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ARAC Testing for Potential Nuclear Regulatory Commission Meteorological Staff Use

L. C. Rosen

Prepared for
U.S. Nuclear Regulatory Commission

Lawrence
Livermore
National
Laboratory

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ABSTRACT

A Nuclear Regulatory Commission (NRC) sponsored project to examine and assess the potential of the Atmospheric Release Advisory Capability (ARAC) for contributing to the emergency response capabilities of the NRC staff is discussed herein. Preliminary planning, installation, and testing of the ARAC site facility at the NRC Incident Response Center are summarized. ARAC participation in two days of field testing at Idaho Falls, Idaho, in July 1981 is examined. The ARAC system is evaluated, with emphasis on communications, meteorology, the suite of models contained within the ARAC system, and the staff. The implications of this project in designing the next-generation ARAC system to service federal and state needs are assessed.

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EXECUTIVE SUMMARY

INTRODUCTION

The Nuclear Regulatory Commission has supported a project with the Lawrence Livermore National Laboratory (LLNL) to examine and assess the potential of the Atmospheric Release Advisory Capability for contributing to the emergency response capabilities of the NRC meteorological staff. The objectives of the project were:

1. To install the Atmospheric Release Advisory Capability (ARAC) site facility terminal, currently available at LLNL, in the NRC Incident Response Center, Bethesda, Maryland, and to proof test the system (terminal, CRT scope, and hardcopy capability) to receive ARAC data and ARAC regional products.

2. To train the NRC meteorological staff in ARAC terminal operation.

3. To engage, together with the NRC meteorological staff, in the design and conduct, of suitable demonstrations of the uses and timeliness of ARAC advisory outputs for emergency response.

SUMMARY AND FACTORS LEARNED

To accomplish the tasks set forth for this project, LLNL delivered an ARAC site facility terminal to NRC Headquarters in FY 1980. During September 1980, representatives from the NRC met at LLNL for a series of orientation and planning meetings. Preliminary testing was performed on the site facility terminal in the fall of 1980.

As its participation during two days of field testing at Idaho Falls in July 1981, ARAC transmitted contours to the site facility terminal at the NRC IRC. Critiques of the testing procedures were written by the NRC staff and sent to the ARAC staff at LLNL during March 1982, for use in assessing future project training for site users and for the design of the next-generation ARAC system. These critiques have provided valuable feedback for use in ARAC system implementation (Appendix A).

At the conclusion of the orientation and planning meetings and the testing at Idaho Falls, the NRC Headquarters staff at IRC had gained the facility to operate the site system and to interpret ARAC output.

The body of experience produced through the use of ARAC advisory information has been invaluable in planning for the inclusion of future site systems, for future training, and for the design of the next-generation ARAC system. The tracer studies at Idaho Falls provided an excellent opportunity to demonstrate the uses of ARAC system output in real-time scenarios. However, had ARAC been informed of the tests earlier and been involved in their planning, the timing and demonstration of ARAC advisory information would undoubtedly have improved. Results from these tracer tests will be used in the future, as part of continuing ARAC model evaluation studies.

This study, as well as a Federal Emergency Management Agency (FEMA)-supported companion study to investigate the feasibility of ARAC as an emergency response for use by states, has pointed out some weaknesses, as well as strong points, in the ARAC software and hardware. A number of the breakdowns that occurred in the hardware during this project were due to the age of the equipment. The hardware is being updated for the next-generation ARAC system, which should minimize down times. Some software errors communicated to ARAC by the NRC staff have already been corrected; the remainder will be eliminated in the next-generation ARAC system. As a result of this study, the philosophy of the next-generation ARAC system will be to treat the ARAC center as a large computational and data source available to the user at his request, as opposed to the present system of sending large quantities of information to the user at the discretion of the ARAC staff. This not only reduces the computer power required at the sites, but allows the user to receive only necessary information at the time it is needed.

The background and description of the ARAC system is contained in Section I of this report. Utilization of ARAC services at the IRC is described under: "Delivery Dates and Initial Testing" and "The Idaho Falls Tests" in Section II. Section III of this report is devoted to an evaluation of the ARAC system, with emphasis on communications, meteorology, the suite of models contained within the ARAC system, and the staff. Section IV discusses the implications this project will have on the design of the next-generation ARAC system to service federal and state needs.

I. ATMOSPHERIC RELEASE ADVISORY CAPABILITY (ARAC)

BACKGROUND

At its inception in 1972, ARAC was viewed by the Atomic Energy Commission (AEC) as a complete emergency response system for the nuclear industry. As the project has moved forward, it has fulfilled this goal by responding to nuclear incidents such as the TMI-2 accident and purge, the COSMOS 9 reentry into Canada, the Titan II accident and, more recently, the Ginna Nuclear Power Plant accident near Rochester, New York. The FY 1981 ARAC responses, listed in Table 1, are indicative of its recent involvement in a broad spectrum of nuclear-related incidents and exercises.

PRESENT SYSTEM

The ARAC system makes available to users predictive data from proven and tested numerical models.[2-6] Geographical scales for ARAC assessments vary from regional (up to 100 km) to global (thousands of km), depending on release conditions. System components are shown in Fig. 1. At present, ARAC services are available to four DOE sites, the Federal Aviation Administration (FAA), DOE emergency response operations (e.g., the Nuclear Emergency Search Team), the NRC's Incident Response Center, two nuclear power plants (Indian Point and Rancho Seco), two state offices for emergency services (New York and California), and three DOD sites.

TABLE 1. Summary of ARAC responses during FY 1981.

Date	Type of response	Location	Event	Duration
10/16/80	Alert	Northern Hemisphere	Chinese atmospheric nuclear test	10 d
10/16/80	Alert	Sunol, California	Truck accident involving radioactive material	3 h
11/20/80	Exercise	Dothan, Alabama	NRC/FEMA/DOE/State of Alabama exercise for Farley Nuclear Power Plant	5 h
01/09/81	Alert	--	NEST response to extortion threat	2 d
09/22/81	Alert	Shippingport, Pennsylvania	Beaver Valley NPP leak	2.5 h
02/17/81	Exercise	National Military Command Center (NMCC)	DOD Command Post Exercise	2 h
02/24/81	Exercise	LLNL, California	LLNL/Livermore, county toxic gas exercise	3 h
03/03/81	Exercise	Camp Roberts, California	Low-key NEST exercise	3 d
03/04/81	Exercise	Oregon/Washington	NRC/DOE low-key exercise for Trojan NPP	3 h
03/11/81	Alert	Delaware/New Jersey	Salem NPP leak	2 h
03/27/81	Alert	Savannah River Plant, South Carolina	Tritium release	5 h
04/09/81	Exercise	LLNL, California	LLNL evacuation exercise	1 h
04/21/81	Exercise	Nevada Test Site	Nuclear Weapons Accident Exercise (NUWAX) -81	6 d

TABLE 1. Continued.

Date	Type of response	Location	Event	Duration
06/09/81	Alert	Baghdad, Iraq	Reactor destruction	2 d
07/16/81	Alert	Dayton, Ohio	Mound Laboratory support request for toxic spill	2 h
07/23/81	Exercise	INEL, Idaho	24-h tracer study	24 h
07/27/81	Exercise	INEL, Idaho	24-h tracer study	24 h
07/29/81	Exercise	Chicago, Illinois	NRC/FEMA/DOE/State of Illinois/State of Wisconsin exercise for Zion NPP	6.5 h
08/05/81	Exercise	--	NEST field exercise	5 d
09/18/81	Exercise	New York	Indian Point NPP/State of New York exercise	4 h
09/25/81	Exercise	New York	Indian Point NPP/State of New York exercise	4 h

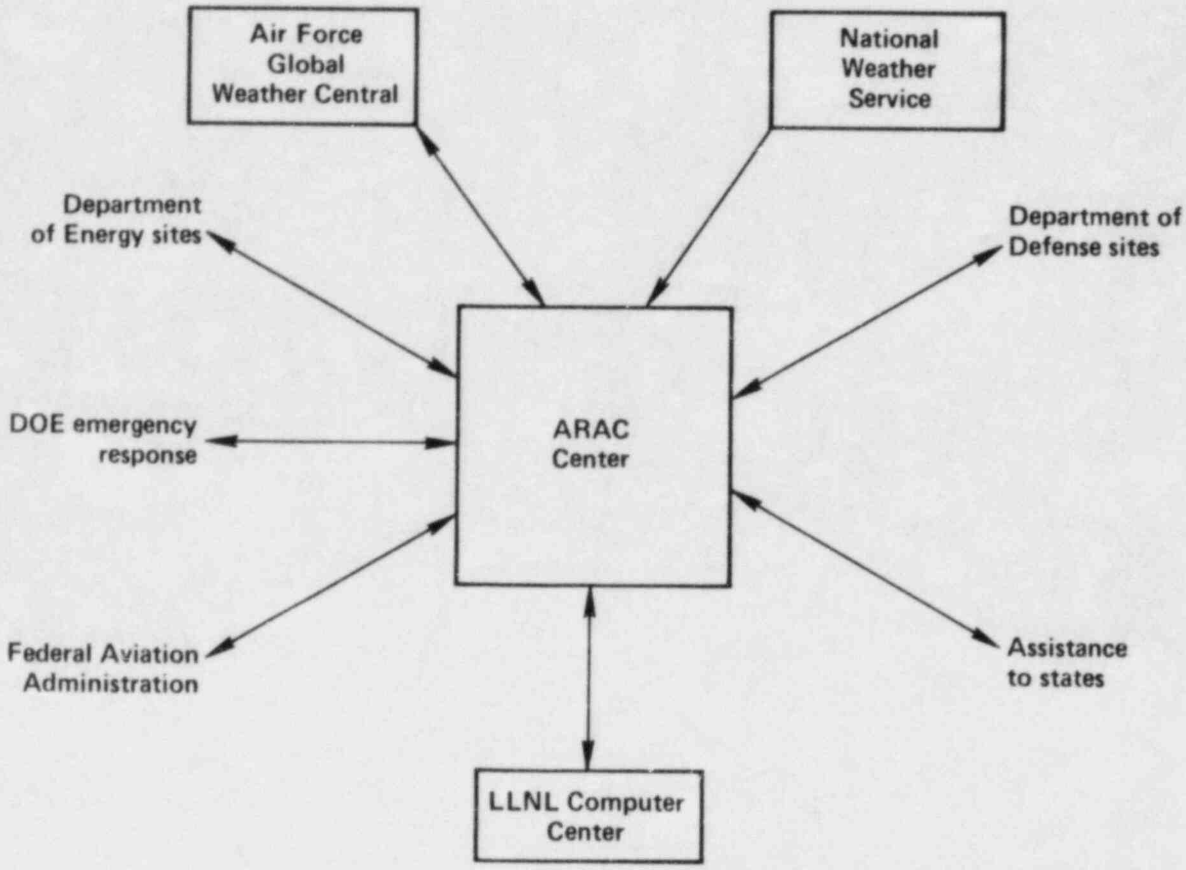


FIGURE 1. ARAC network.

Central Facility

The ARAC center (Fig. 2) is the focal point for data acquisition, data processing, communications, and assessments by means of interconnected minicomputers. One or more of several CDC 7600 computers at the LLNL computer center are used to calculate regional and global atmospheric transport and diffusion estimates. In an atmospheric release emergency, the ARAC staff can obtain exclusive use of a CDC 7600 computer within a matter of minutes after the computer center is notified.

Meteorological data from the Air Force Global Weather Central (AFGWC) at Offutt Air Force Base, Bellevue, Nebraska, are available to the ARAC center through a high-speed data link. The ARAC center can receive, analyze, display, and store meteorological data from worldwide data sources. Selected observational and forecast data are also received on a routine scheduled basis. In an emergency, ARAC can request supplemental data from either the AFGWC computer system or the master data base at Carswell Air Force Base, Fort Worth, Texas. The AFGWC gives ARAC high priority under emergency conditions, thereby speeding the response. Supplemental and backup weather data are presently received from the National Weather Service (NWS) through normal teletype and facsimile channels. In the future, consideration will be given to including the updated NWS Automated Forecast Office Service systems for inclusion in the ARAC network.

