.

Table 7-1. Results of PMF Analysis

Sub-Area	Peak Flow from HEC-1 (cfs)	Peak Flow with 10% Bulking Factor (cfs)		Flow Concentration Point	Peak Flow from HEC-1 (cfs)	Peak Flow with 10% Bulking Factor (cfs)
SB1	4,097	4,510		CP1	6,164	6,780
SB2	2,881	3,170		CP2	18,927	20,820
SB3	7,148	7,860		CP3	20,138	22,150
SB4	5,782	6,360		CP4	25,090	27,600
Aging1	3,436	3,780		CP5	14,235	15,660
SB5	1,925	2,120		CP6	23,427	25,770
SB6	3,290	3,620		CP7	24,733	27,210
SB7	10,053	11,060		CP8	24,935	27,430
SB8	5,757	6,330		CP9	50,219	55,240
SB9	8,684	9,550				
SB10	3,043	3,350				
SB11	2,924	3,220				
SB12	1,300	1,430				
SB13	1,555	1,710				

7.2 FLOOD INUNDATION RESULTS

7.2.1 Flood Inundation Along Channel Segment 1

HEC-RAS software (Ref. 2.2.5) was employed using the cross-section data described in Section 6.1.1.

Table 7-2 summarizes results of the flood routing analysis of PMF peak flow through channel Segment 1. Cross-section locations along channel Segment 1 are shown in Figure 7-1. Between cross-sections 8069 and 9716, channel Segment 1 is located adjacent to the man-made dike system. Downstream from cross-section 8069, between cross-sections 2 and 7695, the ground slopes away from the dike and flow is no longer against the dike. Channel bed, PMF water surface, and minimum top-of-bank profiles along channel Segment 1 are presented in Attachment D.

Theoretically, the peak flow along a channel reach increases gradually toward the downstream direction because the peak flow at a particular channel cross-section is only the peak flow from the drainage area upstream of this cross-section. It is not practical to calculate the peak flow for each individual cross-section. Instead, the PMF peak flows calculated for sub-areas or concentration points in Table 7-1 were applied to the appropriate cross-sections in the HEC-RAS model. For Segment 1, the PMF peak flow of 2,120 cfs for Sub-Area SB5 was used for the reach between cross-sections 2219 to 9716. Downstream of cross-section 1938, where Segment 1 merges with Segment 2, the total flow of 27,600 cfs at Flow Concentration Point CP4 was used to account for the possibility that PMF peak flows in Segment 2 and from Sub-Area SB6 may merge into Segment 1.

Between cross-sections 7695 and 9716 and between 945 and 2219, ineffective flow areas were defined for the left (when facing downstream) portions of the cross-sections. This compensates for the possibility of an obstruction to the left of the main channel because the HEC-RAS software treats ineffective flow areas as stagnant, so they are not actively conveying. This approach keeps the majority of the PMF peak flow staying in the main flow path for more conservative flood inundation estimations. Otherwise, the HEC-RAS model would actively convey flow through the portions of the cross-section with the lowest elevations, whether these occur along the main channel or the overbanks.

Table 7-2. Flood Inundation Results for Segment 1

Stream Cross-Section	Peak PMF Flow (cfs)	Channel Invert Elevation (ft)	Water Surface Elevation (ft)	Channel Velocity (ft/s)	Channel Top width (ft)	Levee Elevation(1) (ft)	Levee Free Board(1) (ft)
9716	2120	3858.2	3862.1	4.9	430.6	3862.4	0.3
9310	2120	3840.5	3844.4	6.6	295.8	3852.5	8.1
8892	2120	3822.5	3826.4	5.8	146.4	3837.5	11.2
8494	2120	3806.8	3811.9	5.9	256.9	3818.1	6.2
8069	2120	3790	3794.6	6.3	297.9	3800.6	6
7695	2120	3771.9	3775.8	6.1	279.4	3784.1	8.3
7306	2120	3749.2	3755.1	9.1	56.5	3771.9	16.8
7030	2120	3737.1	3745.1	7.6	61.3	3771.3	26.2
6730	2120	3730.1	3736.1	7.2	72.7	3762.2	26.1
6433	2120	3723.9	3728.8	5.8	98.5	3750.6	21.8
6041	2120	3711	3717.4	8.1	63.1	3739	21.6
5558	2120	3698	3703.3	6.1	94.3	3722.8	19.5
5180	2120	3686	3690.7	7.6	84.4	3718.8	28
4815	2120	3676.4	3681.9	5.2	104	3699	17.2
4487	2120	3668	3673.3	7.1	95.1	3688.2	14.9
4064	2120	3658	3662.9	4.8	133.3	N/A	N/A
3468	2120	3642	3645.1	7.7	100	N/A	N/A
3008	2120	3628	3634.9	4.5	124.2	N/A	N/A
2601	2120	3619.8	3623.1	8.8	99.6	N/A	N/A
2219	2120	3608	3617.2	1.3	509.4	N/A	N/A
1938	27600	3602	3612.5	8.1	1113.6	N/A	N/A
1656	27600	3594	3603.7	9.4	748.6	N/A	N/A
1426	27600	3588	3597.4	7.8	1044.3	N/A	N/A
1183	27600	3582	3589.3	9.3	998.2	N/A	N/A
945	27600	3576	3582.6	7.4	1097.1	N/A	N/A
661	27600	3568.8	3576.2	6.4	1395.8	N/A	N/A
439	27600	3563.9	3571.3	7	1361.6	N/A	N/A
240	27600	3560	3567.5	7.2	1303.2	N/A	N/A
2	27600	3556	3563.4	5.8	1349.6	N/A	N/A

(1) N/A = Not applicable. Between sections 4064 and 2, channel Segment 2 is between the dike and channel Segment 1, so levee elevations and free board have been provided for channel Segment 2 in Table 7-3.

7.2.2 Flood Inundation Along Channel Segment 2

Table 7-3 summarizes results of the flood routing analysis of PMF peak flows through channel Segment 2. Cross-section locations along channel Segment 2 are shown in Figure 7-1. Between cross-sections 14681 and 2799, channel Segment 2 is located adjacent to the man-made dike system. Downstream from cross-section 2589, between cross-sections 1 and 2589, the ground slopes away from the dike and flow is no longer against the dike.

Downstream from the southwest corner of the Aging Pad complex, where channel Segment 2 crosses the dike system (cross-section 10287 to 9676), the right (south) channel bank is adjacent to the North Portal Loop East dike system. Channel bed, PMF water surface, and minimum top-of-bank profiles along channel Segment 2 are presented in Attachment D.

The PMF peak flow at each cross-section was determined with a similar approach as discussed in 7.2.1.

Table 7-3. Flood Inundation Results for Segment 2

Stream Cross-Section	Peak PMF Flow (cfs)	Channel Invert Elevation (ft)	Water Surface Elevation (ft)	Channel Velocity (ft/s)	Channel Top width (ft)	Left Levee Elevation[1] (ft)	Left Levee Free Board[1] (ft)	Right Levee Elevation [1] (ft)	Right Levee Free Board[1] (ft)
14681	4510	3858.4	3865.8	3.8	433.4	3868.4	2.6	N/A	N/A
14432	4510	3854.6	3861.4	6.6	407.6	3869.5	8.1	N/A	N/A
14197	4510	3850	3855.3	5.8	432.1	3860	4.7	N/A	N/A
13836	4510	3842.5	3844	5.2	421.2	3852.7	8.7	N/A	N/A
13567	4510	3824	3832.8	4.9	213.9	3844	11.2	N/A	N/A
13161	4510	3818.6	3821.3	7.4	370.5	3836.5	15.2	N/A	N/A
12844	4510	3801	3809.8	4.5	140.9	3824.5	14.7	N/A	N/A
12382	6780	3796.5	3804.4	7.7	135.5	3821	16.6	N/A	N/A
12063	6780	3790	3797	8.8	130.2	3816.5	19.5	N/A	N/A
11833	6780	3780	3786.2	12.6	105.2	3810	23.8	N/A	N/A
11529	6780	3769.7	3779.3	7.3	125.6	3800	20.7	N/A	N/A
11193	6780	3765	3775.2	6.8	129	3789.7	14.6	N/A	N/A
10949	6780	3761	3773.9	4.6	173.4	3785	11.1	N/A	N/A
10642	6780	3760	3772.2	5.3	141.2	3781	8.8	N/A	N/A
10287	6780	3760	3765.4	12.1	120.2	N/A	N/A	N/A	N/A
9909	6780	3749.1	3758.8	3.8	380.5	N/A	N/A	N/A	N/A
9676	20820	3744.7	3751.2	13.4	490.6	N/A	N/A	3757.7	6.5
9350	20820	3727	3735.4	12.9	514.2	N/A	N/A	3747	11.6
9065	20820	3712	3723.9	11.9	499.9	N/A	N/A	3732	8.1
8785	20820	3706	3721.1	8.3	412.2	N/A	N/A	3726	4.9
8483	20820	3701.8	3719	7.8	277.5	N/A	N/A	3721.8	2.8
8188	20820	3698.5	3717.6	7.1	280.3	N/A	N/A	3718.5	0.9
7927	20820	3698	3715.8	8.2	221.5	N/A	N/A	3718	2.2
7698	20820	3697	3713.8	8.8	237.5	N/A	N/A	3717	3.2

Stream Cross-Section	Peak PMF Flow (cfs)	Channel Invert Elevation (ft)	Water Surface Elevation (ft)	Channel Velocity (ft/s)	Channel Top width (ft)	Left Levee Elevation(1) (ft)	Left Levee Free Board(1) (ft)	Right Levee Elevation (1) (ft)	Right Levee Free Board(1) (ft)
7489	20820	3696.3	3710.8	10.6	195.6	N/A	N/A	3716.3	5.5
7280	20820	3695.3	3710.1	6.2	283.6	N/A	N/A	3715.3	5.2
7083	20820	3694	3705.7	14.1	179.2	N/A	N/A	3714	8.3
6922	20820	3688	3702.7	10.7	188	N/A	N/A	3708	5.3
6778	20820	3681.3	3696.4	15.3	187.1	3703.4	7	3702.3	6
6662	20820	3675.1	3692.5	9.5	267.2	3696.3	3.8	3702	9.5
6471	20820	3667.8	3683.3	16.2	156.8	3684.7	1.4	3696	12.7
6338	20820	3661.7	3678.9	10.6	220	N/A	N/A	3685	6.1
6147	20820	3656.9	3676.2	7.8	333.5	N/A	N/A	3677.8	1.6
5883	22150	3652	3671.7	9.6	257	N/A	N/A	3678.4	6.7
5618	22150	3646	3668.8	8.2	342.9	N/A	N/A	3675.6	6.8
5404	22150	3652.2	3665.1	10.7	533.4	N/A	N/A	3668.7	3.6
5234	22150	3648.7	3659.1	10.8	681.3	N/A	N/A	3661	1.9
5070	22150	3643.9	3651	9.1	696.7	N/A	N/A	3659.3	8.3
4882	22150	3633.2	3644.3	7.5	859.2	N/A	N/A	3653.8	9.5
4636	22150	3623.4	3632.1	12.6	482.9	N/A	N/A	3646.4	14.3
4339	22150	3609.8	3622.5	8	552	N/A	N/A	3639.9	17.4
4085	22150	3604	3616.4	11.4	264	N/A	N/A	3634.6	18.3
3869	22150	3598	3610.9	9.8	293.6	N/A	N/A	3631.3	20.4
3657	22150	3592.7	3605.6	10.1	300.2	N/A	N/A	3626.7	21.1
3460	22150	3588	3600.9	9.5	330.6	N/A	N/A	3622.3	21.3
3257	22150	3584.7	3595.6	9.2	416.3	N/A	N/A	3617.3	21.7
3012	22150	3579	3590.5	7.2	522.4	N/A	N/A	3612.4	21.9
2799	22150	3574	3582.4	11.2	518.6	N/A	N/A	3608.6	26.2
2589	27600	3569	3576.2	5.1	1395.8	N/A	N/A	3604.4	28.2
2357	27600	3563.9	3571.3	5.8	1361.6	N/A	N/A	3599.8	28.6
2180	27600	3560	3567.5	4.8	1303.2	N/A	N/A	3595	27.5
1943	27600	3556	3563.4	5.2	1349.3	N/A	N/A	3590.4	27
1722	27600	3552	3559.5	6	1241.9	N/A	N/A	3587.3	27.8
1499	27600	3548	3555	5.9	1471.8	N/A	N/A	3584.3	29.3
1371	27600	3546	3552.9	4.7	1532.9	N/A	N/A	3582.7	29.7
1190	27600	3541.2	3550.6	4.8	1630.7	N/A	N/A	3581.8	31.2
984	27600	3537.7	3546.8	5.9	1122	N/A	N/A	3581.2	34.4
882	27600	3534	3544.6	6.3	1096.5	N/A	N/A	3580.7	36
722	27600	3531.2	3540.5	6.8	1177.3	N/A	N/A	3580	39.5
577	27600	3528	3536.7	6.4	1259.1	N/A	N/A	3579.9	43.2
404	27600	3524	3531.5	7.2	1169.8	N/A	N/A	3580.8	49.3
183	27600	3520	3529.8	3.8	1233.8	N/A	N/A	3579.9	50.1
1	55240	3516.1	3528.7	5.1	1493.5	N/A	N/A	3570.8	42.1

(1) N/A = Not Applicable. The left and right levee and free board elevations are shown as N/A when the proposed dike is not adjacent to the channel on either the left or right sides.

7.2.3 Flood Inundation Along Channel Segment 3

Table 7-4 summarizes results of the flood routing analysis of PMF peak flows through channel Segment 3. Cross-section locations are shown in Figure 7-1. Between cross-sections 11551 and 6374, channel Segment 3 is located adjacent to the man-made dike system. Downstream from cross-section 6374, between cross-sections 647 and 6068, the ground slopes away from the dike and flow is no longer against the dike.

Eight 48-foot by 20-foot arch culverts were assumed to convey flow under the "H" road. These culverts can convey the PMF flow under the road with approximately 13 feet of freeboard to the road crest. In the final design, use of a bridge instead of the culverts should be considered. Downstream from the culverts, flow exits Midway Wash.

In Table 7-4, the levee elevations between cross-sections 11551 and 1599 were based on the height of the dike on the left bank of Segment 3 (facing downstream) along the North Portal Loop West, as shown in Attachment A. Between cross-sections 1184 and 647, the levee elevations shown in Table 7-4 were based on the height of the "H" Road (south of channel Segment 3) as shown in Attachment A. However, the elevation of the "H" Road is preliminary, so the downstream inundation area was not mapped in detail on Figure 7-1, and the elevations for sections downstream of cross-section 647 were not shown in Table 7-4.

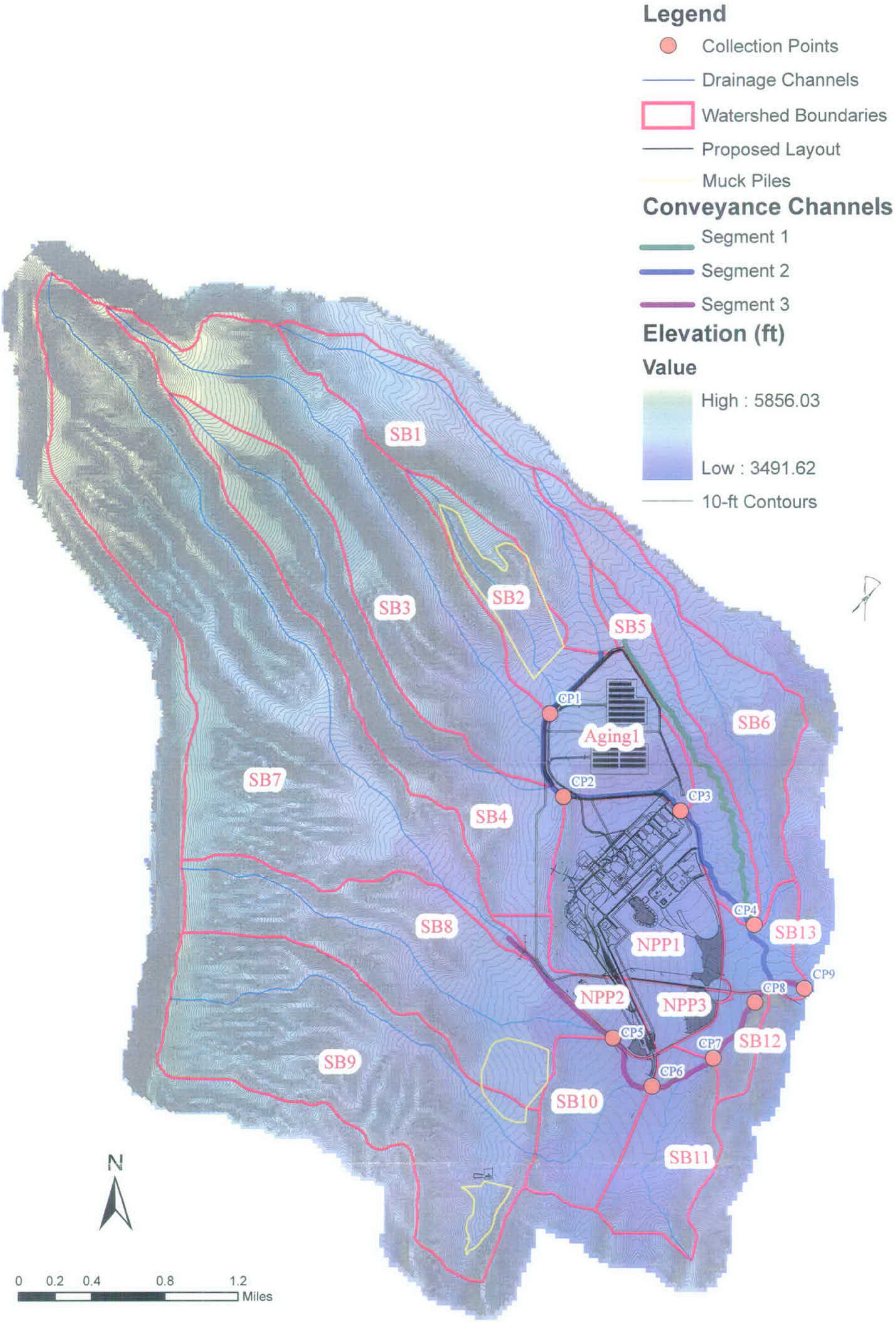
Channel bed, PMF water surface, and minimum top-of-bank profiles along channel Segment 3 are presented in Attachment D.

The PMF peak flow at each cross-section was determined with a similar approach as discussed in 7.2.1. Ineffective flow areas were defined between cross-sections 10716 and 11551.

Table 7-4. Flood Inundation Results for Segment 3

Stream Cross-Section	Peak PMF Flow (cfs)	Channel Invert Elevation (ft)	Water Surface Elevation (ft)	Channel Velocity (ft/s)	Channel Top width (ft)	Levee Elevation (ft)	Levee Free Board (ft)
11551	15660	3795.8	3801.8	6.9	767.6	3807.8	6
11423	15660	3790.2	3796.9	7.8	549.6	3802.2	5.3
11278	15660	3784.4	3791.2	7.8	558.2	3796.1	4.8
11135	15660	3777.4	3785.5	7.6	598	3790.1	4.6
11003	15660	3772.7	3779.4	8.4	522.8	3784.7	5.3
10837	15660	3766	3772.3	8	567.2	3777.8	5.6
10716	15660	3761.5	3767.1	8	639	3772.8	5.7
10536	15660	3754	3758.9	7.4	695	3765.4	6.5
10312	15660	3743.7	3749.6	7	699.2	3756.2	6.6
10074	15660	3734	3739.3	7.4	719.5	3746	6.7
9863	15660	3724.9	3730.2	6.3	916.3	3737.1	6.8
9681	15660	3717.1	3721.1	7.3	892.3	3729.4	8.3
9526	15660	3708.4	3714.2	6.4	819.6	3723.2	9
9328	15660	3700	3706.3	7.3	722.5	3714.7	8.4
9095	15660	3691.8	3697.6	7	657.5	3704.8	7.2
8895	15660	3684	3689.7	8	587.2	3696.6	7

Stream Cross-Section	Peak PMF Flow (cfs)	Channel Invert Elevation (ft)	Water Surface Elevation (ft)	Channel Velocity (ft/s)	Channel Top width (ft)	Levee Elevation (ft)	Levee Free Board (ft)
8736	15660	3678	3684	7.4	520.1	3690.2	6.2
8595	15660	3673.9	3679.4	8	479.6	3684.1	4.7
8468	15660	3668	3677	6.6	526.6	3679.6	2.6
8319	15660	3665.4	3673.2	8.5	1001	3674.4	1.2
8177	15660	3660.9	3667.9	5.3	1337.3	3670.5	2.6
8007	15660	3658.2	3661.8	4.9	1499.5	3667.0	5.2
7811	15660	3650.8	3655.3	4.9	1558.4	3662.8	7.5
7616	15660	3644.9	3650.7	3.9	1561.6	3658.8	8.1
7380	15660	3639.5	3645.8	5.3	921.7	3655.1	9.3
7117	15660	3634	3639.4	5.8	812.6	3652.0	12.6
7014	15660	3631	3636.2	6	993.6	3650.6	14.4
6935	15660	3628.6	3632.5	5.9	1444.1	3648.5	16.0
6735	15660	3618.3	3626.4	5.2	884.3	3646.7	20.3
6374	15660	3608.6	3617	7.3	568.6	3644.2	27.2
6068	15660	3601.6	3611.2	5.2	676.2	3643.3	32.1
5842	25770	3598	3606.9	6.7	818.2	3638.8	31.9
5612	25770	3592	3601.7	6.1	1146.7	3634.5	32.8
5250	25770	3586	3594.6	6.1	828.6	3630.3	35.7
5033	25770	3582	3590.8	6.5	800.9	3624.4	33.6
4778	25770	3576	3586.5	6.3	776.3	3621.7	35.2
4479	25770	3570.6	3583	5.7	670.2	3615.0	32.0
4191	25770	3566	3580.6	5.1	762.4	3606.8	26.2
3806	27210	3560	3574.4	9.2	489.2	3603.0	28.6
3472	27210	3554	3567.4	7.4	600	3600.7	33.3
3272	27210	3551.8	3564.7	6.1	704.9	3587.9	23.2
2855	27210	3543	3557.8	8.4	468.4	3584.5	26.7
2552	27210	3538	3552.3	8	479	3581.6	29.3
2270	27210	3532	3546.9	8.5	459.2	3578.3	31.4
2191	27210	3532	3545.5	8.1	497.9	3574.3	28.8
2044	27210	3530	3543.7	6.6	557	3572	28.3
1860	27430	3527.6	3541.2	7.4	487.1	3570	28.8
1599	27430	3522	3532.2	13.8	342.7	3567	34.8
1406	Culvert						
1184	27430	3513.1	3528.9	3.9	768	3533.7	4.7
1160	27430	3512	3528.9	3.8	827.2	3532.7	3.9
1139	27430	3512	3528.8	3.8	889.5	3532	3.2
1108	27430	3512	3528.7	3.8	819.9	3531.4	2.7
1060	27430	3512	3528.6	4.1	751.2	3530.8	2.2
1019	27430	3512	3528.5	4	823.9	3530.4	1.9
966	55240	3512	3527.1	9.1	712.4	3529.9	2.8
890	55240	3511.2	3525.7	10	655.9	3528.4	2.7
813	55240	3510	3524.3	10.2	729.8	3525.3	1.1
647	55240	3506	3519.3	12.5	580.9	3519.5	0.2



Source for preliminary layout of facilities:	Electronic version of layout shown in Attachment A.
Source for topographic data:	Generated from two datasets. MO9906COV98462.000, containing 2-foot contour data encompassing the North Portal Pad and vicinity and MO0002SPATOP00.001, consisting of an output gridded (100-foot spacing) surface that covers the entire watershed.

