STORMWATER PROJECT MANAGEMENT CONTINUITY PLAN
HOLLOMAN AIR FORCE BASE

WILL DESMARE
AIR COMBAT COMMAND

ABSTRACT

In order to effectively manage a stormwater program at an Air Force Base, as well as stay compliant with all federal, state, and local laws, such as the Clean Water Act, several activities have to be accomplished efficiently and often simultaneously. Some of these activities, like maintaining correct and accurate documentation, are on-going. While other activities, like construction site inspection, are intermittent. All of these activities take some form of training and guidance if they are to be done right.

The primary intent of this paper is to give an overview of these activities as well as list training courses that are available and recommended. Also listed is contact information for various subject matter experts in the realm of stormwater. This paper is divided into two categories. The first category pertains to the day-to-day stormwater program management at an Air Force Base. This category is further divided into those activities that pertain to maintaining compliance with the NPDES industrial multi-sector permit and those activities that have to be accomplished in order to maintain compliance with the NPDES construction permit. The second category describes what documentation must be maintained in order to have a successful stormwater program as well as stay in compliance with all laws pertaining to stormwater. Different forms of storage (i.e. electronic, paper, etc.) are also recommended for each type of documentation.

INTRODUCTION

The purpose of this continuity plan is to ensure that pertinent stormwater data, references, and documents are maintained and there is no loss of integrity for this information due to personnel absence or turnover. An additional goal of this plan is to provide direction to a new stormwater manager at Holloman Air Force Base on day-to-day stormwater activities. This plan addresses the two primary aspects of stormwater management, industrial and construction. There is also an Appendix detailing how all stormwater data, references and documents are to be maintained.

INDUSTRIAL

Stormwater Pollution Prevention Plan (SWPPP)

- Develop a new SWPPP per new EPA Multi Sector General Permit (MSGP) guidelines and requirements. The new MSGP is supposed to be issued by the EPA in late 2008.
- Submit an initial Notice of Intent (NOI) for the new SWPPP (resubmit or amend the NOI at change of command)
- Establish Pollution Prevention Core, Implementation, and Subject Matter expert Teams to develop and implement the new SWPPP. The implementation team will also be responsible for distribution of the new SWPPP.
- Train the Pollution Prevention Teams.
- Conduct/Supervise monthly (or as designated by SWPPP) facility inspections.
- Conduct a site compliance evaluation once a year. Annually document, validate and categorize all findings. For major validated findings, develop a project plan and apply for funding for long-term solutions. For minor validated findings, implement corrective actions.
- Six months after a site compliance evaluation, conduct an assessment of compliance improvements and determine if corrective actions are working

- Implement and monitor an employee training program. Verify training has been conducted for general base personnel. Review and update training materials for the general base population on an annual basis. Develop training materials for Unit Environmental Coordinators (UECs) and construction project managers.
- Oversee stormwater sampling program. Determine sampling requirements and parameters for each outfall. Validate sampling budget.
- Develop multiyear program management plan that addresses sampler repair and replacement, outfall maintenance, inlet grate repair and/or replacement, stormwater dumpster procurement and SWPPP revisions.
- Maintain the SWPPP. Make pen and ink changes to correct deficiencies. Issue a new revision when the base receives a new Wing Commander. When a new SWPPP is issued, EPA headquarters has to be notified.
- Monitor/perform visual outfall inspections quarterly.
- Monitor/perform outfall sampling activities quarterly.
- Submit Discharge Monitoring Reports (DMRs) following the first and second year of the permit period. DMRs are submitted to both the EPA and the State of New Mexico Environmental Department.
- Review, validate and implement corrective actions as required.
- SWPPP modifications must be made within 14 days of discovery of a deficiency.
- Best Management Practice (BMP) modification must take place before the next precipitation event (in all cases no later than 60days after discovery).
- Keep UECs up to date with respect to changes in the SWPPP. Ensure UECs have adequate stormwater information.
- Conduct Periodic review of state TMDLs for incorporation into SWPPP

Financial

- Manage Stormwater funds. Perform cost estimates and verify funding levels are adequate. Provide justification for funding levels in ACES on an annual basis
- Request new funding for emergent problems and long term solutions through ACES. Verify and monitor ACES input information.
- Procure stormwater equipment and supplies through ABSS
- Manage stormwater contracts and contractors. Oversee sampling activities. Validate contractor requirements and requests. Ensure adequate stormwater equipment and supplies are procured.

The Air Combat Command (ACC) contact regarding financing activities as well as technical aspects of stormwater management is:

Mr. Gary Nault
129 Andrews St, Suite 102
Langley VA, 23665-2769
(757)764-9308
Gary.nault@langley.af.mil

The Air Force Institute of Technology (AFIT) stormwater contact is:

GORDON R. TAYLOR, Maj, USAF
Course Director (Env Mgmt)
Air Force Institute of Technology
2950 Hobson Way
WPAFB, OH 45433-7765
(937) 255-5654 x3540
Gordon.Taylor@us.af.mil

The Air Force Regional Environmental Office (REO) stormwater contact is:

Susan Stell
Water Program Manager
AFCEE/TDC
Regional Environ. Office -Dallas
(214) 767-4650, Ext. 4070
Susan.stell@brooks.af.mil

Regulatory Authority

New Mexico does not have primacy with respect to NPDES legislation. The Environmental Protection Agency (EPA) Region 6 has regulatory authority over Holloman Air Force Base stormwater activities. However, all documentation and correspondence (such as NOIs, NOTs, Erosivity Waivers, etc.) are sent to EPA Headquarters in Washington DC. Holloman AFB processes NOIs and NOTs electronically through the EPA website. A listing of the NOIs, NOTs and Erosivity Waivers that Holloman has processed is available at the following EPA website:

http://cfpub.epa.gov/npdes/stormwater/noi/noisearch.cfm

All other EPA correspondence is sent via certified mail to the Headquarters address listed below. Questions concerning compliance issues should be addressed to Brent Larsen, EPA Region 6 stormwater officer. The Holloman JAG should be kept informed of all official conservations between HAFB and EPA Region 6.

The following are addresses, websites and phone numbers for regulatory contacts:

EPA NOI Processing Center
Operated by Avanti Corporation
1200 Pennsylvania Ave., NW
Mail Code: 4203M
Washington, DC
1-866-352-7755
http://cfpub.epa.gov/npdes/stormwater/enoi.cfm

EPA Region 6
Attn: Brent Larsen
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202
(214)665-7523
www.epa.gov/Region6

Even though New Mexico does not have primacy with respect to stormwater, there is a NM stormwater working group whose goal is to obtain primacy. The Holloman AFB storm water manager has volunteered to support this effort. The person in charge of this group is:

Marcy Leavitt, Chief
Surface Water Quality Bureau
New Mexico Environment Department (NMED)
P.O. Box 26110
Santa Fe, NM 87501
(505) 827-2795
marcy.leavitt@state.nm.us

Stormwater program manager training

At a minimum, the stormwater manager at Holloman should have the following training:

From AFIT:

- WENV 541, Water Quality Management
- WESS 030, Industrial Stormwater Management
- WENV 418, Environmental Contracting
- WENV 419, Environmental Planning, Programming, and Budgeting
- WESS 031, Construction Site Stormwater Management

From outside sources:

From Aarcher Institutes of Training (or equivalent):

- Stormwater Management: Permits and Plans
- SPCC Plans: A Practical Approach to Compliance

Aarcher Institute of Environmental Training, LLC
910 Commerce Road
Annapolis, MD 21401
(401)897-0037
www.aarcherinstitute.com

From StormCon (The North American Surface Water Quality Conference & Exposition):

- Certified Professional in Storm Water Quality
- Certified Professional in Erosion and Sediment Control

StormCon
PO Box 3100
Santa Barbara, CA 93130
(805)682-1300X129
www.StormCon.com

Other

Validate and resolve external ESOHCAMP (and other audit) findings. Participate in internal Holloman ESOHCAMP and TAE activities as a stormwater inspector.

Maintain appropriate records in accordance with Appendix A.

Participate in the Holloman Stormwater Working Group. Currently this consists of Holloman AFB, White Sands Missile Range, and NASA Test Facility. Future expansion plans include Kirkland and Cannon Air Force Bases as well as Los Alamos and Sandia National Laboratories. The goal of this working group is to share stormwater information and best practices among federal facilities.

CONSTRUCTION:

Work with Saber, Engineering Flight, tenets, The Corps of Engineers, AFCEE, and the Environmental Flight by reviewing construction and environmental remediation proposals and determine whether an ENOI, Erosivity Waiver or no Storm Water action is required.

Work with the contractor, contractor manager, Deputy Base Civil Engineer (DBCE), Wing Commander's Chief of Staff and the Judge Advocate General (JAG) to adequately process an Electronic Notice of Intent (ENOI) or Erosivity waiver in a timely manner.

For the NOI Process:

- Review and approve the contractors (SWPPP) for accuracy (i.e., erosion and sediment controls, inspection criteria, etc.)
- Work with the DBCE to obtain the certification page
- Work with the JAG and the Chief of Staff to obtain the Wing Commanders approval of the NOI.
- Work with the contractor to ensure their NOI and our NOI arrive at the EPA within one week of each other and 7 days prior to start of construction.
- Perform monthly walk thrus and inspections of the construction site to ensure the contractor is conforming to their own plan (i.e., BMPs are being implemented, followed and evaluated and the contractor is performing and documenting their own storm water inspections)
- When construction has been completed, verify that the site has been adequately restored and that the SWPPP documentation has been maintained.
- Work with the JAG and the Chief of Staff to obtain the Wing Commanders approval of the Notice of Termination (NOT).
- Work with the contractor to ensure their NOT and our NOT arrive at the EPA within one week of each other

For the Erosivity Process:

- Verify the Contractor's calculations, requirements, and parameters
- Work with the JAG and Chief of Staff to obtain the Wing Commanders Approval
- Work with the contractor to ensure their Erosivity Waiver and our Erosivity Waiver arrives at the EPA within one week of each other.
- Monitor the construction site to ensure the project does not exceed the time and size constraints
- Ensure the site has been adequately restored when the construction/remediation activities have been completed.

No stormwater actions are required when the total amount of land to be disturbed is less than one acre.

ANCILLARY NOTES:

1. It should take approximately eighteen months for a new person to become 95% acclimated to the stormwater position and be able to successfully manage this program.
2. Training depends upon funding levels. The AFIT courses are funded through AFIT. This includes travel expenses. AFIT does have the ability to fund non-AFIT classes if the proper justification can be provided.
3. Conduct periodic reviews of the Master sediment control plan.
4. The average tour for the JAG, Chief of Staff, and the Wing Commander is two years.

Stormwater Program Continuity File
Holloman Air Force Base
Appendix A

The purpose of this continuity filing system is to ensure that pertinent stormwater data, references, and documents are maintained and there is no loss of integrity for this information due to personnel absence or turnover.

This filing system consists of three tables. Table 1.0 contains the most important information such as permitting, training, and financial documents. Table 2.0 contains ancillary information that is needed on a daily basis such as project management plans and the sections of the Code of Federal Regulations (CFR) that are pertinent to stormwater operations. Table 3.0 consists of information that should be in the stormwater historical file.

Table 1.0 contains a listing of important stormwater data, references and documents as well as their respective storage requirements. These requirements are electronic, paper and an official filing system. Storage requirements are further broken down. For example, electronic storage requirements are broken down into DVD, flash drive, or Maxtor backup hard drive. It is the intent that both the Flight Chief and the Stormwater Program Manager each keep a copy of the DVD and flash drive. These will be backed up once every two weeks. For paper requirements, the intent is for a hard copy of the document to be kept in the Stormwater Program Manager's office. For the filing system category, the goal is to file either a DVD or a hardcopy of the document in the official office filling system. The specific section is listed for information for each document that has to be filed in this system.

Table 2.0 contains a listing of ancillary information that is pertinent for day-to-day stormwater operations. The storage requirements for these documents can be either paper or electronic. Paper copies are to be kept in the Stormwater Program Manager's office.

Table 3.0 contains a listing of information that should be kept in the Historical file. It is recommended that this information be kept as a paper copy in the storm water program manager's office or archived in a filing system in the restoration office. However, it is also recommended that the paper copies be scanned and converted into electronic PDF files and stored in either DVD or flash drive (these must also be kept in the stormwater program manager's office).

TABLE 1.0 – Important Stormwater Information

Subject	Electronic DVD	FD	HD	Paper	Filing/ System
SWPPP/Appendices	X	X	X	X	X[1]
Training Materials	X		X	X	
Training Videos	X		X		
Training Records				X[2]	X[3]
ESOHTN documentation			X		
Discharge Monitoring Reports				X	X
Sampling Frequencies & Parameters			X	X	
Technical Information on Stormwater samplers				X	
Comprehensive Site Compliance Evaluations			X	X	X
Outfall Inspection Sheets (Completed)				X	
Outfall Inspection Sheets (templates)		X	X	X	
UEC Information		X[4]	X		
Storm Water Maps		X	X		X
Inlet Survey		X[5]	X		
Aces/Financial Data		X	X		
MIPRs/SOWs		X	X	X	X
NOI/NOT/EROSIVITY Forms		X[6]	X	X	X
Sampling Information		X	X	X	
HAFB Construction Inspection Form		X	X		

TABLE 1.0 – Important Stormwater Information (Continued)

Subject	Electronic DVD	FD	HD	Paper	Filing/ System
Construction SWPPP Certification Letter				X	X
Construction SWPPPs	X[7]			X	
Construction Inspections				X[7]	
Sampling Data			X	X	X
Stormwater Email			X		
Stormwater working Group Email			X		
Stormwater ESOHCAMP	X		X	X	
NOI/NOT EXCEL Tracking Program	X		X	X	
Holloman Stormwater Construction Information	X			X	
List of Commonly Used Stormwater websites	X	X	X		
Storm Water Modeling Reports	X	X	X	X	
Master Sediment Control Plan	X		X	X	

1. Since this is an extremely large document, a DVD containing the SWPPP and Appendices will be placed in the official filing system. The hard copy will be kept in the Stormwater Program manager's office.
2. Once the ESOHTN system takes affect, all training documentation will be kept in that data base.
3. A letter will be placed in the official file indicating that these records are in the ESOHTN database.
4. Each Unit Environmental Coordinator (UEC) will also have a DVD with this information on it.
5. This is in EXCEL format only and contains a picture and description of every known inlet and outlet at Holloman Air Force Base.
6. This database is also available via the EPA website: http://cfpub.epa.gov/npdes/stormwater/enoi.cfm
7. These documents have to be kept for a minimum of three years.

TABLE 2.0 – Ancillary Information

Subject	Electronic	Paper
List of unique situations[1]	X	X
Project Management Plan[2]	X	X
Legal Correspondence		X
Stormwater Program Manager Training requirements and opportunities	X	X
Stormwater symposium presentations	X	X
40 CFR (Parts 87 to 135), Stormwater discharges	X	X

1. Such as additional inspection requirements associated with LF-01 (outfall #7)
2. Plan for on-going and future base stormwater improvements (i.e. grate and culvert maintenance, stormwater retention pond construction, etc.)

TABLE 3.0 – Historical File

Subject	Electronic	Paper
Past HAFB MSGP SWPPPs		X
Past Construction SWPPPs[1]		X
Pertinent Past Stormwater Manager Notes	X	
Past Correspondence with NMED/EPA	X	
Past Stormwater Staff Summary sheets	X	
State/EPA stormwater inspection results	X	
List of past Stormwater Managers & subcontractors, state & federal contacts & other base SW managers	X	

1. Only ones that were well written and can be used as examples for future use

Disclaimer
The opinions and conclusions in this paper are the author's alone and do not necessarily reflect those of the United States Air Force or the Federal Government.

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Holloman Air Force Base
Alamogordo, New Mexico

Final Drainage Report
DA001 Through DA004 and
DA009 Through DA011

June 6, 2006

US Army Corps
of Engineers ®

49th Fighter Wing

49th CES/CECN
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Holloman AFB, New Mexico 88330

Holloman Air Force Base, Alamogordo, New Mexico
Final Drainage Report
DA001 Through DA004 and DA009 Through DA011
June 6, 2006
49th Fighter Wing

NPDES COMPLIANCE PROGRAM
HOLLOMAN AIR FORCE BASE
ALAMOGORDO, NEW MEXICO

FINAL DRAINAGE REPORT
DA001 THROUGH DA004 AND DA009 THROUGH DA011

JUNE 6, 2006

Prepared For

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NOTICE

This Final Drainage Report has been prepared for the U.S. Army Corps of Engineers by CH2M HILL for the purpose of aiding in the design and implementation of an effective monitoring program under the National Pollutant Discharge Elimination System (NPDES) at Holloman Air Force Base, New Mexico. As the report relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final evaluation of the NPDES compliance monitoring program may be in the public's interest. The limited objectives of this study and the ongoing nature of the NPDES compliance monitoring, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this report, since subsequent facts may become known that may make this report premature or inaccurate.

Government agencies and their contractors registered with the Defense Technical Information Center should direct requests for copies of this plan to: Defense Technical Information Center, Cameron Station, Alexandria, Virginia 22304-6145.

Non-government agencies may purchase copies of this document from: National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

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This FInal Drainage Report is prepared to provide the results of a HEC-HMS analysis of 7 drainage areas for evaluation of and improvement to the NPDES monitoring program at Holloman Air Force Base, New Mexico.

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PREFACE

This Final Drainage Report has been prepared to present the results of a HEC-HMS drainage analysis conducted for DA001, DA002, DA003, DA004, DA009, DA010, and DA011 at Holloman Air Force Base (AFB). The drainage analysis was performed to gather sufficient data to evaluate the NPDES outfall monitoring points in each drainage area and quantify the design flows and outfall locations to improve the effectiveness of the NPDES compliance monitoring sytem. The plan addresses the preliminary drainage report requirements of the U.S. Army Corps of Engineers (USACE) statement of work, dated 30 September 2003.

This Final Drainage Report was prepared by CH2M HILL in June 2006. Mr. Coy Webb of the 49th Civil Engineering Squadron (CES/CEVN) was the initial base Point of Contact, with final Point of Contact being Mr. George Fish, and Mr. Thomas Zink of the USACE Omaha District served as the Contracting Officer's Representative.

Mike E. Brazie

Mike Brazie, P.E.
CH2M HILL Project Manager

Contents

Section **Page**

Executive Summary **ES-1**

1.0 Introduction **1-1**
1.1 Objectives and Scope 1-1
1.2 Project Approach and Methodology 1-2
1.2.1 Task 1 – Data Collection 1-2
1.2.2 Task 2 – Field Inspection 1-2
1.2.3 Task 3 – Drainage Analysis 1-2
1.2.4 Task 4 – Preliminary Drainage Report 1-4
1.3 Background 1-4

2.0 Drainage Area Descriptions 2-1
2.1 Drainage Area Boundaries 2-1
2.2 Drainage Area Descriptions 2-1
2.2.1 DA001 2-1
2.2.2 DA001-A 2-2
2.2.3 DA002 2-2
2.2.4 DA002-A 2-3
2.2.5 DA002-B 2-3
2.2.6 DA003 2-3
2.2.7 DA004 2-4
2.2.8 DA004-A 2-4
2.2.9 DA009 2-4
2.2.10 DA010 2-5
2.2.11 DA010-A 2-5
2.2.12 DA011 2-5

3.0 Hydrologic Analysis 3-1
3.1 Introduction to the Hydrologic Model 3-1
3.2 Drainage Area Delineation 3-1
3.3 SCS Curve Number 3-2
3.4 Precipitation Analysis 3-2
3.5 Control Specifications 3-2
3.6 Summary of Results Table 3-5

4.0 Drainage Analysis Results 4-1
4.1 Hydrology 4-1
4.2 Pollution Sources 4-3

Contents (continued)

Section **Page**

5.0 Conclusions and Recommendations 5-1
5.1 Conclusions 5-1
5.2 Evaluation of NPDES Compliance 5-1
5.3 Assumptions and Limitations 5-1
5.4 Recommendations 5-2

6.0 References 6-1

Appendices

Appendix A: SCS TR-55 Method

Appendix B: HEC-HMS Summary of Results

Contents (continued)

Tables **Page**

ES-1 HEC-HMS Model Results, Holloman AFB ES-2

3-1 Land Use and Curve Numbers, Holloman AFB 3-3

3-2 Condition Curve Numbers 3-4

3-3 6-Hour Frequency Storm Time Distribution 3-4

3-4 Drainage Area Attributes, Holloman AFB 3-6

4-1 HEC-HMS Estimated Peak Flows and Volumes 4-2

Contents (continued)

Figures **Page**

1-1 Drainage Areas, Holloman AFB 1-3

1-2 Holloman AFB and State of New Mexico 1-5

1-3 Holloman AFB and Local Community 1-5

2-1 DA001 2-7

2-2 DA001-A 2-9

2-3 DA002 2-11

2-4 DA002-A 2-13

2-5 DA002-B 2-15

2-6 DA003 2-17

2-7 DA004 2-19

2-8 DA004-A 2-21

2-9 DA009 2-23

2-10 DA010 2-25

2-11 DA010-A 2-27

2-12 DA011 2-29

5-1 DA011 Subdivision and Delineation 5-3

Acronyms and Abbreviations

ac-ft	acre-foot/feet
AFB	Air Force Base
AFFF	Aqueous Film Forming Foam
AFCEE	Air Force Center for Environmental Excellence
AFI	Air Force Instruction
cfs	cubic feet per second
CN	curve number
DA	drainage area
DRMO	Defense Reutilization and Marketing Office
EPA	U.S. Environmental Protection Agency
GAF	German Air Force
GIS	Geographic Information System
HAFB	Holloman Air Force Base
HEC	Hydrologic Engineering Center
HMS	Hydrologic Modeling System
HOB	Holloman-Gypsum land-Yesum complex
HSG	hydrologic soil group
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PVC	polyvinyl chloride
SOW	Statement of Work
SPCC	Spill Prevention, Control, and Countermeasure
SCS	Soil Conservation Service
SWPPP	Storm Water Pollution Prevention Plan
USACE	U.S. Army Corps of Engineers

Executive Summary

CH2M HILL has prepared this Final Drainage Report to support the evaluation and improvement of the National Pollutant Discharge Elimination System (NPDES) outfall monitoring program at Holloman Air Force Base (AFB), New Mexico. Regulations pursuant to NPDES require that facilities prepare Storm Water Pollution Prevention Plans (SWPPPs) in accordance with "good engineering practices" and to "describe and ensure implementation of practices which will be used to reduce the pollutants in storm water discharges".

The primary mechanism to reduce pollutants in storm water is to minimize or eliminate contact of storm water with pollutant materials. Storm-water discharges also are to be monitored at outfalls from the drainage areas. To effectively meet these requirements, Holloman AFB needs an engineering basis to quantify the design storm discharges from each drainage basin. In addition, the storm-water flow paths need to be determined to ensure that proper procedures are implemented to minimize contact of storm water flows with pollutant sources, and storm-water outfall locations need to be identified to ensure the outfall water quality monitoring systems are in the appropriate locations.

To estimate storm-water flows, a drainage analysis was conducted to quantify the storm-water runoff for the 10-year, 25-year, and 100-year, 6-hour design storms for drainage areas (DAs) DA001, DA002, DA003, DA004, DA009, DA010, DA011, and their contributing run-on areas DA001-A, DA002-A, DA002-B, DA004-A, DA010-A. This was done using the HEC-HMS model. Drainage areas were delineated and model input parameters obtained from survey data provided by Holloman AFB. The purposes of this report are: to provide Holloman AFB with peak discharge and runoff volumes for each DA; to identify potential pollution sources for compliance with NPDES regulations; and to recommend any changes to the outfall monitoring locations that might be appropriate, based on the model results.

The hydrological analysis was performed using geospatial, soil, and climatological data provided by Holloman AFB. These data were analyzed with the Soil Conservation Service (SCS) Curve Number (CN) and TR-55 methods and incorporated into HEC-HMS Version 3.0.0 to calculate the peak flows and volumes for each DA and each design storm. The model results are summarized in Table ES-1.

TABLE ES-1
HEC-HMS Model Results, Holloman AFB

Drainage Area (DA)	Peak Discharge, Q_p (cfs)		Volume, V (ac-ft)		Drainage Area (DA)	Peak Discharge, Q_p (cfs)		Volume, V (ac-ft)	
DA001	Q_{10} =	200.31	V_{10} =	31.614	DA004	Q_{10} =	133.35	V_{10} =	26.637
DA001	Q_{25} =	240.64	V_{25} =	38.497	DA004	Q_{25} =	169.09	V_{25} =	33.986
DA001	Q_{100} =	322.83	V_{100} =	49.134	DA004	Q_{100} =	238.41	V_{100} =	45.731
DA001-A	Q_{10} =	8.7570	V_{10} =	2.1618	DA004-A	Q_{10} =	3.0957	V_{10} =	1.1025
DA001-A	Q_{25} =	13.575	V_{25} =	3.3574	DA004-A	Q_{25} =	6.0371	V_{25} =	2.1125
DA001-A	Q_{100} =	25.121	V_{100} =	5.7472	DA004-A	Q_{100} =	12.914	V_{100} =	4.2735
DA002	Q_{10} =	84.940	V_{10} =	10.303	DA009	Q_{10} =	5.5123	V_{10} =	0.34377
DA002	Q_{25} =	107.73	V_{25} =	13.208	DA009	Q_{25} =	6.8845	V_{25} =	0.43493
DA002	Q_{100} =	153.77	V_{100} =	17.820	DA009	Q_{100} =	9.8011	V_{100} =	0.57897
DA002-A	Q_{10} =	2.2152	V_{10} =	0.52235	DA010	Q_{10} =	1.2254	V_{10} =	0.37536
DA002-A	Q_{25} =	3.5373	V_{25} =	0.83025	DA010	Q_{25} =	3.1814	V_{25} =	0.95159
DA002-A	Q_{100} =	6.6757	V_{100} =	1.4418	DA010	Q_{100} =	8.1492	V_{100} =	2.2519
DA002-B	Q_{10} =	0.7040	V_{10} =	0.18721	DA010-A	Q_{10} =	0.49732	V_{10} =	0.10722
DA002-B	Q_{25} =	1.4174	V_{25} =	0.36532	DA010-A	Q_{25} =	1.0605	V_{25} =	0.21710
DA002-B	Q_{100} =	3.2511	V_{100} =	0.75556	DA010-A	Q_{100} =	2.5787	V_{100} =	0.45920
DA003	Q_{10} =	26.706	V_{10} =	1.8181	DA011	Q_{10} =	32.842	V_{10} =	1.7338
DA003	Q_{25} =	34.217	V_{25} =	2.3528	DA011	Q_{25} =	40.377	V_{25} =	2.1604
DA003	Q_{100} =	50.127	V_{100} =	3.2124	DA011	Q_{100} =	60.191	V_{100} =	2.8396

Note: ac-ft = acre-feet.
cfs = cubic feet per second.

Based on these results, CH2M HILL concludes the following:

1. DA001, DA002, and DA004 have the potential for localized flooding, although the duration of peak flow will be relatively short.
2. The outfall monitoring locations 002, 003, 004, 009, and 010 appear to be appropriate for monitoring storm-water quality from the respective DAs.
3. Discharge from DA010-A contributes a significant portion of the total flow from DA010. At the time of this report, DA101-A is primarily composed of undeveloped land. However, should DA010-A be developed in the future, it could have the potential for contributing a significant portion of pollutants into DA010.
4. There are multiple drainage patterns within DA011 and the existing outfall 011 does not monitor all of the storm water leaving that basin. DA011 could be better modeled with subbasins or breaking it onto two separate DAs.
5. The DAs having the greatest potential for storm-water pollution are DA001, DA002, DA003, and DA004, due to the nature of activities conducted within those basins and the hydrologic characteristics of those basins.

6. Holloman AFB appears to comply with the requirements of the Multi-Sector General Permit.

CH2M HILL recommends the following:

1. The existing DAs are appropriately delineated with the exception of DA001 and DA011. DA001 was delineated prior to the analysis to compensate for improvements to the tarmac and to align it with site contours.

2. DA011 should be further analyzed with subbasins or redefined as multiple DAs. During the analysis, it was noted that the DA has flow in multiple directions. The existing delineation includes the entire adjacent tarmac, but the contours reveal that water flows to the northwest just beyond Buildings 577 and 578, necessitating the need to re-delineate the DA, subdivide, or eliminate. In addition, this DA has two outfalls. The existing or defined outfall is where the storm drain discharges the collected water from the paved parking areas and streets, which is necessary to maintain; however, there also is a natural outfall that is located along the southernmost boundary of the DA that discharges overland flow from the southern portion of the DA. Based on these findings it is recommended that DA011 be subdivided into two separate basins, and re-delineated (see Figure 5.1). Building 577, the parking areas and streets, and the northeastern portion should be its own entity for demonstration purposes of DA011-A. The adjacent area to the west, including Buildings 578 and 579 would be the other subdivided area, while the northwestern portions would be eliminated.

3. Additional drainage analyses should be conducted to determine the influence of the existing storm drains and potential flooding. Backwater from inadequate storm drains may have the potential to flood developed areas and increase the potential for storm-water pollution. Some of the outfall monitoring points have been located where storm drains are assumed to discharge. But if those drains are overtopped, the storm water may bypass the outfall monitors.

1.0 Introduction

CH2M HILL has prepared this Final Drainage Report to describe the procedures and results of a drainage analysis performed at seven drainage areas within Holloman Air Force Base (AFB). This study was conducted to provide a basis for evaluating and improving the storm water pollution prevention and National Pollutant Discharge Elimination System (NPDES) compliance activities at the base. This study has been performed concurrently with the work of another contractor at the base, who is analyzing seven other drainage areas on base.

1.1 Objectives and Scope

The U.S. Environmental Protection Agency (EPA) NPDES Storm Water Phase I Program and the Final Reissuance of NPDES Storm Water Multi-Sector General Permit for Industrial Activities (EPA, 2000) require that industrial facility Storm Water Pollution Prevention Plans (SWPPPs) be prepared in accordance with good engineering practices and "describe and ensure implementation of practices which will be used to reduce the pollutants in storm water discharges" (*Federal Register*, Volume 65, No. 210/4.1.2).

The primary mechanism to reduce pollutants in storm water is to minimize or eliminate contact of storm water with potential pollutant materials. Routine monitoring of storm-water outfalls at Holloman AFB have indicated intermittent, yet regular, exceedances of EPA benchmark concentrations for various compounds. These exceedances are likely related to unidentified and uncontrolled contact of storm water with different permanent and transient pollution sources as a result of localized flooding.

Another requirement of the NPDES Phase I Program is to include, in a facility SWPPP, maps showing storm-water flow directions. The available topographic data, drainage characteristics, and other hydrologic information regarding capacity of existing storm-water management structures at Holloman AFB have been insufficient to provide appropriate mapping for this purpose. Coverage under the Multi-Sector General Permit also requires a certification that storm water discharges "pose no jeopardy to endangered or threatened species".

In the absence of adequate storm-water drainage data and evaluation of storm-water structures, and considering the regular occurrence of benchmark water quality exceedances, it has been difficult to assess the appropriateness of making such a certification for Holloman AFB. All of these issues expose Holloman AFB to potential Notices of Violations and the possibility the base may no longer be considered eligible for coverage under the Multi-Sector General Permit.

Additionally, information regarding facility storm-water drainage, capacity, and flow directions is required in development of plans to address the EPA Spill Prevention, Control, and Countermeasure (SPCC) rule. And finally, Air Force Instruction (AFI) 32-7041, Water Quality Compliance directs compliance with NPDES storm-water regulations and general nonpoint pollution source control. These various regulatory programs and directives

necessitate Holloman AFB have sufficient knowledge, data, mapping, and evaluation of the base's storm-water drainage system. This information is needed not only to comply with regulatory and Air Force directives, but also to be protective of the environment and government property.

The foundation of controlling and managing storm water is to understand facility drainage and have in place adequate and properly located storm-water management facilities. To address these needs, CH2M HILL performed a drainage analysis and prepared this Drainage Report for Drainage Areas DA001, DA002, DA003, DA004, DA009, DA010, and DA011 at Holloman AFB. The drainage analysis has delineated drainage patterns, developed design storm hydrographs, qualitatively assessed existing drainage structures, and estimated storm-water flow paths and distances relative to waters of the United States. These results can provide a basis for future storm-water management programs at Holloman AFB.

1.2 Project Approach and Methodology

This project has been implemented with four tasks in accordance with the September 26, 2003 Statement of Work (SOW). CH2M HILL has analyzed seven of the drainage areas (DAs) at Holloman AFB. A concurrent study by another contractor has performed a similar analysis of an additional seven DAs. CH2M HILL has coordinated this project with the concurrent project so the results of both studies taken together can provide the basis for a basewide SWPPP.

1.2.1 Task 1 – Data Collection

CH2M HILL collected and reviewed the available hydrologic data, including previous drainage studies, for Holloman AFB. Design storms, soil characteristics, and other site information were collected from published and publicly available sources. Topographic, geospatial, and site development data were provided by the base.

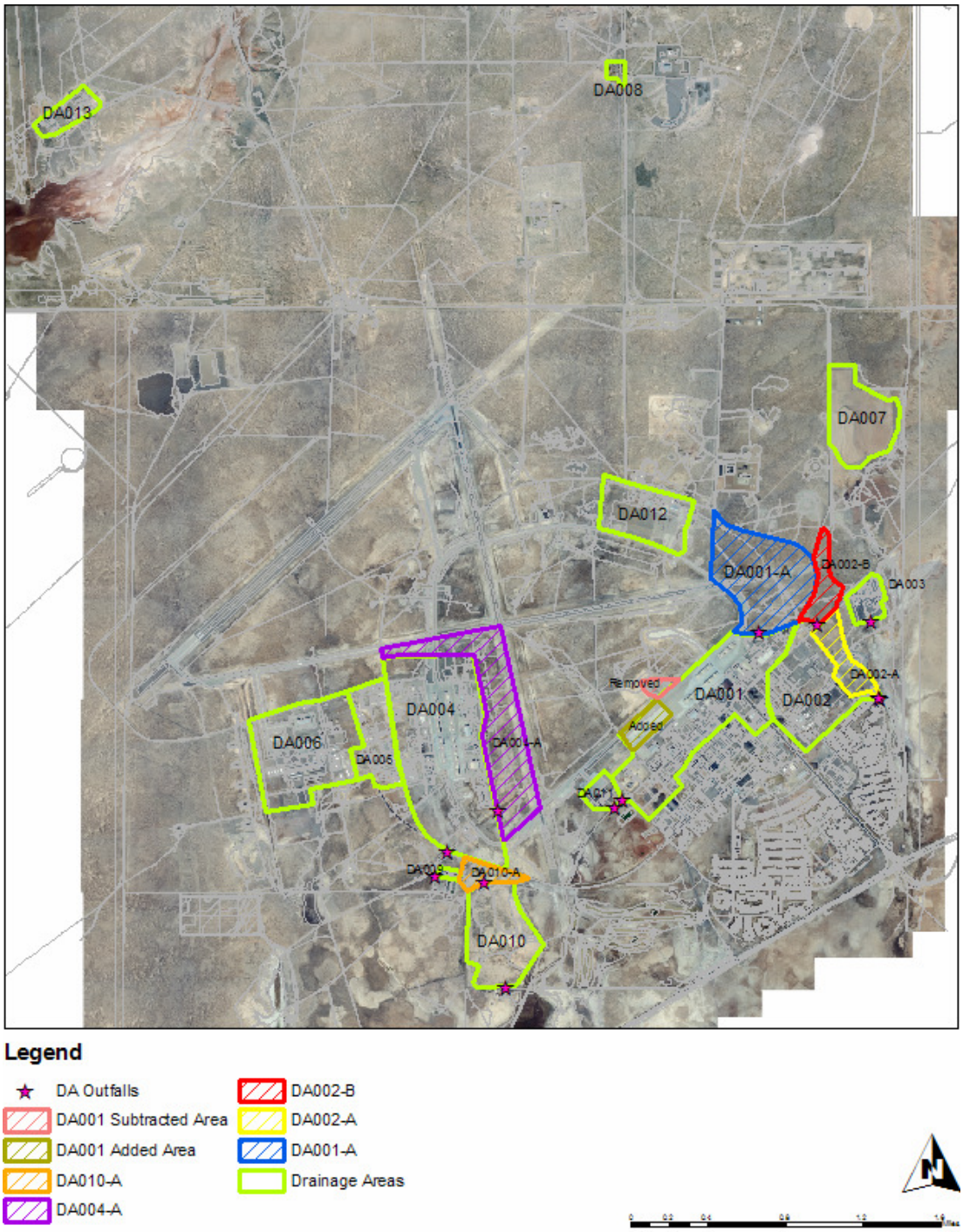
1.2.2 Task 2 – Field Inspection

CH2M HILL performed two field site visits to examine the characteristics of each of the seven DAs and determined the land use and potential pollution sources within each DA. The outfall points and field monitors also were observed during the site visits. These visits were conducted with representatives of Holloman AFB, who described the storm-water issues of concern to the base.

1.2.3 Task 3 – Drainage Analyses

The hydrologic analyses were performed on predefined DAs at Holloman AFB, although the basin delineations were re-evaluated as part of these analyses. CH2M HILL analyzed DA001, DA002, DA003, DA004, DA009, DA010, and DA011 (Figure 1-1). In addition, areas that produced run-on to these DAs were included in the analysis.

Figure 1-1
Drainage Areas, Holloman AFB



The DAs were analyzed using the U.S. Army Corp of Engineer's HEC-HMS, hydrologic modeling system software (2003). Required data were provided by Holloman AFB, which included geospatial, soil, and climatological data.

1.2.4 Task 4 – Preliminary Drainage Report

This report is the Final Drainage Report, constituting the final task of the contract SOW. This report discusses the methodology used in the study, provides the results of the drainage analysis, and provides recommendations for improving storm-water compliance at Holloman AFB.

1.3 Background

Holloman AFB is located in northwestern Otero County, New Mexico, on the north side of U.S. Highway 70 and 9 miles west of the City of Alamogordo (Figures 1-2 and 1-3). This area is a region of limited elevation relief. The terrain where most base activities occur ranges in elevation from 4,110 feet to 4,034 feet above mean sea level, and results in very low slopes on the order of 0.45 percent.

Holloman AFB is located within the central Tularosa Basin, which is a closed structural basin formed by a down-dropped fault block between the San Andres Mountains to the west and the Sacramento Mountains to the east. The basin contains a thick sequence of alluvial and lacustrine deposits of Tertiary and Quaternary age, most of which are saturated with saline water (Orr and Myers, 1986).

Soils throughout the entire basin area are of the Holloman – Gypsum land – Yesum complex, as further discussed in Section 3 of this report. This complex consists of well-drained soils and areas of exposed gypsum. These soils formed in alluvial and eolian gypsiferous sediment (Resource Technology, Inc., 1989). Typically, the surface soil layer is very fine sandy loam. Permeability is moderate, and available water capacity is very low.

The soil at Holloman AFB is predominately silty sand with minor clay content, and has moderate infiltration rates and low runoff. Vegetative cover is primarily desert sagebrush with grass understory in fair condition, and has an approximate cover density of 30 percent. Six of the seven DAs analyzed in this study are located in areas of high commercial or industrial activities. Building aesthetics are typically complemented with artificial desert landscape. The remaining DA is mainly desert sage.

Holloman AFB is located in a semi-arid region of south-central New Mexico. The average annual temperature is 62°F, and the normal annual precipitation is 11.39 inches. Extreme weather conditions coupled with the characteristic low slopes produce the potential for flooding and/or ponding of water. The Tularosa Basin also receives runoff from the surrounding mountains.

Figure 1-2
Holloman AFB and State of New Mexico

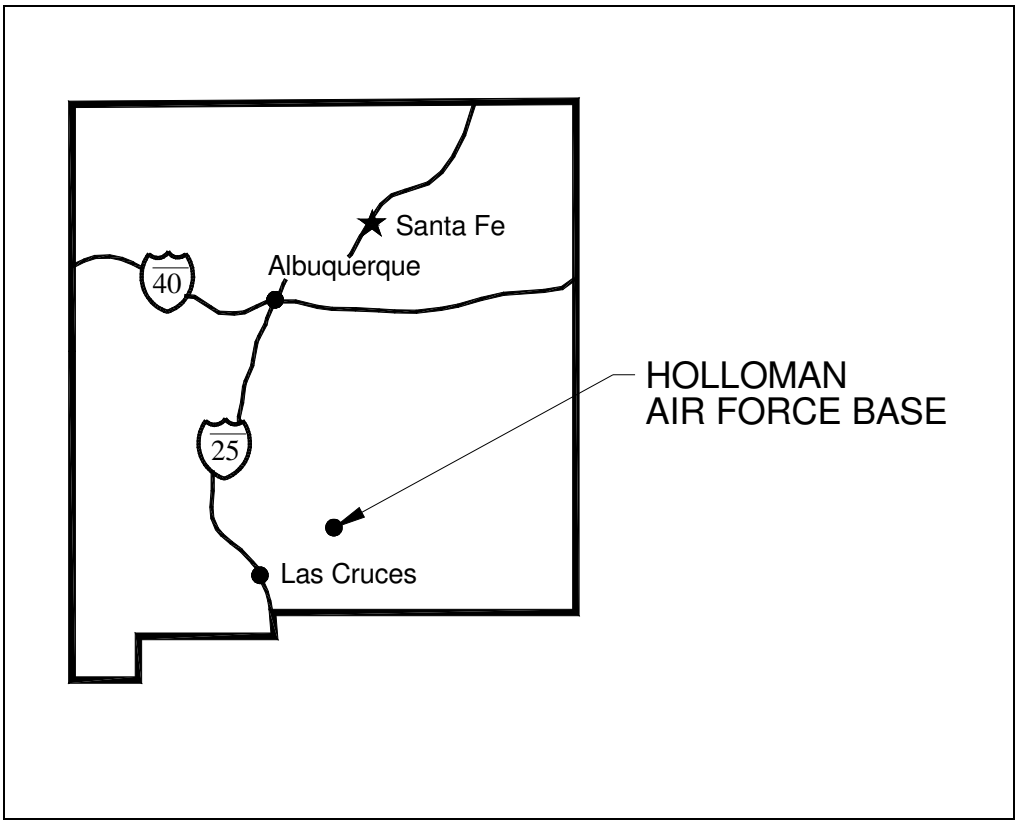
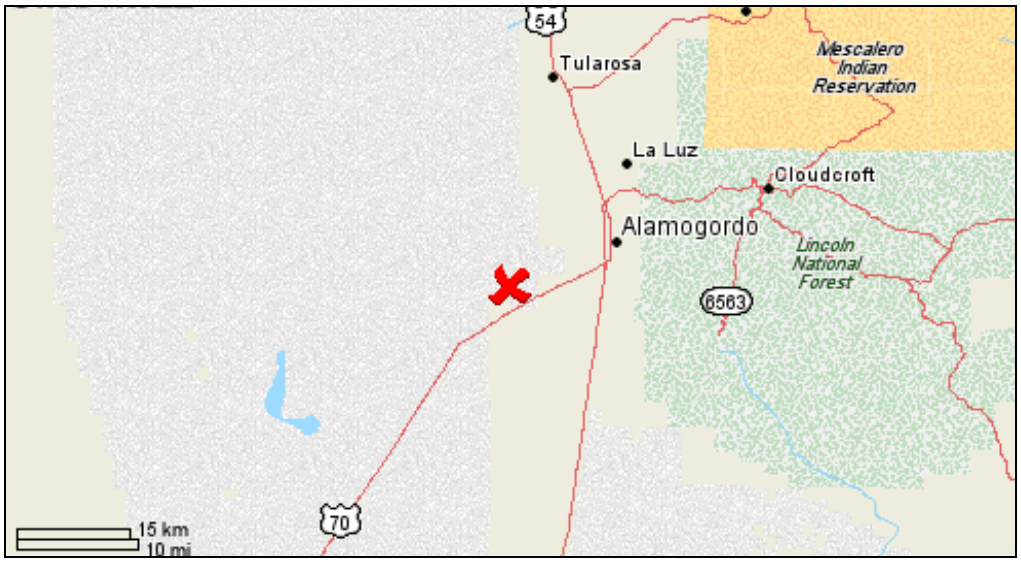


Figure 1-3
Holloman AFB and Local Community



2.0 Drainage Area Descriptions

2.1 Drainage Area Boundaries

All drainage area boundaries remained as previously defined by base personnel, with the exception of DA001. It appears that this DA had improvements to the tarmac, which required a revised delineation to account for these improvements. Also, an area west of the tarmac was eliminated; the contour lines indicated that water flows to the west and does not contribute to DA001. Figures 2-1 through 2-12 illustrate the DAs. In addition, potential contributing areas were included in the analysis, but were modeled as individual DAs. These areas have been identified as DA001-A, DA002-A, DA002-B, DA004-A, and DA010-A, and are named after the DA they potentially impact. There was no change in the location of outfalls.

2.2 Drainage Area Descriptions

This section gives a description of each DA, and serves as a basis for determining the input parameters that were used in the HEC-HMS model. Also, it summarizes the facilities and potential pollution sources in each DA.

2.2.1 DA001

This DA is centrally located with respect to all base activities, and has a land use classification of high urban (see Figure 2-1). The DA serves as a focal point for typical flightline activities, which are mostly comprised of commercial and industrial operations. Through the use of Geographic Information Systems (GIS) and knowledge of base activities, CH2M HILL has determined that the DA is 30 percent commercial, 17 percent industrial, 3 percent urban residential, 5 percent asphalt streets, and 40 percent paved parking areas for privately owned vehicles, and both government owned vehicles and aircraft. The remaining area was determined to be 3 percent artificial desert landscape and 2 percent desert sage in fair condition. This area is equipped with a network of storm drains that collect storm water throughout the DA and discharge at the DA's natural outfall, which is at its southwestern boundary. From there the water flows along drainage ditches to open desert shrubland that may or may not be saturated. It was determined to be approximately 45 percent impervious, 12 percent from structures, and 33 percent from concrete or paved structures. Elevation from outfall to divide ranges from 4,058 to 4,092 feet above sea level, a total of 34 feet of relief.

Industrial facilities subject to storm-water pollution prevention rules include the Main Flightline, Auto Craft Shop, Vehicle Operations, Aerospace Ground Equipment Refueling, Fuel Hangar (Building 315), Base Supply, Aero Club, and the Test Cell. This drainage area discharges to Outfall 001, which is fitted with an ISCO brand auto sampler. This sampler collects water samples from first-flush rainfall at the end of the storm drain under Delaware

Drive. Samples are visually inspected quarterly and the outfall is periodically monitored for contamination that may have resulted from any of the facilities that lie within DA001. The main potential pollution sources at the facilities within DA001 include fuels (JP-8, AVGAS, diesel, and unleaded gasoline), vehicle fluids (motor oil, lubricants, hydraulic fluid, antifreeze), solvents and cleaning agents, paint and thinners, adhesives, and detergents.

Much of the area within DA001 is paved streets or parking lots. Most of the open areas are naturally vegetated or xeriscaped with gravel and native plant species to help reduce erosion and increase aesthetics. Most storm-water runoff within this basin originates as sheet flow that flows into the streets. Street flow enters storm drains, and there are approximately 106 storm drain inlets in DA001 (CH2M HILL, 2005). The two principal storm drains are an underground line beneath Delaware Drive, which discharges at Outfall 001, and a polyvinyl chloride (PVC) storm drain fed by a box culvert, drop inlets, and strip drains, which runs from the German Air Force (GAF) hangars west to 11th Street, and then south to intercept the Delaware Drive drain at Outfall 001. Discharge from Outfall 001 flows to an open channel that flows south and west for more than a mile to the constructed wetlands and periodically discharges to Lake Holloman more than 2 miles away (CH2M HILL, 2005).

2.2.2 DA001-A

DA001-A directly contributes run-on to DA001 from its adjacent location, which is at the north end of the tarmac (see Figure 2-2). The area is a clear-zone for aircraft preparing to take flight or land, and has an associated land use classification as desert shrubland. The land is comprised of 93 percent desert sage in fair condition and 7 percent concrete structure (flightline). The outfall occurs in the middle of the northern edge of DA001. It was determined to be 7 percent impervious with elevation ranging from 4,086 to 4,109 feet, a total of 23 feet of relief.

2.2.3 DA002

This DA is located southeast of DA001 (see Figure 2-3). It is centrally located and has a land use classification of high urban. The area serves as a commercial business center for base personnel, and was determined to be 40 percent commercial, 10 percent industrial, 32 percent streets and parking, 3 percent artificial desert landscaping, and 15 percent desert sage. This area is equipped with a network of storm drains that collect storm water throughout the DA and discharge it at the DA's outfall. From there the water flows down a natural channel until it reaches Dillon's Draw, which is a main watershed channel that flows along the base's eastern border to the south and then turns toward the southeast, leaving the confines of the base. It was determined to be approximately 20 percent impervious, 7 percent from structures, and 13 percent from concrete or paved structures. Elevation from outfall to divide ranges from 4,078 to 4,092 feet, a total of 14 feet of relief.

Industrial facilities within DA002 subject to the storm-water pollution prevention rules include the Base Supply Storage Yard, Base Transportation, Civil Engineering, Defense Reutilization and Marketing Office (DRMO), Entomology, GAF facilities, and a 90-day storage area for hazardous waste. This drainage area constitutes a large portion of the main developed area of the base, including many office buildings and support service facilities.

Runoff from this basin drains to Outfall 002, which is periodically monitored and tested for contamination that may have resulted from contact with the facilities within the basin.

The principal potential pollution sources from facilities within DA002 include fuels (diesel and unleaded gasoline), vehicle fluids (oil, lubricants, hydraulic fluid, antifreeze), insecticides, herbicides, solvents and cleaning agents, paints and thinners, adhesives, Aqueous Film Forming Foam (AFFF), and detergents. A portion of the DRMO and 90-day storage area fall under the classification of industrial Sector K, Hazardous Waste Treatment, Storage, or Disposal Facilities, but they are state-of-the-art facilities with no potential for exposure to storm water (CH2M HILL, 2005).

Much of the basin is developed, including buildings, streets, and parking lots. Most of the open areas are minimally vegetated or xeriscaped with gravel and native plant species to help reduce erosion and enhance aesthetics. The basin contains a storm drain, with approximately 41 inlets that discharges into Dillard Draw (CH2M HILL, 2005).

2.2.4 DA002-A

This DA indirectly contributes to DA002 as it shares its western boundary (see Figure 2-4). It has no influence on DA002 itself, but it shares the same outfall. This shrubland area is mainly open desert sage or artificial landscape, 94 percent in fair condition, with the remaining 6 percent being paved streets and parking areas. It was determined to be 6 percent impervious, with elevation ranging from 4,078 to 4,092 feet, a total of 14 feet of relief.

2.2.5 DA002-B

This DA has the potential to contribute to both DA002 and DA002-A, but more than likely it will impact DA002-A, which shares the same outfall as DA002 (see Figure 2-5). This area has a land use classification as desert shrubland, and is comprised of 98 percent desert sage in fair condition, 1 percent commercial, and 1 percent paved parking. It was determined to be 2 percent impervious, with elevation ranging from 4,090 to 4,102 feet, a total of 12 feet of relief.

2.2.6 DA003

DA003 serves as the fuel storage area for the base flight activities (see Figure 2-6). Fuel tanks are surrounded by dike systems that will hold the contents of the storage tanks in the event of a fuel spill. It is located near the eastern boundary of the base and is surrounded by desert sage. The land use classification is high urban, mainly due to the 30 percent industrial area, and 24 percent paved streets and parking areas. The remaining 46 percent is either artificial desert landscape or desert sage. The area has several small culverts that route the runoff to its outfall located in the middle of the southern boundary. The flow is then overland sheet flow through desert shrubland until it reaches Dillard Draw. It was determined to be approximately 24 percent impervious, 11 percent from structures, and 13 percent from concrete or paved structures. Elevation from outfall to divide ranges from 4,088 to 4,098 feet, a total of 10 feet of relief.

DA003 constitutes a large portion of the Fuels Storage on base. Storm-water discharges from this basin drain to Outfall 003, which is periodically monitored and tested for

contamination. The principal potential pollution sources are antifreeze, lubricants, heating oil, and fuels (JP-8, diesel, and unleaded gasoline). Much of the DA is paved, but most of the open areas are xeriscaped or graveled to minimize erosion and improve aesthetics.

2.2.7 DA004

DA004 is located to the southwest of the two major flightlines, and serves as focal point for tactical fighter operations and maintenance (see Figure 2-7). Its land use classification is high urban, and is comprised of 31 percent commercial and industrial activities, 26 percent streets and paved parking, and 43 percent artificial desert landscape and desert sage. The area has a network of storm drains that collect runoff and discharge it into a trapezoidal channel that routes the water to its outfall, which is located at the middle of its southernmost border. The flow then enters open desert shrubland that may or may not be saturated. It has been determined that the area is 33 percent impervious, 7 percent from structures, and 26 percent from streets and paved parking areas. Elevation from outfall to divide ranges from 4,042 to 4,064 feet, a total of 22 feet of relief.

Classified industrial facilities within DA004 include Hazmat, Sound Suppressors, and the Stealth Squadron. These activities are housed within several buildings within DA004. Much of the DA is developed and paved. Most open areas are graveled or vegetated with natural plant species. Potential pollution sources within DA004 include fuels (JP-8, AVGAS, diesel, unleaded gasoline), lubricants, solvents and cleaning agents, paints and thinners, adhesives, AFFF, and detergents.

There are four storm drain inlets in DA004. These discharge through a culvert at Outfall 004 to a jurisdictional wetland area. Storm water also drains from the southern portion of the base runways, which also discharge through the culvert at Outfall 004.

2.2.8 DA004-A

This DA directly contributes to DA004 (see Figure 2-8). Collected runoff flows south along the eastern edge of DA004 to its outfall, which is a large culvert located at the southern end of the eastern commercial buildings. Its designated land use is desert shrubland, which is comprised of 98 percent desert sage in fair condition and 2 percent paved parking areas. It was determined that the area is 2 percent impervious, and elevation from outfall to divide ranges from 4,045 to 4,068 feet, a total of 23 feet of relief.

2.2.9 DA009

DA009 contains the base's Wastewater Treatment Plant facilities, and is located to the south-central of all base activities (see Figure 2-9). The designated land use is high urban, and is comprised of 23 percent industrial, 8 percent streets, and 69 percent artificial desert landscape. The DA outfall is located at the southwestern corner of the DA, and discharges to open desert shrubland that may or may not be saturated. It has been determined that the area is 31 percent impervious, 23 percent from structures, and 8 percent from streets. Elevation from outfall to divide ranges from 4,040 to 4,042 feet, a total of 2 feet of relief.

DA009 consists of the base Wastewater Treatment Plant, much of which is paved. The open areas are generally graveled, although some areas are naturally vegetation. Drainage from this basin is relatively small compared with the other drainage areas. Storm water from this

basin discharges at Outfall 009 through a culvert to a jurisdictional wetland. The areas around the Wastewater Treatment Plant are drained by two surface ditches, which discharge to the wetland.

2.2.10 DA010

This DA is located in the south-central area of all base activities, and has a land use classification of desert shrubland (see Figure 2-10). It is 100 percent desert sage in fair condition, and 0 percent impervious. The DA outfall is located at the right one-third of the southern boundary. The discharge is overland sheet flow through open desert shrubland prior to reaching the base lake area. Elevation from outfall to divide ranges from 4,031 to 4,040 feet, a total of 7 feet of relief.

DA010 contains the old Wastewater Treatment Plant lagoons, which have been capped with clay material. These six lagoons were formerly used to treat the base's domestic sewage and discharges from the oil/water separators. The lagoons were drained, capped, and graded with a slope of less than 0.5 percent. Much of the area is moderately vegetated, with some erosion control gravel and native plant species placed to reduce erosion. Storm water from DA010 discharges by sheet flow to a drainage ditch, which in turn discharges to Lake Holloman.

2.2.11 DA010-A

DA010-A directly contributes to DA010, and is located to the east of DA009 and north of DA010 (see Figure 2-11). The designated land use classification is desert shrubland, and is comprised of 98.4 percent desert sage in fair condition. The area is 1.6 percent impervious, 0.3 percent from structures, and 1.3 percent from paved parking areas. The DA outfall is located near the middle of the northern boundary of DA010. Elevation from outfall to divide ranges from 4,040 to 4,043 feet, a total of 3 feet of relief.

2.2.12 DA011

This DA is located to the southwest of DA001, and has a land use classification of high urban (see Figure 2-12). The area is comprised of 12 percent commercial, 12 percent streets, 28 percent paved parking, 14 percent artificial desert landscape, and 34 percent desert sage in fair condition. The DA outfall is near the middle of the southeastern boundary. The area has a small network of storm drains that collect runoff and discharge it at the DA's outfall. The discharge is in a natural channel that flows southerly until it reaches open desert shrubland that may or may not be saturated. Elevation from outfall to divide ranges from 4,054 to 4,061 feet, a total of 7 feet of relief.

DA011 includes the T-38 Operations, a developed portion of the base with paved streets and parking lots. There are three storm drain inlets, and storm water discharges through a culvert to a drainage ditch, which in turn discharges to Lake Holloman.

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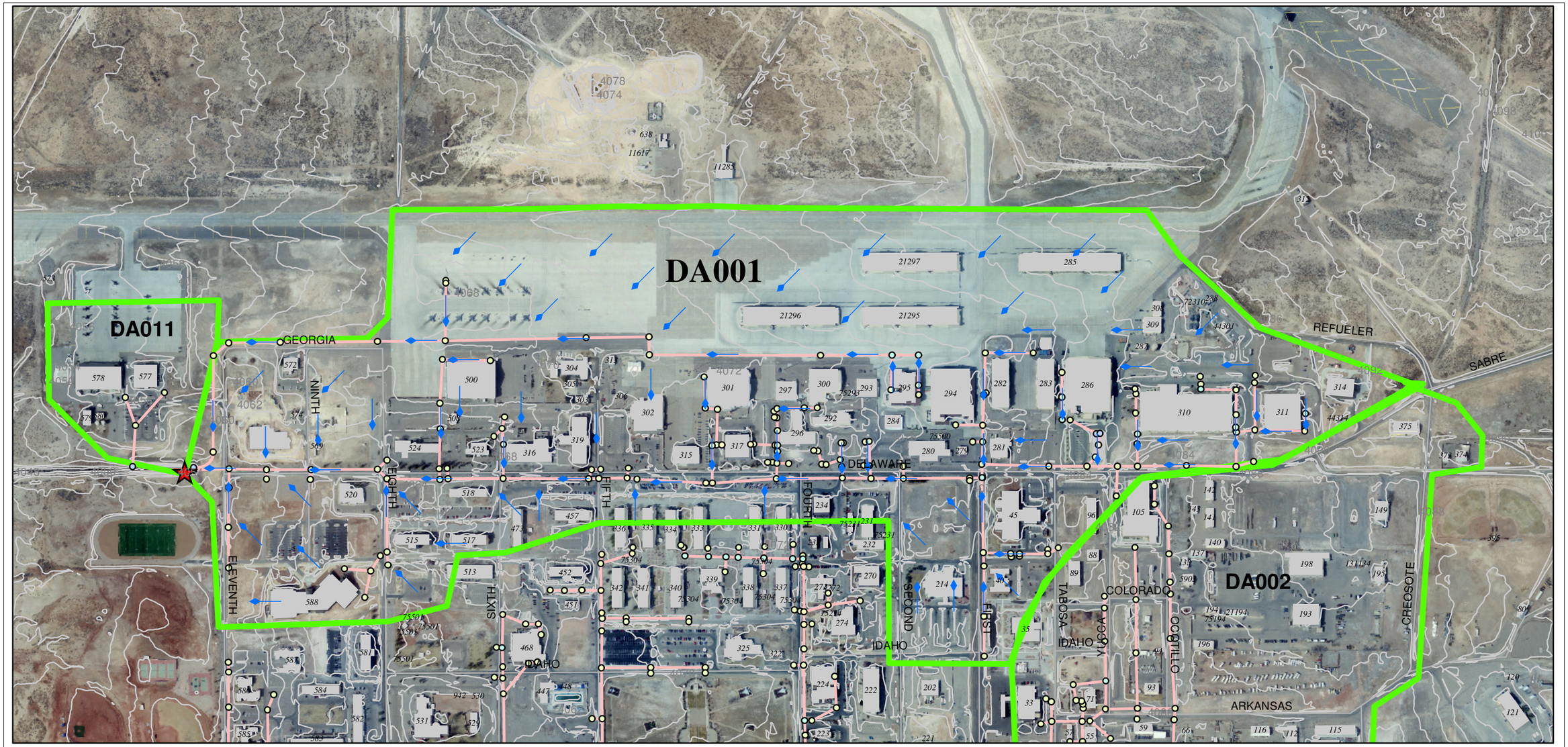

Legend

- DA001 Outfall
- DA001 Flow Direction
- Storm Sewer Fitting Point
- Storm Sewer Junction Point
- Storm Sewer Reservoir Point
- Storm Sewer Discharge Point
- Storm Sewer Inlet Point
- Storm Sewer Line
- Drainage Areas Boundary
- Topographic Contour Lines
- Structures

Note: Building Number Shown in Italics

0 95 190 380 570 760 Feet

Figure 2.1 DA001

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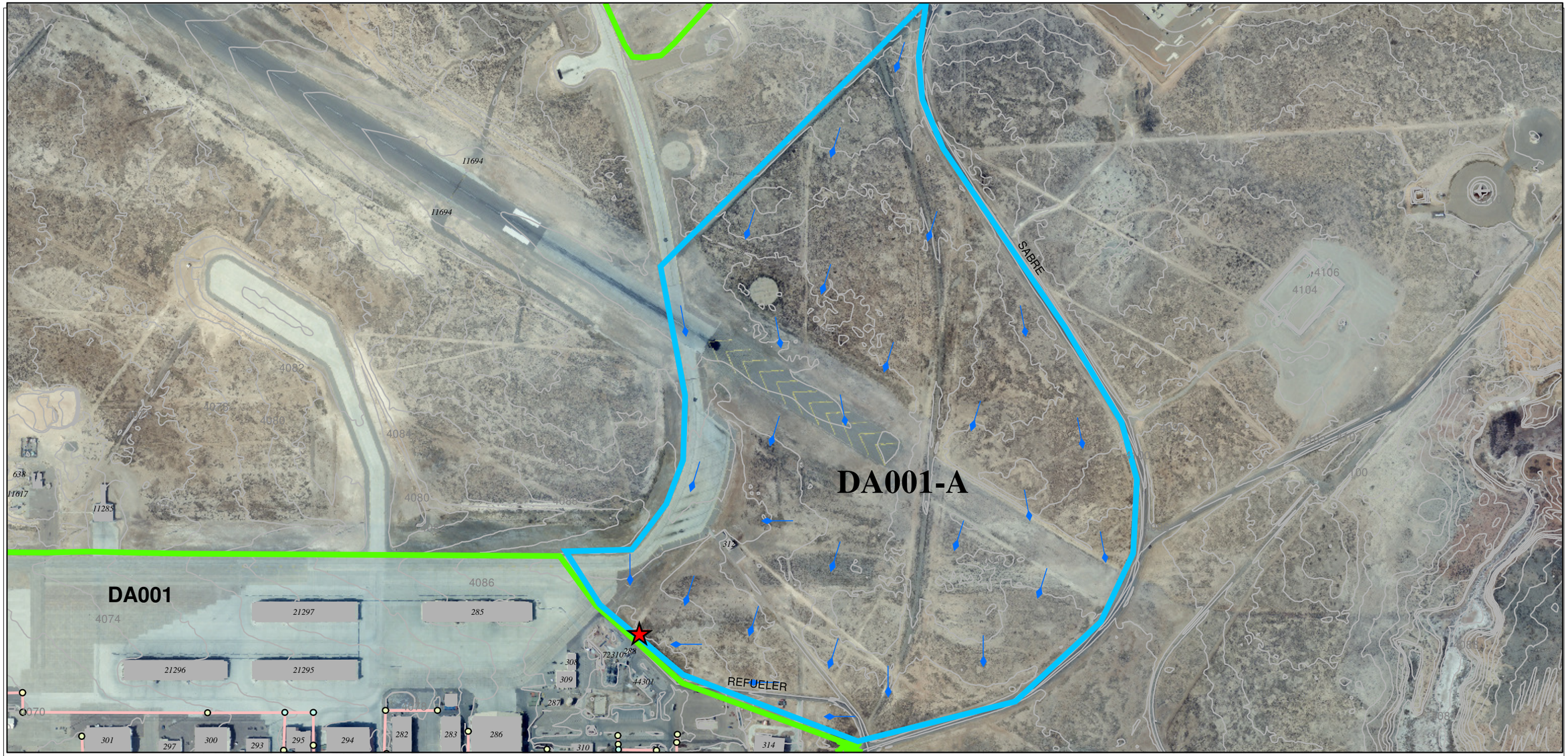


Legend

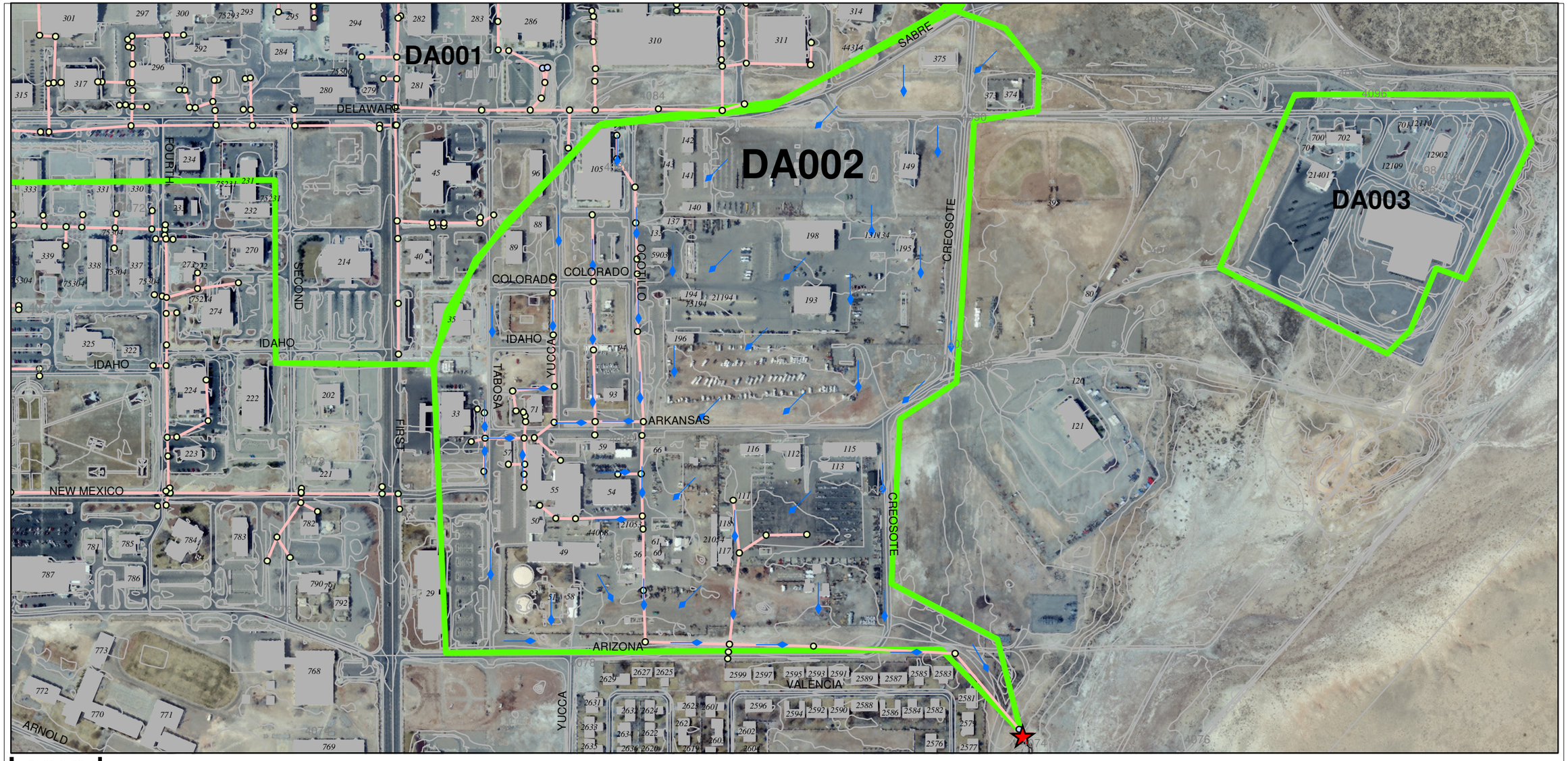
- DA001-A Outfall
- DA001-A Flow Direction
- Storm Sewer Fitting Point
- Storm Sewer Junction Point
- Storm Sewer Reservoir Point
- Storm Sewer Discharge Point
- Storm Sewer Inlet Point
- Contributing Area DA001-A
- Drainage Areas Boundary
- Storm Sewer Line
- Topographic Contour Lines
- Structures