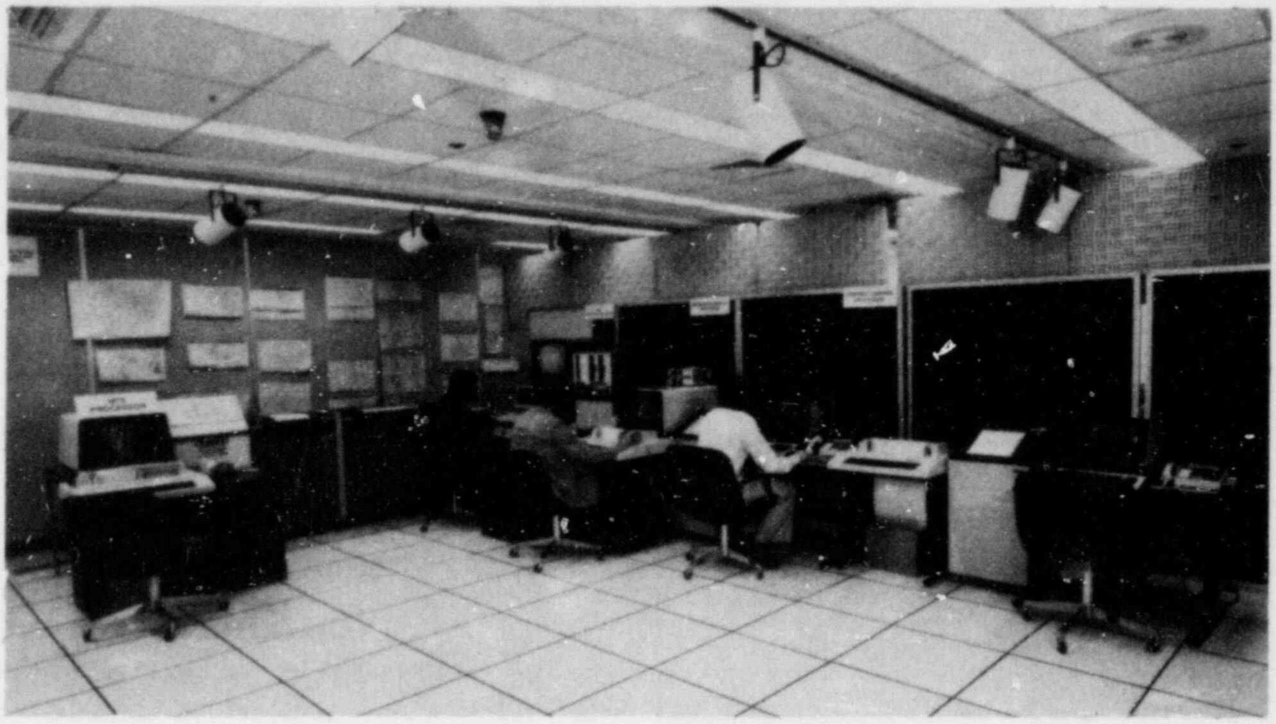


FIGURE 2. ARAC central facility.

On the basis of ARAC's expanding role in emergency response to nuclear incidents and the DOE's responsibility for helping to assess the consequences of a nuclear incident, DOE decided to expand ARAC as a resource to help both federal and state agencies respond to nuclear emergencies. This expansion is presently underway, and results from this study are being used to help design a new expanded ARAC system to meet both federal and state emergency response requirements.

Site Facility

Each ARAC-serviced site has a minicomputer or site terminal that provides local data-acquisition, assessment, and communication capabilities. Some of its specific functions are:

1. To multiplex the environmental sensors.

2. To calculate and display Gaussian diffusion estimates for close-in distances (out to approximately 5 km), using the latest local meteorological data.

3. To transmit local environmental monitor measurements to the LLNL ARAC center.

4. To receive and display regional calculations from the ARAC center.

The site terminal hardware is illustrated in Fig. 3. The central processor is a DEC PDP-11 which has a maximum memory of 28 K words. The terminal uses a

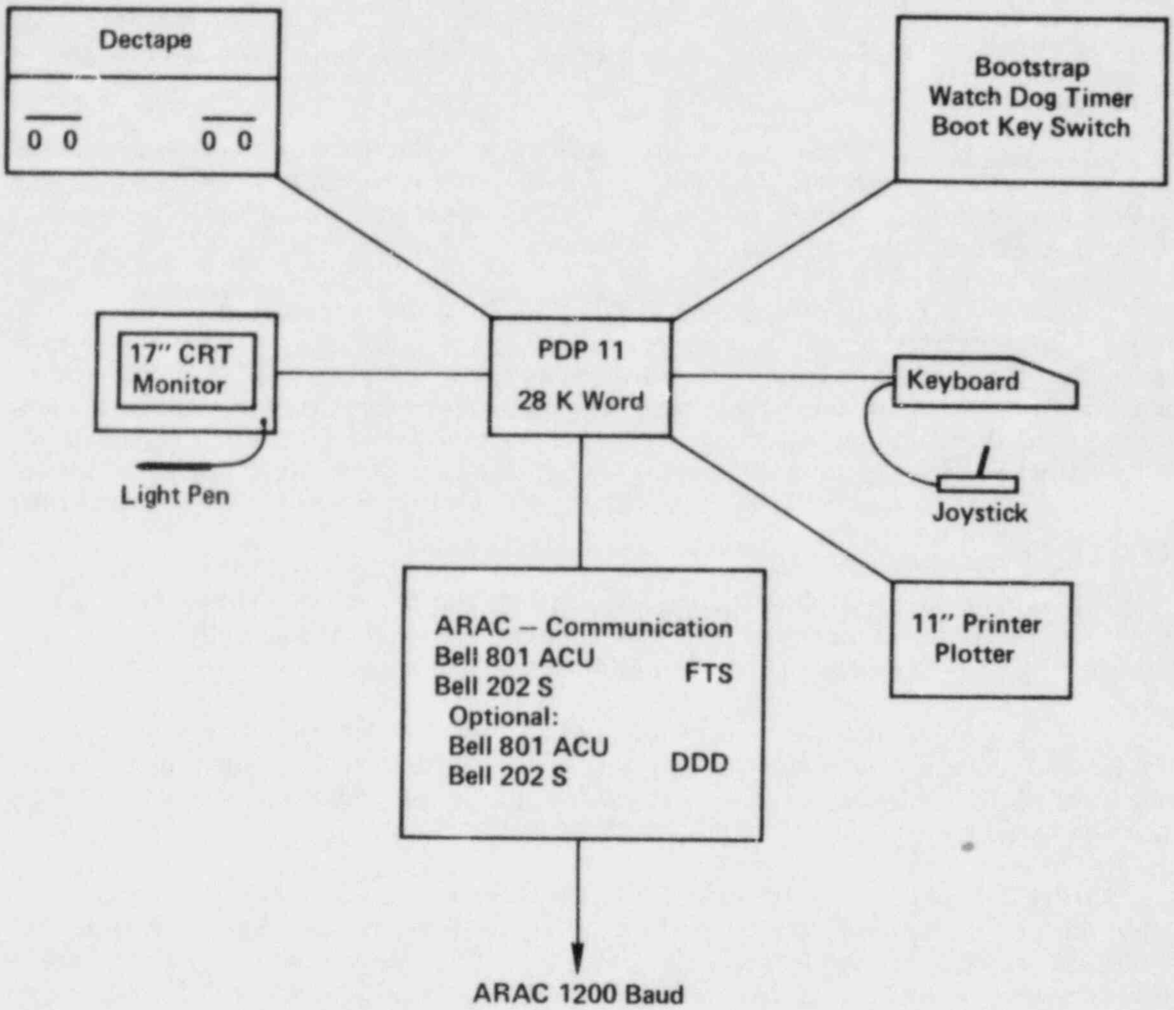


FIGURE 3. ARAC site terminal hardware at the IRC.

DECTAPE for program and data storage. Two graphical output devices are used for displaying maps, overlays, and similar information. The first graphical output device, the 17-in CRT monitor, uses the processor's memory to refresh the graphic display. The second graphical output device, the 11-in printer/plotter, is called the hardcopy device because the display is documented on paper. To communicate with the computer, the operator uses the keyboard and a light pen. By typing appropriate responses on the keyboard, the operator can provide input data and communicate with the site terminal and, with the light pen, can point to a command for an appropriate system response. A watch-dog timer and bootstrap function are provided to start the site terminal and restart when the system is stopped by unexplained or undetected errors. While there are also data lines to collect data from meteorological towers and to communicate them to the ARAC center, no meteorological interface was developed for this study at IRC.

ARAC Models

The ARAC system utilizes a suite of numerical models appropriate to a variety of atmospheric release incidents. The following ARAC models are pertinent to the use of the ARAC service for the release of radionuclides from nuclear power plants.

CPS and IPS.[7] These Gaussian continuous- and instantaneous-point-source diffusion models are part of the menu in ARAC's site system and are used on-site for first-response calculations in the event of an exercise or accidental release. A unit release rate (CPS) or release (IPS) is assumed.

Two modes of operation are available. The more commonly used mode, automatically updated on the screen every 15 min., provides concentration contours overlaid on a geographical map. These contours are calculated from a preselected input file that includes the height and location of the tower from which 15-min. average wind direction and speed are desired, the map size (detailed or regular), and whether the release is a plume or puff. The site system determines the atmospheric stability category by calculating the standard deviation (related to stability) over the 15-min. period.

The second mode allows the user to change the preselected input file. Items that may be changed are the sampler height, location and height of release, half-life, the stability category, and wind direction and speed.

MATHEW.[2,3] This flexible, three-dimensional model provides nondivergent wind fields for use in the ADPIC model and in other studies. It adjusts interpolated wind-field data, subject to the constraints of mass continuity and explicitly introduced topography.

ADPIC.[4,5] The Atmospheric Diffusion Particle-in-Cell (ADPIC) code is a numerical three-dimensional, Cartesian, particle-diffusion code capable of simulating the time-dependent distribution of air pollutants under many conditions. These conditions include space and time-varying wind fields, calm conditions, space-variable surface roughness, wet and dry deposition, radioactive decay, and space- and time-variable diffusion parameters.

Basically, the code solves the three-dimensional advection-diffusion equation in its flux conservative form (pseudovelocity technique) for a given nondivergent advection field by finite difference approximations in Cartesian coordinates. The method is based on the particle-in-cell technique, with the pollutant concentration represented by Lagrangian-marker particles inside a fixed Eulerian grid. This computer model has been used to simulate particulate and gaseous concentrations from one or more sources at distances beyond 100 km, the general deposition of particles with given size distributions, and rainout. In addition, ADPIC calculations have been compared against measurements for four field-diffusion experiments. The MATHEW/ADPIC transport and diffusion models are continually being modified and verified against field tracer studies to provide ARAC users with useful products in a timely manner.

PATRIC.[6] The particle-trajectory-in-cell (PATRIC) model is a transport and diffusion model designed to calculate the three-dimensional distribution of atmospheric pollutants in a given flow field that varies with space and time. The model is capable of computing instantaneous or time-integrated air concentrations and deposition for various instantaneous or continuous sources, including inert and radioactive materials. The PATRIC model was developed to provide a fast-running annual assessment tool that can serve as a basis for dose-to-man calculations. It is generally related to ADPIC in that it is a particle-in-cell model but, because the model includes no topography or vertical wind velocities and because its diffusion calculation is independent of a grid, PATRIC can run about a thousand times faster than real time.

II. UTILIZATION OF ARAC SERVICE AT IRC

The sequence of events leading to and including the implementation of ARAC service at IRC is discussed under the headings: "Delivery Dates and Initial Testing" and "Idaho Falls Tests."

DELIVERY DATES AND INITIAL TESTING

To expedite and facilitate installation and operation of the ARAC site system facility at IRC, NRC personnel received documentation[7,8] and instructions before the system was shipped from LLNL to IRC on April 3, 1980. The equipment manufacturer, DEC, did the initial setup and installation by May 1, 1980. On May 15, 1980, an ARAC staff electronics engineer arrived at IRC to complete the installation and to verify the system. To test this system at NRC, it was decided that no meteorological tower or interface would be established; rather, a site system tape that included a site map for the LLNL area and a fixed set of "canned" tower data was delivered and installed . The site system user's own test tower data could also be used to obtain Gaussian contours.

Initial testing between IRC and ARAC commenced in the summer of 1980. These initial tests were used to acquaint the NRC site system operators with the operation of site/ARAC Central Facility (ACF) communications and to familiarize them with the ARAC-generated contour package.