Title: Yucca Mountain Project Drainage Report and Analysis
Document ID: 000-CDC-MGR0-00100-000 -00A
gPD

URS

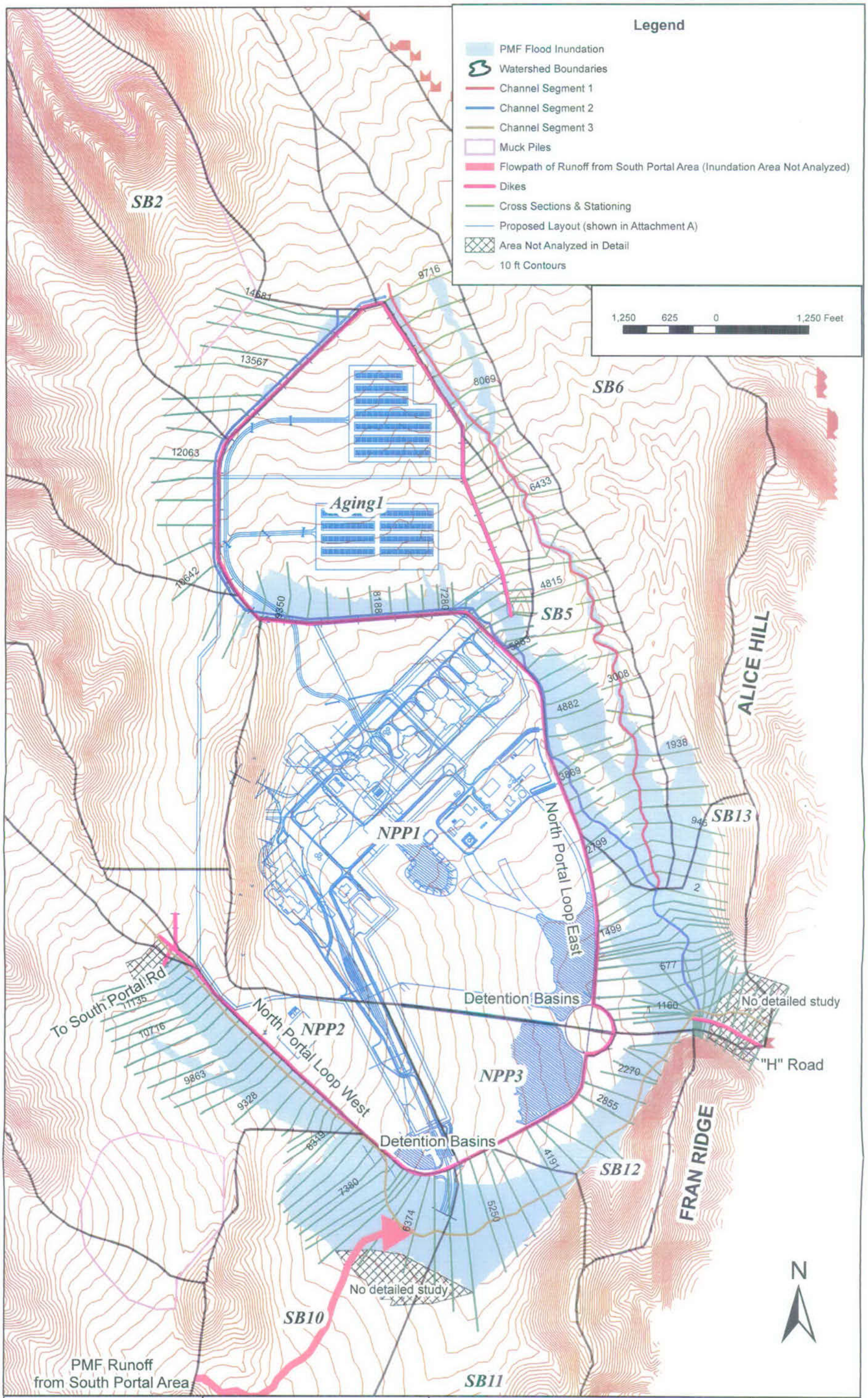
Yucca Mountain

26815949

Sub-Areas Used in the HEC-1 Calculation of the PMF

FIGURE 6-1

URS Corporation, Oakland, CA, 7/23/07 \\S021emc2\yucca_pmf_study\GIS_Project_Files\MXD\Current Working Documents\Sub-basins Used in the HEC-1 Calculation of the PMF down 072307.mxd



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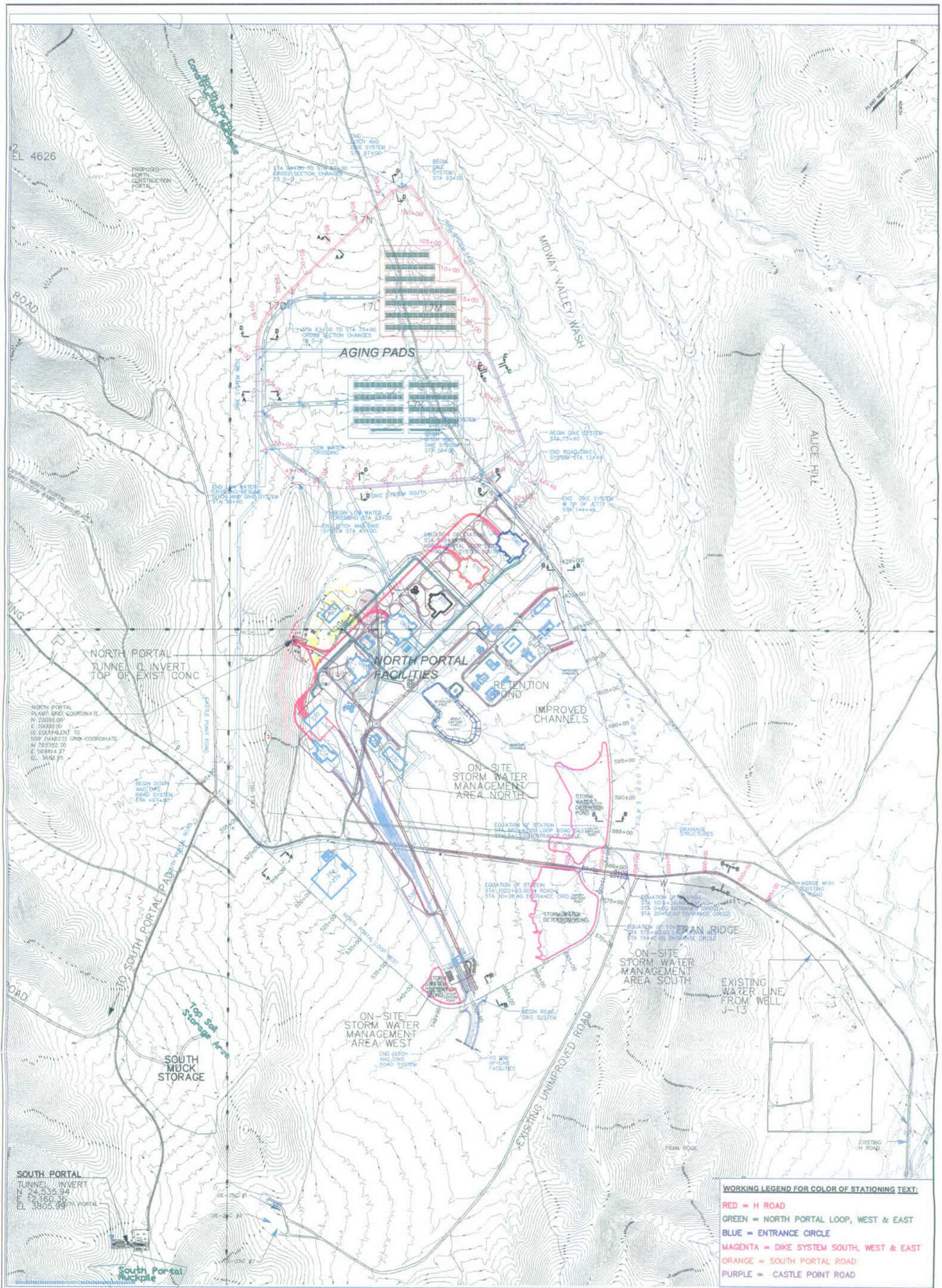
Yucca Mountain

26815949

Probable Maximum Flood Inundation

FIGURE 7-1



URS	Project No.26815949 Yucca Mountain Project Drainage Report and Analysis	Attachment A Preliminary Layout, Plans and Profiles of Facilities at and Near North Portal Pad 000-CDC-MGR0-00100-000-00A 1 of 13	

Aug 14, 2007 – 12:16pm
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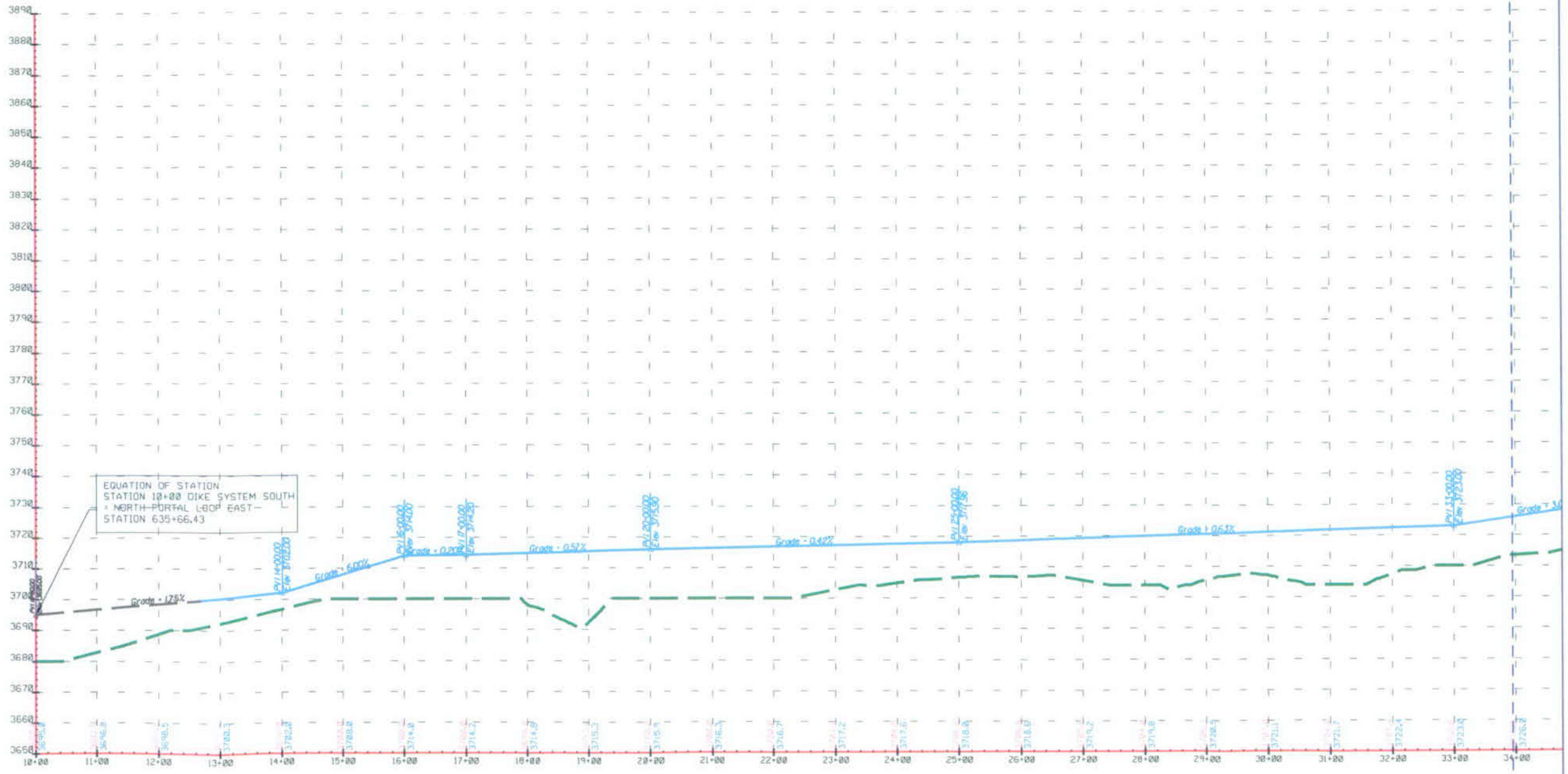

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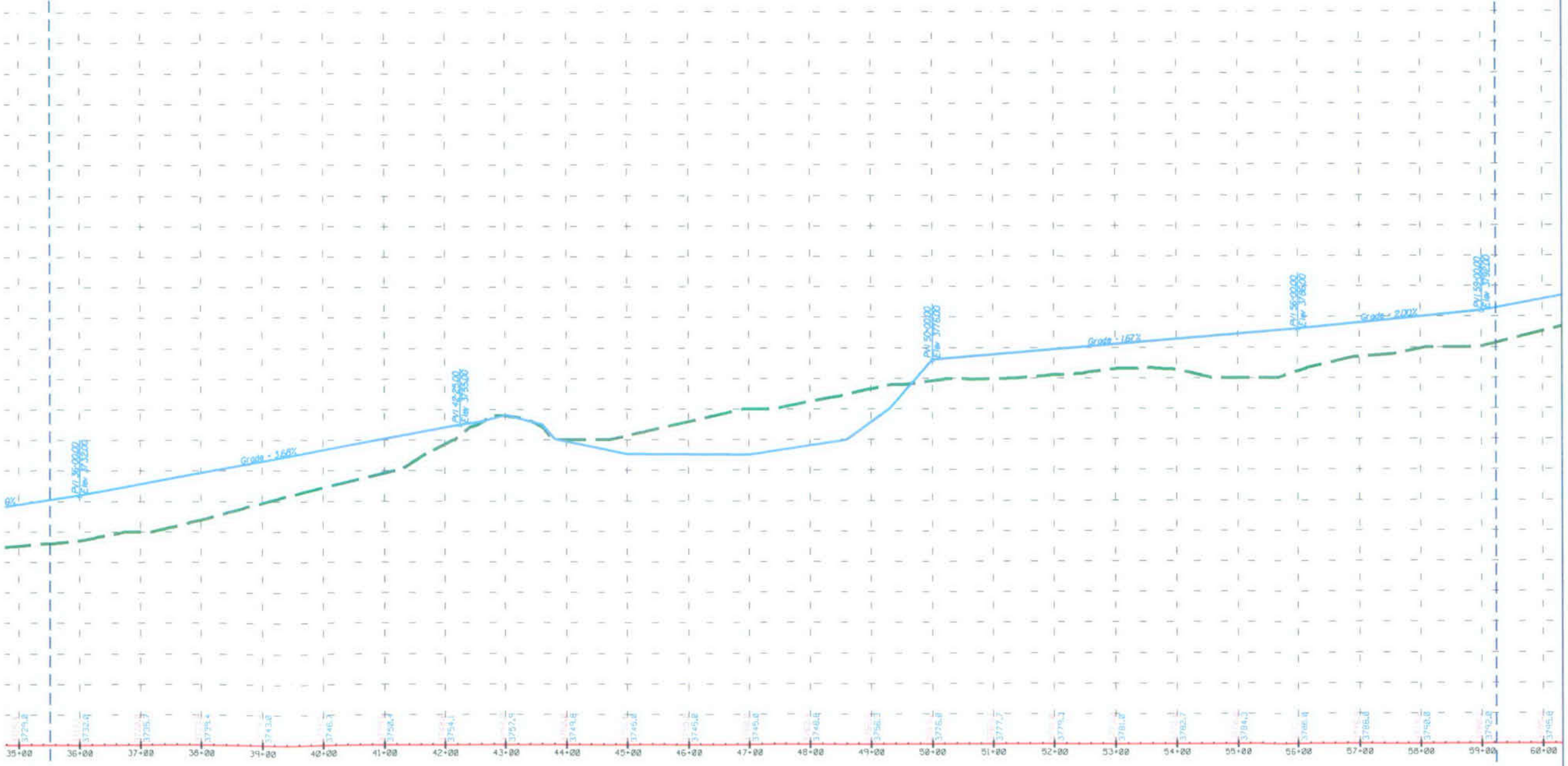

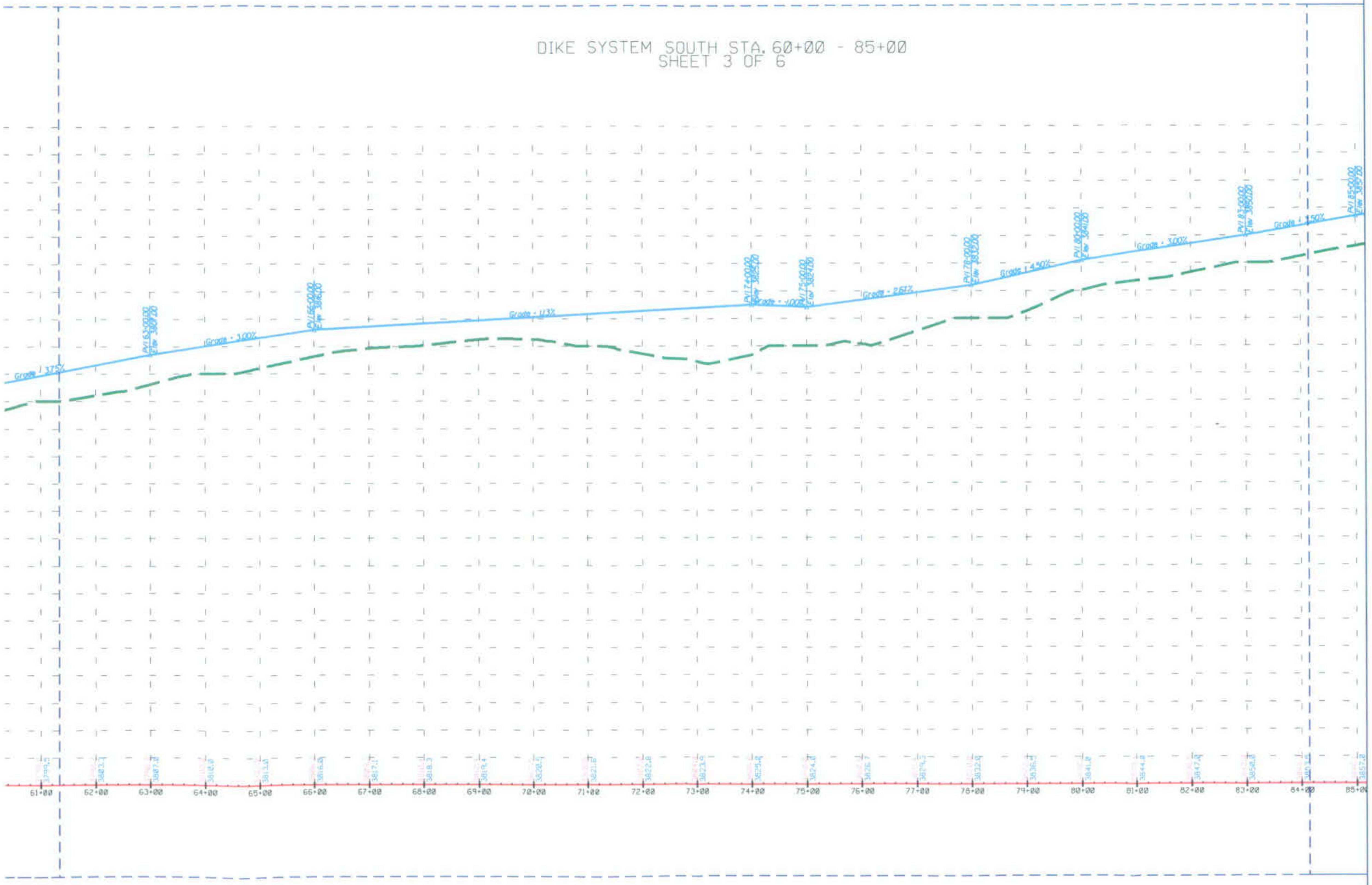
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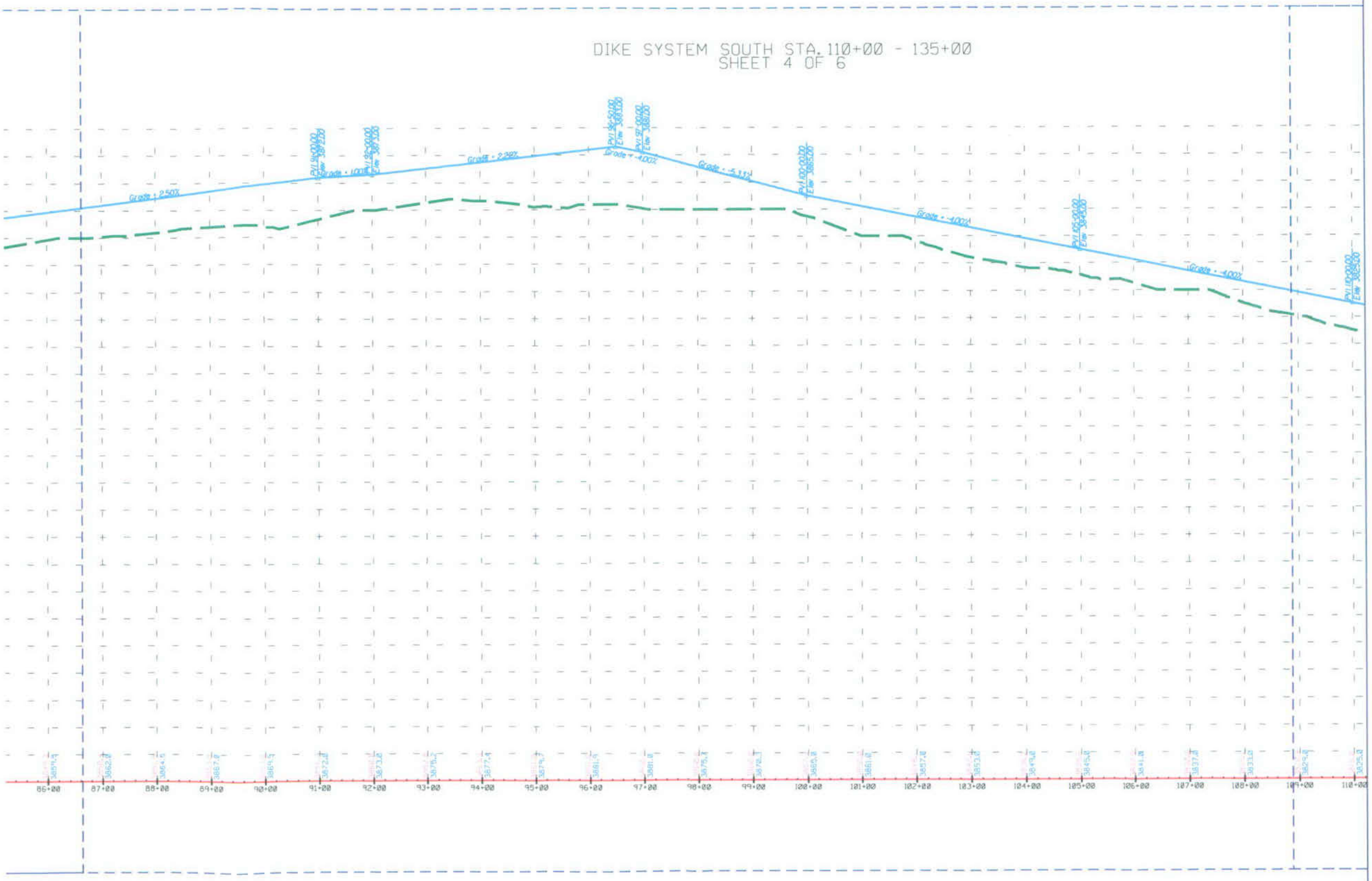
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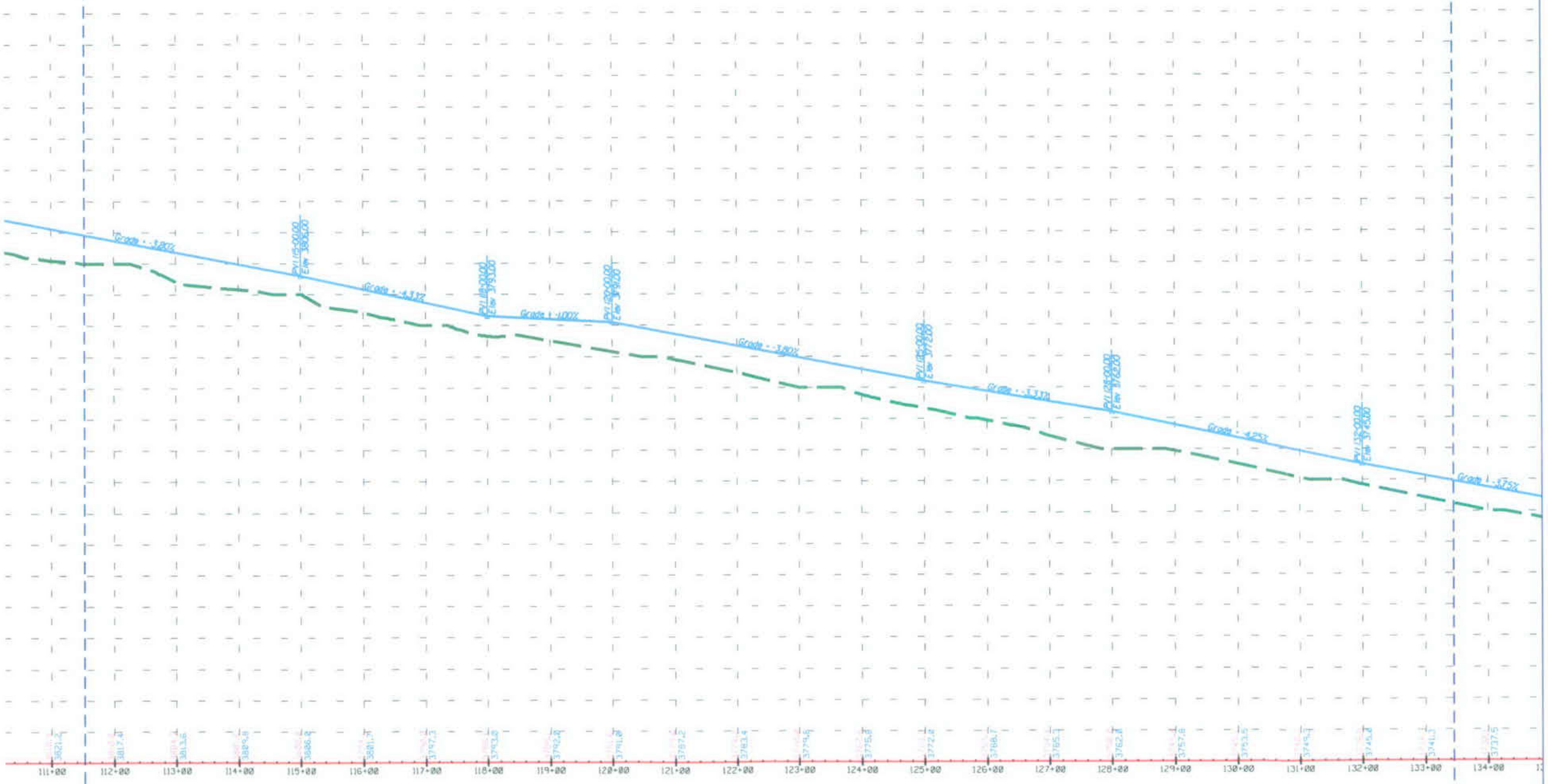