Note: Building Number Shown in Italics

0 105 210 420 630 840 Feet

Figure 2.2 DA001-A

CH2MHILL



Legend

- DA002 Outfall
- DA002 Flow Direction
- Storm Sewer Reservoir Point
- Storm Sewer Junction Point
- Storm Sewer Inlet Point
- Storm Sewer Fitting Point
- Storm Sewer Discharge Point
- Storm Sewer Line
- Drainage Areas Boundary
- Topographic Contour Lines
- Structures

Note: Building Number Shown in Italics

0 90 180 360 540 720 Feet

Figure 2.3 DA002

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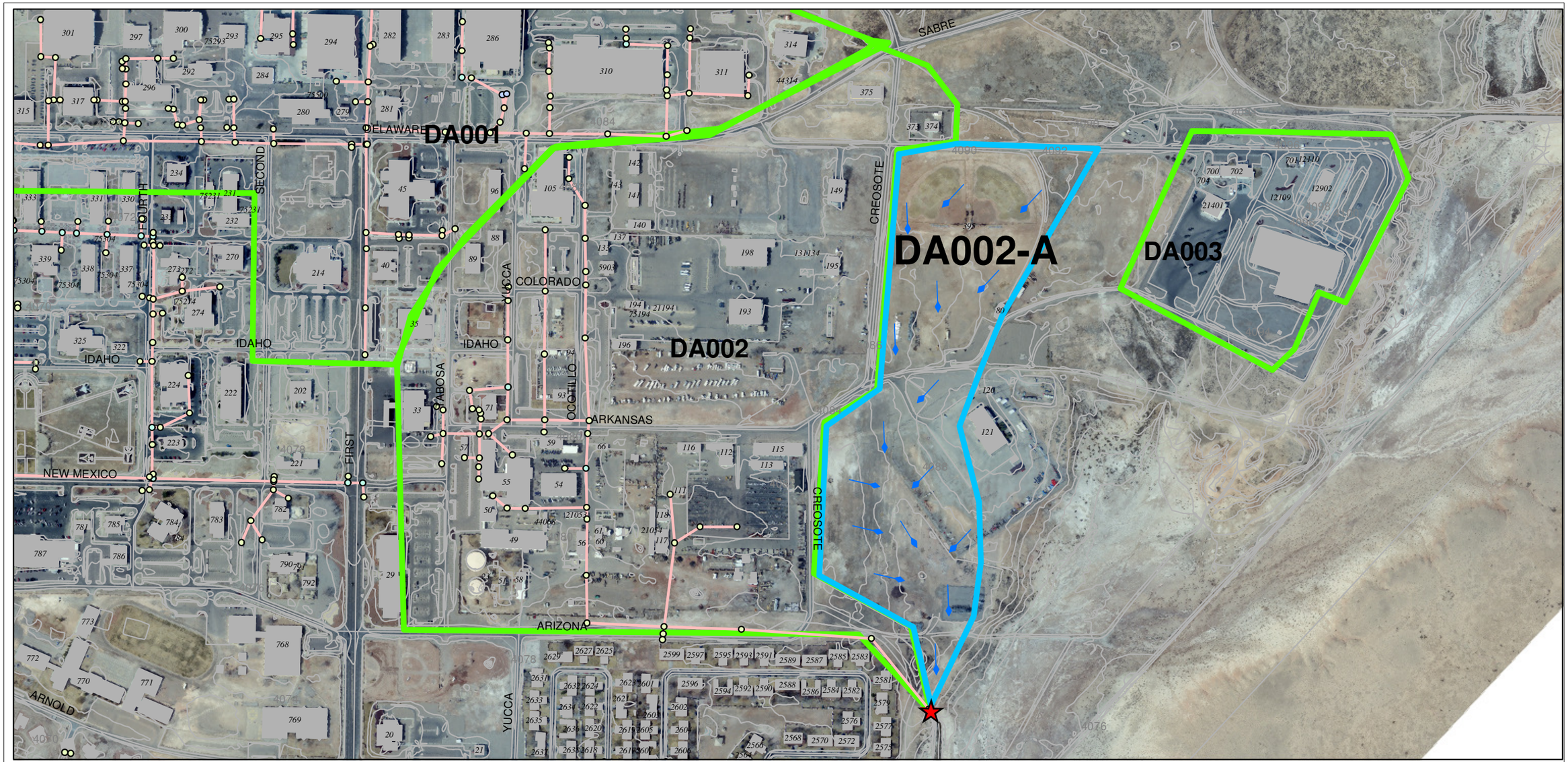


Legend

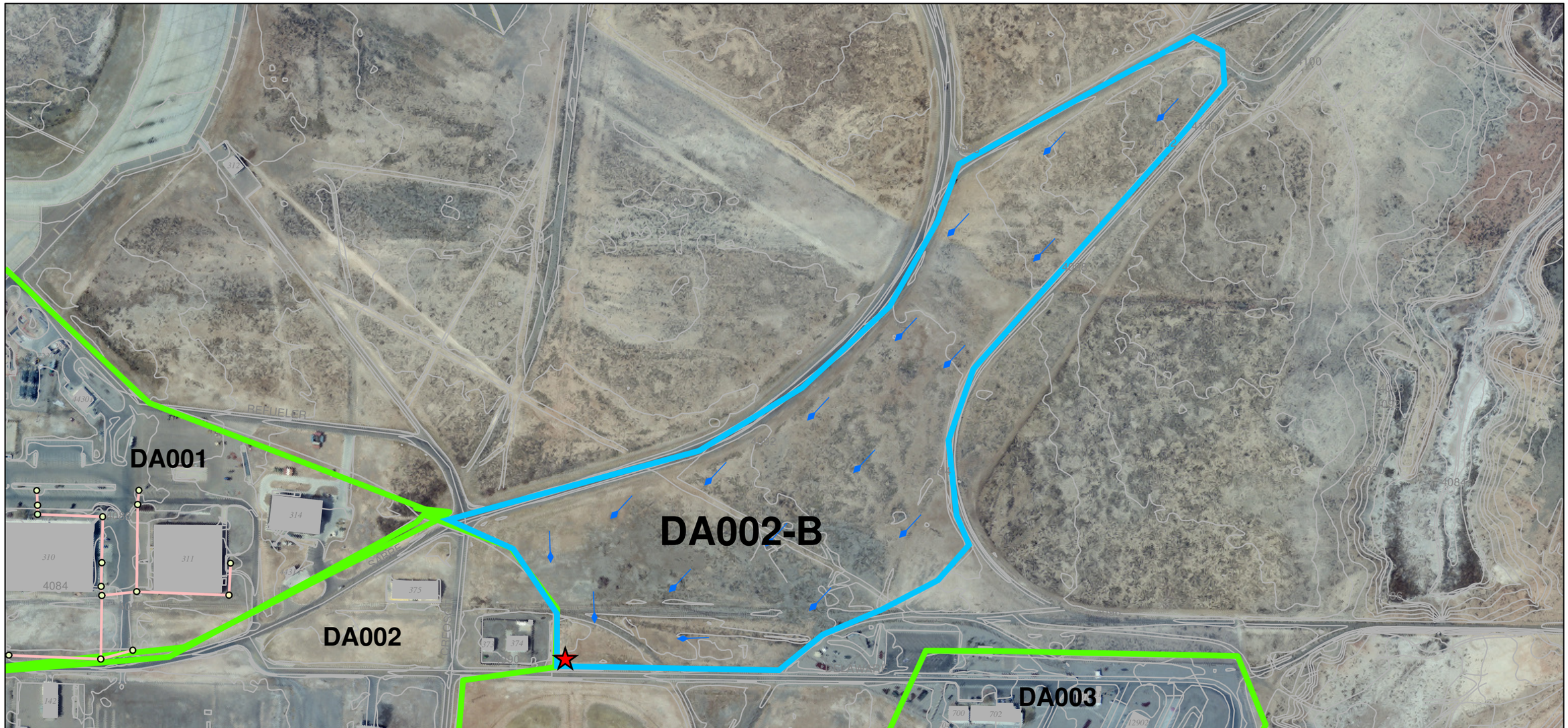
- DA002-A Outfall
- DA002-A Flow Direction
- Storm Sewer Reservoir Point
- Storm Sewer Junction Point
- Storm Sewer Inlet Point
- Storm Sewer Fitting Point
- Storm Sewer Discharge Point
- Storm Sewer Line
- Contributing Area DA002-A
- Drainage Areas Boundary
- Topographic Contour Lines
- Structures

Note: Building Number Shown in Italics

0 100 200 400 600 800 Feet

Figure 2.4 DA002-A

CH2MHILL



Legend

- DA002-B Outfall
- DA002-B Flow Direction
- Storm Sewer Reservoir Point
- Storm Sewer Junction Point
- Storm Sewer Inlet Point
- Storm Sewer Fitting Point
- Storm Sewer Discharge Point
- Storm Sewer Line
- Contributing Area DA002-B
- Drainage Areas Boundary
- Topographic Contour Lines
- Structures

Note: Building Number Shown in Italics

0 65 130 260 390 520 Feet

Figure 2.5 DA002-B

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Legend

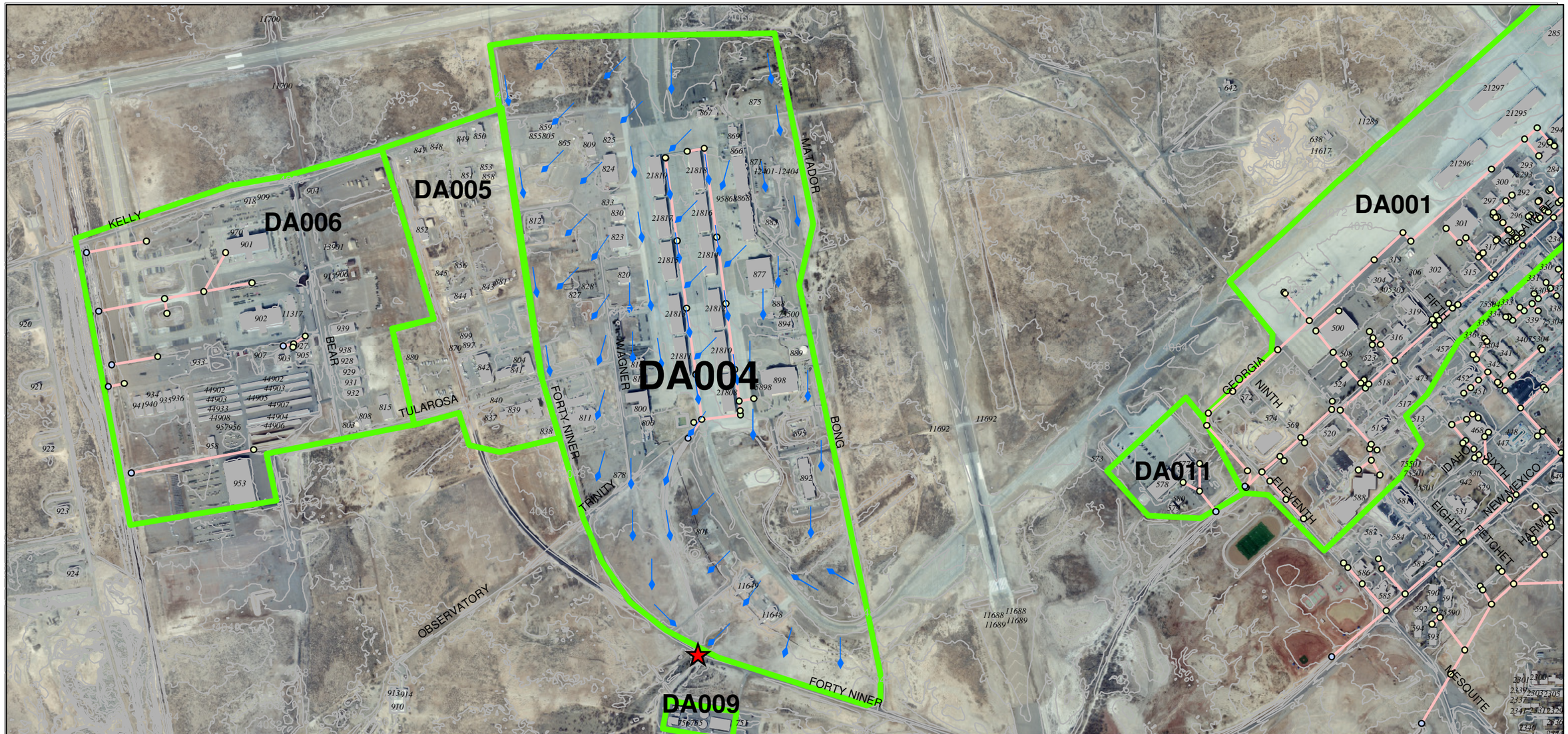
- DA003 Outfall
- DA003 Flow Direction
- Storm Sewer Reservoir Point
- Storm Sewer Junction Point
- Storm Sewer Inlet Point
- Storm Sewer Fitting Point
- Storm Sewer Discharge Point
- Storm Sewer Line
- Drainage Areas Boundary
- Topographic Contour Lines
- Structures

Note: Building Number Shown in Italics

0 35 70 140 210 280 Feet

Figure 2.6 DA003

CH2MHILL



Legend

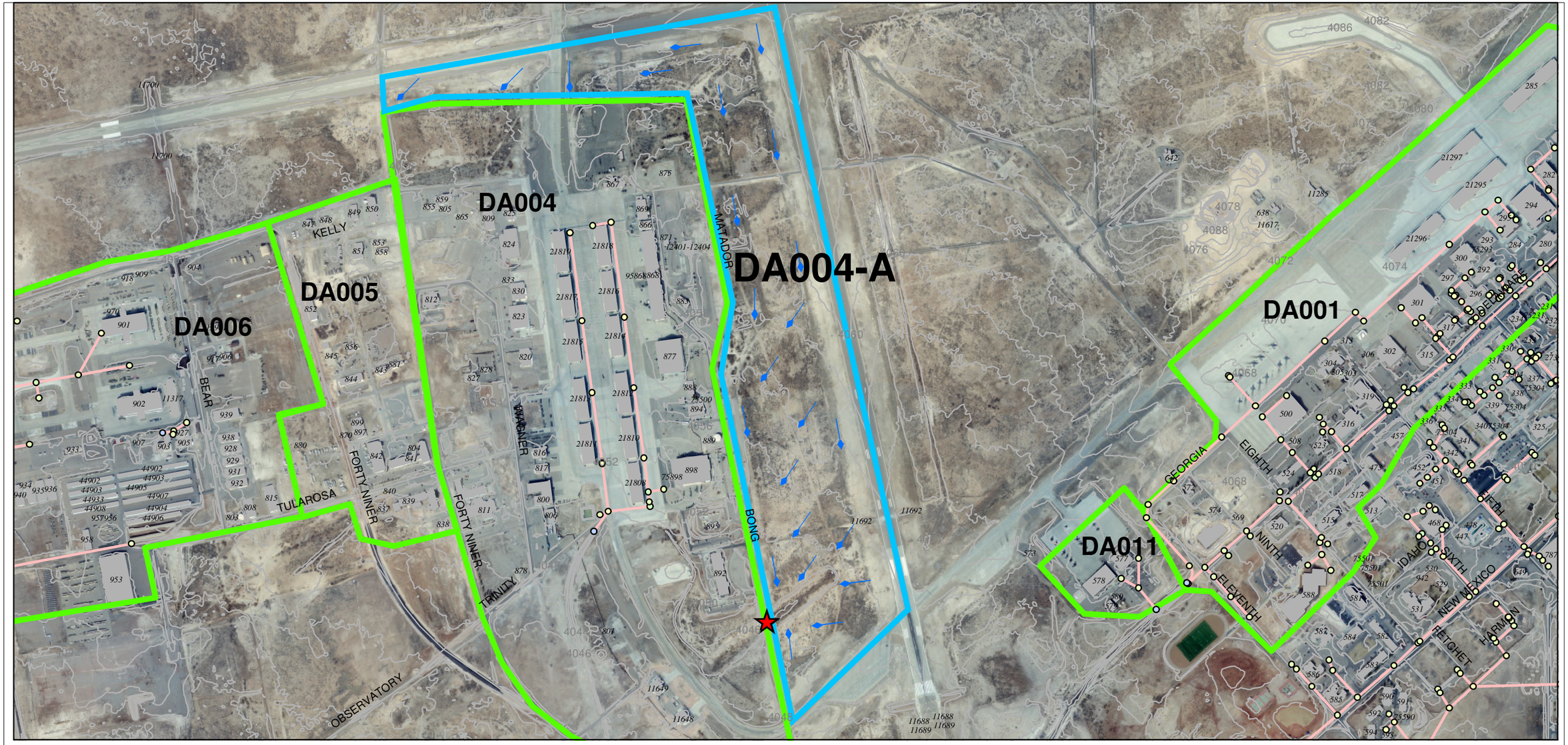
- DA004 Outfall
- DA004 Flow Direction
- Storm Sewer Reservoir Point
- Storm Sewer Junction Point
- Storm Sewer Inlet Point
- Storm Sewer Fitting Point
- Storm Sewer Discharge Point
- Storm Sewer Line
- Drainage Areas Boundary
- Topographic Contour Lines
- Structures

Note: Building Number Shown in Italics

0 190 380 760 1,140 1,520 Feet

Figure 2.7 DA004

CH2MHILL



Legend

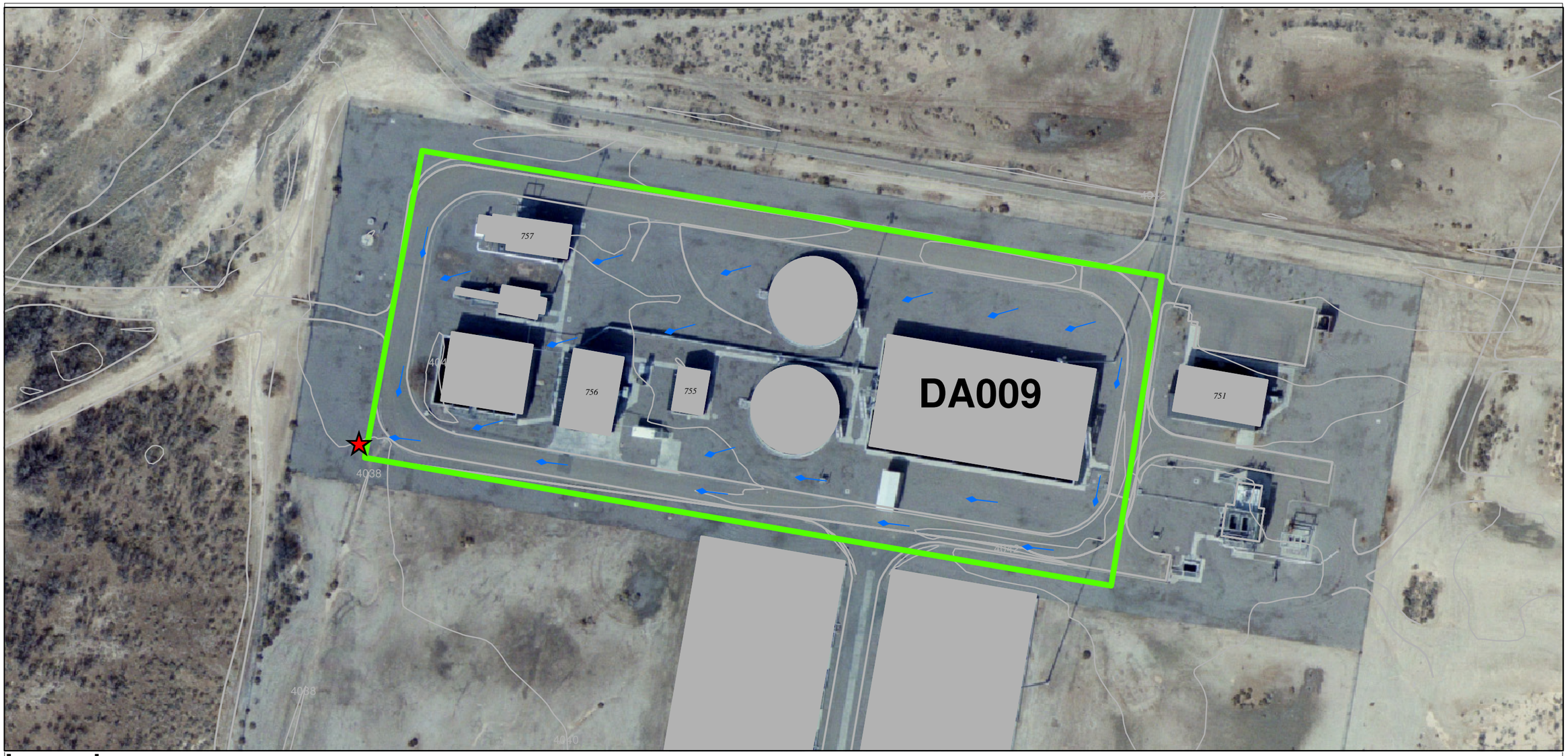
- DA004-A Outfall
- DA004-A Flow Direction
- Storm Sewer Reservoir Point
- Storm Sewer Junction Point
- Storm Sewer Inlet Point
- Storm Sewer Fitting Point
- Storm Sewer Discharge Point
- Storm Sewer Line
- Contributing Area DA004-A
- Drainage Areas Boundary
- Topographic Contour Lines
- Structures

Note: Building Number Shown in Italics

0 187.5 375 750 1,125 1,500 Feet

Figure 2.8 DA004-A

CH2MHILL



Legend

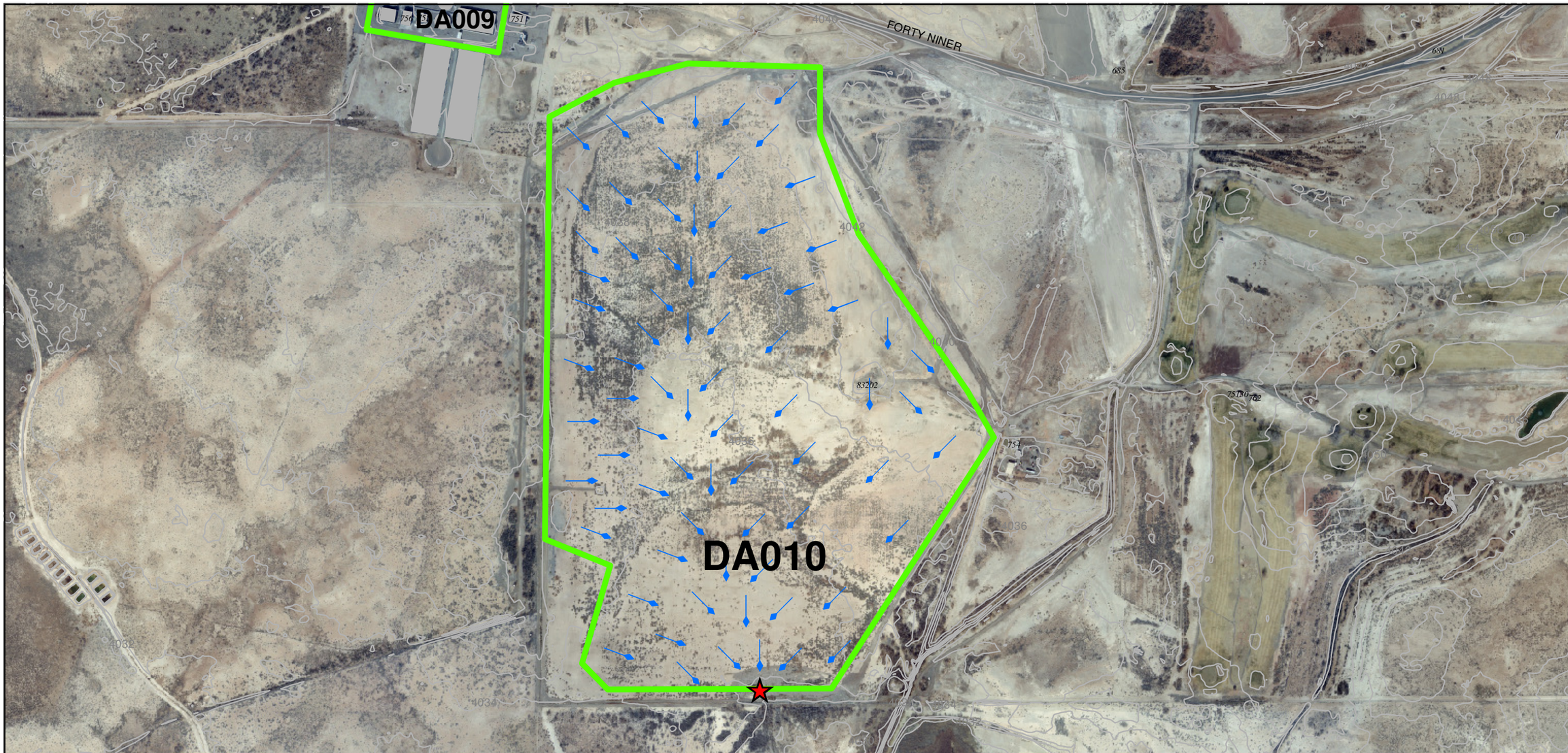
- DA009 Outfall
- DA009 Flow Direction
- Storm Sewer Reservoir Point
- Storm Sewer Junction Point
- Storm Sewer Inlet Point
- Storm Sewer Fitting Point
- Storm Sewer Discharge Point
- Storm Sewer Line
- Drainage Areas Boundary
- Topographic Contour Lines
- Structures

Note: Building Number Shown in Italics

0 20 40 80 120 160 Feet

Figure 2.9 DA009

CH2MHILL



Legend

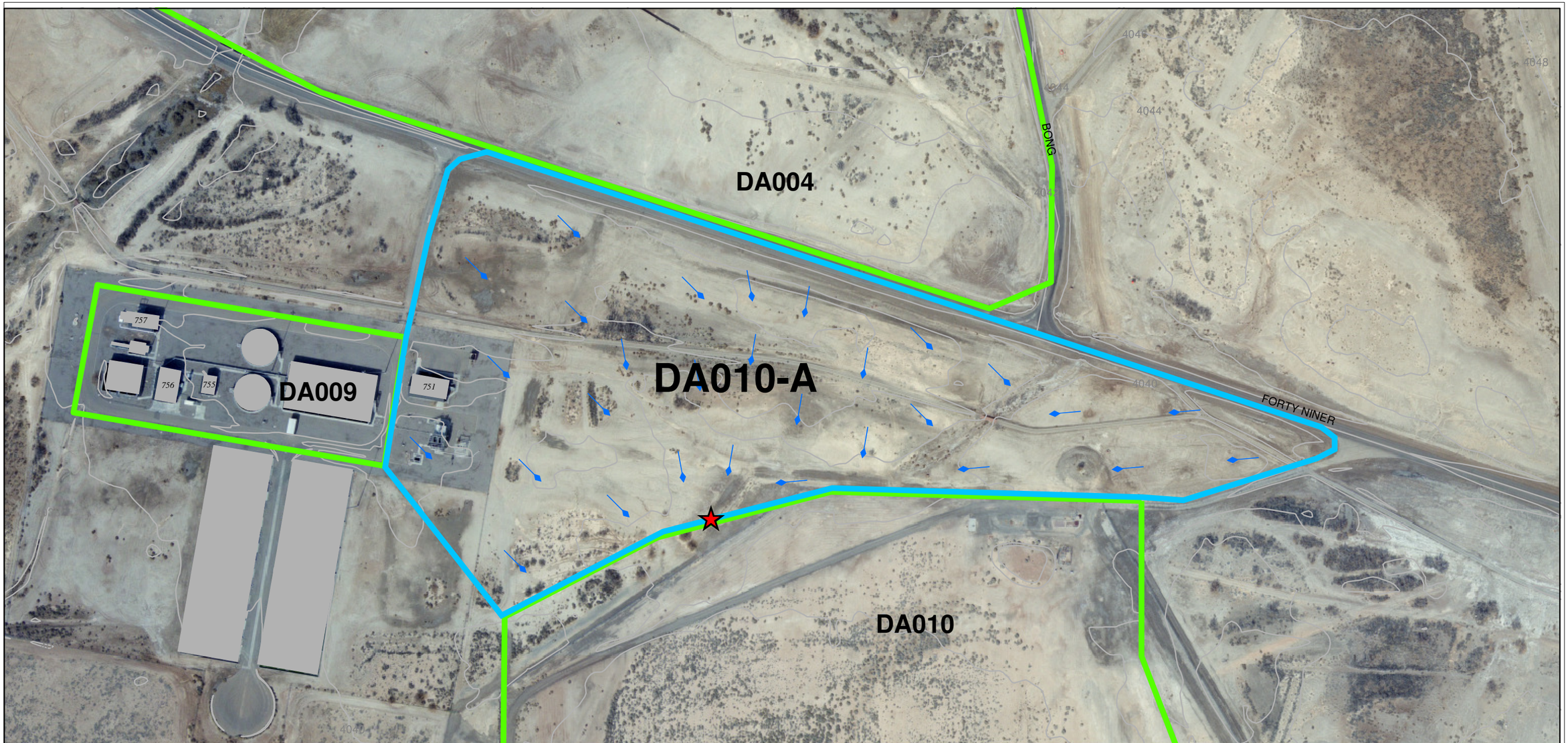
- DA010 Outfall
- DA010 Flow Direction
- Storm Sewer Reservoir Point
- Storm Sewer Junction Point
- Storm Sewer Inlet Point
- Storm Sewer Fitting Point
- Storm Sewer Discharge Point
- Storm Sewer Line
- Drainage Areas Boundary
- Topographic Contour Lines
- Structures

Note: Building Number Shown in Italics

0 95 190 380 570 760 Feet

Figure 2.10 DA010

CH2MHILL



Legend

- DA010-A Outfall
- DA010-A Flow Direction
- Storm Sewer Reservoir Point
- Storm Sewer Junction Point
- Storm Sewer Inlet Point
- Storm Sewer Fitting Point
- Storm Sewer Discharge Point
- Storm Sewer Line
- Contributing Area DA010-A
- Drainage Areas Boundary
- Topographic Contour Lines
- Structures

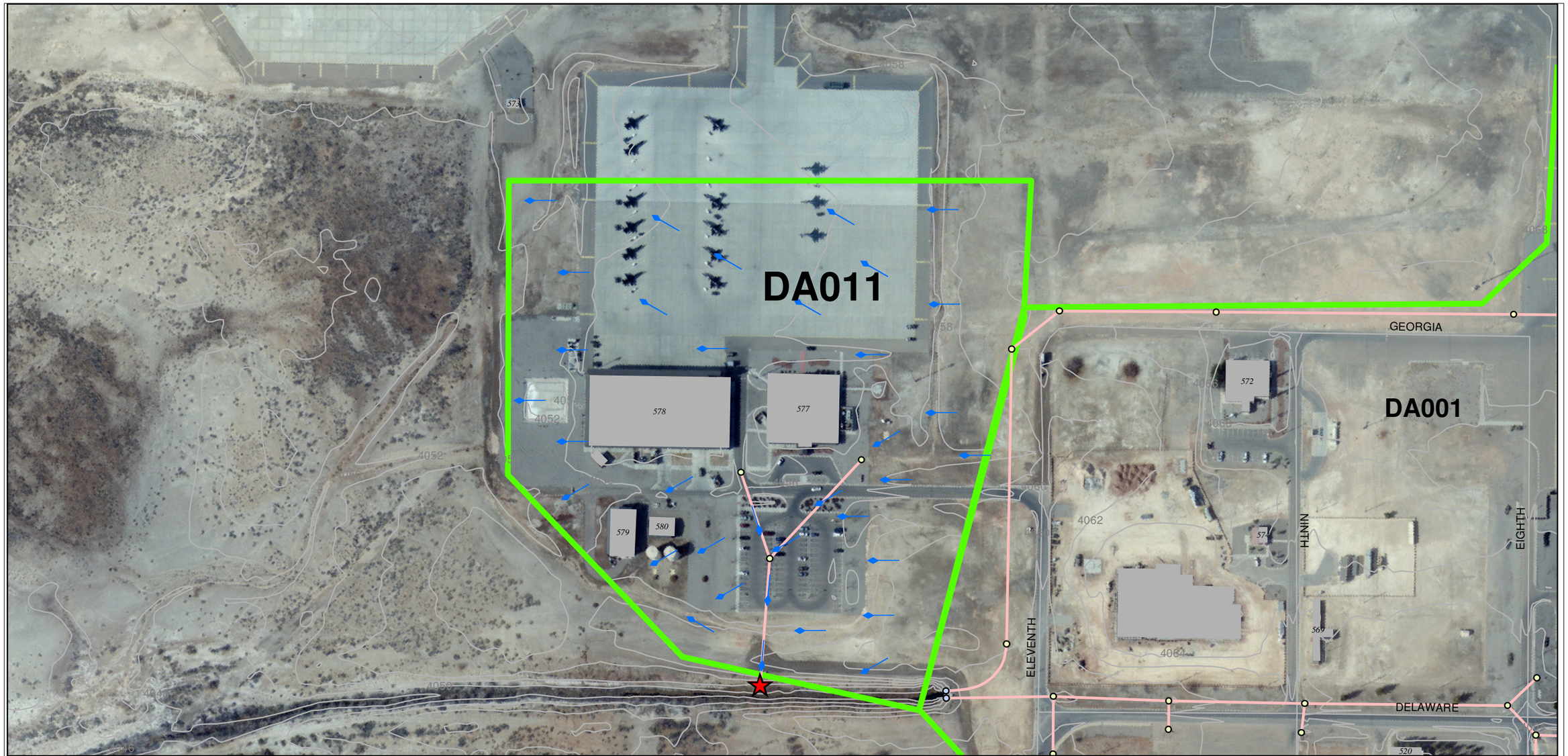
Note: Building Number Shown in Italics

0 45 90 180 270 360 Feet

N

Figure 2.11 DA010-A

CH2MHILL



Legend

- DA011 Outfall
- DA011 Flow Direction
- Storm Sewer Reservoir Point
- Storm Sewer Junction Point
- Storm Sewer Inlet Point
- Storm Sewer Fitting Point
- Storm Sewer Discharge Point
- Storm Sewer Line
- Drainage Areas Boundary
- Topographic Contour Lines
- Structures

Note: Building Number Shown in Italics

0 37.5 75 150 225 300 Feet

Figure 2.12 DA011

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3.0 Hydrologic Analysis

3.1 Introduction to the Hydrologic Model

The hydrology was modeled using the HEC-HMS model. The objectives of this modeling were to

- develop a basis for Holloman AFB to evaluate the existing storm-water system;
- allow modifications in the drainage patterns and flows to be quickly evaluated as new construction is implemented; and
- provide a method for analyzing additional storms or storm-water controls.

All DAs were modeled and analyzed in HEC-HMS Version 2.2.2, a hydrologic modeling system designed to simulate the precipitation-runoff processes of dendritic watersheds. The model includes three components: basin model, meteorological model, and control specifications. The model or project attributes include basin defaults that utilize the Soil Conservation Service (SCS) curve number loss method to calculate the losses from precipitation; the SCS unit hydrograph transform method to calculate the direct runoff from excess precipitation; the lag routing method, which routes channel flow with translation and no attenuation; and the baseflow method set to No Baseflow, a typical condition of the DAs. The meteorological defaults include a 6-hour Frequency Storm for precipitation, and no evapotranspiration.

The HEC-HMS model was selected because of its general availability and acceptance for this type of hydrologic analysis. The model has been developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center (USACE-HEC). The Hydrologic Modeling System (HMS) is designed to simulate the precipitation-runoff process. Drainage basins are configured in the model, and the runoff process is simulated to obtain hydrologic characteristics for specific design or actual storm events. The various input and output data used in the modeling of Holloman AFB are described in the following sections.

3.2 Drainage Area Delineation

Topography is used by the model to delineate the drainage basins for runoff analysis. The topography for the DAs modeled by CH2M HILL was provided by Holloman AFB as GIS data files, which were then imported into HEC-HMS model. The initial DA configurations also were provided by Holloman AFB on hard-copy maps. In most cases the basin boundaries generated by the HEC-HMS model, based on the topography, were very close to those shown on the maps provided by the base.

3.3 SCS Curve Number

The SCS, now called the Natural Resources Conservation Service (NRCS), developed an empirical curve number method to estimate total excess precipitation for a storm based on cumulative precipitation, soil cover, land use, and antecedent moisture. The HEC-HMS model uses these curve numbers (CN) to calculate excess precipitation at each step of the simulation, and these CN values must be input into the model.

Weighted SCS CNs were determined for each DA within the project limits. Determination of the appropriate CN is made by identifying the hydrologic soil data and identifying the land use or land cover of the DA. Soil data were obtained from the NRCS Otero County Soil Survey (NRCS, 2002), and land use and land cover were estimated from the site observations. The soil survey lists seven soil classifications within the confines of Holloman AFB, but the DAs in this analysis are all comprised of the Holloman-Gypsum land-Yesum complex (HOB). This complex consists of large areas of shallow and deep, well-drained soils and areas of exposed gypsum, which are intermingled throughout the complex. Holloman AFB soils have an associated hydrologic soil group (HSG) classification of D, gypsum-land has a HSG classification of C, and Yesum has a HSG classification of B. For the purpose of this analysis, the HOB complex was considered to have a HSG classification of C, which is the mid-point of the three HSGs. HOB is characterized by a moderate rate of infiltration and low surface runoff. Table 3-1 presents typical land uses with their associated CN for western desert regions. In addition, a composite CN was determined for each DA based on the weighted CN and the percentage of impervious area within the DA, and is presented in Table 3-2.

3.4 Precipitation Analysis

By mutual agreement with the base, the Frequency Storm distribution used the 10-year, 25-year, and 100-year recurrence intervals for the 6-hour rainfall events to generate the hydrographs for each DA. This resulted in 1.96-inch, 2.35-inch, and 2.95-inch depths of precipitation, respectively. Table 3-3 presents the time distribution of the precipitation. These values were obtained from the National Oceanic and Atmospheric Administration (NOAA) Precipitation Atlas for New Mexico (2005).

3.5 Control Specifications

The HEC-HMS program will not run without control specifications. Since this project models design storms instead of an actual storm event, an arbitrary time period of August 1, 2004 at 1500 hours through August 2, 2004 at 1500 hours was chosen just to make the model execute. This period was chosen to best represent the monsoon season that typically occurs in this part of New Mexico.

TABLE 3-1
Land Use and Curve Numbers, Holloman AFB

Land Use	Description	Hydrologic Soil Group CN (AMC II)			
		A	B	C	D
High Urban	Commercial and business	89	92	94	95
	Industrial	81	88	91	93
	Transportation: Paved streets with open ditches	83	89	92	93
	Transportation: Paved parking lots, roofs, driveways, etc	98	98	98	98
	Transportation: Dirt roads	72	82	87	89
	Mixed urban or built-up lands	89	92	94	95
	Urban: Artificial desert landscape (impervious weed barrier, desert shrub with 1 to 2 inches sand or gravel mulch and basin borders)	96	96	96	96
	Urban: Natural desert landscape (pervious areas only)	63	77	85	88
Low Urban	Urban Residential: Rural villages, towns, and cities	57	72	81	86
Golf Course	Recreational fields, lawns and parks	62	71	78	81
Forage Crops	Production of grasses, legumes, forbs, or other vegetation on pasture and hayland; includes planting, grazing, haying, or harvesting	64	75	83	85
Grassland	Land dominated by grasses, grasslike plants, shrubs, and forbs	49	69	79	84
Open Water	Streams, canals, rivers, lakes, and reservoirs	100	100	100	100
Barren	Open land with exposed soil with little-to-no vegetation	50	50	50	50
	Dry salt flats	74	84	90	92
	Sandy areas other than beaches	63	77	85	88
Shrubland	Desert sagebrush with grass understory (condition - POOR)	N/A	67	80	85
	Desert sagebrush with grass understory (condition - FAIR)	N/A	51	63	70
	Desert sagebrush with grass understory (condition - GOOD)	N/A	35	47	55
	Desert Shrub: Major plants include saltbush (condition - POOR)	63	77	85	88
	Desert Shrub: Major plants include greasewood, creosotebush, blackbrush, bursage (condition - FAIR)	55	72	81	86
	Desert Shrub: Major plants include palo verde, mesquite, and cactus (condition - GOOD)	49	68	79	84

TABLE 3-2
Condition Curve Numbers

CN (Average)	Corresponding CN	
	Dry	Wet
100	100	100
99	97	100
98	95	99
97	92	99
96	90	98
95	87	98
94	85	98
93	83	97
92	82	97
91	80	96
90	78	96
89	76	96
88	75	95
87	73	95
86	72	94
85	70	94
84	69	93
83	67	93
82	66	92
81	64	92
80	63	91
75	57	88
70	51	85
65	45	82
60	40	78
55	35	74
50	31	70
45	26	65
40	22	60
35	18	55
30	15	50
25	12	43
15	6	30
5	2	13

TABLE 3-3
6-Hour Frequency Storm Time Distribution

Time	10 -yr (in.)	25-yr (in.)	100-yr (in.)
5 min =	0.448	0.527	0.709
15 min =	0.880	1.035	1.393
1 hr =	1.544	1.816	2.444
2 hr =	1.686	1.998	2.617
3 hr =	1.782	2.121	2.733
6 hr =	1.960	2.350	2.950

3.6 Summary of Results Table

Table 3-4 summarizes the drainage characteristics for each DA included in the model. This includes basic geometry, with basin area, length, and slope. Time of concentration is the time it takes for runoff to travel from the hydraulically most distant part of the DA to its outlet. Lag time is the time from the center of mass of excessive rainfall to the peak rate of runoff. The time to peak is the time from the beginning of the rise on the storm hydrograph to the peak of the hydrograph curve.

The weighted CN, time of concentration (t_c), lag time (t_l), 10-85 slope, and initial abstractions were calculated for each DA by utilizing the SCS TR-55 method (see Appendix A). The area and length of the DAs was calculated from the GIS data in ArcMap Version 8.3 provided by the base. These parameters were then included in the HEC-HMS model to produce the Q_{10}, Q_{25}, and Q_{100} peak discharge rates at each outfall. In addition, CNs for both dry and wet conditions were included, but not used in the analysis. Complete HEC-HMS Summary of Results can be viewed in Appendix B.

TABLE 3-4
Drainage Area Attributes, Holloman AFB

Drainage Area (DA)	Area, A (mi^2)	Length, L (ft)	Slope, S_{10-85} (ft/ft)	Initial Abstraction, I_a (in)	Time-of-Concentration, t_c (hr)	Time-of-Concentration, t_c (min)	Lag Time, t_l (hr)	Lag Time, t_l (min)	Time to Peak, t_p (hr)	Time to Peak, t_p (min)	Percent Impervious	Composite CN, CN_{comp}	Dry CN, CN_{dry}	Wet CN, CN_{wet}
DA001	0.3845	6752.47	0.0050	0.083	1.80	108.00	1.10	66.00	1.06	63.60	59%	96	90	98
DA001-A	0.2226	3565.69	0.0063	1.077	2.80	168.00	1.69	101.40	1.79	107.40	7%	65	45	82
DA002	0.1797	3138.08	0.0045	0.198	1.30	78.00	0.80	48.00	0.83	49.80	20%	91	80	96
DA002-A	0.0448	2930.62	0.0050	1.030	2.60	156.00	1.58	94.80	1.68	100.80	6%	66	46	83
DA002-B	0.2226	2671.56	0.0044	1.175	2.80	168.00	1.69	101.40	1.85	111.00	2%	63	43	80
DA003	0.0351	1235.75	0.0084	0.273	0.50	30.00	0.31	18.60	0.31	18.60	24%	88	75	95
DA004	0.4712	5412.04	0.0041	0.273	2.40	144.00	1.46	87.60	1.39	83.40	33%	88	75	95
DA004-A	0.2334	4983.43	0.0047	1.125	4.40	264.00	2.62	157.20	2.87	172.20	2%	64	44	81
DA009	0.0055	663.89	0.0032	0.198	0.50	30.00	0.27	16.20	0.27	16.20	31%	91	80	96
DA010	0.1563	2867.19	0.0032	1.175	3.50	210.00	2.09	125.40	2.32	139.20	0%	63	43	80
DA010-A	0.0280	1203.02	0.0024	1.175	2.00	120.00	1.21	72.60	1.33	79.80	2%	63	43	80
DA011	0.0259	789.93	0.0101	0.222	0.30	18.00	0.18	10.80	0.16	9.60	48%	90	78	96

4.0 Drainage Analysis Results

The HEC-HMS output results are provided in Appendix B. These results include the peak discharge, runoff volume, and storm hydrographs for each DA. The results are shown for each of the design storms (10-year, 25-year, and 100-year, 6-hour storms).

4.1 Hydrology

The peak discharge for each DA was calculated by HEC-HMS using the DA attributes discussed in Section 3 of this report. These basin attributes were entered into the HEC-HMS model, and a configured simulation run was performed utilizing the basin model, meteorological model, and control specifications for each DA, and each of the three specified design storms. Table 4-1 presents a summary of the simulation runs, and the peak discharge and runoff volumes calculated by the model.

The model resulted in peak flows that ranged from low to high flows in the various DAs. DA001, DA002, DA003, and DA004 had the highest flows as a result of their larger geographic areas and higher degree of imperviousness, whereas the model results for DA009, DA010, and DA011 were low to moderate flows.

The results for DA010 and DA011 may not accurately define the flows at the basin outfall monitoring locations. This is because the drainage patterns in those two drainage basins are more complex than the current model simulates. Flows from DA010-A comprise a significant proportion of the total flow out of DA010, and DA011 actually has several outfall locations.

The model results show the contributing drainage area DA010-A contributes 25 percent to 35 percent of the total flow out of DA010. DA010-A is currently 98 percent undeveloped, so pollution contribution from that basin to DA010 is very small, even though its flow contribution to the flow at Outfall 010 is significant.

The drainage pattern in DA011 is very complex with runoff leaving that basin at a variety of locations. However, the current model simulated the basin as a unit with all runoff leaving the basin at Outfall 011. This results in a modeled peak discharge and runoff volume at Outfall 011 that is too high for that location. This situation is discussed further in Section 5.4, but CH2M HILL recommends breaking this DA into subbasins and re-running the model, if more accurate results are desired.

TABLE 4-1
HEC-HMS Estimated Peak Flows and Volumes

Drainage Area (DA)	Peak Discharge, Q_p (cfs)		Volume, V (ac-ft)	
DA001	Q_{10} =	200.31	V_{10} =	31.614
DA001	Q_{25} =	240.64	V_{25} =	38.497
DA001	Q_{100} =	322.83	V_{100} =	49.134
DA001-A	Q_{10} =	8.7570	V_{10} =	2.1618
DA001-A	Q_{25} =	13.575	V_{25} =	3.3574
DA001-A	Q_{100} =	25.121	V_{100} =	5.7472
DA002	Q_{10} =	84.940	V_{10} =	10.303
DA002	Q_{25} =	107.73	V_{25} =	13.208
DA002	Q_{100} =	153.77	V_{100} =	17.820
DA002-A	Q_{10} =	2.2152	V_{10} =	0.52235
DA002-A	Q_{25} =	3.5373	V_{25} =	0.83025
DA002-A	Q_{100} =	6.6757	V_{100} =	1.4418
DA002-B	Q_{10} =	0.7040	V_{10} =	0.18721
DA002-B	Q_{25} =	1.4174	V_{25} =	0.36532
DA002-B	Q_{100} =	3.2511	V_{100} =	0.75556
DA003	Q_{10} =	26.706	V_{10} =	1.8181
DA003	Q_{25} =	34.217	V_{25} =	2.3528
DA003	Q_{100} =	50.127	V_{100} =	3.2124
DA004	Q_{10} =	133.35	V_{10} =	26.637
DA004	Q_{25} =	169.09	V_{25} =	33.986
DA004	Q_{100} =	238.41	V_{100} =	45.731
DA004-A	Q_{10} =	3.0957	V_{10} =	1.1025
DA004-A	Q_{25} =	6.0371	V_{25} =	2.1125
DA004-A	Q_{100} =	12.914	V_{100} =	4.2735
DA009	Q_{10} =	5.5123	V_{10} =	0.34377
DA009	Q_{25} =	6.8845	V_{25} =	0.43493
DA009	Q_{100} =	9.8011	V_{100} =	0.57897
DA010	Q_{10} =	1.2254	V_{10} =	0.37536
DA010	Q_{25} =	3.1814	V_{25} =	0.95159
DA010	Q_{100} =	8.1492	V_{100} =	2.2519
DA010-A	Q_{10} =	0.49732	V_{10} =	0.10722
DA010-A	Q_{25} =	1.0605	V_{25} =	0.21710
DA010-A	Q_{100} =	2.5787	V_{100} =	0.45920
DA011	Q_{10} =	32.842	V_{10} =	1.7338
DA011	Q_{25} =	40.377	V_{25} =	2.1604
DA011	Q_{100} =	60.191	V_{100} =	2.8396

Note:
ac-ft = acre-feet.
cfs = cubic feet per second.

4.2 Pollution Sources

Storm-water pollution is of greatest concern in DAs having land use with a high potential to contribute pollutants, and a large percentage of the drainage area has highly impervious soils or paved surfaces. Such areas produce higher runoff volumes and peak flows, in addition to having a higher risk of pollutants. Drainage areas of most concern in this regard are DA001, DA003, and DA004. The model results for these DAs showed high flows from areas having potential pollution sources based on land use.

As previously described in Section 2.4, DA001 is comprised of 47 percent commercial and industrial activities involving aircraft and flightline operations, and is potentially a greater source of pollutants that could contaminate storm-water runoff. The many aircraft maintenance and storage facilities perform operations with the potential for spills and other releases of hazardous materials. Storms of the magnitude analyzed will produce runoff volumes and discharges large enough to carry contaminated storm water beyond the boundaries of the DA, and could possibly reach the intermittent wetlands downstream from the DA.

DA003 is the fuel storage area, and the peak flow was moderate for the small area of the DA. The stored fuels and the potential for fuel spills could contaminate storm runoff that ultimately reaches Dillard Draw. However, the use of containment dikes around the pollution sources (e.g., aboveground fuel storage tanks) minimize the risk of contaminated storm water leaving the DA. The model did not simulate these containment areas as storage basins, so the resulting peak discharge is higher than would be expected if the integrity of the containment dikes is maintained. The greatest potential for contaminated storm water leaving the DA would be from spills or releases in the parking lots or maintenance facility.

DA004 is comprised of 31 percent commercial and industrial activities, and is a major hub for tactical fighter operations. The maintenance and storage facilities are potential producers of spills and contamination, and when a storm produces high runoff, the contaminated water may reach intermittent wetlands within the confines of the base.

DA002 is a low source for pollution. The DA is comprised of 40 percent commercial and 10 percent industrial activities. The commercial activities are mostly business or office related, while the industrial activities are maintenance related. Moderate flows and volumes coupled with the pollution sources produce a low potential of contamination. The concern for this area is that contaminated runoff could potentially reach Dillard Draw.

The Wastewater Treatment Plant, which is DA009, is also a low source of pollution. Given the small area and the low runoff, the potential pollution impact is small. The potential pollution produced from the plant is very biological in nature and chemicals are rare, although cleanup would still be required. If a spill were to occur during a storm event, the contaminated runoff would reach an intermittent wetland just beyond Outfall 009.

DA010 is open desert shrubland with no pollution sources. The area is intermittently wet and discharges into the base lake area.

DA011 is a moderate source of pollution. Pollution sources are comprised of maintenance facilities located within the DA. The complex nature of the drainage pattern within this DA

makes it difficult to fully analyze the pollution potential or the adequacy of the existing outfall location. Pollution sources on the tarmac would flow towards open shrubland located immediately to the west of the DA. Pollution sources near the parking area would enter the storm drains and eventually reach the intermittent wetland. Pollution near the southern portion of the DA would flow south into open desert shrubland.

The contributing DAs (DA001-A, DA002-A, DA002-B, DA004-A, and DA010-A) produced low flows and volumes. These areas are open desert and have little to no potential of pollution sources, although DA001-A, DA004-A, and DA010-A contribute a significant portion of the flows out of DA001, DA004, and DA010, respectively.

5.0 Conclusions and Recommendations

5.1 Conclusions

Based on the results of this drainage analysis, CH2M HILL concludes the following:

1. DA001, DA002, and DA004 have the potential for high flows and potential flooding during major storm events, although the duration of peak flow will be relatively short.
2. The outfall monitoring locations 002, 003, 004, 009, and 010 appear to be appropriate for monitoring storm water from the respective DAs.
3. DA010-A contributes a significant portion of the total flow from DA010. Currently, the bulk of DA010-A is undeveloped, and so has a low potential for polluting storm water from that basin. However, should DA010-A be developed it could have the potential for transporting pollutants into DA010.
4. There are multiple drainage patterns within DA011 and the existing Outfall 011 does not monitor all of the storm water leaving that basin. DA011 could be better defined and modeled with subbasins, or by breaking it into two or more separate DAs. An additional outfall monitoring location could be considered.
5. The DAs with the greatest potential for storm-water pollution are DA001, DA002, DA003, and DA004. These four basins have the greatest runoff volumes and activities that could result in contamination of storm water.

5.2 Evaluation of NPDES Compliance

Holloman AFB operates under the Multi-Sector General Permit, and appears to comply with the requirements of that permit. The base also has a Storm Water Pollution Prevention Plan (SWPPP) that is being followed and is updated as required. The DAs that have been analyzed as part of this drainage analysis are addressed in the SWPPP, and the HEC-HMS modeling has been consistent with the DA boundary delineations of the SWPPP.

5.3 Assumptions and Limitations

Because this drainage analysis was performed using a hydrologic model, certain inherent limitations must be recognized. In addition, some assumptions had to be made to perform the analysis. These include the following:

- Each DA was modeled without the presence of channels. It was assumed that all runoff would be overland flow and the storm drains were ignored for purposes of modeling. Although this is a reasonable assumption given the scope of work for this project, it does not address potential flooding from backwater at inlets and culverts, or flooding of driving lanes on base roads.

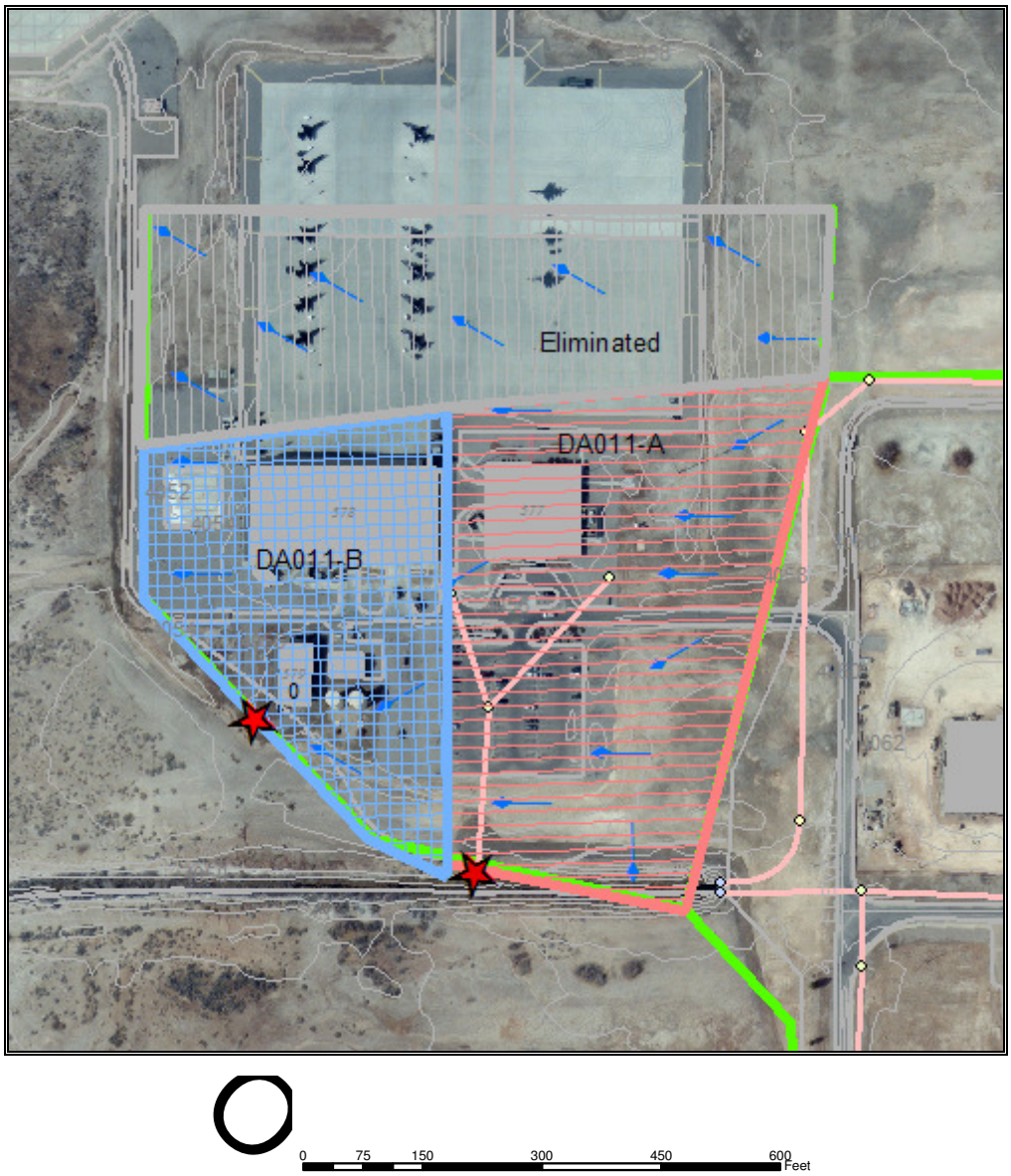
- The absence of channels required the assumption of no base flow in the HEC-HMS model. Given the scope of work for this project and the conditions within the DAs modeled, this is a valid assumption. However, based on field observations, there may be a base flow within some of the channels into which these DAs discharge, and the source of that base flow could not be determined within the scope of this project.
- All DAs were assumed to be in a typical state, and below antecedent moisture at the beginning of the rainfall event modeled. The analysis did not take into consideration that some areas are intermittently wet, and that there are periods of excessive dryness.
- The control specification within the HEC-HMS model was set at a 6-hour interval; however, it was necessary to adjust the timeframe to allow the hydrographs to fully display.

5.4 Recommendations

Based on the results of this analysis, CH2M HILL recommends the following:

1. The existing DAs should remain as currently defined with the exception of DA001 and DA011. DA001 was delineated prior to the analysis to compensate for improvements to the tarmac and to align it with site contours.
2. DA011 should be further analyzed with subbasins or redefined as multiple DAs. During the analysis, it was noted that the DA has flow in multiple directions. The existing delineation includes the entire adjacent tarmac, but the contours reveal that water flows to the northwest just beyond Buildings 577 and 578, necessitating the need to re-delineate the DA, subdivide, or eliminate. In addition, this DA has two outfalls. The existing or defined outfall is where the storm drain discharges the collected water from the paved parking areas and streets, which is necessary to maintain; however, there also is a natural outfall that is located along the southernmost boundary of the DA that discharges overland flow from the southern portion of the DA. Based on these findings it is recommended that DA011 be subdivided into two separate basins, and re-delineated (see Figure 5.1). Building 577, the parking areas and streets, and the northeastern portion should be its own entity for demonstration purposes of DA011-A. The adjacent area to the west, including Buildings 578 and 579 would be the other subdivided area, while the northwestern portions would be eliminated.
3. Additional drainage analyses should be conducted to determine the influence of the existing storm drains and potential flooding. Backwater from inadequate storm drains may have the potential to flood developed areas and increase the potential for storm-water pollution. Some of the outfall monitoring points have been located where storm drains are assumed to discharge. But if those drains are overtopped, the storm water may bypass the outfall monitors.