So that future testing could be planned, an ARAC orientation and planning meeting was held at LLNL on September 16 and 17, 1980. Attendees included representatives from the NRC, Con-Edison, the Power Authority of New York, the New York State Department of Health, and the FEMA.

The meeting had a twofold purpose: (1) to bring together anyone who would be involved in the operation, interpretation, and management of the ARAC site facilities so that they might become more knowledgable about the details of the ARAC system, (2) to plan how to implement the goals and operational procedures of the ARAC for the coming year. The meeting agenda is given in Table 2. As a result of this meeting, the participants were given initial training in and familiarized with the use of the ARAC system. Further, through the interchange of ideas and objectives by meeting participants and the ARAC staff, testing and implementation procedures were established for the project.

During the fall of 1980, preliminary testing of the site facility at IRC concluded with the transmission of three sets of contours. These contours were calculated by utilizing the MATHEW/ADPIC numerical models for a release at the LLNL site. Two of the three sets of contours were received successfully; communication problems invalidated the retrieval of the third set.

TABLE 2. Agenda for ARAC orientation/planning meeting, September 16-17, 1980.

Tuesday, September 16		
8:00-8:30	Check in at the Badge Office	
9:00	Introduction	Len Rosen
9:15	Opening Remarks	Joe Knox
9:45	General Overview	Len Rosen
10:15	Coffee Break	
10:30	ARAC Services	Tom Sullivan
11:30	Lunch	
1:00	ARAC Network	Bryan Lawver
2:00	Coffee Break	
2:15	Demonstration -- Tour in the ARAC Center	
3:15	Discussion	Len Rosen
6:00	No-Host Cocktails and Dinner	
Wednesday, September 17		
8:30	Remarks	Len Rosen
9:00	Con-Edison/PASNY	Lester Cohen
9:30	State of New York	John Matuszek
10:00	NRC Demonstration of Site System at Headquarters	Earl Markee
10:30	NRC Field Experiments	Bob Abbey
11:00	FEMA	Bob Jaske
11:30	Lunch	
1:00	Remarks	Len Rosen
1:15	Planning Session	All Participants
3:30	Action Paper and Wrap-up	All Participants

IDAHO FALLS TESTS

On June 24, 1981, the author received a telephone call from NRC personnel requesting ARAC participation in field experiments to be performed at Idaho Falls, Idaho, during approximately a ten day period in July 1981. ARAC's participation in these tracer tests fell within the objectives of this project to evaluate ARAC advisory information relevant to emergency response at NRC headquarters. Ensuing discussions between ARAC and NRC personnel in July 1981 resulted in the following plan for ARAC participation in the field experiments. Since ARAC personnel could not be committed continuously to potential inclusion in the full 10 days of tests, ARAC was asked to participate in two tests of 8 hours of real time plus an additional 16 hours of meteorological collection. Because of the short preparation time, it was decided that ARAC would not participate before July 21, 1981. The timing of the two tests would be decided jointly by LLNL and NRC, with notification to come 24 hours in advance of a potential real-time test with a window of ± 2 hours. ARAC would then be notified by NRC as soon as the release had started, at which time ARAC would begin producing assessment products. Idaho Falls would be considered an ARAC-serviced site to the extent that terrain, geography, and meteorological stations were on file. ARAC products would go to the NRC IRC site terminal and via telecopier to Idaho Falls. Meteorological data would be collected in real time from both the Idaho Falls Mesonet and the tower located at the release point via remote interogation or by telecopier or voice link, respectively, in case of communications failure. Upper air data for one location was to be sent from Idaho Falls to ARAC via telecopier or voice link. Wind speed and direction at the release point would be communicated to NRC via ACF message so that they could display the Gaussian. This was to be followed, if time allowed, by displays on the IRC site terminal of a PATRIC calculation and then of the MATHEW/ADPIC calculation. Initially, ARAC would calculate hourly surface integrated air, surface instantaneous air, and stack-height instantaneous air.

The first Idaho Falls test in which ARAC participated took place on July 23, 1981. ARAC was notified by IRC of a release at 11 05 GMT. Idaho Falls was then called to obtain wind and stability information. At 1111 GMT, Gaussian model input parameters were transmitted to IRC via ACF message. Transmissions proceeded during the day, but were interrupted by a communication problem that persisted from approximately 1200 to 1345 GMT. During this interval, the telecopier was used to transmit the Gaussian input parameters and MATHEW/ADPIC contours. ARAC output was transmitted to IRC and Idaho Falls until 1900 GMT. The second Idaho Falls test in which ARAC participated took place on July 27, 1982. IRC notified ARAC of the release at 1900 GMT, and ARAC output was transmitted until 0300 on July 28, 1982. Figure 4 summarizes the sequence of ARAC output delivered during both tests. The lower curves reflect transmission of the Gaussian model input parameters via ACF message. The upper curves reflect delivery of the ADPIC and PATRIC model products via the ARAC hardware system (solid line): + for ADPIC, Δ for PATRIC, and - - - for telecopier delivery.

The digitized topography used in the MATHEW/ADPIC calculations is given in Fig. 5. Representative contours transmitted during the first test are shown in Figs. 6-11. Figures 6-8 are PATRIC calculations representing, respectively, instantaneous air at the release height expected at 1700 Z (based on meteorology observed at 1600 Z), the integrated air at 2 m expected at 1800 Z (based on meteorology observed at 1700 Z), and the instantaneous air at 2 m expected at 1900 Z (based on meteorology observed at 1800 Z). Figures 9-11 show ADPIC calculations representing, respectively, the integrated air at 2 m expected at 1400 Z (based on meteorology at 1300 Z), the instantaneous air at 2 m expected at 1500 Z (based on meteorology observed at 1200 Z), and instantaneous air at the release height expected at 1900 Z (based on meteorology observed at 1700 Z). Representative contours transmitted during the second test at Idaho Falls are given in Figs. 12-17. Figures 12-14 are PATRIC calculation contours representing, respectively, integrated air at 2 m and instantaneous air at 2 m, both of which were expected at 2100 Z (based on meteorology observed at 2000 Z) and instantaneous air at the release height expected at 2300 Z (based upon meteorology observed at 2000 Z). The ADPIC calculation contours shown in Figs. 15-17 represent, respectively, the instantaneous air expected at 2000 Z (based on meteorology observed at 1900 Z), instantaneous air at the release height expected at 2200 Z (based on meteorology observed at 1900 Z), and the integrated air at 2 m expected at 0200 Z on July 28, 1981 (based on meteorology observed at 0100 Z).

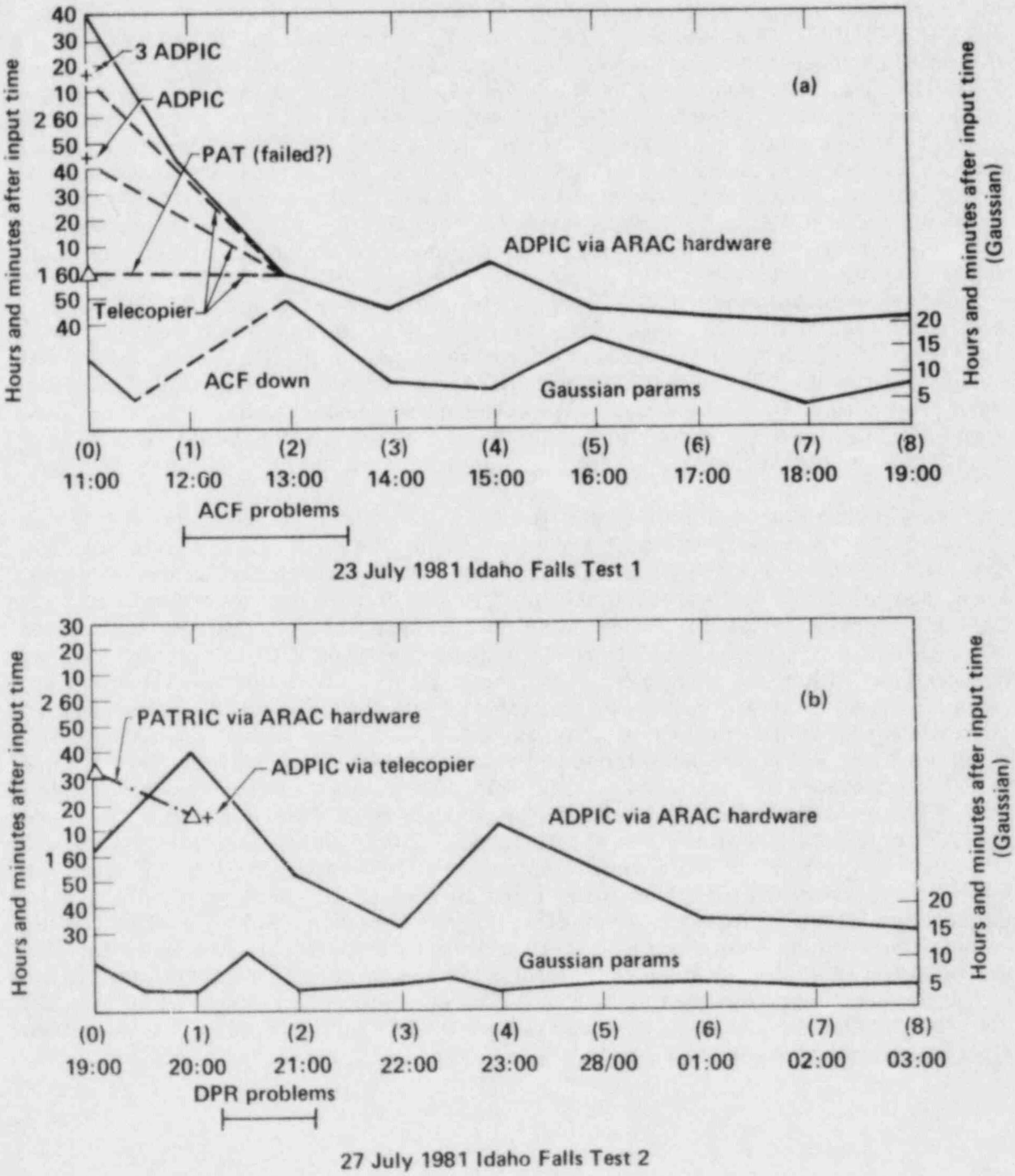


FIGURE 4. Transmission times of ARAC output during Idaho Falls tests.