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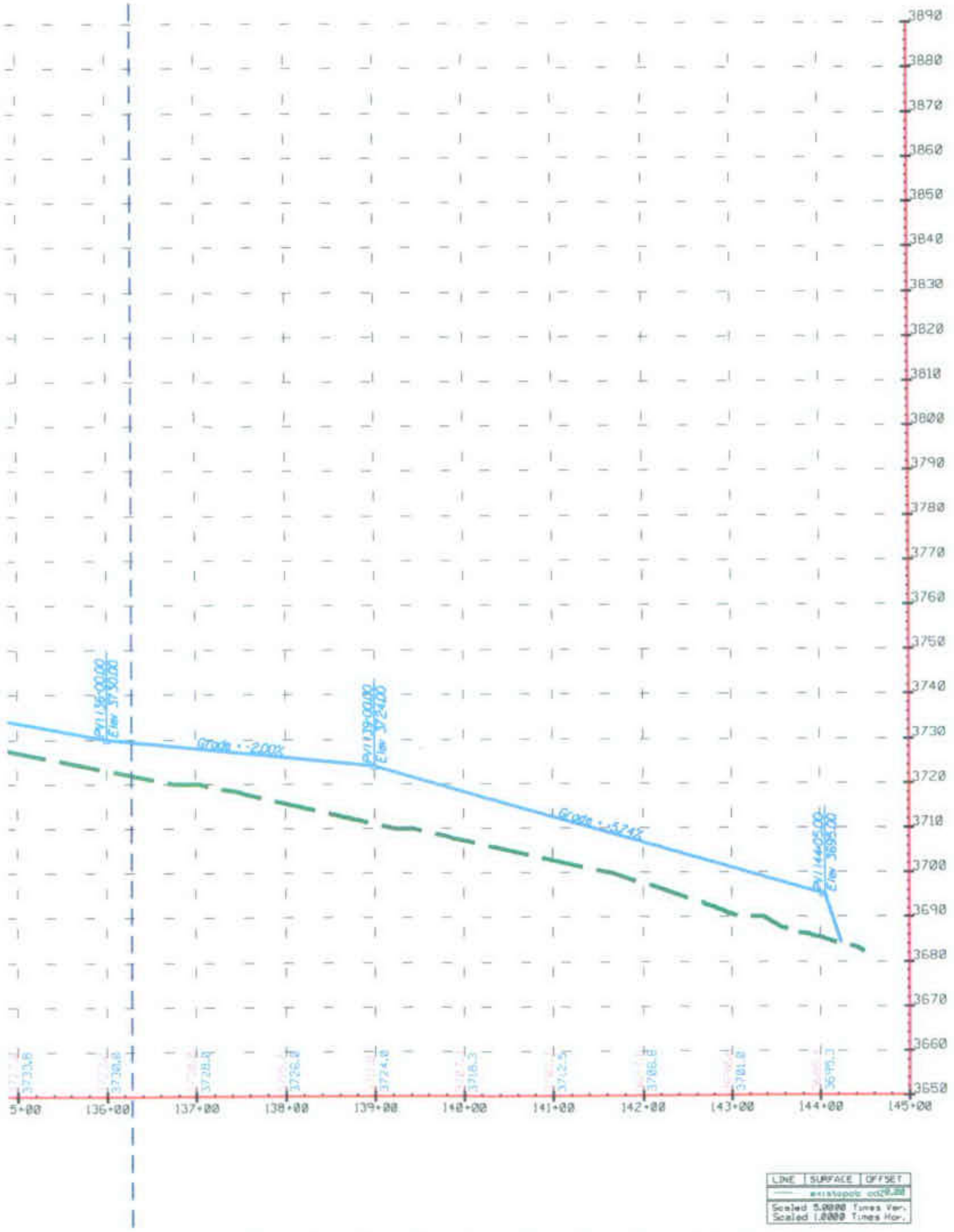

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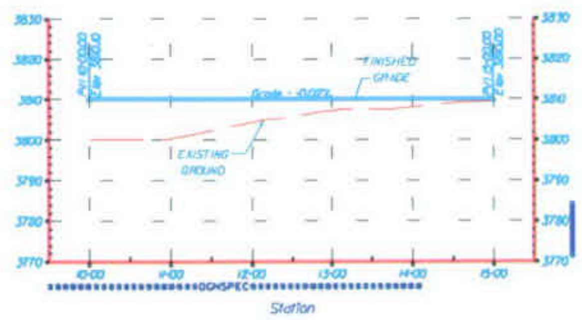

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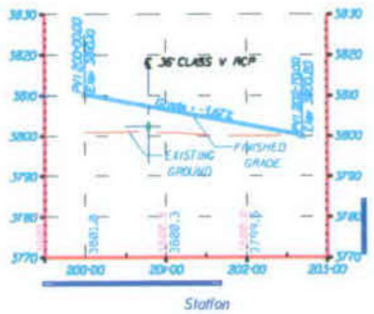

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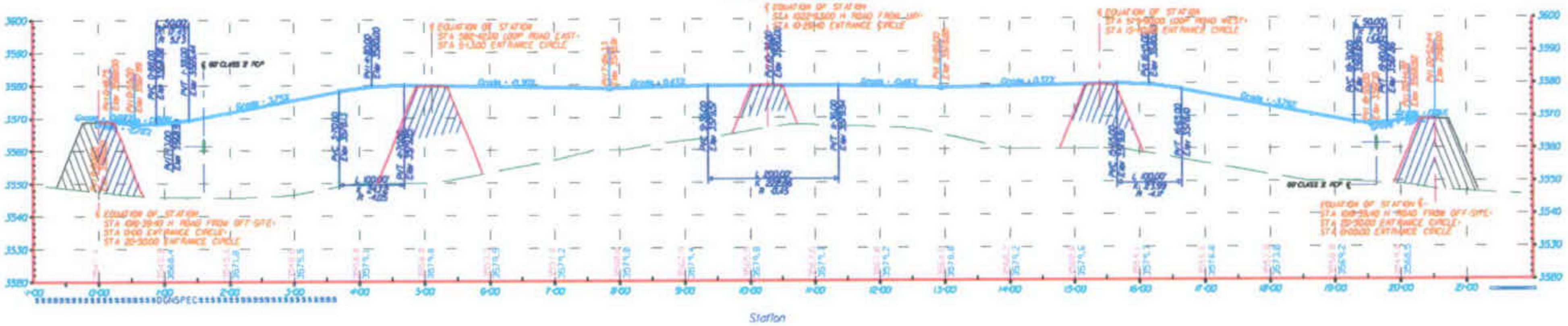

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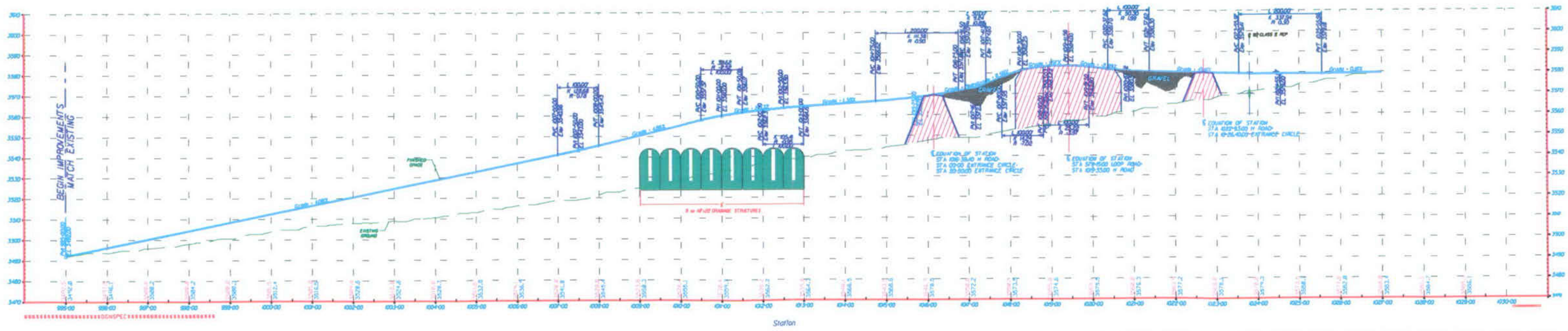

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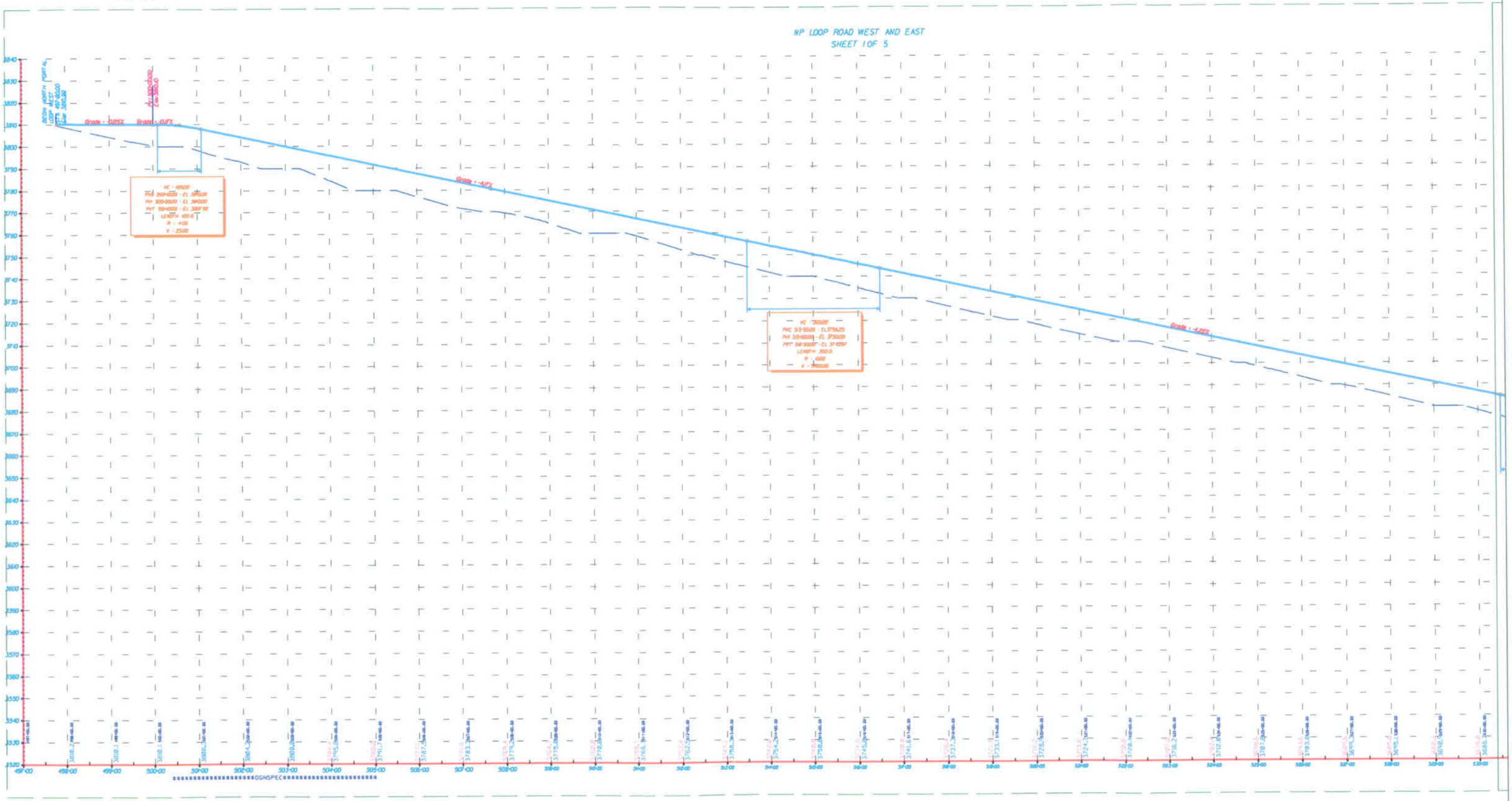

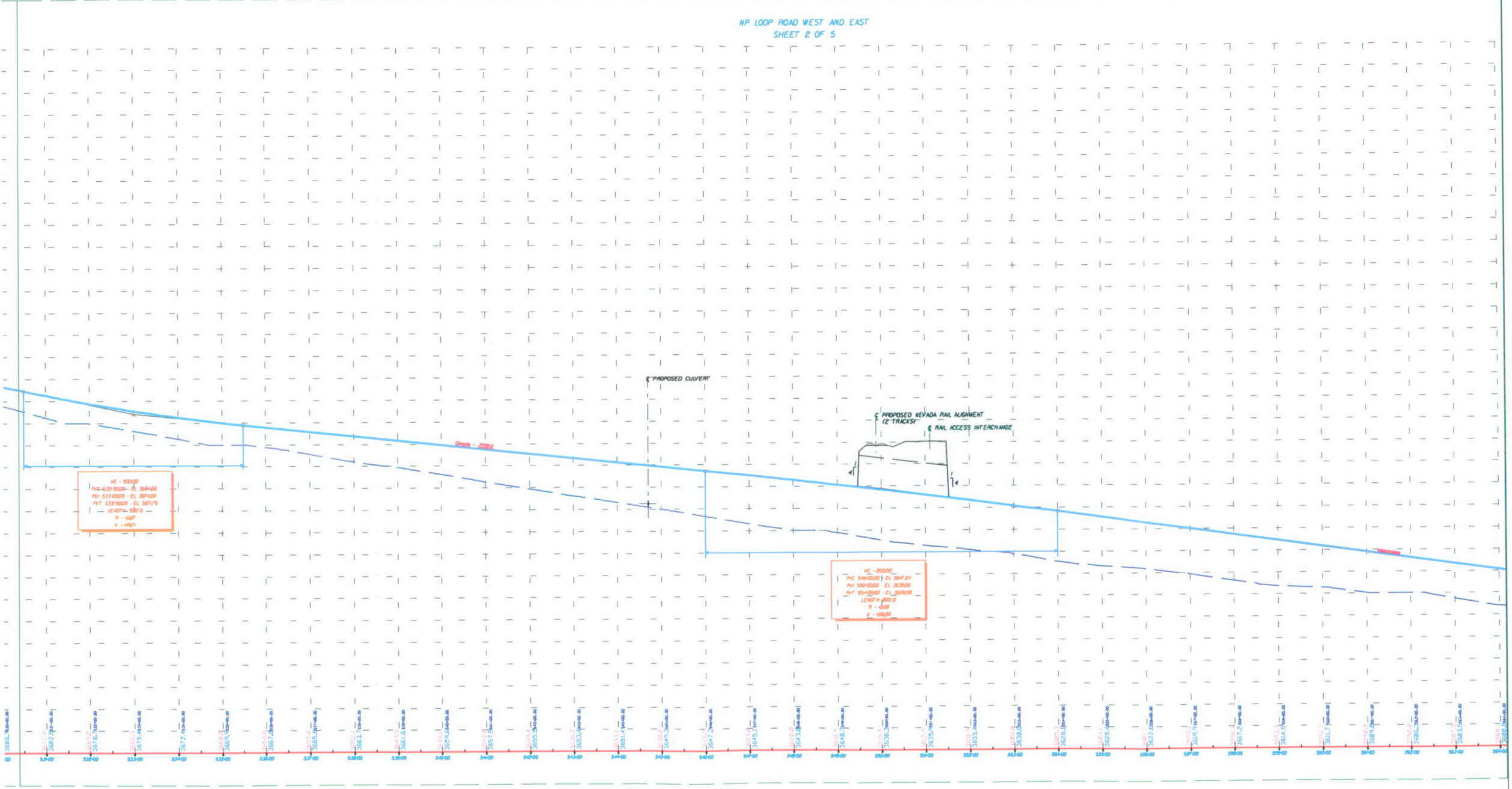
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Yacca Mountain Project Drainage Report and Analysis
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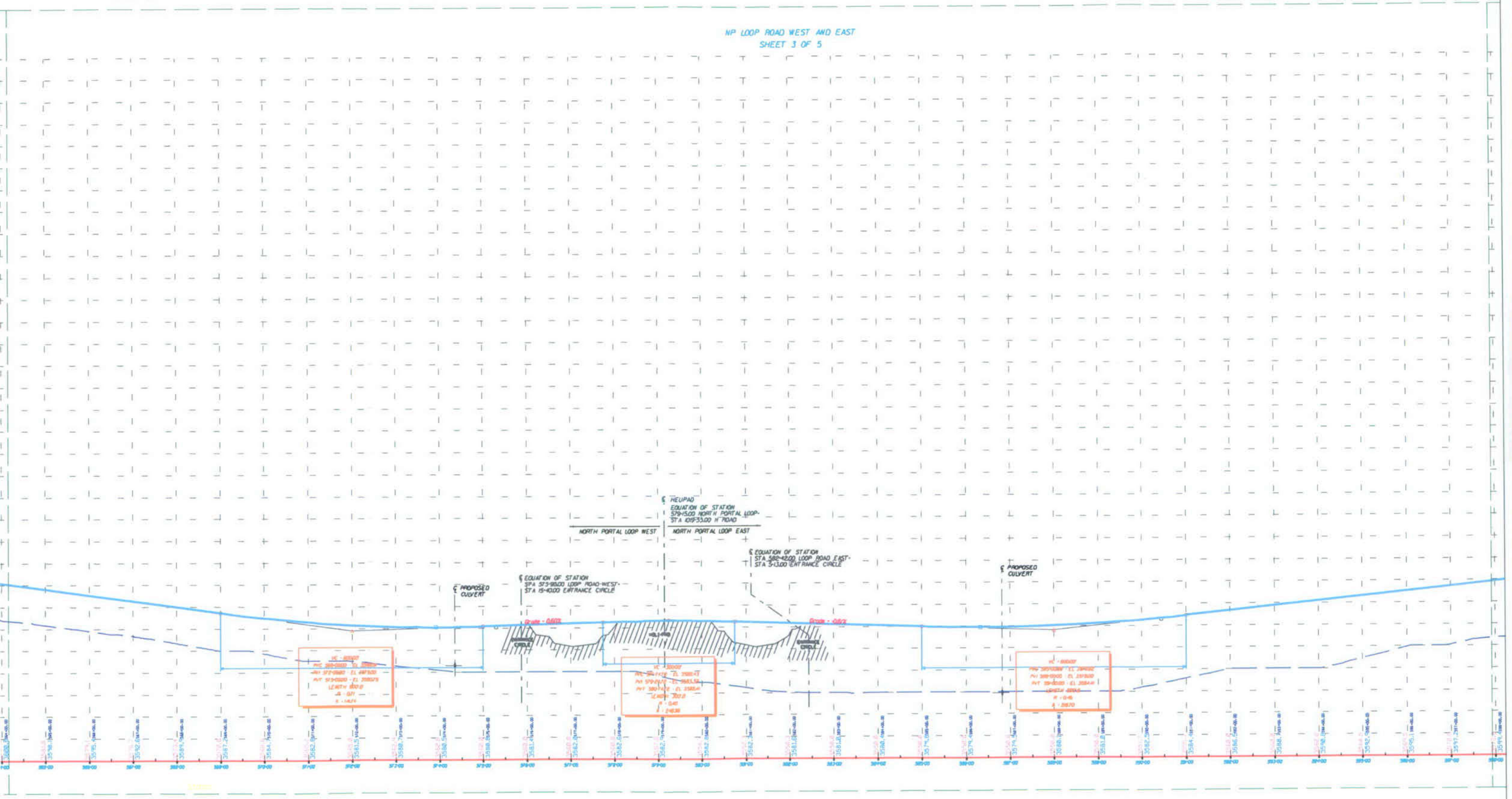

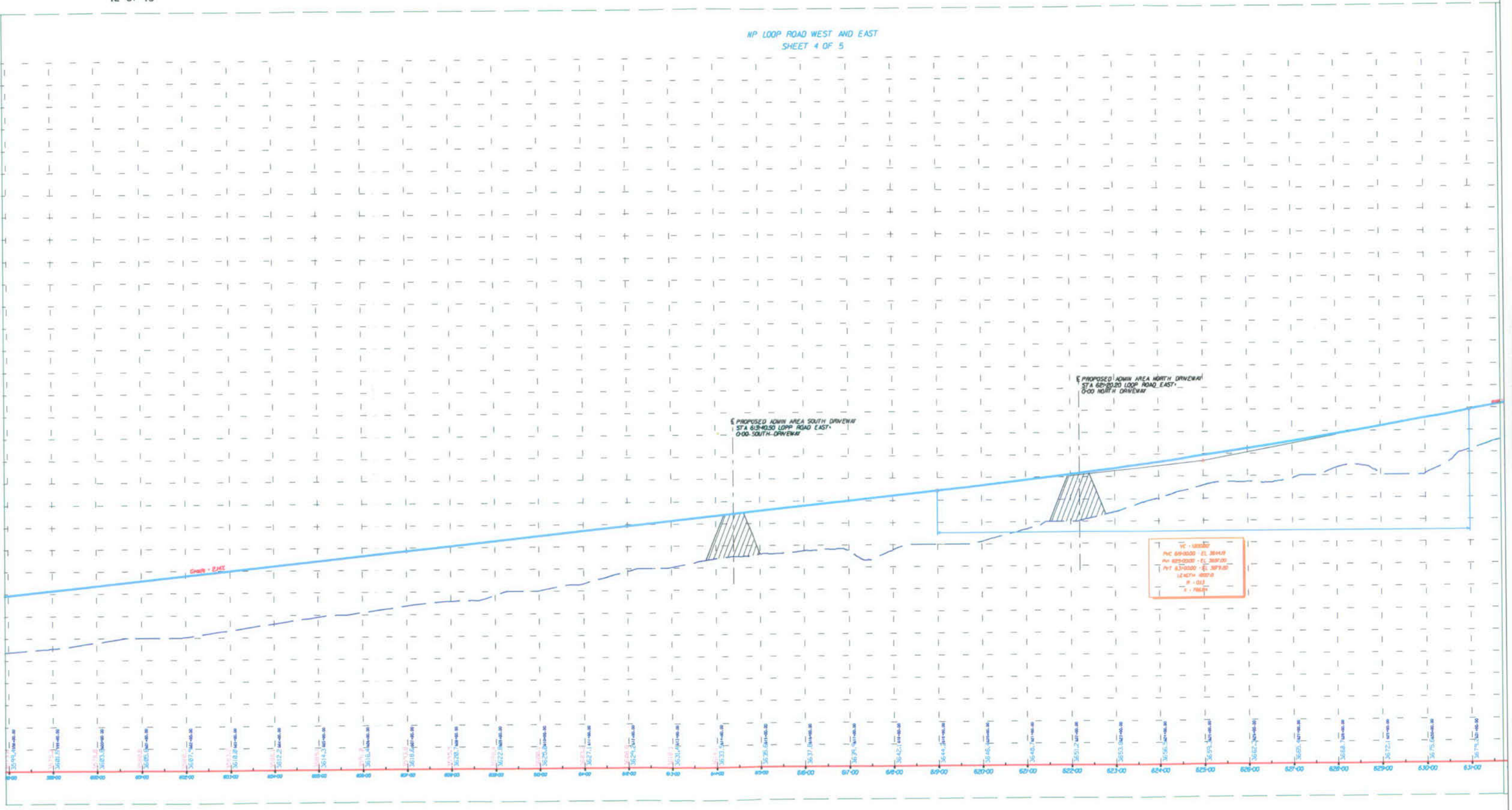
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0+00 NORTH DRIVEWAY
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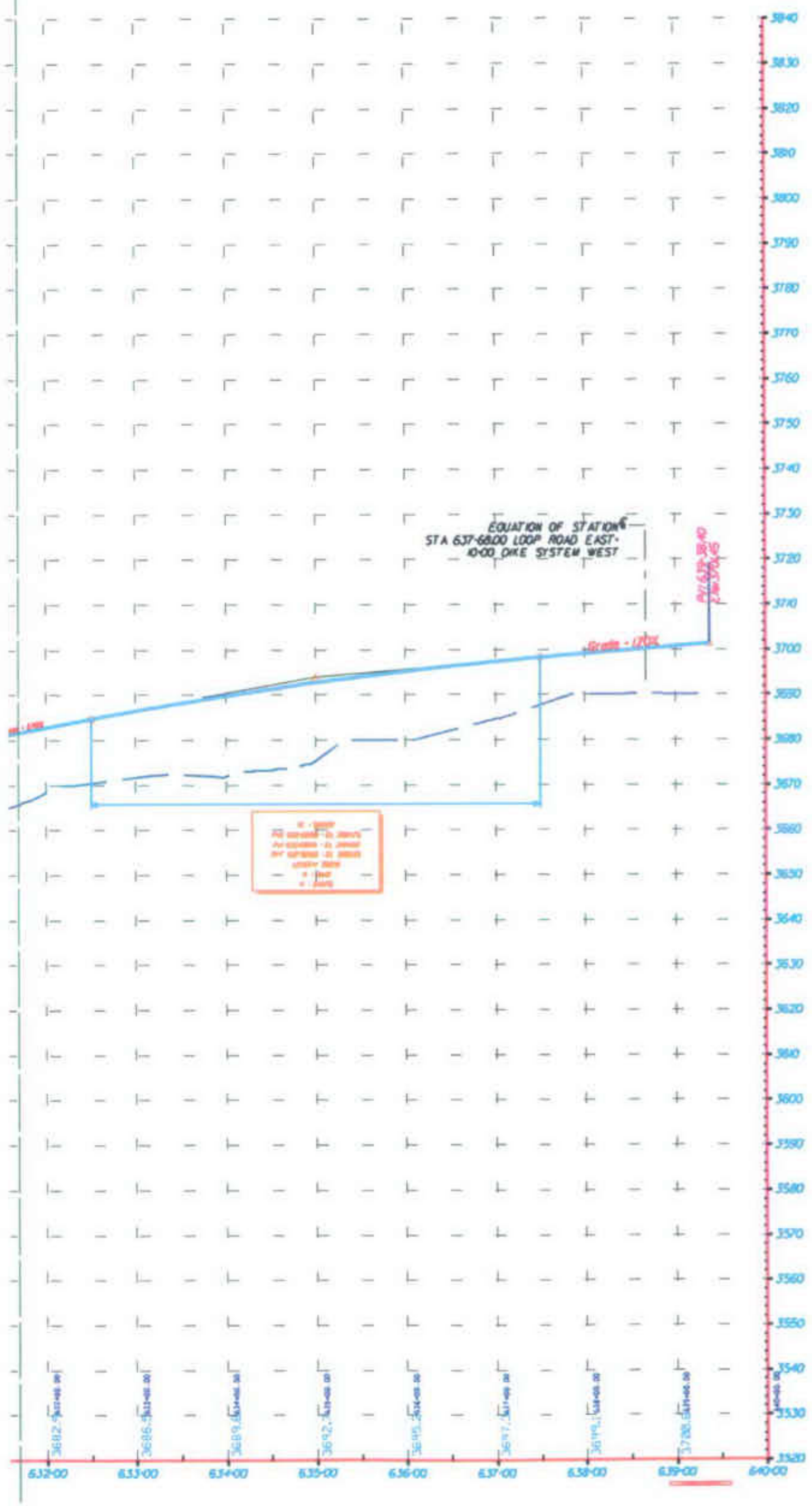