Figure 5-1
DA011 Subdivision and Delineation



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Appendix A

SCS TR-55 Method

DA001 SCS CURVE NUMBER

Curve Number:

Area = 0.38449 mi^2
Length = 6752.47 ft
$S_{10\text{-}85}$ = 0.0050 ft/ft
Percent Impervious = 59 %

Subscript	CN Categories	Hydrologic Soil Group CN				Percentage A, B, C, & D				Area	Area
	(From LU/CN Table)	A	B	C	D	A	B	C	D	%	mi^2
1	Commercial	89	92	94	95	0%	0%	100%	0%	29%	0.111502
2	Industrial	81	88	91	93	0%	0%	100%	0%	16%	0.061518
3	Residential	57	72	81	86	0%	0%	100%	0%	3%	0.011535
4	Paved Streets	83	89	92	93	0%	0%	100%	0%	7%	0.026914
5	Paved Parking	98	98	98	98	0%	0%	100%	0%	40%	0.153796
6	Urban Desert Landscape	63	77	85	88	0%	0%	100%	0%	3%	0.011535
7	Shrubland: Desert Sage - Fair		51	63	70	0%	0%	100%	0%	2%	0.00769
									Total =	100%	0.38449

Weighted CN:

		% Area	
CN_1 =	94	A_1 =	0.111502
CN_2 =	91	A_2 =	0.061518
CN_3 =	81	A_3 =	0.011535
CN_4 =	92	A_4 =	0.026914
CN_5 =	98	A_5 =	0.153796
CN_6 =	85	A_6 =	0.011535
CN_7 =	63	A_7 =	0.00769

Weighted CN:

$CN_w = (A_1*CN_1 + A_2*CN_2 + A_3*CN_3 + A_4*CN_4 + A_5*CN_5 + A_6*CN_6 + A_7*CN_7)/Area$

CN_w = 94

Composite CN:

CN_{comp} =	96	HEC-HMS Input
CN_{dry} =	90	NMDOT Drainage Manual Fig. 3-9; Obtained from SCS TR-55
CN_{wet} =	98	LU & CN Tables
		LU & CN Tables

SCS Runoff CN:

Curve Number, CN =	1000/(10+S)			
Storage, S =	1000/CN-10	S =	0.4167 in	
Initial Abstractions, I_a =	0.2*S	I_a =	0.083333 in	HEC-HMS Input
Time of Concentration, t_c =	$(1.67L^{0.8}[(1000/CN)-9]^{0.7})/1900*S^{0.5}$	t_c =	1.8 hr	
Length, L =	Length from outlet to divide	L =	6752.47 ft	
Slope, S =	Average Watershed Slope (10-85 Slope)	S =	0.50 %	
Composite, CN =	CN_{comp}	CN =	96	

SCS TR-55:

Lag Time, t_l =	$((L^{0.8}(S + 1)^{0.7})/(1900S^{0.5})$	t_l =	1.10 hr	HEC-HMS Input
M =	Impervious Adjustment	M =	0.86	
P =	% Impervious	P =	59.0 %	
		t_l =	0.94 hr	Adjusted Lag Time for Imperviousness
Duration of Storm, D =	$0.133t_c$	D =	0.24 hr	
Time to Peak, t_p =	$D/2+t_l$	t_p =	1.06 hr	
Peak Discharge, Q_p =	$484A/t_p$	Q_p =	175.56 cfs	Unit Hydrograph

DA001-A SCS CURVE NUMBER

Curve Number:

Area = 0.222562 mi^2
Length = 3565.69 ft
$S_{10\text{-}85}$ = 0.0063 ft/ft
Percent Impervious = 7 %

Subscript	CN Categories	Hydrologic Soil Group CN				Percentage A, B, C, & D				Area	Area
	(From LU/CN Table)	A	B	C	D	A	B	C	D	%	mi^2
1	Commercial	89	92	94	95	0%	0%	100%	0%	0%	0
2	Industrial	81	88	91	93	0%	0%	100%	0%	0%	0
3	Paved Streets	83	89	92	93	0%	0%	100%	0%	0%	0
4	Paved Parking	98	98	98	98	0%	0%	100%	0%	7%	0.015579
5	Urban Desert Landscape	63	77	85	88	0%	0%	100%	0%	0%	0
6	Shrubland: Desert Sage - Fair		51	63	70	0%	0%	100%	0%	93%	0.206983
									Total =	100%	0.22256

Weighted CN:

		% Area	
CN_1 =	94	A_1 =	0
CN_2 =	91	A_2 =	0
CN_3 =	92	A_3 =	0
CN_4 =	98	A_4 =	0.015579
CN_5 =	85	A_5 =	0
CN_6 =	63	A_6 =	0.206983

Weighted CN:

$CN_w = (A_1{*}CN_1 + A_2{*}CN_2 + A_3{*}CN_3 + A_4{*}CN_4 + A_5{*}CN_5 + A_6{*}CN_6)/Area$

CN_w = 65

Composite CN:

CN_{comp} =	65	HEC-HMS Input
CN_{dry} =	45	NMDOT Drainage Manual Fig. 3-9; Obtained from SCS TR-55
CN_{wet} =	82	LU & CN Tables

LU & CN Tables

SCS Runoff CN:

Curve Number, CN =	1000/(10+S)			
Storage, S =	1000/CN-10	S =	5.3846 in	
Initial Abstractions, I_a =	0.2*S	I_a =	1.076923 in	HEC-HMS Input
Time of Concentration, t_c =	$(1.67L^{0.8}[(1000/CN)-9]^{0.7})/1900{*}S^{0.5}$	t_c =	2.8 hr	
Length, L =	Length	L =	3565.69 ft	
Slope, S =	Average Watershed Slope (10-85 Slope)	S =	0.63 %	
Composite, CN =	CN_{comp}	CN =	65	

SCS TR-55:

Lag Time, t_l =	$((L^{0.8}(S + 1)^{0.7})/(1900S^{0.5})$	t_l =	1.69 hr	HEC-HMS Input
M =	Impervious Adjustment	M =	0.95	
P =	% Impervious	P =	7.0 %	
		t_l =	1.60 hr	Adjusted Lag Time for Imperviousness
Duration of Storm, D =	$0.133t_c$	D =	0.37 hr	
Time to Peak, t_p =	$D/2+t_l$	t_p =	1.79 hr	
Peak Discharge, Q_p =	$484A/t_p$	Q_p =	60.18 cfs	Unit Hydrograph

DA002 SCS CURVE NUMBER

Curve Number:

Area = 0.179685 mi^2
Length = 3138.08 ft
$S_{10\text{-}85}$ = 0.0045 ft/ft
Percent Impervious = 20 %

Subscript	CN Categories	Hydrologic Soil Group CN				Percentage A, B, C, & D				Area	Area
	(From LU/CN Table)	A	B	C	D	A	B	C	D	%	mi^2
1	Commercial	89	92	94	95	0%	0%	100%	0%	40%	0.071874
2	Industrial	81	88	91	93	0%	0%	100%	0%	10%	0.017969
3	Paved Streets	83	89	92	93	0%	0%	100%	0%	12%	0.021562
4	Paved Parking	98	98	98	98	0%	0%	100%	0%	20%	0.035937
5	Urban Desert Landscape	63	77	85	88	0%	0%	100%	0%	3%	0.005391
6	Shrubland: Desert Sage - Fair		51	63	70	0%	0%	100%	0%	15%	0.026953
									Total =	100%	0.17969

Weighted CN:

		% Area	
CN_1 =	94	A_1 =	0.071874
CN_2 =	91	A_2 =	0.017969
CN_3 =	92	A_3 =	0.021562
CN_4 =	98	A_4 =	0.035937
CN_5 =	85	A_5 =	0.005391
CN_6 =	63	A_6 =	0.026953

Weighted CN:

$CN_w = (A_1*CN_1 + A_2*CN_2 + A_3*CN_3 + A_4*CN_4 + A_5*CN_5 + A_6*CN_6)/Area$

CN_w = 89

Composite CN:

CN_{comp} =	91	HEC-HMS Input
		NMDOT Drainage Manual Fig. 3-9; Obtained from SCS TR-55
CN_{dry} =	80	LU & CN Tables
CN_{wet} =	96	LU & CN Tables

SCS Runoff CN:

Curve Number, CN =	1000/(10+S)			
Storage, S =	1000/CN-10	S =	0.9890 in	
Initial Abstractions, I_a =	0.2*S	I_a =	0.197802 in	HEC-HMS Input
Time of Concentration, t_c =	$(1.67L^{0.8}[(1000/CN)-9]^{0.7})/1900*S^{0.5}$	t_c =	1.3 hr	
Length, L =	Length	L =	3138.08 ft	
Slope, S =	Average Watershed Slope (10-85 Slope)	S =	0.45 %	
Composite, CN =	CN_{comp}	CN =	91	

SCS TR-55:

Lag Time, t_l =	$((L^{0.8}(S + 1)^{0.7})/(1900S^{0.5})$	t_l =	0.80 hr	HEC-HMS Input
M =	Impervious Adjustment	M =	0.92	
P =	% Impervious	P =	20.0 %	
		t_l =	0.74 hr	Adjusted Lag Time for Imperviousness
Duration of Storm, D =	$0.133t_c$	D =	0.18 hr	
Time to Peak, t_p =	$D/2+t_l$	t_p =	0.83 hr	
Peak Discharge, Q_p =	$484A/t_p$	Q_p =	104.78 cfs	Unit Hydrograph

DA002-A SCS CURVE NUMBER

Curve Number:

Area = 0.055153 mi^2
Length = 2930.62 ft
$S_{10\text{-}85}$ = 0.0050 ft/ft
Percent Impervious = 6 %

Subscript	CN Categories	Hydrologic Soil Group CN				Percentage A, B, C, & D				Area	Area
	(From LU/CN Table)	A	B	C	D	A	B	C	D	%	mi^2
1	Commercial	89	92	94	95	0%	0%	100%	0%	0%	0
2	Industrial	81	88	91	93	0%	0%	100%	0%	0%	0
3	Paved Streets	83	89	92	93	0%	0%	100%	0%	3%	0.001655
4	Paved Parking	98	98	98	98	0%	0%	100%	0%	3%	0.001655
5	Urban Desert Landscape	63	77	85	88	0%	0%	100%	0%	0%	0
6	Shrubland: Desert Sage - Fair		51	63	70	0%	0%	100%	0%	94%	0.051844
									Total =	100%	0.05515

Weighted CN:

		% Area	
CN_1 =	94	A_1 =	0
CN_2 =	91	A_2 =	0
CN_3 =	92	A_3 =	0.001655
CN_4 =	98	A_4 =	0.001655
CN_5 =	85	A_5 =	0
CN_6 =	63	A_6 =	0.051844

Weighted CN:

$CN_w = (A_1*CN_1 + A_2*CN_2 + A_3*CN_3 + A_4*CN_4 + A_5*CN_5 + A_6*CN_6)/Area$

CN_w = 65

Composite CN:

CN_{comp} = 66 — HEC-HMS Input; NMDOT Drainage Manual Fig. 3-9; Obtained from SCS TR-55
CN_{dry} = 46 — LU & CN Tables
CN_{wet} = 83 — LU & CN Tables

SCS Runoff CN:

Curve Number, CN = 1000/(10+S)
Storage, S = 1000/CN-10 — S = 5.1515 in
Initial Abstractions, I_a = 0.2*S — I_a = 1.030303 in — HEC-HMS Input

Time of Concentration, t_c = $(1.67L^{0.8}[(1000/CN)-9]^{0.7})/1900*S^{0.5}$ — t_c = 2.6 hr
Length, L = Length — L = 2930.62 ft
Slope, S = Average Watershed Slope (10-85 Slope) — S = 0.50 %
Composite, CN = CN_{comp} — CN = 66

SCS TR-55:

Lag Time, t_l = $((L^{0.8}(S + 1)^{0.7})/(1900S^{0.5})$ — t_l = 1.58 hr — HEC-HMS Input
M = Impervious Adjustment — M = 0.96
P = % Impervious — P = 6.0 %
t_l = 1.51 hr — Adjusted Lag Time for Imperviousness

Duration of Storm, D = $0.133t_c$ — D = 0.35 hr
Time to Peak, t_p = $D/2+t_l$ — t_p = 1.68 hr
Peak Discharge, Q_p = $484A/t_p$ — Q_p = 15.89 cfs — Unit Hydrograph

DA002-B SCS CURVE NUMBER

Curve Number:

Area = 0.044788 mi^2
Length = 2671.56 ft
$S_{10\text{-}85}$ = 0.0044 ft/ft
Percent Impervious = 2 %

Subscript	CN Categories	Hydrologic Soil Group CN				Percentage A, B, C, & D				Area	Area
	(From LU/CN Table)	A	B	C	D	A	B	C	D	%	mi^2
1	Commercial	89	92	94	95	0%	0%	100%	0%	0.5%	0.000224
2	Industrial	81	88	91	93	0%	0%	100%	0%	0%	0
3	Paved Streets	83	89	92	93	0%	0%	100%	0%	0%	0
4	Paved Parking	98	98	98	98	0%	0%	100%	0%	0.5%	0.000224
5	Urban Desert Landscape	63	77	85	88	0%	0%	100%	0%	0%	0
6	Shrubland: Desert Sage - Fair		51	63	70	0%	0%	100%	0%	99%	0.04434
									Total =	100%	0.04479

Weighted CN:

		% Area	
CN_1 =	94	A_1 =	0.000224
CN_2 =	91	A_2 =	0
CN_3 =	92	A_3 =	0
CN_4 =	98	A_4 =	0.000224
CN_5 =	85	A_5 =	0
CN_6 =	63	A_6 =	0.04434

Weighted CN:

$CN_w = (A_1{*}CN_1 + A_2{*}CN_2 + A_3{*}CN_3 + A_4{*}CN_4 + A_5{*}CN_5 + A_6{*}CN_6)/Area$

CN_w = 63

Composite CN:

CN_{comp} =	63	HEC-HMS Input
CN_{dry} =	43	NMDOT Drainage Manual Fig. 3-9; Obtained from SCS TR-55
CN_{wet} =	80	LU & CN Tables

LU & CN Tables

SCS Runoff CN:

Curve Number, CN =	1000/(10+S)			
Storage, S =	1000/CN-10	S =	5.8730 in	
Initial Abstractions, I_a =	0.2*S	I_a =	1.174603 in	HEC-HMS Input
Time of Concentration, t_c =	$(1.67L^{0.8}[(1000/CN)-9]^{0.7})/1900{*}S^{0.5}$	t_c =	2.8 hr	
Length, L =	Length	L =	2671.56 ft	
Slope, S =	Average Watershed Slope (10-85 Slope)	S =	0.44 %	
Composite, CN =	CN_{comp}	CN =	63	

SCS TR-55:

Lag Time, t_l =	$((L^{0.8}(S+1)^{0.7})/(1900S^{0.5})$	t_l =	1.69 hr	HEC-HMS Input
M =	Impervious Adjustment	M =	0.99	
P =	% Impervious	P =	2.0 %	
		t_l =	1.66 hr	Adjusted Lag Time for Imperviousness
Duration of Storm, D =	$0.133t_c$	D =	0.37 hr	
Time to Peak, t_p =	$D/2+t_l$	t_p =	1.85 hr	
Peak Discharge, Q_p =	$484A/t_p$	Q_p =	11.72 cfs	Unit Hydrograph

DA003 SCS CURVE NUMBER

Curve Number:

Area = 0.035054 mi^2
Length = 1235.75 ft
$S_{10\text{-}85}$ = 0.0084 ft/ft
Percent Impervious = 24 %

Subscript	CN Categories	Hydrologic Soil Group CN				Percentage A, B, C, & D				Area	Area
	(From LU/CN Table)	A	B	C	D	A	B	C	D	%	mi^2
1	Commercial	89	92	94	95	0%	0%	100%	0%	0%	0
2	Industrial	81	88	91	93	0%	0%	100%	0%	30%	0.010516
3	Paved Streets	83	89	92	93	0%	0%	100%	0%	2%	0.000701
4	Paved Parking	98	98	98	98	0%	0%	100%	0%	22%	0.007712
5	Urban Desert Landscape	63	77	85	88	0%	0%	100%	0%	18%	0.00631
6	Shrubland: Desert Sage - Fair		51	63	70	0%	0%	100%	0%	28%	0.009815
									Total =	100%	0.03505

Weighted CN:

		% Area	
CN_1 =	94	A_1 =	0
CN_2 =	91	A_2 =	0.010516
CN_3 =	92	A_3 =	0.000701
CN_4 =	98	A_4 =	0.007712
CN_5 =	85	A_5 =	0.00631
CN_6 =	63	A_6 =	0.009815

Weighted CN:

$CN_w = (A_1*CN_1 + A_2*CN_2 + A_3*CN_3 + A_4*CN_4 + A_5*CN_5 + A_6*CN_6)/Area$

CN_w = 84

Composite CN:

CN_{comp} = 88 — HEC-HMS Input; NMDOT Drainage Manual Fig. 3-9; Obtained from SCS TR-55
CN_{dry} = 75 — LU & CN Tables
CN_{wet} = 95 — LU & CN Tables

SCS Runoff CN:

Curve Number, CN = 1000/(10+S)
Storage, S = 1000/CN-10 — S = 1.3636 in
Initial Abstractions, I_a = 0.2*S — I_a = 0.272727 in — HEC-HMS Input

Time of Concentration, t_c = $(1.67L^{0.8}[(1000/CN)-9]^{0.7})/1900*S^{0.5}$ — t_c = 0.5 hr
Length, L = Length — L = 1235.75 ft
Slope, S = Average Watershed Slope (10-85 Slope) — S = 0.84 %
Composite, CN = CN_{comp} — CN = 88

SCS TR-55:

Lag Time, t_l = $((L^{0.8}(S + 1)^{0.7})/(1900S^{0.5})$ — t_l = 0.31 hr — HEC-HMS Input
M = Impervious Adjustment — M = 0.88
P = % Impervious — P = 24.0 %
t_l = 0.27 hr — Adjusted Lag Time for Imperviousness

Duration of Storm, D = $0.133t_c$ — D = 0.07 hr
Time to Peak, t_p = $D/2+t_l$ — t_p = 0.31 hr
Peak Discharge, Q_p = $484A/t_p$ — Q_p = 54.73 cfs — Unit Hydrograph

DA004 SCS CURVE NUMBER

Curve Number:

Area = 0.471152 mi^2
Length = 5412.04 ft
$S_{10\text{-}85}$ = 0.0041 ft/ft
Percent Impervious = 33 %

Subscript	CN Categories	Hydrologic Soil Group CN				Percentage A, B, C, & D				Area	Area
	(From LU/CN Table)	A	B	C	D	A	B	C	D	%	mi^2
1	Commercial	89	92	94	95	0%	0%	100%	0%	18%	0.084807
2	Industrial	81	88	91	93	0%	0%	100%	0%	13%	0.06125
3	Paved Streets	83	89	92	93	0%	0%	100%	0%	3%	0.014135
4	Paved Parking	98	98	98	98	0%	0%	100%	0%	23%	0.108365
5	Urban Desert Landscape	63	77	85	88	0%	0%	100%	0%	7%	0.032981
6	Shrubland: Desert Sage - Fair		51	63	70	0%	0%	100%	0%	36%	0.169615
									Total =	100%	0.47115

Weighted CN:

		% Area	
CN_1 =	94	A_1 =	0.084807
CN_2 =	91	A_2 =	0.06125
CN_3 =	92	A_3 =	0.014135
CN_4 =	98	A_4 =	0.108365
CN_5 =	85	A_5 =	0.032981
CN_6 =	63	A_6 =	0.169615

Weighted CN:

$CN_w = (A_1*CN_1 + A_2*CN_2 + A_3*CN_3 + A_4*CN_4 + A_5*CN_5 + A_6*CN_6)/Area$

CN_w = 83

Composite CN:

CN_{comp} =	88	HEC-HMS Input
CN_{dry} =	75	NMDOT Drainage Manual Fig. 3-9; Obtained from SCS TR-55
CN_{wet} =	95	LU & CN Tables
		LU & CN Tables

SCS Runoff CN:

Curve Number, CN =	1000/(10+S)			
Storage, S =	1000/CN-10	S =	1.3636 in	
Initial Abstractions, I_a =	0.2*S	I_a =	0.272727 in	HEC-HMS Input
Time of Concentration, t_c =	$(1.67L^{0.8}[(1000/CN)-9]^{0.7})/1900*S^{0.5}$	t_c =	2.4 hr	
Length, L =	Length	L =	5412.04 ft	
Slope, S =	Average Watershed Slope (10-85 Slope)	S =	0.41 %	
Composite, CN =	CN_{comp}	CN =	88	

SCS TR-55:

Lag Time, t_l =	$((L^{0.8}(S + 1)^{0.7})/(1900S^{0.5})$	t_l =	1.46 hr	HEC-HMS Input
M =	Impervious Adjustment	M =	0.84	
P =	% Impervious	P =	33.0 %	
		t_l =	1.23 hr	Adjusted Lag Time for Imperviousness
Duration of Storm, D =	$0.133t_c$	D =	0.32 hr	
Time to Peak, t_p =	$D/2+t_l$	t_p =	1.39 hr	
Peak Discharge, Q_p =	$484A/t_p$	Q_p =	164.06 cfs	Unit Hydrograph

DA004-A SCS CURVE NUMBER

Curve Number:

Area = 0.233383 mi^2
Length = 4983.43 ft
$S_{10\text{-}85}$ = 0.0047 ft/ft
Percent Impervious = 2 %

Subscript	CN Categories	Hydrologic Soil Group CN				Percentage A, B, C, & D				Area	Area
	(From LU/CN Table)	A	B	C	D	A	B	C	D	%	mi^2
1	Commercial	89	92	94	95	0%	0%	100%	0%	0%	0
2	Industrial	81	88	91	93	0%	0%	100%	0%	0%	0
3	Paved Streets	83	89	92	93	0%	0%	100%	0%	0%	0
4	Paved Parking	98	98	98	98	0%	0%	100%	0%	2%	0.004668
5	Urban Desert Landscape	63	77	85	88	0%	0%	100%	0%	0%	0
6	Shrubland: Desert Sage - Fair		51	63	70	0%	0%	100%	0%	98%	0.228715
									Total =	100%	0.23338

Weighted CN:

		% Area	
CN_1 =	94	A_1 =	0
CN_2 =	91	A_2 =	0
CN_3 =	92	A_3 =	0
CN_4 =	98	A_4 =	0.004668
CN_5 =	85	A_5 =	0
CN_6 =	63	A_6 =	0.228715

Weighted CN:

$CN_w = (A_1*CN_1 + A_2*CN_2 + A_3*CN_3 + A_4*CN_4 + A_5*CN_5 + A_6*CN_6)/Area$

CN_w = 64

Composite CN:

CN_{comp} = 64 — HEC-HMS Input; NMDOT Drainage Manual Fig. 3-9; Obtained from SCS TR-55
CN_{dry} = 44 — LU & CN Tables
CN_{wet} = 81 — LU & CN Tables

SCS Runoff CN:

Curve Number, CN = 1000/(10+S)
Storage, S = 1000/CN-10 — S = 5.6250 in
Initial Abstractions, I_a = 0.2*S — I_a = 1.125 in — HEC-HMS Input

Time of Concentration, t_c = $(1.67L^{0.8}[(1000/CN)-9]^{0.7})/1900*S^{0.5}$ — t_c = 4.4 hr
Length, L = Length — L = 4983.43 ft
Slope, S = Average Watershed Slope (10-85 Slope) — S = 0.47 %
Composite, CN = CN_{comp} — CN = 64

SCS TR-55:

Lag Time, t_l = $((L^{0.8}(S + 1)^{0.7})/(1900S^{0.5})$ — t_l = 2.62 hr — HEC-HMS Input
M = Impervious Adjustment — M = 0.99
P = % Impervious — P = 2.0 %
t_l = 2.58 hr — Adjusted Lag Time for Imperviousness

Duration of Storm, D = $0.133t_c$ — D = 0.58 hr
Time to Peak, t_p = $D/2+t_l$ — t_p = 2.87 hr
Peak Discharge, Q_p = $484A/t_p$ — Q_p = 39.36 cfs — Unit Hydrograph

DA009 SCS CURVE NUMBER

Curve Number:

Area = 0.005544 mi^2
Length = 663.886 ft
$S_{10\text{-}85}$ = 0.0032 ft/ft
Percent Impervious = 31 %

Subscript	CN Categories	Hydrologic Soil Group CN				Percentage A, B, C, & D				Area	Area
	(From LU/CN Table)	A	B	C	D	A	B	C	D	%	mi^2
1	Commercial	89	92	94	95	0%	0%	100%	0%	0%	0
2	Industrial	81	88	91	93	0%	0%	100%	0%	23%	0.001275
3	Paved Streets	83	89	92	93	0%	0%	100%	0%	8%	0.000444
4	Paved Parking	98	98	98	98	0%	0%	100%	0%	0%	0
5	Urban Desert Landscape	63	77	85	88	0%	0%	100%	0%	69%	0.003825
6	Shrubland: Desert Sage - Fair		51	63	70	0%	0%	100%	0%	0%	0
									Total =	100%	0.00554

Weighted CN:

		% Area	
CN_1 =	94	A_1 =	0
CN_2 =	91	A_2 =	0.001275
CN_3 =	92	A_3 =	0.000444
CN_4 =	98	A_4 =	0
CN_5 =	85	A_5 =	0.003825
CN_6 =	63	A_6 =	0

Weighted CN:

$CN_w = (A_1*CN_1 + A_2*CN_2 + A_3*CN_3 + A_4*CN_4 + A_5*CN_5 + A_6*CN_6)/Area$

CN_w = 87

Composite CN:

CN_{comp} =	91	HEC-HMS Input
		NMDOT Drainage Manual Fig. 3-9; Obtained from SCS TR-55
CN_{dry} =	80	LU & CN Tables
CN_{wet} =	96	LU & CN Tables

SCS Runoff CN:

Curve Number, CN =	1000/(10+S)			
Storage, S =	1000/CN-10	S =	0.9890 in	
Initial Abstractions, I_a =	0.2*S	I_a =	0.197802 in	HEC-HMS Input
Time of Concentration, t_c =	$(1.67L^{0.8}[(1000/CN)-9]^{0.7})/1900*S^{0.5}$	t_c =	0.5 hr	
Length, L =	Length	L =	663.886 ft	
Slope, S =	Average Watershed Slope (10-85 Slope)	S =	0.32 %	
Composite, CN =	CN_{comp}	CN =	91	

SCS TR-55:

Lag Time, t_l =	$((L^{0.8}(S + 1)^{0.7})/(1900S^{0.5})$	t_l =	0.27 hr	HEC-HMS Input
M =	Impervious Adjustment	M =	0.88	
P =	% Impervious	P =	31.0 %	
		t_l =	0.24 hr	Adjusted Lag Time for Imperviousness
Duration of Storm, D =	$0.133t_c$	D =	0.06 hr	
Time to Peak, t_p =	$D/2+t_l$	t_p =	0.27 hr	
Peak Discharge, Q_p =	$484A/t_p$	Q_p =	9.94 cfs	Unit Hydrograph

DA010 SCS CURVE NUMBER

Curve Number:

Area = 0.156278 mi^2
Length = 2867.19 ft
$S_{10\text{-}85}$ = 0.0032 ft/ft
Percent Impervious = 0 %

Subscript	CN Categories	Hydrologic Soil Group CN				Percentage A, B, C, & D				Area	Area
	(From LU/CN Table)	A	B	C	D	A	B	C	D	%	mi^2
1	Commercial	89	92	94	95	0%	0%	100%	0%	0%	0
2	Industrial	81	88	91	93	0%	0%	100%	0%	0%	0
3	Paved Streets	83	89	92	93	0%	0%	100%	0%	0%	0
4	Paved Parking	98	98	98	98	0%	0%	100%	0%	0%	0
5	Urban Desert Landscape	63	77	85	88	0%	0%	100%	0%	0%	0
6	Shrubland: Desert Sage - Fair		51	63	70	0%	0%	100%	0%	100%	0.156278
									Total =	100%	0.15628

Weighted CN:

		% Area	
CN_1 =	94	A_1 =	0
CN_2 =	91	A_2 =	0
CN_3 =	92	A_3 =	0
CN_4 =	98	A_4 =	0
CN_5 =	85	A_5 =	0
CN_6 =	63	A_6 =	0.156278

Weighted CN:

$CN_w = (A_1*CN_1 + A_2*CN_2 + A_3*CN_3 + A_4*CN_4 + A_5*CN_5 + A_6*CN_6)/Area$

CN_w = 63

Composite CN:

CN_{comp} =	63	HEC-HMS Input
CN_{dry} =	43	NMDOT Drainage Manual Fig. 3-9; Obtained from SCS TR-55
CN_{wet} =	80	LU & CN Tables

SCS Runoff CN:

Curve Number, CN =	1000/(10+S)			
Storage, S =	1000/CN-10	S =	5.8730 in	
Initial Abstractions, I_a =	0.2*S	I_a =	1.174603 in	HEC-HMS Input
Time of Concentration, t_c =	$(1.67L^{0.8}[(1000/CN)-9]^{0.7})/1900*S^{0.5}$	t_c =	3.5 hr	
Length, L =	Length	L =	2867.19 ft	
Slope, S =	Average Watershed Slope (10-85 Slope)	S =	0.32 %	
Composite, CN =	CN_{comp}	CN =	63	

SCS TR-55:

Lag Time, t_l =	$((L^{0.8}(S + 1)^{0.7})/(1900S^{0.5})$	t_l =	2.09 hr	HEC-HMS Input
M =	Impervious Adjustment	M =	1.00	
P =	% Impervious	P =	0.0 %	
		t_l =	2.09 hr	Adjusted Lag Time for Imperviousness
Duration of Storm, D =	$0.133t_c$	D =	0.46 hr	
Time to Peak, t_p =	$D/2+t_l$	t_p =	2.32 hr	
Peak Discharge, Q_p =	$484A/t_p$	Q_p =	32.60 cfs	Unit Hydrograph

DA010-A SCS CURVE NUMBER

Curve Number:

Area = 0.028038 mi^2
Length = 1203.02 ft
$S_{10\text{-}85}$ = 0.0024 ft/ft
Percent Impervious = 1.6 %

Subscript	CN Categories	Hydrologic Soil Group CN				Percentage A, B, C, & D				Area	Area
	(From LU/CN Table)	A	B	C	D	A	B	C	D	%	mi^2
1	Commercial	89	92	94	95	0%	0%	100%	0%	0%	0
2	Industrial	81	88	91	93	0%	0%	100%	0%	0.3%	8.41E-05
3	Paved Streets	83	89	92	93	0%	0%	100%	0%	1.3%	0.000364
4	Paved Parking	98	98	98	98	0%	0%	100%	0%	0%	0
5	Urban Desert Landscape	63	77	85	88	0%	0%	100%	0%	0%	0
6	Shrubland: Desert Sage - Fair		51	63	70	0%	0%	100%	0%	98.4%	0.027589
									Total =	100%	0.02804

Weighted CN:

		% Area	
CN_1 =	94	A_1 =	0
CN_2 =	91	A_2 =	8.41E-05
CN_3 =	92	A_3 =	0.000364
CN_4 =	98	A_4 =	0
CN_5 =	85	A_5 =	0
CN_6 =	63	A_6 =	0.027589

Weighted CN:

$CN_w = (A_1{*}CN_1 + A_2{*}CN_2 + A_3{*}CN_3 + A_4{*}CN_4 + A_5{*}CN_5 + A_6{*}CN_6)/Area$

CN_w = 63

Composite CN:

CN_{comp} =	63	HEC-HMS Input
CN_{dry} =	43	NMDOT Drainage Manual Fig. 3-9; Obtained from SCS TR-55
CN_{wet} =	80	LU & CN Tables
		LU & CN Tables

SCS Runoff CN:

Curve Number, CN = 1000/(10+S)
Storage, S = 1000/CN-10
Initial Abstractions, I_a = 0.2*S

S = 5.8730 in
I_a = 1.174603 in — HEC-HMS Input

Time of Concentration, t_c = $(1.67L^{0.8}[(1000/CN)-9]^{0.7})/1900{*}S^{0.5}$
Length, L = Length
Slope, S = Average Watershed Slope (10-85 Slope)
Composite, CN = CN_{comp}

t_c = 2.0 hr
L = 1203.02 ft
S = 0.24 %
CN = 63

SCS TR-55:

Lag Time, t_l = $((L^{0.8}(S + 1)^{0.7})/(1900S^{0.5})$
M = Impervious Adjustment
P = % Impervious

t_l = 1.21 hr — HEC-HMS Input
M = 0.99
P = 1.6 %
t_l = 1.20 hr — Adjusted Lag Time for Imperviousness

Duration of Storm, D = $0.133t_c$
Time to Peak, t_p = $D/2+t_l$
Peak Discharge, Q_p = $484A/t_p$

D = 0.27 hr
t_p = 1.33 hr
Q_p = 10.20 cfs — Unit Hydrograph

DA011 SCS CURVE NUMBER

Curve Number:

Area = 0.025884 mi^2
Length = 789.9338 ft
$S_{10\text{-}85}$ = 0.0101 ft/ft
Percent Impervious = 48 %

Subscript	CN Categories	Hydrologic Soil Group CN				Percentage A, B, C, & D				Area	Area
	(From LU/CN Table)	A	B	C	D	A	B	C	D	%	mi^2
1	Commercial	89	92	94	95	0%	0%	100%	0%	12%	0.003106
2	Industrial	81	88	91	93	0%	0%	100%	0%	0%	0
3	Paved Streets	83	89	92	93	0%	0%	100%	0%	12%	0.003106
4	Paved Parking	98	98	98	98	0%	0%	100%	0%	28%	0.007248
5	Urban Desert Landscape	63	77	85	88	0%	0%	100%	0%	14%	0.003624
6	Shrubland: Desert Sage - Fair		51	63	70	0%	0%	100%	0%	34%	0.008801
									Total =	100%	0.02588

Weighted CN:

		% Area	
CN_1 =	94	A_1 =	0.003106
CN_2 =	91	A_2 =	0
CN_3 =	92	A_3 =	0.003106
CN_4 =	98	A_4 =	0.007248
CN_5 =	85	A_5 =	0.003624
CN_6 =	63	A_6 =	0.008801

Weighted CN:

$CN_w = (A_1*CN_1 + A_2*CN_2 + A_3*CN_3 + A_4*CN_4 + A_5*CN_5 + A_6*CN_6)/Area$

CN_w = 83

Composite CN:

CN_{comp} = 90 — HEC-HMS Input; NMDOT Drainage Manual Fig. 3-9; Obtained from SCS TR-55
CN_{dry} = 78 — LU & CN Tables
CN_{wet} = 96 — LU & CN Tables

SCS Runoff CN:

Curve Number, CN = 1000/(10+S)
Storage, S = 1000/CN-10 — S = 1.1111 in
Initial Abstractions, I_a = 0.2*S — I_a = 0.222222 in — HEC-HMS Input

Time of Concentration, t_c = $(1.67L^{0.8}[(1000/CN)-9]^{0.7})/1900*S^{0.5}$ — t_c = 0.3 hr
Length, L = Length — L = 789.9338 ft
Slope, S = Average Watershed Slope (10-85 Slope) — S = 1.01 %
Composite, CN = CN_{comp} — CN = 90

SCS TR-55:

Lag Time, t_l = $((L^{0.8}(S + 1)^{0.7})/(1900S^{0.5})$ — t_l = 0.18 hr — HEC-HMS Input
M = Impervious Adjustment — M = 0.79
P = % Impervious — P = 48.0 %
t_l = 0.14 hr — Adjusted Lag Time for Imperviousness

Duration of Storm, D = $0.133t_c$ — D = 0.04 hr
Time to Peak, t_p = $D/2+t_l$ — t_p = 0.16 hr
Peak Discharge, Q_p = $484A/t_p$ — Q_p = 78.30 cfs — Unit Hydrograph

Appendix B

HEC-HMS Summary of Results

HMS * Summary of Results

Project : HAFB_DA001_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA0001
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET-MODEL
Execution Time	: 13Apr05 1003	Control Specs	: HAFB CONTROL

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA001	200.31	01 Aug 04 1910	31.614	0.384

HMS * Summary of Results for HAFB DA001

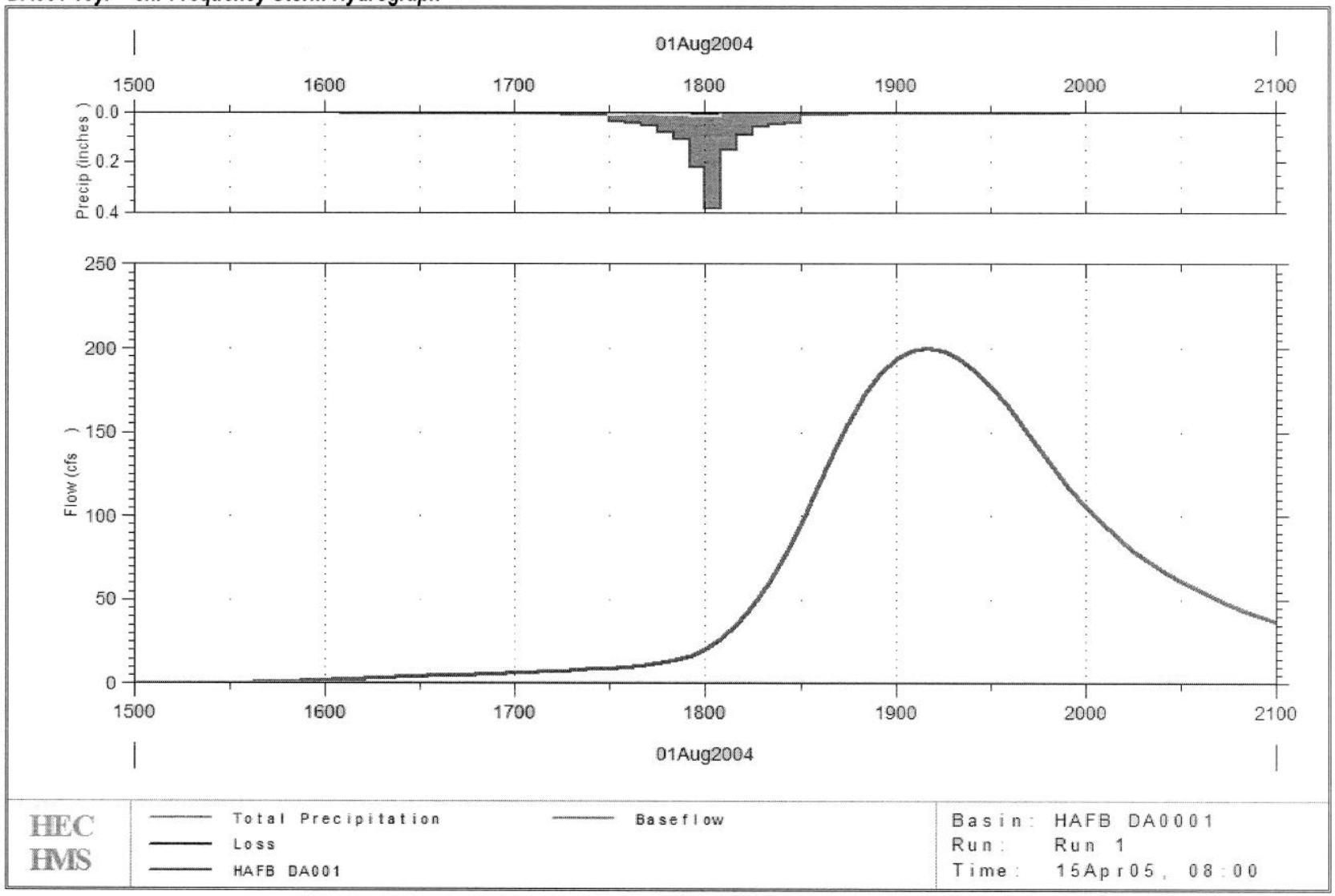
Project : HAFB_DA001_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA0001
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET-MODEL
Execution Time	: 13Apr05 1003	Control Specs	: HAFB CONTROL

Computed Results

Peak Discharge	: 200.31 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1910
Total Precipitation	: 1.71 (in)	Total Direct Runoff	: 1.54 (in)
Total Loss	: 0.17 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.54 (in)	Total Discharge	: 1.54 (in)

DA001 10yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA001_25yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA0001

End of Run : 01Aug04 2100 Met. Model : HAFB MET-MODEL

Execution Time : 22Apr05 0916 Control Specs : HAFB CONTROL

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA001	240.64	01 Aug 04 1910	34.978	0.384

HMS * Summary of Results for HAFB DA001

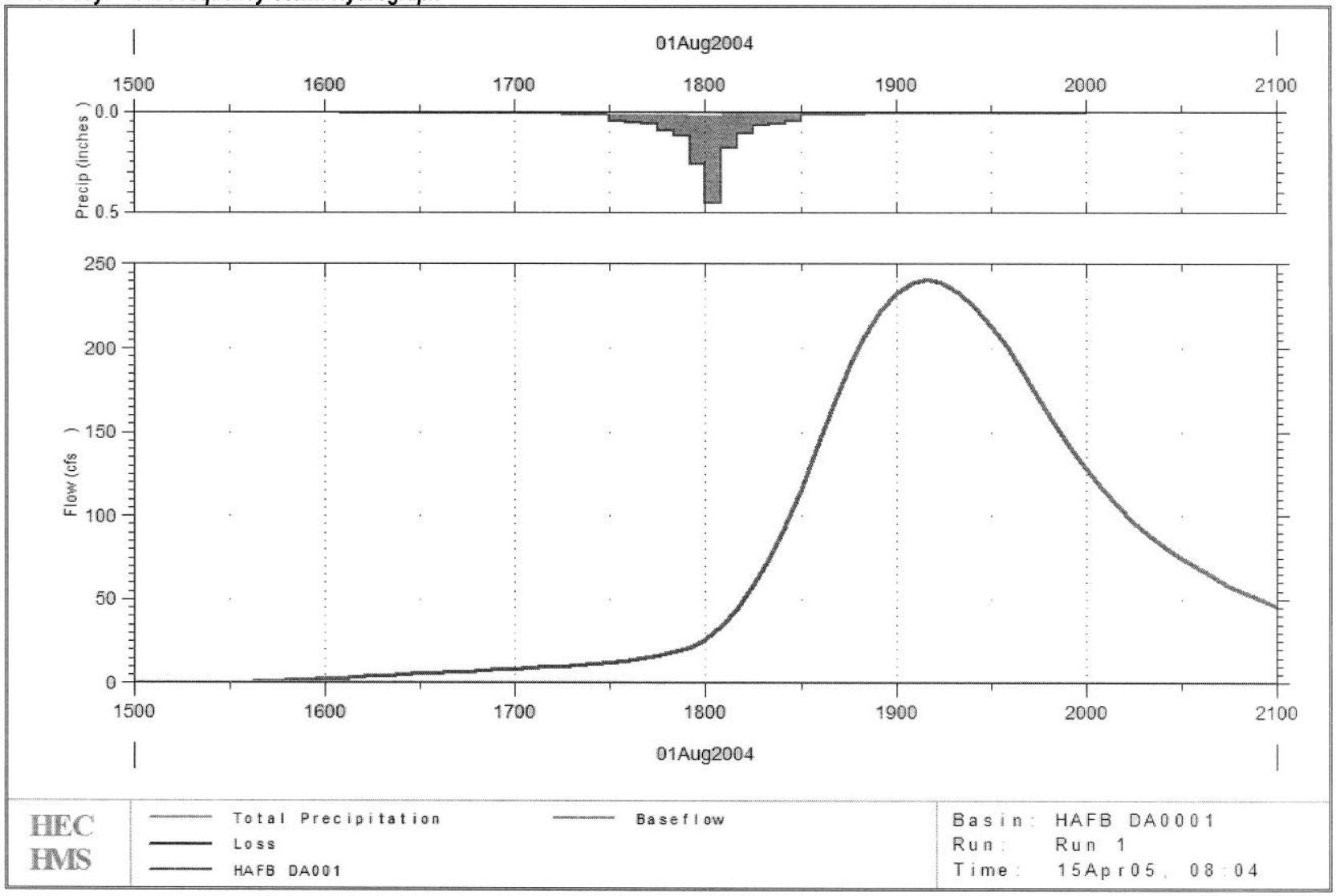
Project : HAFB_DA001_25yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA0001
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET-MODEL
Execution Time	: 13Apr05 1006	Control Specs	: HAFB CONTROL

Computed Results

Peak Discharge	: 240.64 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1910
Total Precipitation	: 2.05 (in)	Total Direct Runoff	: 1.88 (in)
Total Loss	: 0.18 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.88 (in)	Total Discharge	: 1.88 (in)

DA001 25yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA001_100yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA0001

End of Run : 01Aug04 2100 Met. Model : HAFB MET-MODEL

Execution Time : 22Apr05 0918 Control Specs : HAFB CONTROL

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA001	322.83	01 Aug 04 1910	45.190	0.384

HMS * Summary of Results for HAFB DA001

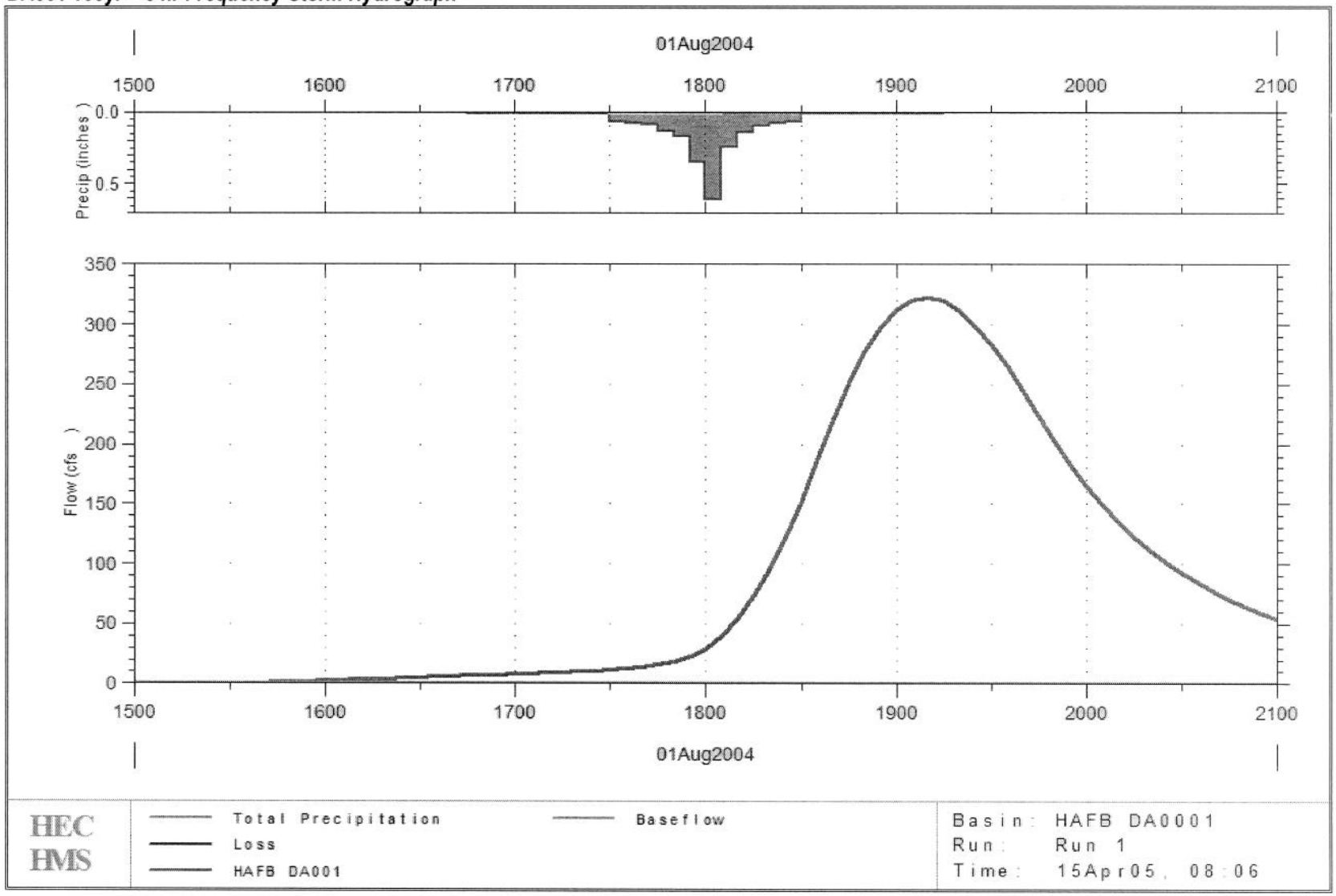
Project : HAFB_DA001_100yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA0001
End of Run	: 01Aug04 2100	Met. Model	: HAFB MET-MODEL
Execution Time	: 22Apr05 0918	Control Specs	: HAFB CONTROL

Computed Results

Peak Discharge	: 322.83 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1910
Total Precipitation	: 2.58 (in)	Total Direct Runoff	: 2.20 (in)
Total Loss	: 0.18 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 2.40 (in)	Total Discharge	: 2.20 (in)

DA001 100yr – 6 hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA001-A_10yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA001-A

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA001-A

Execution Time : 13Apr05 0953 Control Specs : HAFB CONTROL DA001-A

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA001-A	8.7570	01 Aug 04 1955	2.1618	0.223

HMS * Summary of Results for HAFB DA001-A

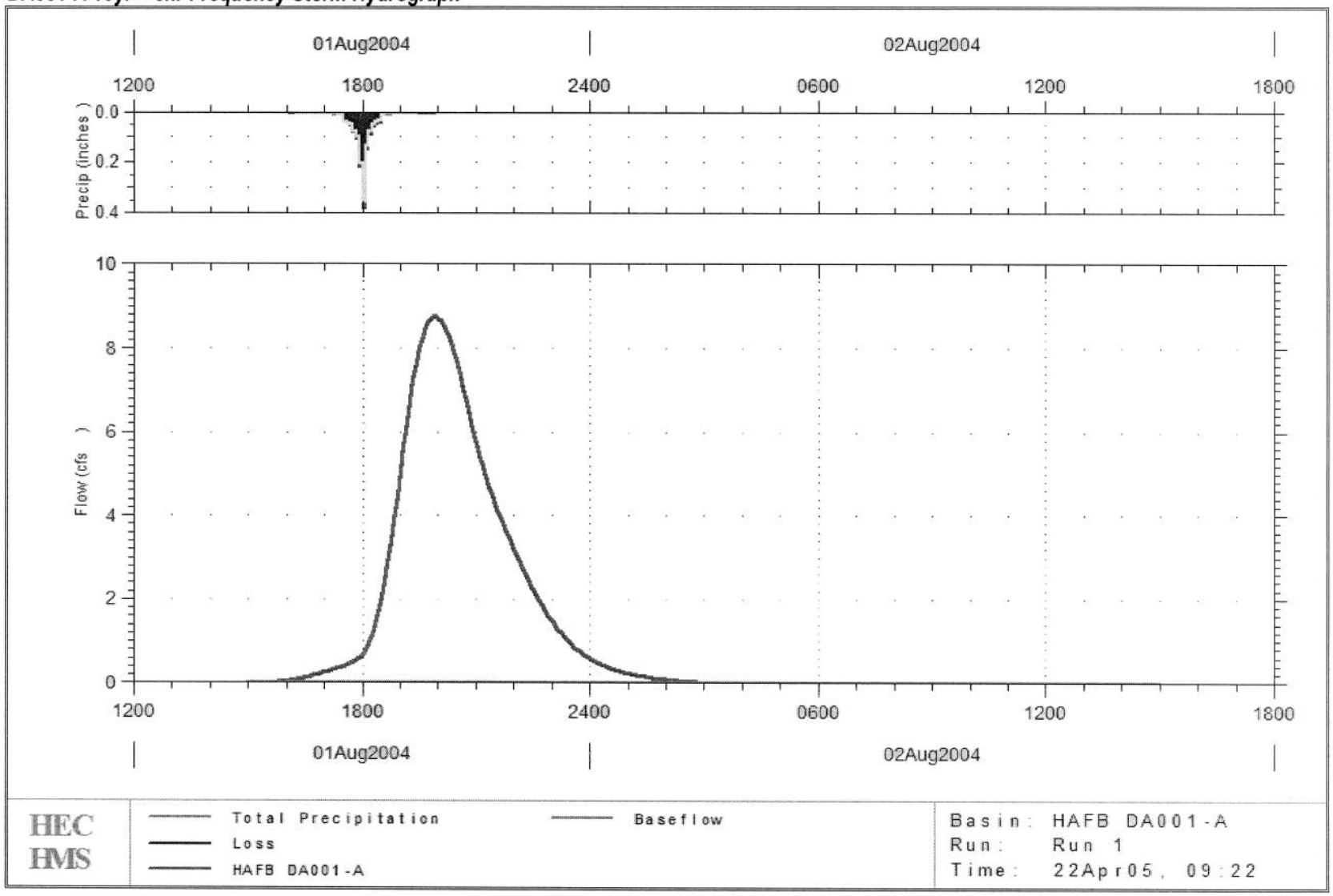
Project : HAFB_DA001-A_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA001-A
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA001-A
Execution Time	: 13Apr05 0953	Control Specs	: HAFB CONTROL DA001-A

Computed Results

Peak Discharge	: 8.7570 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1955
Total Precipitation	: 1.71 (in)	Total Direct Runoff	: 0.18 (in)
Total Loss	: 1.53 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.18 (in)	Total Discharge	: 0.18 (in)

DA001-A 10yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA001-A_25yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA001-A

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA001-A

Execution Time : 13Apr05 0957 Control Specs : HAFB CONTROL DA001-A

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA001-A	13.575	01 Aug 04 1955	3.3574	0.223

HMS * Summary of Results for HAFB DA001-A

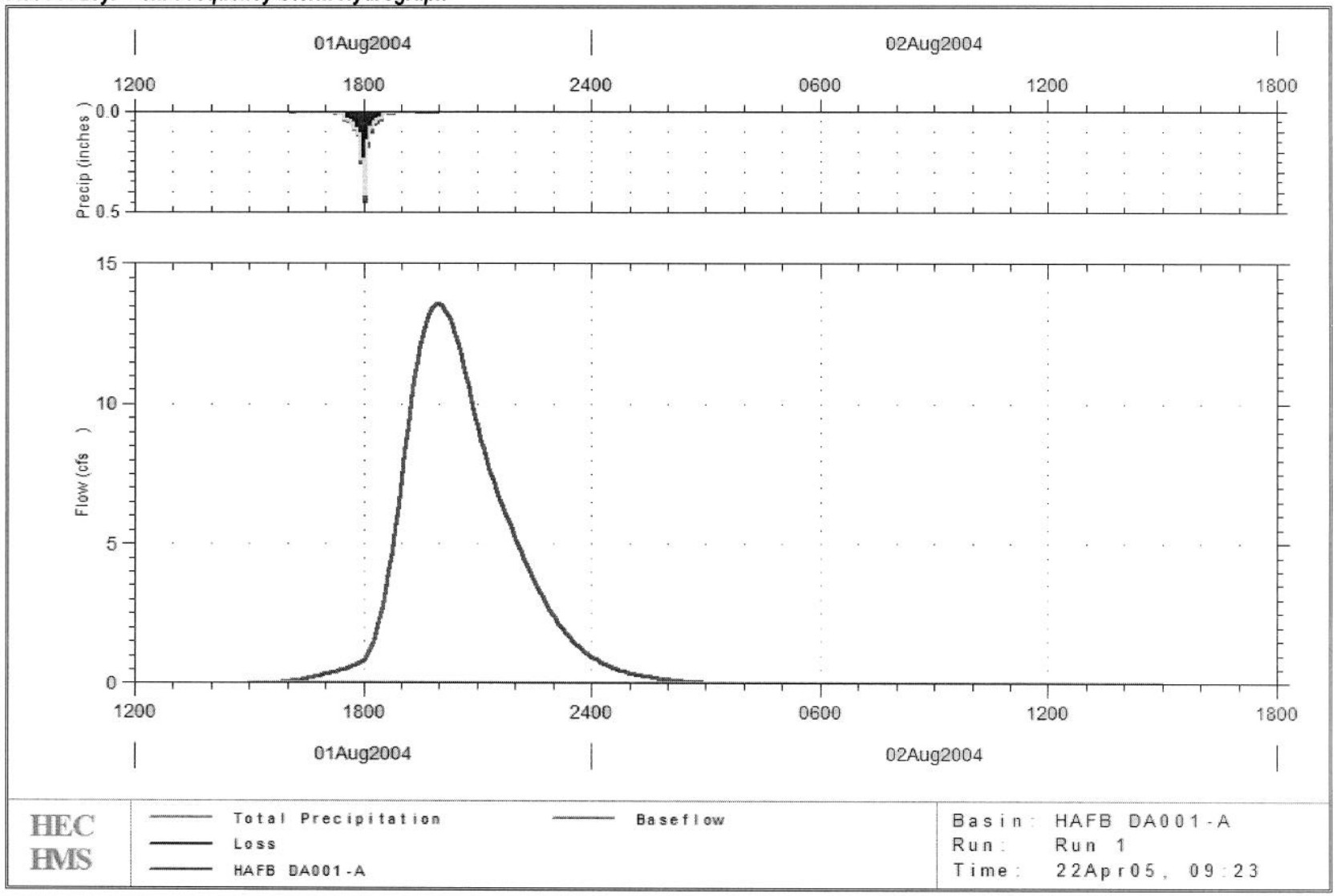
Project : HAFB_DA001-A_25yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA001-A
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA001-A
Execution Time	: 13Apr05 0957	Control Specs	: HAFB CONTROL DA001-A

Computed Results

Peak Discharge	: 13.575 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1955
Total Precipitation	: 2.05 (in)	Total Direct Runoff	: 0.28 (in)
Total Loss	: 1.77 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.28 (in)	Total Discharge	: 0.28 (in)

DA001-A 25yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA001-A_100yrFQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA001-A

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA001-A

Execution Time : 13Apr05 0959 Control Specs : HAFB CONTROL DA001-A

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA001-A	25.121	01 Aug 04 1955	5.7472	0.223

HMS * Summary of Results for HAFB DA001-A

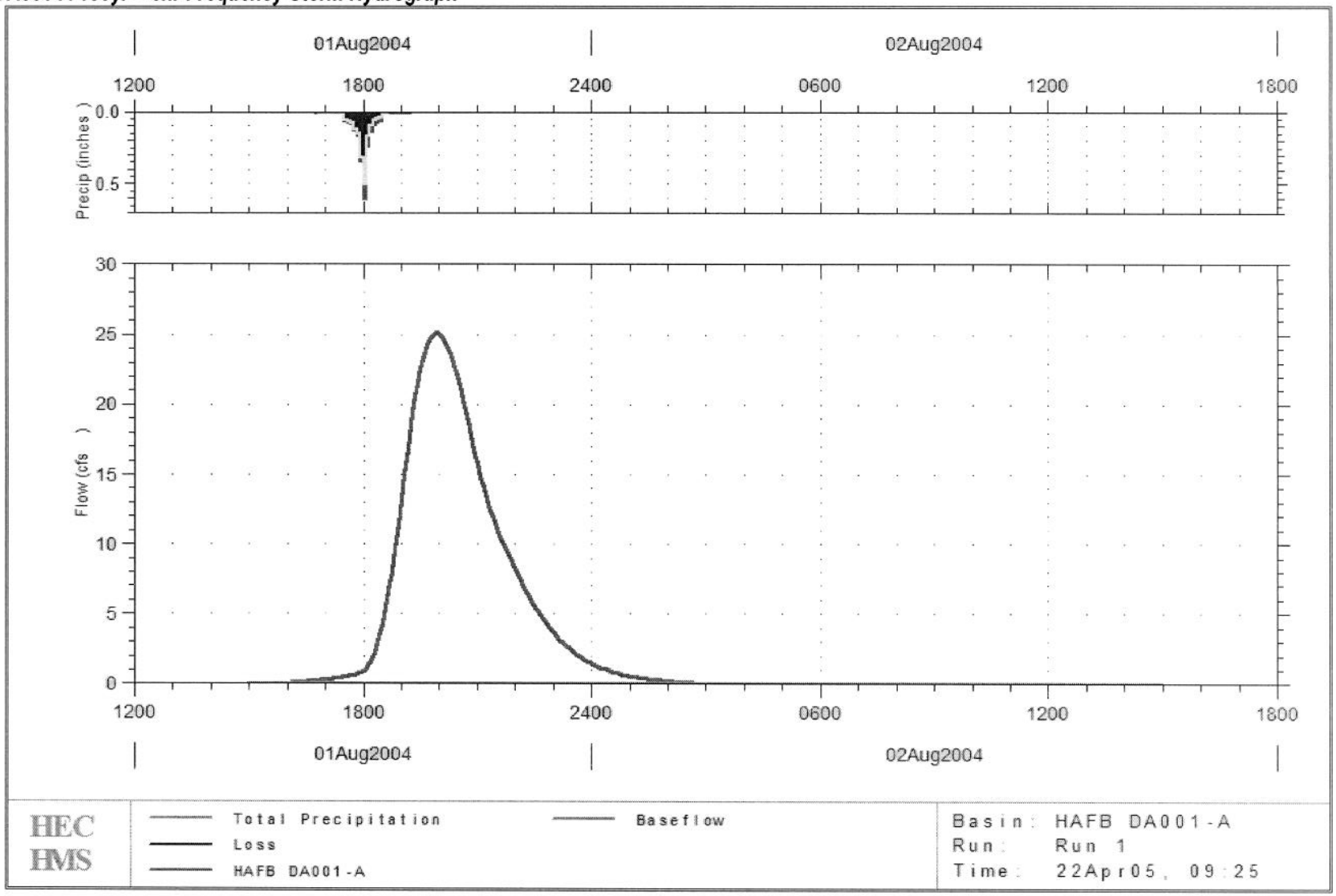
Project : HAFB_DA001-A_100yrFQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA001-A
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA001-A
Execution Time	: 13Apr05 0959	Control Specs	: HAFB CONTROL DA001-A

Computed Results

Peak Discharge	: 25.121 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1955
Total Precipitation	: 2.58 (in)	Total Direct Runoff	: 0.48 (in)
Total Loss	: 2.09 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.48 (in)	Total Discharge	: 0.48 (in)

DA001-A 100yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA002_10yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA002

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA002

Execution Time : 13Apr05 1016 Control Specs : HAFB CONTROL DA002

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA002	84.940	01 Aug 04 1855	10.303	0.180

HMS * Summary of Results for HAFB DA002

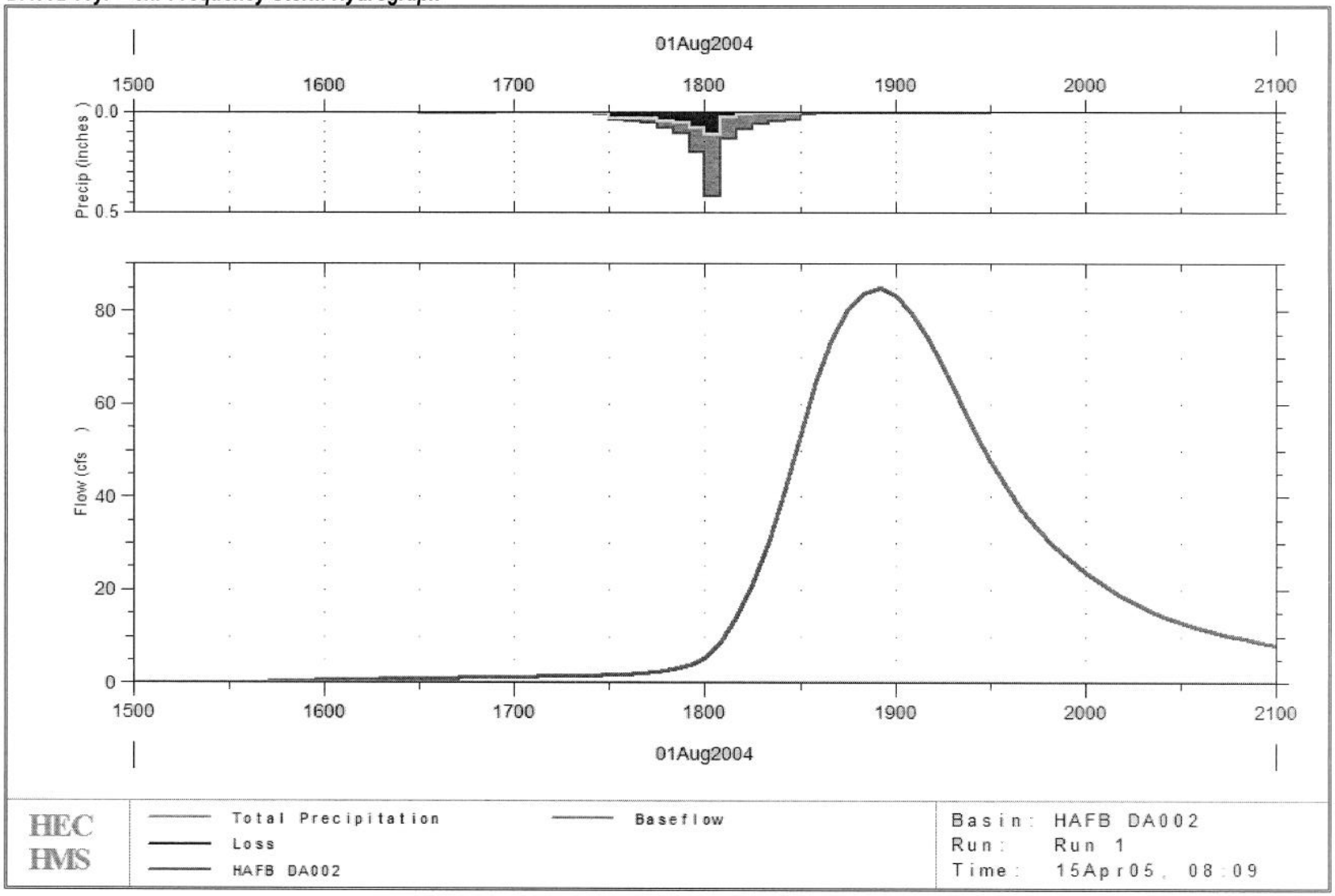
Project : HAFB_DA002_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA002
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA002
Execution Time	: 13Apr05 1016	Control Specs	: HAFB CONTROL DA002

Computed Results

Peak Discharge	: 84.940 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1855
Total Precipitation	: 1.71 (in)	Total Direct Runoff	: 1.08 (in)
Total Loss	: 0.64 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.08 (in)	Total Discharge	: 1.08 (in)

DA002 10yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA002_25yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA002

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA002

Execution Time : 13Apr05 1017 Control Specs : HAFB CONTROL DA002

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA002	107.73	01 Aug 04 1855	13.208	0.180

HMS * Summary of Results for HAFB DA002

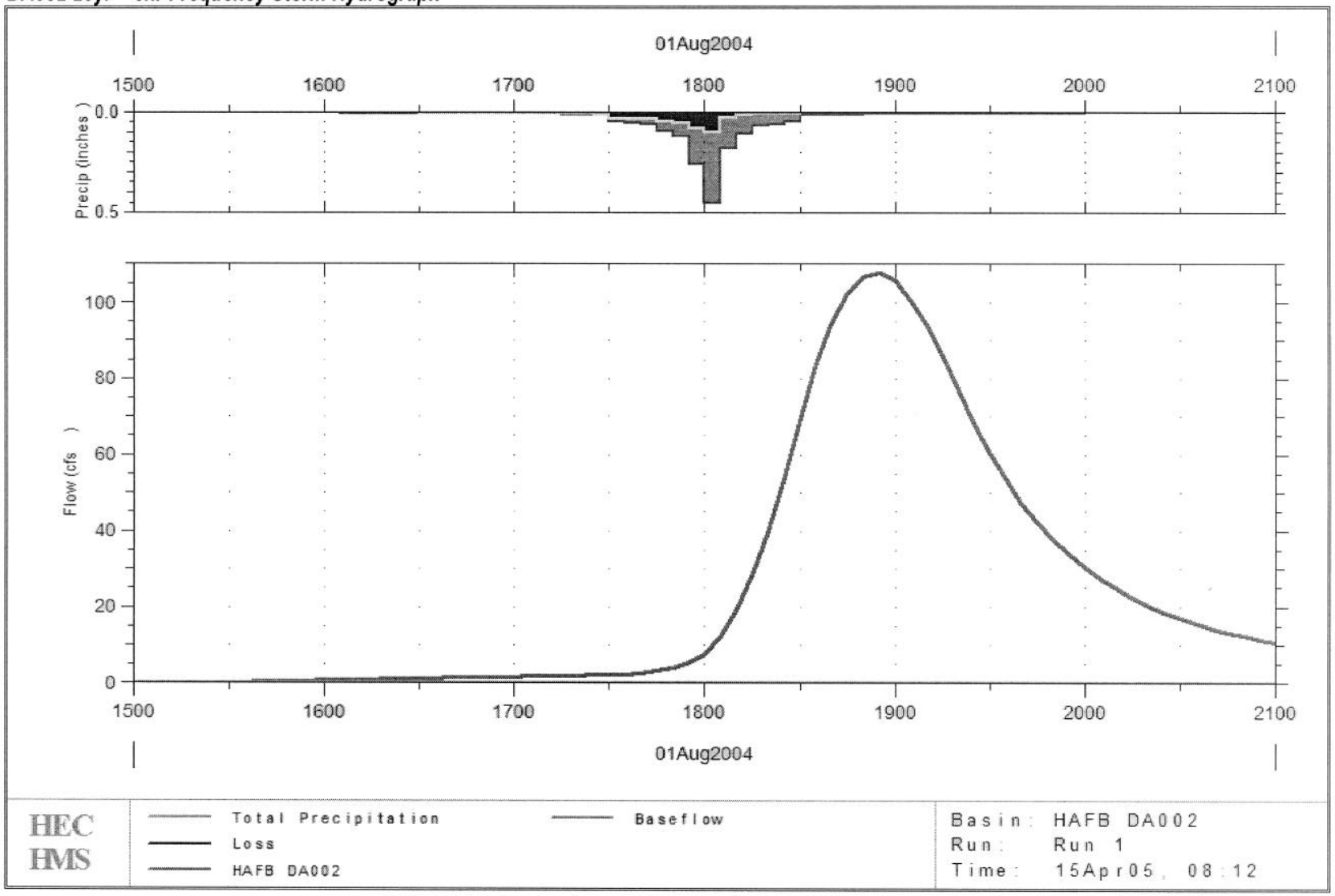
Project : HAFB_DA002_25yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA002
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA002
Execution Time	: 13Apr05 1017	Control Specs	: HAFB CONTROL DA002

Computed Results

Peak Discharge	: 107.73 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1855
Total Precipitation	: 2.05 (in)	Total Direct Runoff	: 1.38 (in)
Total Loss	: 0.67 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.38 (in)	Total Discharge	: 1.38 (in)

DA002 25yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA002_100yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA002

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA002

Execution Time : 13Apr05 1019 Control Specs : HAFB CONTROL DA002

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA002	153.77	01 Aug 04 1855	17.820	0.180

HMS * Summary of Results for HAFB DA002

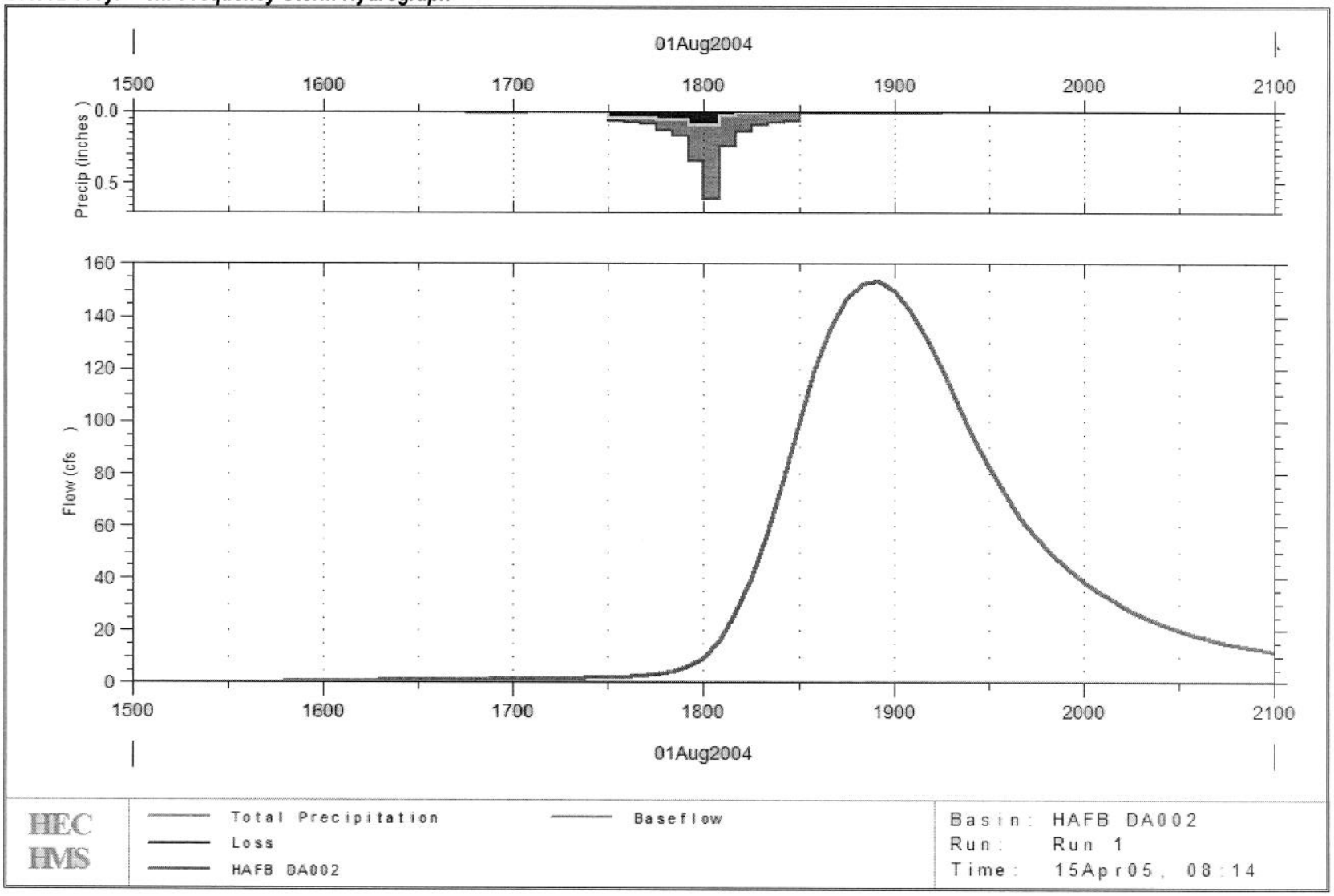
Project : HAFB_DA002_100yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA002
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA002
Execution Time	: 13Apr05 1019	Control Specs	: HAFB CONTROL DA002