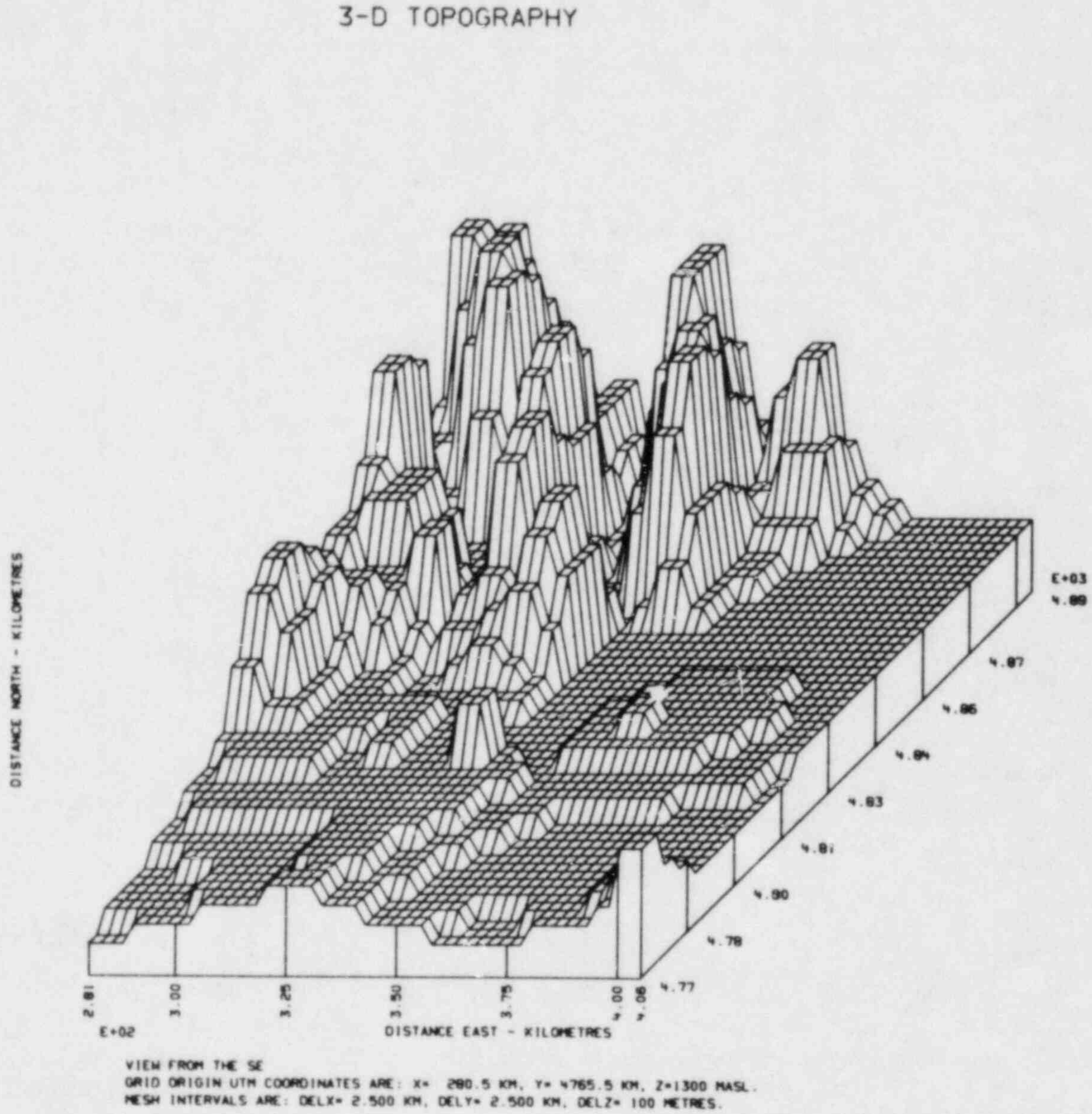
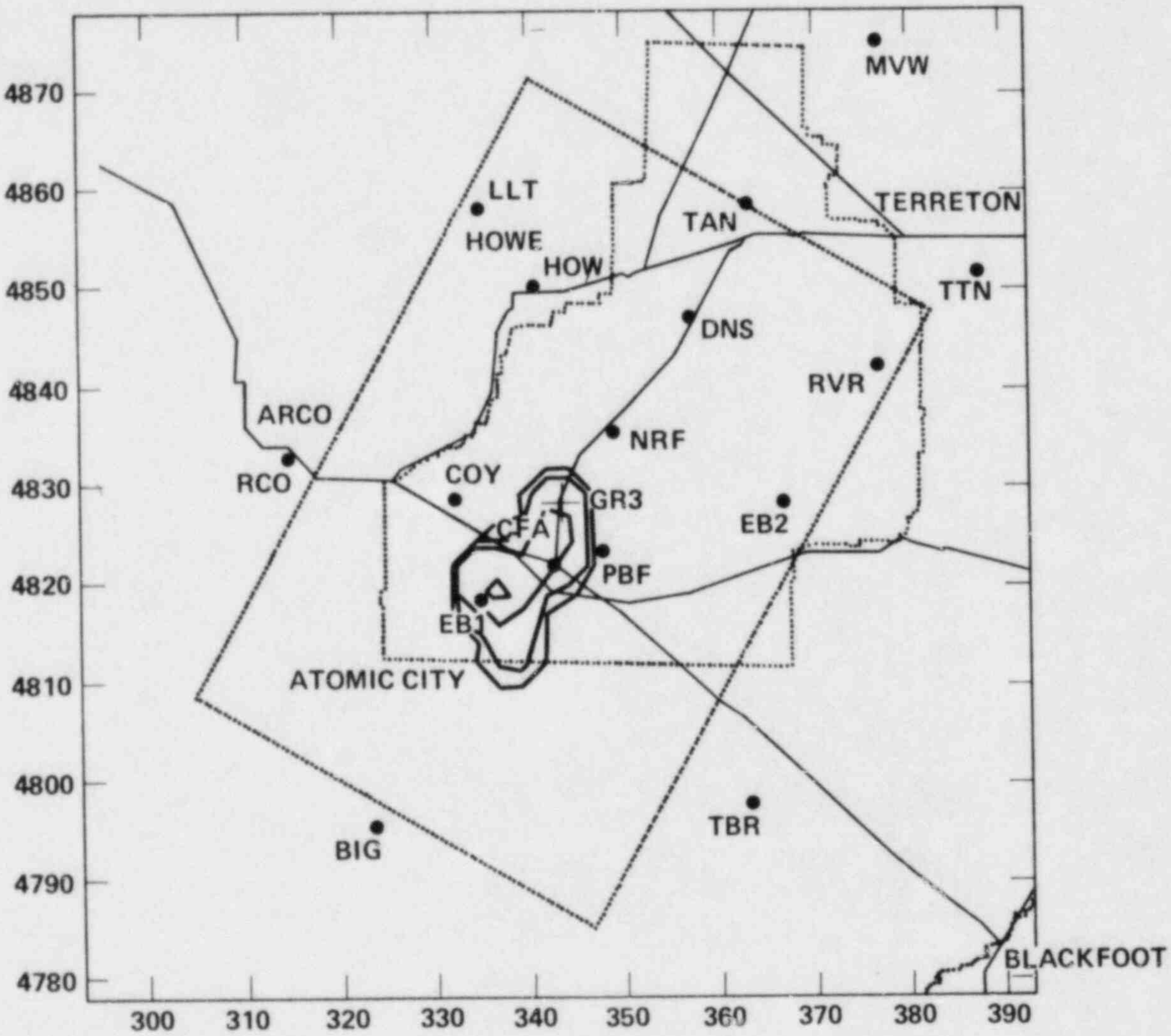
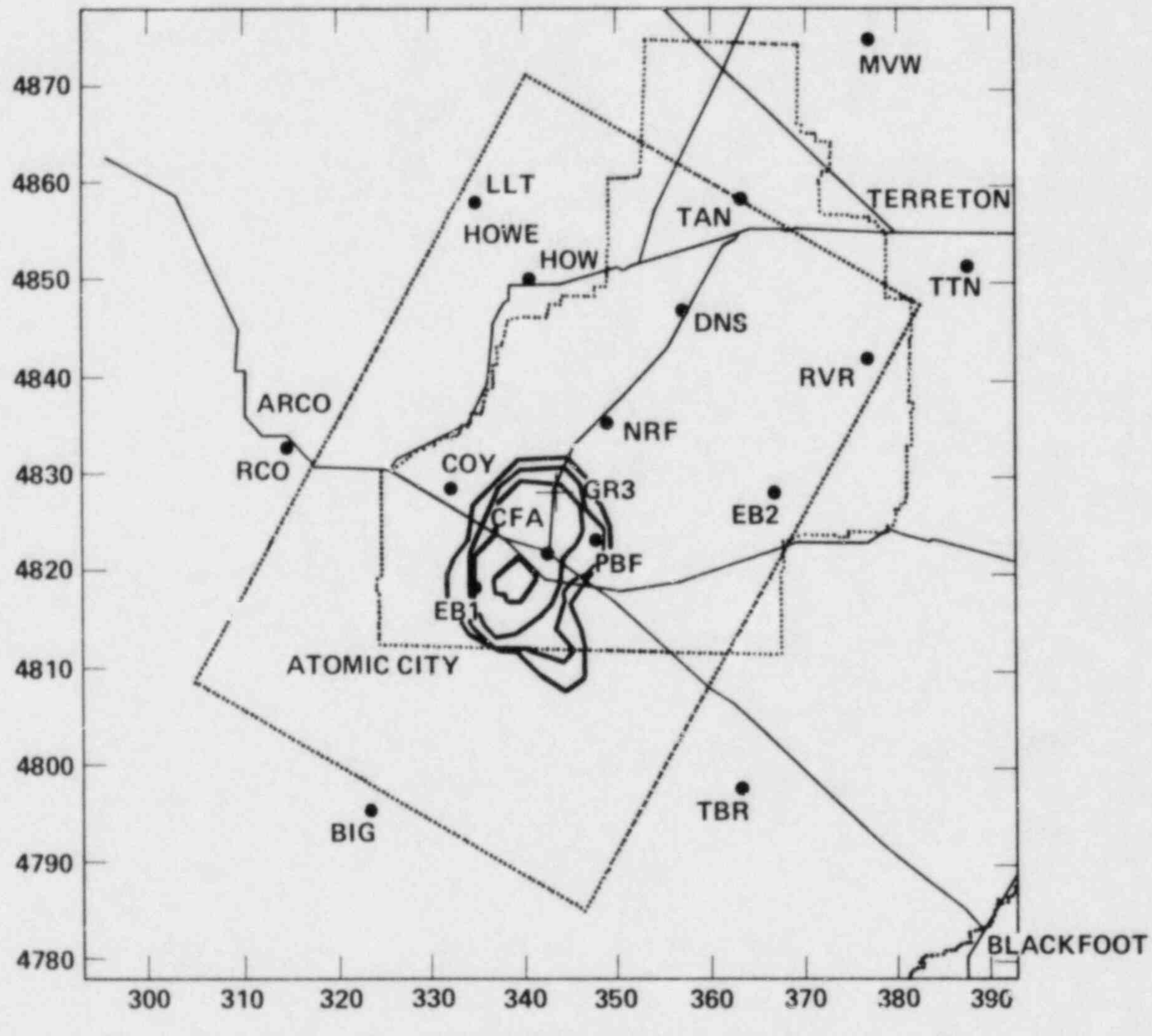


FIGURE 5. Topography.



1981 IDAHO FIELD EXPERIMENT (PAT CALC) MAX= 4.24E-05
SF6 BASED ON 1600Z 7/23/81 ISOPLETHS 3.E-05 3.E-06 3.E-07 3.E-08S/M3
INST AIR AT 46.M EXPECTED AT 1700Z

FIGURE 6. Idaho Falls test July 23, 1981, PATRIC calculation instantaneous air at 46 m expected at 1700Z.



1981 IDAHO FIELD EXPERIMENT (PAT CALC) MAX= 2.48E-02
SF6 BASED ON 1700Z 7/23/81 ISOPLETHS 1.E-02 1.E-03 1.E-04 1.E-05S2/M3
INTEGRATED AT 2.M EXPECTED AT 1800Z

FIGURE 7. Idaho Falls test July 23, 1981, PATRIC calculation integrated at 2 m expected at 1800Z.