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RD   3500   .02      .09             TRAP      88      3                      RD            087
*
KK AGING                                                                      KK            045
KM  COMPUTE RUNOFF FROM Aging pad area USING OVERLAND FLOW ELEMENT                   KM            046
BA 0.460                                                                      BA            008
LU     1      1.5     25.5      1      1.5     100                            LU            057
UK  4000    .03        .1      83       50                                    UK            114
UK   900    .02        .1      17       50                                    UK            114
RK  3500    .02       .09              TRAP      88      3     NO      50
*
*                                                                             *            001
KK   CP3                                                                      KK            045
KM COMBINE FLOWS FROM CP2 and Aging1                                          KM            046
HC     2                                                                      HC            030
*
KKCP3CP4                                                                      KK            045
KM   ROUTE HYDROGRAPH FROM CP3 TO CP4                                         KM            046
RD   4100    .03       .09             TRAP      30      4                    RD            087
*
KK   SB5                                                                      KK            045
KM   SCS RUNOFF COMPUTATION FOR SB5                                           KM            046
BA 0.39                                                                       BA            008
LU     1      1.5     0                                                       LU            057
UD  .64
*
KK   SB6                                                                      KK            045
KM   SCS RUNOFF COMPUTATION FOR SB6                                           KM            046
BA 0.76                                                                       BA            008
UD  .76
*
KK   CP4                                                                      KK            045
KM COMBINE FLOWS FROM SB5,SB6 and CP3                                         KM            046
HC     3                                                                      HC            030
*
KKCP4CP9                                                                      KK            045
KM  ROUTE HYDROGRAPH FROM CP4 TO CP9                                          KM            046
RD   3000   .02      .09             TRAP      30      20                     RD            087
*
KK  SB13                                                                      KK            045
KM   SCS RUNOFF COMPUTATION FOR SB13                                          KM            046
BA 0.19                                                                       BA            008
UD  .30
*
* Bottom of Northern watershed
*
*
*
*
*       south Portal Area
KK   SB7                                                                      KK            045
KM SCS RUNOFF COMPUTATION FOR SB7                                              KM            046
BA 2.9                                                                         BA            008
PB                                                                             PB            069
PI  .020   0.020   .020   .020   .020   .020   .020   .020   .020   .020PI                 073
PI  .020   0.020   .020   .020   .020   .020   .020   .020   .020   .020PI                 073
PI  .030    .030   .030   .030   .030   .030   .030   .030   .030   .030PI                 073
PI  .030    .030   .030   .030   .030   .030   .030   .030   .030   .030PI                 073
PI  .080    .080   .080   .080   .080   .080   .080   .080   .080   .080PI                 073
PI  .080    .080   .080   .080   .080   .080   .080   .080   .080   .080PI                 073
PI  1.10    1.10   1.10   1.10   1.10    .36    .36    .36    .36    .36PI                 073
PI   .18     .18    .18    .18    .18    .16    .16    .16    .16    .16PI                 073
PI   .04     .04    .04    .04    .04    .04    .04    .04    .04    .04PI                 073
PI   .04     .04    .04    .04    .04    .04    .04    .04    .04    .04PI                 073
PI  .025    .025   .025   .025   .025   .025   .025   .025   .025   .025PI                 073
PI  .025    .025   .025   .025   .025   .025   .025   .025   .025   .025PI                 073
UD  .92                                                                       UD            112
*                                                                             *             001
KKSB7CP5                                                                      KK            045
KM   ROUTE HYDROGRAPH FROM SB7 TO CP5                                         KM            046
RD   3200    .04      .09             TRAP      30      20                    RD            087
*                                                                             *             001
KK  SB8                                                                       KK            045
KM SCS RUNOFF COMPUTATION FOR SB8                                             KM            046
BA 1.2                                                                        BA            008
UD  .60                                                                       UD            112
*
KK   CP5                                                                      KK            045
```

```
KM  COMBINE HYDROGRAPHS FROM SB7, SB8                                      KM          046
HC     2                                                                   HC          030
*
KKCP5CP6                                                                   KK          045
KM  ROUTE HYDROGRAPH FROM CP5 TO CP6                                       KM          046
RD  2000   .03      .09             TRAP      30      20                   RD          087
*
KK  SB9                                                                    KK          045
KM SCS RUNOFF COMPUTATION FOR SB9                                          KM          046
BA 1.7                                                                     BA          008
UD  .55                                                                    UD          112
*                                                                          *           001
KKSB9CP6                                                                   KK          045
KM  ROUTE HYDROGRAPH FROM SB9 TO CP6                                       KM          046
RD  4700   .03      .09             TRAP      30      20                   RD          087
*
KK  SB10                                                                   KK          045
KM SCS RUNOFF COMPUTATION FOR SB10                                         KM          046
BA 0.44                                                                    BA          008
UD  .35                                                                    UD          112
*
KK   CP6                                                                   KK          045
KM  COMBINE HYDROGRAPHS FROM CP5, SB10, SB9                                KM          046
HC     3                                                                   HC          030
*
KKCP6CP7                                                                   KK          045
KM  ROUTE HYDROGRAPH FROM CP6 TO CP7                                       KM          046
RD  2100   .02      .09            TRAP       30      10                   RD          087
*
KK  SB11                                                                   KK          045
KM SCS RUNOFF COMPUTATION FOR SB11                                         KM          046
BA 0.46                                                                    BA          008
UD  .40                                                                    UD          112
*
KK   CP7                                                                   KK          045
KM  COMBINE HYDROGRAPHS FROM CP6, SB11                                     KM          046
HC     2                                                                   HC          030
*
KKCP7CP8                                                                   KK          045
KM  ROUTE HYDROGRAPH FROM CP7 TO CP8                                       KM          046
RD  2000   .02      .09             TRAP      30      4                    RD          087
*
KK  SB12                                                                   KK          045
KM SCS RUNOFF COMPUTATION FOR SB12                                         KM          046
BA 0.15                                                                    BA          008
UD  .24                                                                    UD          112
*
KK   CP8                                                                   KK          045
KM  COMBINE HYDROGRAPHS FROM CP7, SB12                                     KM          046
HC     2                                                                   HC          030
*
KKCP8CP9                                                                   KK          045
KM  ROUTE HYDROGRAPH FROM CP8 TO CP9                                       KM          046
RD  1700   .02      .09             TRAP      30      3                    RD          087
*
*   combine south and north portal areas
*
KK CP9                                                                     KK          045
KM  COMBINE HYDROGRAPHS FROM CP4, SB13, CP8                                KM          046
HC     3                                                                   HC          030
*
*
ZZ
```

```
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   10AUG07  TIME  10:41:35   *                              *          (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

                   1            ID            HEC-1 FLOOD HYDROGRAPH SIMULATION
                   2            ID            YUCCA MOUNTAIN FLOOD STUDY PROJECT
                   3            ID            ANALYSIS BY URS CORPORATION
                   4            ID  FILE IDENTIFICATION INFORMATION
                   5            ID  FILENAME--\\S021emc2\yucca_pmf_study\HEC1\HEC-1\FINAL4.HC1
                                *           this run is based on response to comments
                                *           FIND Q AT CRITICAL LOCATIONS AFTER CONSTRUCTION OF FACILITIES
                                *           NUMBER OF BASINS DEFINED USING THE 2007 DRAWINGS SHOWN IN
                                *           ATTACHMENT A.
                                *
                                *
                                *           SET BASE OF WATERSHED AT THE GAP AT ALICE HILL
                   6            ID            USE PMP CALCULATED FOR STORM AT PORTAL & FACILITY
                   7            ID            PMP obtained from previous PMF study - ANL-EBS-MD-000060 Rev 00D
                   8            ID            PMP - 10/1/98  (COE ENGINEERING MANUAL TIME SEQUENCE)
                                *
                                *
                   9            ID
                                *DIAGRAM
                  10            IT       3 01OCT98    0000      200
```

```
   11          IO      3       0
               *
               *       watersheds are input in order from NE to SW as much as possible
               *
               *
               *

   12          KK      SB1 watershed
   13          KM     SCS RUNOFF COMPUTATION FOR SB1
   14          BA     0.83
   15          IN      3 01OCT98    0000
   16          PB
   17          PI     .015   0.015    .015     .015     .015     .015     .015     .015     .015     .015
   18          PI     .015   0.015    .015     .015     .015     .015     .015     .015     .015     .015
   19          PI     .025    .025    .025     .025     .025     .025     .025     .025     .025     .025
   20          PI     .025    .025    .025     .025     .025     .025     .025     .025     .025     .025
   21          PI     .085    .085    .085     .085     .085     .085     .085     .085     .085     .085
   22          PI     .085    .085    .085     .085     .085     .085     .085     .085     .085     .085
   23          PI     1.18    1.18    1.18     1.18     1.18      .38      .38      .38      .38      .38
   24          PI      .18     .18     .18      .18      .18      .14      .14      .14      .14      .14
   25          PI      .04     .04     .04      .04      .04      .04      .04      .04      .04      .04
   26          PI      .04     .04     .04      .04      .04      .04      .04      .04      .04      .04
   27          PI     .025    .025    .025     .025     .025     .025     .025     .025     .025     .025
   28          PI     .025    .025    .025     .025     .025     .025     .025     .025     .025     .025
   29          LU        1     1.5
   30          UD      .64
               *

   31          KK    SB1CP1
   32          KM     ROUTE HYDROGRAPH FROM SB1 TO CP1
   33          RD     2400    .02     .09             TRAP      78       3
               *
1                                       HEC-1 INPUT                                       PAGE  2

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

   34          KK      SB2
   35          KM      SCS RUNOFF COMPUTATION FOR SB2
   36          BA    0.42
   37          UD     .40
               *

   38          KK      CP1
   39          KM    COMBINE FLOWS FROM SB1 AND SB2
   40          HC        2
               *

   41          KK    CP1CP2
   42          KM     ROUTE HYDROGRAPH FROM CP1 TO CP2
   43          RD     2600    .02     .09             TRAP      68       3
               *

   44          KK      SB3
   45          KM      SCS RUNOFF COMPUTATION FOR SB3
   46          BA    1.6
   47          UD     .73
               *
```

```
          48            KK     SB4
          49            KM     SCS RUNOFF COMPUTATION FOR SB4
          50            BA   1.2
          51            UD    .66
                        *

          52            KK     CP2
          53            KM   COMBINE FLOWS FROM SB3, SB4 and CP1
          54            HC       3
                        *

          55            KK  CP2CP3
          56            KM    ROUTE HYDROGRAPH FROM CP2 TO CP3
          57            RD    3500   .02      .09              TRAP      88      3
                        *

          58            KK   AGING
          59            KM    COMPUTE RUNOFF FROM Aging pad area USING OVERLAND FLOW ELEMENT
          60            BA   0.460
          61            LU       1     1.5    25.5       1     1.5     100
          62            UK   .4000   .03        .1      83      50
          63            UK     900   .02        .1      17      50
          64            RK    3500   .02      .09              TRAP      88       3      NO      50
                        *
                        *                                                                        *

          65            KK     CP3
          66            KM   COMBINE FLOWS FROM CP2 and Aging1
          67            HC       2
                        *
 1                                         HEC-1 INPUT                                  PAGE  3

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

          68            KK  CP3CP4
          69            KM    ROUTE HYDROGRAPH FROM CP3 TO CP4
          70            RD    4100   .03      .09              TRAP      30      4
                        *

          71            KK     SB5
          72            KM     SCS RUNOFF COMPUTATION FOR SB5
          73            BA   0.39
          74            LU       1     1.5     0
          75            UD    .64
                        *

          76            KK     SB6
          77            KM     SCS RUNOFF COMPUTATION FOR SB6
          78            BA   0.76
          79            UD    .76
                        *

          80            KK     CP4
          81            KM   COMBINE FLOWS FROM SB5,SB6 and CP3
          82            HC       3
                        *
```

```
  83          KK  CP4CP9
  84          KM    ROUTE HYDROGRAPH FROM CP4 TO CP9
  85          RD    3000   .02      .09             TRAP      30      20
              *

  86          KK    SB13
  87          KM     SCS RUNOFF COMPUTATION FOR SB13
  88          BA   0.19
  89          UD    .30
              *
              * Bottom of Northern watershed
              *
              *
              *
              *
              *        south Portal Area

  90          KK     SB7
  91          KM   SCS RUNOFF COMPUTATION FOR SB7
  92          BA   2.9
  93          PB
  94          PI    .020  0.020   .020    .020    .020    .020    .020    .020    .020    .020
  95          PI    .020  0.020   .020    .020    .020    .020    .020    .020    .020    .020
  96          PI    .030   .030   .030    .030    .030    .030    .030    .030    .030    .030
  97          PI    .030   .030   .030    .030    .030    .030    .030    .030    .030    .030
  98          PI    .080   .080   .080    .080    .080    .080    .080    .080    .080    .080
  99          PI    .080   .080   .080    .080    .080    .080    .080    .080    .080    .080
 100          PI    1.10   1.10   1.10    1.10    1.10     .36     .36     .36     .36     .36
 101          PI     .18    .18    .18     .18     .18     .16     .16     .16     .16     .16
 102          PI     .04    .04    .04     .04     .04     .04     .04     .04     .04     .04
 103          PI     .04    .04    .04     .04     .04     .04     .04     .04     .04     .04
1                                     HEC-1 INPUT                                                 PAGE  4

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

 104          PI    .025   .025   .025    .025    .025    .025    .025    .025    .025    .025
 105          PI    .025   .025   .025    .025    .025    .025    .025    .025    .025    .025
 106          UD    .92
              *

 107          KK  SB7CP5
 108          KM    ROUTE HYDROGRAPH FROM SB7 TO CP5
 109          RD    3200   .04      .09             TRAP      30      20
              *

 110          KK    SB8
 111          KM   SCS RUNOFF COMPUTATION FOR SB8
 112          BA   1.2
 113          UD    .60
              *

 114          KK     CP5
 115          KM    COMBINE HYDROGRAPHS FROM SB7, SB8
 116          HC       2
              *

 117          KK  CP5CP6
```

```
  118          KM    ROUTE HYDROGRAPH FROM CP5 TO CP6
  119          RD    2000   .03      .09              TRAP      30      20
               *

  120          KK     SB9
  121          KM   SCS RUNOFF COMPUTATION FOR SB9
  122          BA   1.7
  123          UD    .55
               *

  124          KK  SB9CP6
  125          KM    ROUTE HYDROGRAPH FROM SB9 TO CP6
  126          RD    4700   .03      .09              TRAP      30      20
               *

  127          KK    SB10
  128          KM   SCS RUNOFF COMPUTATION FOR SB10
  129          BA   0.44
  130          UD    .35
               *

  131          KK     CP6
  132          KM    COMBINE HYDROGRAPHS FROM CP5, SB10, SB9
  133          HC       3
               *

  134          KK  CP6CP7
  135          KM    ROUTE HYDROGRAPH FROM CP6 TO CP7
  136          RD    2100   .02      .09            TRAP      30      10
               *
1                                    HEC-1 INPUT                                          PAGE  5

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


  137          KK    SB11
  138          KM   SCS RUNOFF COMPUTATION FOR SB11
  139          BA   0.46
  140          UD    .40
               *

  141          KK     CP7
  142          KM    COMBINE HYDROGRAPHS FROM CP6, SB11
  143          HC       2
               *

  144          KK  CP7CP8
  145          KM    ROUTE HYDROGRAPH FROM CP7 TO CP8
  146          RD    2000   .02      .09              TRAP      30       4
               *

  147          KK    SB12
  148          KM   SCS RUNOFF COMPUTATION FOR SB12
  149          BA   0.15
  150          UD    .24
               *

  151          KK     CP8
```

```
            152           KM    COMBINE HYDROGRAPHS FROM CP7, SB12
            153           HC       2
                          *

            154           KK  CP8CP9
            155           KM    ROUTE HYDROGRAPH FROM CP8 TO CP9
            156           RD    1700   .02      .09             TRAP      30      3
                          *
                          *   combine south and north portal areas
                          *

            157           KK   CP9
            158           KM    COMBINE HYDROGRAPHS FROM CP4, SB13, CP8
            159           HC       3
                          *
                          *
            160           ZZ
1
                 SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

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

    12         SB1
                 V
                 V
    31      SB1CP1
                 .
                 .
    34           .         SB2
                 .           .
                 .           .
    38         CP1............
                 V
                 V
    41      CP1CP2
                 .
                 .
    44           .         SB3
                 .           .
                 .           .
    48           .           .         SB4
                 .           .           .
                 .           .           .
    52         CP2........................
                 V
                 V
    55      CP2CP3
                 .
                 .
    58           .       AGING
                 .           .
                 .           .
    65         CP3............
                 V
                 V
    68      CP3CP4
```

```
              .
              .
 71           .         SB5
              .           .
              .           .
 76           .           .         SB6
              .           .           .
              .           .           .
 80        CP4........................
              V
              V
 83      CP4CP9
              .
              .
 86           .        SB13
              .           .
              .           .
 90           .           .         SB7
              .           .           V
              .           .           V
107           .           .      SB7CP5
              .           .           .
              .           .           .
110           .           .           .         SB8
              .           .           .           .
              .           .           .           .
114           .           .         CP5............
              .           .           V
              .           .           V
117           .           .      CP5CP6
              .           .           .
              .           .           .
120           .           .           .         SB9
              .           .           .           V
              .           .           .           V
124           .           .           .      SB9CP6
              .           .           .           .
              .           .           .           .
127           .           .           .           .        SB10
              .           .           .           .           .
              .           .           .           .           .
131           .           .         CP6........................
              .           .           V
              .           .           V
134           .           .      CP6CP7
              .           .           .
              .           .           .
137           .           .           .        SB11
              .           .           .           .
              .           .           .           .
141           .           .         CP7............
              .           .           V
              .           .           V
144           .           .      CP7CP8
              .           .           .
              .           .           .
147           .           .           .        SB12
              .           .           .           .
```

```
                 .           .           .           .
   151           .           .         CP8............
                 .           .           V
                 .           .           V
   154           .           .      CP8CP9
                 .           .           .
                 .           .           .
   157       CP9 ........................

 (***) 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   10AUG07  TIME  10:41:35   *                                                    *            (916) 756-1104            *
 *                                       *                                                    *                                      *
 *****************************************                                                    ****************************************



                                     HEC-1 FLOOD HYDROGRAPH SIMULATION
                                     YUCCA MOUNTAIN FLOOD STUDY PROJECT
                                     ANALYSIS BY URS CORPORATION
                           FILE IDENTIFICATION INFORMATION
                           FILENAME--\\S021emc2\yucca_pmf_study\HEC1\HEC-1\FINAL4.HC1
                                     USE PMP CALCULATED FOR STORM AT PORTAL & FACILITY
                                     PMP obtained from previous PMF study - ANL-EBS-MD-000060 Rev 00D
                                     PMP - 10/1/98  (COE ENGINEERING MANUAL TIME SEQUENCE)


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

      IT          HYDROGRAPH TIME DATA
                         NMIN           3  MINUTES IN COMPUTATION INTERVAL
                        IDATE      1OCT98  STARTING DATE
                        ITIME        0000  STARTING TIME
                           NQ         200  NUMBER OF HYDROGRAPH ORDINATES
                       NDDATE      1OCT98  ENDING DATE
                       NDTIME        0957  ENDING TIME
                       ICENT           19  CENTURY MARK

                    COMPUTATION INTERVAL      .05 HOURS
                         TOTAL TIME BASE     9.95 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


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


              ***************
              *             *
  12 KK       *     SB1     *    watershed
              *             *
              ***************
                                SCS RUNOFF COMPUTATION FOR SB1

  15 IN              TIME DATA FOR INPUT TIME SERIES
                          JXMIN           3   TIME INTERVAL IN MINUTES
                         JXDATE      1OCT98   STARTING DATE
                         JXTIME           0   STARTING TIME

                   SUBBASIN RUNOFF DATA

  14 BA              SUBBASIN CHARACTERISTICS
                          TAREA         .83   SUBBASIN AREA

                     PRECIPITATION DATA

  16 PB                   STORM       13.20   BASIN TOTAL PRECIPITATION

  17 PI                INCREMENTAL PRECIPITATION PATTERN
                            .01       .01       .01       .02       .01       .02       .02       .02       .01       .02
                            .02       .02       .02       .02       .02       .02       .02       .01       .01       .01
                            .03       .03       .03       .03       .03       .03       .03       .03       .02       .02
                            .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                            .08       .08       .09       .09       .09       .09       .09       .09       .09       .09
                            .09       .09       .09       .09       .08       .09       .09       .09       .09       .09
                           1.18      1.18      1.18      1.18      1.18       .38       .38       .38       .38       .38
                            .18       .18       .18       .18       .18       .14       .14       .14       .14       .14
                            .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                            .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                            .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                            .02       .02       .02       .02       .02       .02       .02       .02       .02       .02

  29 LU              UNIFORM LOSS RATE
                          STRTL        1.00   INITIAL LOSS
                          CNSTL        1.50   UNIFORM LOSS RATE
                         RTIMP          .00   PERCENT IMPERVIOUS AREA

  30 UD              SCS DIMENSIONLESS UNITGRAPH
                           TLAG         .64   LAG

                                                                ***

                                                           UNIT HYDROGRAPH
                                                       66 END-OF-PERIOD ORDINATES
                 14.       39.       74.      115.      169.      236.      313.      399.      472.      529.
                570.      597.      602.      600.      587.      559.      528.      493.      453.      407.
                353.      305.      265.      233.      206.      182.      162.      146.      129.      115.
                101.       88.       79.       70.       62.       55.       48.       43.       38.       33.
```

```
                 29.        26.        23.        21.        18.        16.        14.        12.        11.        10.
                  9.         8.         7.         6.         6.         5.         5.         4.         3.         3.
                  2.         2.         2.         1.         1.         0.

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

                           HYDROGRAPH AT STATION      SB1

     TOTAL RAINFALL =    13.20, TOTAL LOSS =     5.12, TOTAL EXCESS =     8.08

  PEAK FLOW      TIME                            MAXIMUM AVERAGE FLOW
                                     6-HR         24-HR        72-HR       9.95-HR
+   (CFS)        (HR)
                              (CFS)
+    4097.       3.85                 721.          435.         435.          435.
                           (INCHES)  8.076         8.076        8.076         8.076
                            (AC-FT)   358.          358.         358.          358.

                           CUMULATIVE AREA =      .83 SQ MI


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

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               *            *
  31 KK        *    SB1CP1  *
               *            *
               **************
                             ROUTE HYDROGRAPH FROM SB1 TO CP1

                  HYDROGRAPH ROUTING DATA

  33 RD             MUSKINGUM-CUNGE CHANNEL ROUTING
                               L        2400.   CHANNEL LENGTH
                               S        .0200   SLOPE
                               N         .090   CHANNEL ROUGHNESS COEFFICIENT
                              CA          .00   CONTRIBUTING AREA
                           SHAPE         TRAP   CHANNEL SHAPE
                              WD        78.00   BOTTOM WIDTH OR DIAMETER
                               Z         3.00   SIDE SLOPE

                                                                           ***
                                       COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                            COMPUTATION TIME STEP
                    ELEMENT     ALPHA       M        DT          DX         PEAK       TIME TO      VOLUME      MAXIMUM
                                                                                         PEAK                   CELERITY
                                                   (MIN)        (FT)        (CFS)       (MIN)        (IN)        (FPS)

                     MAIN        .17       1.59     3.00       800.00     4093.01      234.00        8.08        8.61

                                           INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL


                     MAIN        .17       1.59     3.00                  4093.01      234.00        8.08
```

```
CONTINUITY SUMMARY (AC-FT) - INFLOW= .3575E+03 EXCESS= .0000E+00 OUTFLOW= .3576E+03 BASIN STORAGE= .1048E-01 PERCENT ERROR=     .0


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

                              HYDROGRAPH AT STATION   SB1CP1

  PEAK FLOW      TIME                               MAXIMUM AVERAGE FLOW
                                         6-HR        24-HR        72-HR       9.95-HR
+    (CFS)       (HR)
                                (CFS)
+    4093.       3.90                    721.         435.         435.         435.
                              (INCHES)  8.079        8.079        8.079        8.079
                               (AC-FT)   358.         358.         358.         358.