Computed Results

Peak Discharge	: 153.77 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1855
Total Precipitation	: 2.58 (in)	Total Direct Runoff	: 1.86 (in)
Total Loss	: 0.72 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.86 (in)	Total Discharge	: 1.86 (in)

DA002 100yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA002-A_10yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA002-A

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA002-A

Execution Time : 13Apr05 1026 Control Specs : HAFB CONTROL DA002-A

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA002-A	2.2152	01 Aug 04 1950	0.52235	0.055

HMS * Summary of Results for HAFB DA002-A

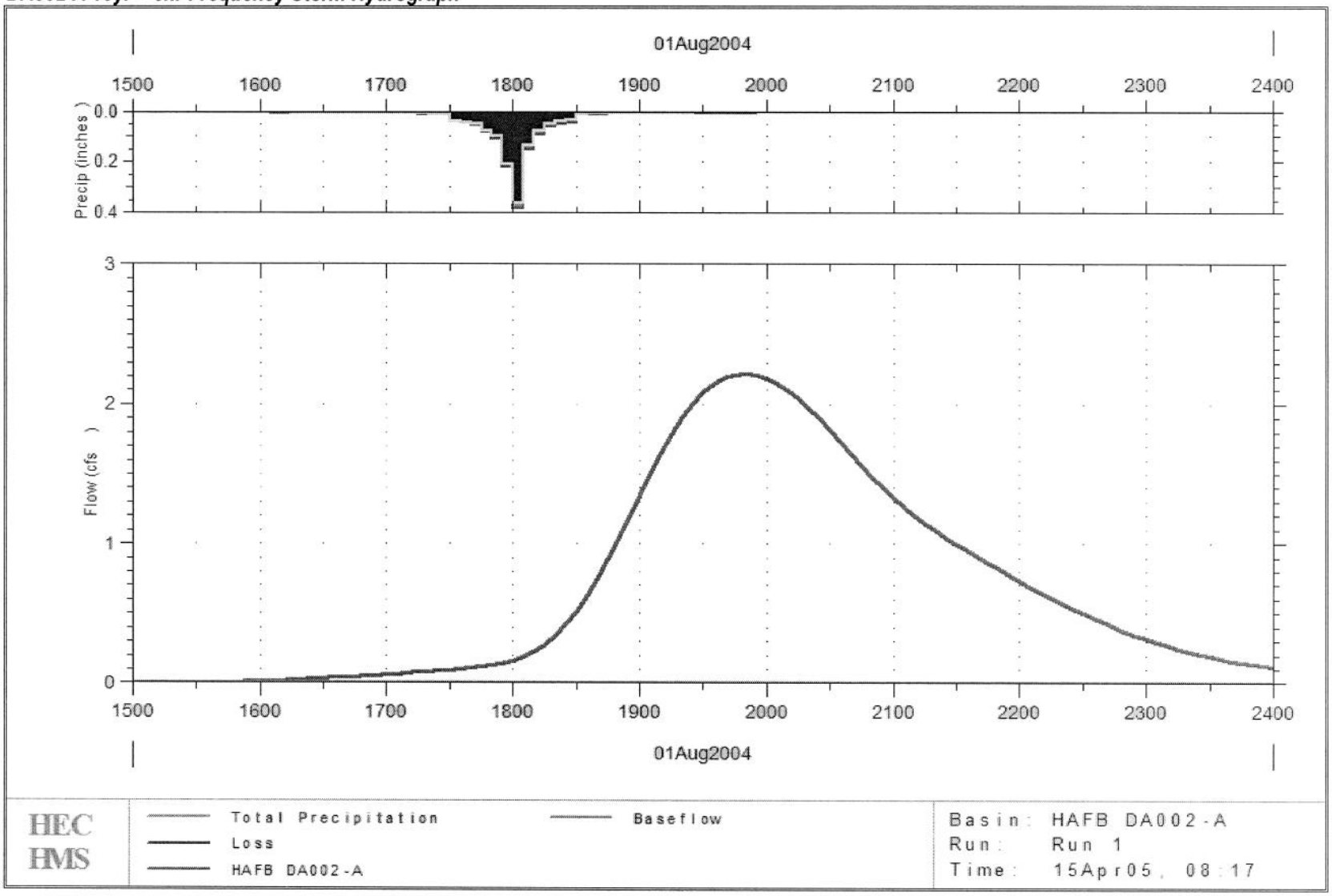
Project : HAFB_DA002-A_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA002-A
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA002-A
Execution Time	: 13Apr05 1026	Control Specs	: HAFB CONTROL DA002-A

Computed Results

Peak Discharge	: 2.2152 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1950
Total Precipitation	: 1.71 (in)	Total Direct Runoff	: 0.18 (in)
Total Loss	: 1.53 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.18 (in)	Total Discharge	: 0.18 (in)

DA002-A 10yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFN_DA002-A_25yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA002-A

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA002-A

Execution Time : 13Apr05 1028 Control Specs : HAFB CONTROL DA002-A

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA002-A	3.5373	01 Aug 04 1950	0.83025	0.055

HMS * Summary of Results for HAFB DA002-A

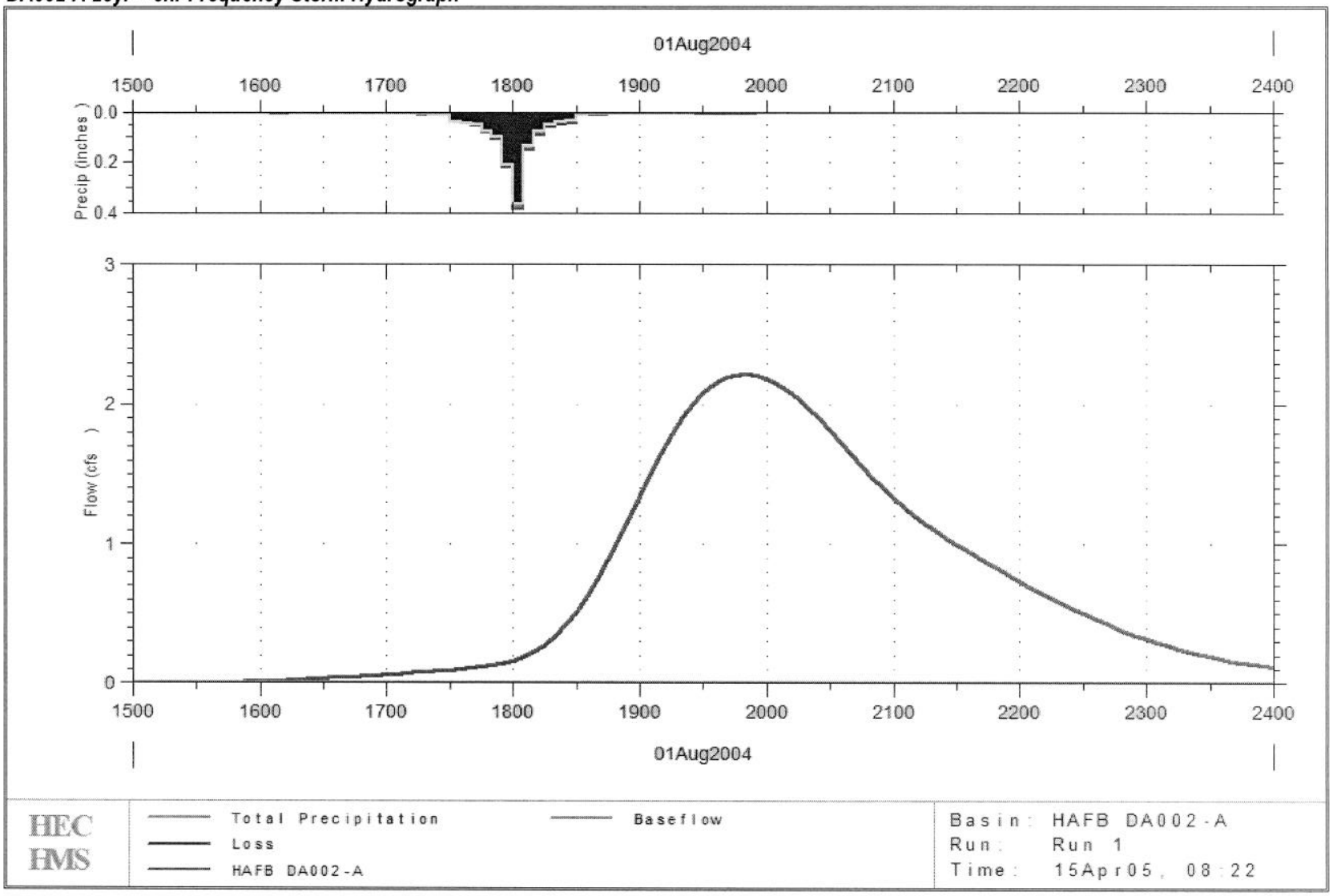
Project : HAFN_DA002-A_25yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA002-A
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA002-A
Execution Time	: 13Apr05 1028	Control Specs	: HAFB CONTROL DA002-A

Computed Results

Peak Discharge	: 3.5373 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1950
Total Precipitation	: 2.05 (in)	Total Direct Runoff	: 0.28 (in)
Total Loss	: 1.77 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.28 (in)	Total Discharge	: 0.28 (in)

DA002-A 25yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA002-A_100yrFQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA002-A

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA002-A

Execution Time : 13Apr05 1030 Control Specs : HAFB CONTROL DA002-A

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA002-A	6.6757	01 Aug 04 1950	1.4418	0.055

HMS * Summary of Results for HAFB DA002-A

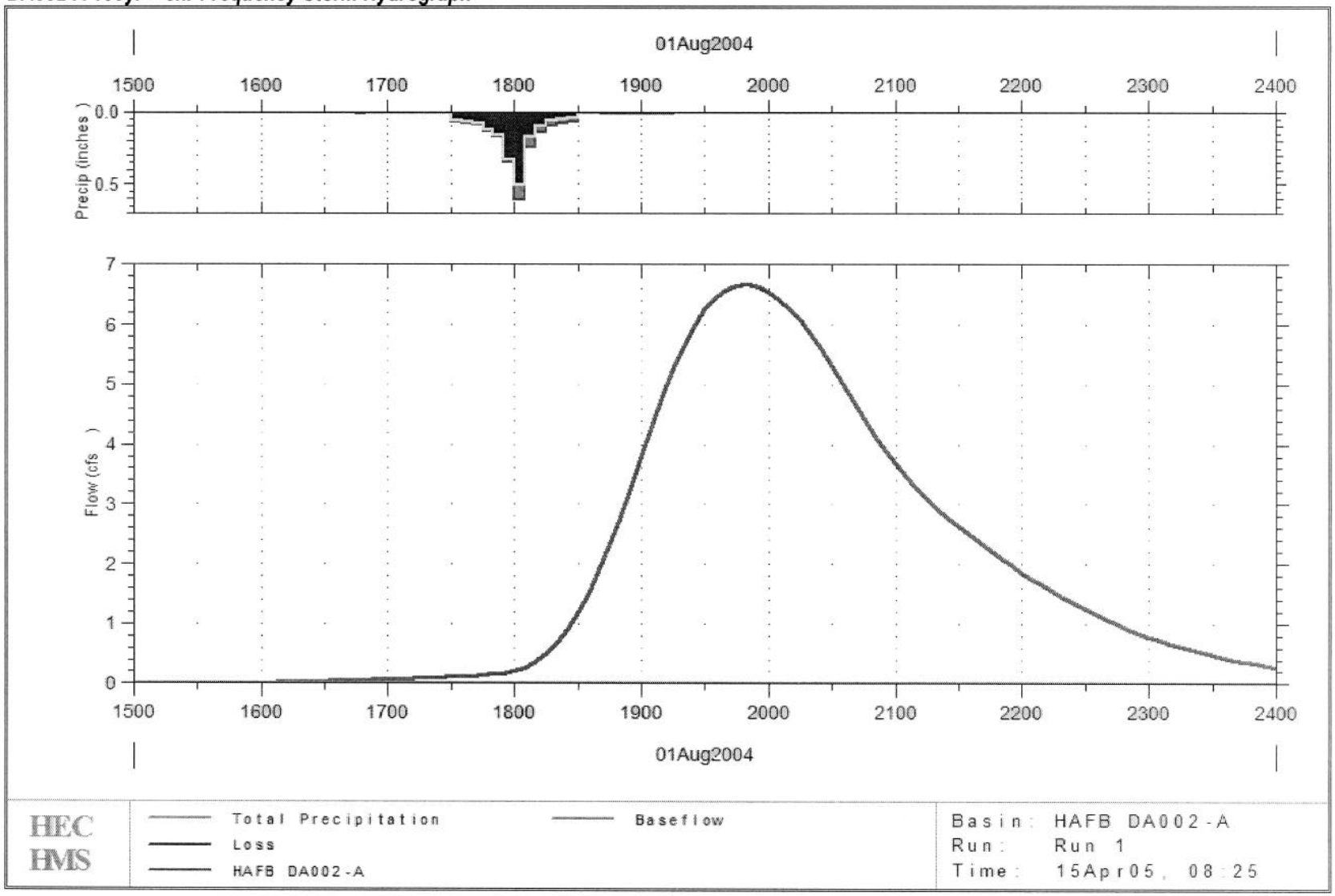
Project : HAFB_DA002-A_100yrFQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA002-A
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA002-A
Execution Time	: 13Apr05 1030	Control Specs	: HAFB CONTROL DA002-A

Computed Results

Peak Discharge	: 6.6757 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1950
Total Precipitation	: 2.58 (in)	Total Direct Runoff	: 0.49 (in)
Total Loss	: 2.09 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.49 (in)	Total Discharge	: 0.49 (in)

DA002-A 100yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA002-B_10yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA002-B

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA002-B

Execution Time : 13Apr05 1031 Control Specs : HAFB CONTROL DA002-B

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA002-B	0.70400	01 Aug 04 2005	0.18721	0.045

HMS * Summary of Results for HAFB DA002-B

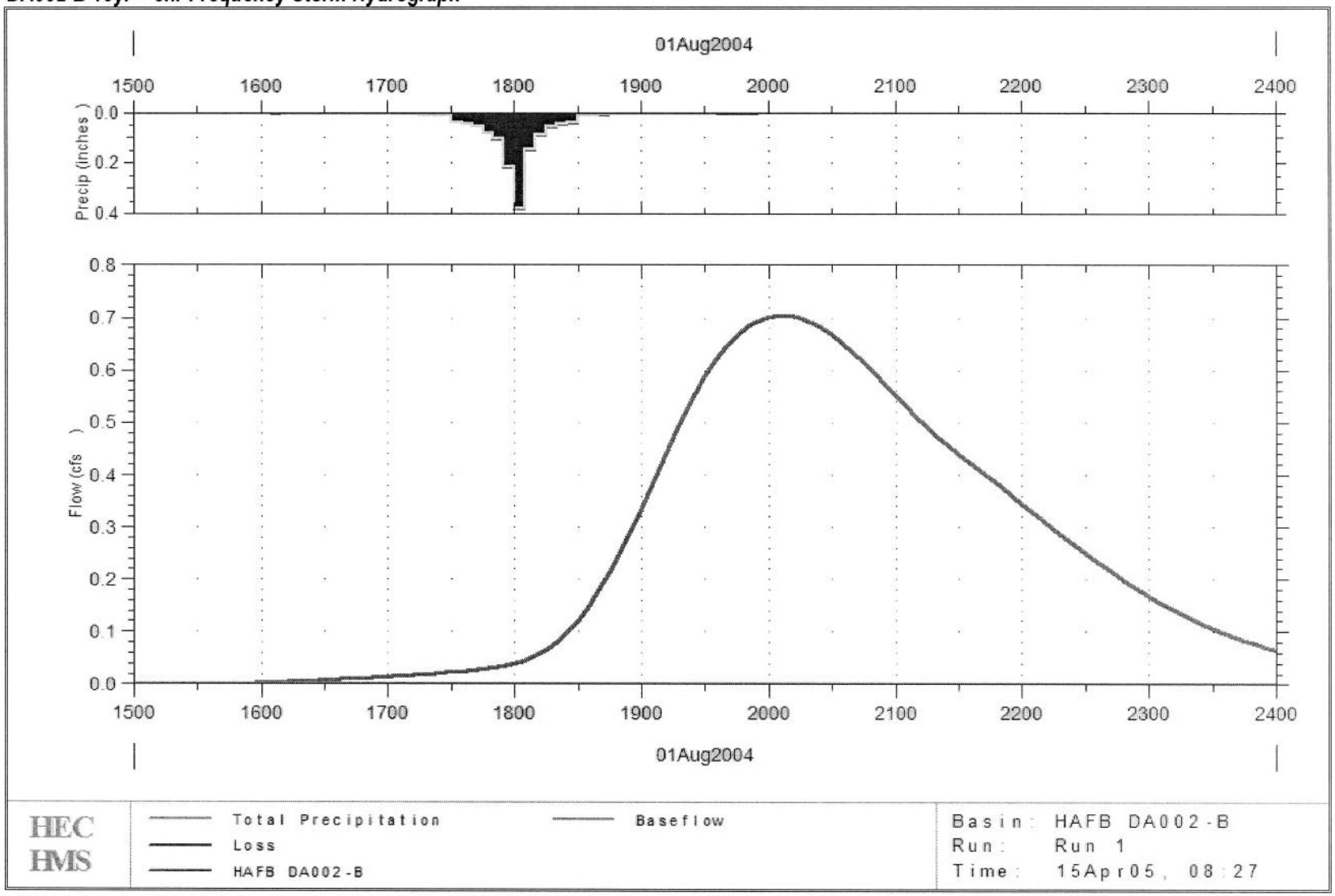
Project : HAFB_DA002-B_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA002-B
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA002-B
Execution Time	: 13Apr05 1031	Control Specs	: HAFB CONTROL DA002-B

Computed Results

Peak Discharge	: 0.70400 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 2005
Total Precipitation	: 1.71 (in)	Total Direct Runoff	: 0.08 (in)
Total Loss	: 1.63 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.08 (in)	Total Discharge	: 0.08 (in)

DA002-B 10yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA002-B_25yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA002-B

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA002-B

Execution Time : 13Apr05 1033 Control Specs : HAFB CONTROL DA002-B

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA002-B	1.4174	01 Aug 04 2005	0.36532	0.045

HMS * Summary of Results for HAFB DA002-B

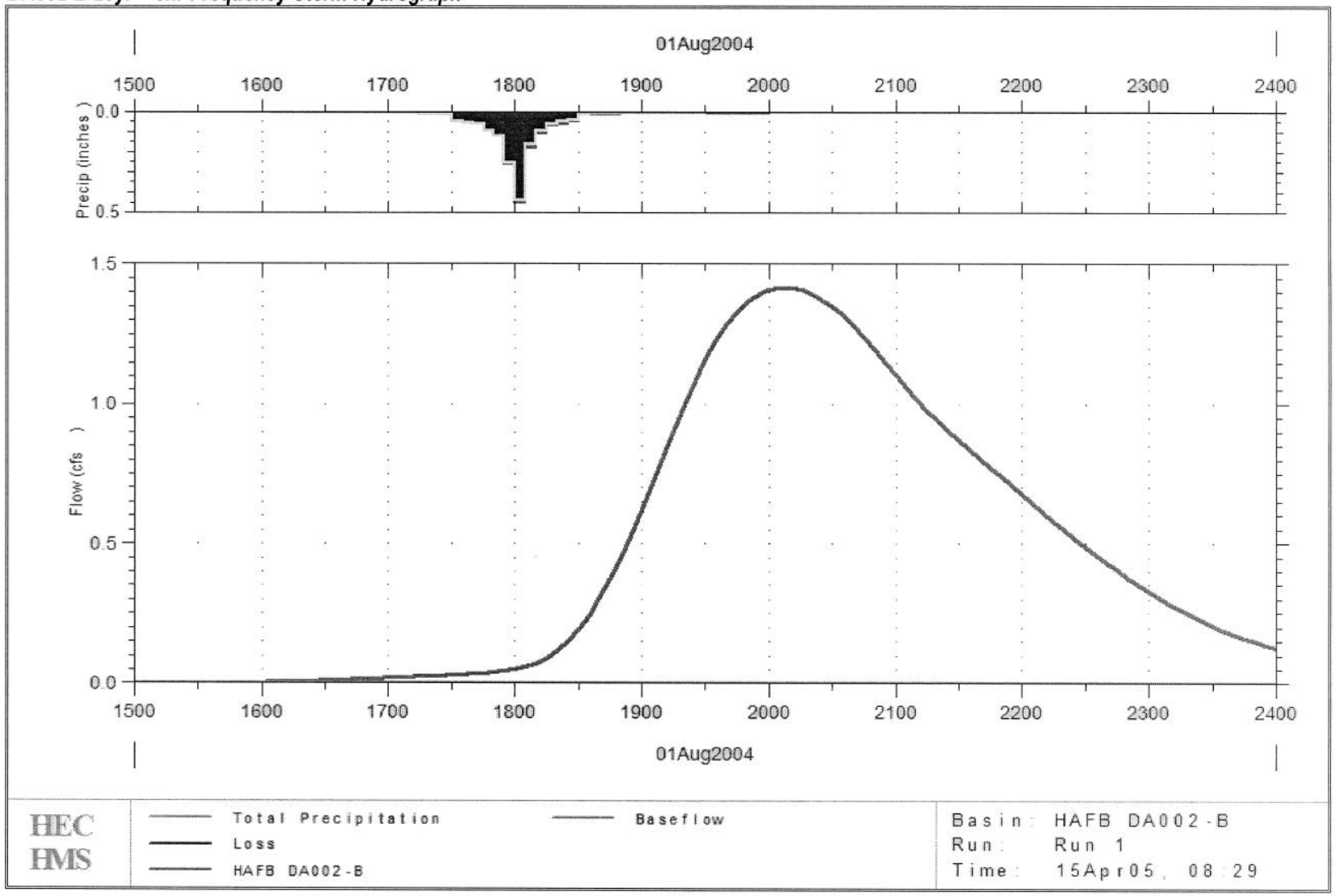
Project : HAFB_DA002-B_25yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA002-B
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA002-B
Execution Time	: 13Apr05 1033	Control Specs	: HAFB CONTROL DA002-B

Computed Results

Peak Discharge	: 1.4174 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 2005
Total Precipitation	: 2.05 (in)	Total Direct Runoff	: 0.15 (in)
Total Loss	: 1.90 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.15 (in)	Total Discharge	: 0.15 (in)

DA002-B 25yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA002-B_100yrFQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA002-B

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA002-B

Execution Time : 13Apr05 1034 Control Specs : HAFB CONTROL DA002-B

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA002-B	3.2511	01 Aug 04 2000	0.75556	0.045

HMS * Summary of Results for HAFB DA002-B

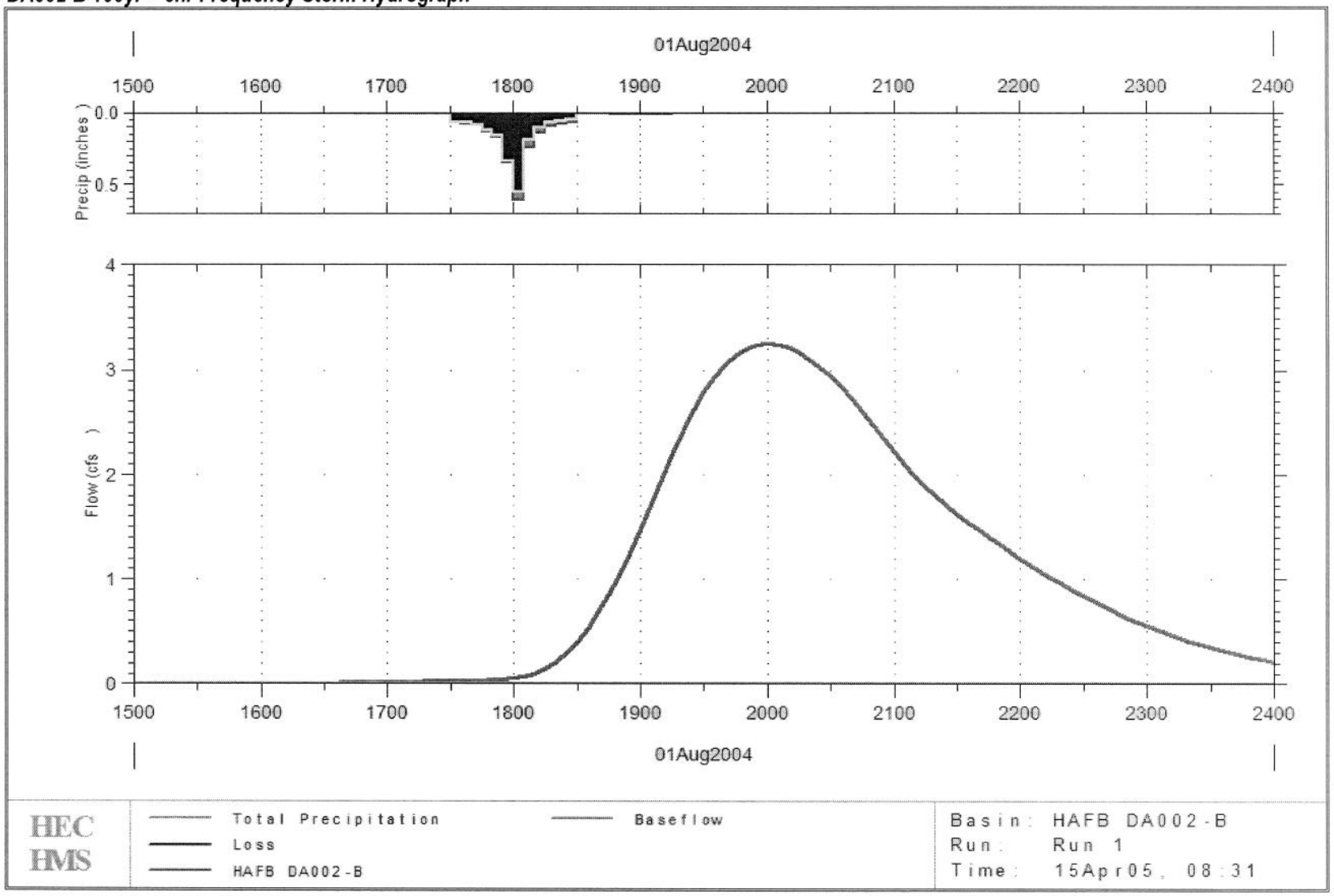
Project : HAFB_DA002-B_100yrFQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA002-B
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA002-B
Execution Time	: 13Apr05 1034	Control Specs	: HAFB CONTROL DA002-B

Computed Results

Peak Discharge	: 3.2511 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 2000
Total Precipitation	: 2.58 (in)	Total Direct Runoff	: 0.32 (in)
Total Loss	: 2.26 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.32 (in)	Total Discharge	: 0.32 (in)

DA002-B 100yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA003_10yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA003

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA003

Execution Time : 13Apr05 1039 Control Specs : HAFB CONTROL DA003

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA003	26.706	01 Aug 04 1825	1.8181	0.035

HMS * Summary of Results for HAFB DA003

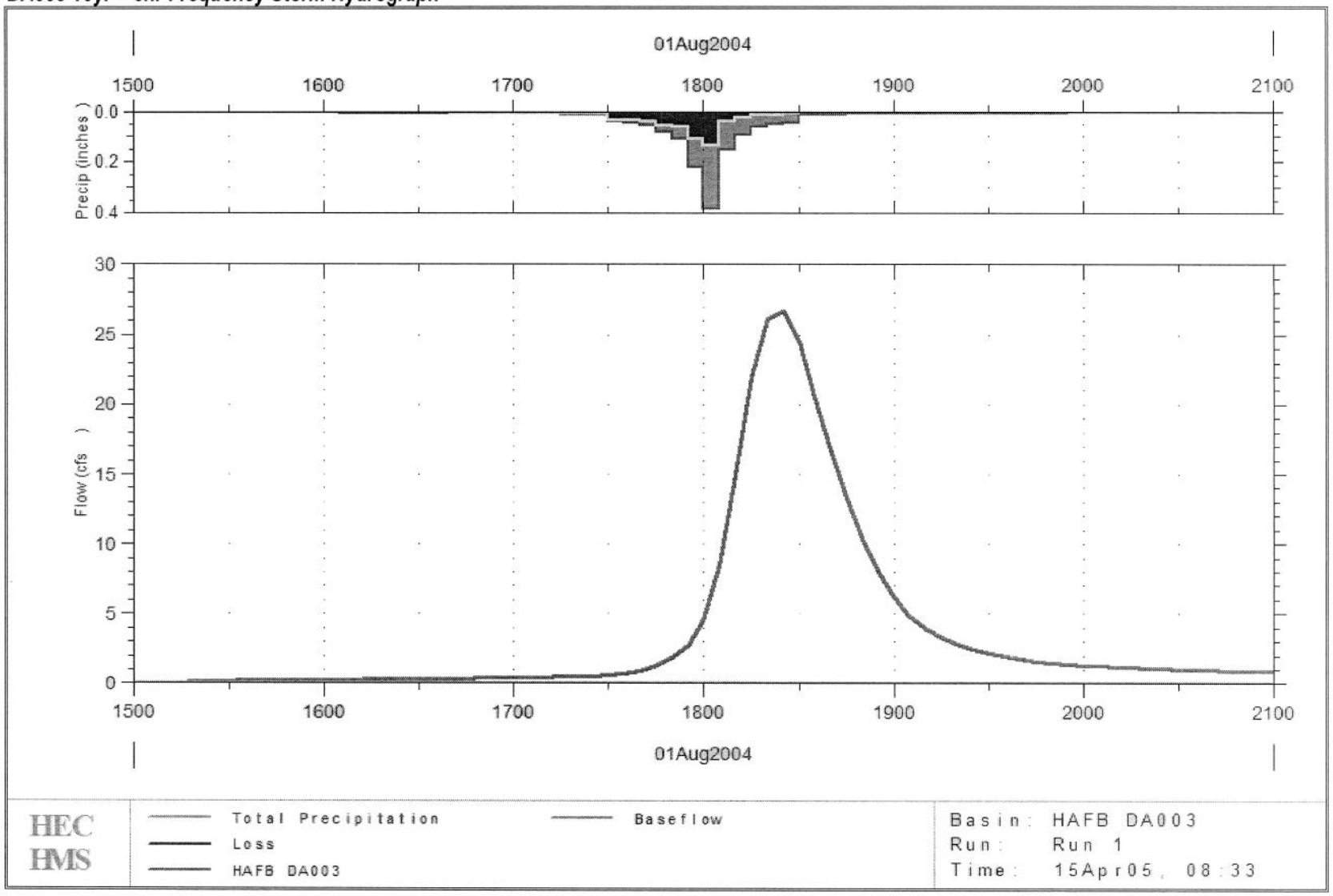
Project : HAFB_DA003_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA003
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA003
Execution Time	: 13Apr05 1039	Control Specs	: HAFB CONTROL DA003

Computed Results

Peak Discharge	: 26.706 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1825
Total Precipitation	: 1.71 (in)	Total Direct Runoff	: 0.97 (in)
Total Loss	: 0.74 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.97 (in)	Total Discharge	: 0.97 (in)

DA003 10yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA003_25yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA003

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA003

Execution Time : 13Apr05 1040 Control Specs : HAFB CONTROL DA003

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA003	34.217	01 Aug 04 1825	2.3528	0.035

HMS * Summary of Results for HAFB DA003

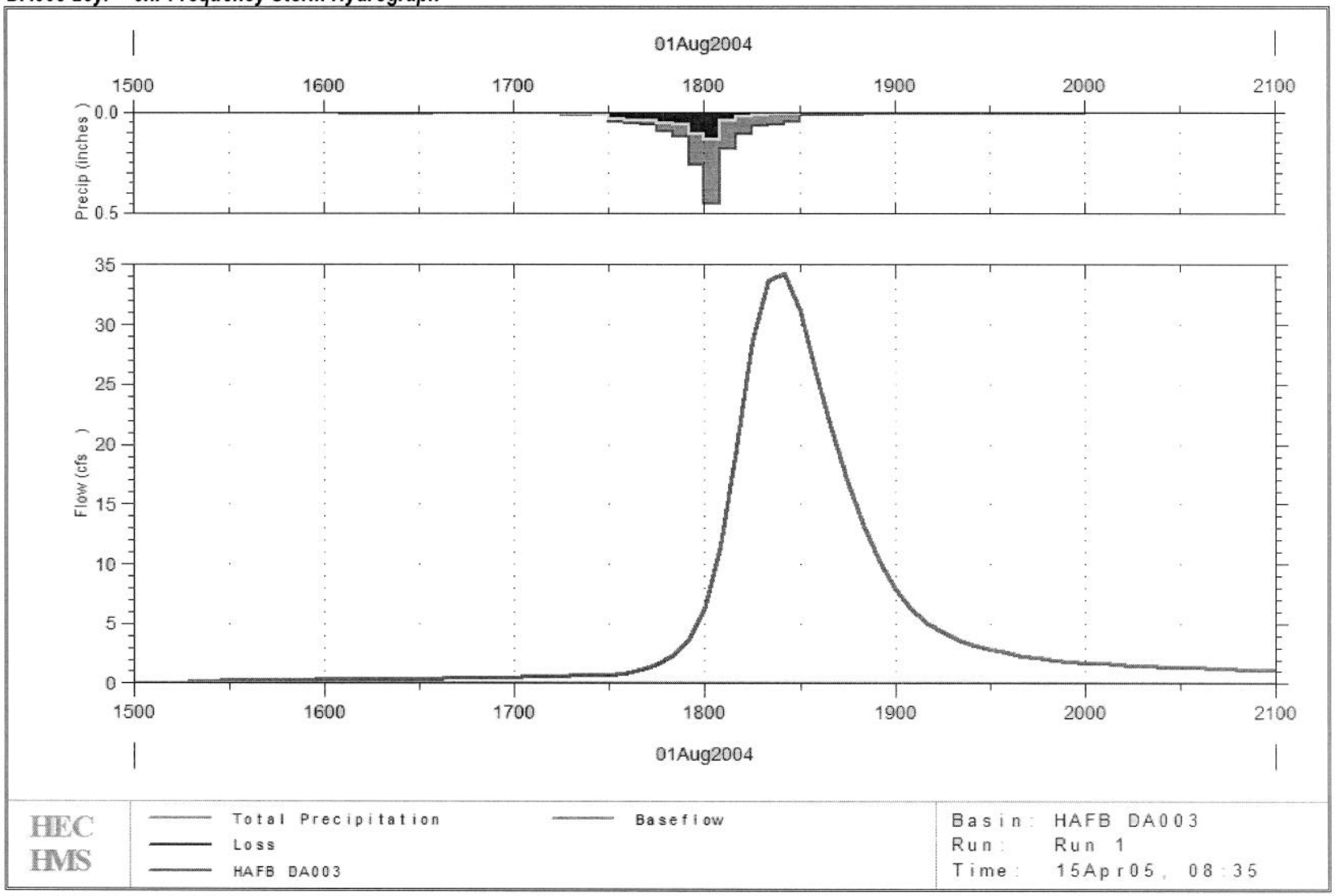
Project : HAFB_DA003_25yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA003
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA003
Execution Time	: 13Apr05 1040	Control Specs	: HAFB CONTROL DA003

Computed Results

Peak Discharge	: 34.217 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1825
Total Precipitation	: 2.05 (in)	Total Direct Runoff	: 1.26 (in)
Total Loss	: 0.79 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.26 (in)	Total Discharge	: 1.26 (in)

DA003 25yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA003_100yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA003

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA003

Execution Time : 13Apr05 1042 Control Specs : HAFB CONTROL DA003

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA003	50.127	01 Aug 04 1825	3.2124	0.035

HMS * Summary of Results for HAFB DA003

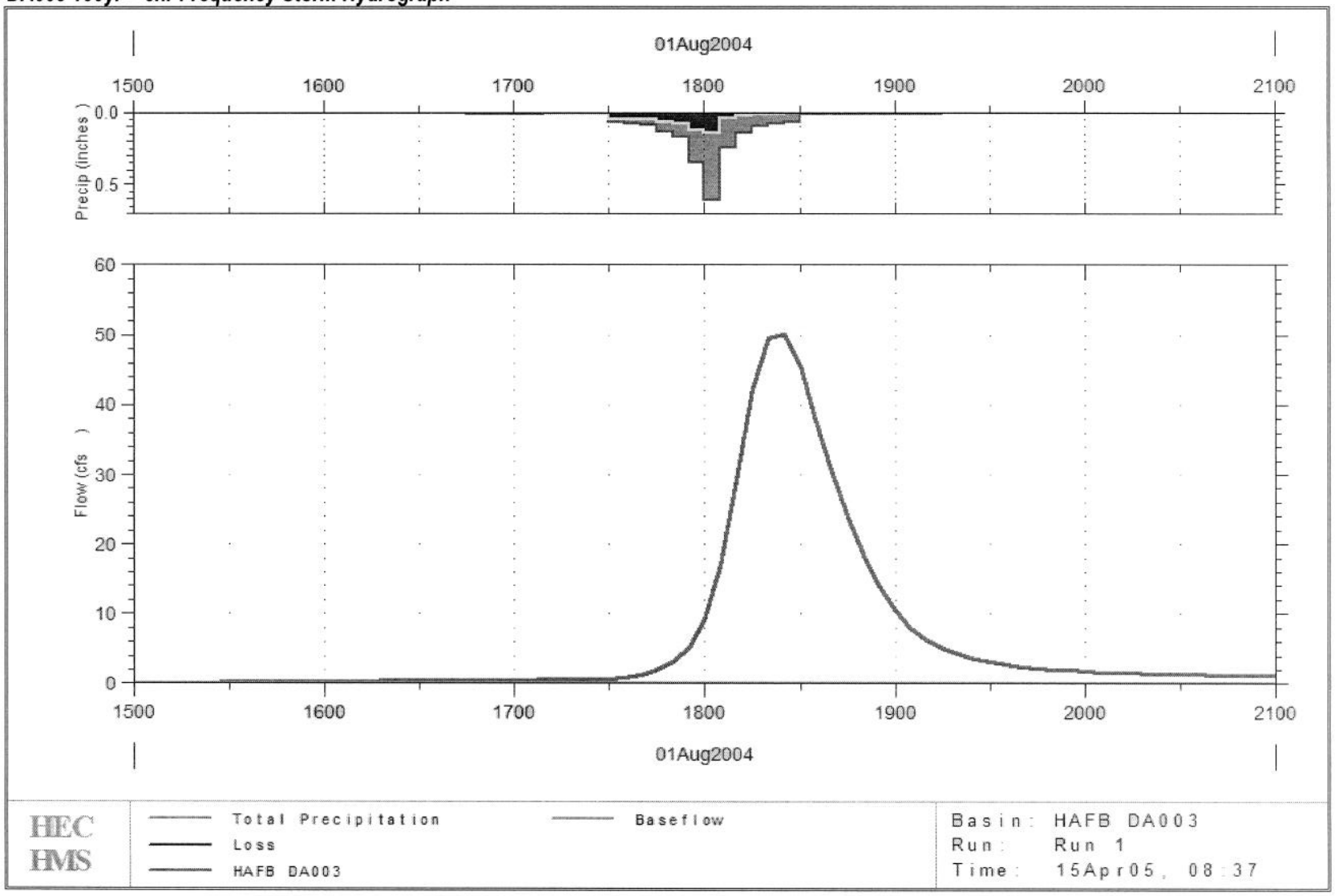
Project : HAFB_DA003_100yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA003
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA003
Execution Time	: 13Apr05 1042	Control Specs	: HAFB CONTROL DA003

Computed Results

Peak Discharge	: 50.127 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1825
Total Precipitation	: 2.58 (in)	Total Direct Runoff	: 1.72 (in)
Total Loss	: 0.86 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.72 (in)	Total Discharge	: 1.72 (in)

DA003 100yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA004_10yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA004

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA004

Execution Time : 13Apr05 1043 Control Specs : HAFB CONTROL DA004

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA004	133.35	01 Aug 04 1935	26.637	0.471

HMS * Summary of Results for HAFB DA004

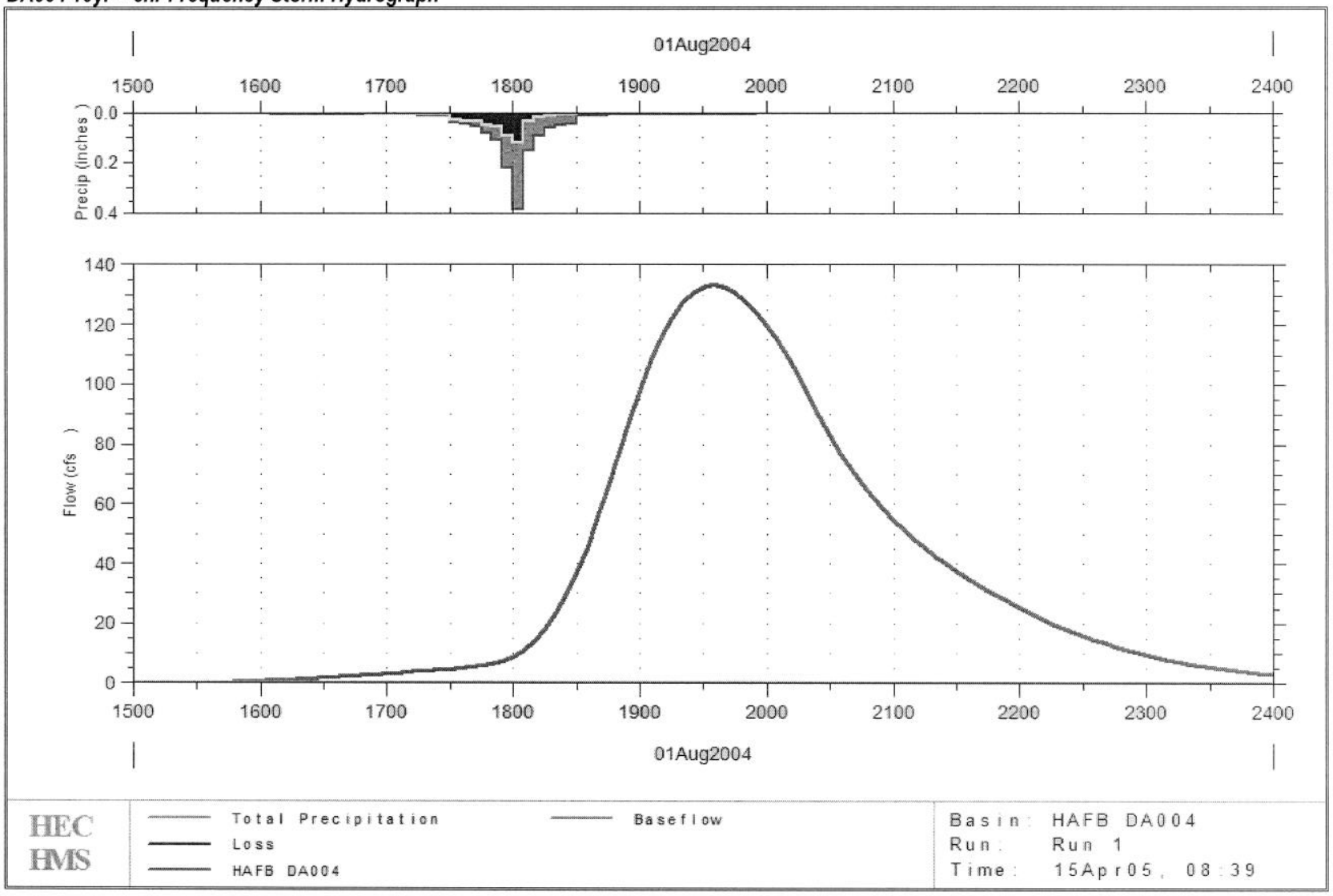
Project : HAFB_DA004_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA004
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA004
Execution Time	: 13Apr05 1043	Control Specs	: HAFB CONTROL DA004

Computed Results

Peak Discharge	: 133.35 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1935
Total Precipitation	: 1.71 (in)	Total Direct Runoff	: 1.06 (in)
Total Loss	: 0.65 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.06 (in)	Total Discharge	: 1.06 (in)

DA004 10yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA004_25yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA004

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA004

Execution Time : 13Apr05 1045 Control Specs : HAFB CONTROL DA004

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA004	169.09	01 Aug 04 1935	33.986	0.471

HMS * Summary of Results for HAFB DA004

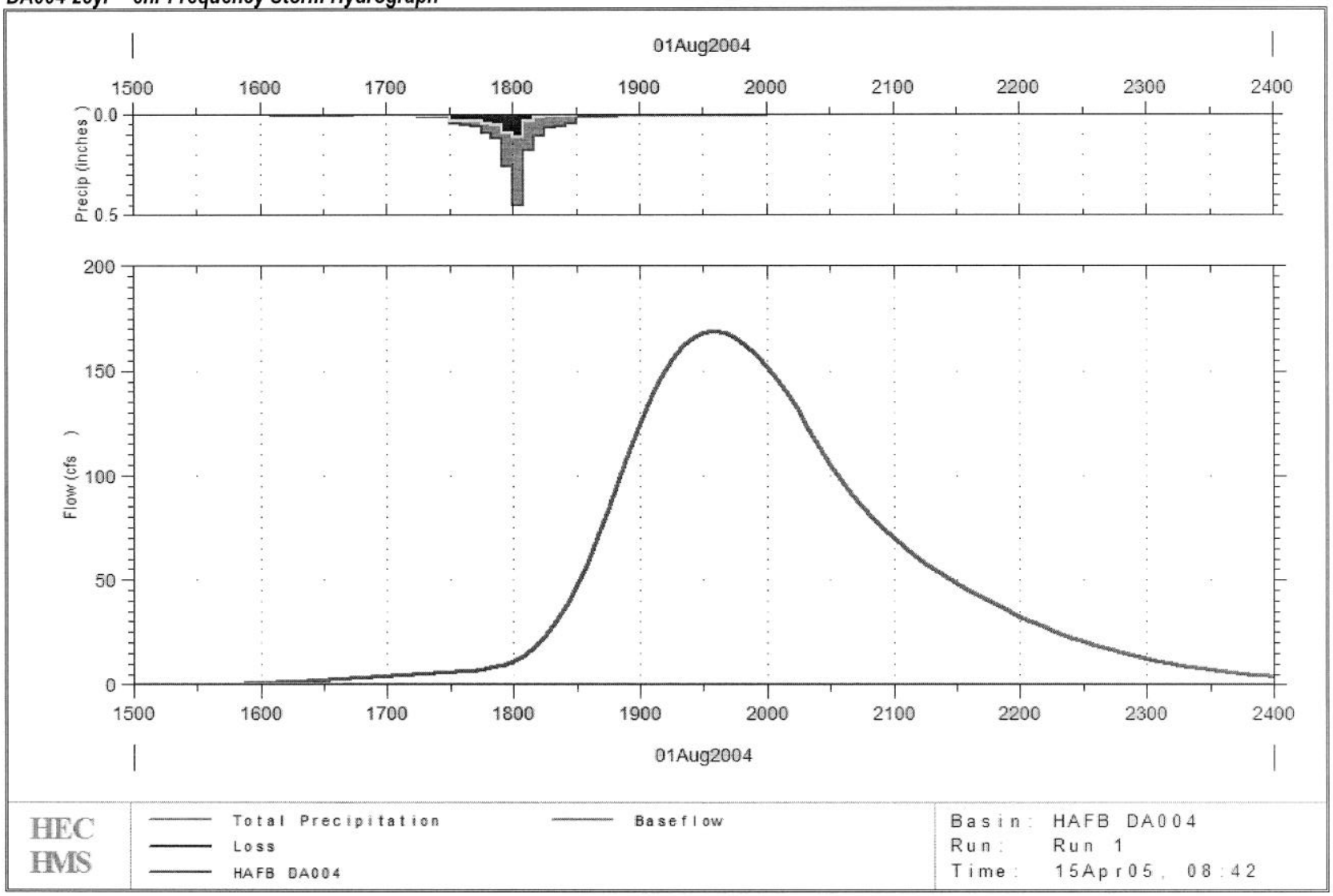
Project : HAFB_DA004_25yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA004
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA004
Execution Time	: 13Apr05 1045	Control Specs	: HAFB CONTROL DA004

Computed Results

Peak Discharge	: 169.09 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1935
Total Precipitation	: 2.05 (in)	Total Direct Runoff	: 1.35 (in)
Total Loss	: 0.70 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.35 (in)	Total Discharge	: 1.35 (in)

DA004 25yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA004_100yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA004

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA004

Execution Time : 13Apr05 1046 Control Specs : HAFB CONTROL DA004

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA004	238.41	01 Aug 04 1935	45.731	0.471

HMS * Summary of Results for HAFB DA004

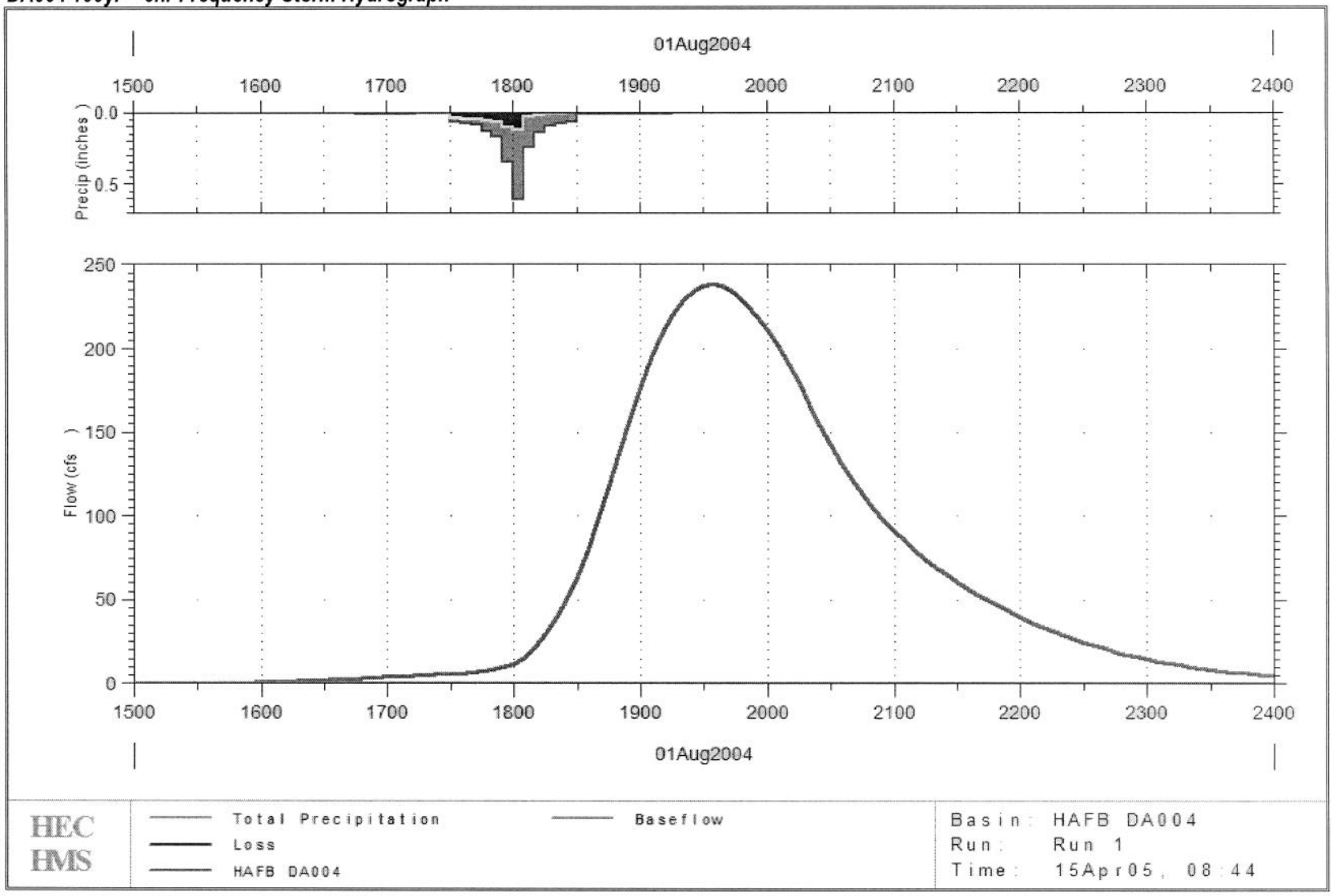
Project : HAFB_DA004_100yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA004
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA004
Execution Time	: 13Apr05 1046	Control Specs	: HAFB CONTROL DA004

Computed Results

Peak Discharge	: 238.41 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1935
Total Precipitation	: 2.58 (in)	Total Direct Runoff	: 1.82 (in)
Total Loss	: 0.76 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.82 (in)	Total Discharge	: 1.82 (in)

DA004 100yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA004-A_10yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA004-A

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA004-A

Execution Time : 13Apr05 1050 Control Specs : HAFB CONTROL DA004-A

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA004-A	3.0957	01 Aug 04 2115	1.1025	0.233

HMS * Summary of Results for HAFB DA004-A

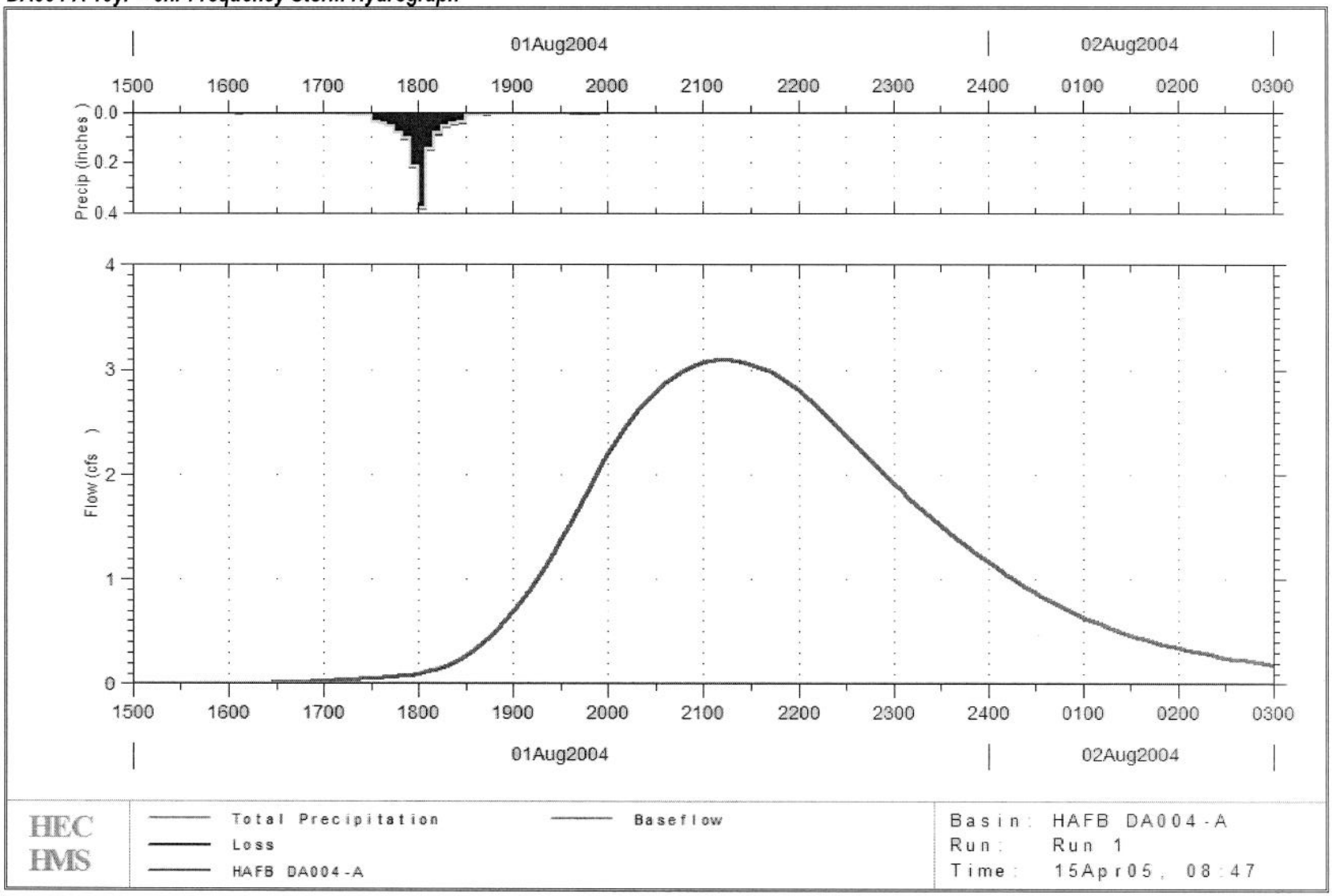
Project : HAFB_DA004-A_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA004-A
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA004-A
Execution Time	: 13Apr05 1050	Control Specs	: HAFB CONTROL DA004-A

Computed Results

Peak Discharge	: 3.0957 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 2115
Total Precipitation	: 1.71 (in)	Total Direct Runoff	: 0.09 (in)
Total Loss	: 1.62 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.09 (in)	Total Discharge	: 0.09 (in)

DA004-A 10yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA004-A_25yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA004-A

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA004-A

Execution Time : 13Apr05 1051 Control Specs : HAFB CONTROL DA004-A

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA004-A	6.0371	01 Aug 04 2110	2.1125	0.233

HMS * Summary of Results for HAFB DA004-A

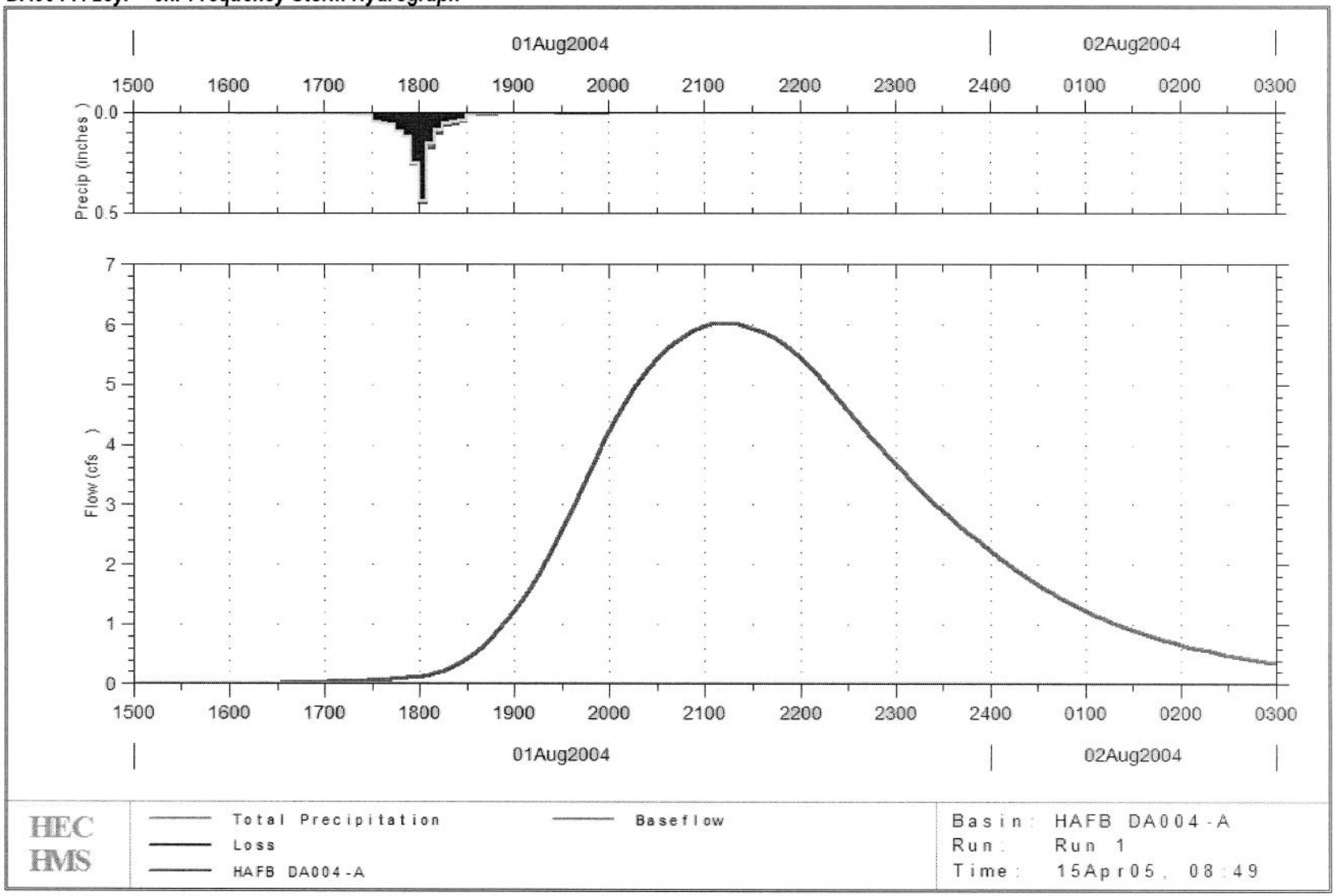
Project : HAFB_DA004-A_25yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA004-A
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA004-A
Execution Time	: 13Apr05 1051	Control Specs	: HAFB CONTROL DA004-A

Computed Results

Peak Discharge	: 6.0371 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 2110
Total Precipitation	: 2.05 (in)	Total Direct Runoff	: 0.17 (in)
Total Loss	: 1.88 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.17 (in)	Total Discharge	: 0.17 (in)

DA004-A 25yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA004-A_100yrFQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA004-A

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA004-A

Execution Time : 13Apr05 1053 Control Specs : HAFB CONTROL DA004-A

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA004-A	12.914	01 Aug 04 2100	4.2735	0.233

HMS * Summary of Results for HAFB DA004-A

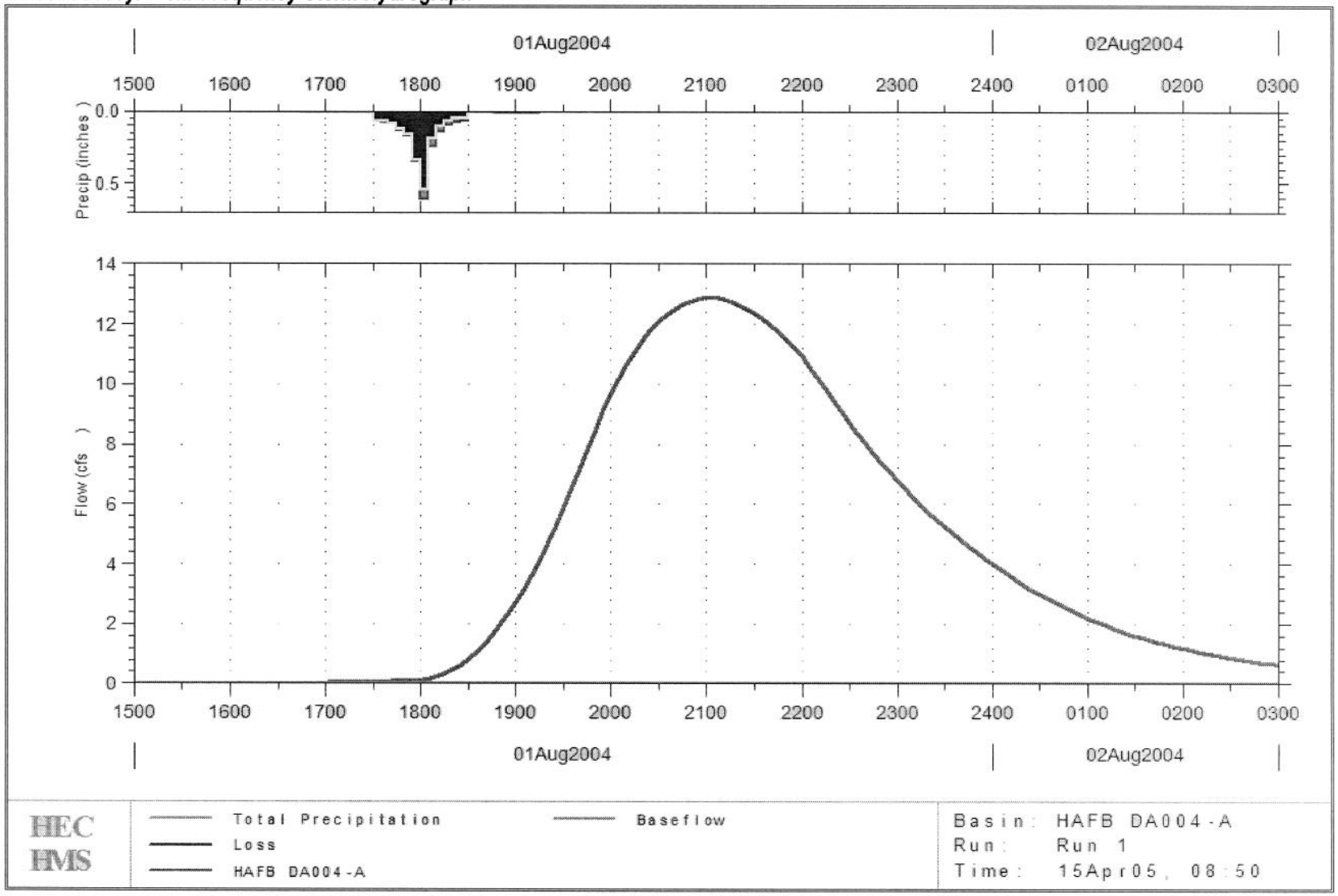
Project : HAFB_DA004-A_100yrFQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA004-A
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA004-A
Execution Time	: 13Apr05 1053	Control Specs	: HAFB CONTROL DA004-A

Computed Results

Peak Discharge	: 12.914 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 2100
Total Precipitation	: 2.58 (in)	Total Direct Runoff	: 0.34 (in)
Total Loss	: 2.23 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.34 (in)	Total Discharge	: 0.34 (in)

DA004-A 100yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA009_10yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA009

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA009

Execution Time : 13Apr05 1054 Control Specs : HAFB CONTROL DA009

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA009	5.5123	01 Aug 04 1820	0.34377	0.006