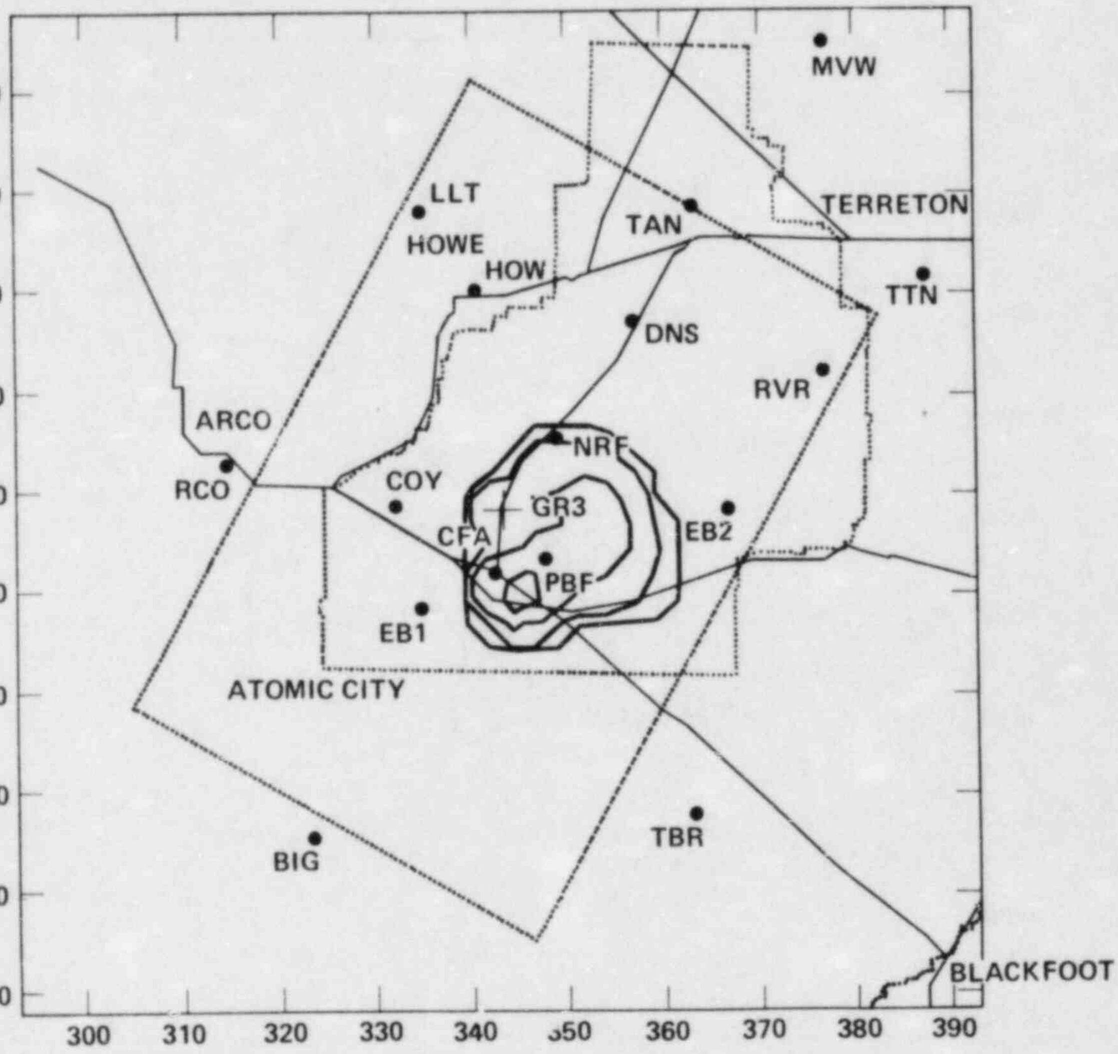


FIGURE 8. Idaho Falls test July 23, 1981, PATRIC calculation instantaneous air at 2 m expected at 1900Z.

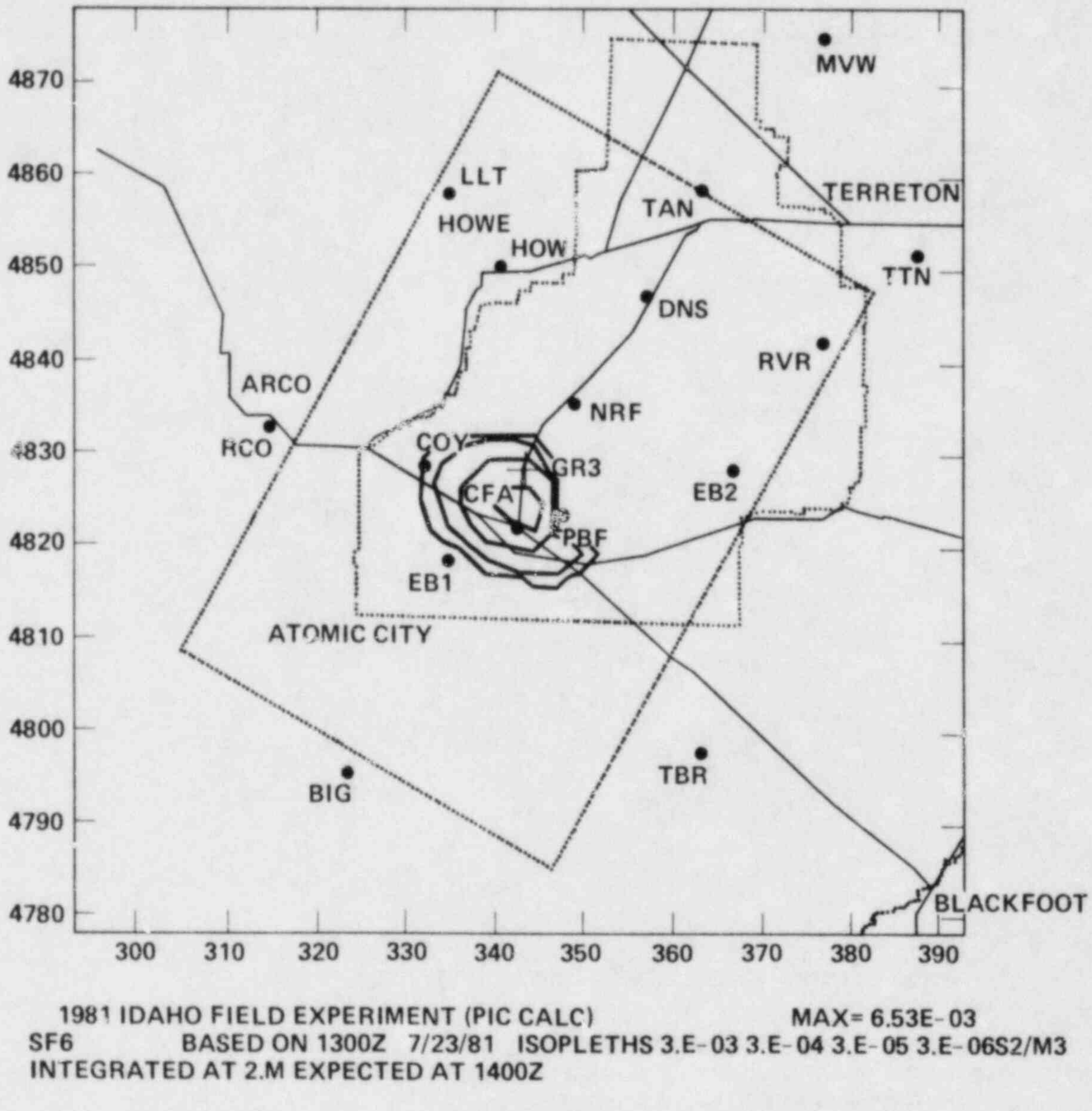
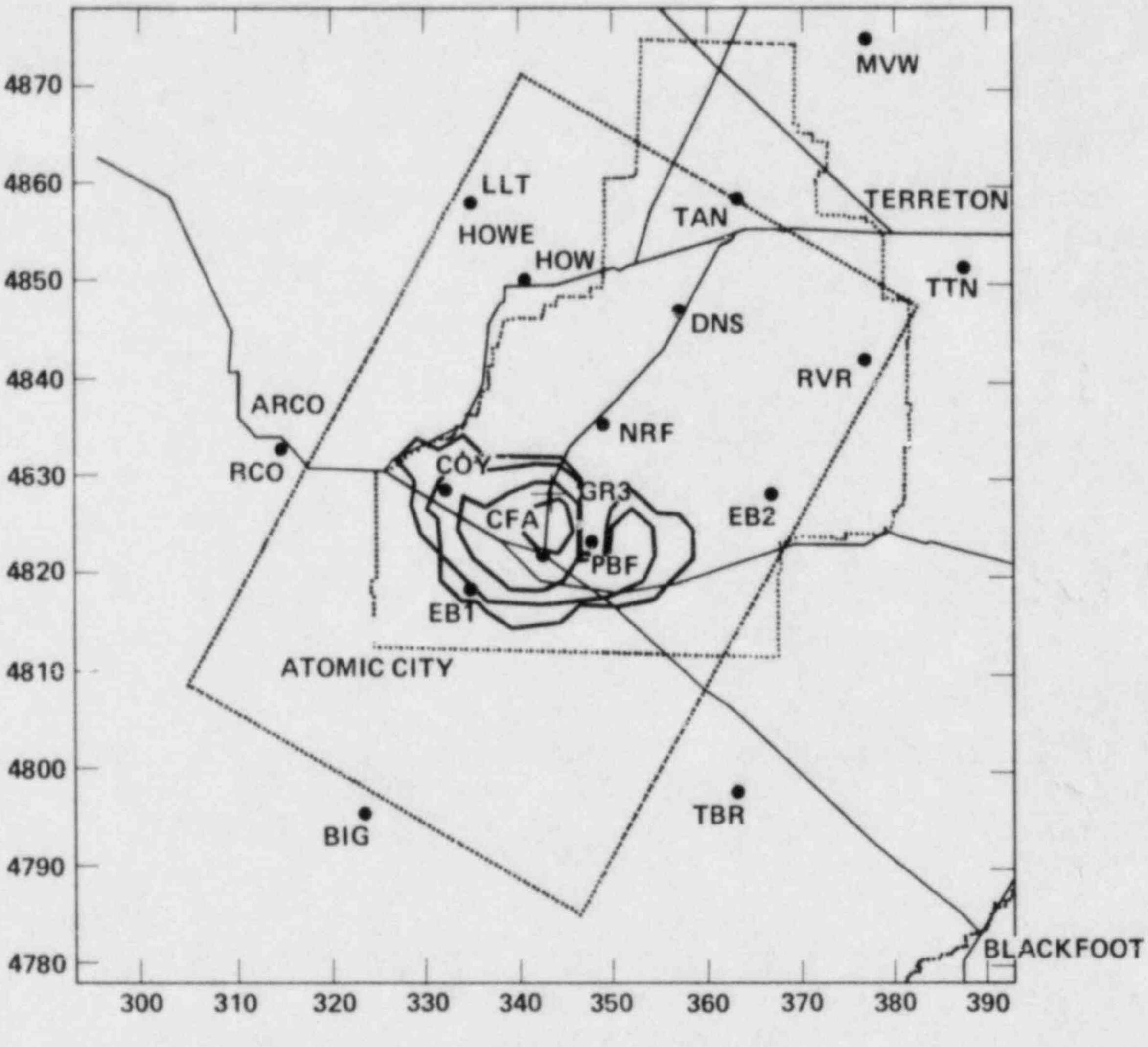


FIGURE 9. Idaho Falls test July 23, 1981, ADPIC calculation integrated at 2 m expected at 1400Z.



1981 IDAHO FIELD EXPERIMENT (PIC CALC) MAX= 2.76E-06
SF6 BASED ON 1200Z 7/23/81 ISOPLETHS 1.E-06 1.E-07 1.E-08 1.E-09S/M3
INST AIR AT 2.M EXPECTED AT 1500Z

FIGURE 10. Idaho Falls test July 23, 1981, ADPIC calculation instantaneous air at 2 m expected at 1500Z.

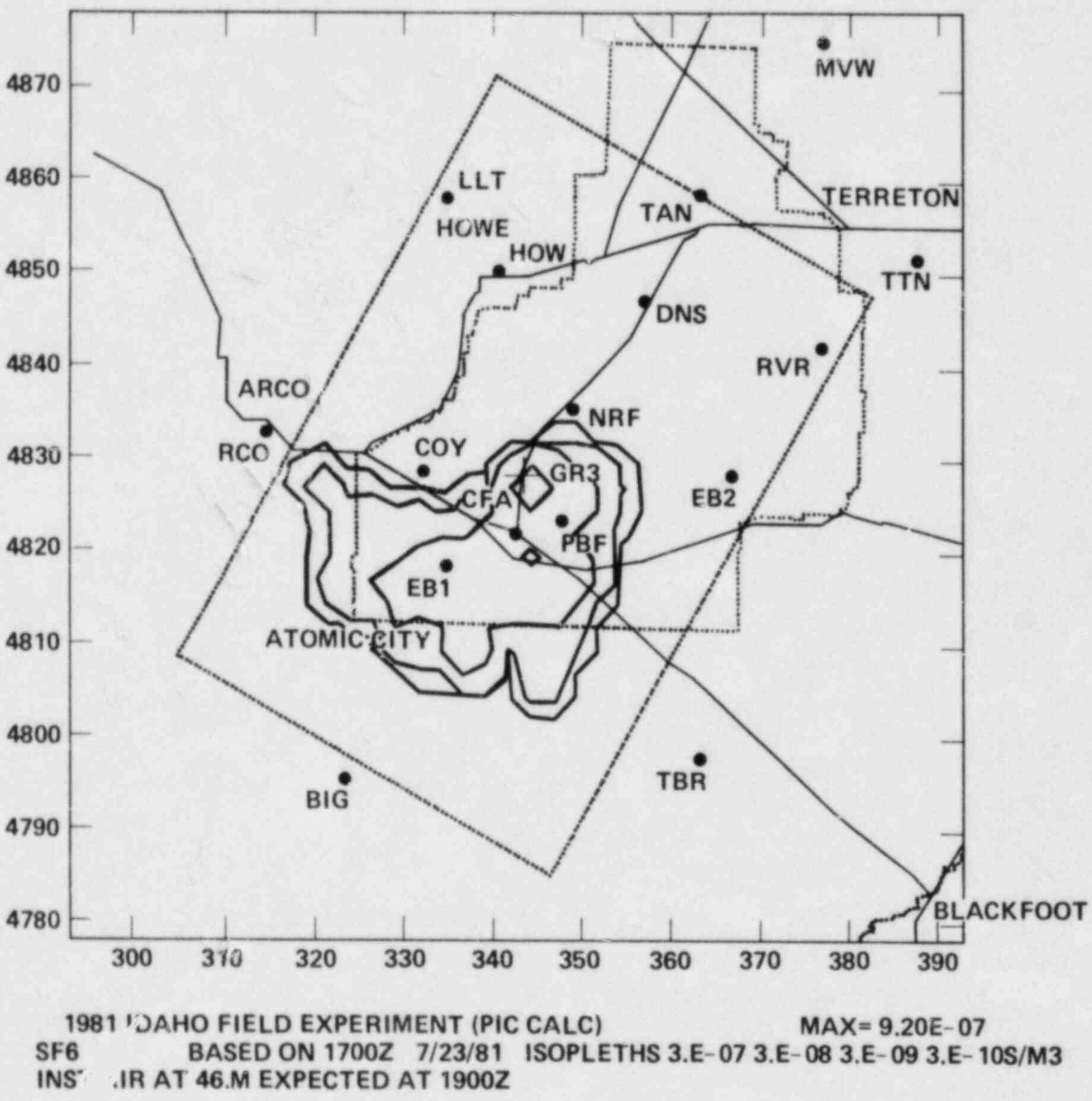


FIGURE 11. Idaho Falls test July 23, 1981, ADPIC calculation instantaneous air at 46 m expected at 1900Z.