                              CUMULATIVE AREA =      .83 SQ MI


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

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              *            *
   34 KK      *      SB2   *
              *            *
              **************
                              SCS RUNOFF COMPUTATION FOR SB2

                     SUBBASIN RUNOFF DATA

   36 BA               SUBBASIN CHARACTERISTICS
                             TAREA          .42   SUBBASIN AREA

                       PRECIPITATION DATA

   16 PB                     STORM        13.20   BASIN TOTAL PRECIPITATION

   17 PI                 INCREMENTAL PRECIPITATION PATTERN
                             .01        .01        .01        .02        .01        .02        .02        .02        .01        .02
                             .02        .02        .02        .02        .02        .02        .02        .01        .01        .01
                             .03        .03        .03        .03        .03        .03        .03        .03        .02        .02
                             .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                             .08        .08        .09        .09        .09        .09        .09        .09        .09        .09
                             .09        .09        .09        .09        .08        .09        .09        .09        .09        .09
                            1.18       1.18       1.18       1.18       1.18        .38        .38        .38        .38        .38
                             .18        .18        .18        .18        .18        .14        .14        .14        .14        .14
                             .04        .04        .04        .04        .04        .04        .04        .04        .04        .04
                             .04        .04        .04        .04        .04        .04        .04        .04        .04        .04
                             .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                             .02        .02        .02        .02        .02        .02        .02        .02        .02        .02

   29 LU               UNIFORM LOSS RATE
                             STRTL         1.00   INITIAL LOSS
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                        CNSTL        1.50  UNIFORM LOSS RATE
                        RTIMP         .00  PERCENT IMPERVIOUS AREA

   37 UD         SCS DIMENSIONLESS UNITGRAPH
                        TLAG          .40  LAG

                                                            ***

                                                       UNIT HYDROGRAPH
                                                  42 END-OF-PERIOD ORDINATES
                  20.        63.       121.       202.       304.       394.       451.       474.       474.       451.
                 412.       367.       308.       245.       198.       163.       134.       113.        94.        77.
                  63.        52.        43.        36.        29.        24.        20.        17.        14.        11.
                   9.         8.         6.         5.         5.         4.         3.         3.         2.         1.
                   1.         0.

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

                                HYDROGRAPH AT STATION       SB2

     TOTAL RAINFALL =    13.20, TOTAL LOSS =     5.12, TOTAL EXCESS =     8.08

    PEAK FLOW      TIME                              MAXIMUM AVERAGE FLOW
                                          6-HR          24-HR         72-HR       9.95-HR
 +    (CFS)        (HR)
                                (CFS)
 +     2881.       3.60                   365.          220.          220.          220.
                              (INCHES)   8.076         8.076         8.076         8.076
                               (AC-FT)    181.          181.          181.          181.

                              CUMULATIVE AREA =      .42 SQ MI


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

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                 *            *
   38 KK         *      CP1   *
                 *            *
                 **************
                                 COMBINE FLOWS FROM SB1 AND SB2

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

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

                                HYDROGRAPH AT STATION       CP1

    PEAK FLOW      TIME                              MAXIMUM AVERAGE FLOW
                                          6-HR          24-HR         72-HR       9.95-HR
 +    (CFS)        (HR)
                                (CFS)
```

```
+    6164.      3.75                1086.        655.        655.        655.
                         (INCHES)   8.078       8.078       8.078       8.078
                          (AC-FT)    539.        539.        539.        539.

                          CUMULATIVE AREA =    1.25 SQ MI




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

            ***************
            *             *
  41 KK     *    CP1CP2   *
            *             *
            ***************
                       ROUTE HYDROGRAPH FROM CP1 TO CP2

                HYDROGRAPH ROUTING DATA

  43 RD           MUSKINGUM-CUNGE CHANNEL ROUTING
                             L       2600.  CHANNEL LENGTH
                             S       .0200  SLOPE
                             N        .090  CHANNEL ROUGHNESS COEFFICIENT
                            CA         .00  CONTRIBUTING AREA
                         SHAPE        TRAP  CHANNEL SHAPE
                            WD       68.00  BOTTOM WIDTH OR DIAMETER
                             Z        3.00  SIDE SLOPE

                                                                           ***
                                     COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                               COMPUTATION TIME STEP
                    ELEMENT     ALPHA       M         DT         DX        PEAK     TIME TO       VOLUME     MAXIMUM
                                                                                     PEAK                   CELERITY
                                                     (MIN)      (FT)      (CFS)     (MIN)         (IN)       (FPS)

                     MAIN        .19       1.58       3.00     866.67    6159.40    228.00        8.08       10.29

                                                    INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                     MAIN        .19       1.58       3.00               6159.40    228.00        8.08

CONTINUITY SUMMARY (AC-FT) - INFLOW= .5385E+03 EXCESS= .0000E+00 OUTFLOW= .5387E+03 BASIN STORAGE= .9970E-02 PERCENT ERROR=     .0


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

                          HYDROGRAPH AT STATION    CP1CP2

  PEAK FLOW      TIME                               MAXIMUM AVERAGE FLOW
                                        6-HR         24-HR        72-HR       9.95-HR
+   (CFS)        (HR)
                            (CFS)
```

```
+    6159.      3.80                1086.       655.        655.        655.
                          (INCHES)  8.080      8.080       8.080       8.080
                           (AC-FT)   539.       539.        539.        539.

                         CUMULATIVE AREA =     1.25 SQ MI


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

               **************
               *            *
  44 KK        *      SB3   *
               *            *
               **************
                              SCS RUNOFF COMPUTATION FOR SB3

                  SUBBASIN RUNOFF DATA

  46 BA             SUBBASIN CHARACTERISTICS
                          TAREA        1.60  SUBBASIN AREA

                    PRECIPITATION DATA

  16 PB                   STORM       13.20  BASIN TOTAL PRECIPITATION

  17 PI                INCREMENTAL PRECIPITATION PATTERN
                           .01      .01      .01      .02      .01      .02      .02      .02      .01      .02
                           .02      .02      .02      .02      .02      .02      .02      .01      .01      .01
                           .03      .03      .03      .03      .03      .03      .03      .03      .02      .02
                           .02      .02      .02      .02      .02      .02      .02      .02      .02      .02
                           .08      .08      .09      .09      .09      .09      .09      .09      .09      .09
                           .09      .09      .09      .09      .08      .09      .09      .09      .09      .09
                          1.18     1.18     1.18     1.18     1.18      .38      .38      .38      .38      .38
                           .18      .18      .18      .18      .18      .14      .14      .14      .14      .14
                           .04      .04      .04      .04      .04      .04      .04      .04      .04      .04
                           .04      .04      .04      .04      .04      .04      .04      .04      .04      .04
                           .02      .02      .02      .02      .02      .02      .02      .02      .02      .02
                           .02      .02      .02      .02      .02      .02      .02      .02      .02      .02

  29 LU             UNIFORM LOSS RATE
                          STRTL        1.00  INITIAL LOSS
                          CNSTL        1.50  UNIFORM LOSS RATE
                          RTIMP         .00  PERCENT IMPERVIOUS AREA

  47 UD             SCS DIMENSIONLESS UNITGRAPH
                           TLAG         .73  LAG

                                                    ***

                                             UNIT HYDROGRAPH
                                        75 END-OF-PERIOD ORDINATES
              20.       54.      101.      162.      233.      314.      422.      539.      668.      778.
             872.      946.      990.     1016.     1023.     1018.      998.      957.      910.      860.
             806.      740.      668.      586.      516.      455.      408.      366.      327.      293.
             267.      242.      217.      196.      176.      155.      140.      127.      113.      102.
```

```
                 92.        82.        73.        66.        59.        53.        48.        43.        38.        35.
                 31.        28.        25.        22.        20.        18.        16.        15.        13.        12.
                 11.        10.         9.         8.         8.         7.         6.         5.         4.         4.
                  3.         2.         2.         1.         0.

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

                           HYDROGRAPH AT STATION      SB3

           TOTAL RAINFALL =   13.20, TOTAL LOSS =    5.12, TOTAL EXCESS =    8.08

        PEAK FLOW      TIME                            MAXIMUM AVERAGE FLOW
                                             6-HR         24-HR        72-HR       9.95-HR
   +     (CFS)         (HR)
                                     (CFS)
   +      7148.        3.95                  1390.         838.         838.         838.
                                  (INCHES)   8.076        8.076        8.076        8.076
                                   (AC-FT)    689.         689.         689.         689.

                                 CUMULATIVE AREA =     1.60 SQ MI


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

                  **************
                  *            *
  48 KK           *     SB4    *
                  *            *
                  **************
                                   SCS RUNOFF COMPUTATION FOR SB4

                         SUBBASIN RUNOFF DATA

  50 BA                    SUBBASIN CHARACTERISTICS
                                 TAREA        1.20  SUBBASIN AREA

                           PRECIPITATION DATA

  16 PB                          STORM       13.20  BASIN TOTAL PRECIPITATION

  17 PI                          INCREMENTAL PRECIPITATION PATTERN
                                 .01       .01       .01       .02       .01       .02       .02       .02       .01       .02
                                 .02       .02       .02       .02       .02       .02       .02       .01       .01       .01
                                 .03       .03       .03       .03       .03       .03       .03       .03       .02       .02
                                 .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                                 .08       .08       .09       .09       .09       .09       .09       .09       .09       .09
                                 .09       .09       .09       .09       .08       .09       .09       .09       .09       .09
                                1.18      1.18      1.18      1.18      1.18       .38       .38       .38       .38       .38
                                 .18       .18       .18       .18       .18       .14       .14       .14       .14       .14
                                 .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                                 .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                                 .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                                 .02       .02       .02       .02       .02       .02       .02       .02       .02       .02

  29 LU                    UNIFORM LOSS RATE
```

```
                          STRTL         1.00  INITIAL LOSS
                          CNSTL         1.50  UNIFORM LOSS RATE
                          RTIMP          .00  PERCENT IMPERVIOUS AREA

  51 UD          SCS DIMENSIONLESS UNITGRAPH
                          TLAG           .66  LAG

                                                                 ***

                                                      UNIT HYDROGRAPH
                                                 68 END-OF-PERIOD ORDINATES
                  19.         53.         99.        155.        227.        314.        415.        533.        636.        722.
                 788.        826.        842.        844.        838.        803.        763.        718.        669.        609.
                 542.        469.        407.        359.        317.        280.        249.        223.        201.        178.
                 159.        141.        123.        111.         98.         87.         78.         68.         61.         54.
                  47.         42.         38.         33.         30.         27.         24.         21.         19.         17.
                  15.         13.         12.         10.          9.          8.          8.          7.          6.          5.
                   5.          4.          3.          3.          2.          2.          1.          0.

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

                                   HYDROGRAPH AT STATION       SB4

     TOTAL RAINFALL =    13.20, TOTAL LOSS =     5.12, TOTAL EXCESS =     8.08

   PEAK FLOW      TIME                                 MAXIMUM AVERAGE FLOW
                                               6-HR        24-HR       72-HR        9.95-HR
 +    (CFS)        (HR)
                                   (CFS)
 +     5782.       3.90                        1042.         629.        629.          629.
                                 (INCHES)      8.076        8.076       8.076         8.076
                                  (AC-FT)       517.         517.        517.          517.

                                  CUMULATIVE AREA =     1.20 SQ MI


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

                 **************
                 *            *
  52 KK          *     CP2    *
                 *            *
                 **************
                                   COMBINE FLOWS FROM SB3, SB4 and CP1

  54 HC          HYDROGRAPH COMBINATION
                          ICOMP            3  NUMBER OF HYDROGRAPHS TO COMBINE
                                                                 ***

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

                                   HYDROGRAPH AT STATION       CP2

   PEAK FLOW      TIME                                 MAXIMUM AVERAGE FLOW
```

```
                                             6-HR        24-HR        72-HR       9.95-HR
+   (CFS)        (HR)
                                 (CFS)
+  18927.        3.90                       3519.        2122.        2122.        2122.
                               (INCHES)     8.078        8.078        8.078        8.078
                                (AC-FT)     1745.        1745.        1745.        1745.

                                CUMULATIVE AREA =     4.05 SQ MI


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

             **************
             *            *
  55 KK      *   CP2CP3   *
             *            *
             **************
                               ROUTE HYDROGRAPH FROM CP2 TO CP3

                HYDROGRAPH ROUTING DATA

  57 RD           MUSKINGUM-CUNGE CHANNEL ROUTING
                            L       3500.  CHANNEL LENGTH
                            S       .0200  SLOPE
                            N        .090  CHANNEL ROUGHNESS COEFFICIENT
                           CA         .00  CONTRIBUTING AREA
                        SHAPE        TRAP  CHANNEL SHAPE
                           WD       88.00  BOTTOM WIDTH OR DIAMETER
                            Z       30.00  SIDE SLOPE

                                                                      ***
                                       COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                              COMPUTATION TIME STEP
                   ELEMENT    ALPHA      M        DT        DX        PEAK    TIME TO     VOLUME    MAXIMUM
                                                                              PEAK                 CELERITY
                                                 (MIN)     (FT)       (CFS)    (MIN)       (IN)      (FPS)

                    MAIN        .26     1.41      3.00    875.00  18905.50    240.00       8.08       8.03

                                                 INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                    MAIN        .26     1.41      3.00            18905.50    240.00       8.08

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1745E+04 EXCESS= .0000E+00 OUTFLOW= .1745E+04 BASIN STORAGE= .1214E-01 PERCENT ERROR=    .0


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

                             HYDROGRAPH AT STATION   CP2CP3

  PEAK FLOW     TIME                              MAXIMUM AVERAGE FLOW
```

```
                                              6-HR         24-HR         72-HR       9.95-HR
+    (CFS)         (HR)
                                 (CFS)
+    18906.        4.00                     3520.        2122.         2122.         2122.
                               (INCHES)     8.080        8.080         8.080         8.080
                               (AC-FT)      1745.        1745.         1745.         1745.

                               CUMULATIVE AREA =     4.05 SQ MI


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


                **************
                *            *
   58 KK        *    AGING   *
                *            *
                **************
                                   COMPUTE RUNOFF FROM Aging pad area USING OVERLAND FLOW ELEMENT

                   SUBBASIN RUNOFF DATA

   60 BA             SUBBASIN CHARACTERISTICS
                           TAREA          .46   SUBBASIN AREA

                     PRECIPITATION DATA

   16 PB                   STORM        13.20   BASIN TOTAL PRECIPITATION

   17 PI               INCREMENTAL PRECIPITATION PATTERN
                           .01       .01       .01       .02       .01       .02       .02       .02       .01       .02
                           .02       .02       .02       .02       .02       .02       .02       .01       .01       .01
                           .03       .03       .03       .03       .03       .03       .03       .03       .02       .02
                           .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                           .08       .08       .09       .09       .09       .09       .09       .09       .09       .09
                           .09       .09       .09       .09       .08       .09       .09       .09       .09       .09
                          1.18      1.18      1.18      1.18      1.18       .38       .38       .38       .38       .38
                           .18       .18       .18       .18       .18       .14       .14       .14       .14       .14
                           .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                           .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                           .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                           .02       .02       .02       .02       .02       .02       .02       .02       .02       .02

   61 LU             UNIFORM LOSS RATE
                           STRTL         1.00   INITIAL LOSS
                           CNSTL         1.50   UNIFORM LOSS RATE
                           RTIMP        25.50   PERCENT IMPERVIOUS AREA

                       LOSS RATE VARIABLES FOR SECOND OVERLAND FLOW ELEMENT
                           STRTL         1.00   INITIAL LOSS
                           CNSTL         1.50   UNIFORM LOSS RATE
                           RTIMP       100.00   PERCENT IMPERVIOUS AREA

                     KINEMATIC WAVE
   62 UK               OVERLAND-FLOW ELEMENT NO. 1
                               L        4000.   OVERLAND FLOW LENGTH
```

```
                          S        .0300  SLOPE
                          N         .100  ROUGHNESS COEFFICIENT
                         PA         83.0  PERCENT OF SUBBASIN
                      DXMIN           50  MINIMUM NUMBER OF DX INTERVALS
  63 UK              OVERLAND-FLOW ELEMENT NO. 2
                          L         900.  OVERLAND FLOW LENGTH
                          S        .0200  SLOPE
                          N         .100  ROUGHNESS COEFFICIENT
                         PA         17.0  PERCENT OF SUBBASIN
                      DXMIN           50  MINIMUM NUMBER OF DX INTERVALS

                    KINEMATIC WAVE
  64 RK              MAIN CHANNEL
                          L        3500.  CHANNEL LENGTH
                          S        .0200  SLOPE
                          N         .090  CHANNEL ROUGHNESS COEFFICIENT
                         CA          .46  CONTRIBUTING AREA
                      SHAPE         TRAP  CHANNEL SHAPE
                         WD        88.00  BOTTOM WIDTH OR DIAMETER
                          Z         3.00  SIDE SLOPE
                     NDXMIN           50  MINIMUM NUMBER OF DX INTERVALS
                     RUPSTQ           NO  ROUTE UPSTREAM HYDROGRAPH

                                                          ***
                                         COMPUTED KINEMATIC PARAMETERS
                                               VARIABLE TIME STEP
                                           (DT SHOWN IS A MINIMUM)

                     ELEMENT     ALPHA      M         DT        DX       PEAK    TIME TO    VOLUME   MAXIMUM
                                                                                   PEAK               CELERITY
                                                     (MIN)     (FT)      (CFS)     (MIN)      (IN)     (FPS)

                     PLANE1       2.58     1.67        .54     80.00    2970.04    208.64      9.31      3.09
                     PLANE2       2.11     1.67        .31     18.00    1189.81    194.88     13.18      1.99
                     MAIN          .15     1.59        .27     70.00    3441.74    202.75      9.94     10.32

  CONTINUITY SUMMARY (AC-FT) - INFLOW= .0000E+00  EXCESS= .2461E+03 OUTFLOW= .2439E+03 BASIN STORAGE= .1963E+01 PERCENT ERROR=     .1

                                         INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                     MAIN          .15     1.59       3.00              3436.19    204.00      9.94

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

                            HYDROGRAPH AT STATION    AGING

     TOTAL RAINFALL =    13.20, TOTAL LOSS =     3.17, TOTAL EXCESS =    10.03

    PEAK FLOW      TIME                          MAXIMUM AVERAGE FLOW
                                         6-HR        24-HR       72-HR       9.95-HR
 +   (CFS)         (HR)
                               (CFS)
 +    3436.        3.40                   486.        297.        297.         297.
                             (INCHES)    9.825       9.943       9.943        9.943
                              (AC-FT)     241.        244.        244.         244.
```

```
                        CUMULATIVE AREA =      .46 SQ MI


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

               **************
               *            *
  65 KK        *       CP3  *
               *            *
               **************
                              COMBINE FLOWS FROM CP2 and Aging1

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

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

                         HYDROGRAPH AT STATION       CP3

  PEAK FLOW      TIME                              MAXIMUM AVERAGE FLOW
                                          6-HR         24-HR        72-HR       9.95-HR
+   (CFS)        (HR)
                             (CFS)
+   20138.       3.95                     4006.        2419.        2419.        2419.
                          (INCHES)        8.258        8.270        8.270        8.270
                           (AC-FT)        1986.        1989.        1989.        1989.

                        CUMULATIVE AREA =     4.51 SQ MI


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

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               *            *
  68 KK        *    CP3CP4  *
               *            *
               **************
                               ROUTE HYDROGRAPH FROM CP3 TO CP4

                  HYDROGRAPH ROUTING DATA

  70 RD             MUSKINGUM-CUNGE CHANNEL ROUTING
                              L        4100.  CHANNEL LENGTH
                              S        .0300  SLOPE
                              N         .090  CHANNEL ROUGHNESS COEFFICIENT
                             CA          .00  CONTRIBUTING AREA
                          SHAPE         TRAP  CHANNEL SHAPE
                             WD        30.00  BOTTOM WIDTH OR DIAMETER
                              Z        40.00  SIDE SLOPE
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                                                                         ***
                                              COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                                     COMPUTATION TIME STEP
                       ELEMENT     ALPHA         M          DT          DX         PEAK      TIME TO      VOLUME      MAXIMUM
                                                                                               PEAK                    CELERITY
                                                           (MIN)       (FT)       (CFS)      (MIN)        (IN)        (FPS)

                        MAIN         .47       1.35        3.00      820.00    20106.10     243.00        8.27         8.41

                                                 INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL


                        MAIN         .47       1.35        3.00                20106.10     243.00        8.27

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1989E+04 EXCESS= .0000E+00 OUTFLOW= .1989E+04 BASIN STORAGE= .7397E+00 PERCENT ERROR=      .0


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

                                   HYDROGRAPH AT STATION    CP3CP4

   PEAK FLOW      TIME                                 MAXIMUM AVERAGE FLOW
                                             6-HR         24-HR         72-HR       9.95-HR
 +   (CFS)        (HR)
                                   (CFS)
 +   20106.       4.05                       4006.        2419.         2419.         2419.
                                (INCHES)     8.259        8.271         8.271         8.271
                                 (AC-FT)     1987.        1989.         1989.         1989.

                                CUMULATIVE AREA =     4.51 SQ MI


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                *            *
    71 KK       *       SB5  *
                *            *
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                                    SCS RUNOFF COMPUTATION FOR SB5

                     SUBBASIN RUNOFF DATA

    73 BA              SUBBASIN CHARACTERISTICS
                             TAREA          .39   SUBBASIN AREA

                       PRECIPITATION DATA

    16 PB                    STORM        13.20   BASIN TOTAL PRECIPITATION

    17 PI                   INCREMENTAL PRECIPITATION PATTERN
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```
                       .01        .01        .01        .02        .01        .02        .02        .02        .01        .02
                       .02        .02        .02        .02        .02        .02        .02        .01        .01        .01
                       .03        .03        .03        .03        .03        .03        .03        .03        .02        .02
                       .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                       .08        .08        .09        .09        .09        .09        .09        .09        .09        .09
                       .09        .09        .09        .09        .08        .09        .09        .09        .09        .09
                      1.18       1.18       1.18       1.18       1.18        .38        .38        .38        .38        .38
                       .18        .18        .18        .18        .18        .14        .14        .14        .14        .14
                       .04        .04        .04        .04        .04        .04        .04        .04        .04        .04
                       .04        .04        .04        .04        .04        .04        .04        .04        .04        .04
                       .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                       .02        .02        .02        .02        .02        .02        .02        .02        .02        .02

  74 LU         UNIFORM LOSS RATE
                      STRTL        1.00  INITIAL LOSS
                      CNSTL        1.50  UNIFORM LOSS RATE
                      RTIMP         .00  PERCENT IMPERVIOUS AREA

  75 UD         SCS DIMENSIONLESS UNITGRAPH
                       TLAG         .64  LAG

                                                        ***

                                                    UNIT HYDROGRAPH
                                                 66 END-OF-PERIOD ORDINATES
                 6.        18.        35.        54.        80.       111.       147.       188.       222.       248.
               268.       281.       283.       282.       276.       263.       248.       232.       213.       191.
               166.       143.       124.       110.        97.        86.        76.        68.        61.        54.
                48.        41.        37.        33.        29.        26.        23.        20.        18.        15.
                14.        12.        11.        10.         8.         8.         7.         6.         5.         5.
                 4.         4.         3.         3.         3.         2.         2.         2.         2.         1.
                 1.         1.         1.         1.         0.         0.

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

                           HYDROGRAPH AT STATION       SB5

    TOTAL RAINFALL =    13.20, TOTAL LOSS =     5.12, TOTAL EXCESS =     8.08

   PEAK FLOW      TIME                             MAXIMUM AVERAGE FLOW
                                        6-HR         24-HR        72-HR       9.95-HR

 +   (CFS)        (HR)
                              (CFS)
 +    1925.       3.85                   339.          204.         204.         204.
                            (INCHES)    8.076         8.076        8.076        8.076
                             (AC-FT)     168.          168.         168.         168.

                            CUMULATIVE AREA =      .39 SQ MI


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                 *            *
  76 KK          *      SB6   *
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8PD

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                    *      *
                    **************
                                   SCS RUNOFF COMPUTATION FOR SB6

                      SUBBASIN RUNOFF DATA

  78 BA                 SUBBASIN CHARACTERISTICS
                              TAREA        .76   SUBBASIN AREA

                        PRECIPITATION DATA

  16 PB                       STORM      13.20   BASIN TOTAL PRECIPITATION

  17 PI                   INCREMENTAL PRECIPITATION PATTERN
                              .01       .01       .01       .02       .01       .02       .02       .02       .01       .02
                              .02       .02       .02       .02       .02       .02       .02       .01       .01       .01
                              .03       .03       .03       .03       .03       .03       .03       .03       .02       .02
                              .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                              .08       .08       .09       .09       .09       .09       .09       .09       .09       .09
                              .09       .09       .09       .09       .08       .09       .09       .09       .09       .09
                             1.18      1.18      1.18      1.18      1.18       .38       .38       .38       .38       .38
                              .18       .18       .18       .18       .18       .14       .14       .14       .14       .14
                              .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                              .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                              .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                              .02       .02       .02       .02       .02       .02       .02       .02       .02       .02

  74 LU                 UNIFORM LOSS RATE
                              STRTL       1.00   INITIAL LOSS
                              CNSTL       1.50   UNIFORM LOSS RATE
                              RTIMP        .00   PERCENT IMPERVIOUS AREA

  79 UD                 SCS DIMENSIONLESS UNITGRAPH
                               TLAG        .76   LAG
                                                                         ***

                                                                  UNIT HYDROGRAPH
                                                             78 END-OF-PERIOD ORDINATES
                   9.        23.        44.        70.        99.       135.       179.       228.       285.       336.
                 384.       417.       443.       461.       466.       467.       464.       450.       432.       411.
                 388.       364.       334.       302.       266.       236.       209.       188.       169.       152.
                 137.       124.       114.       103.        93.        84.        75.        67.        61.        55.
                  49.        45.        40.        36.        33.        29.        26.        24.        21.        19.
                  17.        16.        14.        13.        12.        10.         9.         8.         8.         7.
                   6.         6.         5.         5.         4.         4.         4.         3.         3.         3.
                   2.         2.         2.         1.         1.         1.         0.         0.