HMS * Summary of Results for HAFB DA009

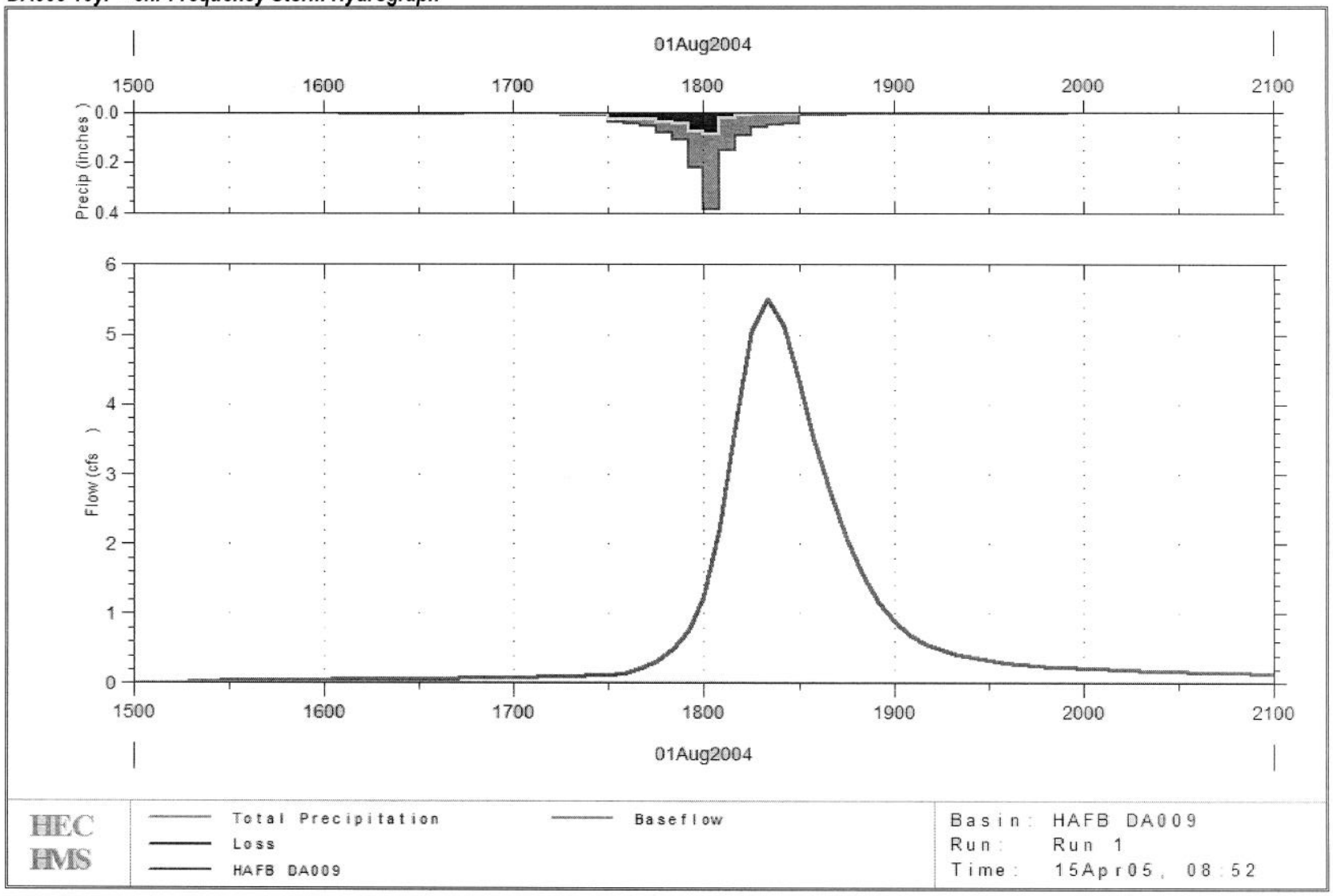
Project : HAFB_DA009_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA009
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA009
Execution Time	: 13Apr05 1054	Control Specs	: HAFB CONTROL DA009

Computed Results

Peak Discharge	: 5.5123 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1820
Total Precipitation	: 1.71 (in)	Total Direct Runoff	: 1.16 (in)
Total Loss	: 0.55 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.16 (in)	Total Discharge	: 1.16 (in)

DA009 10yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA009_25yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA009

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA009

Execution Time : 13Apr05 1055 Control Specs : HAFB CONTROL DA009

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA009	6.8845	01 Aug 04 1820	0.43493	0.006

HMS * Summary of Results for HAFB DA009

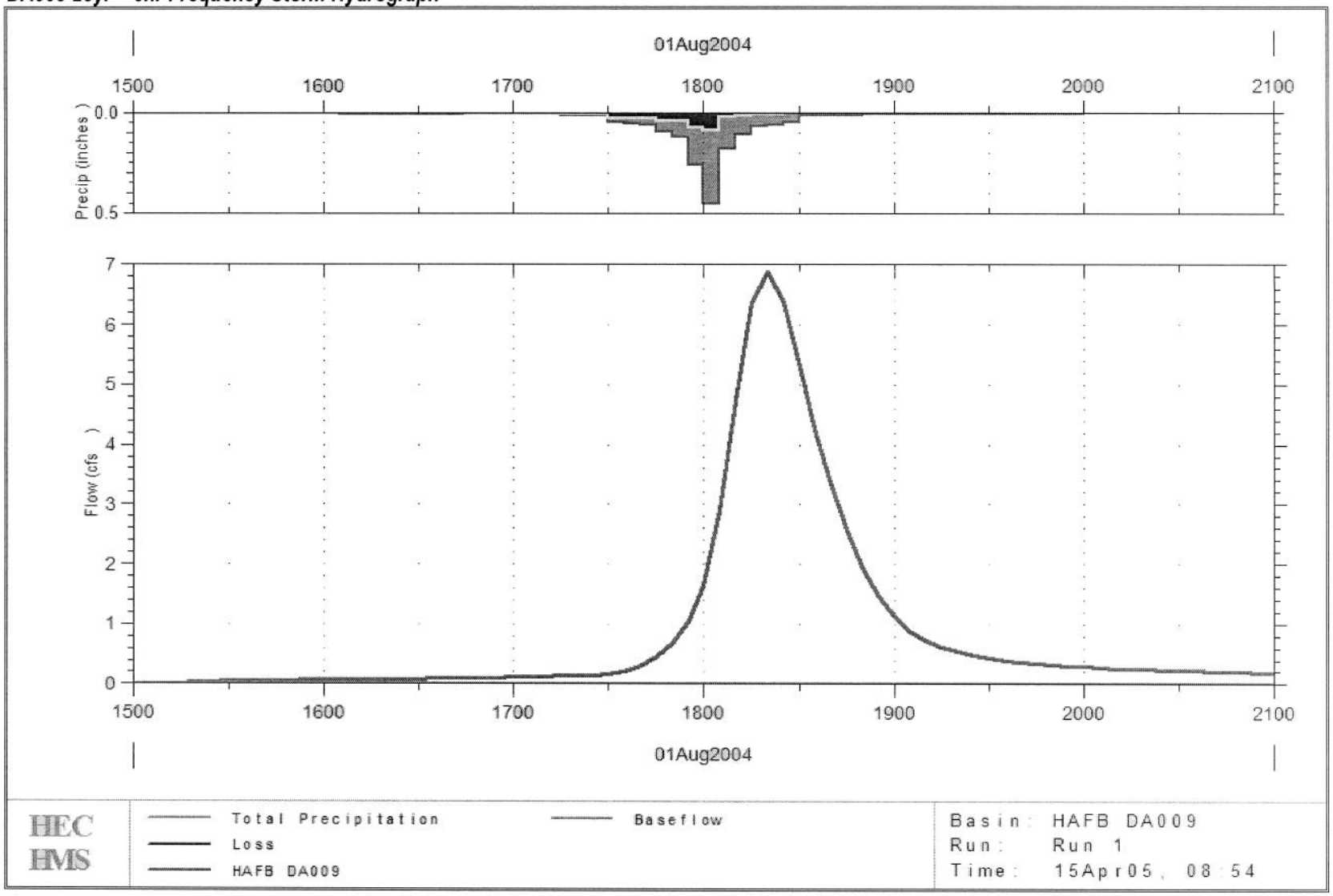
Project : HAFB_DA009_25yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA009
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA009
Execution Time	: 13Apr05 1055	Control Specs	: HAFB CONTROL DA009

Computed Results

Peak Discharge	: 6.8845 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1820
Total Precipitation	: 2.05 (in)	Total Direct Runoff	: 1.47 (in)
Total Loss	: 0.58 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.47 (in)	Total Discharge	: 1.47 (in)

DA009 25yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA009_100yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA009

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA009

Execution Time : 13Apr05 1057 Control Specs : HAFB CONTROL DA009

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA009	9.8011	01 Aug 04 1820	0.57897	0.006

HMS * Summary of Results for HAFB DA009

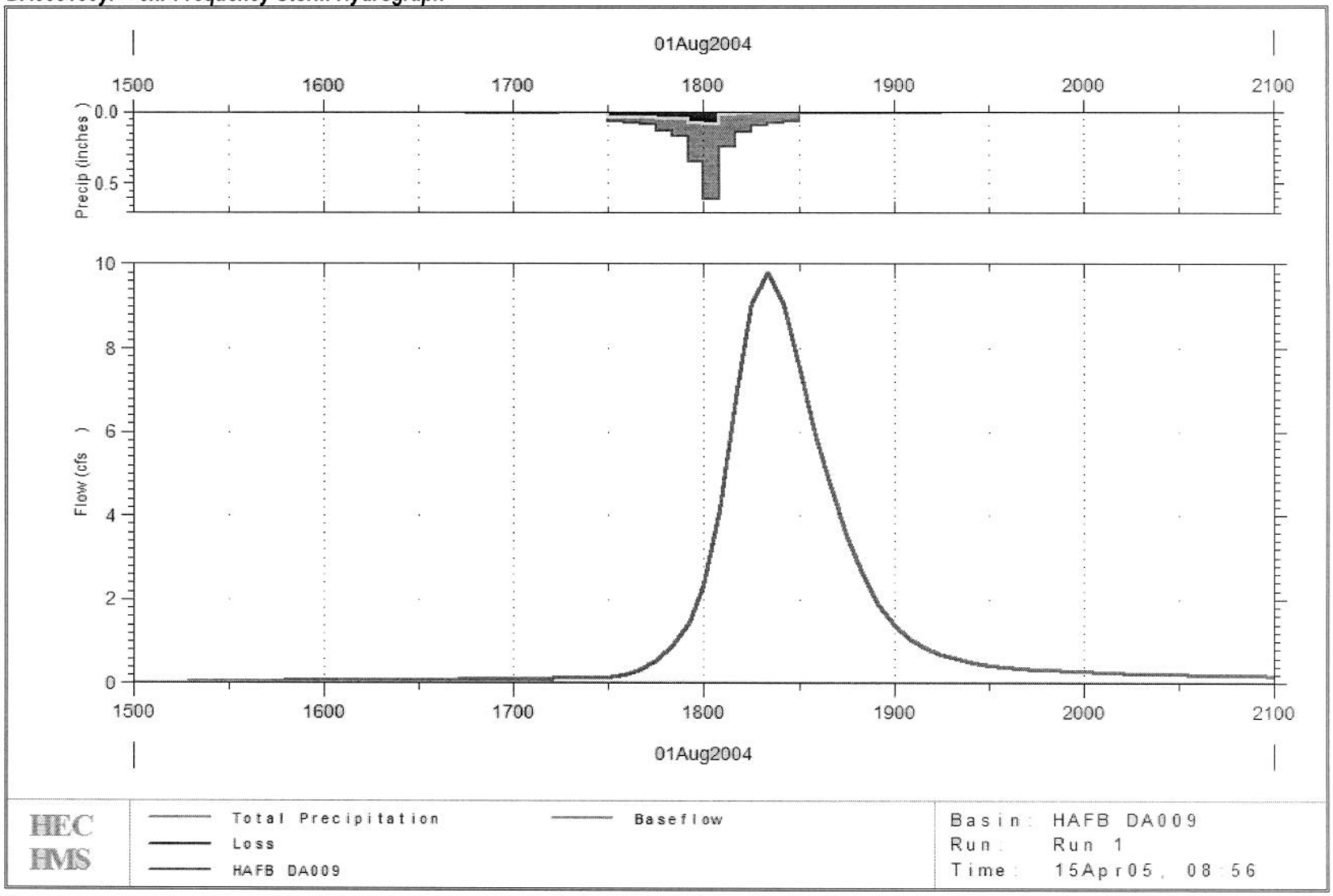
Project : HAFB_DA009_100yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA009
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA009
Execution Time	: 13Apr05 1057	Control Specs	: HAFB CONTROL DA009

Computed Results

Peak Discharge	: 9.8011 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1820
Total Precipitation	: 2.58 (in)	Total Direct Runoff	: 1.96 (in)
Total Loss	: 0.62 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.96 (in)	Total Discharge	: 1.96 (in)

DA009100yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA010_10yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA010

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA010

Execution Time : 13Apr05 1101 Control Specs : HAFB CONTROL DA010

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA010	1.2254	01 Aug 04 2105	0.37536	0.156

HMS * Summary of Results for HAFB DA010

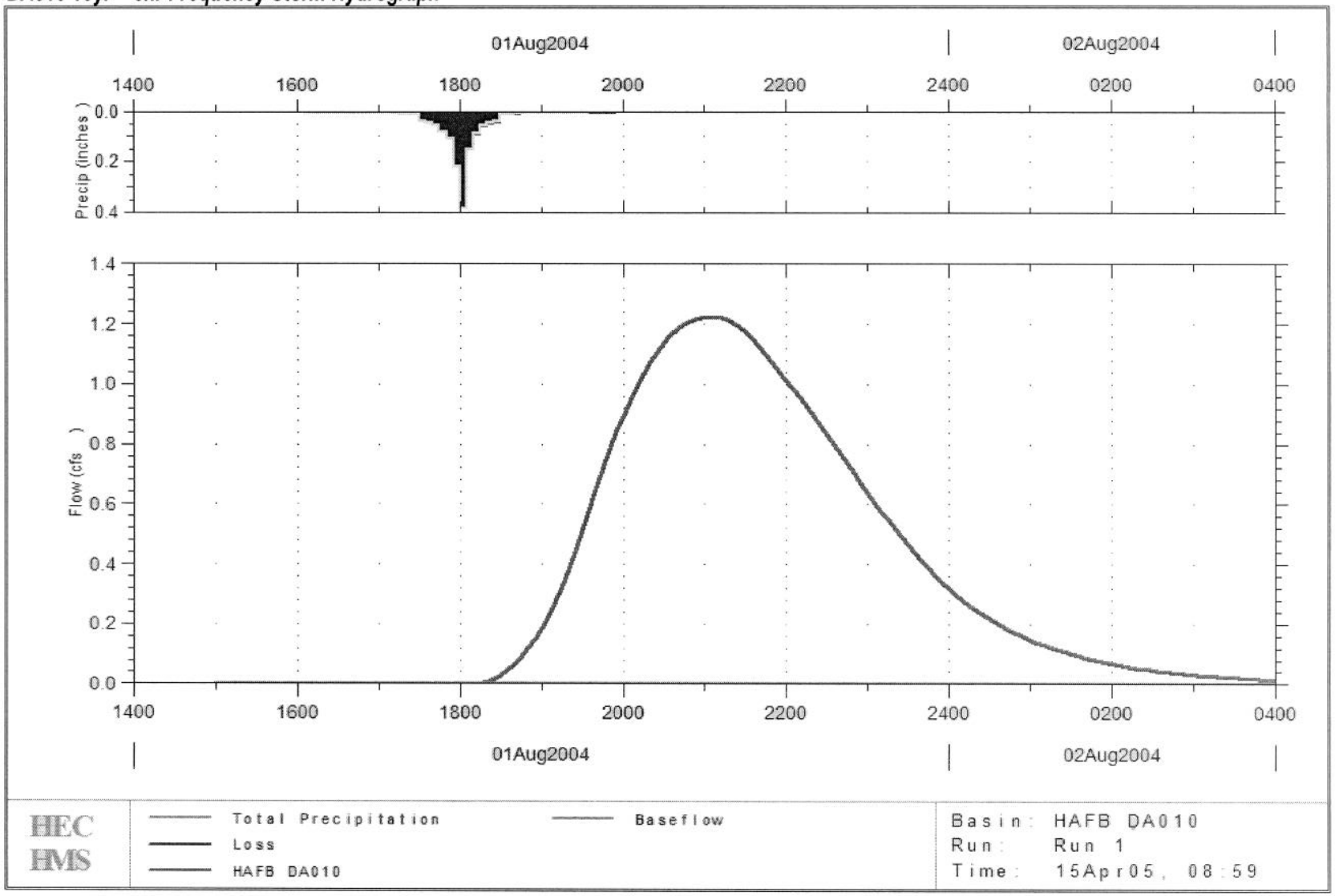
Project : HAFB_DA010_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA010
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA010
Execution Time	: 13Apr05 1101	Control Specs	: HAFB CONTROL DA010

Computed Results

Peak Discharge	: 1.2254 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 2105
Total Precipitation	: 1.71 (in)	Total Direct Runoff	: 0.05 (in)
Total Loss	: 1.67 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.05 (in)	Total Discharge	: 0.05 (in)

DA010 10yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA010_25yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA010

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA010

Execution Time : 13Apr05 1102 Control Specs : HAFB CONTROL DA010

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA010	3.1814	01 Aug 04 2045	0.95159	0.156

HMS * Summary of Results for HAFB DA010

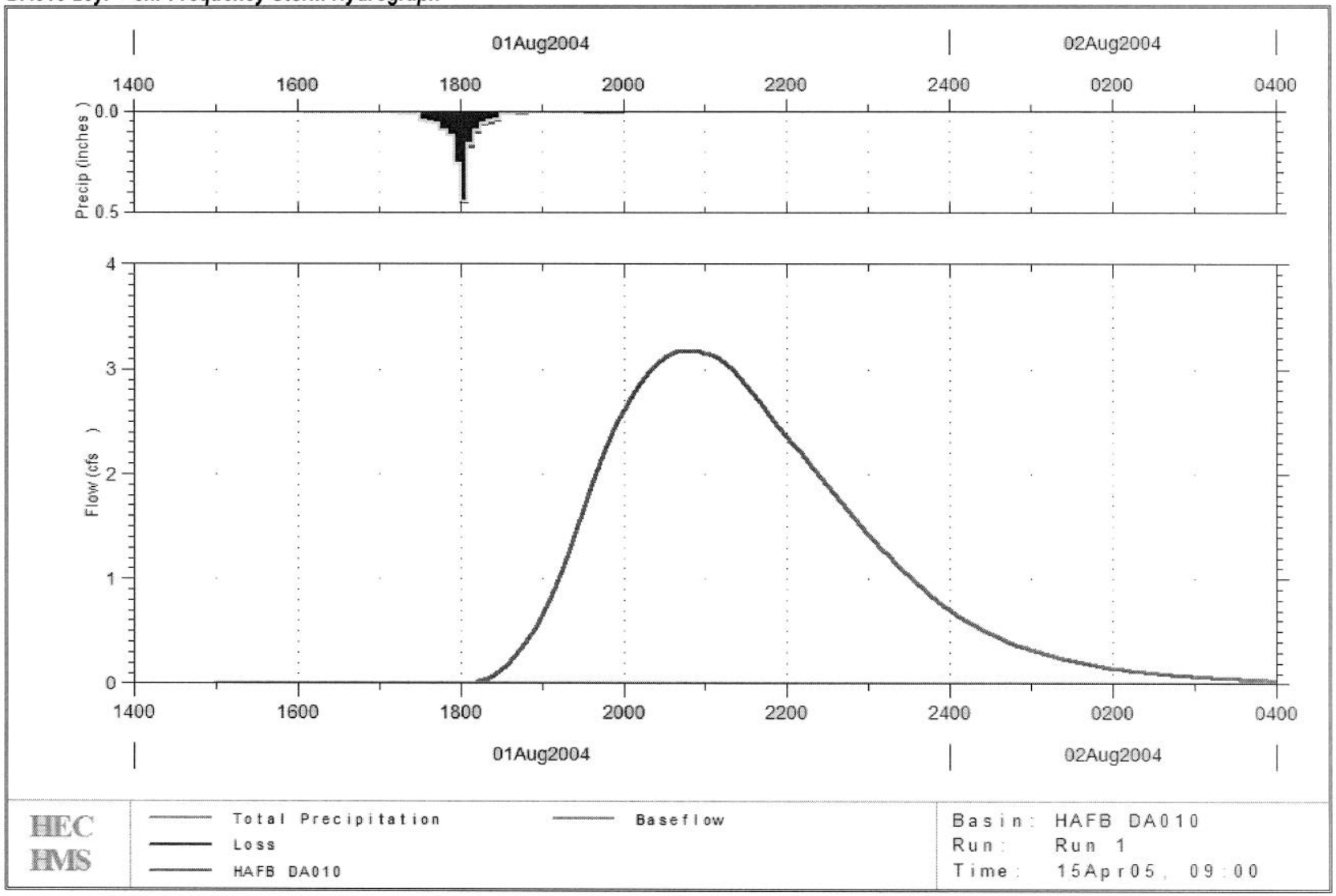
Project : HAFB_DA010_25yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA010
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA010
Execution Time	: 13Apr05 1102	Control Specs	: HAFB CONTROL DA010

Computed Results

Peak Discharge	: 3.1814 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 2045
Total Precipitation	: 2.05 (in)	Total Direct Runoff	: 0.11 (in)
Total Loss	: 1.94 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.11 (in)	Total Discharge	: 0.11 (in)

DA010 25yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA010_100yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA010

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA010

Execution Time : 13Apr05 1104 Control Specs : HAFB CONTROL DA010

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA010	8.1492	01 Aug 04 2030	2.2519	0.156

HMS * Summary of Results for HAFB DA010

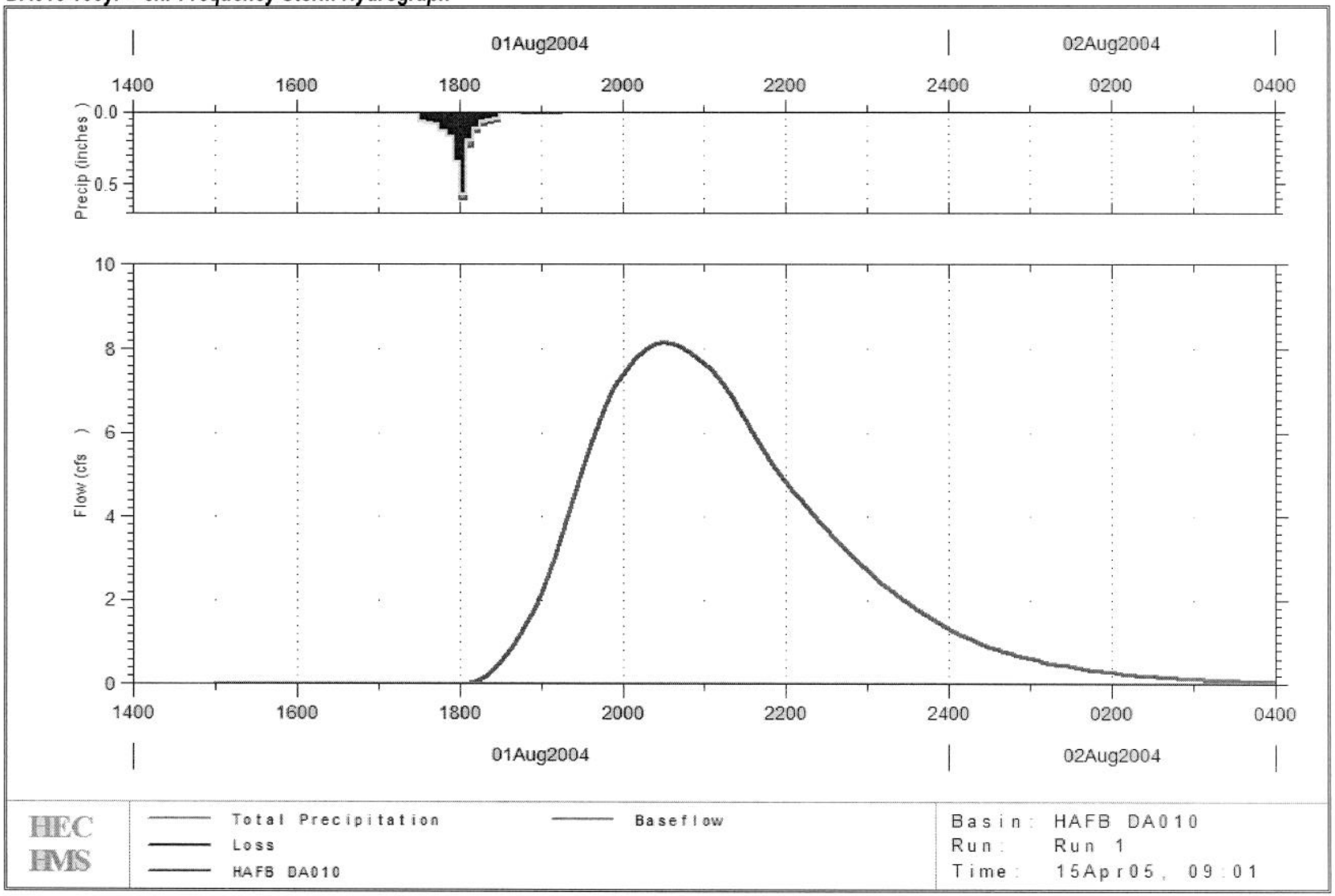
Project : HAFB_DA010_100yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA010
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA010
Execution Time	: 13Apr05 1104	Control Specs	: HAFB CONTROL DA010

Computed Results

Peak Discharge	: 8.1492 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 2030
Total Precipitation	: 2.58 (in)	Total Direct Runoff	: 0.27 (in)
Total Loss	: 2.31 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.27 (in)	Total Discharge	: 0.27 (in)

DA010 100yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA010-A_10yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA010-A

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA010-A

Execution Time : 13Apr05 1105 Control Specs : HAFB CONTROL DA010-A

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA010-A	0.49732	01 Aug 04 1935	0.10722	0.028

HMS * Summary of Results for HAFB DA010-A

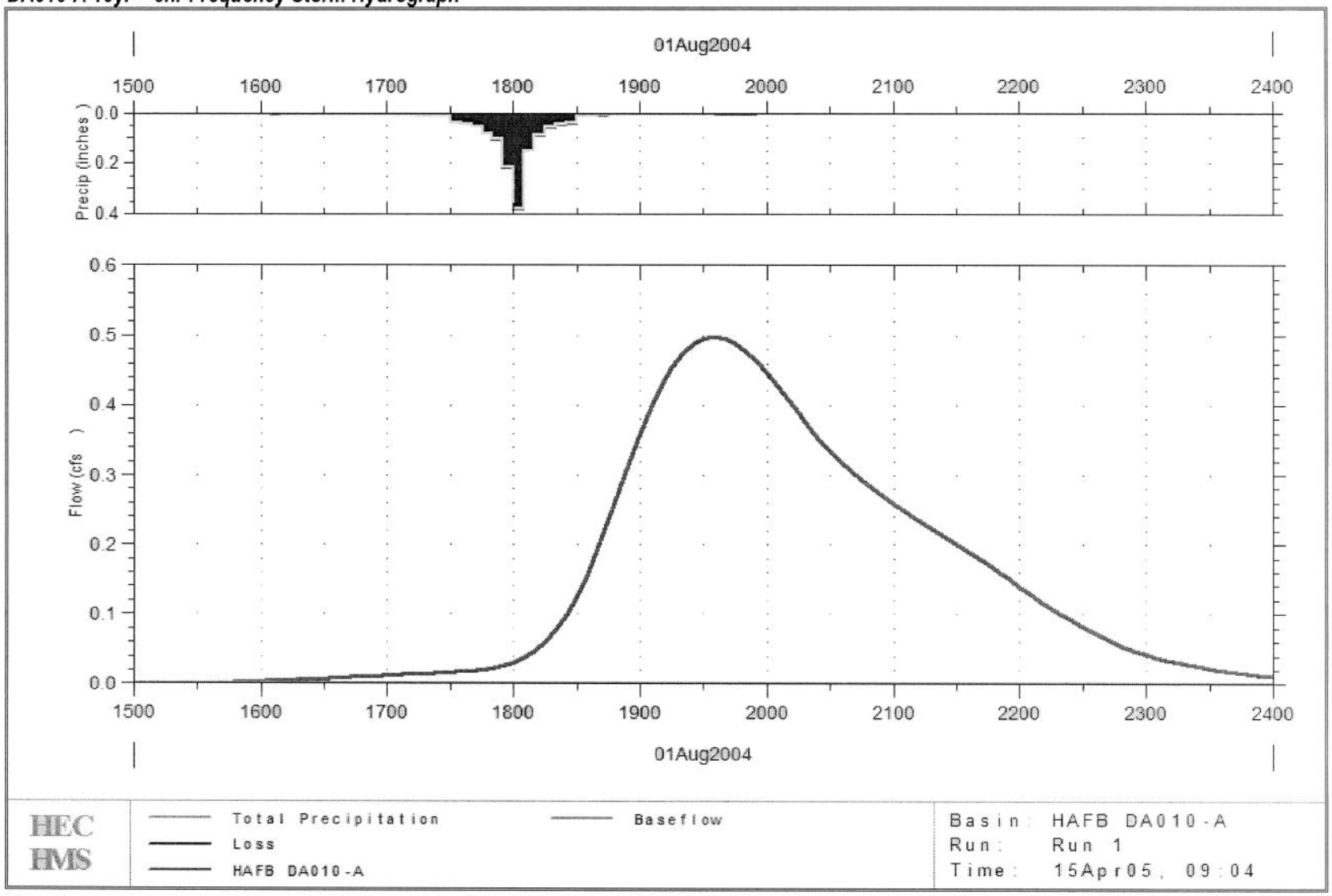
Project : HAFB_DA010-A_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA010-A
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA010-A
Execution Time	: 13Apr05 1105	Control Specs	: HAFB CONTROL DA010-A

Computed Results

Peak Discharge	: 0.49732 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1935
Total Precipitation	: 1.71 (in)	Total Direct Runoff	: 0.07 (in)
Total Loss	: 1.64 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.07 (in)	Total Discharge	: 0.07 (in)

DA010-A 10yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA010-A_25yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA010-A

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA010-A

Execution Time : 13Apr05 1107 Control Specs : HAFB CONTROL DA010-A

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA010-A	1.0605	01 Aug 04 1935	0.21710	0.028

HMS * Summary of Results for HAFB DA010-A

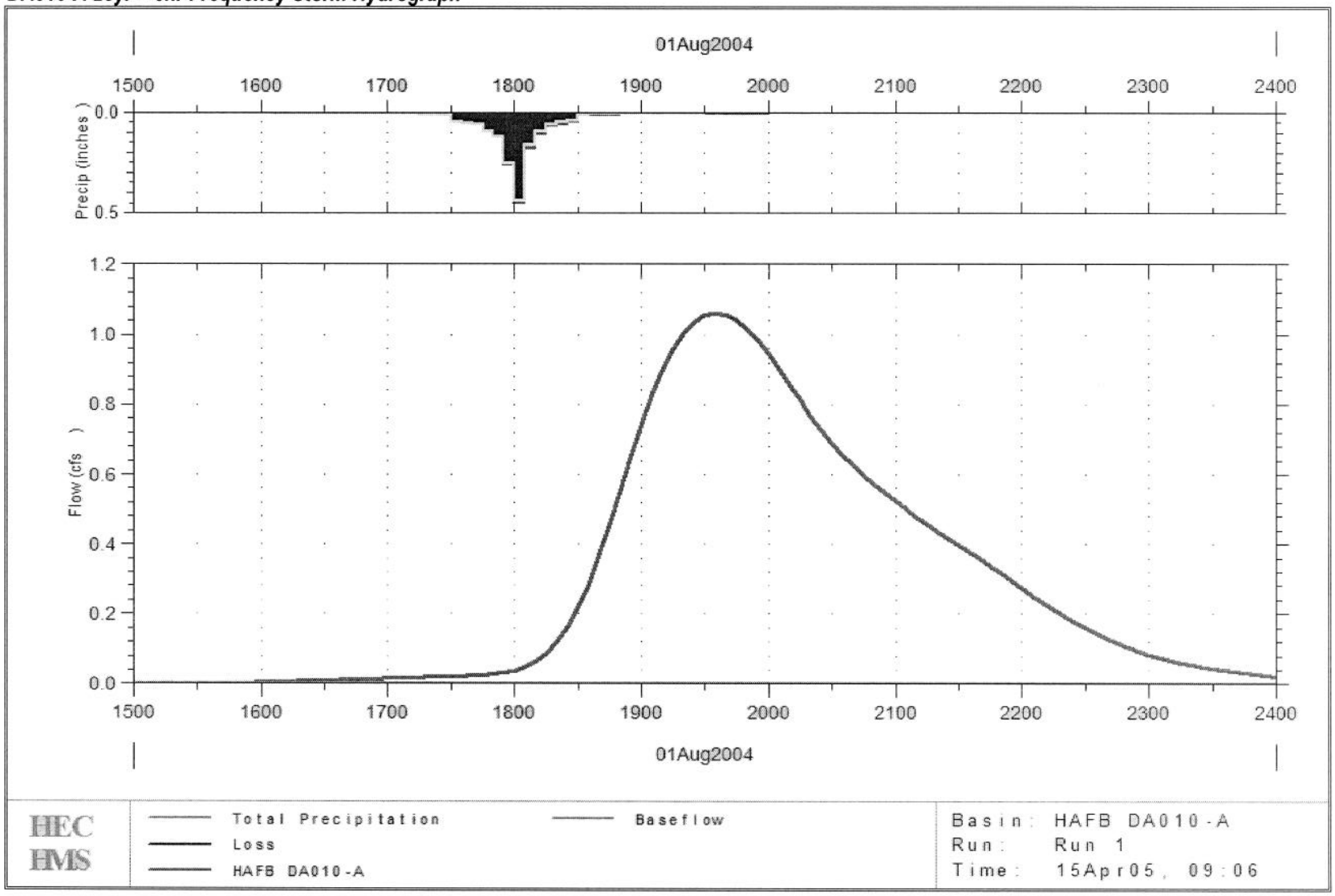
Project : HAFB_DA010-A_25yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA010-A
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA010-A
Execution Time	: 13Apr05 1107	Control Specs	: HAFB CONTROL DA010-A

Computed Results

Peak Discharge	: 1.0605 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1935
Total Precipitation	: 2.05 (in)	Total Direct Runoff	: 0.15 (in)
Total Loss	: 1.91 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.15 (in)	Total Discharge	: 0.15 (in)

DA010-A 25yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA010-A_100yrFQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA010-A

End of Run : 02Aug04 1500 Met. Model : HAFB MET DA010-A

Execution Time : 13Apr05 1108 Control Specs : HAFB CONTROL DA010-A

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA010-A	2.5787	01 Aug 04 1930	0.45920	0.028

HMS * Summary of Results for HAFB DA010-A

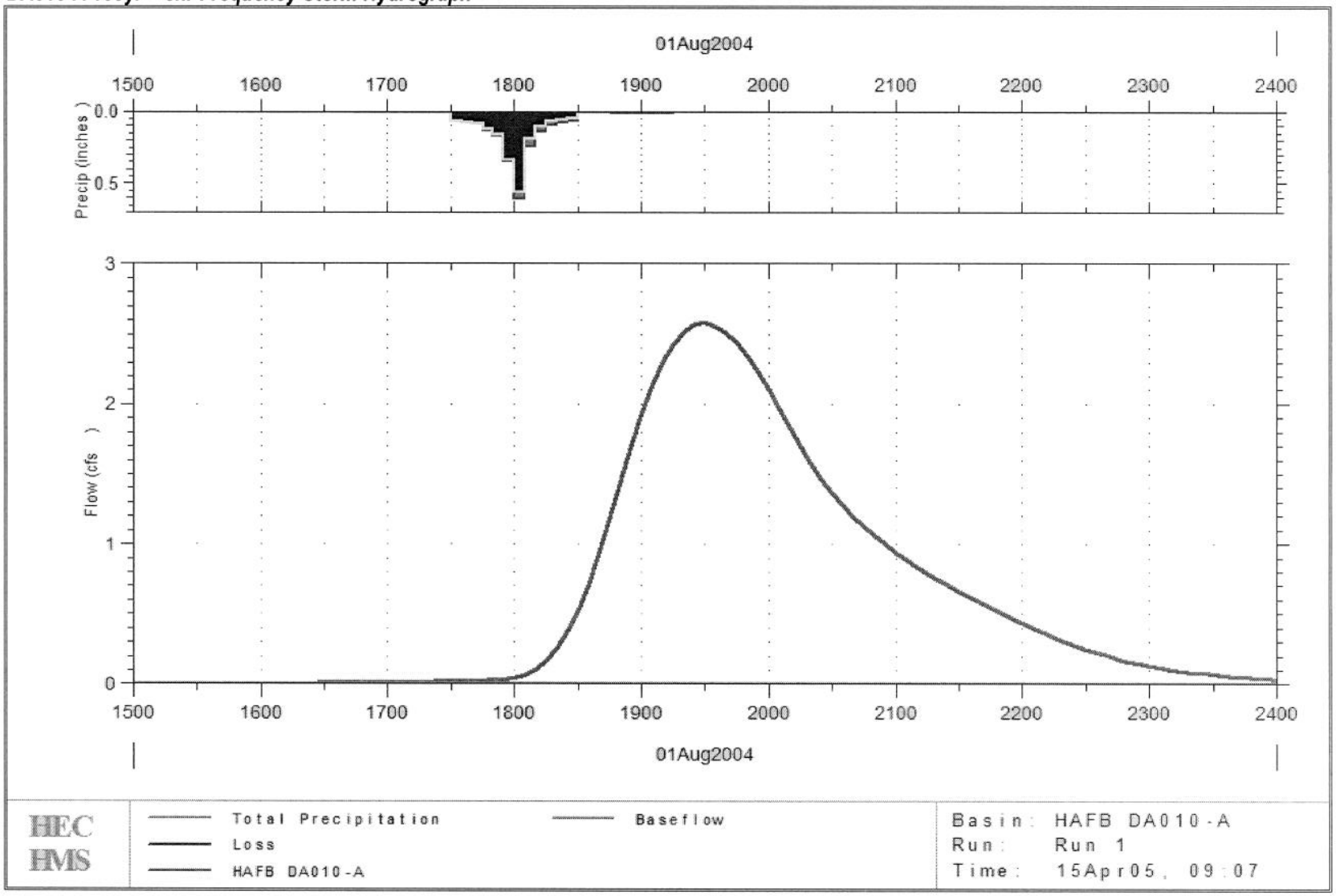
Project : HAFB_DA010-A_100yrFQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA010-A
End of Run	: 02Aug04 1500	Met. Model	: HAFB MET DA010-A
Execution Time	: 13Apr05 1108	Control Specs	: HAFB CONTROL DA010-A

Computed Results

Peak Discharge	: 2.5787 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1930
Total Precipitation	: 2.58 (in)	Total Direct Runoff	: 0.31 (in)
Total Loss	: 2.27 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 0.31 (in)	Total Discharge	: 0.31 (in)

DA010-A 100yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA011_10yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA011

End of Run : 01Aug04 2100 Met. Model : HAFB MET DA011

Execution Time : 20Apr05 0904 Control Specs : HAFB CONTROL DA011

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA011	32.842	01 Aug 04 1815	1.7338	0.026

HMS * Summary of Results for HAFB DA011

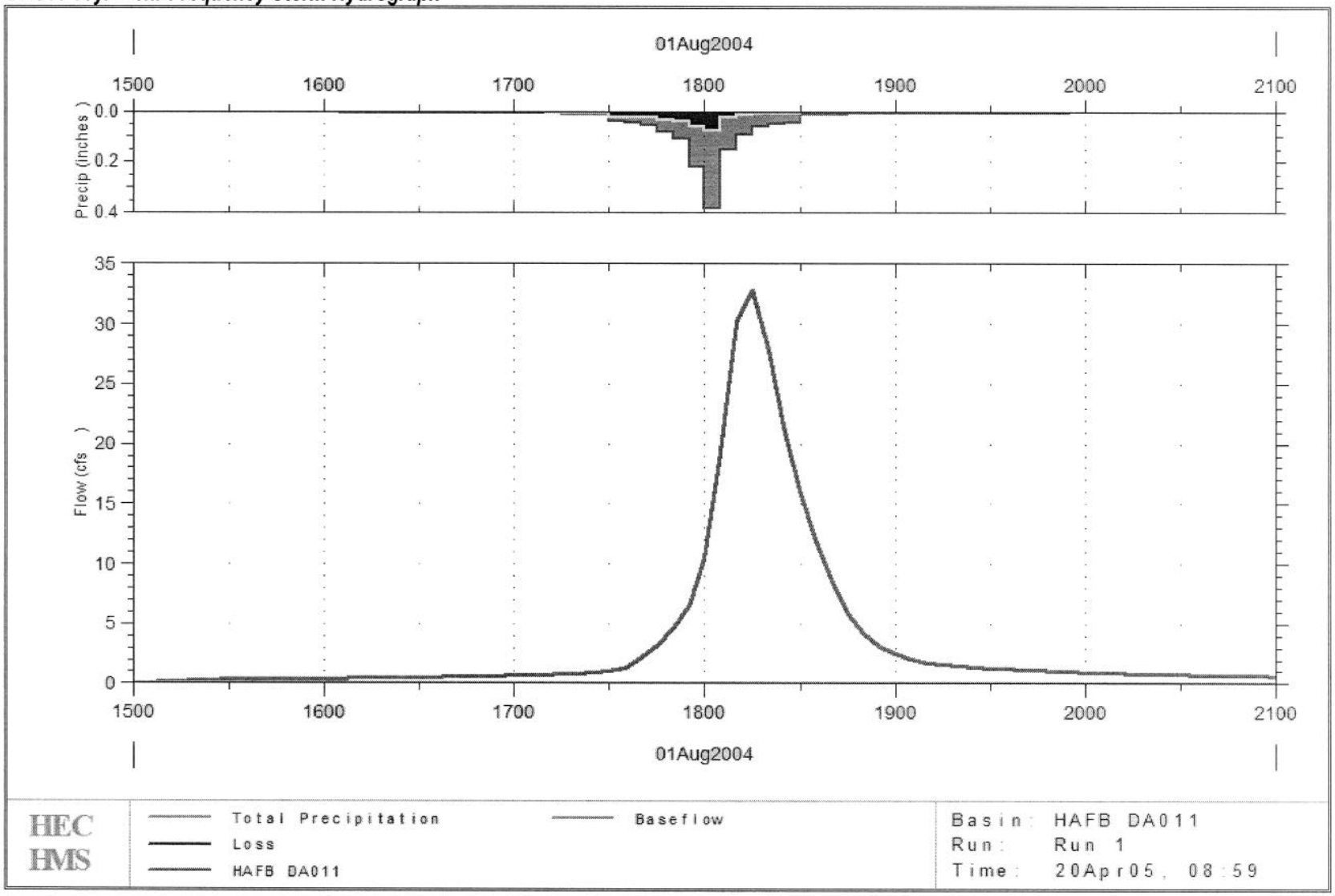
Project : HAFB_DA011_10yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA011
End of Run	: 01Aug04 2100	Met. Model	: HAFB MET DA011
Execution Time	: 20Apr05 0904	Control Specs	: HAFB CONTROL DA011

Computed Results

Peak Discharge	: 32.842 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1815
Total Precipitation	: 1.71 (in)	Total Direct Runoff	: 1.26 (in)
Total Loss	: 0.45 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.27 (in)	Total Discharge	: 1.26 (in)

DA011 10yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA011_25yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA011

End of Run : 01Aug04 2100 Met. Model : HAFB MET DA011

Execution Time : 20Apr05 0902 Control Specs : HAFB CONTROL DA011

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA011	40.377	01 Aug 04 1815	2.1604	0.026

HMS * Summary of Results for HAFB DA011

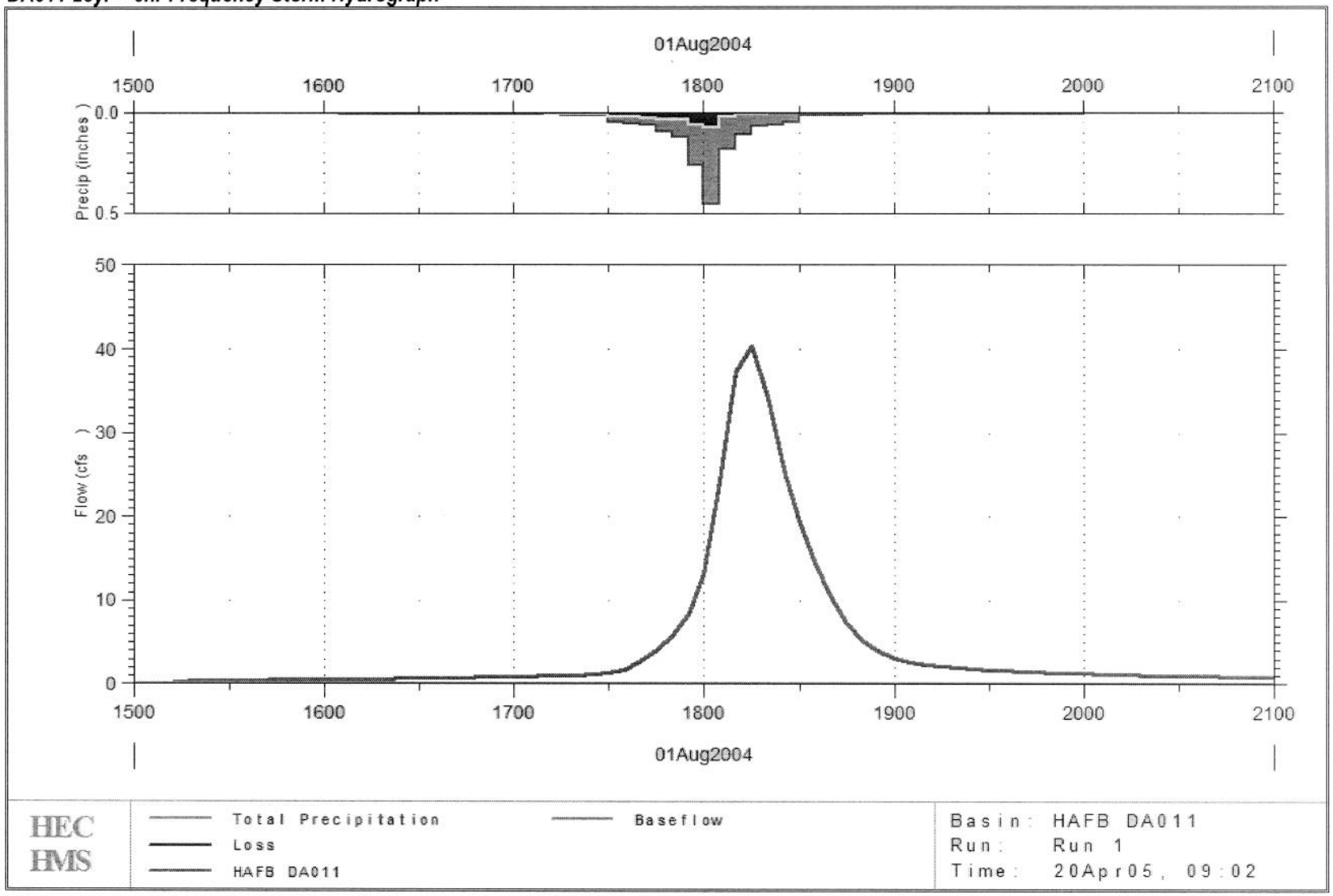
Project : HAFB_DA011_25yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA011
End of Run	: 01Aug04 2100	Met. Model	: HAFB MET DA011
Execution Time	: 20Apr05 0902	Control Specs	: HAFB CONTROL DA011

Computed Results

Peak Discharge	: 40.377 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1815
Total Precipitation	: 2.05 (in)	Total Direct Runoff	: 1.56 (in)
Total Loss	: 0.48 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 1.58 (in)	Total Discharge	: 1.56 (in)

DA011 25yr – 6hr Frequency Storm Hydrograph



HMS * Summary of Results

Project : HAFB_DA011_100yr_FQ Run Name : Run 1

Start of Run : 01Aug04 1500 Basin Model : HAFB DA011

End of Run : 01Aug04 2100 Met. Model : HAFB MET DA011

Execution Time : 20Apr05 0905 Control Specs : HAFB CONTROL DA011

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
HAFB DA011	60.191	01 Aug 04 1812	2.8396	0.026

HMS * Summary of Results for HAFB DA011

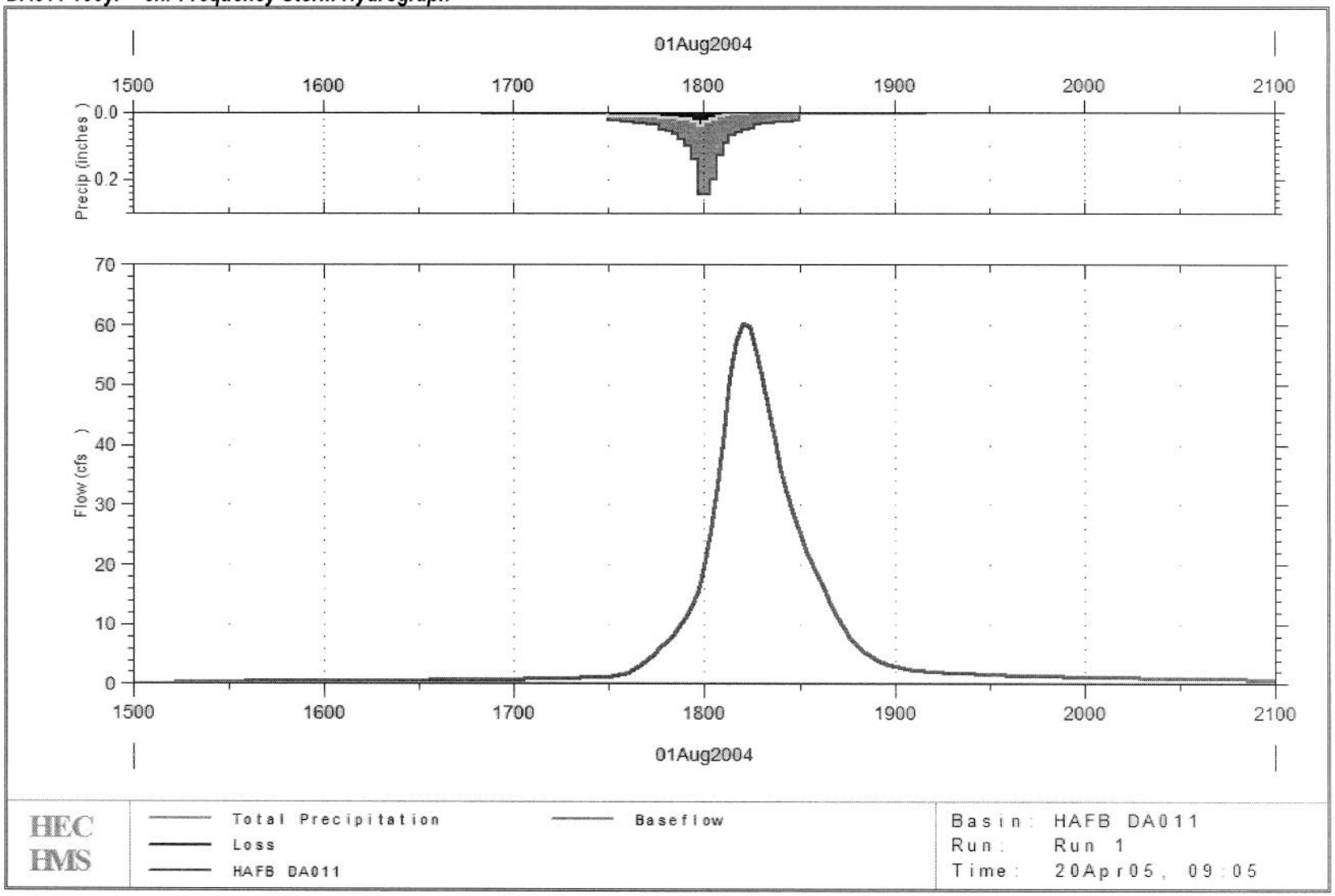
Project : HAFB_DA011_100yr_FQ Run Name : Run 1

Start of Run	: 01Aug04 1500	Basin Model	: HAFB DA011
End of Run	: 01Aug04 2100	Met. Model	: HAFB MET DA011
Execution Time	: 20Apr05 0905	Control Specs	: HAFB CONTROL DA011

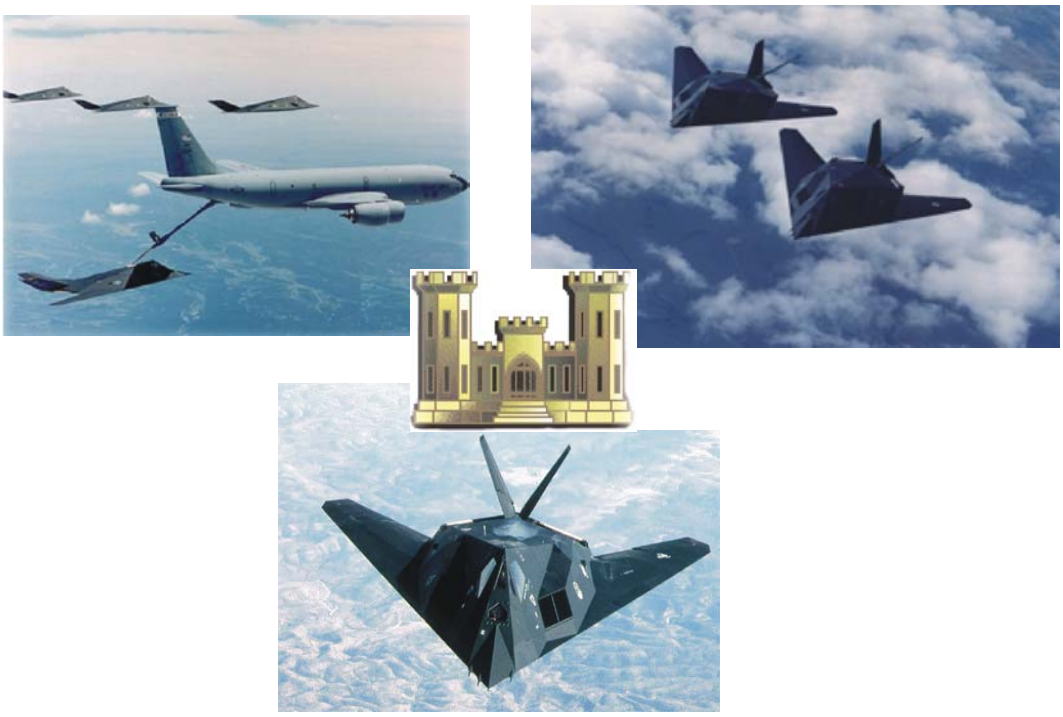
Computed Results

Peak Discharge	: 60.191 (cfs)	Date/Time of Peak Discharge	: 01 Aug 04 1812
Total Precipitation	: 2.58 (in)	Total Direct Runoff	: 2.06 (in)
Total Loss	: 0.51 (in)	Total Baseflow	: 0.00 (in)
Total Excess	: 2.07 (in)	Total Discharge	: 2.06 (in)

DA011 100yr – 6hr Frequency Storm Hydrograph



STORM WATER MODELING REPORT



Holloman Air Force Base
New Mexico

February 2006

Contract No.: DACA45-03-D-0023
Task Order No.: 01
Bhate Project No.: 9030232

Headquarters, Air Combat Command
Langley Air Force Base, Virginia

49 CES/CEV
Holloman Air Force Base, New Mexico

STORM WATER MODELING REPORT

HOLLOMAN AIR FORCE BASE
ALAMOGORDO, OTERO COUNTY, NEW MEXICO

Prepared for:

U.S. Army Corps of Engineers
Omaha District
Omaha, Nebraska

Contract No. DACA45-03-D-0023
Task Order No. 01

February 2006

Prepared by:

Bhate Environmental Associates, Inc.
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Birmingham, Alabama 35205

Bhate Project No. 9030232.23.01

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STORM WATER MODELING REPORT
HOLLOMAN AIR FORCE BASE
ALAMOGORDO, OTERO COUNTY, NEW MEXICO
REVIEW SHEET

This *Storm Water Modeling Report* has been reviewed and approved by:

		February 17, 2006
Karen J. Niebuhr, P.E. Senior Engineer	Signature	Date
		February 17, 2006
Frank Gardner, P.G. Program Manager	Signature	Date

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STORM WATER MODELING REPORT
HOLLOMAN AIR FORCE BASE
ALAMOGORDO, OTERO COUNTY, NEW MEXICO

TABLE OF CONTENTS

List of Acronyms and Abbreviations iii

1 Introduction 1-1
- 1.1 Purpose of the Storm Water Modeling Report 1-1
- 1.2 Objective of the Storm Water Modeling Report 1-1
- 1.3 Use of this Storm Water Modeling Report 1-2
- 1.4 Report Organization and Methodology 1-2
  - 1.4.1 Task 1 – Data Collection 1-2
  - 1.4.2 Task 2 – Field Inspection 1-2
  - 1.4.3 Task 3 – Watershed Modeling 1-2
  - 1.4.4 Task 4 – Results and Conclusions 1-3

2 General Information 2-1
- 2.1 Site Location and Characteristics 2-1
- 2.2 Topography 2-1
- 2.3 Soil Characteristics 2-1
- 2.4 Vegetative Cover 2-4
- 2.5 Rainfall 2-4
- 2.6 Drainage Areas 2-4
  - 2.6.1 DA-005 2-4
  - 2.6.2 DA-006 2-4
  - 2.6.3 DA-007 2-4
  - 2.6.4 DA-008 2-5
  - 2.6.5 DA-012 2-5
  - 2.6.6 DA-013 2-5
  - 2.6.7 DA-014 2-5

3 Storm Water Modeling 3-1
- 3.1 General 3-1
- 3.2 Limitations to Model 3-1
- 3.3 Results 3-2

4 Conclusions 4-1
- 4.1 Drainage Area 005 4-1
- 4.2 Drainage Area 006 4-1
- 4.3 Drainage Area 007 4-1

4.4 Drainage Area 008 4-1
4.5 Drainage Area 012 4-2
4.6 Drainage Area 013 4-2

5 References 5-1

Figures

1 Drainage Areas Plan
2 6- Hour Design Storm Distribution Curve
3 Location Map
4 Existing Soil Type
5 Isopluvials of 10-yr 24-hour Precipitation Depth in Inches
6 Isopluvials of 25-yr 24-hour Precipitation Depth in Inches
7 Isopluvials of 100-yr 24-hour Precipitation Depth in Inches

Table

1 Summary of Storm Water Modeling Results

Appendices

A Drainage Area Storm Water Modeling Results
B NRCS Soil Types and Groups
C Runoff Curve Numbers for Urban Areas
D Point Precipitation Frequency Estimates from NOAA Atlas 14

LIST OF ACRONYMS AND ABBREVIATIONS

AAF	Army Air Field
AEC	Alamogordo Gypsum Land Complex
BEAR	Basic Expeditionary Airfield Resources
Bhate	Bhate Environmental Associates, Inc.
CN	Curve Number
DA	Drainage Area
EPA	Environmental Protection Agency
GIS	Geographic Information System
HAFB	Holloman Air Force Base
HEC	Hydrologic Engineering Center
HMS	Hydrologic Modeling System
HOB	Holloman-Gypsum land – Yesum complex
MEA	Mead Silty Clay
MMG	49th Materiel Maintenance Group
MSGP	Multi-Sector General Permit
NMED	New Mexico Environment Department
NMSHTD	New Mexico State Highway and Transportation Department
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
P.E.	Professional Engineer
P.G.	Professional Geologist
SCP	Sediment Control Plan
SCS	Soil Conservation Service
SOW	Statement of Work
SWPPP	Storm Water Pollution Prevention Plan
TR20	Technical Release 20
TR55	Technical Release 55
USACE	United States Army Corps of Engineers
WMS	Watershed Modeling System

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1 INTRODUCTION

This *Storm Water Modeling Report* was developed by Bhate Environmental Associates, Inc., (Bhate), for the U.S. Army Corps of Engineers (USACE), Omaha District. This report will provide information related to 10-year, 25-year, and 100-year storm water flow rates from several industrialized areas, as previously designated in the *Draft Storm Water Pollution Prevention Plan* (SWPPP) developed for Holloman Air Force Base (HAFB), New Mexico, by CH2M Hill, dated September 2003. The SWPPP is required under the *National Pollutant Discharge Elimination System (NPDES) Storm Water Multi-Sector General Permit for Industrial Activities*, Environmental Protection Agency (EPA), October 30, 2000.

The industrialized areas studied for the purpose of this report are: Drainage Areas (DA) DA-005, DA-006, DA-007, DA-008, DA-012, DA-013, and DA-014. The study also included re-evaluating the delineation of each area to assure that the drainage patterns from each area remain valid. Any changes made to the delineation of an area or to the outflow point of an area are also discussed and can be used to update the industrial area drainage patterns in the SWPPP when the Multi-Sector General Permit (MSGP) is re-issued and the SWPPP is updated to be in compliance with the new permit.

1.1 Purpose of the Storm Water Modeling Report

As storm water events occur, changes occur to the ground upon which the precipitation falls. This report studies these changes, their effect on the topography, and the general conditions as related to industrialized areas DA-005, DA-006, DA-007, DA-008, DA-012, DA-013, and DA-014 (Figure 1). Land use changes brought about by development within each drainage area were also studied. Both conditions can affect storm water runoff flow patterns which were determined using watershed modeling software. The results of the modeling were then compared to those presented in the existing SWPPP, and recommended updates are given for the SWPPP when it is revised after the new MSGP is issued.

1.2 Objective of the Storm Water Modeling Report

The objective of this report is to study the storm water flow patterns from industrialized drainage areas DA-005, DA-006, DA-007, DA-008, DA-012, DA-013, and DA-014. This was accomplished with the use of a computer-aided storm water modeling program called Watershed Modeling System (WMS) 7.0 by Environmental Modeling Systems, Inc.

This report does not make specific determinations of any existing storm water handling features or measures (such as pipe sizing) but it will bring to light any questionable conditions relating to storm water flow from the areas.

1.3 Use of this Storm Water Modeling Report

It is the intent that this report be used for reevaluating the previous conclusions made in the HAFB SWPPP using updated information concerning topography, soil types, development, and land use. The results of this report are to be compared to existing assumptions used to create the SWPPP and determine if the plan remains viable. The results of this report can also be used to determine areas of concern as they pertain to storm water handling systems which are in place and may need to be reevaluated and/or redesigned.

1.4 Report Organization and Methodology

This report is organized into sections that correlate with the general methodology for obtaining the results for this report.

1.4.1 Task 1 – Data Collection

A review was performed of the available hydrologic data for HAFB including previous drainage studies such as the *Master Drainage Plan* prepared by Resource Technology, Inc., dated September 1989. Design storms, soil characteristics, and other site information were collected from published and publicly available sources such as the National Weather Service / National Oceanic & Atmospheric Administration (NOAA), Natural Resources Conservation Service (NRCS), New Mexico State Highway and Transportation Department (NMSHTD), EPA, New Mexico Environment Department (NMED), the internet site MapQuest, and the USACE. Topographic and geospatial data, Geographic Information System (GIS), was provided by HAFB which included the results of the most recent aerial survey of HAFB performed in 2004.

1.4.2 Task 2 – Field Inspection

A field visit was performed to examine the characteristics of industrialized drainage areas DA-005, DA-006, DA-007, DA-008, DA-012, DA-013, and DA-014 as designated in the SWPPP. During the field visit, land use and the existing outfall points and field monitors of each of the industrialized drainage areas were noted. The visit was conducted with local representatives of HAFB and Bhate, who described the areas and possible areas of concern observed throughout the previous three years since the preparation of the draft SWPPP (CH2M Hill, September 2003).

1.4.3 Task 3 – Watershed Modeling

Available information concerning topography, land use, rainfall data, soil types, etc., was entered into the watershed modeling software. Storm water events for the 10-year, 25-year, and 100-year storms were applied using the Type II, 6-hour storm distribution model as defined by the Soil Conservation Service (SCS). The general definition of this model is shown on the graph provided as Figure 2.

1.4.4 Task 4 – Results and Conclusions

Table 1 gives a general overview of the results of the storm water modeling for the above-referenced industrialized drainage areas. In-depth results of the storm water modeling are provided in Appendix A.

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2 GENERAL INFORMATION

The following sections summarize existing general HAFB information.

2.1 Site Location and Characteristics

HAFB is located in southeastern New Mexico in Otero County, New Mexico, approximately 100 miles north-northeast of El Paso, Texas, and six miles west of Alamogordo, New Mexico (Figure 3). HAFB was first established in 1942 as Alamogordo Army Air Field (AAF). From 1942 through 1945, Alamogordo AAF served as the training grounds for over 20 different flight groups, flying primarily B-17s, B-24s, and B-29s. After World War II, most operations had ceased at the base. In 1947, Air Materiel Command announced the air field would be its primary site for the testing and development of un-manned aircraft, guided missiles, and other research programs. On January 13, 1948, the Alamogordo installation was renamed Holloman Air Force Base, in honor of the late Col. George V. Holloman; a pioneer in guided missile research. In 1968, the 49th Tactical Fighter Wing arrived at HAFB and has remained since. Today, HAFB also serves as the training center for the German Air Force's Tactical Training Center.

2.2 Topography

HAFB is located in a region of limited elevation relief. The terrain where most base activities occur ranges in elevation from 4,034 to 4,110 feet above mean sea level, and results in slight slopes on the order of 0.5 percent. The overall site elevations range from 4,185 feet at the highest point on the basin divide to 4,020 feet at Lake Holloman, which is the natural drainage outfall for most of the basin area. This limits the runoff volume and velocity from the base as a whole; however, there are areas that adjoin major wet-weather drainage ways (arroyos) that may convey sediment off-site. HAFB is within the Tularosa Drainage Basin, which is a closed structural basin formed by a down-dropped fault block between the San Andres Mountains to the west and the Sacramento Mountains to the east. The basin contains a thick sequence of alluvial and lacustrine deposits of Tertiary and Quaternary age, most of which are saturated with saline water (*Master Drainage Plan for Holloman Air Force Base*, Resource Technology, Inc, September 1989).

The existing topography for each of the industrialized drainage areas is shown in Appendix A, as part of the appropriate drainage area sub-section. The contour lines shown are at 2-foot intervals and show the generally northeast to southwest slope of the areas which is common to the entire base.

2.3 Soil Characteristics

The entire Tularosa Basin is a faulted inter-montane depression containing a thick (up to 8,000 feet) sequence of alluvial and lacustrine deposits of Tertiary and Quarternary (Cenozoic) age. Sand, gravel, silt, and clay make up these bolson deposits with extensive gypsum in the surface layers. The area has been classified into the Chihuahuan Desert scrub Biotic Community

(*Master Drainage Plan for Holloman Air Force Base*, Resource Technology, Inc, September 1989).

The predominant existing soil types for HAFB are shown in Figure 4. According to the *Soil Survey of Otero County Area, New Mexico*, United States Department of Agriculture Soil Conservation Service and Forest Service in cooperation with the New Mexico State University Agricultural Experiment Station, June 1981, the following soil descriptions apply to soil types Alamogordo-Gypsum land complex (AEC), Holloman-Gypsum land-Yesum complex (HOB), and Mead silty clay loam (MEA) which make up the majority of the HAFB land area:

AEC: 0 to 5 percent slopes. This complex consists of relatively small areas of deep, well drained Alamogordo soil and areas of exposed gypsum. These areas are quite intermingled and are difficult to delineate. The landscape is mainly broad, dissected pediment toe slopes and filled valleys. The soil formed in highly gypsiferous alluvium and eolian deposits. Areas are broad and irregularly shaped and are 1,000 to more than 2,000 acres in size. Individual areas of each part are 10 to 30 acres in size. Alamogordo soil makes up about 50 percent of each mapped area. Typically, a desert pavement about ½" thick is on the surface. The surface layer is light brown very fine sandy loam about 7 inches thick. The upper 8 inches of the substratum is pinkish white very fine sandy loam that is very high in gypsum. Below that, the substratum is light brown very fine sandy loam to a depth of more than 60 inches. The amount of gypsum decreases with depth. Permeability of this soil is moderately rapid, and available water capacity is low. Gypsum land makes up about 30 percent of each mapped area. It is hard or soft exposed gypsum. In some areas the gypsum is covered by about 1 inch of eolian very fine sand. A desert pavement is commonly on the surface. The gypsum is 18 to more than 30 inches thick. Some parts of the exposed gypsum are eroded Alamogordo soils.