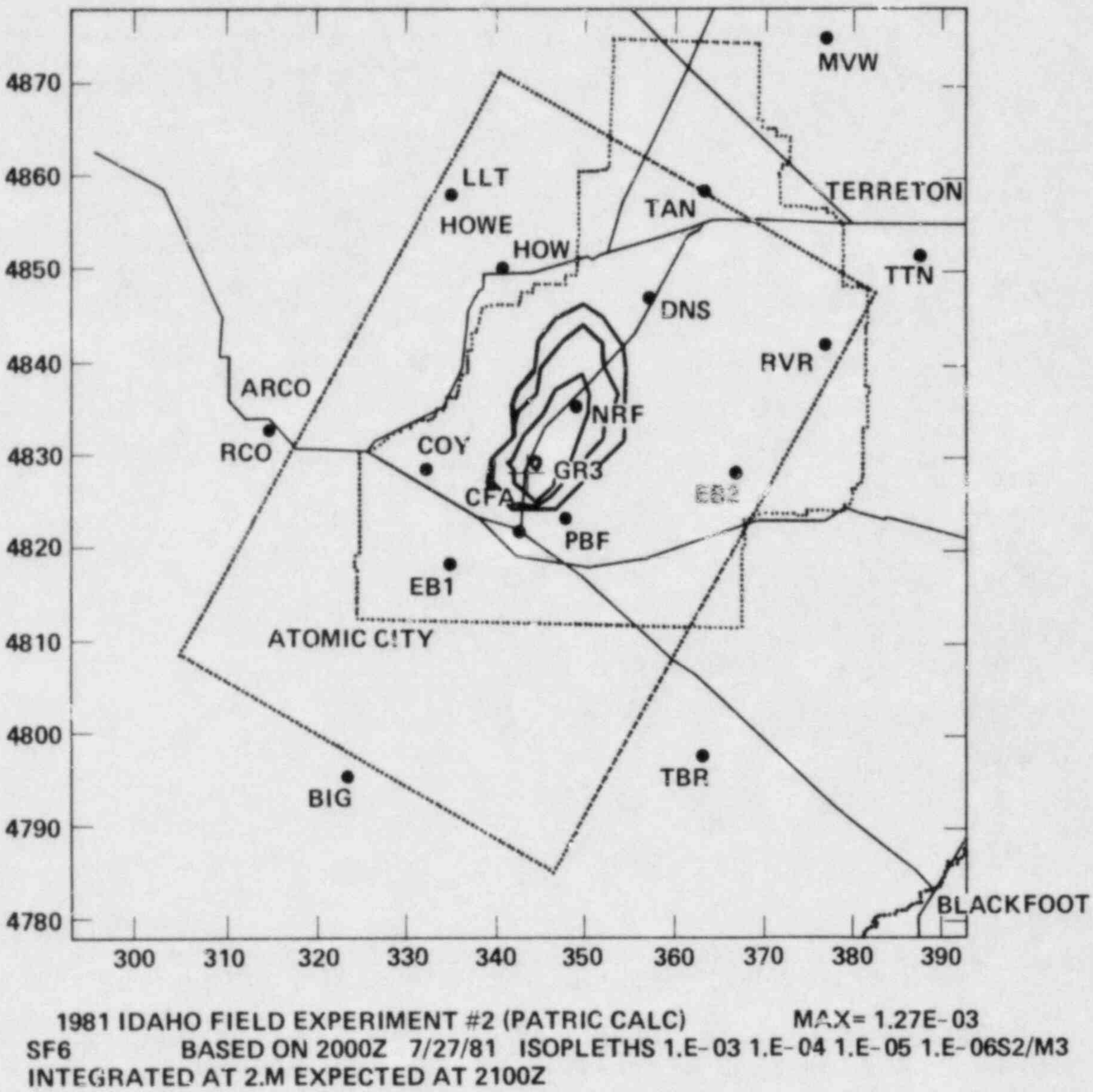
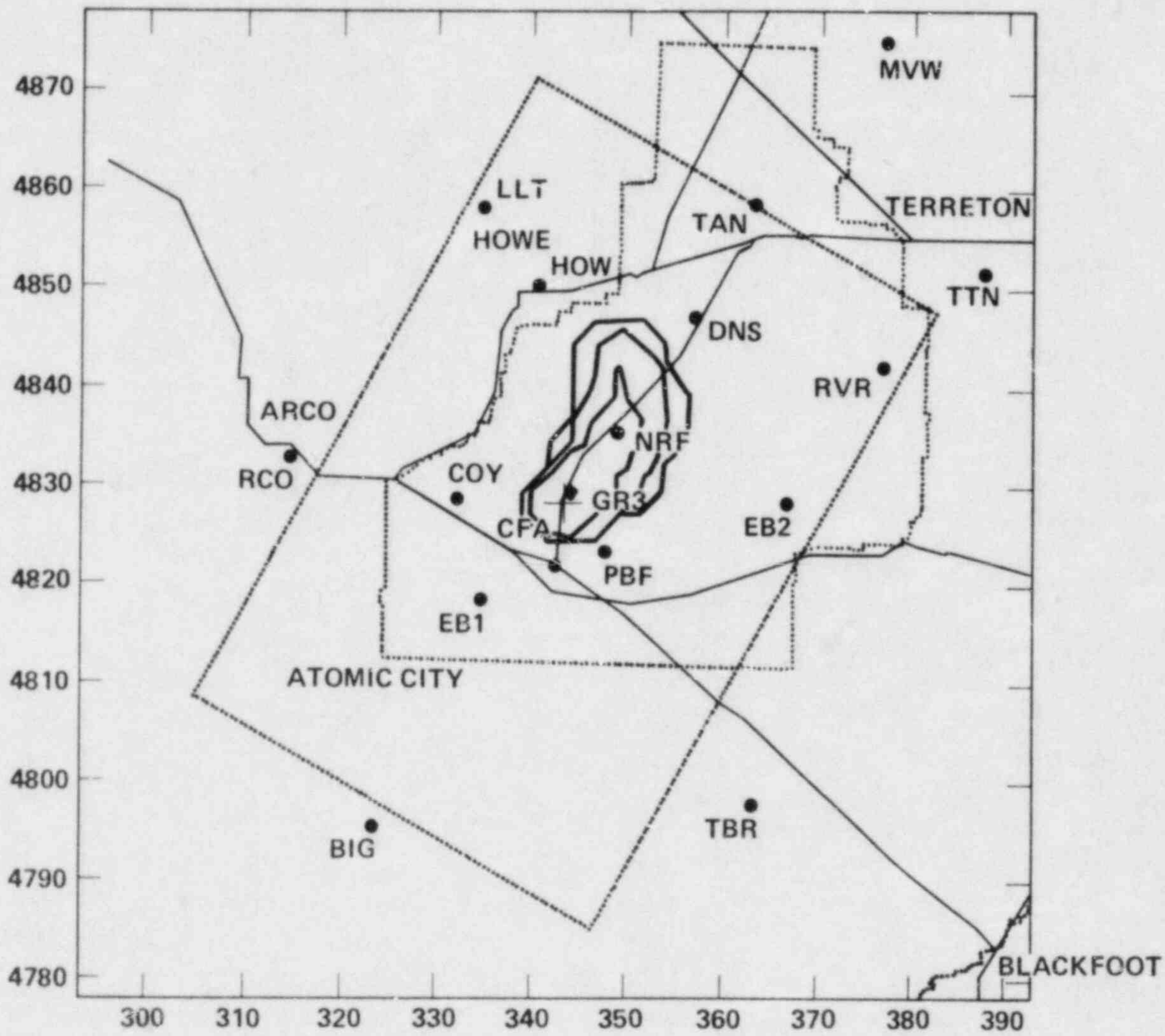


FIGURE 12. Idaho Falls test July 27, 1981, PATRIC calculation integrated at 2 m expected at 2100Z.



1981 IDAHO FIELD EXPERIMENT #2 (PATRIC CALC) MAX= 3.58E-06
SFG BASED ON 2000Z 7/27/81 ISOPLETHS 3.E-06 3.E-07 3.E-08 3.E-09S/M3
INST AIR AT 2.M EXPECTED AT 2100Z

FIGURE 13. Idaho Falls test July 27, 1981, PATRIC calculation instantaneous air at 2 m expected at 2100Z.

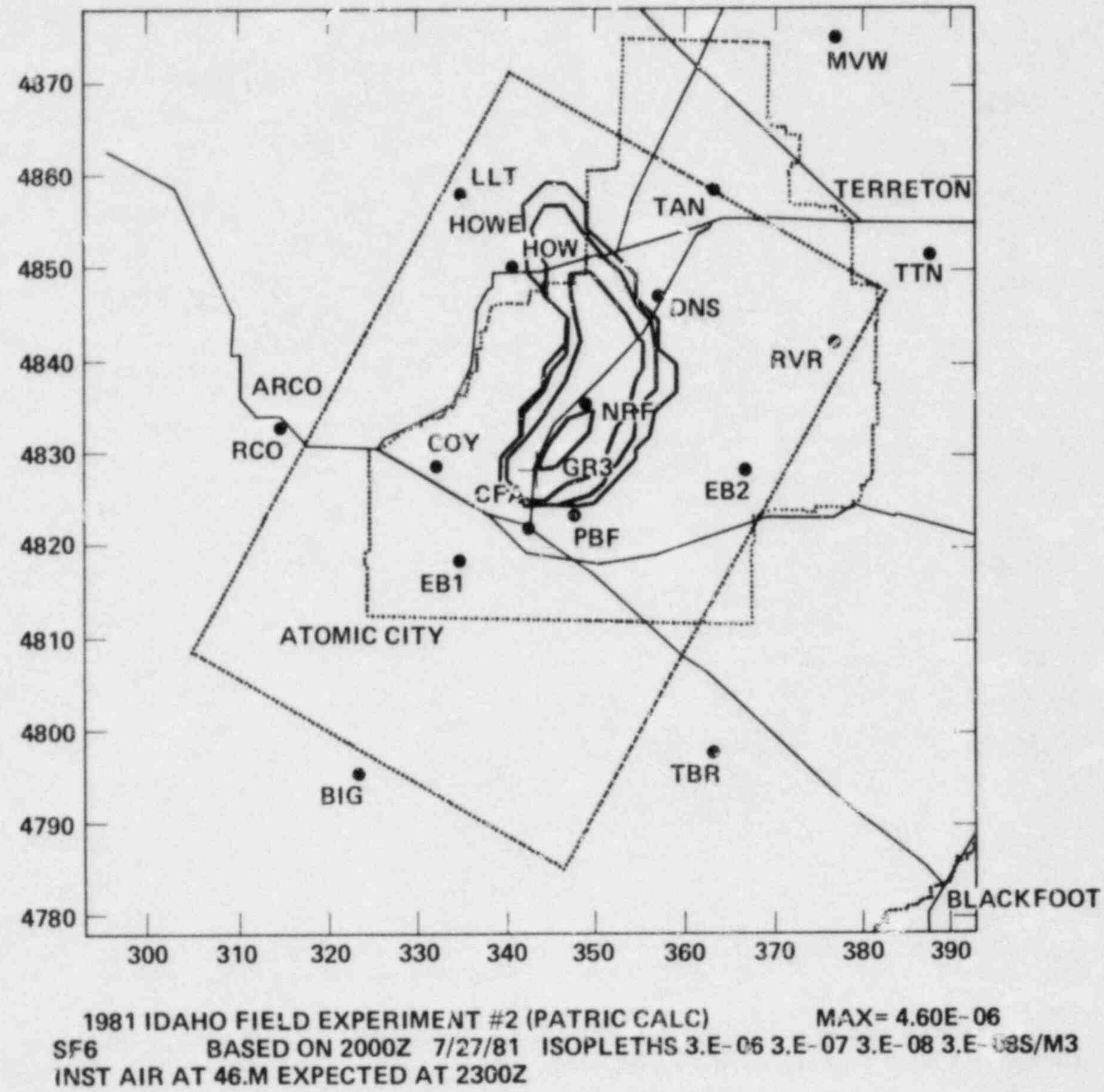


FIGURE 14. Idaho Falls test July 27, 1981, PATRIC calculation instantaneous air at 46 m expected at 2300Z.