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

                                 HYDROGRAPH AT STATION       SB6

     TOTAL RAINFALL =   13.20, TOTAL LOSS =    5.12, TOTAL EXCESS =    8.08

   PEAK FLOW      TIME                           MAXIMUM AVERAGE FLOW
                                          6-HR        24-HR        72-HR       9.95-HR
 +  (CFS)         (HR)
                                  (CFS)
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+     3290.        4.00                 660.         398.         398.          398.
                           (INCHES)    8.076        8.076        8.076         8.076
                            (AC-FT)     327.         327.         327.          327.

                          CUMULATIVE AREA =      .76 SQ MI


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

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              *            *
   80 KK      *      CP4   *
              *            *
              **************
                            COMBINE FLOWS FROM SB5,SB6 and CP3

   82 HC            HYDROGRAPH COMBINATION
                          ICOMP            3  NUMBER OF HYDROGRAPHS TO COMBINE

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

                          HYDROGRAPH AT STATION      CP4

   PEAK FLOW      TIME                              MAXIMUM AVERAGE FLOW
                                          6-HR        24-HR        72-HR        9.95-HR
+    (CFS)        (HR)
                            (CFS)
+    25090.       4.05                  5005.        3022.        3022.         3022.
                           (INCHES)    8.222        8.231        8.231         8.231
                            (AC-FT)     2482.        2485.        2485.         2485.

                          CUMULATIVE AREA =    5.66 SQ MI


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

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              *            *
   83 KK      *    CP4CP9  *
              *            *
              **************
                            ROUTE HYDROGRAPH FROM CP4 TO CP9

                 HYDROGRAPH ROUTING DATA

   85 RD          MUSKINGUM-CUNGE CHANNEL ROUTING
                              L        3000.  CHANNEL LENGTH
                              S        .0200  SLOPE
                              N         .090  CHANNEL ROUGHNESS COEFFICIENT
                             CA          .00  CONTRIBUTING AREA
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                    SHAPE         TRAP  CHANNEL SHAPE
                       WD        30.00  BOTTOM WIDTH OR DIAMETER
                        Z        20.00  SIDE SLOPE

                                                              ***
                                       COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                                COMPUTATION TIME STEP
                  ELEMENT     ALPHA          M          DT          DX        PEAK      TIME TO      VOLUME      MAXIMUM
                                                                                           PEAK                  CELERITY
                                                        (MIN)       (FT)      (CFS)      (MIN)        (IN)        (FPS)

                   MAIN         .41        1.37        3.00     1000.00   25046.78     246.00        8.23        9.46

                                              INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                   MAIN         .41        1.37        3.00                25046.78     246.00        8.23

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .2485E+04 EXCESS= .0000E+00 OUTFLOW= .2485E+04 BASIN STORAGE= .6271E+00 PERCENT ERROR=    .0


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

                         HYDROGRAPH AT STATION    CP4CP9

  PEAK FLOW       TIME                                  MAXIMUM AVERAGE FLOW
                                               6-HR          24-HR          72-HR         9.95-HR
+   (CFS)         (HR)
                                  (CFS)
+   25047.        4.10                        5006.          3022.          3022.          3022.
                              (INCHES)        8.223          8.231          8.231          8.231
                               (AC-FT)        2482.          2485.          2485.          2485.

                             CUMULATIVE AREA =      5.66 SQ MI


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

              ***************
              *             *
   86 KK      *      SB13   *
              *             *
              ***************
                               SCS RUNOFF COMPUTATION FOR SB13

                 SUBBASIN RUNOFF DATA

   88 BA          SUBBASIN CHARACTERISTICS
                     TAREA           .19   SUBBASIN AREA

                  PRECIPITATION DATA
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 16 PB                STORM       13.20  BASIN TOTAL PRECIPITATION

 17 PI            INCREMENTAL PRECIPITATION PATTERN
                      .01       .01       .01       .02       .01       .02       .02       .02       .01       .02
                      .02       .02       .02       .02       .02       .02       .02       .01       .01       .01
                      .03       .03       .03       .03       .03       .03       .03       .03       .02       .02
                      .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                      .08       .08       .09       .09       .09       .09       .09       .09       .09       .09
                      .09       .09       .09       .09       .08       .09       .09       .09       .09       .09
                     1.18      1.18      1.18      1.18      1.18       .38       .38       .38       .38       .38
                      .18       .18       .18       .18       .18       .14       .14       .14       .14       .14
                      .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                      .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                      .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                      .02       .02       .02       .02       .02       .02       .02       .02       .02       .02

 74 LU          UNIFORM LOSS RATE
                      STRTL        1.00  INITIAL LOSS
                      CNSTL        1.50  UNIFORM LOSS RATE
                      RTIMP         .00  PERCENT IMPERVIOUS AREA

 89 UD          SCS DIMENSIONLESS UNITGRAPH
                       TLAG         .30  LAG

                                                       ***

                                                  UNIT HYDROGRAPH
                                             32 END-OF-PERIOD ORDINATES
                  19.        56.       115.       193.       253.       280.       280.       257.       224.       179.
                 132.       102.        79.        63.        49.        38.        30.        23.        18.        14.
                  11.         8.         7.         5.         4.         3.         3.         2.         2.         1.
                   1.         0.

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

                           HYDROGRAPH AT STATION     SB13

   TOTAL RAINFALL =    13.20, TOTAL LOSS =     5.12, TOTAL EXCESS =     8.08

  PEAK FLOW     TIME                               MAXIMUM AVERAGE FLOW
                                             6-HR        24-HR        72-HR       9.95-HR

+   (CFS)       (HR)
                                (CFS)
+    1555.      3.45                          165.        100.         100.         100.
                              (INCHES)       8.076       8.076        8.076        8.076
                               (AC-FT)         82.         82.          82.          82.

                          CUMULATIVE AREA =      .19 SQ MI


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

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                *            *
 90 KK          *       SB7  *
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              *              *
              ****************
                         SCS RUNOFF COMPUTATION FOR SB7

 15 IN          TIME DATA FOR INPUT TIME SERIES
                      JXMIN          3  TIME INTERVAL IN MINUTES
                      JXDATE    1OCT98  STARTING DATE
                      JXTIME         0  STARTING TIME

             SUBBASIN RUNOFF DATA

 92 BA          SUBBASIN CHARACTERISTICS
                      TAREA       2.90  SUBBASIN AREA

                PRECIPITATION DATA

 93 PB                STORM      12.90  BASIN TOTAL PRECIPITATION

 94 PI            INCREMENTAL PRECIPITATION PATTERN
                       .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                       .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                       .03       .03       .03       .03       .03       .03       .03       .03       .03       .03
                       .03       .03       .03       .03       .03       .03       .03       .03       .03       .03
                       .08       .08       .08       .08       .08       .08       .08       .08       .08       .08
                       .08       .08       .08       .08       .08       .08       .08       .08       .08       .08
                      1.10      1.10      1.10      1.10      1.10       .36       .36       .36       .36       .36
                       .18       .18       .18       .18       .18       .16       .16       .16       .16       .16
                       .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                       .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                       .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                       .02       .02       .02       .02       .02       .02       .02       .02       .02       .02

 74 LU          UNIFORM LOSS RATE
                      STRTL       1.00  INITIAL LOSS
                      CNSTL       1.50  UNIFORM LOSS RATE
                      RTIMP        .00  PERCENT IMPERVIOUS AREA

106 UD          SCS DIMENSIONLESS UNITGRAPH
                      TLAG         .92  LAG

                                                         ***

                                                    UNIT HYDROGRAPH
                                                 94 END-OF-PERIOD ORDINATES
              24.       51.      105.      164.      234.      313.      407.      515.      640.      779.
             928.     1061.     1187.     1282.     1368.     1420.     1467.     1475.     1482.     1474.
            1458.     1411.     1361.     1306.     1248.     1185.     1114.     1035.      947.      853.
             771.      692.      634.      579.      532.      486.      446.      409.      381.      352.
             323.      297.      273.      250.      226.      208.      192.      176.      161.      148.
             137.      125.      113.      105.       96.       88.       80.       74.       68.       62.
              57.       53.       48.       44.       41.       38.       34.       31.       29.       27.
              24.       22.       20.       19.       17.       16.       15.       14.       13.       12.
              11.       10.        9.        8.        7.        7.        6.        5.        4.        4.
               3.        2.        1.        0.

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                      HYDROGRAPH AT STATION      SB7
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    TOTAL RAINFALL =   12.90, TOTAL LOSS =     5.30, TOTAL EXCESS =     7.60

   PEAK FLOW      TIME                          MAXIMUM AVERAGE FLOW
                                          6-HR        24-HR       72-HR       9.95-HR
 +   (CFS)        (HR)
                                 (CFS)
 +   10053.       4.15                    2370.        1429.       1429.        1429.
                               (INCHES)   7.600        7.600       7.600        7.600
                                (AC-FT)   1175.        1175.       1175.        1175.

                                CUMULATIVE AREA =     2.90 SQ MI


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


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               *            *
   107 KK      *    SB7CP5  *
               *            *
               **************
                                  ROUTE HYDROGRAPH FROM SB7 TO CP5

                 HYDROGRAPH ROUTING DATA

   109 RD          MUSKINGUM-CUNGE CHANNEL ROUTING
                              L        3200.  CHANNEL LENGTH
                              S        .0400  SLOPE
                              N         .090  CHANNEL ROUGHNESS COEFFICIENT
                             CA          .00  CONTRIBUTING AREA
                          SHAPE         TRAP  CHANNEL SHAPE
                             WD        30.00  BOTTOM WIDTH OR DIAMETER
                              Z        20.00  SIDE SLOPE

                                                                ***
                                         COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                                COMPUTATION TIME STEP
                    ELEMENT     ALPHA        M          DT          DX         PEAK     TIME TO      VOLUME     MAXIMUM
                                                                                         PEAK                  CELERITY
                                                       (MIN)       (FT)       (CFS)     (MIN)        (IN)       (FPS)

                     MAIN         .59       1.37        3.00      800.00   10052.46     255.00        7.60       9.48

                                                 INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                     MAIN         .59       1.37        3.00               10052.46     255.00        7.60

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1175E+04 EXCESS= .0000E+00 OUTFLOW= .1176E+04 BASIN STORAGE= .5540E-02 PERCENT ERROR=     .0


       ***            ***            ***            ***            ***
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                              HYDROGRAPH AT STATION    SB7CP5

   PEAK FLOW      TIME                            MAXIMUM AVERAGE FLOW
                                           6-HR         24-HR         72-HR        9.95-HR
 +   (CFS)        (HR)
                                (CFS)
 +   10052.       4.25                     2371.         1430.         1430.         1430.
                             (INCHES)      7.600         7.601         7.601         7.601
                              (AC-FT)      1176.         1176.         1176.         1176.

                             CUMULATIVE AREA =     2.90 SQ MI


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

                ***************
                *             *
  110 KK        *     SB8     *
                *             *
                ***************
                                SCS RUNOFF COMPUTATION FOR SB8

                  SUBBASIN RUNOFF DATA

  112 BA            SUBBASIN CHARACTERISTICS
                          TAREA         1.20   SUBBASIN AREA

                    PRECIPITATION DATA

   93 PB                  STORM        12.90   BASIN TOTAL PRECIPITATION

   94 PI              INCREMENTAL PRECIPITATION PATTERN
                          .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                          .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                          .03        .03        .03        .03        .03        .03        .03        .03        .03        .03
                          .03        .03        .03        .03        .03        .03        .03        .03        .03        .03
                          .08        .08        .08        .08        .08        .08        .08        .08        .08        .08
                          .08        .08        .08        .08        .08        .08        .08        .08        .08        .08
                         1.10       1.10       1.10       1.10       1.10        .36        .36        .36        .36        .36
                          .18        .18        .18        .18        .18        .16        .16        .16        .16        .16
                          .04        .04        .04        .04        .04        .04        .04        .04        .04        .04
                          .04        .04        .04        .04        .04        .04        .04        .04        .04        .04
                          .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                          .02        .02        .02        .02        .02        .02        .02        .02        .02        .02

   74 LU            UNIFORM LOSS RATE
                          STRTL         1.00   INITIAL LOSS
                          CNSTL         1.50   UNIFORM LOSS RATE
                          RTIMP          .00   PERCENT IMPERVIOUS AREA

  113 UD            SCS DIMENSIONLESS UNITGRAPH
                           TLAG          .60   LAG

                                                              ***
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                                                 UNIT HYDROGRAPH
                                            62 END-OF-PERIOD ORDINATES
         22.        67.       126.       199.       288.       406.       542.       672.       781.       863.
        907.       924.       924.       907.       863.       811.       753.       687.       609.       520.
        445.       388.       340.       297.       260.       233.       206.       181.       159.       136.
        122.       107.        94.        83.        71.        63.        55.        48.        43.        37.
         33.        29.        25.        22.        19.        17.        15.        13.        12.        10.
          9.         8.         8.         7.         6.         5.         4.         3.         3.         2.
          1.         0.

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

                         HYDROGRAPH AT STATION      SB8

     TOTAL RAINFALL =    12.90, TOTAL LOSS =     5.30, TOTAL EXCESS =     7.60

   PEAK FLOW      TIME                              MAXIMUM AVERAGE FLOW
                                            6-HR        24-HR         72-HR       9.95-HR
 +   (CFS)        (HR)
                                (CFS)
 +    5757.       3.80                       981.        592.          592.          592.
                              (INCHES)      7.600       7.600         7.600         7.600
                               (AC-FT)       486.        486.          486.          486.

                              CUMULATIVE AREA =      1.20 SQ MI


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

               **************
               *            *
  114 KK       *       CP5  *
               *            *
               **************
                                COMBINE HYDROGRAPHS FROM SB7, SB8

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

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

                         HYDROGRAPH AT STATION       CP5

   PEAK FLOW      TIME                              MAXIMUM AVERAGE FLOW
                                            6-HR        24-HR         72-HR       9.95-HR
 +   (CFS)        (HR)
                                (CFS)
 +   14235.       4.05                      3351.       2021.         2021.         2021.
                              (INCHES)      7.600       7.600         7.600         7.600
                               (AC-FT)      1662.       1662.         1662.         1662.

                              CUMULATIVE AREA =      4.10 SQ MI
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*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

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              *            *
 117 KK       *   CP5CP6   *
              *            *
              **************
                           ROUTE HYDROGRAPH FROM CP5 TO CP6

                HYDROGRAPH ROUTING DATA

 119 RD           MUSKINGUM-CUNGE CHANNEL ROUTING
                               L       2000.  CHANNEL LENGTH
                               S       .0300  SLOPE
                               N        .090  CHANNEL ROUGHNESS COEFFICIENT
                              CA         .00  CONTRIBUTING AREA
                           SHAPE        TRAP  CHANNEL SHAPE
                              WD       30.00  BOTTOM WIDTH OR DIAMETER
                               Z       20.00  SIDE SLOPE

                                                        ***
                                    COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                        COMPUTATION TIME STEP
                  ELEMENT     ALPHA       M          DT         DX        PEAK    TIME TO      VOLUME     MAXIMUM
                                                                                    PEAK                  CELERITY
                                                   (MIN)       (FT)      (CFS)     (MIN)        (IN)       (FPS)

                   MAIN         .51      1.37       3.00    1000.00   14233.66    246.00        7.60        9.39

                                           INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                   MAIN         .51      1.37       3.00              14233.66    246.00        7.60

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1662E+04 EXCESS= .0000E+00 OUTFLOW= .1662E+04 BASIN STORAGE= .2786E-02 PERCENT ERROR=     .0


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

                         HYDROGRAPH AT STATION    CP5CP6

  PEAK FLOW      TIME                          MAXIMUM AVERAGE FLOW
                                        6-HR        24-HR        72-HR       9.95-HR
+   (CFS)        (HR)
                             (CFS)
+   14234.       4.10                  3352.        2021.        2021.        2021.
                           (INCHES)    7.600        7.601        7.601        7.601
                            (AC-FT)    1662.        1662.        1662.        1662.

                          CUMULATIVE AREA =    4.10 SQ MI
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*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

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              *            *
 120 KK       *      SB9   *
              *            *
              **************
                             SCS RUNOFF COMPUTATION FOR SB9

                 SUBBASIN RUNOFF DATA

 122 BA           SUBBASIN CHARACTERISTICS
                        TAREA         1.70   SUBBASIN AREA

                  PRECIPITATION DATA

  93 PB                 STORM        12.90   BASIN TOTAL PRECIPITATION

  94 PI             INCREMENTAL PRECIPITATION PATTERN
                        .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                        .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                        .03       .03       .03       .03       .03       .03       .03       .03       .03       .03
                        .03       .03       .03       .03       .03       .03       .03       .03       .03       .03
                        .08       .08       .08       .08       .08       .08       .08       .08       .08       .08
                        .08       .08       .08       .08       .08       .08       .08       .08       .08       .08
                       1.10      1.10      1.10      1.10      1.10       .36       .36       .36       .36       .36
                        .18       .18       .18       .18       .18       .16       .16       .16       .16       .16
                        .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                        .04       .04       .04       .04       .04       .04       .04       .04       .04       .04
                        .02       .02       .02       .02       .02       .02       .02       .02       .02       .02
                        .02       .02       .02       .02       .02       .02       .02       .02       .02       .02

  74 LU           UNIFORM LOSS RATE
                        STRTL         1.00   INITIAL LOSS
                        CNSTL         1.50   UNIFORM LOSS RATE
                        RTIMP          .00   PERCENT IMPERVIOUS AREA

 123 UD           SCS DIMENSIONLESS UNITGRAPH
                         TLAG          .55   LAG

                                                                          ***

                                                                     UNIT HYDROGRAPH
                                                                57 END-OF-PERIOD ORDINATES
                 37.      117.      221.      353.      522.      730.      962.     1161.     1301.     1388.
               1422.     1422.     1388.     1311.     1223.     1124.     1002.      859.      725.      618.
                535.      462.      400.      354.      309.      270.      232.      200.      175.      151.
                132.      114.       99.       85.       74.       65.       56.       49.       42.       37.
                 32.       28.       24.       21.       18.       16.       14.       13.       11.       10.
                  8.        7.        6.        4.        3.        2.        1.

    ***              ***              ***              ***              ***
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                          HYDROGRAPH AT STATION      SB9

    TOTAL RAINFALL =    12.90, TOTAL LOSS =     5.30, TOTAL EXCESS =     7.60

   PEAK FLOW     TIME                                 MAXIMUM AVERAGE FLOW
                                           6-HR        24-HR        72-HR       9.95-HR
 +   (CFS)       (HR)
                               (CFS)
 +    8684.      3.75                      1390.        838.         838.         838.
                             (INCHES)      7.600        7.600        7.600        7.600
                              (AC-FT)       689.         689.         689.         689.

                            CUMULATIVE AREA =     1.70 SQ MI



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

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              *            *
   124 KK     *    SB9CP6  *
              *            *
              **************
                             ROUTE HYDROGRAPH FROM SB9 TO CP6

                 HYDROGRAPH ROUTING DATA

   126 RD          MUSKINGUM-CUNGE CHANNEL ROUTING
                             L        4700.  CHANNEL LENGTH
                             S        .0300  SLOPE
                             N         .090  CHANNEL ROUGHNESS COEFFICIENT
                            CA          .00  CONTRIBUTING AREA
                         SHAPE         TRAP  CHANNEL SHAPE
                            WD        30.00  BOTTOM WIDTH OR DIAMETER
                             Z        20.00  SIDE SLOPE
                                                                         ***
                                       COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                              COMPUTATION TIME STEP
                    ELEMENT     ALPHA       M          DT          DX        PEAK     TIME TO     VOLUME     MAXIMUM
                                                                                        PEAK                 CELERITY
                                                      (MIN)       (FT)      (CFS)      (MIN)       (IN)       (FPS)

                     MAIN         .51      1.37        3.00      783.33    8680.31    234.00       7.60       8.21

                                           INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL


                     MAIN         .51      1.37        3.00                8680.31    234.00       7.60

CONTINUITY SUMMARY (AC-FT) - INFLOW= .6891E+03 EXCESS= .0000E+00 OUTFLOW= .6895E+03 BASIN STORAGE= .9283E-02 PERCENT ERROR=    -.1
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        ***             ***             ***             ***             ***

                                 HYDROGRAPH AT STATION   SB9CP6

   PEAK FLOW       TIME                                MAXIMUM AVERAGE FLOW
                                             6-HR         24-HR          72-HR         9.95-HR
+    (CFS)         (HR)
                                  (CFS)
+    8680.         3.90                     1390.          838.           838.           838.
                               (INCHES)     7.604         7.604          7.604          7.604
                                (AC-FT)      689.          689.           689.           689.

                                CUMULATIVE AREA =     1.70 SQ MI


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

              **************
              *            *
   127 KK     *     SB10   *
              *            *
              **************
                                  SCS RUNOFF COMPUTATION FOR SB10

                    SUBBASIN RUNOFF DATA

   129 BA             SUBBASIN CHARACTERISTICS
                            TAREA          .44   SUBBASIN AREA

                      PRECIPITATION DATA

    93 PB                   STORM        12.90   BASIN TOTAL PRECIPITATION

    94 PI               INCREMENTAL PRECIPITATION PATTERN
                             .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                             .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                             .03        .03        .03        .03        .03        .03        .03        .03        .03        .03
                             .03        .03        .03        .03        .03        .03        .03        .03        .03        .03
                             .08        .08        .08        .08        .08        .08        .08        .08        .08        .08
                             .08        .08        .08        .08        .08        .08        .08        .08        .08        .08
                            1.10       1.10       1.10       1.10       1.10        .36        .36        .36        .36        .36
                             .18        .18        .18        .18        .18        .16        .16        .16        .16        .16
                             .04        .04        .04        .04        .04        .04        .04        .04        .04        .04
                             .04        .04        .04        .04        .04        .04        .04        .04        .04        .04
                             .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                             .02        .02        .02        .02        .02        .02        .02        .02        .02        .02

    74 LU             UNIFORM LOSS RATE
                            STRTL         1.00   INITIAL LOSS
                            CNSTL         1.50   UNIFORM LOSS RATE
                            RTIMP          .00   PERCENT IMPERVIOUS AREA

   130 UD             SCS DIMENSIONLESS UNITGRAPH
                             TLAG          .35   LAG
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80

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                                                                   ***

                                                              UNIT HYDROGRAPH
                                                         37 END-OF-PERIOD ORDINATES
                    30.         91.        176.        303.        435.        528.        563.        563.        528.        473.
                   405.        318.        248.        199.        159.        131.        106.         83.         68.         55.
                    44.         35.         28.         23.         19.         15.         12.         10.          8.          6.
                     5.          4.          4.          3.          2.          1.          0.

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

                                    HYDROGRAPH AT STATION     SB10

    TOTAL RAINFALL =    12.90, TOTAL LOSS =    5.30, TOTAL EXCESS =    7.60

   PEAK FLOW     TIME                           MAXIMUM AVERAGE FLOW
                                        6-HR          24-HR          72-HR        9.95-HR
 +   (CFS)       (HR)
                                (CFS)
 +    3043.      3.55                    360.          217.           217.           217.
                              (INCHES)  7.600         7.600          7.600          7.600
                               (AC-FT)   178.          178.           178.           178.

                            CUMULATIVE AREA =       .44 SQ MI


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

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                *            *
   131 KK       *       CP6  *
                *            *
                **************
                                COMBINE HYDROGRAPHS FROM CP5, SB10, SB9

   133 HC           HYDROGRAPH COMBINATION
                          ICOMP            3  NUMBER OF HYDROGRAPHS TO COMBINE
                                                                   ***

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

                                    HYDROGRAPH AT STATION      CP6

   PEAK FLOW     TIME                           MAXIMUM AVERAGE FLOW
                                        6-HR          24-HR          72-HR        9.95-HR
 +   (CFS)       (HR)
                                (CFS)
 +   23427.      4.00                   5101.         3077.          3077.          3077.
                              (INCHES)  7.601         7.602          7.602          7.602
                               (AC-FT)  2530.         2530.          2530.          2530.

                            CUMULATIVE AREA =      6.24 SQ MI
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*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

                **************
                *            *
 134 KK         *   CP6CP7   *
                *            *
                **************
                              ROUTE HYDROGRAPH FROM CP6 TO CP7

                     HYDROGRAPH ROUTING DATA

 136 RD                MUSKINGUM-CUNGE CHANNEL ROUTING
                                 L       2100.  CHANNEL LENGTH
                                 S       .0200  SLOPE
                                 N        .090  CHANNEL ROUGHNESS COEFFICIENT
                                CA         .00  CONTRIBUTING AREA
                             SHAPE        TRAP  CHANNEL SHAPE
                                WD      300.00  BOTTOM WIDTH OR DIAMETER
                                 Z      100.00  SIDE SLOPE

                                                                               ***
                                                 COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                                        COMPUTATION TIME STEP
                        ELEMENT     ALPHA         M         DT         DX       PEAK     TIME TO      VOLUME      MAXIMUM
                                                                                          PEAK                     CELERITY
                                                          (MIN)       (FT)     (CFS)     (MIN)        (IN)        (FPS)

                          MAIN        .16        1.42       3.00     525.00  23431.39    243.00        7.60        6.01

                                                        INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                          MAIN        .16        1.42       3.00             23431.39    243.00        7.60

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .2530E+04 EXCESS= .0000E+00 OUTFLOW= .2530E+04 BASIN STORAGE= .9920E-02 PERCENT ERROR=     .0


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

                              HYDROGRAPH AT STATION   CP6CP7

  PEAK FLOW       TIME                              MAXIMUM AVERAGE FLOW
                                             6-HR        24-HR       72-HR       9.95-HR
+   (CFS)         (HR)
                                   (CFS)
+   23431.        4.05                       5102.       3077.       3077.       3077.
                                 (INCHES)    7.602       7.603       7.603       7.603
                                  (AC-FT)    2530.       2530.       2530.       2530.