HOB: 0 to 5 percent slopes. This complex consists of large areas of shallow and deep, well drained soils and areas of exposed gypsum. These areas are so intermingled that it is difficult to delineate. This complex is on the valley floor of the Tularosa Basin. The soils formed in alluvial and eolian gypsiferous sediment. Mapped areas are wide and elongated and are 4,000 to 10,000 acres in size. The shallow Holloman soil makes up about 35 percent of the complex. Typically, the surface layer is light brown very fine sandy loam about 3 inches thick. The upper 13 inches of the substratum is pink very fine sandy loam that is very high in gypsum. Beneath that to a depth of 60 inches is white gypsum. This soil is calcareous and mildly alkaline to moderately alkaline throughout. Permeability is moderate, available water capacity is very low. Gypsum land makes up about 30 percent of the complex. Typically, less than 1 inch of very fine sandy loam overlies soft to hard, white gypsum. The deep Yesum very fine sandy loam makes up about 20 percent of the complex. Typically, the surface layer is light brown very fine sandy loam about 3 inches thick. The upper 9 inches of the substratum is light brown fine sandy loam that is high in gypsum. The next 8 inches is pinkish white very fine sandy loam that is very high in gypsum. Below that, the substratum is pink very fine sandy loam to a depth of more than 60 inches. The soil is calcareous throughout and is mildly alkaline. Permeability is moderate, and available water capacity is moderate. Many fine gypsum crystals are

throughout the profile. The wind erosion hazard is severe where the surface is bare, especially in spring, when strong winds are common.

MEA: 0 to 1 percent slopes. This deep, poorly drained, nearly level soil is on outer fringes of alluvial fans. This soil formed in fine textured alluvium over lacustrine lake sediment. It is very high in salt accumulation because of periodic flooding and poor drainage. Slopes are smooth and concave. The unit is in one area of about 2,100 acres. The area is elongated, conforming to narrow bottom land. Typically, the surface layer is reddish brown silty clay loam and clay loam about 5 inches thick. The substratum, to a depth of 48 inches, is light reddish brown clay that has a high content of salts. Below that, the substratum is lacustrine material of variable texture and color to a depth of more than 60 inches. Permeability is very slow and available water capacity is low. Tilth is poor, and the soil can be worked only over a narrow range of moisture conditions.

For the purpose of performing the storm water modeling, NRCS hydrologic groups were associated with each soil type. Hydrologic groups were labeled as “A”, “B”, “C”, or “D” with “A” being the “best” soil as far as erosion, drainage, stability, etc. are concerned, and “D” being the worst. Appendix B lists all soil types found in Otero County, New Mexico. The information was downloaded from the NRCS website. The following hydrologic groups were associated with the soil types listed above:

AEC: Alamogordo-Gypsum land complex: Hydrologic Group C.

HOB: Holloman-Gypsum land-Yesum complex: Hydrologic Group C. Based on the NRCS table found in Appendix B, this soil type could be categorized as being either “B” or “C”. According to the description listed above, the gypsum layer of the soil tends to make up the upper layers while the Yesum portion of the soil is found in the deeper layers. For this reason, this soil type was assigned the hydrologic group of “C” since storm waters primarily affect the upper layers.

MEA: Mead silty clay loam: Hydrologic Group D.

The general soil type of each drainage area is given in Table 1 as well as being part of the results shown in Appendix A under the appropriate drainage area sub-section.

Soil types are used to determine Curve Number (CN) values for use in the storm water modeling software. CN values reflect the amount of water that runs off an area; the higher the number, the more water runs off. For example, paved areas can have CN values up to 95 whereas unpaved areas could have a CN number in the 60’s. More water runs off the paved areas than from the unpaved; therefore, paved areas are assigned a higher CN value. In order to correctly apply CN values to areas that are paved and unpaved, composite CN values are used in the modeling process. This is achieved by determining the percentages of the total area that are to receive different CN values and then performing a weighted average of the individual CN values to calculate a composite CN value for the entire area. CN values for urban areas are included as Appendix C.

2.4 Vegetative Cover

HAFB is a sparsely vegetated site with poor soils and limited rainfall to encourage growth of new vegetative cover. Many of the present types of native volunteer vegetation are not suitable for protection from erosive potential/energy from rainfall or runoff. As such, vegetative cover was not considered in the storm water modeling process.

2.5 Rainfall

Rainfall data for this project was obtained from publicly available sources located at the NOAA[1] website. The tables and associated information are presented as Appendix D. Isopluvials of 10-year, 25-year, and 100-year precipitation depths, in inches, are presented as Figures 5, 6, and 7, respectively. These maps serve as a visual aide in depicting rainfall amounts throughout the mapped area only, and are not intended to provide specific design criteria.

2.6 Drainage Areas

The following drainage areas were evaluated for storm water runoff as part of this report.

2.6.1 DA-005

Activities in DA-005 include Army Fueling, Aerospace Fuel Testing, NewTech, Non-Destructive Inspections, and Phillips Balloon Laboratory. DA-005 is located west of DA-004 and is estimated at approximately 64 acres. Storm water from this area discharges to isolated depressions to the southwest.

2.6.2 DA-006

Drainage Area 006 is located on the western edge of the main base activities, south of Runway 07 and Taxi-way L. This 157-acre area houses the 49th Materiel Maintenance Group (MMG), and is referred to as Basic Expeditionary Airfield Resources (BEAR) Base. Storm water from these areas either exit via a drainage channel along the western edge or discharges to the south to a designated wetland. Each of these ultimately discharges to Lake Holloman.

2.6.3 DA-007

Drainage Area 007 is located on the eastern side of HAFB. Discharge from this area goes directly to Dillard Draw by way of three outfall locations: DA-007, DA-007A, and DA-007B. This drainage area is a former capped and closed landfill that is approximately 84 acres.

[1] http://hdsc.nws.noaa.gov/hdsc/pfds/sa/nm_pfds.html

2.6.4 DA-008

DA-008 is located northwest of the main developed area of the base and contains the Test Track and its support services. The size is estimated to be 27 acres. Storm water from this area discharges to the Lost River. HAFB's SWPPP states that storm water exits this area via sheet flow; however, there is a designated discharge structure and sampling point southwest of the drainage area.

2.6.5 DA-012

The activities in this area are generally limited to storage of equipment. Reportedly, storm water from this 79-acre drainage area discharges to an isolated surface depression in the southeast corner. During the site inspection and in evaluating the contours, it appeared that storm water flows to the southwest.

2.6.6 DA-013

This area contains The Recycling Center and the local Bhate field office. It is located in the middle section of HAFB, west of Building 1266. It is estimated to be approximately 6 acres.

2.6.7 DA-014

Drainage Area 014 is located west of the main base activities. The area is approximately 47 acres and is largely unimproved. It contains the Asphalt/Concrete Recycling Center. There is an outfall structure for this area; however, the site has been graded so that no storm water exits the area. Therefore, this area was not modeled due to zero discharge of storm water.

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3 STORM WATER MODELING

WMS 7.0 is a hydrologic modeling program used for watershed analysis, using the Hydrologic Engineering Center (HEC) HEC-1 model, HEC-Hydrologic Modeling System (HMS) HEC-HMS model, NRCS Project Formulation Hydrology Technical Release 20 (TR20) model, NRCS Urban Hydrology for Small Watersheds Technical Release 55 (TR55) model, Rational Method, and various other models for determining storm water flow patterns over a specified watershed area. The watershed areas studied for the purpose of this report are the industrialized drainage areas described in Section 2.6 of this report. WMS also provides tools for automated watershed and sub-basin delineation. This feature was used to verify the existing drainage area delineations and make any adjustments as needed. WMS can also perform automated curve number generation which is used to determining the proper runoff coefficient for the drainage areas. In order to perform this task, WMS requires soils information which was provided by HAFB. This soil data is presented in Figure 4. Time of concentration computation is also part of WMS's capabilities and is used for creating hydrographs, determining peak flows, flow durations, etc. These results can be used to determine pipe sizes, retention pond sizing, sediment control measure requirements, etc., but is beyond the scope of this project.

3.1 General

In order to enter the necessary information into the WMS modeling software, it was necessary to begin by importing the appropriate aerial photographs of the subject area to assist in the visualization process which helps to develop correct drainage delineations based on roads, buildings, and drainage structures (ditches, flumes, etc.). Also imported into the modeling project was the contour data which was provided by HAFB in the form of an ARCVIEW shape file. Contour data provided by HAFB was from a 2004 aerial survey performed on the entire base as part of an unrelated HAFB project. Roadway data, buildings data, and soil type data were also provided by HAFB in the form of shape files which were imported into the WMS program. All data was imported directly into the program without the need of intermediate manipulation.

3.2 Limitations to Model

The limitations of the WMS modeling software generally deal with the lack of an ability to export graphical data from the program to either ARCVIEW or AutoCAD. This limitation was dealt with by using AutoCAD to create the graphical representation figures necessary to compare the existing industrialized drainage area delineations to the new delineations (if any) established during the performance of the storm water modeling. The figure for each area showing the existing delineations and any changes to the delineations are presented in Appendix A under the appropriate drainage area sub-section. Any proposed changes to the outfall locations for the drainage areas as well as any other pertinent data are also depicted in these figures.

3.3 Results

The results of the storm water modeling are presented in an overview in Table 1 while the in-depth results are presented in Appendix A under the appropriate drainage area sub-section.

4 CONCLUSIONS

Evaluation of the storm water runoff from the above-referenced industrialized drainage areas using the WMS modeling software yielded the following results:

4.1 Drainage Area 005

The existing delineation for DA-005 as defined in the SWPPP remains valid and has not been found to require modification. All storm waters were found to drain to the existing outfall structure located in the southwest corner of the area. Therefore, the outfall structure will not be required to relocate. Upon comparison with previously determined storm water flow rates and time to peak flow, it was determined that there has not been a significant change in either the flow rates or time to peak flow.

4.2 Drainage Area 006

The existing delineation for DA-006 as defined in the SWPPP remains valid and has not been found to require modification. All storm waters were found to drain to the existing outfall structure located in the western edge of the area and the existing outfall is therefore not required to be relocated. Upon comparison with previously determined storm water flow rates and time to peak flow, it was determined that there has not been a significant change in either the flow rates or time to peak flow.

4.3 Drainage Area 007

The existing delineation for DA-007 as defined in the SWPPP remains valid and has not been found to require modification. All storm waters were found to drain to the existing outfall structures located along the eastern perimeter of the area and are therefore not required to be relocated. Upon comparison with previously determined storm water flow rates and time to peak flow, it was determined that there has not been a significant change in either the flow rates or time to peak flow.

4.4 Drainage Area 008

The existing delineation for DA-008 as defined in the SWPPP remains valid and has not been found to require modification. All storm waters were found to essentially drain as sheet flow towards the arroyo located directly to the south of the area. The existing outfall structure located southwest of the area does not accurately collect runoff from the area based on the modeling efforts. It is recommended that the outfall location be relocated south of the area as shown in Appendix A under the appropriate section dealing with DA-008. It is also recommended that effort be made to create a diversion structure that will capture sheet flow from the area and direct it to the newly relocated outfall location. The diversion structure should be constructed along the southern edge of the area beginning at the eastern edge and terminated in a location that will lead

waters to the relocated outfall. Upon comparison with previously determined storm water flow rates and time to peak flow, it was determined that there has not been a significant change in either the flow rates or time to peak flow.

4.5 Drainage Area 012

The existing delineation for DA-012 as defined in the SWPPP remains valid and has not been found to require modification. As mentioned previously, storm water runoff from this area was previously determined to migrate towards the depression located in the southeast corner of the area. According to the site visit and upon review of the contours, it was found that waters from this area run towards the southwest corner of the area as shown in Appendix A under the appropriate section dealing with DA-012. Upon comparison with previously determined storm water flow rates and time to peak flow, it was determined that there has not been a significant change in either the flow rates or time to peak flow.

4.6 Drainage Area 013

The existing delineation for DA-013 as defined in the SWPPP remains valid and has not been found to require modification. All storm waters were found to drain to the existing outfall structure located north of the area and the existing outfall structure is therefore not required to be relocated. Upon comparison with previously determined storm water flow rates and time to peak flow, it was determined that there has not been a significant change in either the flow rates or time to peak flow.

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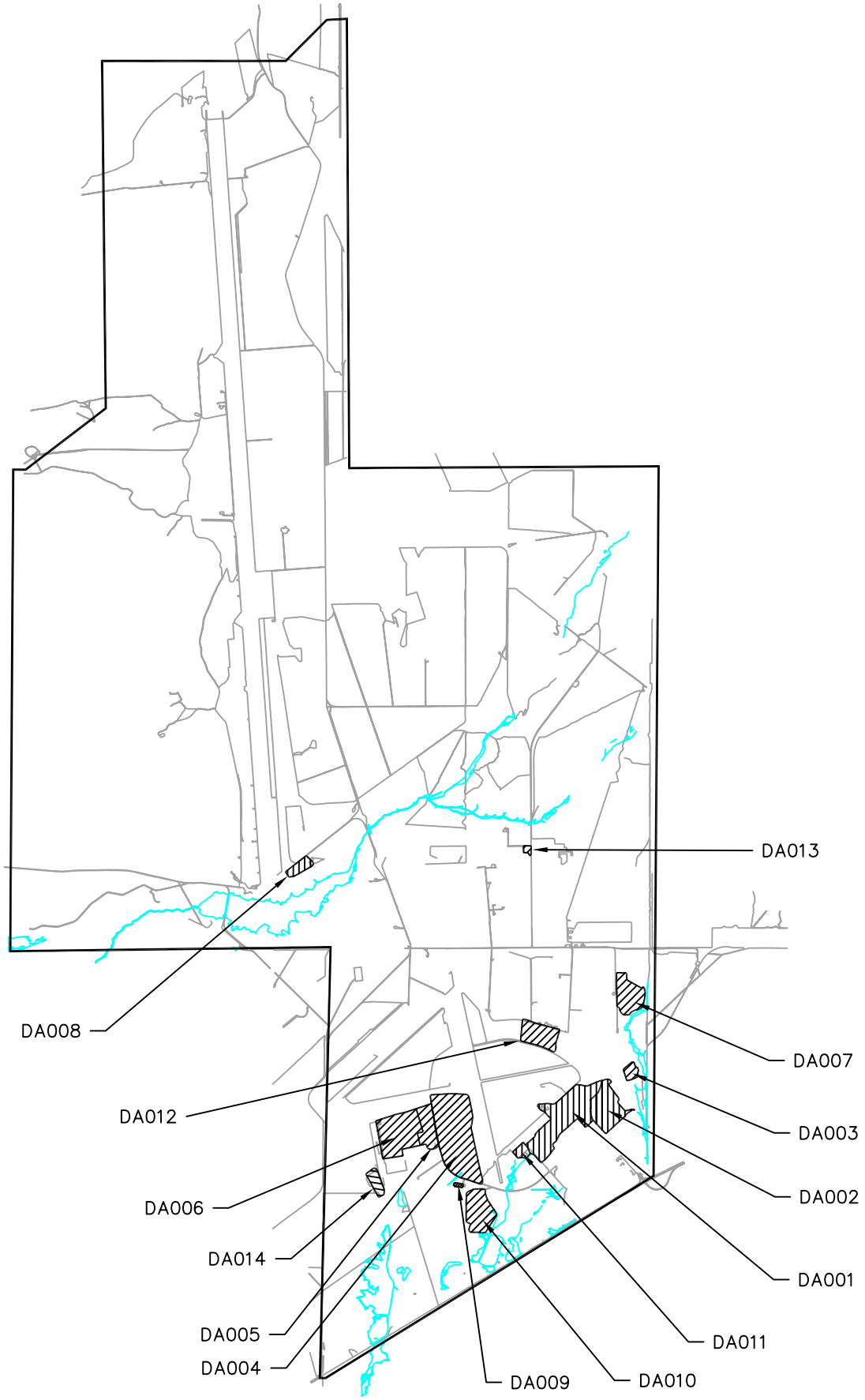
FIGURES



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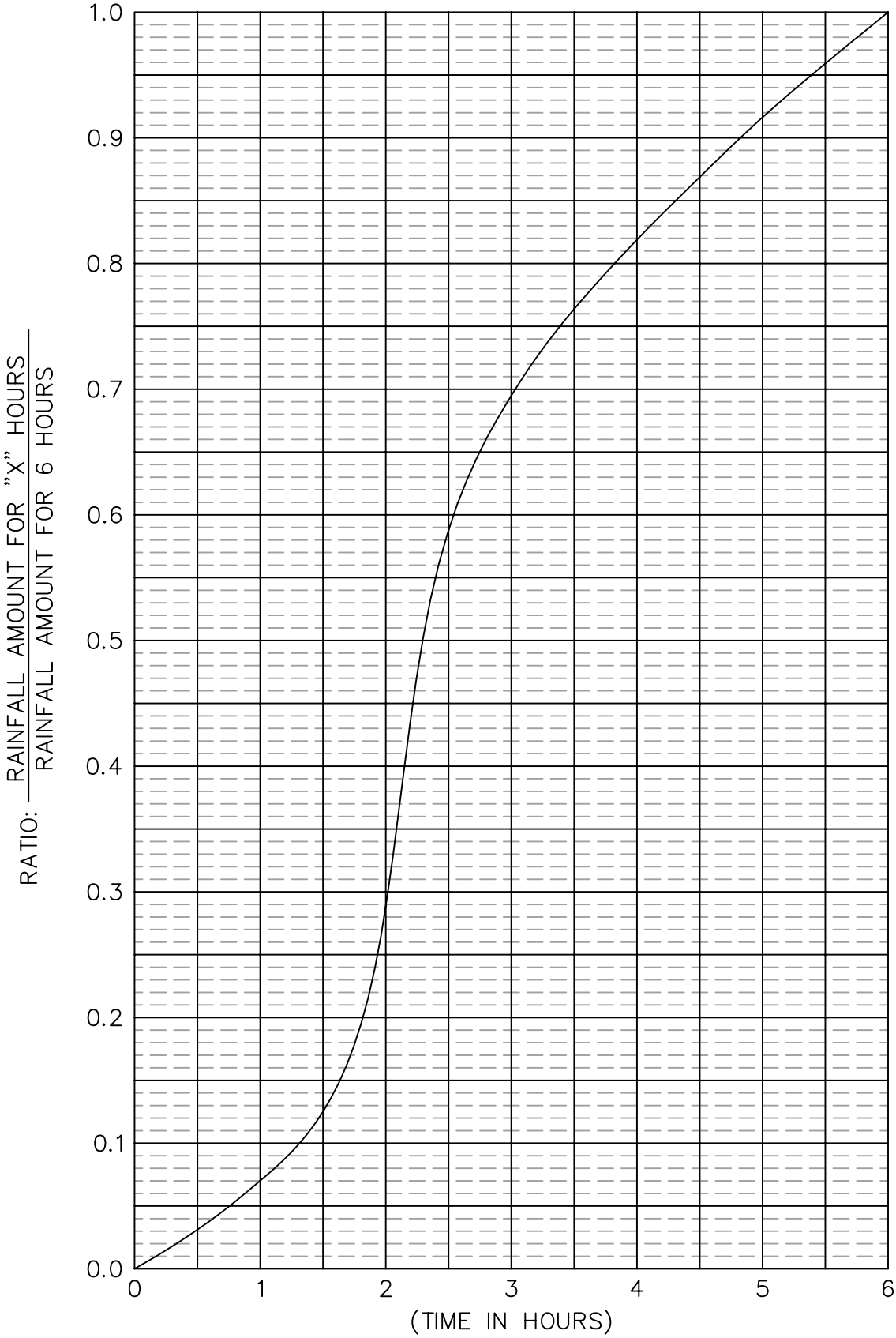
DRAINAGE AREAS PLAN

PROJECT NO.	SCALE	DATE	DRAWN BY: SKN/MRM
9030232	NTS	12/21/05	DRAWING NO: Figure 1

Storm Water Modeling Report
Holloman AFB
Alamogordo, NM

Figure 1



RATIO	TIME (HOURS)
0.5	0.027
1.0	0.070
1.5	0.124
2.0	0.230
2.5	0.560
3.0	0.700
3.5	0.758
4.0	0.824
4.5	0.869
5.0	0.918
5.5	0.945
6.0	1.000

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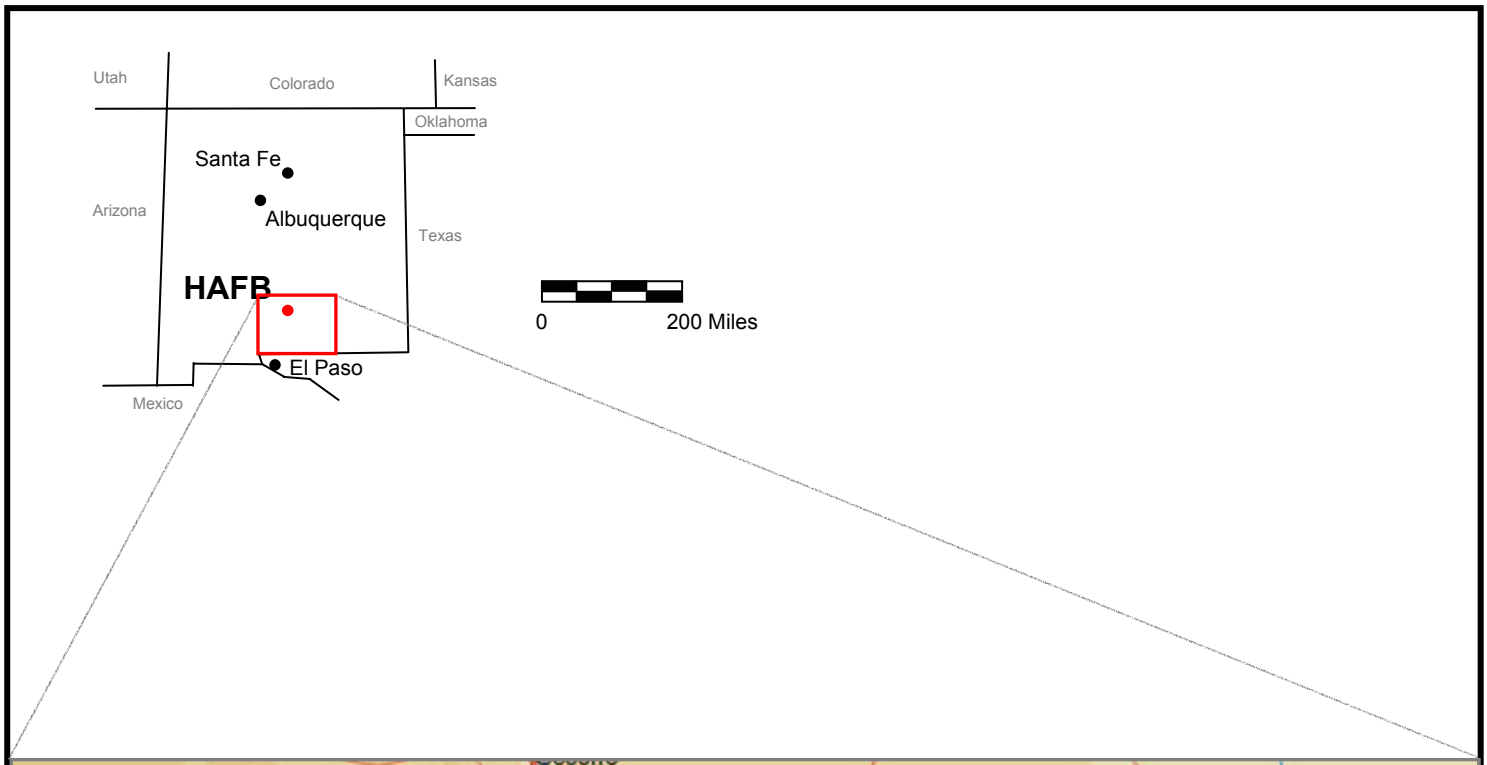
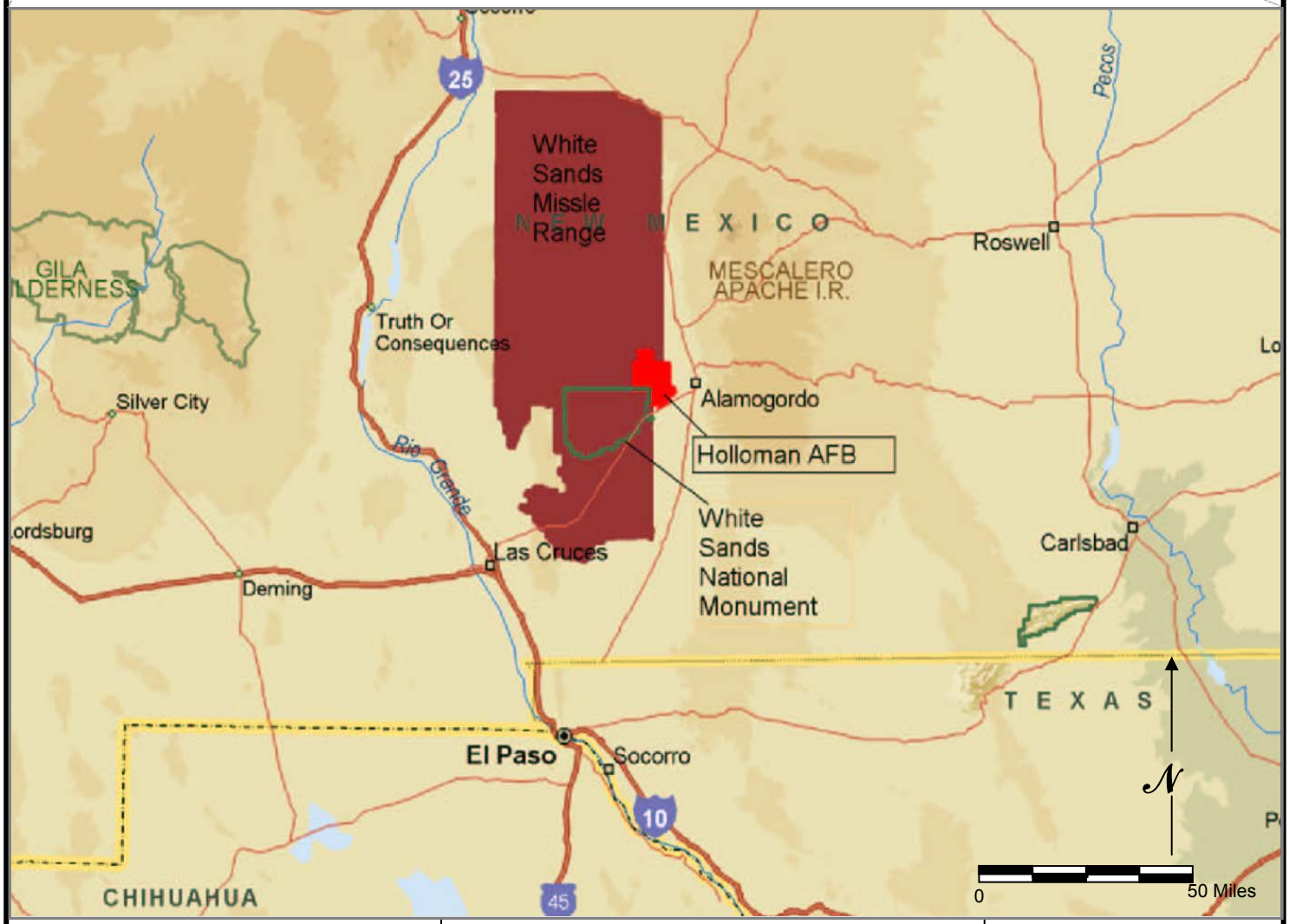
6-HOUR DESIGN STORM DISTRIBUTION CURVE

PROJECT NO.	SCALE	DATE	DRAWN BY: SKN/MRM
9030232	NTS	12/21/05	DRAWING NO: Figure 2

Storm Water Modeling Report
Holloman AFB
Alamogordo, NM

Figure 2





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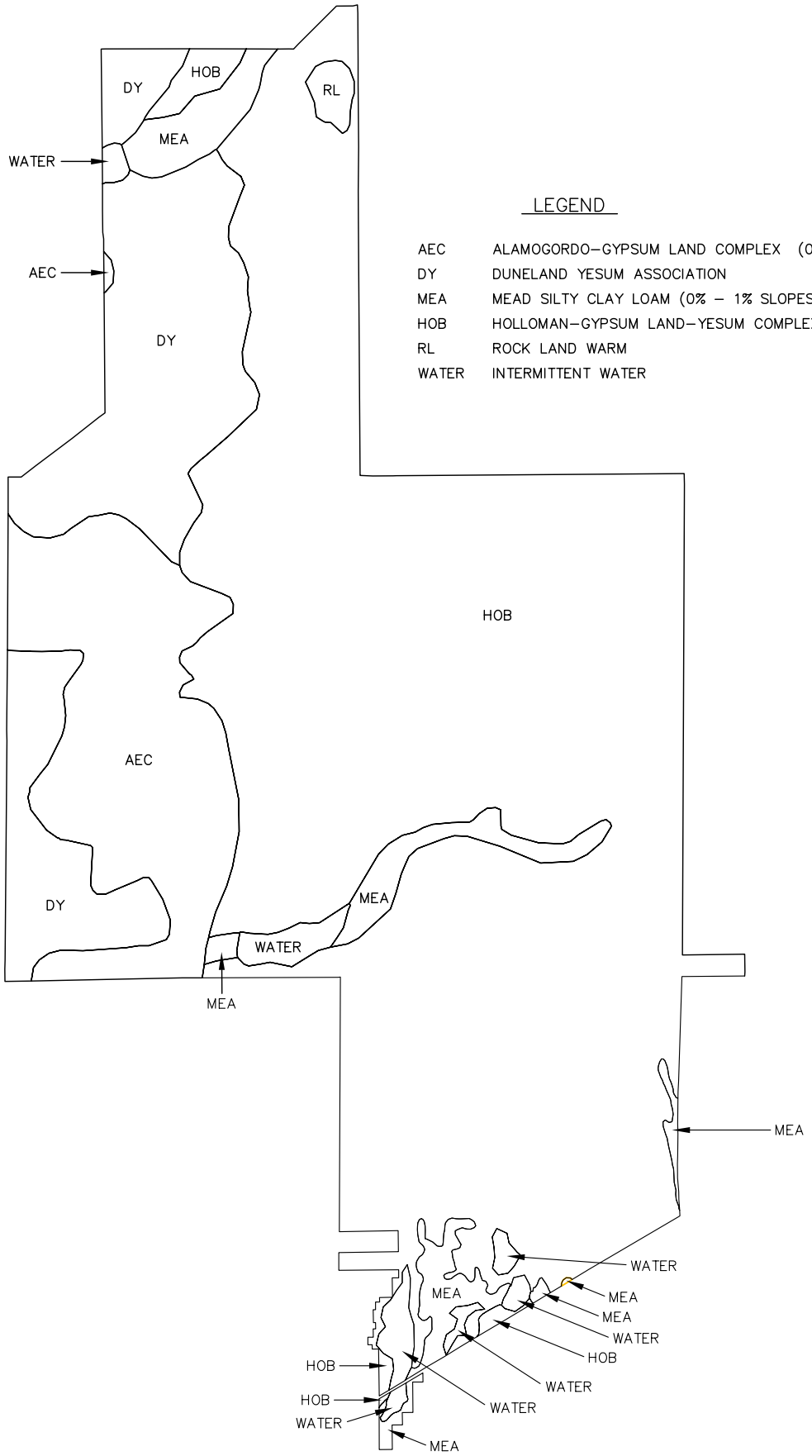
LOCATION MAP

PROJECT NO.:	SCALE:	DATE:	DRAWN BY:
9030232	SHOWN	11/05	SSD
			FILE: Figure 1

Figure 3

Holloman AFB, New Mexico



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EXISTING SOIL TYPE

PROJECT NO.	SCALE	DATE	DRAWN BY: SKN/MRM
9030232	NTS	12/21/05	DRAWING NO: Figure 4

Storm Water Modeling Report
Holloman AFB
Alamogordo, NM

Figure 4

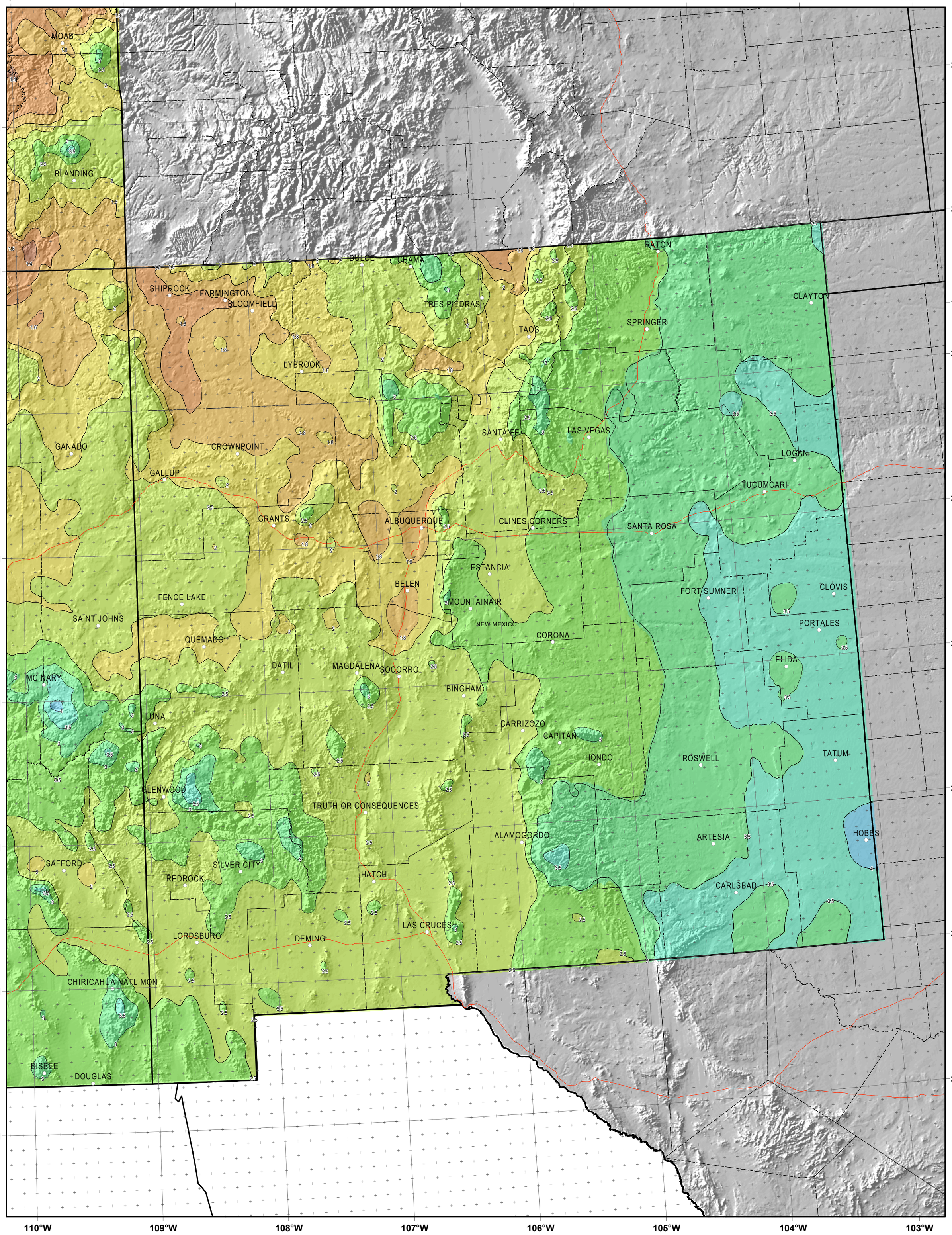


Figure 5: NEW MEXICO

Isopluvials of 10-yr 24-hour precipitation depth in inches

Based on a Partial Duration Series

NOAA Atlas 14, Volume 1, Version 3
Semiarid Southwestern United States

Prepared by U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
OFFICE OF HYDROLOGIC DEVELOPMENT
HYDROMETEOROLOGICAL DESIGN STUDIES CENTER
January 2004

N

SCALE 1:2,000,000

0 10 20 30 40 50 Miles

0 5 10 20 30 40 50 60 70 Kilometers

Projection: Lambert Conformal Conic; Datum NAD83; Standard Parallels: 38˚ and 45˚; Central Meridian 112˚.

Inches

1.1 - 1.2	1.9 - 2.0	3.6 - 4.0	7.1 - 8.0
1.3 - 1.4	2.1 - 2.5	4.1 - 5.0	8.1 - 9.0
1.5 - 1.6	2.6 - 3.0	5.1 - 6.0	9.1 - 10.0
1.7 - 1.8	3.1 - 3.5	6.1 - 7.0	10.1 - 11.0

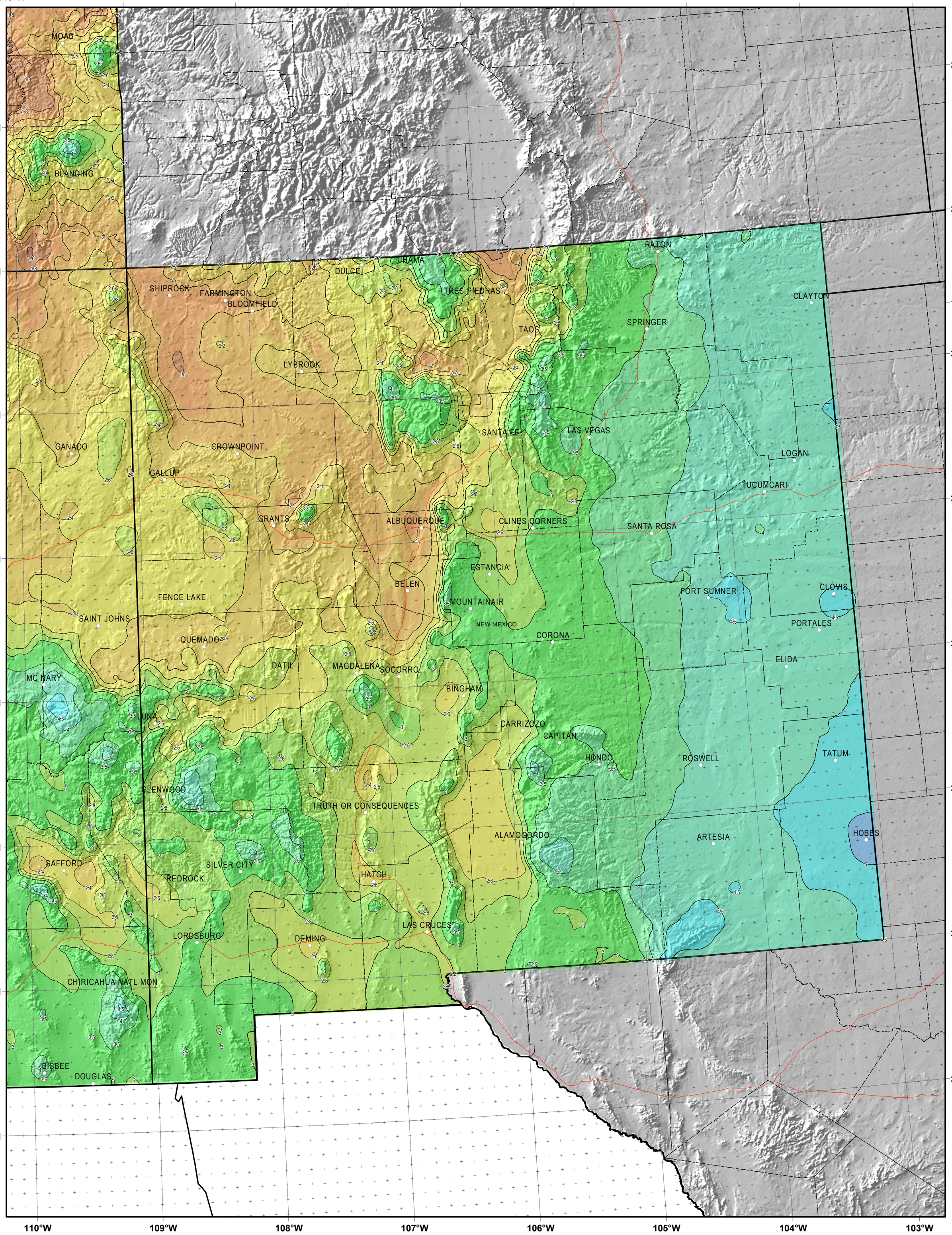


Figure 6: NEW MEXICO

Isopluvials of 25-yr 24-hour precipitation depth in inches

Based on a Partial Duration Series

NOAA Atlas 14, Volume 1, Version 3
Semiarid Southwestern United States

Prepared by U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
OFFICE OF HYDROLOGIC DEVELOPMENT
HYDROMETEOROLOGICAL DESIGN STUDIES CENTER
January 2004

N

SCALE 1:2,000,000

0 10 20 30 40 50 Miles

0 5 10 20 30 40 50 60 70 Kilometers

Projection: Lambert Conformal Conic; Datum NAD83; Standard Parallels: 38° and 45°; Central Meridian 112°.

Inches

1.3 - 1.4	2.1 - 2.2	2.9 - 3.0	4.6 - 5.0	8.1 - 9.0
1.5 - 1.6	2.3 - 2.4	3.1 - 3.5	5.1 - 6.0	9.1 - 10.0
1.7 - 1.8	2.5 - 2.6	3.6 - 4.0	6.1 - 7.0	10.1 - 11.0
1.9 - 2.0	2.7 - 2.8	4.1 - 4.5	7.1 - 8.0	11.1 - 12.0
				12.1 - 13.0
				13.1 - 14.0

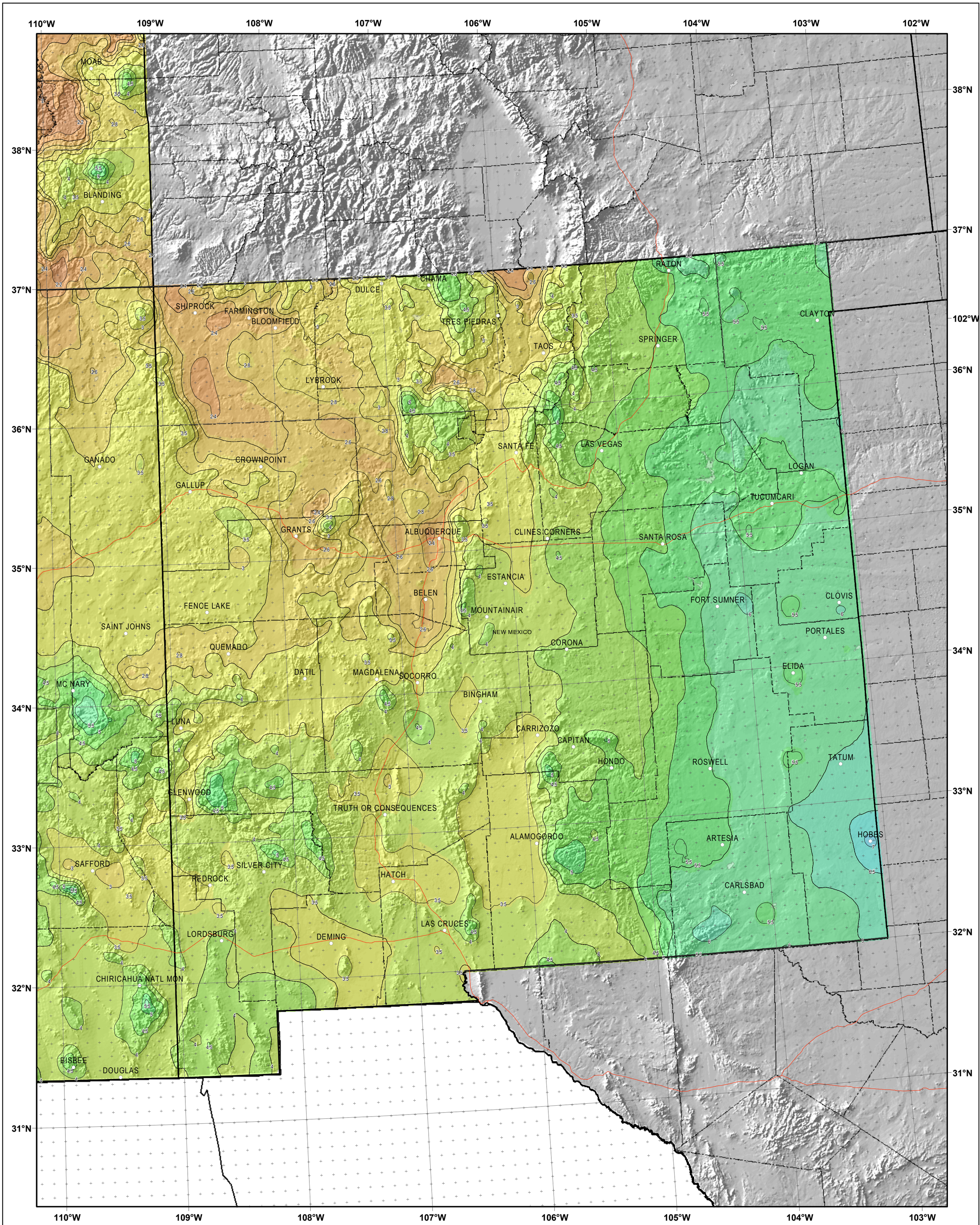


Figure 7: NEW MEXICO

Isopluvials of 100-yr 24-hour precipitation depth in inches

Based on a Partial Duration Series

Inches

1.57 - 1.60	2.41 - 2.57	4.01 - 4.50	6.51 - 7.00	11.01 - 12.00
1.61 - 1.80	2.58 - 2.76	4.51 - 5.00	7.01 - 7.97	12.01 - 13.03
1.81 - 2.00	2.77 - 3.00	5.01 - 5.52	7.98 - 9.02	13.04 - 14.00
2.01 - 2.20	3.01 - 3.53	5.53 - 6.00	9.03 - 10.00	14.01 - 15.00
2.21 - 2.40	3.54 - 4.00	6.01 - 6.50	10.01 - 11.00	15.01 - 16.00
				16.01 - 17.00
				17.01 - 18.00
				18.01 - 19.00

N

SCALE 1:2,000,000

0 10 20 30 40 50 Miles

0 5 10 20 30 40 50 60 70 Kilometers

Projection: Lambert Conformal Conic; Datum NAD83; Standard Parallels: 38˚ and 45˚; Central Meridian 112˚.

NOAA Atlas 14, Volume 1, Version 3
Semiarid Southwestern United States

Prepared by U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
OFFICE OF HYDROLOGIC DEVELOPMENT
HYDROMETEOROLOGICAL DESIGN STUDIES CENTER
January 2004

TABLE

Table 1
Summary of Storm Water Modeling Results
Storm Water Modeling Report
Holloman Air Force Base
Alamogordo, New Mexico
Contract No.: DACA45-03-D-0023
Task Order No.: 01
Bhate Proj. No.: 9030232

10-year Storm

Drainage Area	Area (acres)	% Impervious	Soil Type	Hydrologic Soil Group	Composite CN	Storm Distribution	Modeling Results Peak Flow (cfs)	Modeling Results Time to Peak Flow (minutes)
DA-005		33	HOB	C	73.5	Type II - 6-hour	486.54	390
DA-006	156.77	25	HOB	C	70	Type II - 6-hour	307.95	475
DA-007A	34.67	0	HOB	C	80	Type II - 6-hour	474.25	235
DA-007B	21.82	0	HOB	C	80	Type II - 6-hour	300.72	235
DA-007C	26.89	0	HOB	C	80	Type II - 6-hour	354.2	245
DA-008	26.75	25	HOB	C	75	Type II - 6-hour	203.62	350
DA-012	78.62	33	HOB	C	73.5	Type II - 6-hour	630.86	385
DA-013	5.62	25	MEA	D	75	Type II - 6-hour	41.34	360

25-year Storm

Drainage Area	Area (acres)	% Impervious	Soil Type	Hydrologic Soil Group	Composite CN	Storm Distribution	Modeling Results Peak Flow (cfs)	Modeling Results Time to Peak Flow (minutes)
DA-005	64.07	33	HOB	C	73.5	Type II - 6-hour	1034.38	380
DA-006	156.77	25	HOB	C	70	Type II - 6-hour	1056.58	450
DA-007A	34.67	0	HOB	C	80	Type II - 6-hour	919.43	215
DA-007B	21.82	0	HOB	C	80	Type II - 6-hour	582.74	215
DA-007C	26.89	0	HOB	C	80	Type II - 6-hour	683.88	225
DA-008	26.75	25	HOB	C	75	Type II - 6-hour	372.96	230
DA-012	78.62	33	HOB	C	73.5	Type II - 6-hour	1,314.19	370
DA-013	5.62	25	MEA	D	75	Type II - 6-hour	75	350

100-year Storm

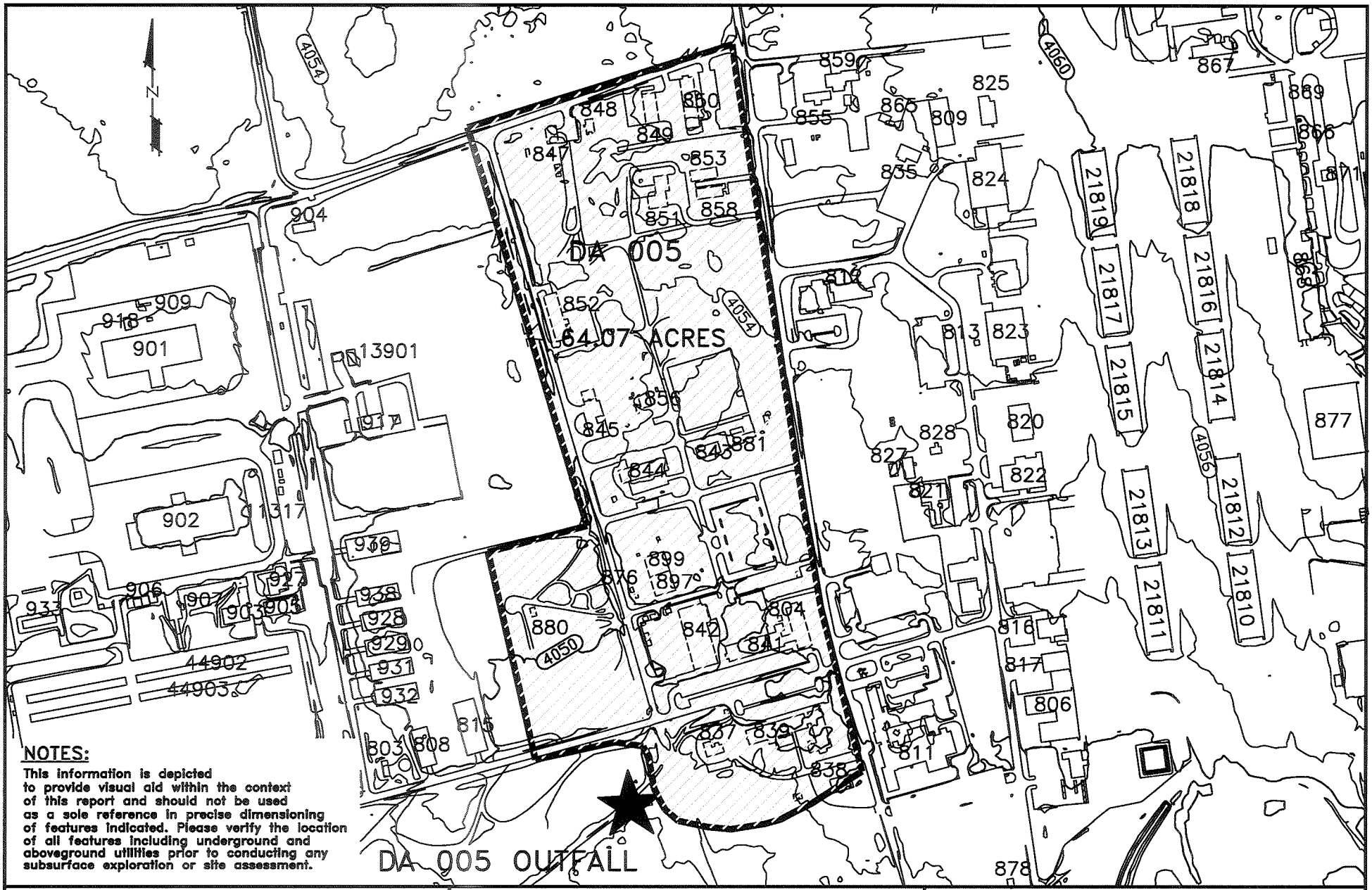
Drainage Area	Area (acres)	% Impervious	Soil Type	Hydrologic Soil Group	Composite CN	Storm Distribution	Modeling Results Peak Flow (cfs)	Modeling Results Time to Peak Flow (minutes)
DA-005	64.07	33	HOB	C	73.5	Type II - 6-hour	2,894.6	350
DA-006	156.77	25	HOB	C	70	Type II - 6-hour	2,973.69	430
DA-007A	34.67	0	HOB	C	80	Type II - 6-hour	1,992.82	205
DA-007B	21.82	0	HOB	C	80	Type II - 6-hour	1,262.9	204
DA-007C	26.89	0	HOB	C	80	Type II - 6-hour	1,470.8	210
DA-008	26.75	25	HOB	C	75	Type II - 6-hour	963.54	200
DA-012	78.62	33	HOB	C	73.5	Type II - 6-hour	2,820.22	290
DA-013	5.62	25	MEA	D	75	Type II - 6-hour	185.46	215

HOB - Holloman-Gypsum land - Yesum complex
MEA - Mead Silty Clay
DA - Drainage Area
CN - Curve Number
cfs - cubic feet per second

APPENDIX A

DRAINAGE AREA STORM WATER MODELING RESULTS

Drainage Area 005



NOTES:

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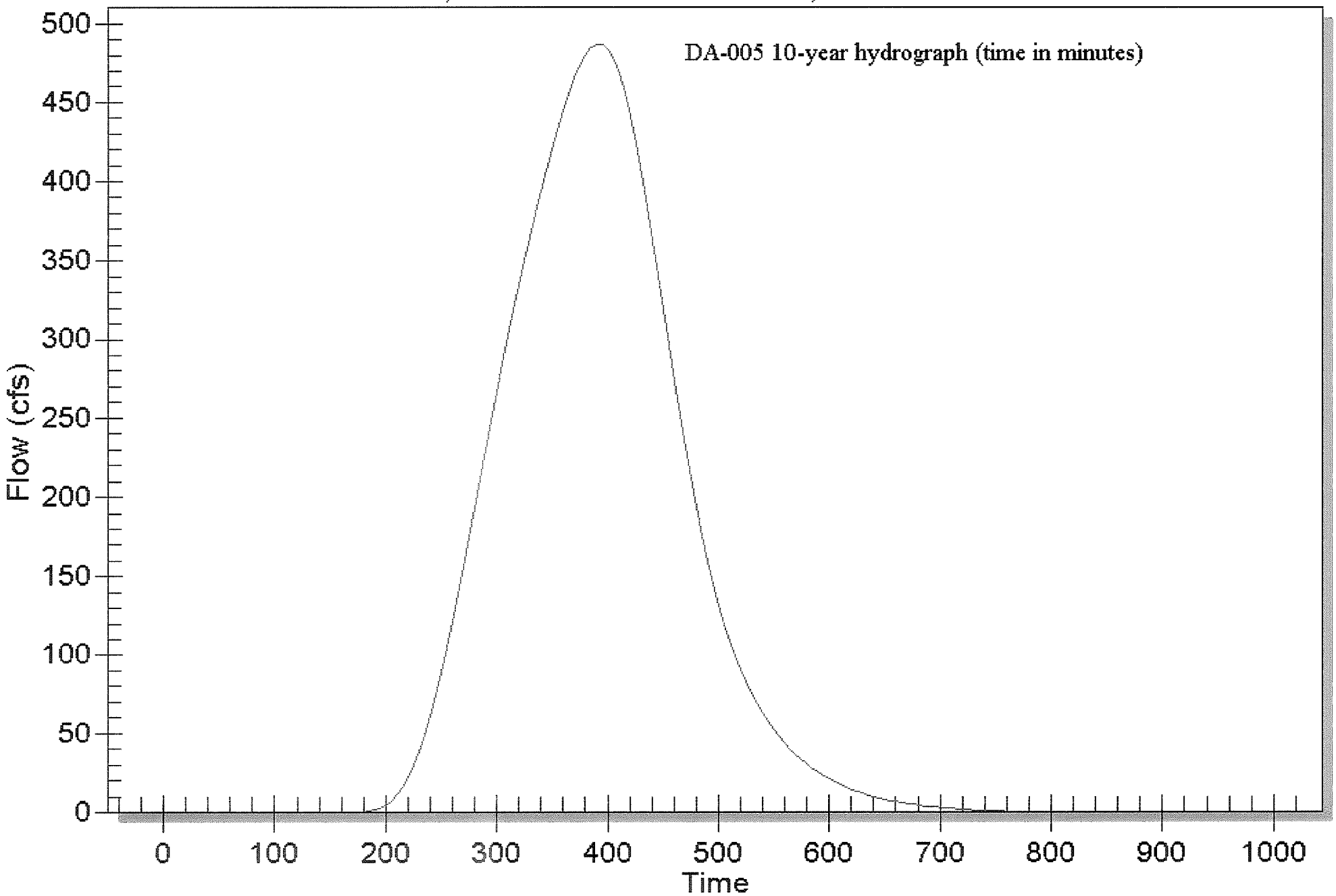
STORMWATER MODELING REPORT
HOLLOMAN AIR FORCE BASE
ALAMOGORDO, NEW MEXICO

PROJECT NO.	SCALE	DATE	DRAWN BY: SKN
9030232	1"=500'	12/07/05	DRAWING NO: DA005

DRAINAGE AREA DA005
AREA DELINEATION

Flow vs. Time

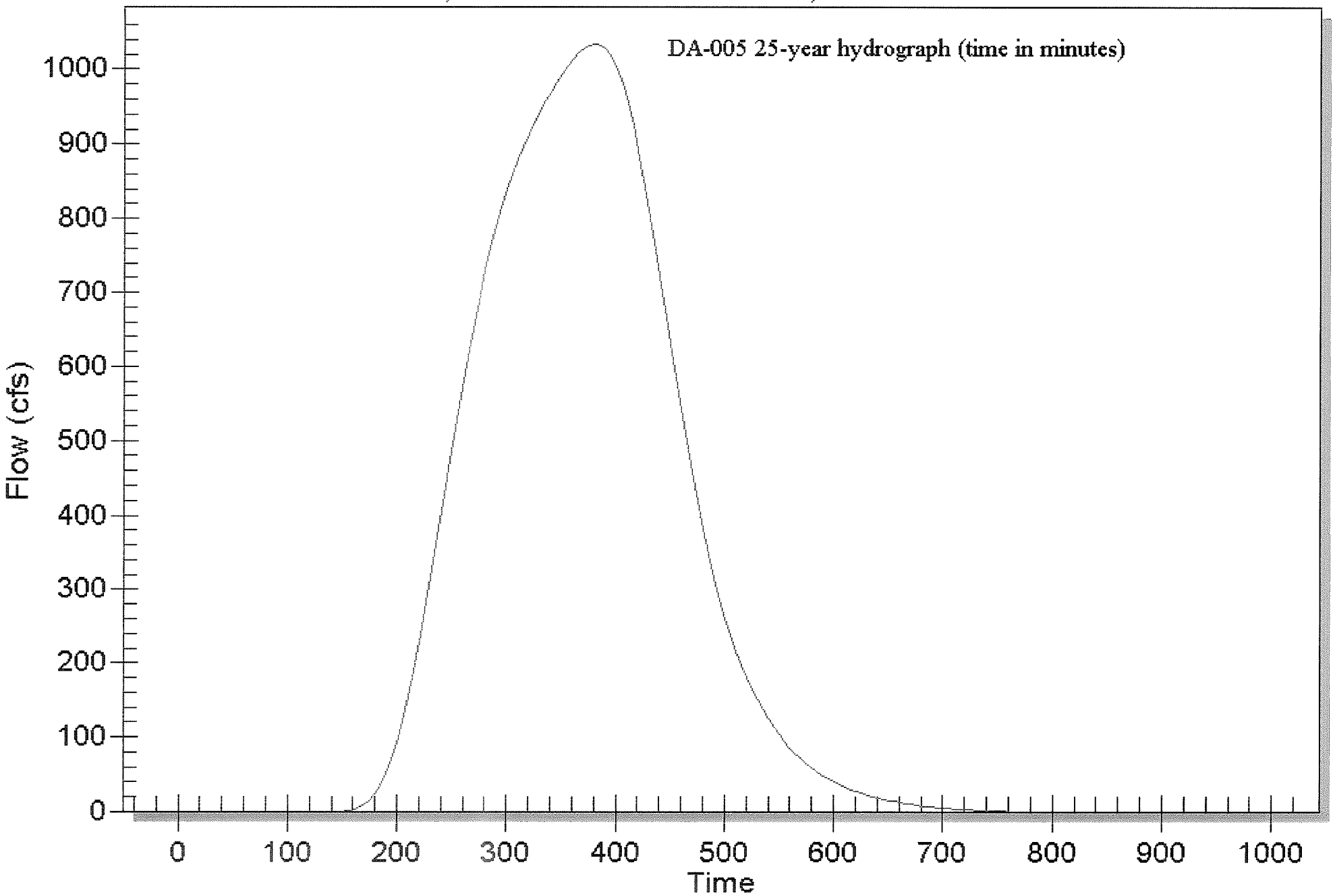
PEAK: 486.54; TIME OF PEAK: 390min.; VOLUME: 5396739.90



Index 1,6B,P:486.54,T:390,V:5396739.9

Flow vs. Time

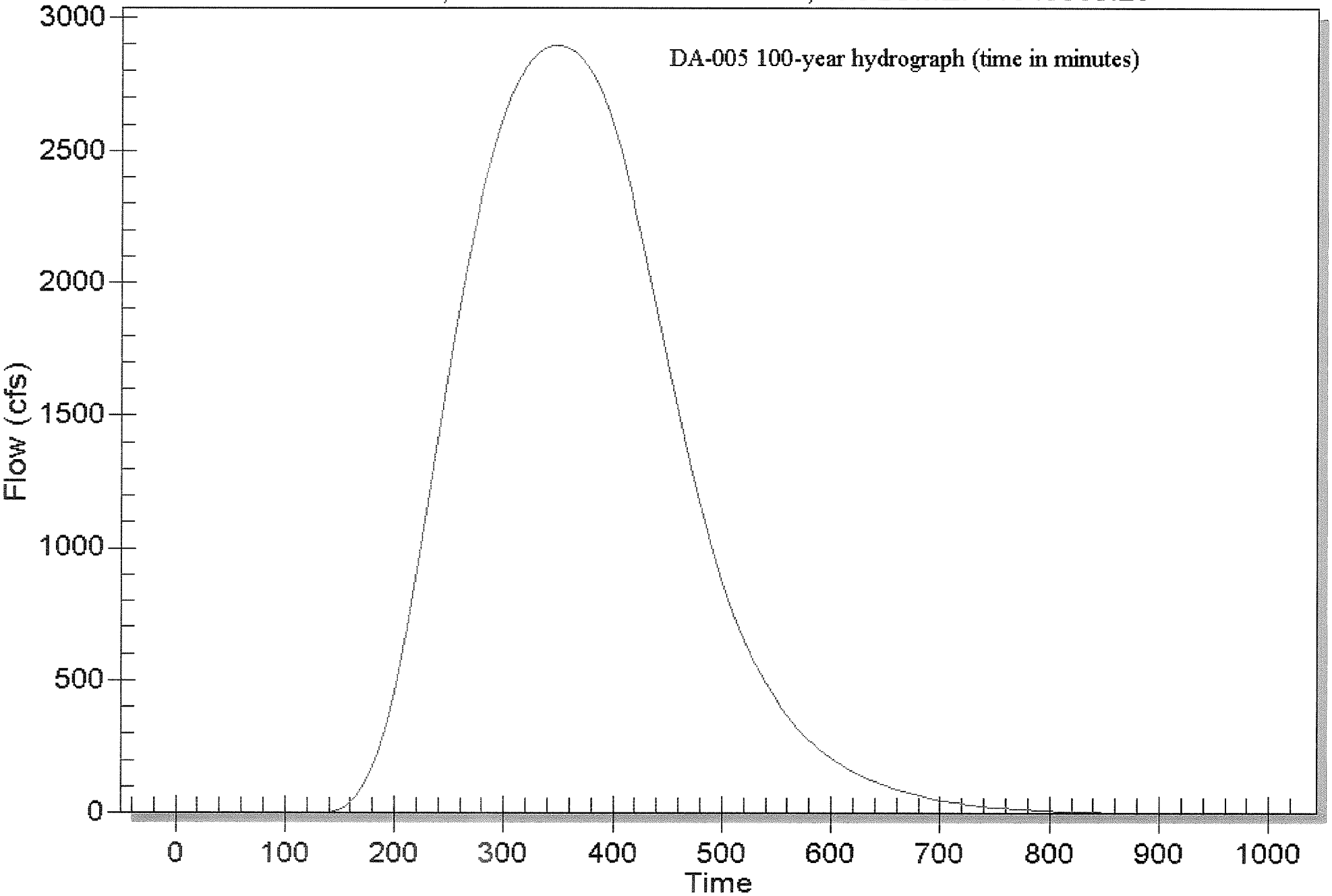
PEAK: 1034.38; TIME OF PEAK: 380min.; VOLUME: 13445586.90