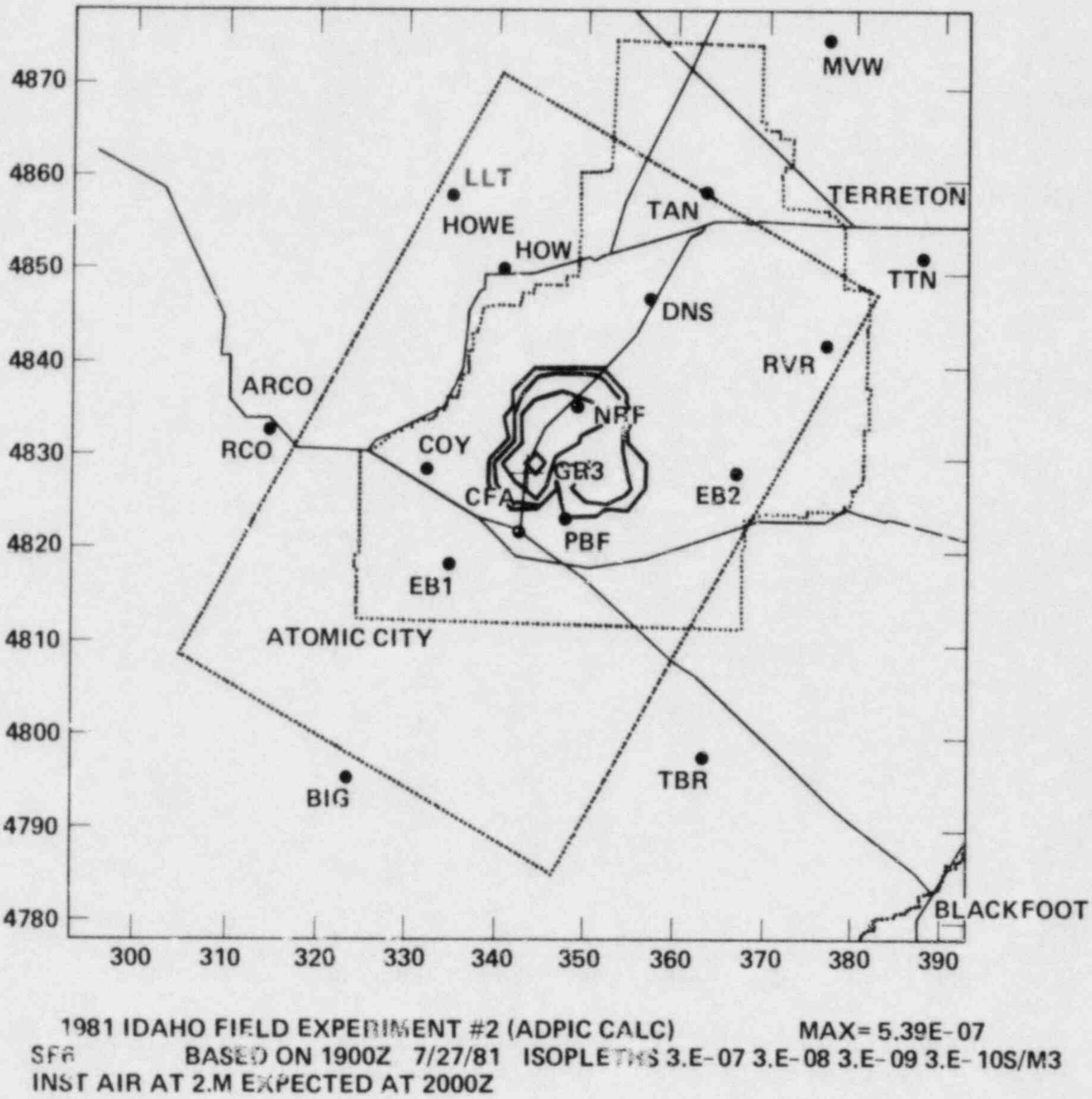


FIGURE 15. Idaho Falls test July 27, 1981, ADPIC calculation instantaneous air at 2 m expected at 2000Z.

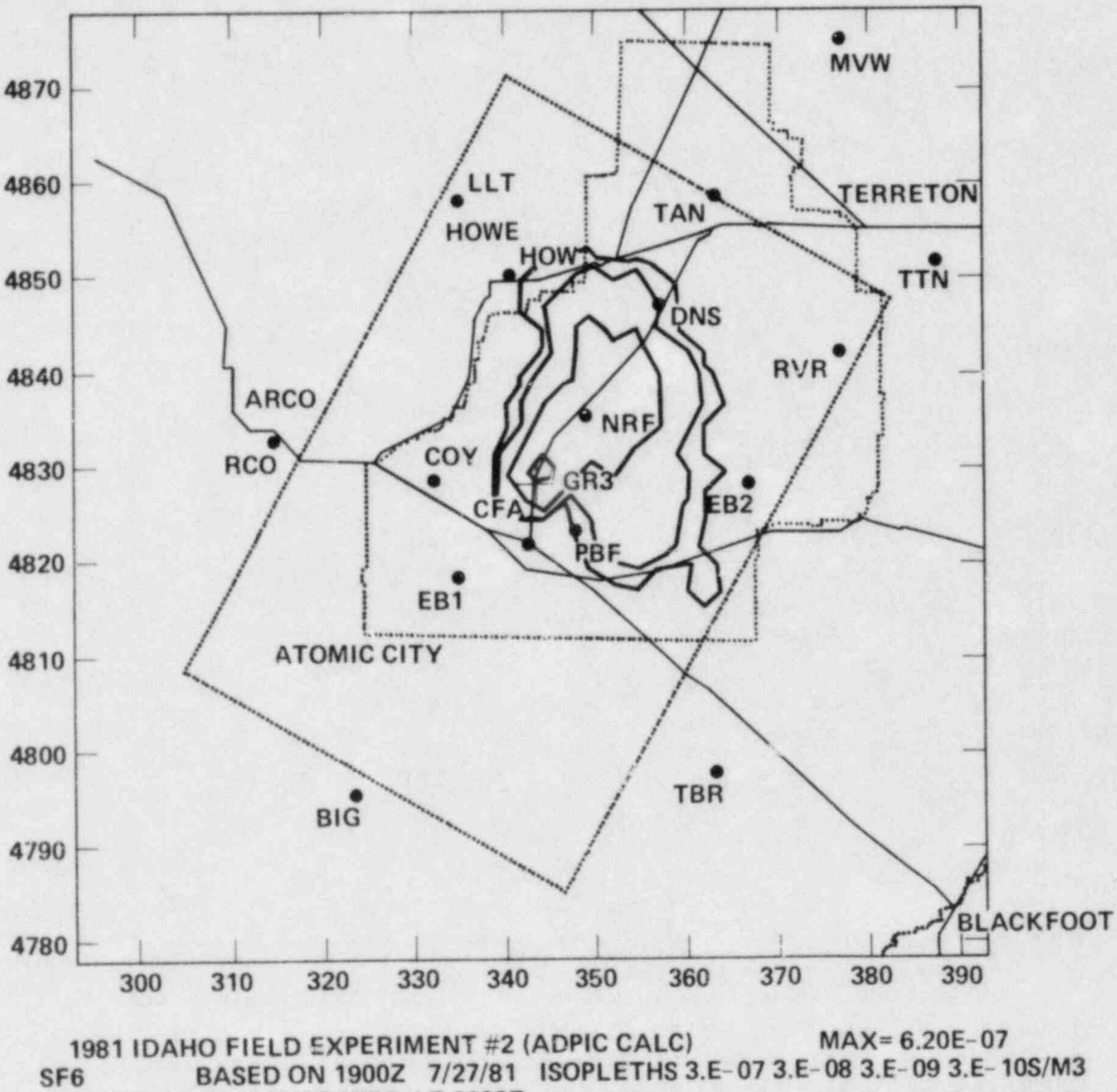


FIGURE 16. Idaho Falls test July 27, 1981, ADPIC calculation instantaneous air at 46 m expected at 2200Z.

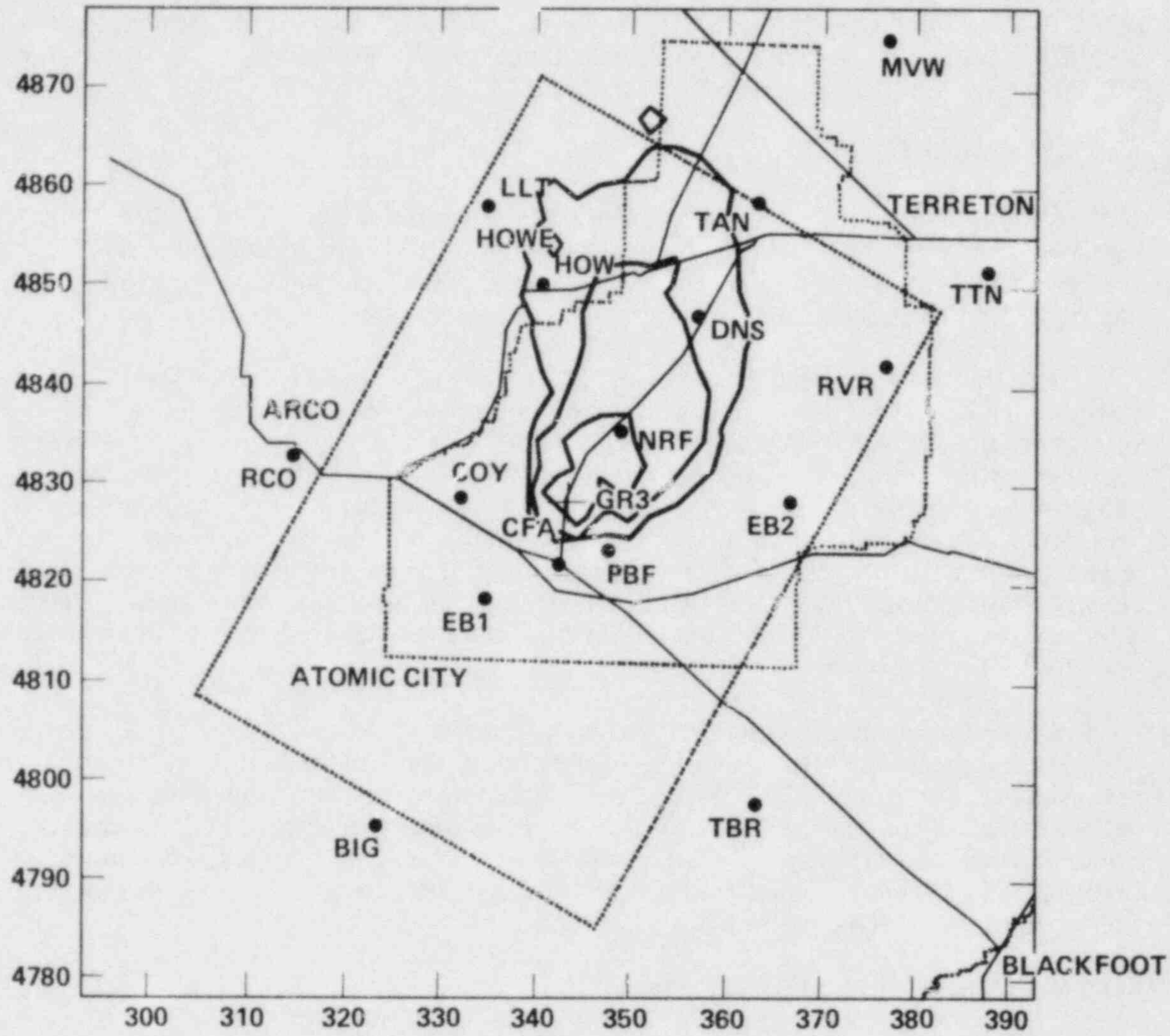


FIGURE 17. Idaho Falls test July 28, 1981, ADPIC calculation integrated at 2 m expected at 0200Z.