                                 CUMULATIVE AREA =      6.24 SQ MI
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*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

              **************
              *            *
 137 KK       *     SB11   *
              *            *
              **************
                             SCS RUNOFF COMPUTATION FOR SB11

                 SUBBASIN RUNOFF DATA

 139 BA           SUBBASIN CHARACTERISTICS
                        TAREA          .46  SUBBASIN AREA

                  PRECIPITATION DATA

  93 PB                 STORM        12.90  BASIN TOTAL PRECIPITATION

  94 PI             INCREMENTAL PRECIPITATION PATTERN
                        .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                        .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                        .03        .03        .03        .03        .03        .03        .03        .03        .03        .03
                        .03        .03        .03        .03        .03        .03        .03        .03        .03        .03
                        .08        .08        .08        .08        .08        .08        .08        .08        .08        .08
                        .08        .08        .08        .08        .08        .08        .08        .08        .08        .08
                       1.10       1.10       1.10       1.10       1.10        .36        .36        .36        .36        .36
                        .18        .18        .18        .18        .18        .16        .16        .16        .16        .16
                        .04        .04        .04        .04        .04        .04        .04        .04        .04        .04
                        .04        .04        .04        .04        .04        .04        .04        .04        .04        .04
                        .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                        .02        .02        .02        .02        .02        .02        .02        .02        .02        .02

  74 LU           UNIFORM LOSS RATE
                        STRTL         1.00  INITIAL LOSS
                        CNSTL         1.50  UNIFORM LOSS RATE
                        RTIMP          .00  PERCENT IMPERVIOUS AREA

 140 UD           SCS DIMENSIONLESS UNITGRAPH
                         TLAG          .40  LAG

                                                                   ***

                                                             UNIT HYDROGRAPH
                                                        42 END-OF-PERIOD ORDINATES
                  22.        69.       133.       221.       333.       432.       493.       520.       520.       493.
                 452.       402.       337.       268.       217.       178.       146.       124.       103.        84.
                  69.        57.        48.        39.        32.        26.        22.        18.        15.        12.
                  10.         8.         7.         6.         5.         4.         4.         3.         2.         2.
                   1.         0.