Index 1,6B,P:1034.38,T:380,V:13445586.9

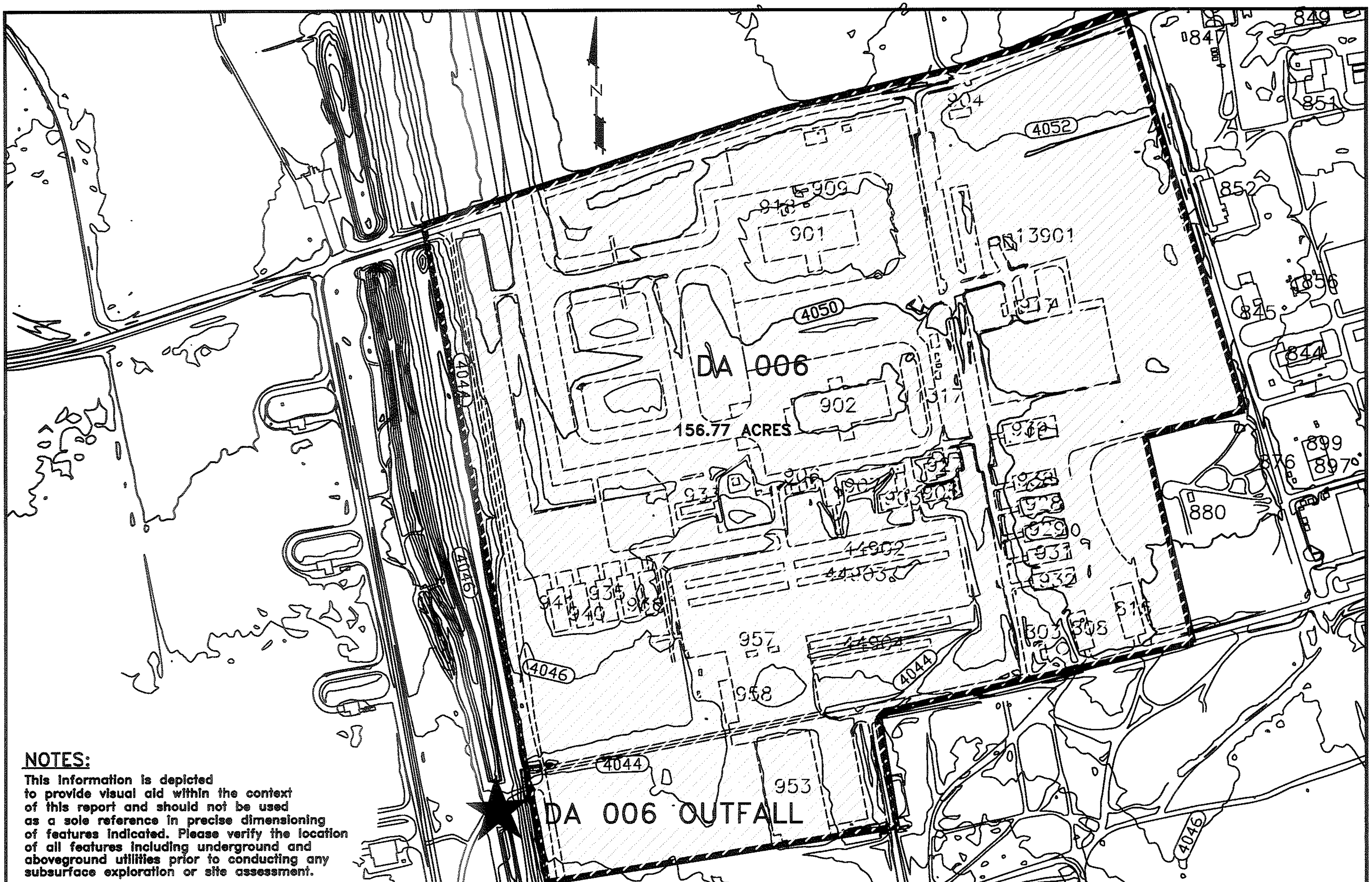
Flow vs. Time

PEAK: 2894.60; TIME OF PEAK: 350min.; VOLUME: 41045905.20



Index 1,6B,P:2894.60,T:350,V:41045905.2

Drainage Area 006



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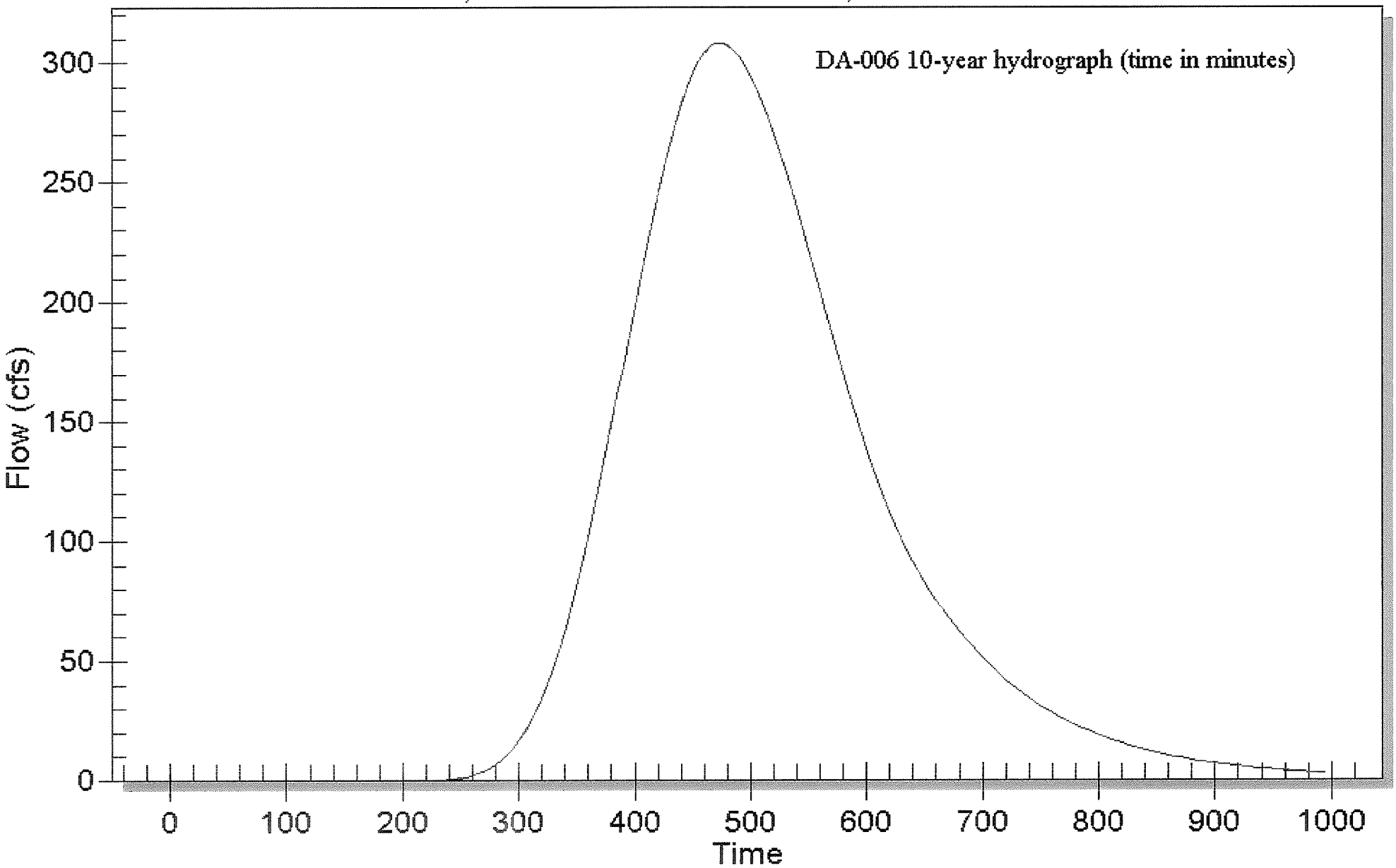
STORMWATER MODELING REPORT
HOLLOMAN AIR FORCE BASE
ALAMOGORDO, NEW MEXICO

PROJECT NO.	SCALE	DATE	DRAWN BY:	DRAWING NO:
9030232	1"=500'	12/07/05	SKN	DA006

DRAINAGE AREA DA006
AREA DELINEATION

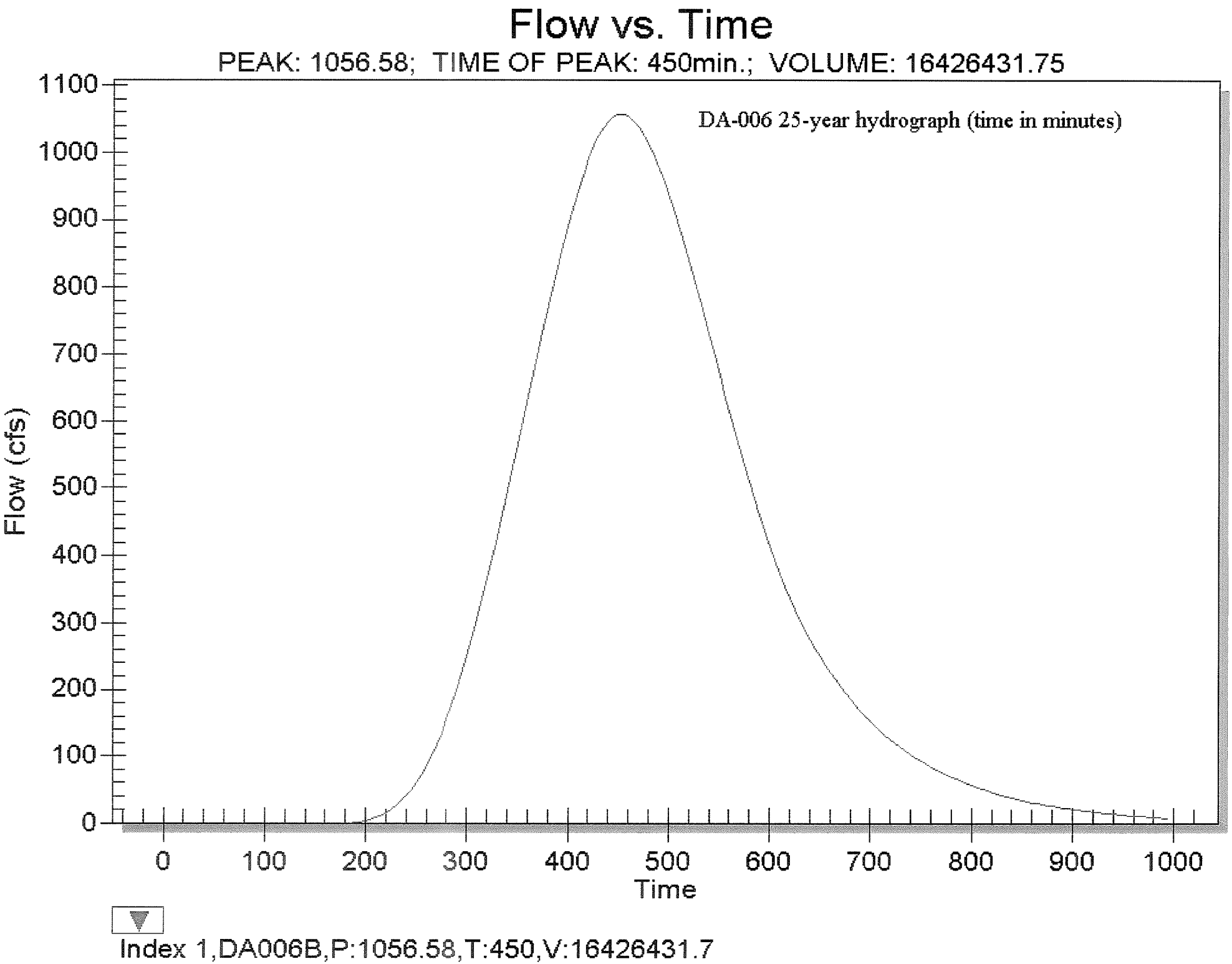
Flow vs. Time

PEAK: 307.95; TIME OF PEAK: 475min.; VOLUME: 4365757.65



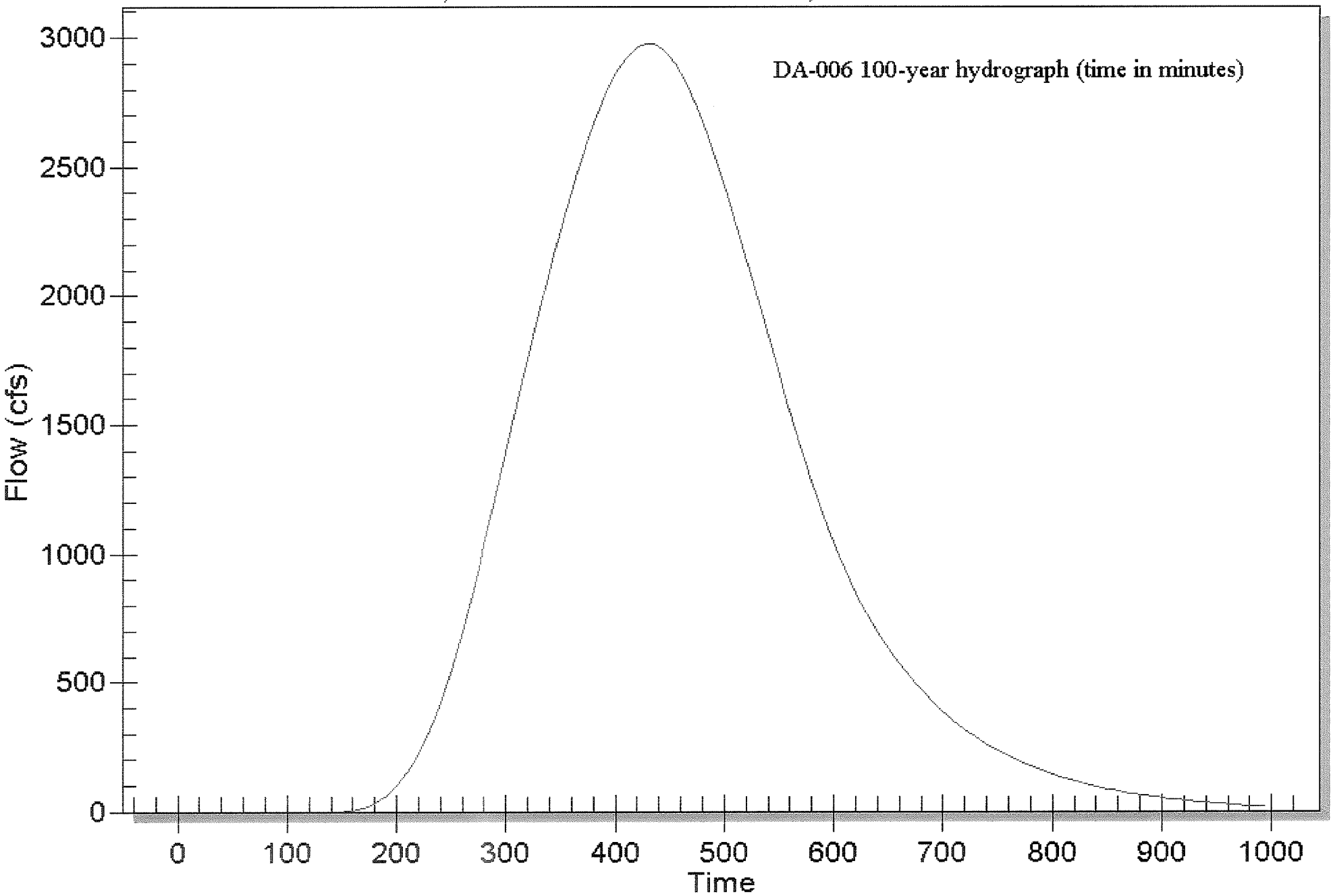
Index 1,DA006B,P:307.95,T:475,V:4365757.7

Index 1,DA006B,P:307.95,T:475,V:4365757.7


Flow vs. Time
PEAK: 1056.58; TIME OF PEAK: 450min.; VOLUME: 16426431.75
DA-006 25-year hydrograph (time in minutes)
Flow (cfs)
1100
1000
900
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
900
1000
Time
Index 1,DA006B,P:1056.58,T:450,V:16426431.7

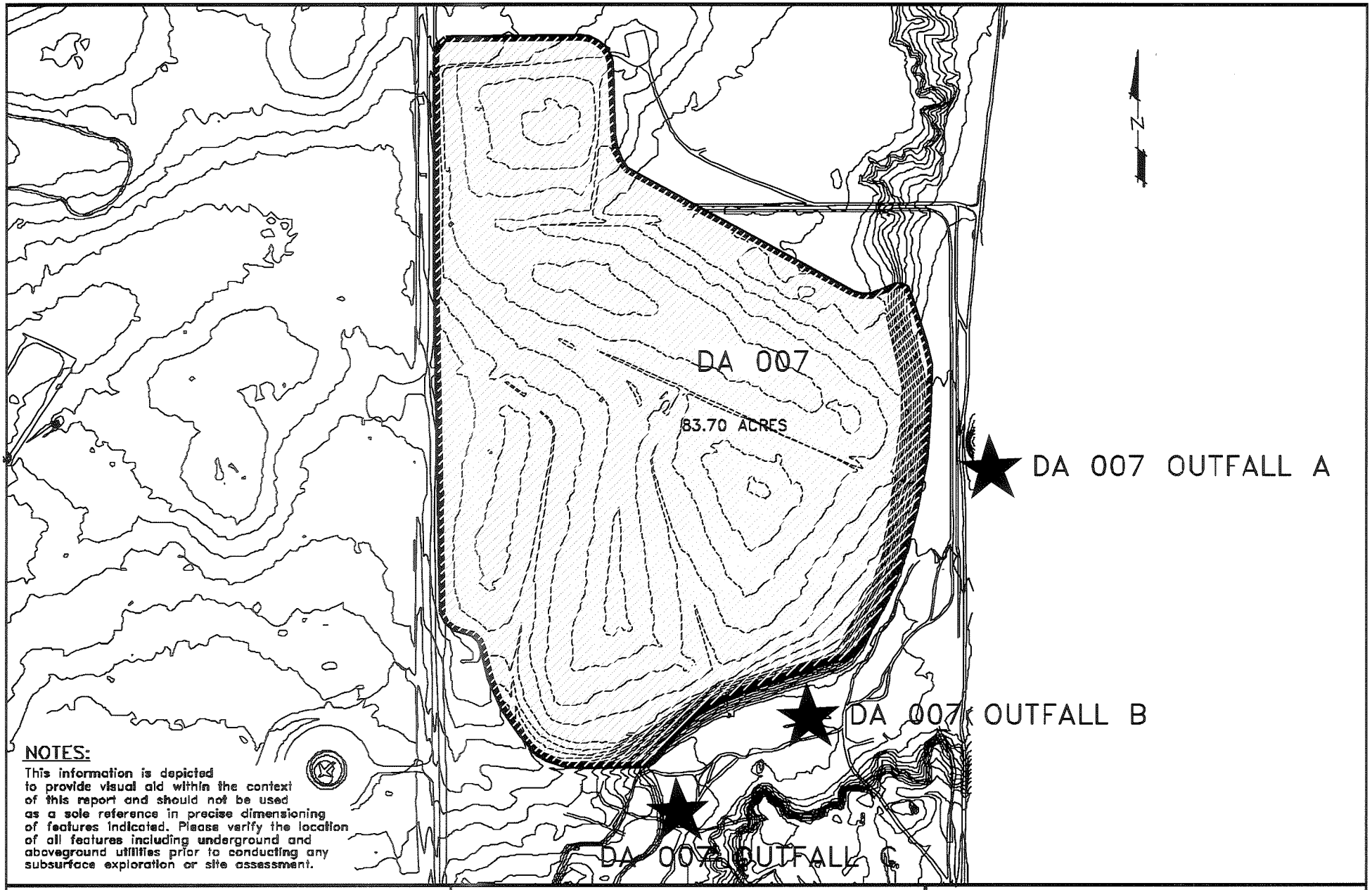
Flow vs. Time

PEAK: 2973.69; TIME OF PEAK: 430min.; VOLUME: 50457952.50



Index 1,DA006B,P:2973.69,T:430,V:50457952.5

Drainage Area 007



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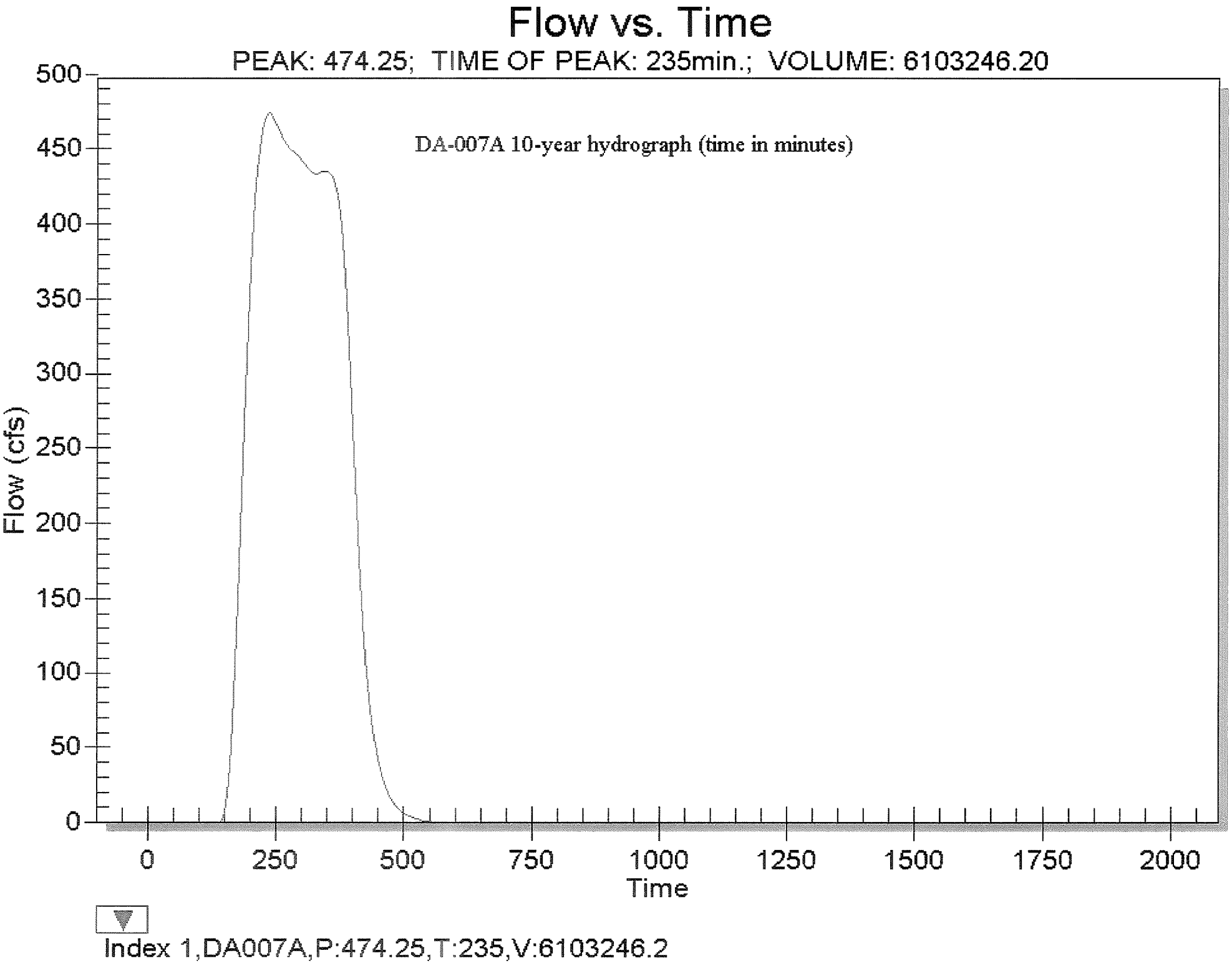
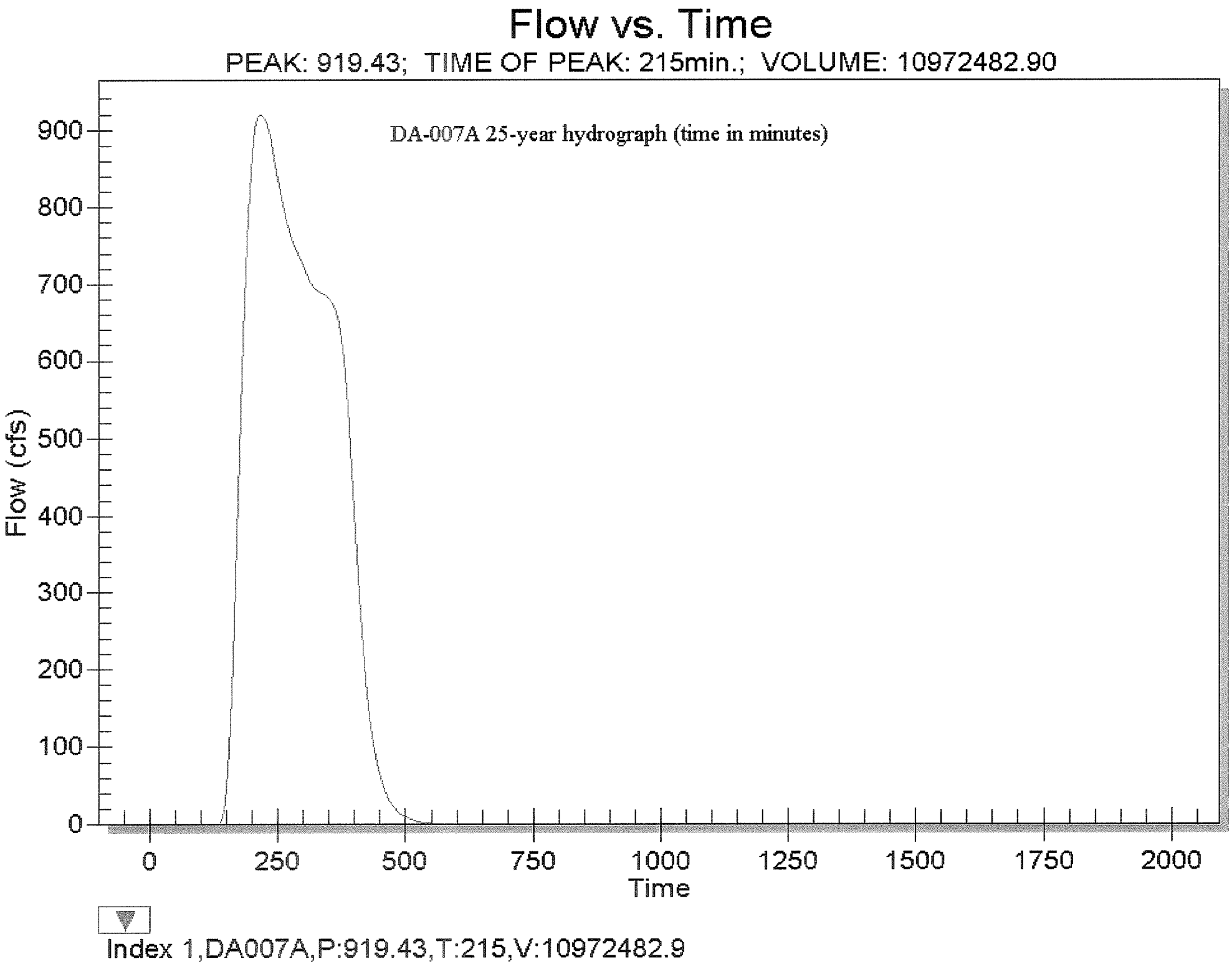
STORMWATER MODELING REPORT
HOLLOMAN AIR FORCE BASE
ALAMOGORDO, NEW MEXICO

PROJECT NO.	SCALE	DATE	DRAWN BY: SKN
9030232	1"=500'	12/07/05	DRAWING NO: DA007

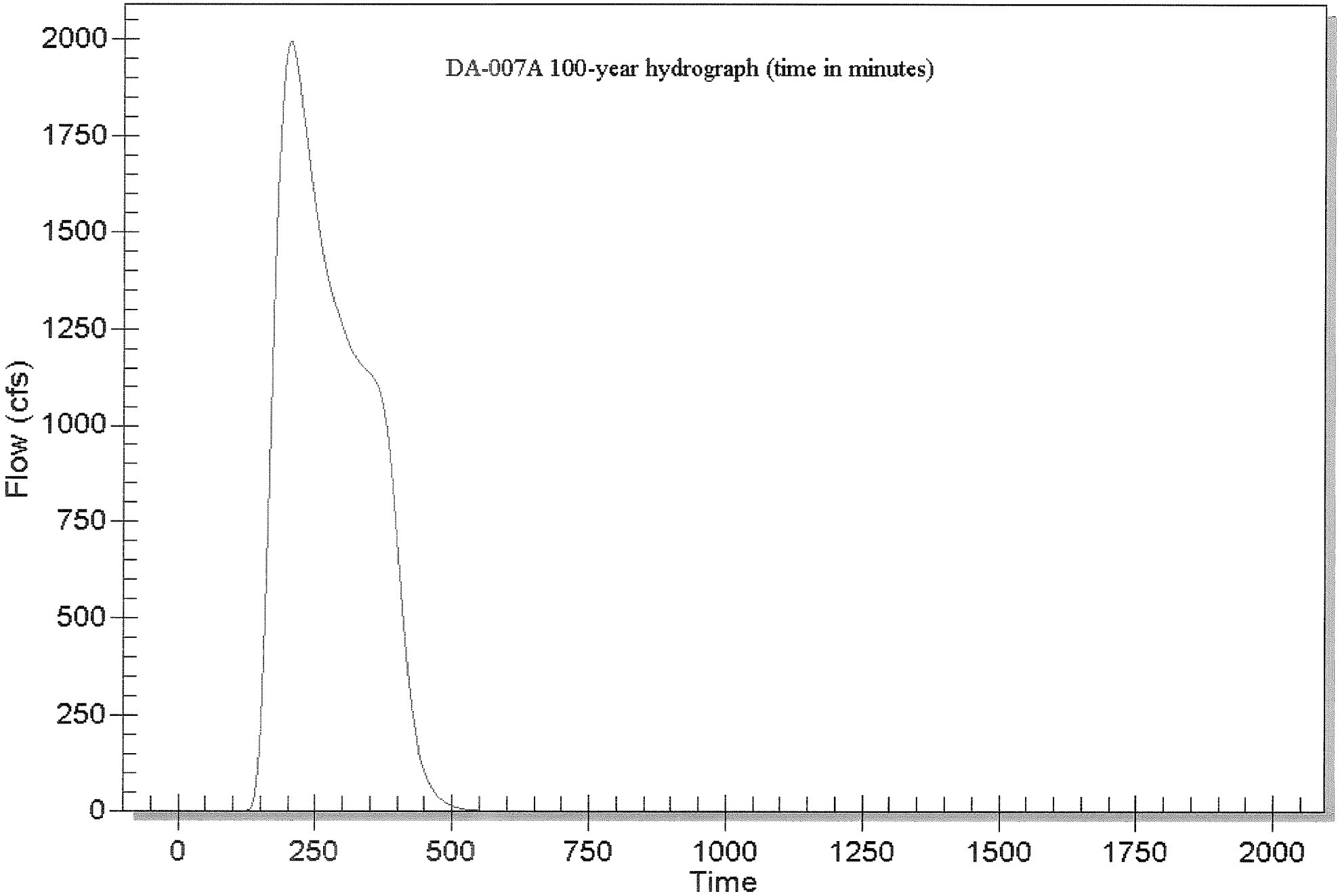
DRAINAGE AREA DA007
AREA DELINEATION


Flow vs. Time
PEAK: 474.25; TIME OF PEAK: 235min.; VOLUME: 6103246.20
DA-007A 10-year hydrograph (time in minutes)
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0
250
500
750
1000
1250
1500
1750
2000
Time
Index 1,DA007A,P:474.25,T:235,V:6103246.2


Flow vs. Time
PEAK: 919.43; TIME OF PEAK: 215min.; VOLUME: 10972482.90
DA-007A 25-year hydrograph (time in minutes)
Flow (cfs)
900
800
700
600
500
400
300
200
100
0
0
250
500
750
1000
1250
1500
1750
2000
Time
Index 1,DA007A,P:919.43,T:215,V:10972482.9

Flow vs. Time

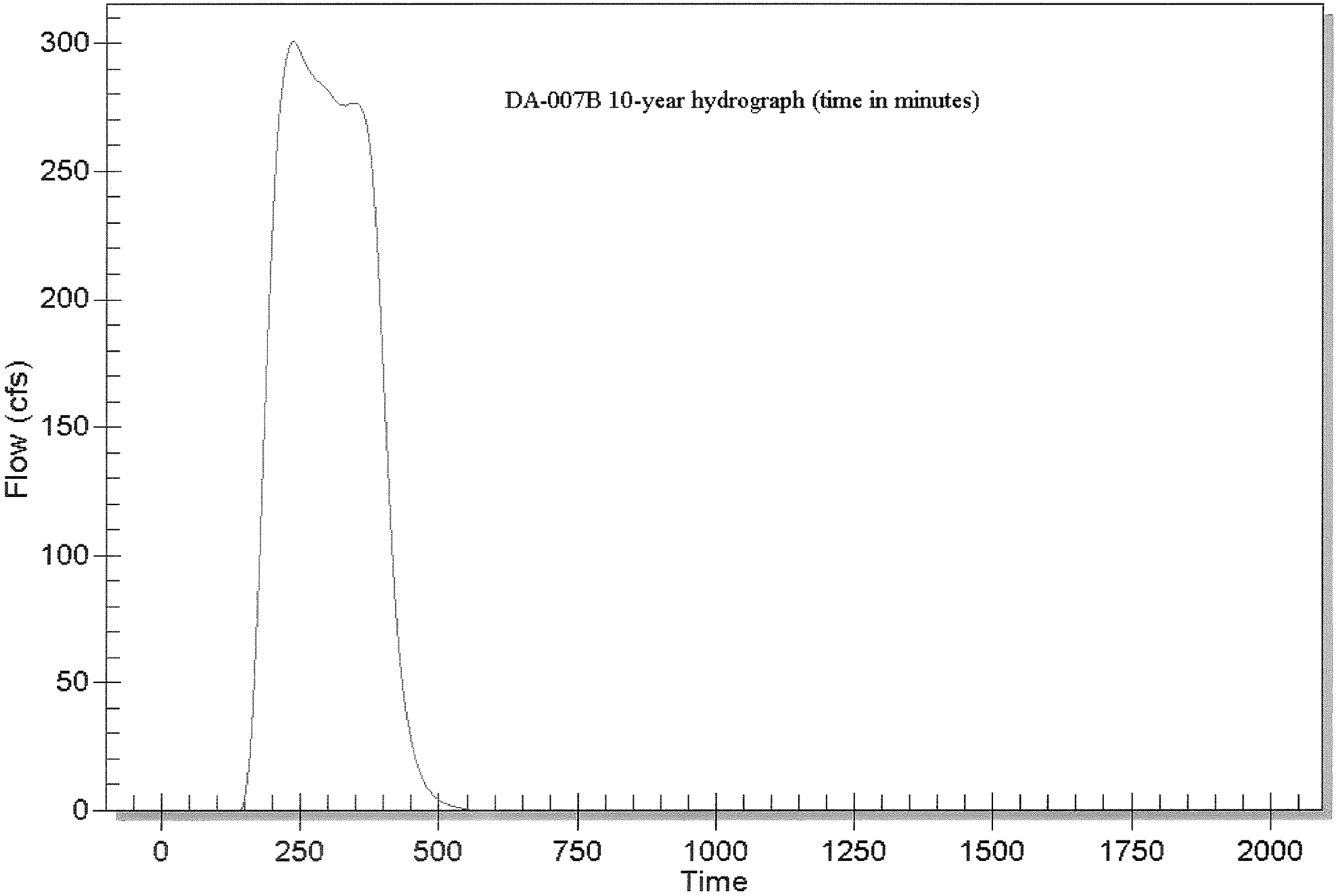
PEAK: 1992.82; TIME OF PEAK: 205min.; VOLUME: 21085083.00



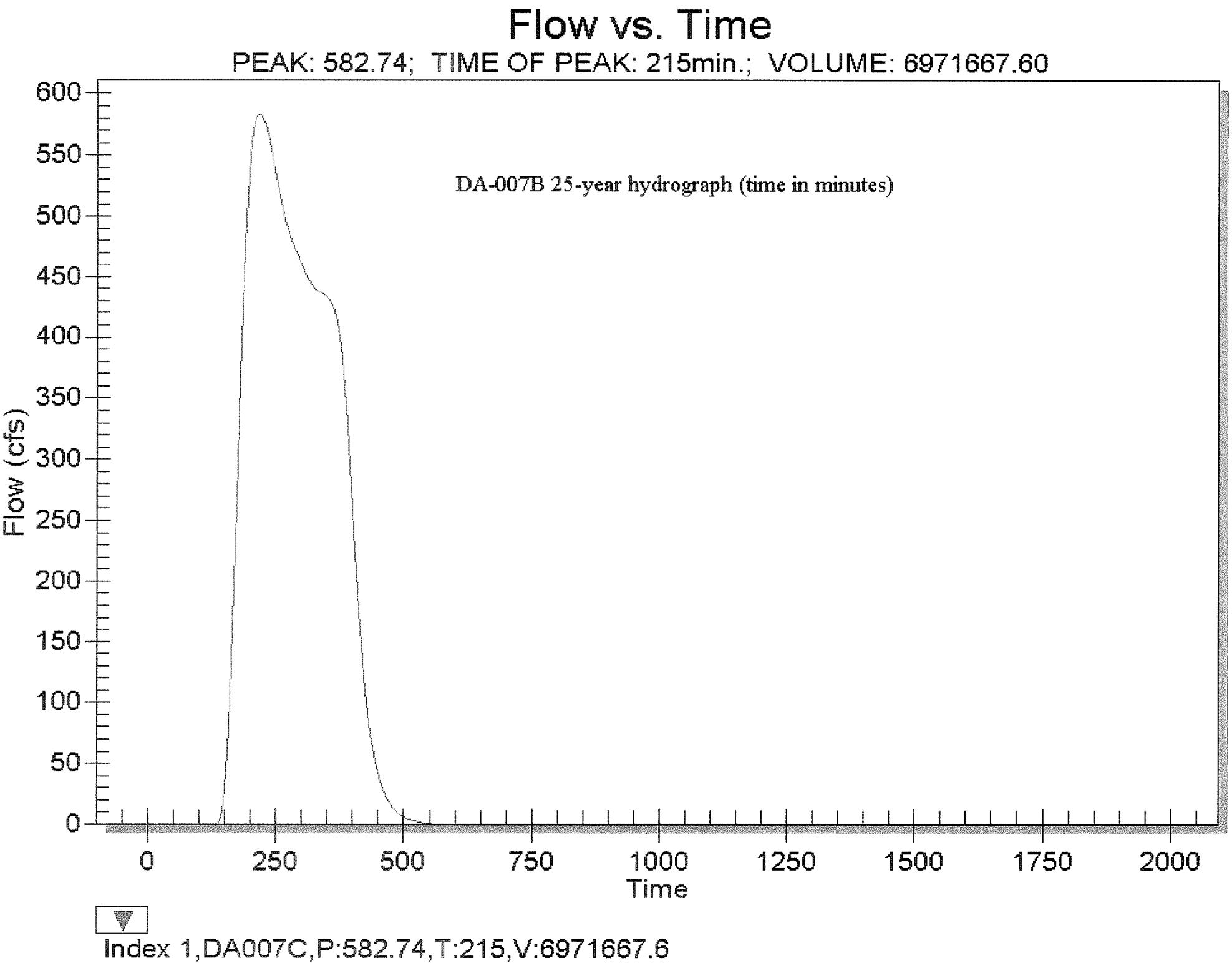
Index 1,DA007A,P:1992.82,T:205,V:21085083.0

Flow vs. Time

PEAK: 300.72; TIME OF PEAK: 235min.; VOLUME: 3877864.80

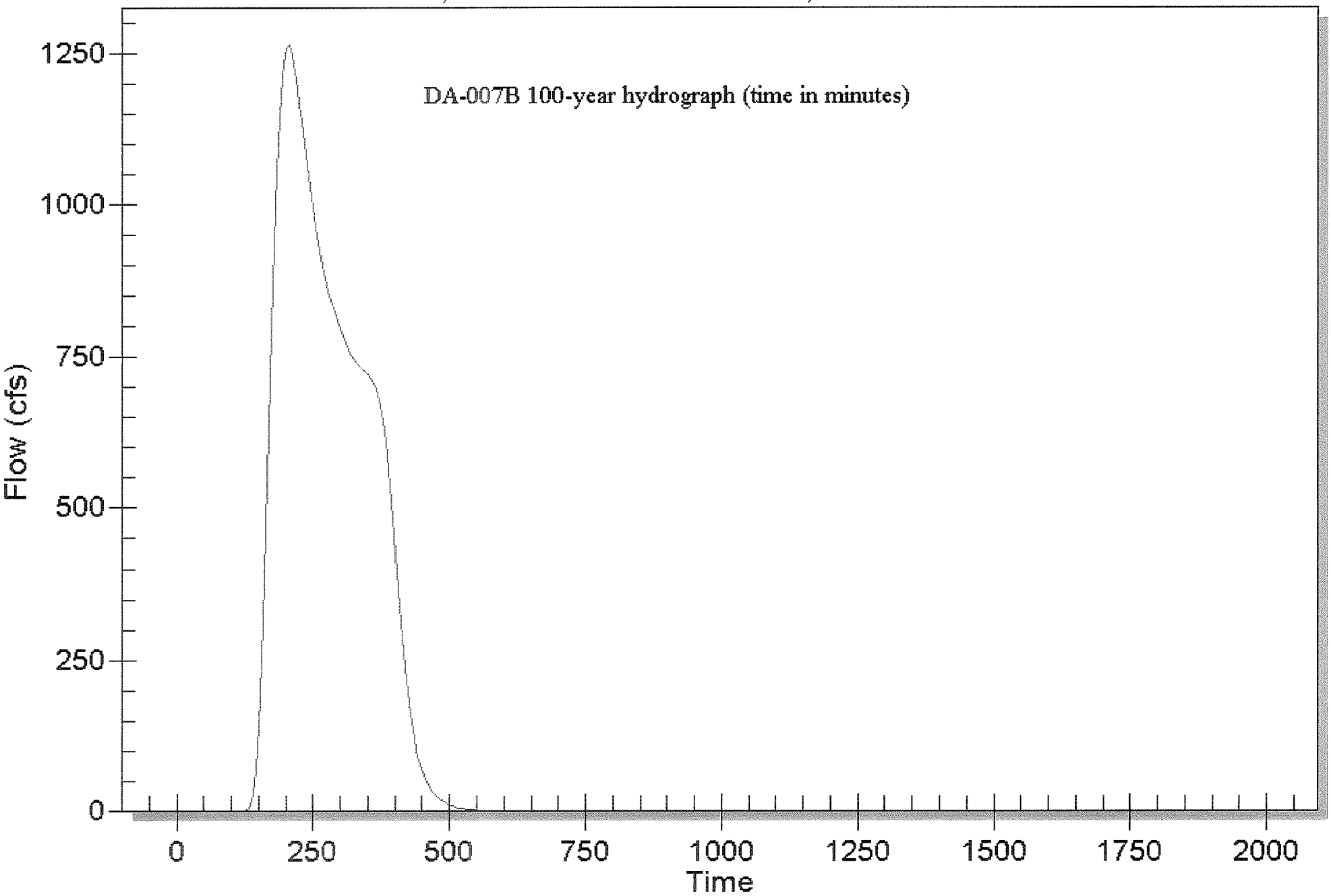


Index 1,7C,P:300.72,T:235,V:3877864.8

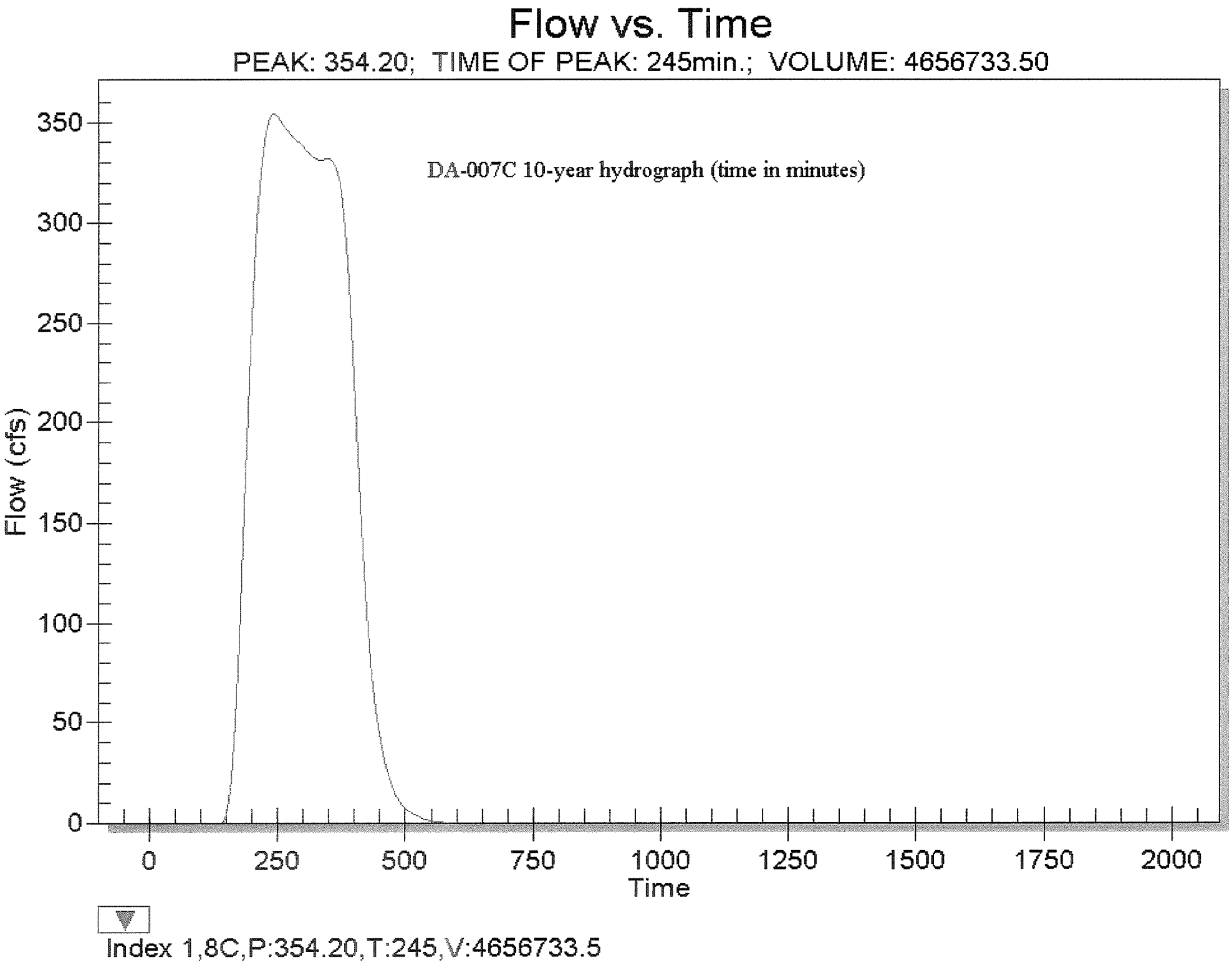

Flow vs. Time
PEAK: 582.74; TIME OF PEAK: 215min.; VOLUME: 6971667.60
DA-007B 25-year hydrograph (time in minutes)
Flow (cfs)
600
550
500
450
400
350
300
250
200
150
100
50
0
0
250
500
750
1000
1250
1500
1750
2000
Time
Index 1,DA007C,P:582.74,T:215,V:6971667.6

Flow vs. Time

PEAK: 1262.90; TIME OF PEAK: 205min.; VOLUME: 13396986.00

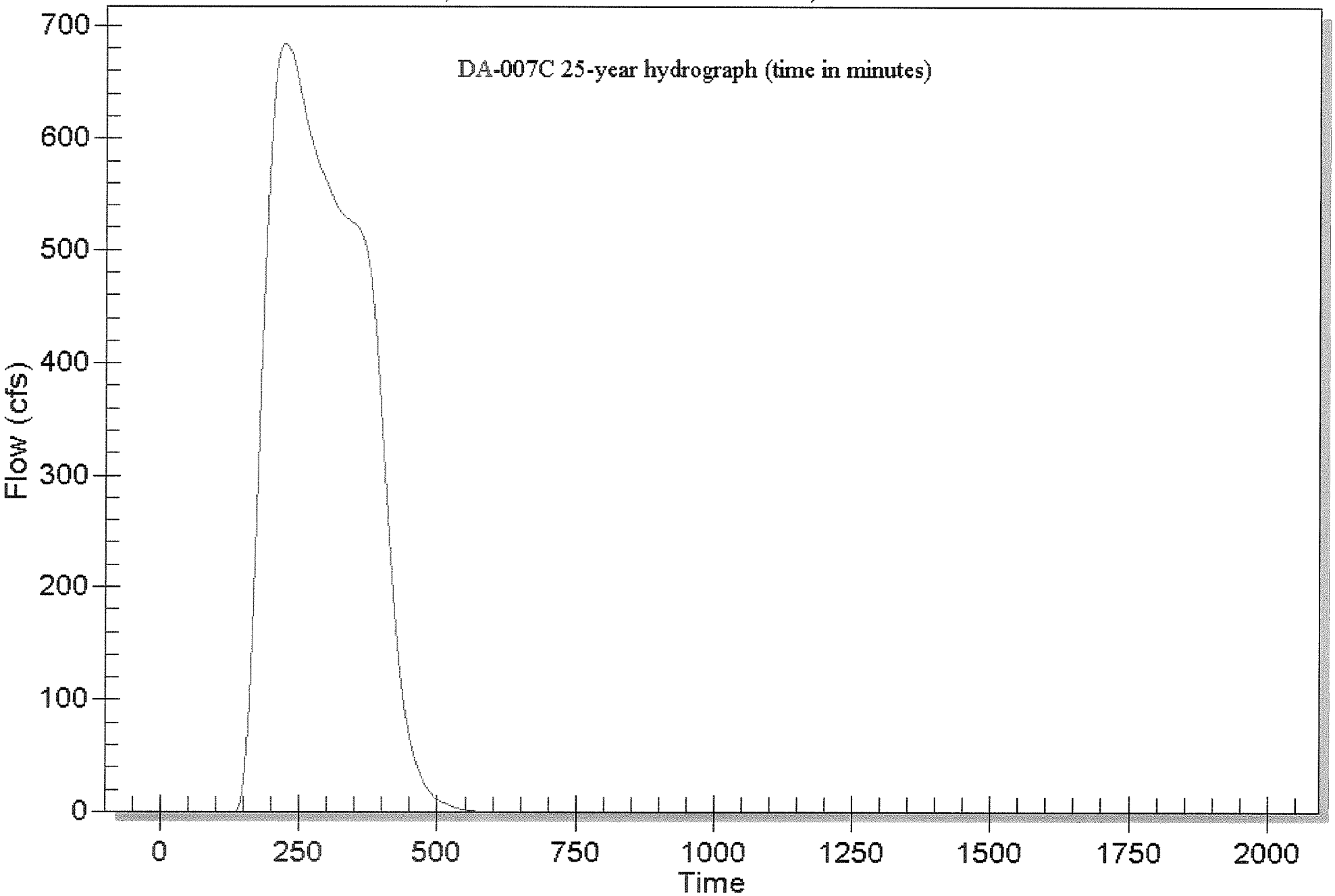


Index 1,DA007C,P:1262.90,T:205,V:13396986.0


Flow vs. Time
PEAK: 354.20; TIME OF PEAK: 245min.; VOLUME: 4656733.50
DA-007C 10-year hydrograph (time in minutes)
Flow (cfs)
350
300
250
200
150
100
50
0
0
250
500
750
1000
1250
1500
1750
2000
Time
Index 1,8C,P:354.20,T:245,V:4656733.5

Flow vs. Time

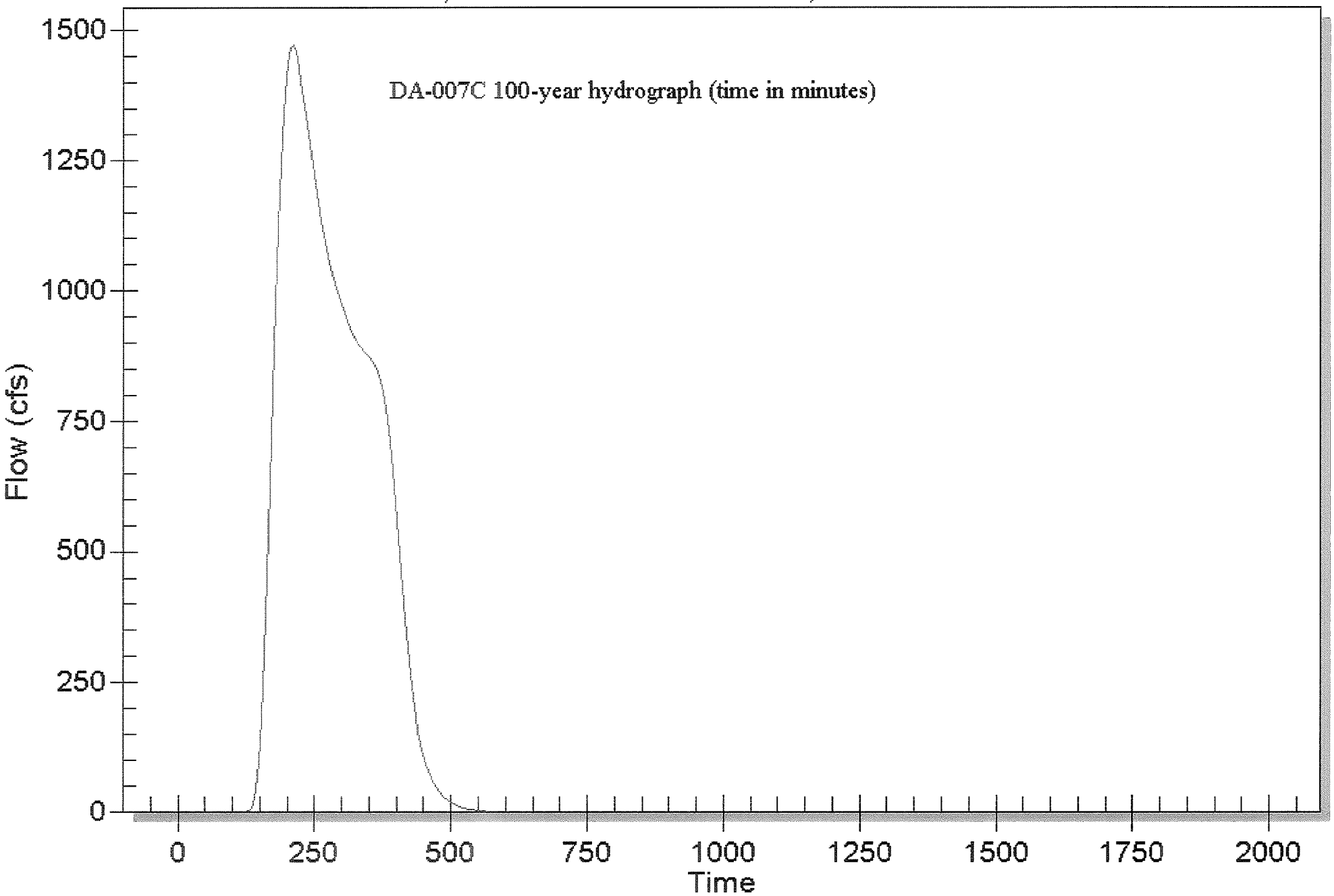
PEAK: 683.88; TIME OF PEAK: 225min.; VOLUME: 8371929.60



Index 1,DA007D,P:683.88,T:225,V:8371929.6

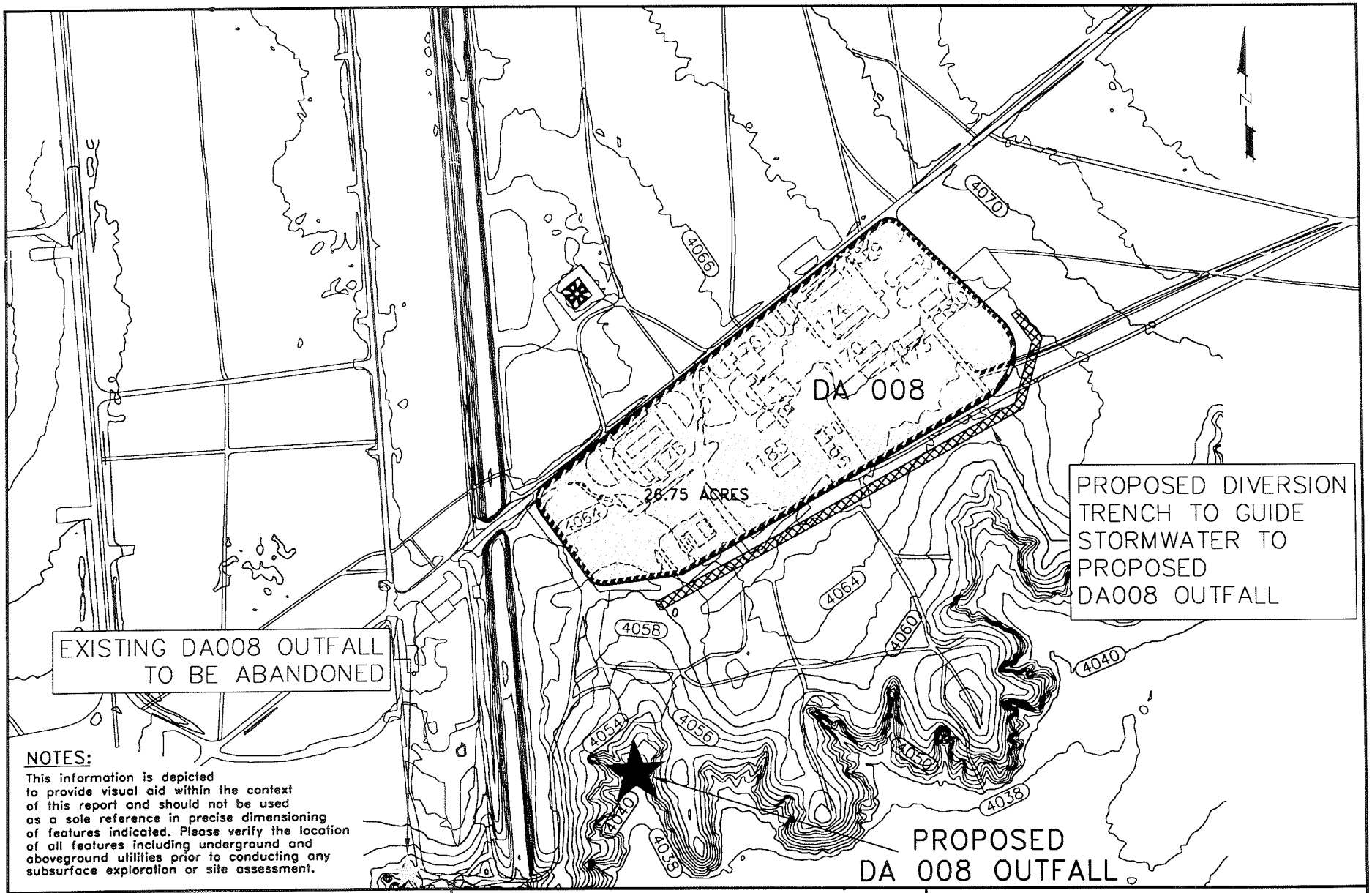
Flow vs. Time

PEAK: 1470.80; TIME OF PEAK: 210min.; VOLUME: 16087774.50



Index 1,DA007D,P:1470.80,T:210,V:16087774.5

Drainage Area 008



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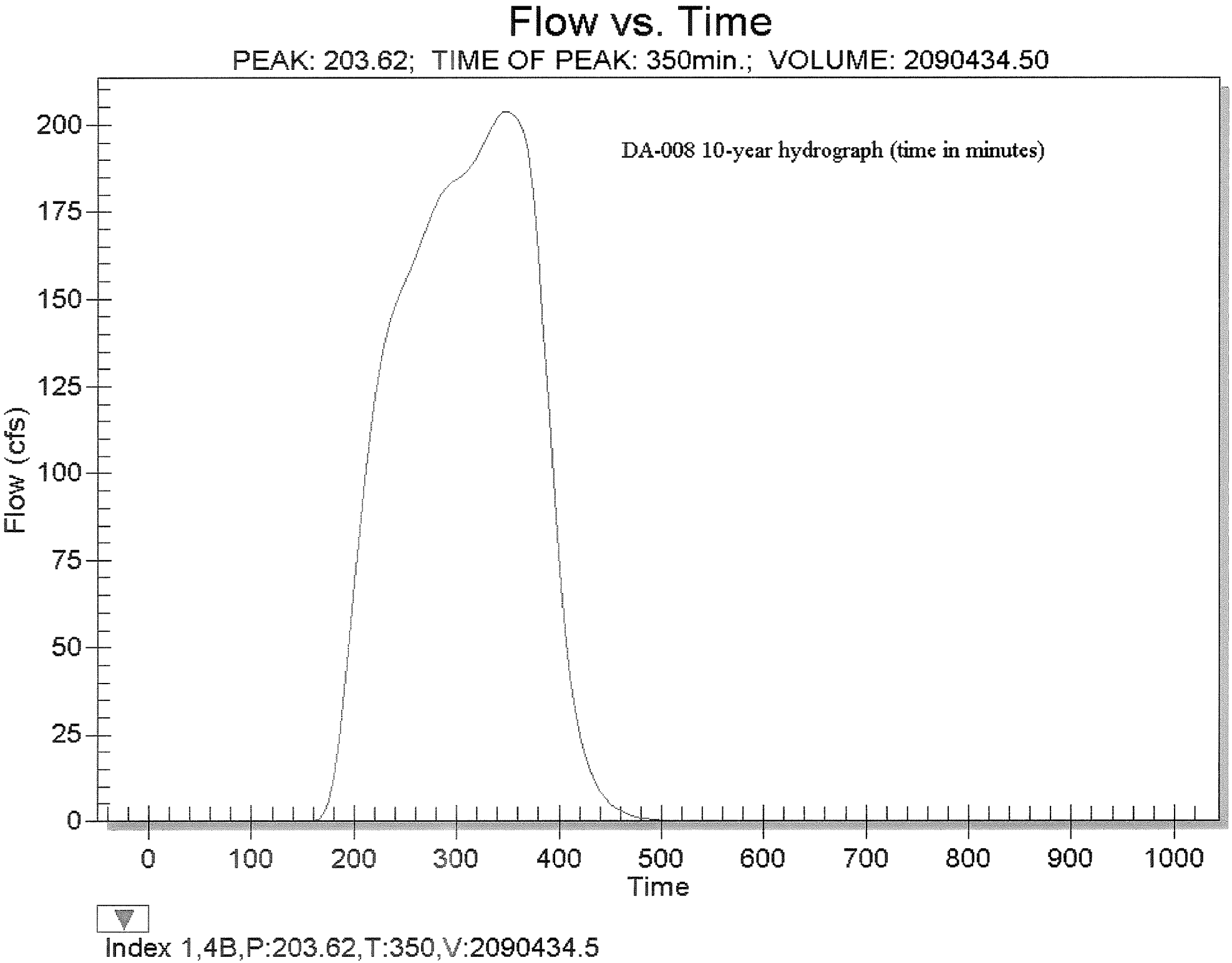
STORMWATER MODELING REPORT
HOLLOMAN AIR FORCE BASE
ALAMOGORDO, NEW MEXICO

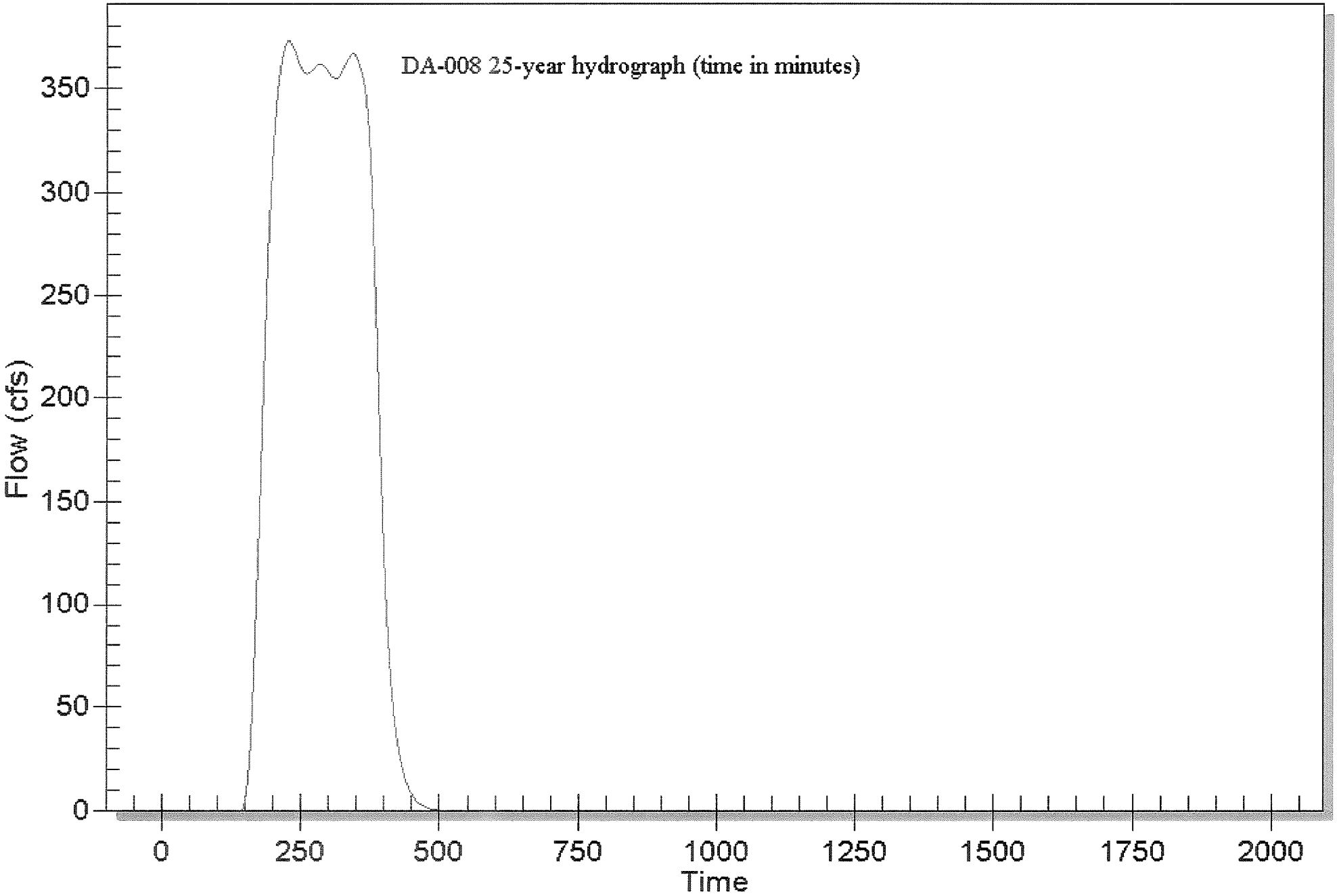
PROJECT NO.	SCALE	DATE	DRAWN BY:
9030232	1"=500'	12/07/05	SKN
			DRAWING NO: DA008