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

                                HYDROGRAPH AT STATION      SB11

   TOTAL RAINFALL =    12.90, TOTAL LOSS =      5.30, TOTAL EXCESS =     7.60
```

8PD

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   PEAK FLOW      TIME                          MAXIMUM AVERAGE FLOW
                                        6-HR        24-HR        72-HR       9.95-HR
 +   (CFS)        (HR)
                              (CFS)
 +    2924.       3.60                  376.         227.         227.          227.
                            (INCHES)    7.600        7.600        7.600         7.600
                             (AC-FT)    186.         186.         186.          186.

                           CUMULATIVE AREA =      .46 SQ MI


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

              **************
              *            *
   141 KK     *       CP7  *
              *            *
              **************
                                COMBINE HYDROGRAPHS FROM CP6, SB11

   143 HC          HYDROGRAPH COMBINATION
                         ICOMP            2  NUMBER OF HYDROGRAPHS TO COMBINE

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

                            HYDROGRAPH AT STATION      CP7

   PEAK FLOW      TIME                          MAXIMUM AVERAGE FLOW
                                        6-HR        24-HR        72-HR       9.95-HR
 +   (CFS)        (HR)
                              (CFS)
 +   24733.       4.05                  5477.        3304.        3304.         3304.
                            (INCHES)    7.601        7.603        7.603         7.603
                             (AC-FT)    2716.        2717.        2717.         2717.

                           CUMULATIVE AREA =     6.70 SQ MI


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

              **************
              *            *
   144 KK     *    CP7CP8  *
              *            *
              **************
                                ROUTE HYDROGRAPH FROM CP7 TO CP8

                HYDROGRAPH ROUTING DATA
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146 RD          MUSKINGUM-CUNGE CHANNEL ROUTING
                              L        2000.  CHANNEL LENGTH
                              S        .0200  SLOPE
                              N         .090  CHANNEL ROUGHNESS COEFFICIENT
                             CA          .00  CONTRIBUTING AREA
                          SHAPE         TRAP  CHANNEL SHAPE
                             WD        30.00  BOTTOM WIDTH OR DIAMETER
                              Z        40.00  SIDE SLOPE

                                                                  ***
                                    COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                           COMPUTATION TIME STEP
                  ELEMENT      ALPHA        M         DT        DX        PEAK     TIME TO      VOLUME      MAXIMUM
                                                                                    PEAK                   CELERITY
                                                     (MIN)     (FT)      (CFS)     (MIN)        (IN)        (FPS)

                   MAIN          .38       1.35       3.00    666.67  24724.83    246.00        7.60         7.63

                                           INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                   MAIN          .38       1.35       3.00            24724.83    246.00        7.60

CONTINUITY SUMMARY (AC-FT) - INFLOW= .2717E+04 EXCESS= .0000E+00 OUTFLOW= .2717E+04 BASIN STORAGE= .1205E-01 PERCENT ERROR=     .0


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

                            HYDROGRAPH AT STATION    CP7CP8

   PEAK FLOW      TIME                          MAXIMUM AVERAGE FLOW
                                         6-HR        24-HR        72-HR       9.95-HR
 +   (CFS)        (HR)
                              (CFS)
 +   24725.       4.10                   5477.        3304.        3304.        3304.
                           (INCHES)      7.601        7.603        7.603        7.603
                            (AC-FT)      2716.        2717.        2717.        2717.

                           CUMULATIVE AREA =     6.70 SQ MI


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

                **************
                *            *
147 KK          *     SB12   *
                *            *
                **************
                              SCS RUNOFF COMPUTATION FOR SB12

                  SUBBASIN RUNOFF DATA
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 149 BA          SUBBASIN CHARACTERISTICS
                       TAREA          .15  SUBBASIN AREA

                 PRECIPITATION DATA

  93 PB                STORM        12.90  BASIN TOTAL PRECIPITATION

  94 PI            INCREMENTAL PRECIPITATION PATTERN
                        .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                        .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                        .03        .03        .03        .03        .03        .03        .03        .03        .03        .03
                        .03        .03        .03        .03        .03        .03        .03        .03        .03        .03
                        .08        .08        .08        .08        .08        .08        .08        .08        .08        .08
                        .08        .08        .08        .08        .08        .08        .08        .08        .08        .08
                       1.10       1.10       1.10       1.10       1.10        .36        .36        .36        .36        .36
                        .18        .18        .18        .18        .18        .16        .16        .16        .16        .16
                        .04        .04        .04        .04        .04        .04        .04        .04        .04        .04
                        .04        .04        .04        .04        .04        .04        .04        .04        .04        .04
                        .02        .02        .02        .02        .02        .02        .02        .02        .02        .02
                        .02        .02        .02        .02        .02        .02        .02        .02        .02        .02

  74 LU          UNIFORM LOSS RATE
                       STRTL         1.00  INITIAL LOSS
                       CNSTL         1.50  UNIFORM LOSS RATE
                       RTIMP          .00  PERCENT IMPERVIOUS AREA

 150 UD          SCS DIMENSIONLESS UNITGRAPH
                        TLAG          .24  LAG

                                                                   ***

                                                              UNIT HYDROGRAPH
                                                         26 END-OF-PERIOD ORDINATES
                 25.        77.       163.       241.       272.       266.       231.       183.       126.        92.
                 69.        51.        37.        28.        20.        15.        11.         8.         6.         4.
                  3.         3.         2.         1.         1.         0.

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

                                 HYDROGRAPH AT STATION      SB12

   TOTAL RAINFALL =     12.90, TOTAL LOSS =     5.30, TOTAL EXCESS =     7.60

  PEAK FLOW      TIME                          MAXIMUM AVERAGE FLOW
                                       6-HR        24-HR       72-HR       9.95-HR
+   (CFS)        (HR)
                              (CFS)
+   1300.        3.40                   123.          74.         74.          74.
                            (INCHES)   7.600        7.600       7.600        7.600
                             (AC-FT)     61.          61.         61.          61.

                               CUMULATIVE AREA =      .15 SQ MI

*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
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               **************
               *            *
 151 KK        *      CP8   *
               *            *
               **************
                               COMBINE HYDROGRAPHS FROM CP7, SB12

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

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

                            HYDROGRAPH AT STATION      CP8

 PEAK FLOW      TIME                              MAXIMUM AVERAGE FLOW
                                           6-HR       24-HR        72-HR       9.95-HR
+   (CFS)        (HR)
                              (CFS)
+   24935.       4.10                     5599.       3378.        3378.        3378.
                           (INCHES)       7.600       7.603        7.603        7.603
                            (AC-FT)       2777.       2778.        2778.        2778.

                           CUMULATIVE AREA =     6.85 SQ MI


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

               **************
               *            *
 154 KK        *   CP8CP9   *
               *            *
               **************
                               ROUTE HYDROGRAPH FROM CP8 TO CP9

                 HYDROGRAPH ROUTING DATA

 156 RD            MUSKINGUM-CUNGE CHANNEL ROUTING
                                L       1700.  CHANNEL LENGTH
                                S       .0200  SLOPE
                                N        .090  CHANNEL ROUGHNESS COEFFICIENT
                               CA         .00  CONTRIBUTING AREA
                            SHAPE        TRAP  CHANNEL SHAPE
                               WD       30.00  BOTTOM WIDTH OR DIAMETER
                                Z       30.00  SIDE SLOPE
                                                                         ***
                                           COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                                   COMPUTATION TIME STEP
                     ELEMENT      ALPHA        M          DT         DX        PEAK     TIME TO      VOLUME      MAXIMUM
                                                                                          PEAK                   CELERITY
                                                        (MIN)       (FT)      (CFS)      (MIN)        (IN)        (FPS)
```

```
                      MAIN        .40       1.36       3.00     850.00  24919.09    249.00       7.60       8.32

                                            INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                      MAIN        .40       1.36       3.00             24919.09    249.00       7.60

CONTINUITY SUMMARY (AC-FT) - INFLOW= .2778E+04 EXCESS= .0000E+00 OUTFLOW= .2778E+04 BASIN STORAGE= .2106E-01 PERCENT ERROR=    .0


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

                         HYDROGRAPH AT STATION    CP8CP9

 PEAK FLOW      TIME                            MAXIMUM AVERAGE FLOW
                                      6-HR       24-HR       72-HR      9.95-HR
+   (CFS)       (HR)
                           (CFS)
+   24919.      4.15                  5600.       3378.       3378.       3378.
                         (INCHES)     7.600       7.603       7.603       7.603
                          (AC-FT)     2777.       2778.       2778.       2778.

                        CUMULATIVE AREA =     6.85 SQ MI


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

            **************
            *            *
 157 KK     *     CP9    *
            *            *
            **************
                           COMBINE HYDROGRAPHS FROM CP4, SB13, CP8

 159 HC         HYDROGRAPH COMBINATION
                      ICOMP           3  NUMBER OF HYDROGRAPHS TO COMBINE
                                                                  ***

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

                         HYDROGRAPH AT STATION    CP9

 PEAK FLOW      TIME                            MAXIMUM AVERAGE FLOW
                                      6-HR       24-HR       72-HR      9.95-HR
+   (CFS)       (HR)
                           (CFS)
+   50219.      4.15                 10769.       6499.       6499.       6499.
                         (INCHES)     7.884       7.890       7.890       7.890
                          (AC-FT)     5340.       5344.       5344.       5344.

                        CUMULATIVE AREA =    12.70 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
+                           SB1      4097.    3.85         721.        435.        435.        .83

          ROUTED TO
+                         SB1CP1     4093.    3.90         721.        435.        435.        .83

          HYDROGRAPH AT
+                           SB2      2881.    3.60         365.        220.        220.        .42

          2 COMBINED AT
+                           CP1      6164.    3.75        1086.        655.        655.       1.25

          ROUTED TO
+                         CP1CP2     6159.    3.80        1086.        655.        655.       1.25

          HYDROGRAPH AT
+                           SB3      7148.    3.95        1390.        838.        838.       1.60

          HYDROGRAPH AT
+                           SB4      5782.    3.90        1042.        629.        629.       1.20

          3 COMBINED AT
+                           CP2     18927.    3.90        3519.       2122.       2122.       4.05

          ROUTED TO
+                         CP2CP3    18906.    4.00        3520.       2122.       2122.       4.05

          HYDROGRAPH AT
+                         AGING      3436.    3.40         486.        297.        297.        .46

          2 COMBINED AT
+                           CP3     20138.    3.95        4006.       2419.       2419.       4.51

          ROUTED TO
+                         CP3CP4    20106.    4.05        4006.       2419.       2419.       4.51

          HYDROGRAPH AT
+                           SB5      1925.    3.85         339.        204.        204.        .39

          HYDROGRAPH AT
+                           SB6      3290.    4.00         660.        398.        398.        .76

          3 COMBINED AT
+                           CP4     25090.    4.05        5005.       3022.       3022.       5.66

          ROUTED TO
+                         CP4CP9    25047.    4.10        5006.       3022.       3022.       5.66
```

```
           HYDROGRAPH AT
+                            SB13      1555.     3.45        165.       100.       100.        .19
           HYDROGRAPH AT
+                            SB7      10053.     4.15       2370.      1429.      1429.       2.90
           ROUTED TO
+                          SB7CP5     10052.     4.25       2371.      1430.      1430.       2.90
           HYDROGRAPH AT
+                            SB8       5757.     3.80        981.       592.       592.       1.20
           2 COMBINED AT
+                            CP5      14235.     4.05       3351.      2021.      2021.       4.10
           ROUTED TO
+                          CP5CP6     14234.     4.10       3352.      2021.      2021.       4.10
           HYDROGRAPH AT
+                            SB9       8684.     3.75       1390.       838.       838.       1.70
           ROUTED TO
+                          SB9CP6      8680.     3.90       1390.       838.       838.       1.70
           HYDROGRAPH AT
+                            SB10      3043.     3.55        360.       217.       217.        .44
           3 COMBINED AT
+                            CP6      23427.     4.00       5101.      3077.      3077.       6.24
           ROUTED TO
+                          CP6CP7     23431.     4.05       5102.      3077.      3077.       6.24
           HYDROGRAPH AT
+                            SB11      2924.     3.60        376.       227.       227.        .46
           2 COMBINED AT
+                            CP7      24733.     4.05       5477.      3304.      3304.       6.70
           ROUTED TO
+                          CP7CP8     24725.     4.10       5477.      3304.      3304.       6.70
           HYDROGRAPH AT
+                            SB12      1300.     3.40        123.        74.        74.        .15
           2 COMBINED AT
+                            CP8      24935.     4.10       5599.      3378.      3378.       6.85
           ROUTED TO
+                          CP8CP9     24919.     4.15       5600.      3378.      3378.       6.85
           3 COMBINED AT
+                            CP9      50219.     4.15      10769.      6499.      6499.      12.70
1
                                    SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE ROUTING
                                      (FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)
                                                                      INTERPOLATED TO
                                                                    COMPUTATION INTERVAL
```

```
                ISTAQ    ELEMENT      DT       PEAK     TIME TO    VOLUME      DT       PEAK     TIME TO    VOLUME
                                                          PEAK                                     PEAK

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

                 SB1CP1   MANE        3.00   4093.01    234.00      8.08       3.00   4093.01    234.00       8.08

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .3575E+03 EXCESS= .0000E+00 OUTFLOW= .3576E+03 BASIN STORAGE= .1048E-01 PERCENT ERROR=    .0

                 CP1CP2   MANE        3.00   6159.40    228.00      8.08       3.00   6159.40    228.00       8.08

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .5385E+03 EXCESS= .0000E+00 OUTFLOW= .5387E+03 BASIN STORAGE= .9970E-02 PERCENT ERROR=    .0

                 CP2CP3   MANE        3.00  18905.50    240.00      8.08       3.00  18905.50    240.00       8.08

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1745E+04 EXCESS= .0000E+00 OUTFLOW= .1745E+04 BASIN STORAGE= .1214E-01 PERCENT ERROR=    .0

                  AGING   MANE         .27   3441.74    202.75      9.94       3.00   3436.19    204.00       9.94

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .0000E+00 EXCESS= .2461E+03 OUTFLOW= .2439E+03 BASIN STORAGE= .1963E+01 PERCENT ERROR=    .1

                 CP3CP4   MANE        3.00  20106.10    243.00      8.27       3.00  20106.10    243.00       8.27

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1989E+04 EXCESS= .0000E+00 OUTFLOW= .1989E+04 BASIN STORAGE= .7397E+00 PERCENT ERROR=    .0

                 CP4CP9   MANE        3.00  25046.78    246.00      8.23       3.00  25046.78    246.00       8.23

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .2485E+04 EXCESS= .0000E+00 OUTFLOW= .2485E+04 BASIN STORAGE= .6271E+00 PERCENT ERROR=    .0

                 SB7CP5   MANE        3.00  10052.46    255.00      7.60       3.00  10052.46    255.00       7.60

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1175E+04 EXCESS= .0000E+00 OUTFLOW= .1176E+04 BASIN STORAGE= .5540E-02 PERCENT ERROR=    .0

                 CP5CP6   MANE        3.00  14233.66    246.00      7.60       3.00  14233.66    246.00       7.60

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .1662E+04 EXCESS= .0000E+00 OUTFLOW= .1662E+04 BASIN STORAGE= .2786E-02 PERCENT ERROR=    .0

                 SB9CP6   MANE        3.00   8680.31    234.00      7.60       3.00   8680.31    234.00       7.60

 CONTINUITY SUMMARY (AC-FT) - INFLOW= .6891E+03 EXCESS= .0000E+00 OUTFLOW= .6895E+03 BASIN STORAGE= .9283E-02 PERCENT ERROR=   -.1
```

```
            CP6CP7  MANE         3.00  23431.39    243.00      7.60      3.00  23431.39    243.00        7.60

CONTINUITY SUMMARY (AC-FT) - INFLOW= .2530E+04 EXCESS= .0000E+00 OUTFLOW= .2530E+04 BASIN STORAGE= .9920E-02 PERCENT ERROR=    .0

            CP7CP8  MANE         3.00  24724.83    246.00      7.60      3.00  24724.83    246.00        7.60

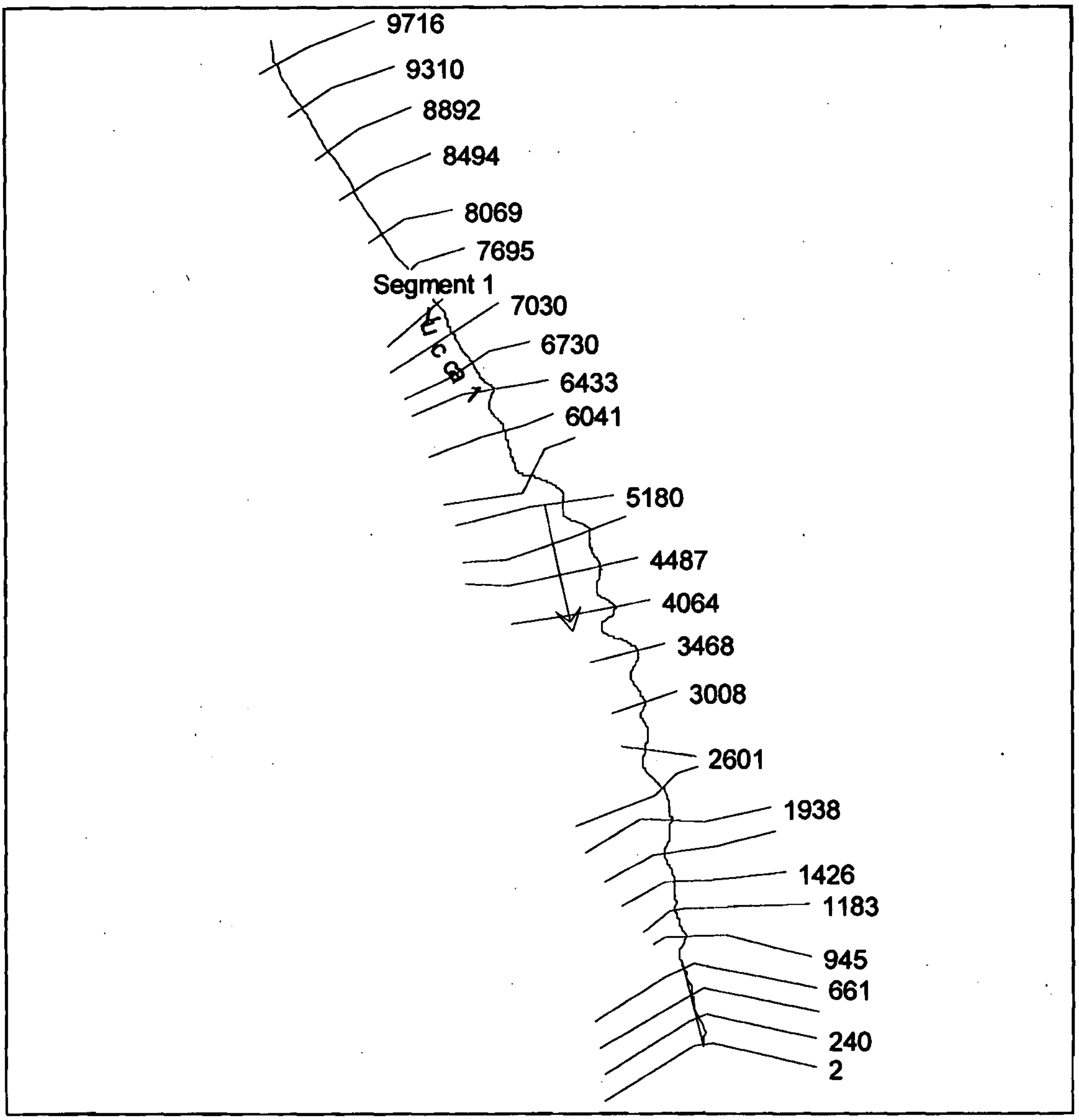
CONTINUITY SUMMARY (AC-FT) - INFLOW= .2717E+04 EXCESS= .0000E+00 OUTFLOW= .2717E+04 BASIN STORAGE= .1205E-01 PERCENT ERROR=    .0

            CP8CP9  MANE         3.00  24919.09    249.00      7.60      3.00  24919.09    249.00        7.60

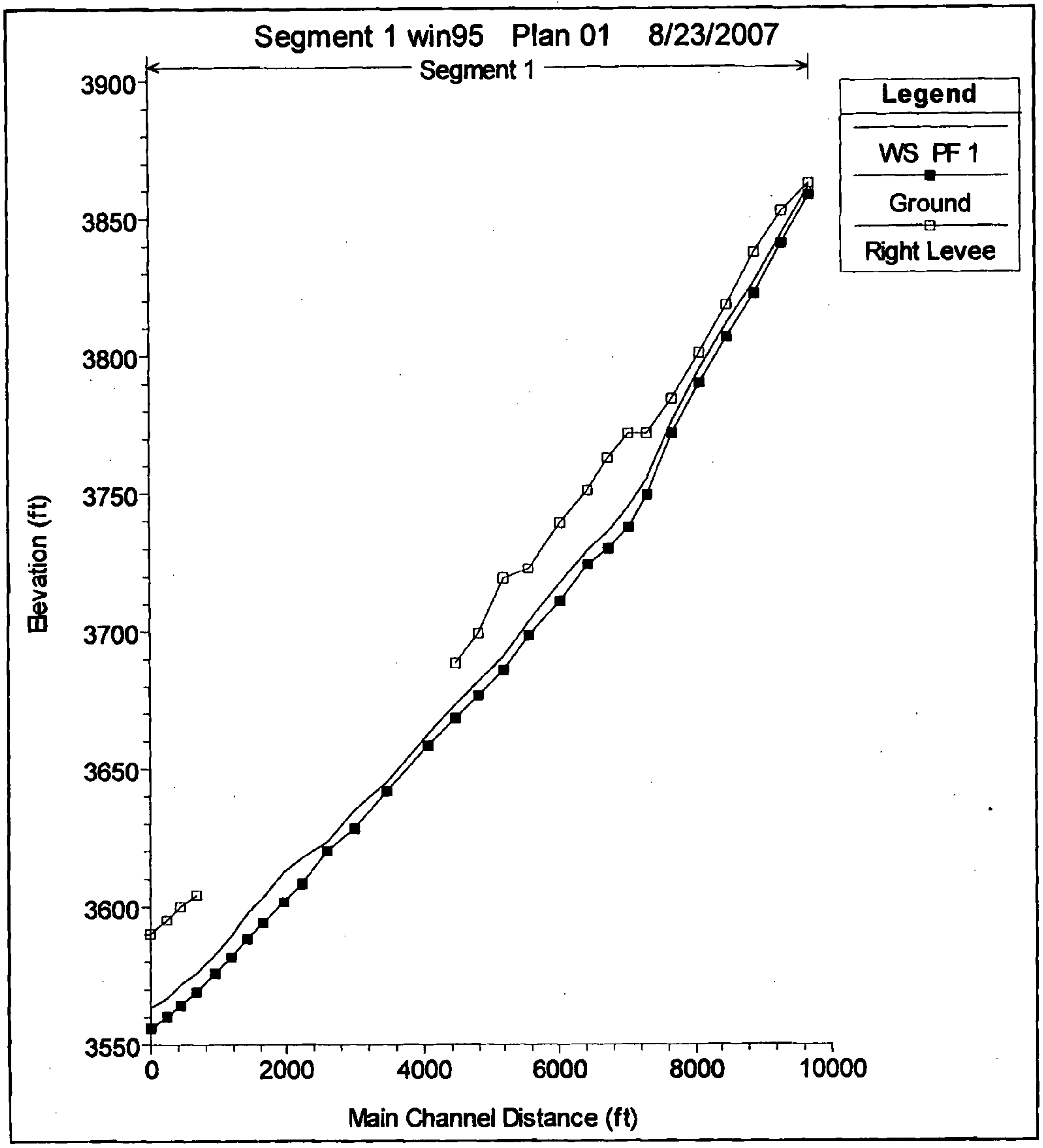
CONTINUITY SUMMARY (AC-FT) - INFLOW= .2778E+04 EXCESS= .0000E+00 OUTFLOW= .2778E+04 BASIN STORAGE= .2106E-01 PERCENT ERROR=    .0


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

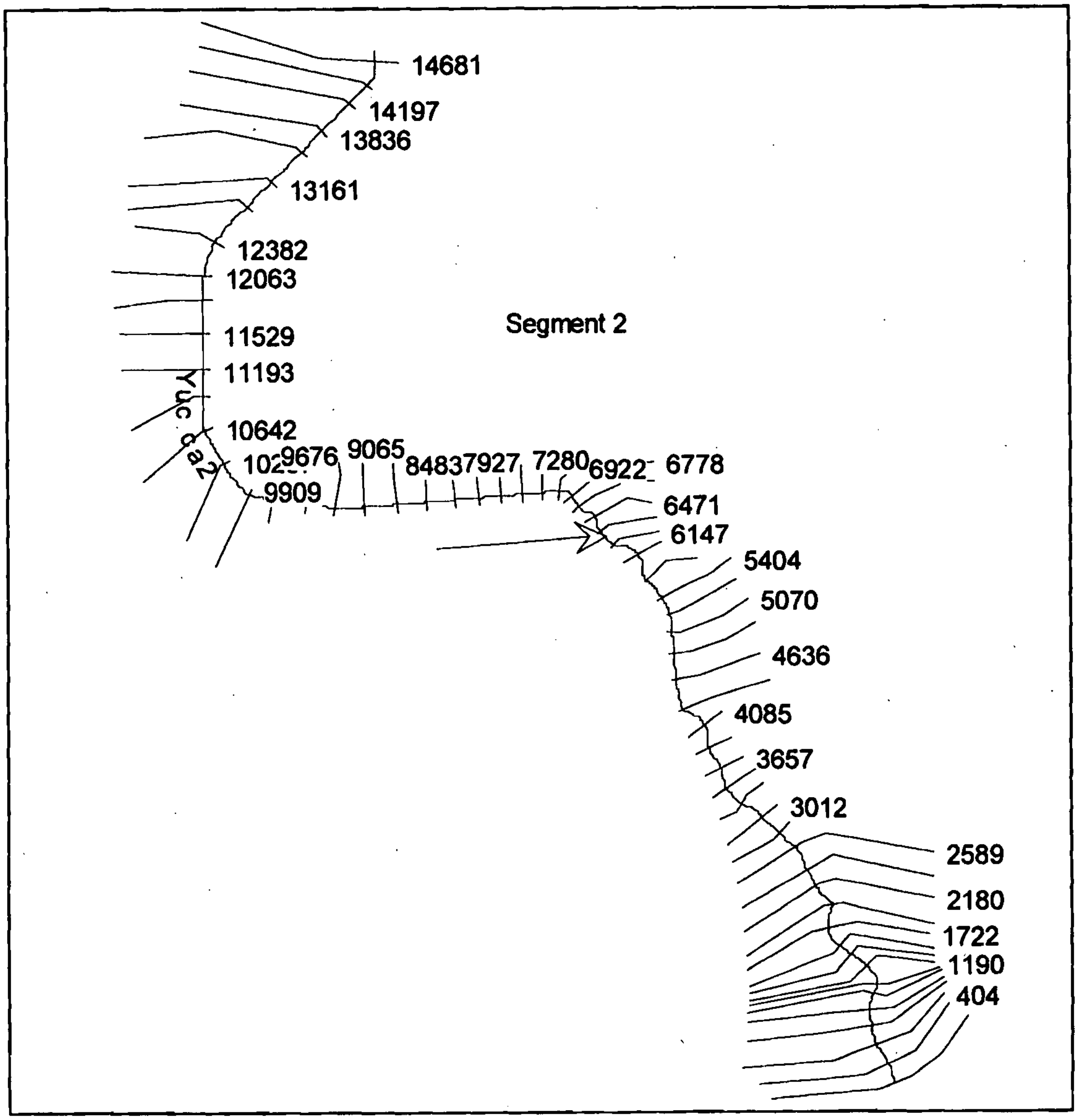
HEC-RAS Schematic for Segment 1



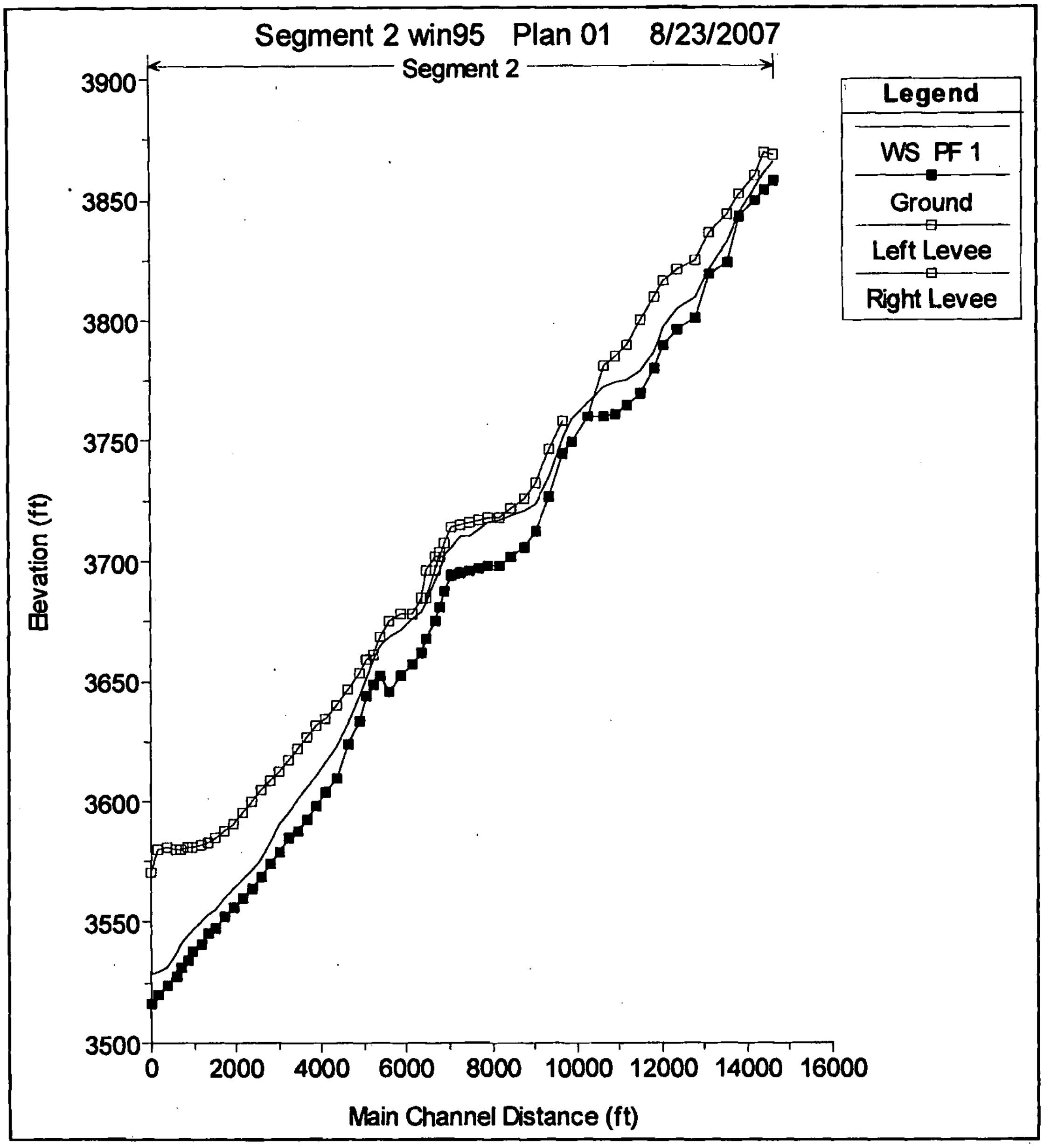
Water Surface Profile of Probable Maximum Flood for Segment 1



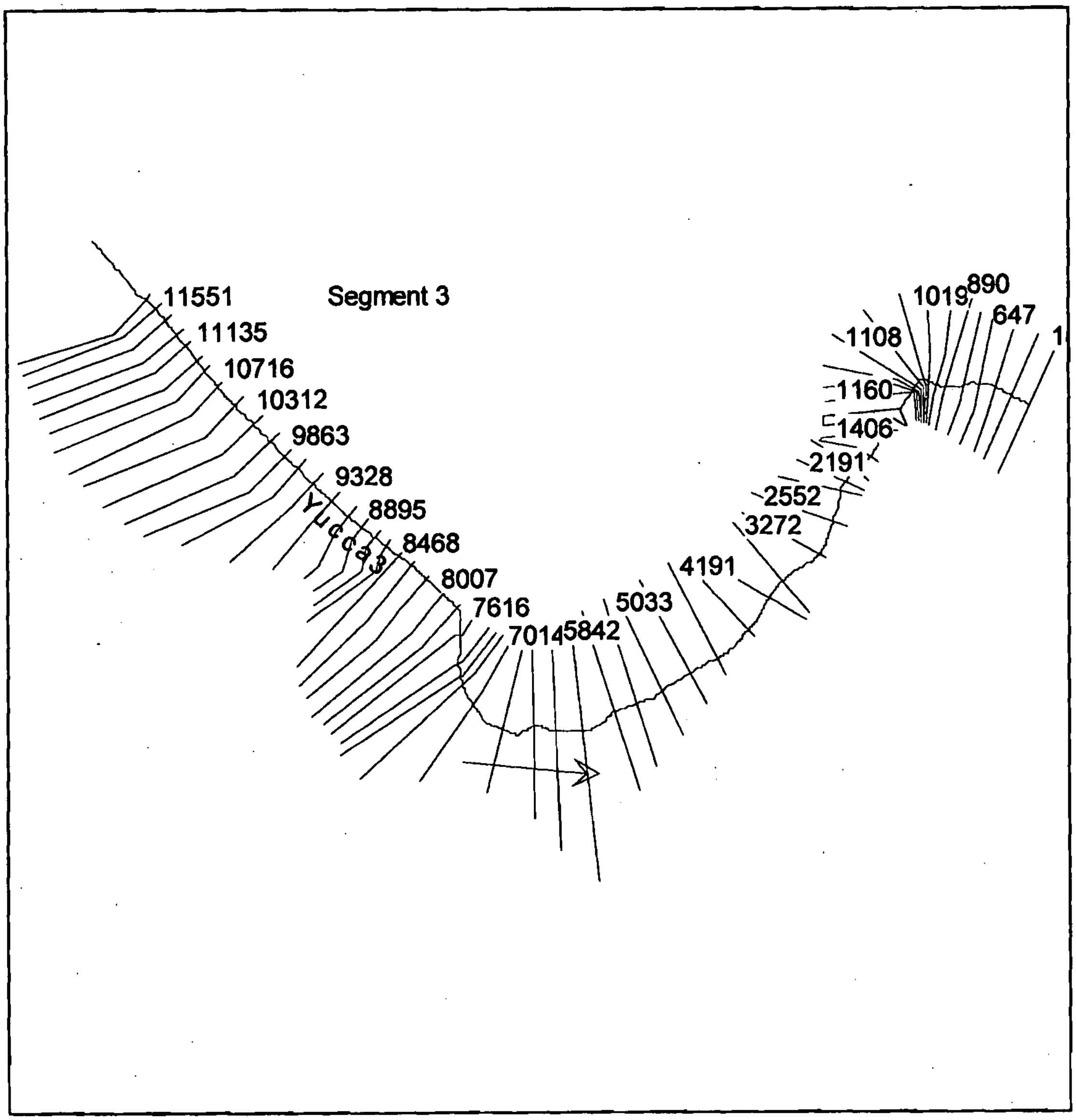
HEC-RAS Schematic for Segment 2



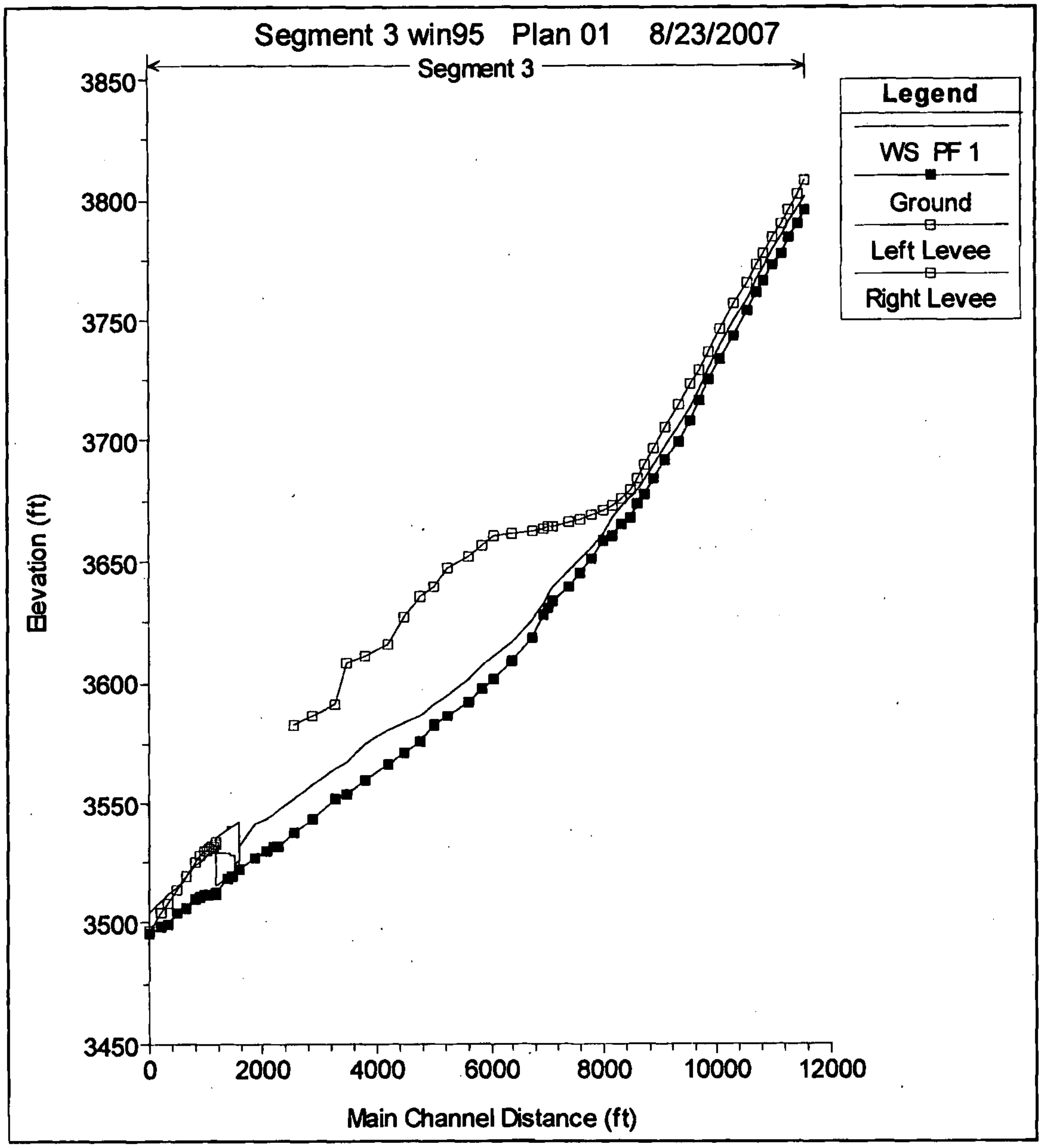
Water Surface Profile of Probable Maximum Flood for Segment 2



HEC-RAS Schematic for Segment 3



Water Surface Profile of Probable Maximum Flood for Segment 3



Note: Left levee elevations have changed from those shown between HEC-RAS stations 8468 and 2552 (North Portal Loop Road West stations 531+00 and 572+00). The revised road profile is shown in Attachment A. The revised values for levee freeboard are included in Table 7-4: Flood Inundation Results for Segment 3.

The procedures presented in HMR 49 (Ref. 2.2.16) were used to calculate the PMP in the vicinity of the South Portal. The calculations on the following pages (performed using United States customary units) show that the 6-hour duration local storm PMP of 12.9 inches is more severe than the largest 6-hour general storm of 5.8 inches, which was calculated to occur during the month of September. The local storm PMP hyetograph has been included in this attachment.

Table 6.1.--General-storm PMP computations for the Colorado River and Great basin

Drainage Midway Valley - South Portal Area   Area 6.5 mi^2 (km^2)

Latitude 36° 51', Longitude 116° 27 of basin center

Month September

Step		Duration (hrs)						
		6	12	18	24	48	72	
A. Convergence PMP								
1. Drainage average value from one of figures 2.5 to 2.16	10.8 in. (mm)							
2. Reduction for barrier-elevation [fig. 2.18]	65 %							
3. Barrier-elevation reduced PMP [step 1 X step 2]	7.0 in. (mm)							
4. Durational variation [figs. 2.25 to 2.27 and table 2.7].		68	NA	NA	NA	NA	NA	%
5. Convergence PMP for indicated durations [steps 3 X 4]		4.8	NA	NA	NA	NA	NA	in. (mm)
6. Incremental 10 mi^2 (26 km^2) PMP [successive subtraction in step 5]		4.8	NA	NA	NA	NA	NA	in. (mm)
7. Areal reduction [select from figs. 2.28 and 2.29]		100	NA	NA	NA	NA	NA	%
8. Areally reduced PMP [step 6 X step 7]		4.8	NA	NA	NA	NA	NA	in. (mm)
9. Drainage average PMP [accumulated values of step 8]		4.8	NA	NA	NA	NA	NA	in. (mm)
B. Orographic PMP								
1. Drainage average orographic index from figure 3.11a to d.	3.0 in. (mm)							
2. Areal reduction [figure 3.20]	100 %							
3. Adjustment for month [one of figs. 3.12 to 3.17]	100 %							
4. Areally and seasonally adjusted PMP [steps 1 X 2 X 3]	3.0 in. (mm)							
5. Durational variation [table 3.6]		32	NA	NA	NA	NA	NA	%
6. Orographic PMP for given durations [steps 4 X 5]		1.0	NA	NA	NA	NA	NA	in. (mm)
C. Total PMP								
1. Add steps A9 and B6		5.8	NA	NA	NA	NA	NA	in. (mm)

2. PMP for other durations from smooth curve fitted to plot of computed data.

3. Comparison with local-storm PMP (see sec. 6.3).

Table 6.3A.--Local-storm PMP computation, Colorado River, Great Basin and California drainages. For drainage average depth PMP. Go to table 6.3B if areal variation is required.

Drainage Midway Valley - South Portal Area Area 6.5 mi^2 (km^2)
Latitude 36° 51' Longitude 116° 27' Minimum Elevation 3520 ft (m)

Steps correspond to those in sec. 6.3A.

1. Average 1-hr 1-mi^2 (2.6-km^2) PMP for drainage [fig. 4.5]. 10.3 in. (mm)

2. a. Reduction for elevation. [No adjustment for elevations up to 5,000 feet (1,524 m): 5% decrease per 1,000 feet (305 m) above 5,000 feet (1,524 m)]. 100 %

   b. Multiply step 1 by step 2a. 10.3 in. (mm)

3. Average 6/1-hr ratio for drainage [fig. 4.7]. 1.36

	Duration (hr)									
	1/4	1/2	3/4	1	2	3	4	5	6	
4. Durational variation for 6/1-hr ratio of step 3 [table 4.4].	67	85	94	100	116	124	129	133	136	%
5. 1-mi^2 (2.6-km^2) PMP for indicated durations [step 2b X step 4].	6.9	8.8	9.7	10.3	11.9	12.8	13.3	13.7	14.0	in. (mm)
6. Areal reduction [fig. 4.9].	80	83	85	87	88	89	90	91	92	%
7. Areal reduced PMP [steps 5 X 6].	5.5	7.3	8.2	9.0	10.5	11.4	12.0	12.5	12.9	in. (mm)
8. Incremental PMP [successive subtraction in step 7].				9.0	1.5	0.9	0.6	0.5	0.4	in. (mm)
	5.5	1.8	0.9	0.8	} 15-min. increments					

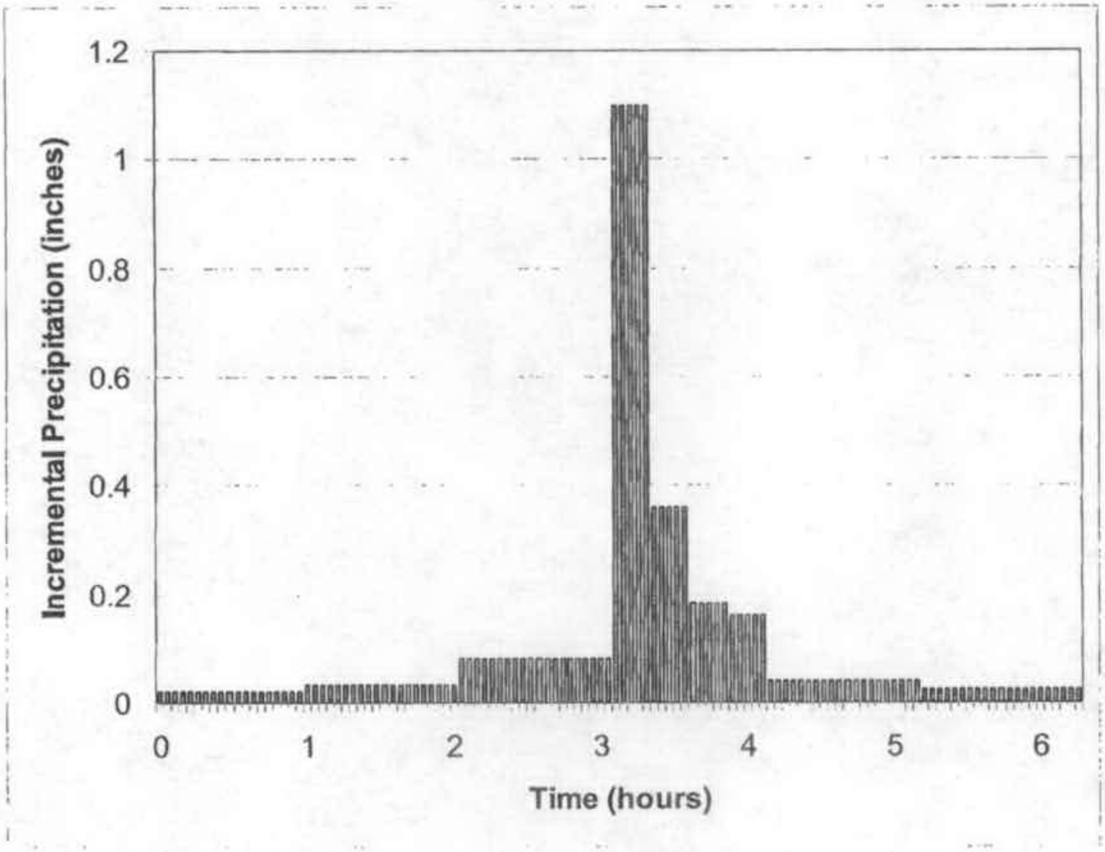
9. Time sequence of incremental PMP according to:

Used EM 1110-2-1411 COE
Method as in previous report
(Ref. 2.2.6, p. 16)

Hourly increments [table 4.7]. 0.4 0.6 1.5 9.0 0.9 0.5 in. (mm)

Four largest 15-min. increments [table 4.8]. 5.5 1.8 0.9 0.8 in. (mm)

PMP Hyetograph for the South Portal
(3-minute interval)



Attachment F
HEC-1 Schematic
000-CDC-MGR0-00100-000 -00A JLT
Page 1 of 2

```
                SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

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

   12         SB1
                V
                V
   31      SB1CP1
                .
                .
   34           .         SB2
                .           .
                .           .
   38         CP1............
                V
                V
   41      CP1CP2
                .
                .
   44           .         SB3
                .           .
                .           .
   48           .           .         SB4
                .           .           .
                .           .           .
   52         CP2........................
                V
                V
   55      CP2CP3
                .
                .
   58           .       AGING
                .           .
                .           .
   65         CP3............
                V
                V
   68      CP3CP4
                .
                .
   71           .         SB5
                .           .
                .           .
   76           .           .         SB6
                .           .           .
                .           .           .
   80         CP4........................
```

```
              V
              V
 83      CP4CP9
              .
              .
 86           .        SB13
              .           .
              .           .
 90           .           .         SB7
              .           .           V
              .           .           V
107           .           .      SB7CP5
              .           .           .
              .           .           .
110           .           .           .        SB8
              .           .           .           .
              .           .           .           .
114           .           .         CP5............
              .           .           V
              .           .           V
117           .           .      CP5CP6
              .           .           .
              .           .           .
120           .           .           .         SB9
              .           .           .           V
              .           .           .           V
124           .           .           .      SB9CP6
              .           .           .           .
              .           .           .           .
127           .           .           .           .        SB10
              .           .           .           .           .
              .           .           .           .           .
131           .           .         CP6........................
              .           .           V
              .           .           V
134           .           .      CP6CP7
              .           .           .
              .           .           .
137           .           .           .        SB11
              .           .           .           .
              .           .           .           .
141           .           .         CP7............
              .           .           V
              .           .           V
144           .           .      CP7CP8
              .           .           .
              .           .           .
147           .           .           .        SB12
              .           .           .           .
              .           .           .           .
151           .           .         CP8............
              .           .           V
              .           .           V
154           .           .      CP8CP9
              .           .           .
              .           .           .
157       CP9  ........................
```