DRAINAGE AREA DA008
AREA DELINEATION

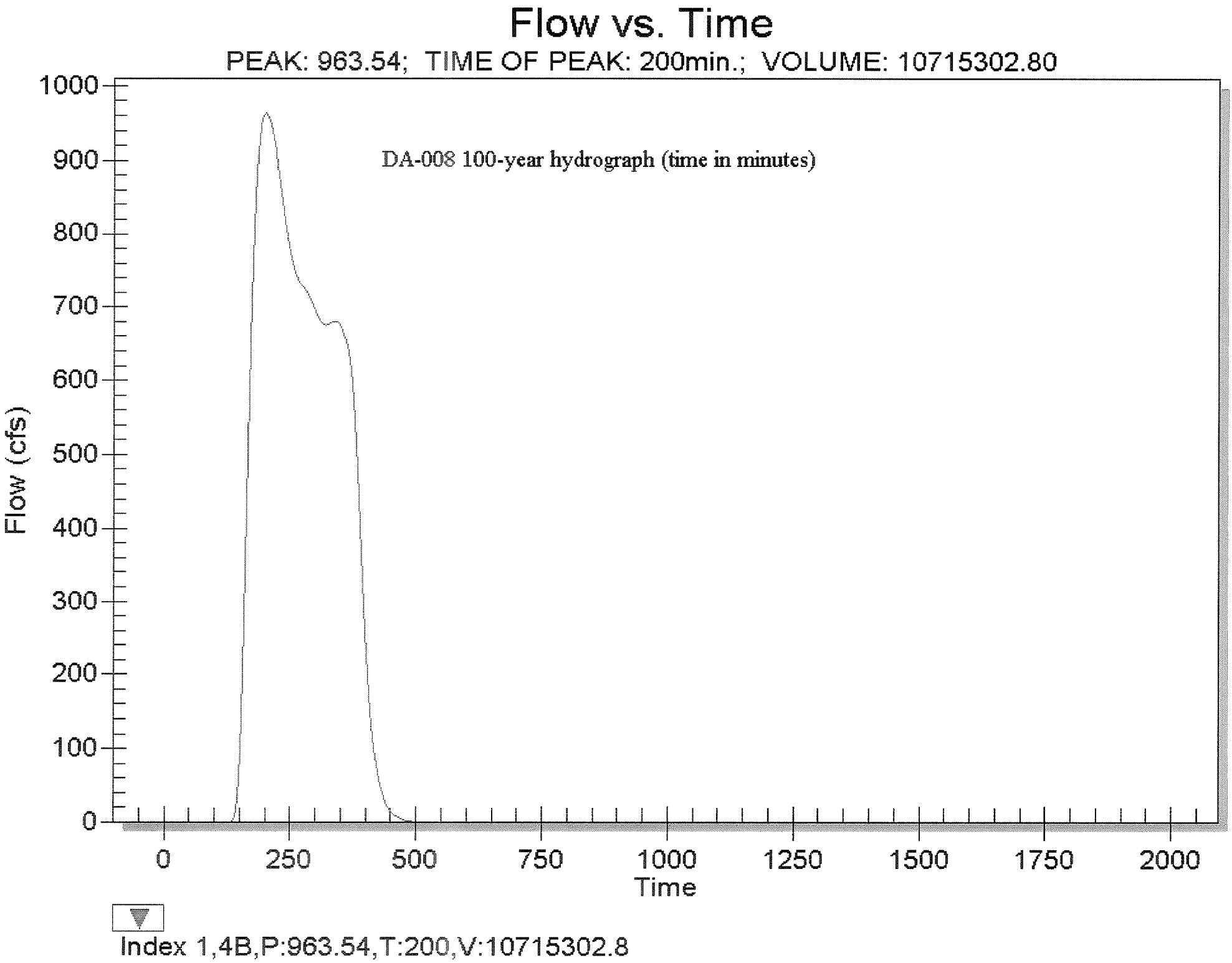

Flow vs. Time
PEAK: 203.62; TIME OF PEAK: 350min.; VOLUME: 2090434.50
DA-008 10-year hydrograph (time in minutes)
Flow (cfs)
0
25
50
75
100
125
150
175
200
0
100
200
300
400
500
600
700
800
900
1000
Time
Index 1,4B,P:203.62,T:350,V:2090434.5

Flow vs. Time

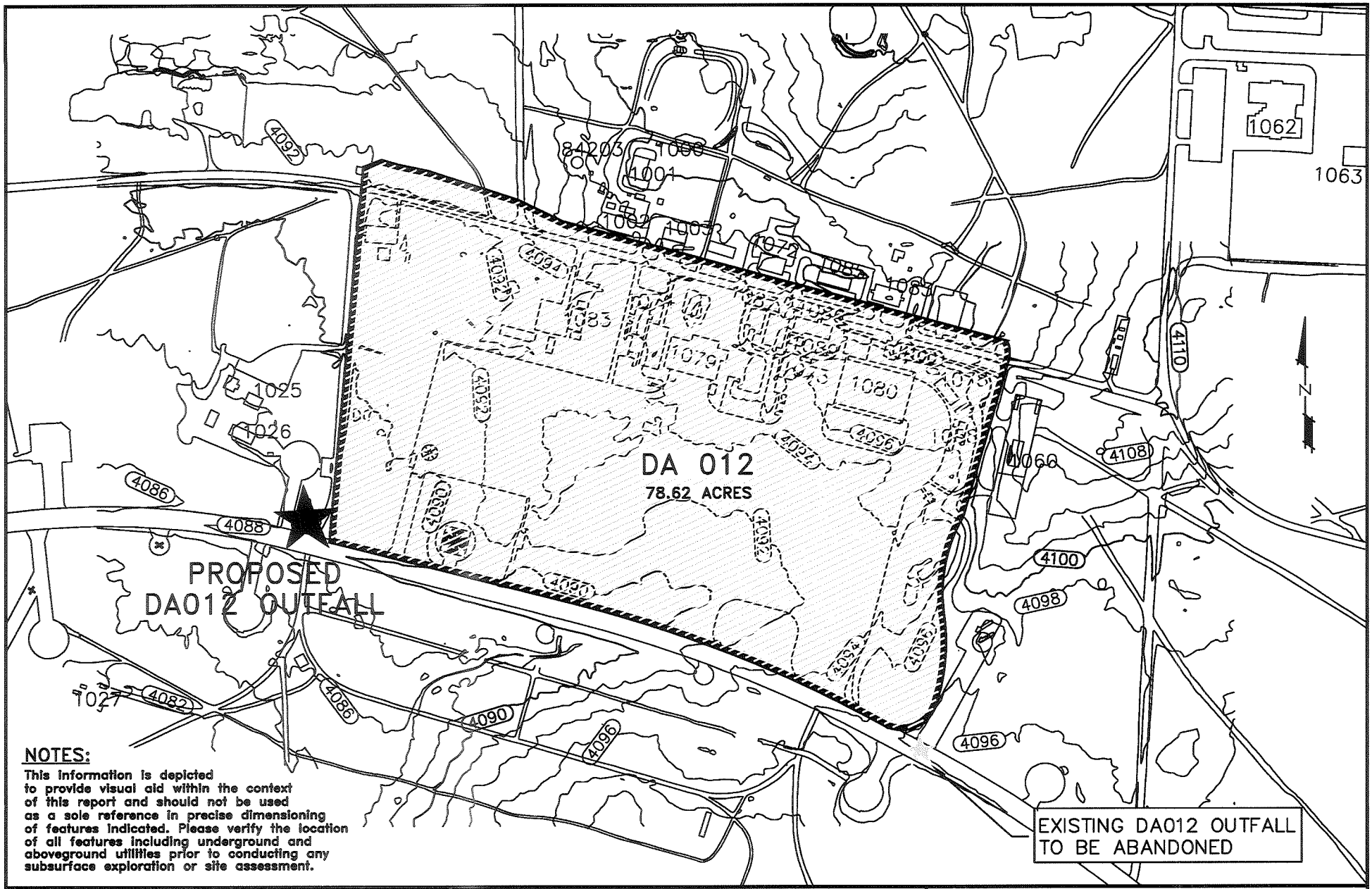
PEAK: 372.96; TIME OF PEAK: 230min.; VOLUME: 4691743.20



Index 1,4B,P:372.96,T:230,V:4691743.2


Flow vs. Time
PEAK: 963.54; TIME OF PEAK: 200min.; VOLUME: 10715302.80
DA-008 100-year hydrograph (time in minutes)
Flow (cfs)
1000
900
800
700
600
500
400
300
200
100
0
0
250
500
750
1000
1250
1500
1750
2000
Time
Index 1,4B,P:963.54,T:200,V:10715302.8

Drainage Area 012



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ENGINEERING, SCIENCE AND CONSTRUCTION

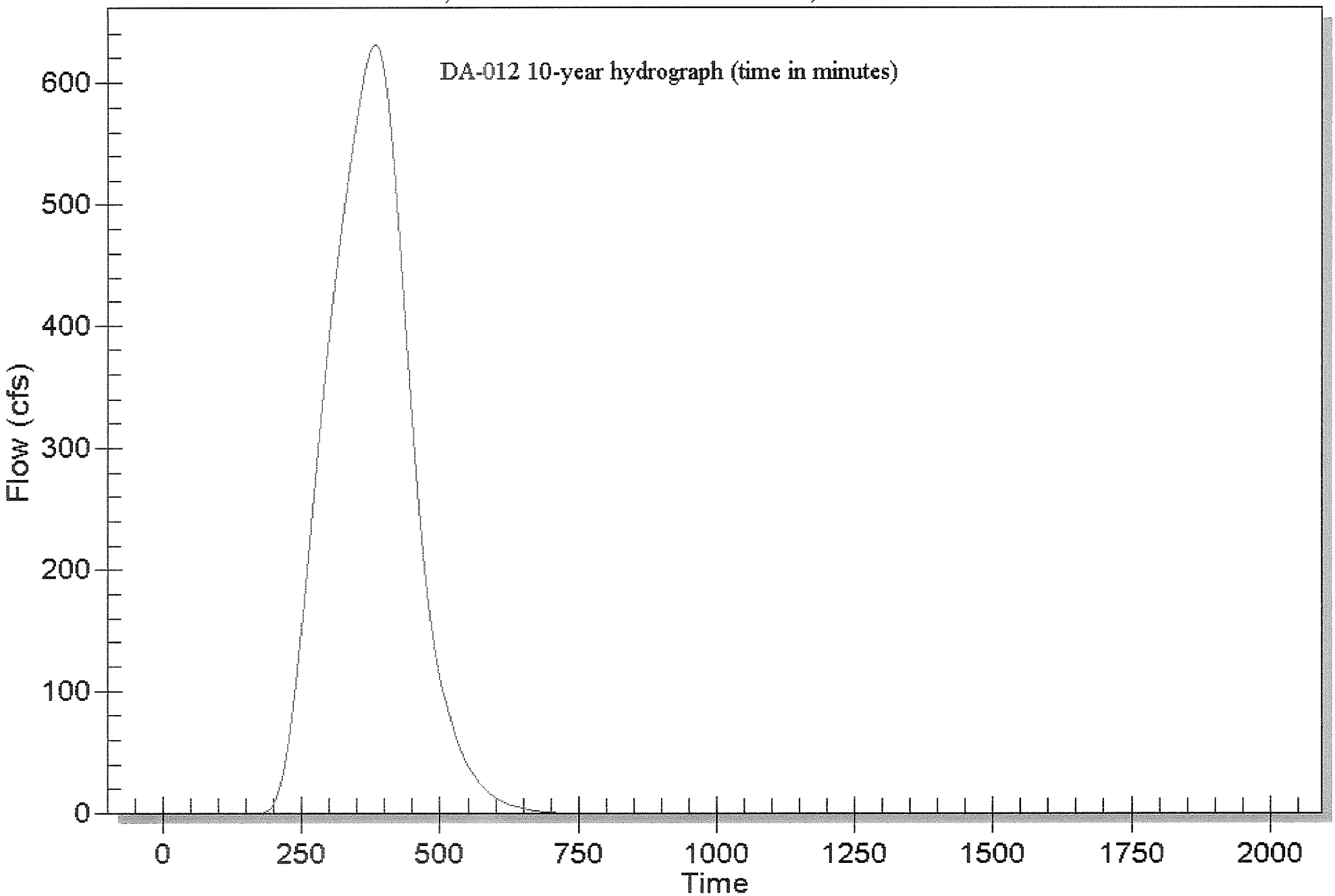
STORMWATER MODELING REPORT
HOLLOMAN AIR FORCE BASE
ALAMOGORDO, NEW MEXICO

PROJECT NO.	SCALE	DATE	DRAWN BY: SKN
9030232	1"=500'	12/07/05	DRAWING NO: DA012

DRAINAGE AREA DA012
AREA DELINEATION

Flow vs. Time

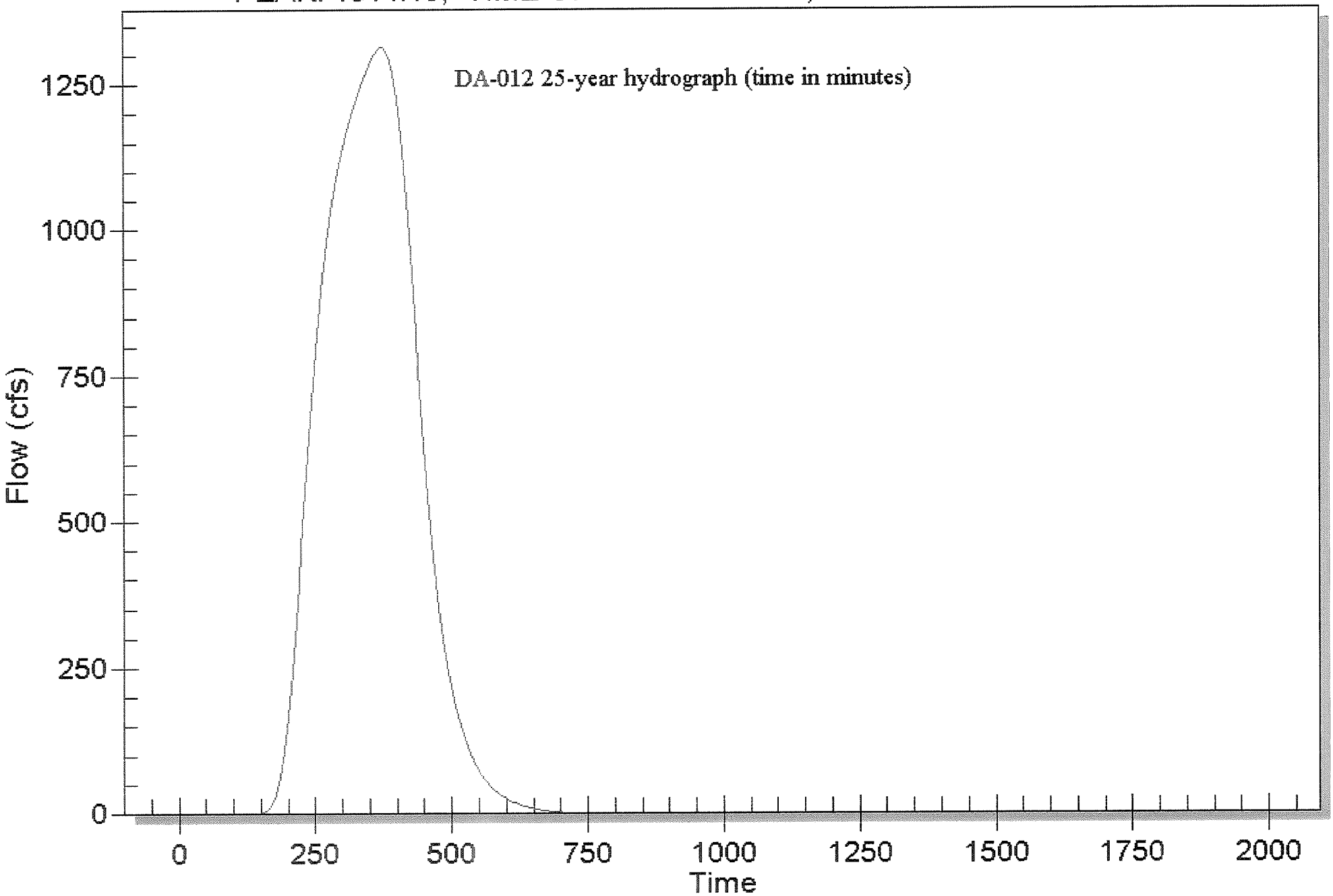
PEAK: 630.86; TIME OF PEAK: 385min.; VOLUME: 6663330.90



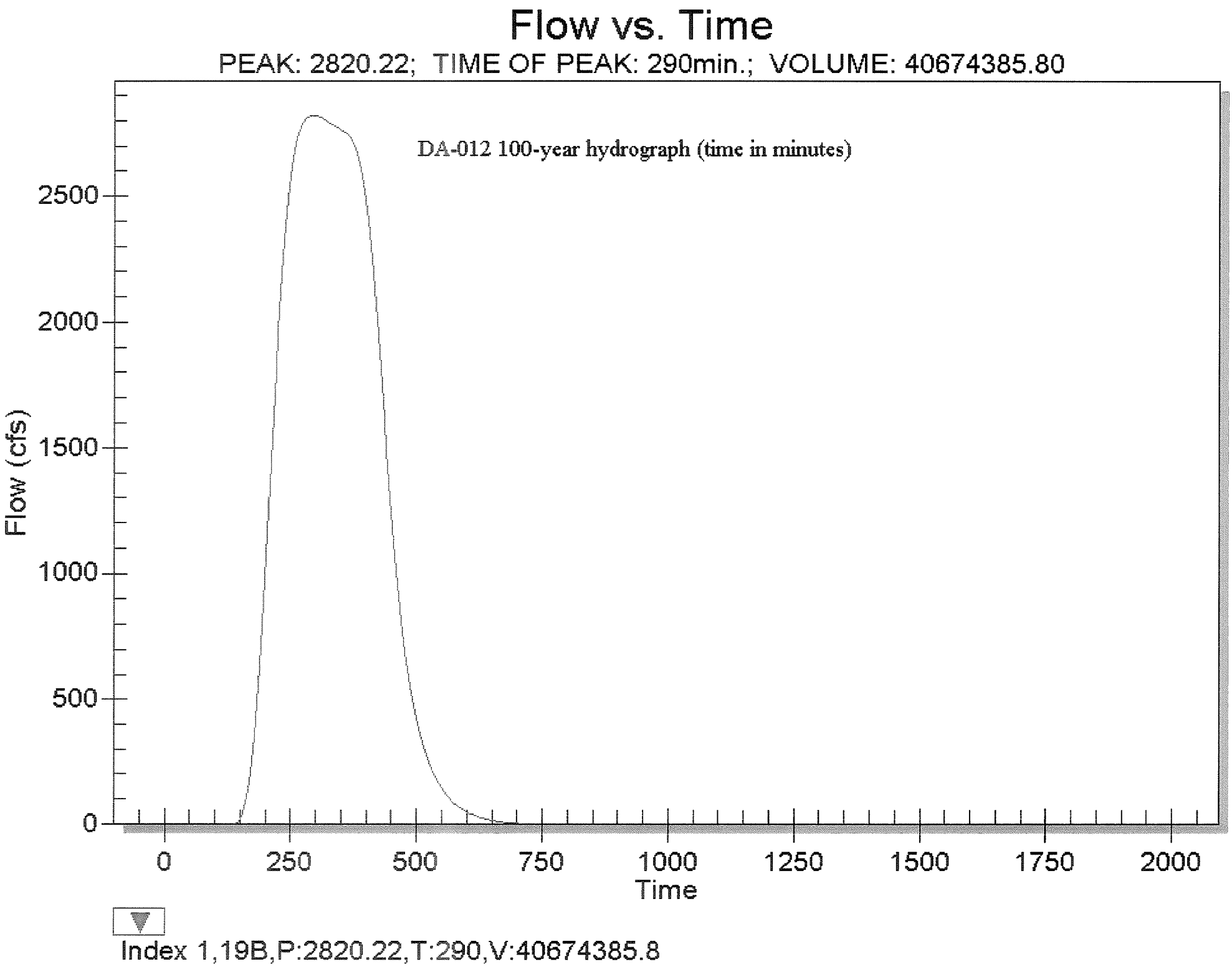
Index 1,19B,P:630.86,T:385,V:6663330.9

Flow vs. Time

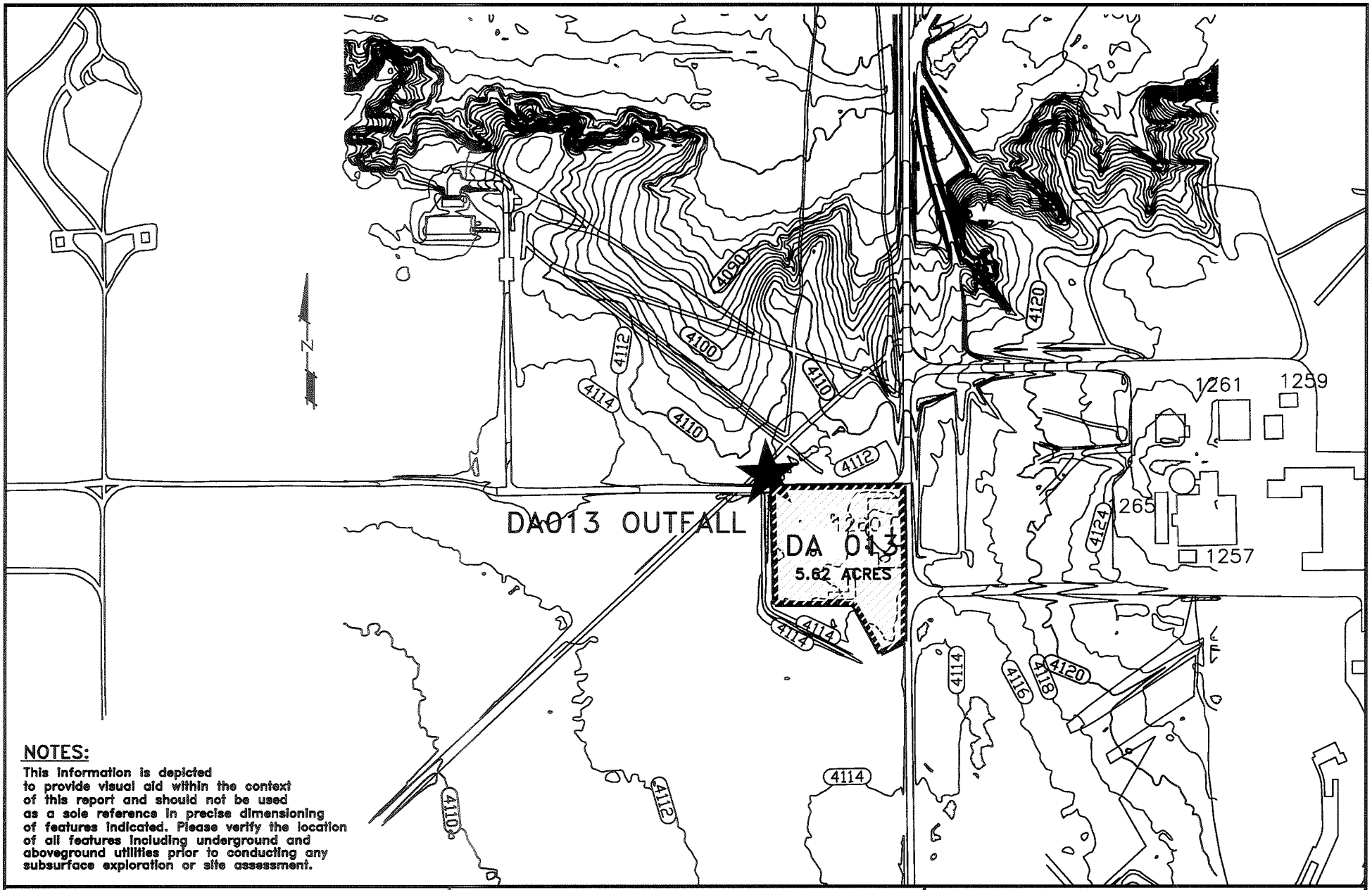
PEAK: 1314.19; TIME OF PEAK: 370min.; VOLUME: 16601195.10



Index 1,19B,P:1314.19,T:370,V:16601195.1


Flow vs. Time
PEAK: 2820.22; TIME OF PEAK: 290min.; VOLUME: 40674385.80
DA-012 100-year hydrograph (time in minutes)
Flow (cfs)
2500
2000
1500
1000
500
0
0
250
500
750
1000
1250
1500
1750
2000
Time
Index 1,19B,P:2820.22,T:290,V:40674385.8

Drainage Area 013



NOTES:

This information is depicted to provide visual aid within the context of this report and should not be used as a sole reference in precise dimensioning of features indicated. Please verify the location of all features including underground and aboveground utilities prior to conducting any subsurface exploration or site assessment.

bhate associates
ENGINEERING, SCIENCE AND CONSTRUCTION

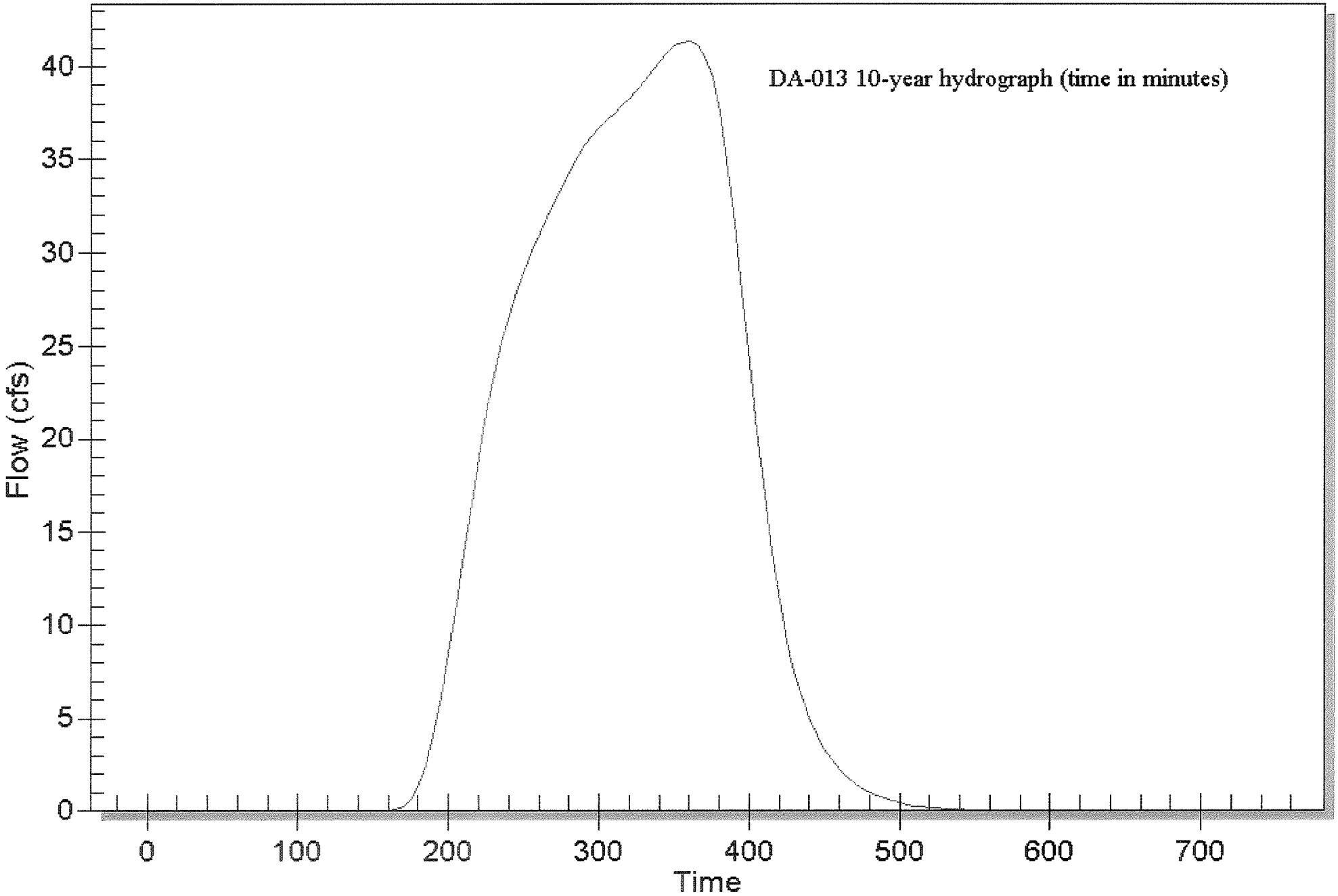
STORMWATER MODELING REPORT
HOLLOMAN AIR FORCE BASE
ALAMOGORDO, NEW MEXICO

PROJECT NO.	SCALE	DATE	DRAWN BY: SKN
9030232	1"=500'	12/07/05	DRAWING NO: DA013

DRAINAGE AREA DA013
AREA DELINEATION

Flow vs. Time

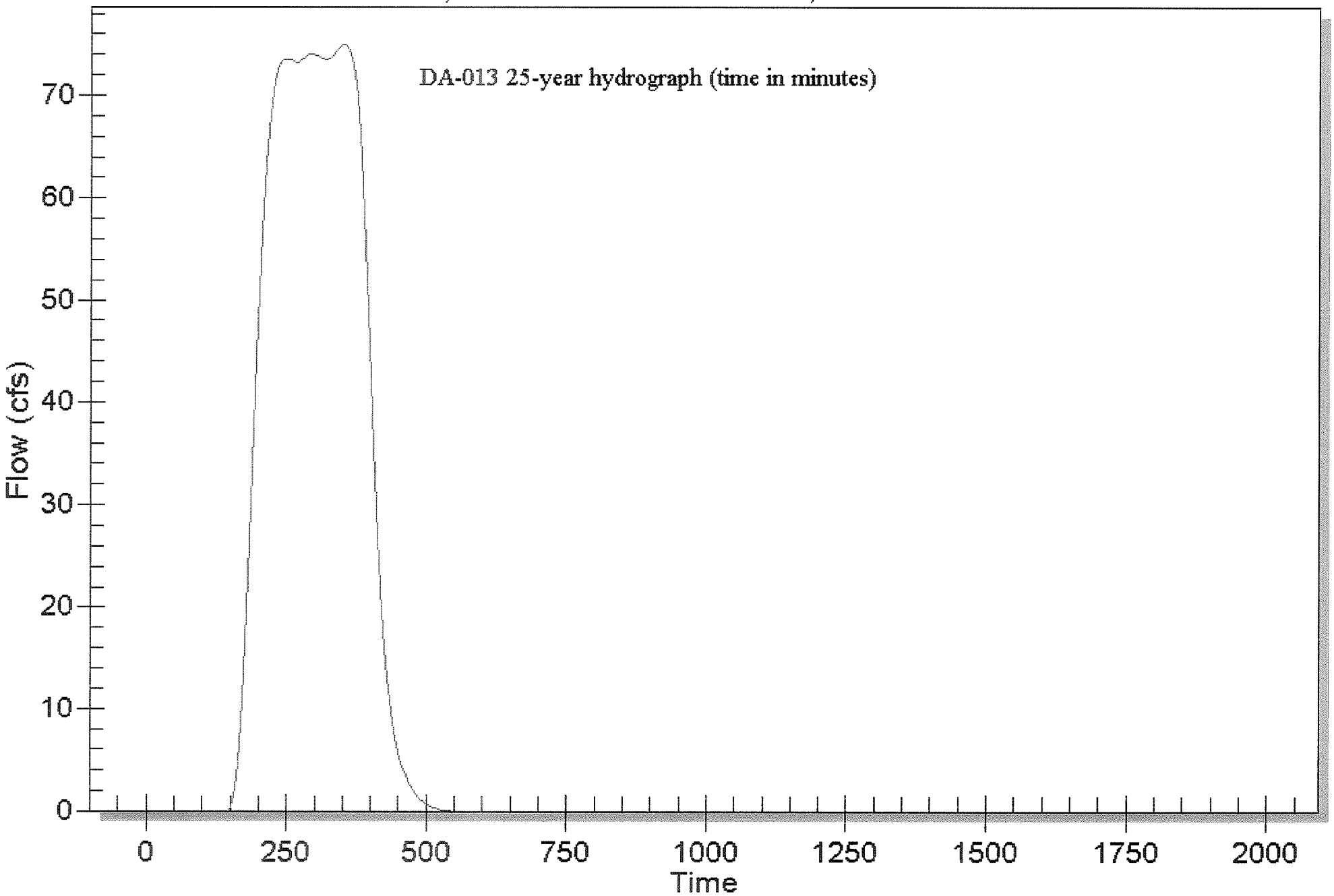
PEAK: 41.34; TIME OF PEAK: 360min.; VOLUME: 430986.00



Index 1,22B,P:41.34,T:360,V:430986.0

Flow vs. Time

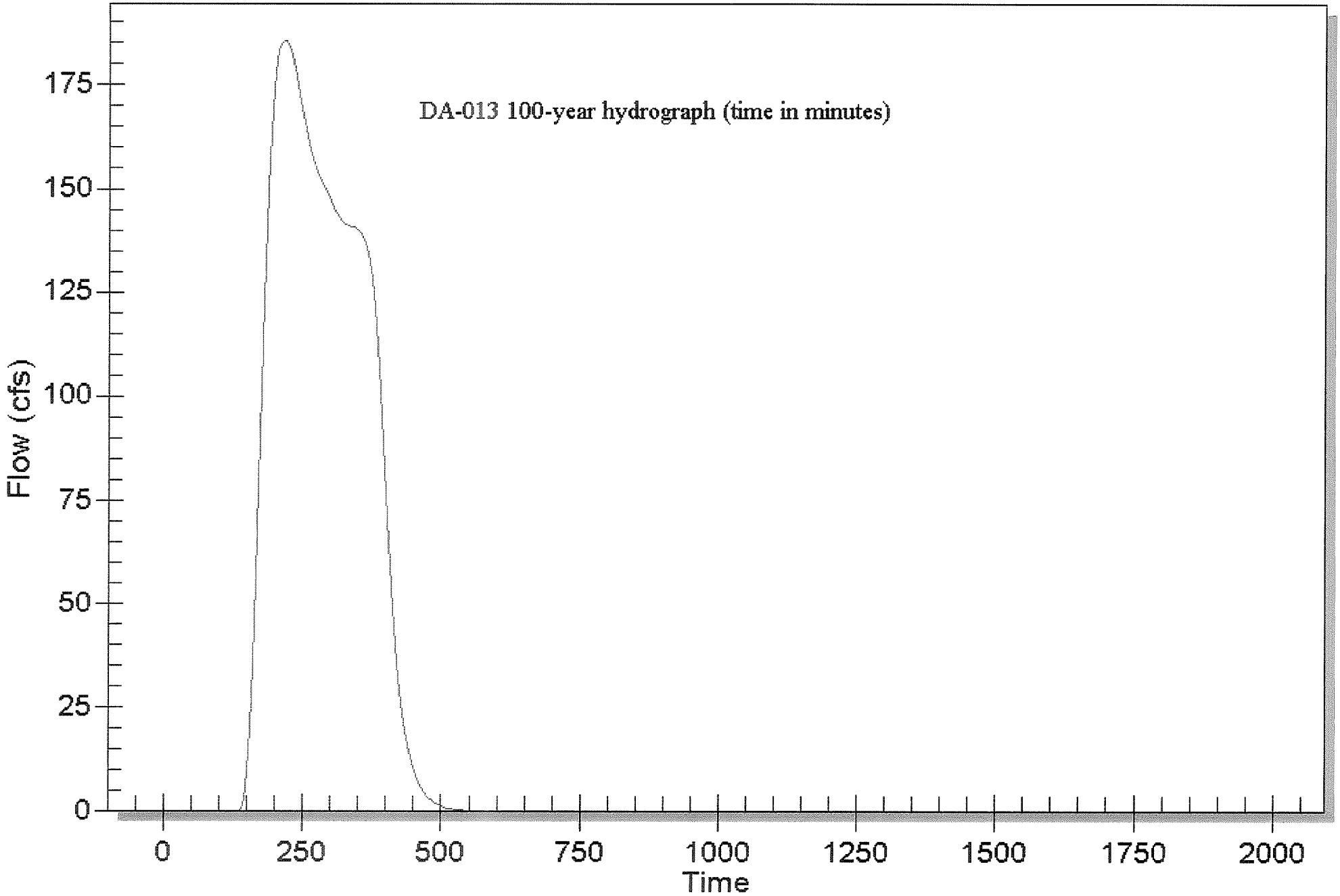
PEAK: 75.00; TIME OF PEAK: 350min.; VOLUME: 967302.30



Index 1,5C,P:75.00,T:350,V:967302.3

Flow vs. Time

PEAK: 185.46; TIME OF PEAK: 215min.; VOLUME: 2209186.20



Index 1,5C,P:185.46,T:215,V:2209186.2

APPENDIX B

NRCS SOIL TYPES AND GROUPS

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

[Depths of layers are in feet. See text for definitions of terms used in this table. Estimates of the frequency of ponding and flooding apply to the whole year rather than to individual months. Absence of an entry indicates that the feature is not a concern or that data were not estimated]

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
AbB:										
Alamogordo	B	Very low	Jan-Dec			---	---	None	---	None
AcA:										
Alamogordo	B	Low	Jan-Dec			---	---	None	---	None
AdB:										
Alamogordo	B	Very low	Jan-Dec			---	---	None	---	None
Aztec	C	Very low	Jan-Dec			---	---	None	---	None
AEC:										
Alamogordo	B	Very low	Jan-Dec			---	---	None	---	None
Gypsum land	C	---	Jan-Dec			---	---	None	---	None
AGE:										
Alamogordo	B	Medium	Jan-Dec			---	---	None	---	None
Aztec	C	Very high	Jan-Dec			---	---	None	---	None
Gypsum land	C	---	Jan-Dec			---	---	None	---	None
AhB:										
Alamogordo	B	Very low	Jan-Dec			---	---	None	---	None
McCullough	B	Very low	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
AkA:										
Alamogordo variant	B	Low	Jan-Dec			---	---	None	---	None
AMC:										
Armesa	B	Low	Jan-Dec			---	---	None	---	None
AnD:										
Aztec	C	High	Jan-Dec			---	---	None	---	None
AoB:										
Aztec	C	Medium	Jan-Dec			---	---	None	---	None
Alamogordo	B	Very low	Jan-Dec			---	---	None	---	None
AZF:										
Aztec	C	Very high	Jan-Dec			---	---	None	---	None
Rock outcrop	D	---	Jan-Dec			---	---	None	---	None
Lozier	D	High	Jan-Dec			---	---	None	---	None
BAF:										
Badland	D	---	Jan-Dec			---	---	None	---	None
BOA:										
Bluepoint	A	Negligible	Jan-Dec			---	---	None	---	None
Onite	B	Very low	Jan-Dec			---	---	None	---	None
Wink	B	Very low	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
BRF:										
Borrego	D	Very high	Jan-Dec			---	---	None	---	None
CFA:										
Crowflats	B	Low	June	---	---	---	---	None	Very brief	Occasional
			July	---	---	---	---	None	Very brief	Occasional
			August	---	---	---	---	None	Very brief	Occasional
			September	---	---	---	---	None	Very brief	Occasional
DEB:										
Deama	D	Very high	Jan-Dec			---	---	None	---	None
DEF:										
Deama	D	Very high	Jan-Dec			---	---	None	---	None
DRF:										
Deama	D	Very high	Jan-Dec			---	---	None	---	None
Rock outcrop	D	---	Jan-Dec			---	---	None	---	None
DRG:										
Deama	D	Very high	Jan-Dec			---	---	None	---	None
Rock outcrop	D	---	Jan-Dec			---	---	None	---	None
DSF:										
Deama	D	Very high	Jan-Dec			---	---	None	---	None
Rock outcrop	D	---	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
DSF:										
Holloman variant	C	High	Jan-Dec			---	---	None	---	None
DTB:										
Dona Ana	B	Low	Jan-Dec			---	---	None	---	None
Berino	B	Low	Jan-Dec			---	---	None	---	None
DUMP:										
Dumps	---	---	Jan-Dec			---	---	None	---	None
DYE:										
Dye	D	Very high	Jan-Dec			---	---	None	---	None
Encierro	D	Very high	Jan-Dec			---	---	None	---	None
ECF:										
Ector	D	Very high	Jan-Dec			---	---	None	---	None
Rock outcrop	D	---	Jan-Dec			---	---	None	---	None
ESB:										
Espy	D	Medium	Jan-Dec			---	---	None	---	None
Shanta variant	B	Medium	Jan-Dec			---	---	None	---	None
GP:										
Pits, gravel	A	---	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
Gu:										
Gullied land	---	---	January	---	---	---	---	None	Brief	Occasional
			February	---	---	---	---	None	Brief	Occasional
			March	---	---	---	---	None	Brief	Occasional
			April	---	---	---	---	None	Brief	Occasional
			May	---	---	---	---	None	Brief	Occasional
			June	---	---	---	---	None	Brief	Occasional
			July	---	---	---	---	None	Brief	Occasional
			August	---	---	---	---	None	Brief	Occasional
			September	---	---	---	---	None	Brief	Occasional
			December	---	---	---	---	None	Brief	Occasional
GyC:										
Gypsum land	C	---	Jan-Dec			---	---	None	---	None
GyE:										
Gypsum land	C	---	Jan-Dec			---	---	None	---	None
GZB:										
Gypsum land	C	---	Jan-Dec			---	---	None	---	None
Holloman	D	Low	Jan-Dec			---	---	None	---	None
HbA:										
Holloman	D	Low	Jan-Dec			---	---	None	---	None
HcA:										
Holloman	D	Low	Jan-Dec			---	---	None	---	None
Gypsum land	C	---	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
HOB:										
Holloman	D	Low	Jan-Dec			---	---	None	---	None
Gypsum land	C	---	Jan-Dec			---	---	None	---	None
Yesum	B	Low	Jan-Dec			---	---	None	---	None
HPB:										
Holloman	D	Low	Jan-Dec			---	---	None	---	None
Reeves	B	Low	Jan-Dec			---	---	None	---	None
JAB:										
Jal	B	Low	Jan-Dec			---	---	None	---	None
Tome	B	Medium	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
JEC:										
Jerag	D	Very high	Jan-Dec			---	---	None	---	None
Philder	D	Very high	Jan-Dec			---	---	None	---	None
Armesa	B	Low	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
LAB:										
La Fonda	B	Low	Jan-Dec			---	---	None	---	None
LbB:										
Largo	B	Low	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
LcA:										
Largo	B	Medium	Jan-Dec			---	---	None	---	None
LdA:										
Largo	B	Low	Jan-Dec			---	---	None	---	None
LDB:										
Largo	B	Low	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
LdB:										
Largo	B	Low	Jan-Dec			---	---	None	---	None
LdB2:										
Largo	B	Low	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
LeA:										
Largo	B	Low	June	---	---	---	---	None	Very brief	Occasional
			July	---	---	---	---	None	Very brief	Occasional
			August	---	---	---	---	None	Very brief	Occasional
			September	---	---	---	---	None	Very brief	Occasional
			October	---	---	---	---	None	Very brief	Occasional
LfB:										
Largo	B	Low	Jan-Dec			---	---	None	---	None
Ogral	B	Very low	Jan-Dec			---	---	None	---	None
LGB:										
Largo	B	Low	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
Ogral	B	Very low	Jan-Dec			---	---	None	---	None
LOB:										
Lozier	D	Very high	Jan-Dec			---	---	None	---	None
Rock outcrop	D	---	Jan-Dec			---	---	None	---	None
LOD:										
Lozier	D	Very high	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
LOD:										
Rock outcrop	D	---	Jan-Dec			---	---	None	---	None
McB:										
McCullough	B	Very low	Jan-Dec			---	---	None	---	None
MdA:										
McCullough variant	B	Low	Jan-Dec			---	---	None	---	None
MEA:										
Mead	D	Very high	January	3.0-4.0	>6.0	---	---	None	---	None
			February	3.0-4.0	>6.0	---	---	None	---	None
			March	3.0-4.0	>6.0	---	---	None	---	None
			April	3.0-4.0	>6.0	---	---	None	---	None
			May	3.0-4.0	>6.0	---	---	None	---	None
			June	3.0-4.0	>6.0	---	---	None	Very brief	Occasional
			July	3.0-4.0	>6.0	---	---	None	Very brief	Occasional
			August	3.0-4.0	>6.0	---	---	None	Very brief	Occasional
			September	3.0-4.0	>6.0	---	---	None	Very brief	Occasional
			October	3.0-4.0	>6.0	---	---	None	Very brief	Occasional
			November	3.0-4.0	>6.0	---	---	None	---	None
			December	3.0-4.0	>6.0	---	---	None	---	None
MJA:										
Mimbres	B	Medium	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
MJA:										
Jal	B	Low	Jan-Dec			---	---	None	---	None
MPA:										
Mimbres	B	Medium	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
Prelo	B	Medium	Jan-Dec			---	---	None	---	None
MTA:										
Mimbres	B	Medium	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
Tome	B	Medium	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
MXC:										
Montecito	B	High	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
NaC:										
Nickel	B	High	Jan-Dec			---	---	None	---	None
Aztec	C	High	Jan-Dec			---	---	None	---	None
NTD:										
Nickel	C	High	Jan-Dec			---	---	None	---	None
Tencee	D	Very high	Jan-Dec			---	---	None	---	None
OPB:										
Onite	B	Very low	Jan-Dec			---	---	None	---	None
Pintura	A	Negligible	Jan-Dec			---	---	None	---	None
PAE:										
Pena	B	Medium	Jan-Dec			---	---	None	---	None
Aztec variant	B	Low	Jan-Dec			---	---	None	---	None
PCB:										
Pena	B	Medium	Jan-Dec			---	---	None	---	None
Cale	B	Medium	Jan-Dec			---	---	None	---	None
Kerrick	B	Low	Jan-Dec			---	---	None	---	None
PDF:										
Pena variant	B	High	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
PDF:										
Rock outcrop	D	---	Jan-Dec			---	---	None	---	None
PEC:										
Philder	D	Very high	Jan-Dec			---	---	None	---	None
PFB:										
Philder	D	Very high	Jan-Dec			---	---	None	---	None
Armesa	B	Low	Jan-Dec			---	---	None	---	None
PGB:										
Pintura	A	Negligible	Jan-Dec			---	---	None	---	None
Dona Ana	B	Low	Jan-Dec			---	---	None	---	None
PHB:										
Pintura	A	Negligible	Jan-Dec			---	---	None	---	None
Tome	B	Low	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
Dona Ana	B	Low	Jan-Dec			---	---	None	---	None
PkA:										
Prelo	B	Medium	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
PlA:										
Prelo	B	Medium	Jan-Dec			---	---	None	---	None
PmA:										
Prelo	B	Medium	Jan-Dec			---	---	None	---	None
PmB:										
Prelo	B	Medium	Jan-Dec			---	---	None	---	None
PmB2:										
Prelo	B	Medium	Jan-Dec			---	---	None	---	None
PnA:										
Prelo	B	Medium	Jan-Dec			---	---	None	---	None
POB:										
Prelo	B	Medium	Jan-Dec			---	---	None	---	None
PpA:										
Prelo	B	Medium	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
PvB:										
Prelo	B	Medium	Jan-Dec			---	---	None	---	None
Prelo variant	B	Medium	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
RAB:										
Reakor	B	Medium	Jan-Dec			---	---	None	---	None
Tome	B	Medium	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
Tencee	D	Very high	Jan-Dec			---	---	None	---	None
RbA:										
Reeves	B	Low	Jan-Dec			---	---	None	---	None
RcB2:										
Reeves	B	Low	Jan-Dec			---	---	None	---	None
RdA:										
Reeves	B	Low	June	---	---	---	---	None	Very brief	Occasional
			July	---	---	---	---	None	Very brief	Occasional
			August	---	---	---	---	None	Very brief	Occasional
			September	---	---	---	---	None	Very brief	Occasional
REB:										
Reeves variant	B	Low	Jan-Dec			---	---	None	---	None
Shanta	B	Low	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
RFA:										
Reyab	B	Medium	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
Armesa	B	Low	Jan-Dec			---	---	None	---	None
ROG:										
Rock outcrop	D	---	Jan-Dec			---	---	None	---	None
RPG:										
Rock outcrop	D	---	Jan-Dec			---	---	None	---	None
Deama	D	Very high	Jan-Dec			---	---	None	---	None
RRF:										
Rock outcrop	D	---	Jan-Dec			---	---	None	---	None
Lozier	D	Very high	Jan-Dec			---	---	None	---	None
RTE:										
Rock outcrop	D	---	Jan-Dec			---	---	None	---	None
Tortugas	D	Very high	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
RTE:										
Ustifluvents	D	Negligible	March	---	---	---	---	None	Long	Frequent
			April	---	---	---	---	None	Long	Frequent
			May	---	---	---	---	None	Long	Frequent
			June	---	---	---	---	None	Long	Frequent
			July	---	---	---	---	None	Long	Frequent
			August	---	---	---	---	None	Long	Frequent
			September	---	---	---	---	None	Long	Frequent
			October	---	---	---	---	None	Long	Frequent
RUA:										
Ruidoso	C	Low	Jan-Dec			---	---	None	---	None
Ruidoso Variant	C	Low	Jan-Dec			---	---	None	---	None
Rw:										
Riverwash, sandy	D	---	January	0.0-2.0	>6.0	---	---	None	Very long	Frequent
			February	0.0-2.0	>6.0	---	---	None	Very long	Frequent
			March	0.0-2.0	>6.0	---	---	None	Very long	Frequent
			April	0.0-2.0	>6.0	---	---	None	Very long	Frequent
			May	0.0-2.0	>6.0	---	---	None	Very long	Frequent
			June	0.0-2.0	>6.0	---	---	None	Very long	Frequent
			July	0.0-2.0	>6.0	---	---	None	Very long	Frequent
			August	0.0-2.0	>6.0	---	---	None	---	None
			September	0.0-2.0	>6.0	---	---	None	---	None
			October	0.0-2.0	>6.0	---	---	None	Very long	Frequent
			November	0.0-2.0	>6.0	---	---	None	Very long	Frequent
			December	0.0-2.0	>6.0	---	---	None	Very long	Frequent

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
SGA:										
Shanta	B	Low	May	---	---	---	---	None	Very brief	Occasional
			June	---	---	---	---	None	Very brief	Occasional
			July	---	---	---	---	None	Very brief	Occasional
			August	---	---	---	---	None	Very brief	Occasional
			September	---	---	---	---	None	Very brief	Occasional
			October	---	---	---	---	None	Very brief	Occasional
Gabaldon	B	Low	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
TAC:										
Tencee	D	Very high	Jan-Dec			---	---	None	---	None
TbA:										
Tobler	B	Low	June	---	---	---	---	None	Very brief	Occasional
			July	---	---	---	---	None	Very brief	Occasional
			August	---	---	---	---	None	Very brief	Occasional
			September	---	---	---	---	None	Very brief	Occasional
TcA:										
Tome	B	Medium	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
TcB:										
Tome	B	Medium	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
TDB:										
Tome	B	Medium	March	---	---	---	---	None	Very brief	Rare
			April	---	---	---	---	None	Very brief	Rare
			May	---	---	---	---	None	Very brief	Rare
			June	---	---	---	---	None	Very brief	Rare
			July	---	---	---	---	None	Very brief	Rare
			August	---	---	---	---	None	Very brief	Rare
TeB:										
Tome	B	Medium	June	---	---	---	---	None	Brief	Occasional
			July	---	---	---	---	None	Brief	Occasional
			August	---	---	---	---	None	Brief	Occasional
			September	---	---	---	---	None	Brief	Occasional
TfB:										
Emot	B	Very low	Jan-Dec			---	---	None	---	None
Tome	B	Medium	Jan-Dec			---	---	None	---	None
TOE:										
Tortugas	D	Very high	Jan-Dec			---	---	None	---	None

Water Features

Otero Area, New Mexico, Parts of Otero, Eddy and Chaves Counties

Map symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
TPE:										
Tortugas	D	Very high	Jan-Dec			---	---	None	---	None
Deama	D	Very high	Jan-Dec			---	---	None	---	None
TPG:										
Tortugas	D	Very high	Jan-Dec			---	---	None	---	None
Deama	D	Very high	Jan-Dec			---	---	None	---	None
TvA:										
Torrifluvents	B	Very low	June	---	---	---	---	None	Very brief	Frequent
			July	---	---	---	---	None	Very brief	Frequent
			August	---	---	---	---	None	Very brief	Frequent
			September	---	---	---	---	None	Very brief	Frequent
			October	---	---	---	---	None	Very brief	Frequent
UaA:										
Ustic Torriorthents	B	Medium	June	---	---	---	---	None	Very brief	Frequent
			July	---	---	---	---	None	Very brief	Frequent
			August	---	---	---	---	None	Very brief	Frequent
			September	---	---	---	---	None	Very brief	Frequent
			October	---	---	---	---	None	Very brief	Frequent

Water Features

This table gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

Surface runoff refers to the loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover. The concept indicates relative runoff for very specific conditions. It is assumed that the surface of the soil is bare and that the retention of surface water resulting from irregularities in the ground surface is minimal. The classes are negligible, very low, low, medium, high, and very high.

The months in the table indicate the portion of the year in which a water table, ponding, and/or flooding is most likely to be a concern.

Water table refers to a saturated zone in the soil. The water features table indicates, by month, depth to the top (upper limit) and base (lower limit) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

Ponding is standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation. The table indicates surface water depth and the duration and frequency of ponding. Duration is expressed as very brief if less than 2 days, brief if 2 to 7 days, long if 7 to 30 days, and very long if more than 30 days. Frequency is expressed as none, rare, occasional, and frequent. None means that ponding is not probable; rare that it is unlikely but possible under unusual weather conditions (the chance of ponding is nearly 0 percent to 5 percent in any year); occasional that it occurs, on the average, once or less in 2 years (the chance of ponding is 5 to 50 percent in any year); and frequent that it occurs, on the average, more than once in 2 years (the chance of ponding is more than 50 percent in any year).

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Duration and frequency are estimated. Duration is expressed as extremely brief if 0.1 hour to 4 hours, very brief if 4 hours to 2 days, brief if 2 to 7 days, long if 7 to 30 days, and very long if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. None means that flooding is not probable; very rare that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); rare that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); occasional that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); frequent that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and very frequent that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Water Features

APPENDIX C

RUNOFF CURVE NUMBERS FOR URBAN AREAS

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition, and I_a=0.2S
[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c Runoff curve numbers for other agricultural lands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.
2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.
3 *Poor*: <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.
4 Actual curve number is less than 30; use CN = 30 for runoff computations.
5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.
6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d Runoff curve numbers for arid and semiarid rangelands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition [2]	A [3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

1 Average runoff condition, and I_a, = 0.2S. For range in humid regions, use table 2-2c.
2 Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
3 Curve numbers for group A have been developed only for desert shrub.

APPENDIX D

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

New Mexico 32.892 N 106.007 W 4229 feet

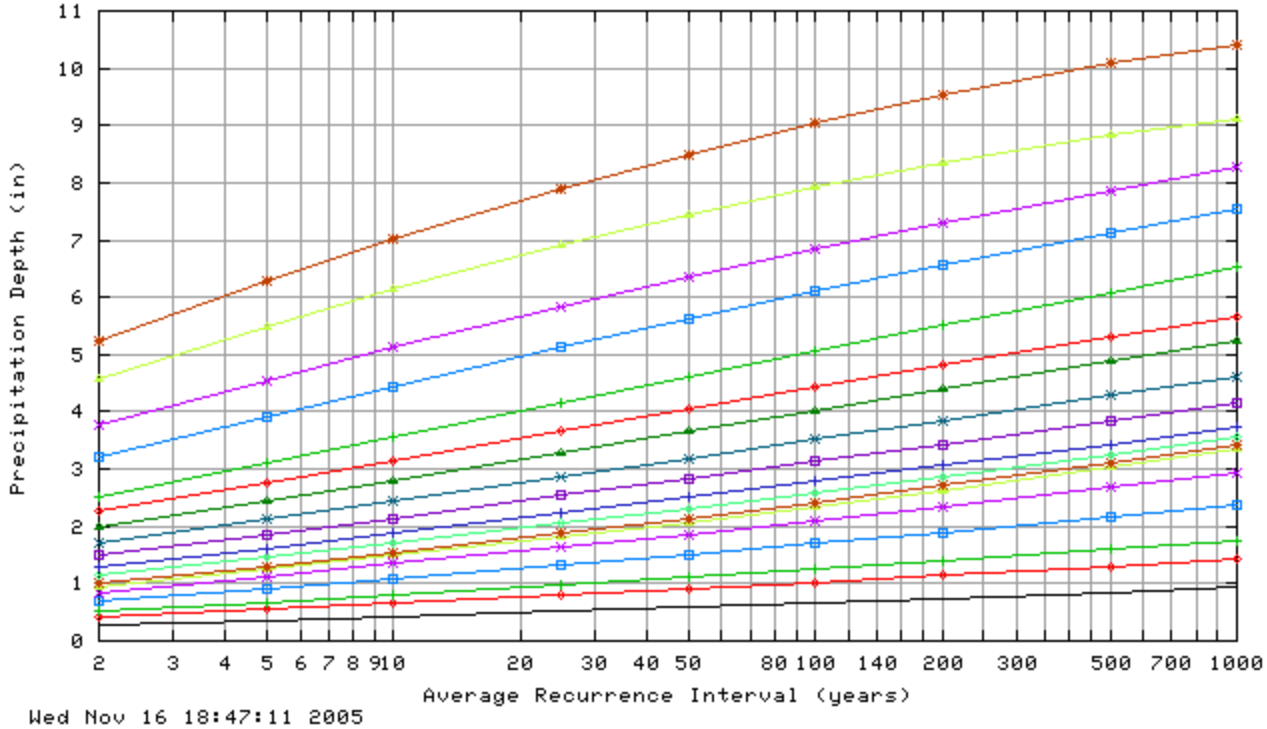
from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 1, Version 3
G.M. Bonnin, D. Todd, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2003
Extracted: Wed Nov 16 2005

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
2	0.27	0.41	0.51	0.69	0.85	0.95	1.01	1.14	1.29	1.49	1.72	1.98	2.26	2.52	3.21	3.75	4.59	5.25
5	0.36	0.55	0.68	0.91	1.13	1.25	1.31	1.45	1.62	1.86	2.13	2.44	2.76	3.10	3.92	4.54	5.49	6.28
10	0.43	0.65	0.81	1.09	1.35	1.50	1.55	1.70	1.89	2.14	2.45	2.80	3.15	3.55	4.44	5.12	6.14	7.01
25	0.52	0.79	0.98	1.32	1.64	1.82	1.88	2.05	2.23	2.53	2.87	3.28	3.66	4.15	5.12	5.84	6.92	7.90
50	0.59	0.90	1.12	1.51	1.87	2.08	2.14	2.31	2.50	2.83	3.19	3.65	4.05	4.60	5.62	6.36	7.45	8.50
100	0.67	1.02	1.26	1.70	2.11	2.35	2.42	2.58	2.78	3.13	3.52	4.02	4.44	5.06	6.10	6.85	7.93	9.05
200	0.75	1.14	1.41	1.90	2.35	2.63	2.71	2.86	3.06	3.44	3.85	4.39	4.81	5.51	6.56	7.31	8.36	9.53
500	0.85	1.29	1.60	2.16	2.67	3.02	3.11	3.25	3.43	3.83	4.28	4.88	5.29	6.09	7.13	7.87	8.83	10.08
1000	0.93	1.42	1.76	2.37	2.93	3.34	3.42	3.55	3.72	4.14	4.61	5.24	5.65	6.53	7.54	8.26	9.13	10.42

* These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.

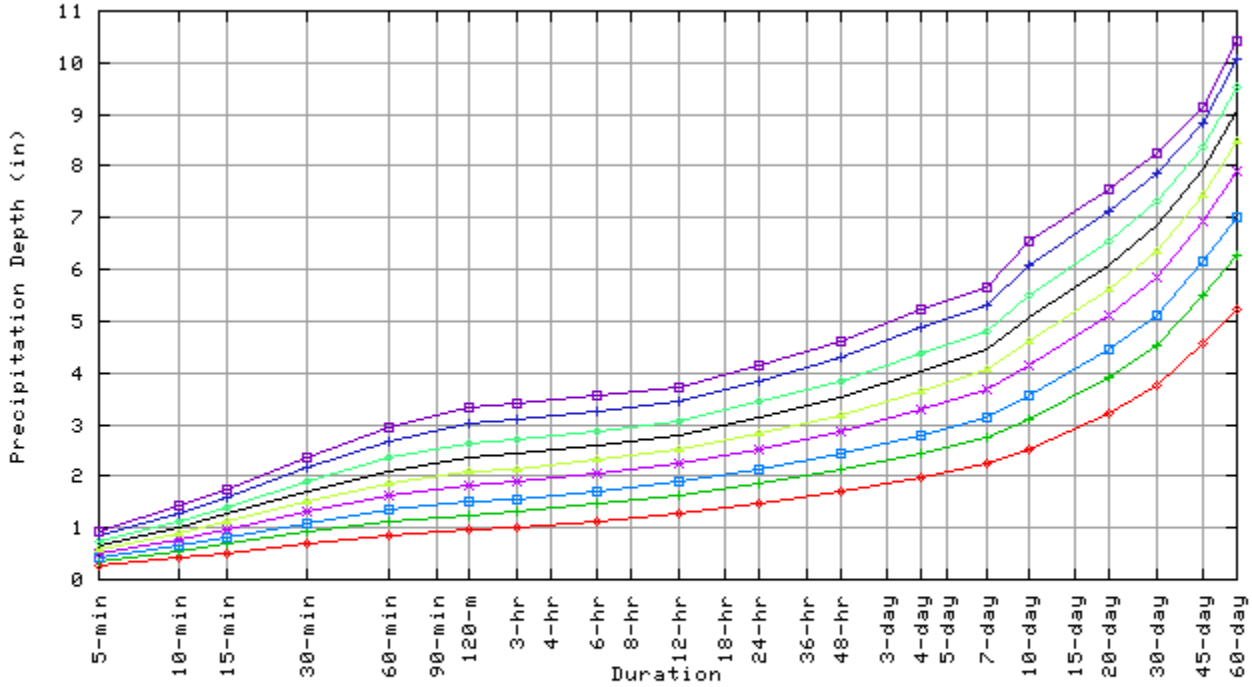
Partial duration based Point Precipitation Frequency Estimates Version: 3
32.892 N 106.007 W 4229 ft



Wed Nov 16 18:47:11 2005

Duration			
5-min	120-m	48-hr	30-day
10-min	3-hr	4-day	45-day
15-min	6-hr	7-day	60-day
30-min	12-hr	10-day	
60-min	24-hr	20-day	

Partial duration based Point Precipitation Frequency Estimates Version: 3
32.892 N 106.007 W 4229 ft



Wed Nov 16 18:47:11 2005

Average Recurrence Interval (years)	
1 in 2	1 in 100
1 in 5	1 in 200
1 in 10	1 in 500
1 to 25	1 in 1000
1 in 50	

Confidence Limits -

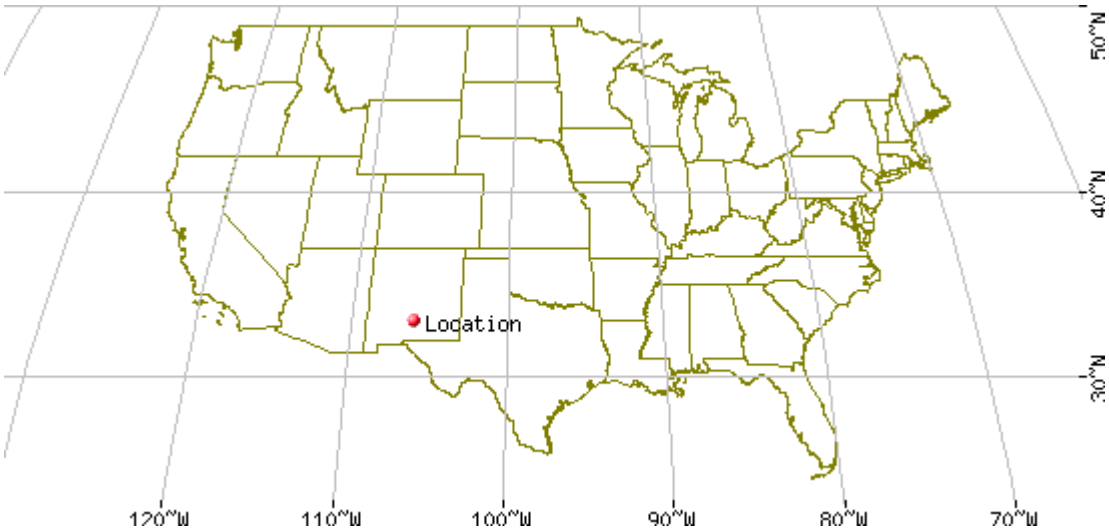
* Upper bound of the 90% confidence interval Precipitation Frequency Estimates (inches)																		
ARI (years)**	**5 min**	**10 min**	**15 min**	**30 min**	**60 min**	**120 min**	**3 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**4 day**	**7 day**	**10 day**	**20 day**	**30 day**	**45 day**	**60 day**
2	0.31	0.47	0.58	0.78	0.96	1.07	1.13	1.27	1.42	1.63	1.85	2.12	2.42	2.73	3.46	4.02	4.89	5.57
5	0.41	0.62	0.77	1.03	1.28	1.40	1.46	1.61	1.79	2.02	2.29	2.62	2.94	3.35	4.21	4.85	5.85	6.65
10	0.48	0.74	0.91	1.23	1.52	1.66	1.71	1.88	2.07	2.33	2.63	2.99	3.36	3.84	4.77	5.47	6.53	7.41
25	0.59	0.89	1.10	1.49	1.84	2.02	2.08	2.25	2.45	2.75	3.08	3.51	3.90	4.48	5.50	6.23	7.35	8.35
50	0.67	1.02	1.26	1.70	2.10	2.29	2.36	2.53	2.74	3.06	3.43	3.90	4.31	4.98	6.04	6.79	7.93	8.99
100	0.75	1.15	1.42	1.91	2.37	2.59	2.66	2.83	3.05	3.39	3.78	4.29	4.72	5.48	6.56	7.32	8.44	9.57
200	0.84	1.28	1.58	2.13	2.64	2.91	2.98	3.15	3.35	3.73	4.14	4.70	5.13	5.97	7.06	7.81	8.90	10.08
500	0.96	1.46	1.81	2.44	3.02	3.33	3.42	3.58	3.78	4.17	4.61	5.24	5.66	6.62	7.69	8.42	9.40	10.68
1000	1.05	1.60	1.98	2.67	3.30	3.69	3.78	3.92	4.11	4.50	4.97	5.64	6.05	7.11	8.14	8.85	9.72	11.05

* The **upper** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **greater** than.
** These precipitation frequency estimates are based on a partial duration series. **ARI** is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

* Lower bound of the 90% confidence interval Precipitation Frequency Estimates (inches)																		
ARI (years)**	**5 min**	**10 min**	**15 min**	**30 min**	**60 min**	**120 min**	**3 hr**	**6 hr**	**12 hr**	**24 hr**	**48 hr**	**4 day**	**7 day**	**10 day**	**20 day**	**30 day**	**45 day**	**60 day**
2	0.24	0.36	0.45	0.60	0.75	0.86	0.91	1.03	1.17	1.37	1.60	1.86	2.12	2.34	3.00	3.52	4.32	4.93
5	0.32	0.48	0.59	0.80	0.99	1.13	1.18	1.32	1.47	1.70	1.98	2.28	2.59	2.88	3.66	4.25	5.17	5.91
10	0.38	0.57	0.71	0.96	1.18	1.33	1.39	1.54	1.72	1.96	2.28	2.61	2.96	3.30	4.14	4.80	5.78	6.60
25	0.45	0.69	0.86	1.15	1.43	1.61	1.67	1.83	2.02	2.30	2.67	3.06	3.43	3.84	4.76	5.48	6.51	7.43
50	0.51	0.78	0.97	1.30	1.61	1.82	1.90	2.06	2.25	2.56	2.96	3.40	3.78	4.25	5.21	5.95	7.01	7.99
100	0.57	0.88	1.08	1.46	1.81	2.05	2.12	2.28	2.48	2.82	3.25	3.72	4.13	4.65	5.65	6.40	7.47	8.49
200	0.64	0.97	1.20	1.62	2.00	2.28	2.36	2.51	2.71	3.08	3.55	4.06	4.46	5.05	6.06	6.81	7.87	8.95
500	0.72	1.10	1.37	1.84	2.28	2.57	2.65	2.81	3.00	3.40	3.92	4.48	4.90	5.55	6.57	7.31	8.32	9.47
1000	0.78	1.19	1.48	1.99	2.46	2.80	2.88	3.03	3.24	3.65	4.19	4.79	5.20	5.92	6.92	7.65	8.62	9.79

* The **lower** bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are **less** than.
** These precipitation frequency estimates are based on a partial duration maxima series. **ARI** is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

Maps -



These maps were produced using a direct map request from the
U.S. Census Bureau Mapping and Cartographic Resources
Tiger Map Server.

Climate Data Sources -

Precipitation frequency results are based on data from a variety of sources, but largely NCDC. The following links provide general information about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study, please refer to our documentation.

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