III. EVALUATION OF THE ARAC SYSTEM

The NRC participants in this project were asked to submit written critiques of the ARAC system after the completion of testing. These critiques, given verbatum in Appendix A, along with ARAC staff evaluations and the informal communications between ARAC and NRC participants, contributed to the body of experience evaluated and discussed within this section.

Overall, the NRC staff said they were "impressed with the system, its fast response, well-documented outputs, and well-informed operators" (see Appendix A). Specific evaluations are discussed below under the subheadings: "Communications," "Meteorology and Suite of Models," and "Staff."

COMMUNICATIONS

Communication by the site system user consists of the site system operator's interaction via the keyboard to obtain such menu information as Gaussian plots, and the site system's interaction via the console, with the ACF to send and receive messages and to receive contours.

The preliminary testing and two full tracer field exercises on July 23 and 27, 1981, enabled the NRC operators to become proficient at obtaining menu information through operation of the keyboard. However, because no meteorological interface was established at IRC, meteorological data had to be supplied to the site by putting "canned" data on a tape or by communicating it, as was done in the Idaho Falls tests. Because of the age of the hardware, the project was fraught with certain problems. For example, the joy stick broke, the light pen worked inefficiently, the tape drive broke, and the site tape stretched. The design of the next generation ARAC system, which utilizes state-of-the-art hardware, will remedy these problems.

Communications between the site system user and the ACF presented problems associated with message interruptions that disturbed the transmittal of messages and contours. The NRC staff commented that the time interval set in the software when in the communications mode was too short. Of necessity, the operator had to periodically hit the delete key so as not to lose the images of the contours displayed. These factors have been considered in the design of the next-generation ARAC system.

METEOROLOGY AND SUITE OF MODELS

The three numerical models used to determine concentration contours during this project were Gaussian, PATRIC, and MATHEW/ADPIC, all of which are described briefly in section I. Normally, the meteorological tower interface would supply tower data directly to the site system for the purpose of computing Gaussian contours. As discussed earlier, this information was supplied by tape for the preliminary testing and by the ACF during the Idaho Falls tests of July 17 and 23, 1981. During the tracer field studies, the ACF interrogated the Idaho Falls mesonet. One set of upper air data was supplied hourly to the ACF. This meteorological input was used to develop the wind fields generated in PATRIC and MATHEW/ADPIC. The models employed have been evaluated with respect to their accuracy in past experiments. In particular, MATHEW/ADPIC had been compared successfully with measurements using methyl iodine tracers at Idaho Falls, Idaho and ^{41}Ar plumes at Savannah River Laboratory.[5] Thus, evaluation of the models herein is concerned with such factors as availability, timing, and comprehensibility. In the future, however, the ARAC staff will analyze data from the tracer experiments in ARAC model evaluation studies.

The response time for the tranmission of ARAC output is given in Figure 4 for the July 23, 1981 and July 27, 1981 tests at Idaho Falls. The Gaussian model was generally available at the IRC site system using data supplied by the ACF within 15 minutes. During some exercise hours, the ADPIC output was delayed at times by more than two hours. This was due in large part to hardware breakdowns and communications interruptions. Further, the time required to plot the contours frequently consumed a large fraction of the time between hourly transmissions, thus eliminating the possibility of transmitting many messages at these times. These problems have been considered carefully in the design of the next-generation ARAC system.

STAFF

The staffs of the ACF and the NRC IRC form an integral part of the ARAC system. The ACF staff is comprised of meteorologists, physicists, computer scientists, and electronic engineers. The site system staff is generally composed of personnel from fewer disciplines. In particular, the IRC must depend on service contracts with the manufacturer to ensure continued operation of the hardware. In general, the project has been marked by the cooperation of the staffs of the NRC IRC and ARAC who worked together in executing, completing, and evaluating the use of the ARAC system at the NRC IRC.

IV. IMPLICATIONS TOWARD THE DESIGN OF THE NEXT-GENERATION ARAC SYSTEM

The experience gained in this pilot project as well as a companion FEMA study has been of great value in designing the next-generation ARAC system, which is expected to be operational by mid FY 1984. The next- generation ARAC system is expected to include state offices, as appropriate. Basically, the current site system performs five distinct functions: (1) meteorological data collection and display, (2) local Gaussian plume projections, (3) transmission of meteorological data to the ARAC center, (4) transmission and display of regional model contour products from the ARAC center, and (5) a user-to-ARAC operator message facility. Of these, functions (2), (4), and (5) will be retained in the new site system together with some additional functions.

The collection and transmission of meteorological data from the site to the ARAC facility will be accomplished by a separate computer that conforms to the standards for data collection and reporting set forth in NUREG-0654. The site system will have access to this data either directly as a user of the meteorological system or indirectly by way of the ARAC center or network gateway. In this type of network, the user need not know the actual source of the data.

To optimize the ARAC system's speed of response to an emergency situation, it is highly desirable to have an automated method for collecting all necessary meteorological data. A proposed computer-to-computer communication standard for an emergency response system, in particular the next-generation ARAC system, is discussed in detail in Appendix B of this report.

It has been the experience of ARAC, in particular during the TMI accident and during the Idaho Falls testing, that a direct intercomputer link is very useful in the retrieval of necessary data without manual interaction. However, certain flaws become evident (namely the high initial start-up effort), error detection and connection is difficult to impossible, and low-speed links make collection slow and error correction even harder. The proposal for computer-to-computer communications is intended to correct these deficiencies.

The standard protocols and ways of collecting meteorological data are given in detail in Appendix B. This proposal for computer-to-computer communications is directed at answering a variety of needs for sites, agencies, and ARAC: automated meteorological data collections, standardized formats for all ARAC users, error-free data transmissions, an increased data transfer rate, remote software distribution capabilities, on-site calibrations of meteorological systems, and interim ARAC product distributions. The site system will retain the capability to generate local model predictions based on local or user-specified meteorological data. Either an enhanced Gaussian model or a range of other model types up to and including direct access to MATHEW/ADPIC-type models may be used. These codes will be executed either at the ARAC facility or locally, depending on the type of code and the configuration of the user's site system. The physical site system may consist of anything from a simple graphics terminal and hardcopy unit that can request and display data as generated by the ARAC facility to a VAX-class machine with multiple graphics workstations capable of generating complex modeling information locally. Again, the user need not be aware of the type of system used since the same functionality will be available to all users. A typical site may have only a small meteorological data collection computer and a simple graphics terminal to request and display data. A state or regional response center may well have a VAX-class machine with local modeling capabilities. It will be up to the user to decide the speed and usage requirements for his site to determine what level of system is required. Typical installations may run from a low of about $25 K up to more than $200 K for a large multi-user regional response system. One advantage of this type of network is that the computing resources may be spread over a large area, giving all users an improved reliability and response. In addition, the user is basically in control of the information he receives. There is no need to send six regional model contours to a user who only wants one, which takes time and increases the confusion at the user's end. In an emergency, the ARAC facility will make available to the user a broad range of products from which to select. During routine operations when only a simple advisory calculation is needed, the user may select the data type and parameters directly without the direct intervention of the ARAC staff.

V. REFERENCES

1. Dickerson, M. H. and R. C. Orphan, "Atmospheric Release Advisory Capability," Nucl. Safety, 17(3), 281-289, 1976.

2. Sherman, C. A., "MATHEW: A Mass-Adjusted Three-Dimensional Wind Field Model," Ph.D. thesis, University of California, Davis, California, 1978a.

Published as UCRL-52479, Lawrence Livermore National Laboratory, Livermore, California.

3. Sherman, C. A., "A Mass-Consistent Model for Wind Fields Over Complex Terrain," UCRL-76171, Rev. 3, Lawrence Livermore National Laboratory, Livermore, California. Published in J. Appl. Meteor., 17(3), 312-319, 1979b.

4. Lange, R, P. H. Gudiksen, and K. R. Peterson, "ADPIC: A Three-Dimensional Computer Code for the Study of Pollutant Dispersal and Deposition on the Regional Scale," UCRL-76492, Lawrence Livermore National Laboratory, Livermore, California, 1975.

5. Lange, R., "ADPIC: A Three-Dimensional Particle-in-Cell Model for the Dispersal of Atmospheric Pollutants and Its Validation Against Regional Tracer Studies," UCRL-76170, Rev. 3, Lawrence Livermore National Laboratory, Livermore, California. Published in J. Appl. Meteor., 17(3), 320-329, 1978a.

6. Lange, R., PATRIC: A Three-Dimensional Particle-in-Cell Sequential Puff Code for Modeling the Transport and Diffusion of Atmospheric Pollutants," UCID-17701, Lawrence Livermore National Laboratory, Livermore, California, 1978b.

7. Lawver, B. S., "ARAC Site Terminal Installation Guide," UCID-18569, Lawrence Livermore National Laboratory, Livermore, California, 1980.

8. Cassaro, E. and L. Lomonaco, "Operators Guide: Atmospheric Release Advisory Capability (ARAC) Site Facility," UCID-18050, Lawrence Livermore National Laboratory, Livermore, California, 1979.

APPENDIX A. COMMENTS BY NRC STAFF

COMMENT 1 -- NRC ARAC Capabilities When System was Received

- Can only run cases for LLNL area (includes San Francisco) [only map tape]
- Have a fixed set of "tower" data in system [on tape]
- Can also make up data.
- Can run infinite number of Gaussian cases using "tower" or own data.
- Can list off three results from ADPIC model [fourth contains errors] that were run as test cases by LLNL last spring (1980).
- Can telephonically connect the LLNL operator and type messages on terminal.
- Can receive messages from LLNL on terminal and results from LLNL test (if LLNL is source point).
- Cannot initiate test cases of regional model from IRC.

COMMENT 2 -- ARAC System

Menu

1. met parameters
2. met tower
3. wind rose
4. site map -- 200 km x 200 km
5. (detailed) site map
6. regional map
7. trajectory map
8. Gaussian calculation
9. regional map calculations
10. communications with ACF
11. disconnect
12. set emergency
13. plot

Comments

- The output from the Gaussian calculation only includes stability, the output should also print the wind speed, wind direction and observation time for each calculation.
- In case of a system malfunction where a command procedure is faulty (misunderstood or ambiguous) the error incurred causes the mini to reboot and begin again. If communications were set with ARF, the flags remain open and the computer to computer link is undisturbed.

- When in the communication mode with ARF, the time interval set in the software for reestablishing contact with ARF is short. This creates several difficulties when working with the system. First, you are never quite sure whether ARF is trying to communicate with the user or it's just the computers shaking hands. The second situation that arises when in the communication mode is, in order to view the contours without losing the image, you have to periodically hit the delete key, to keep from going into the send subroutine. If you miss hitting the key in time you lose your image.

- Our plotting package works fine. The graphics are clear and seem to be concise. The software encourages wasting paper which should be changed. Since the plotter has a paper advance there is no need to skip two sheets of paper between graphs.

- The response times were short and improved with system operation. ARF was able to receive met data, run their model (ADPIC), and send us the results (integrated and instantaneous contours), within one hour. The values received were forecast concentrations valid one or two hours after the observation time. When having computer difficulties, the telefax system was used as a backup. Hard copies of the ADPIC output were sent via the 3-M (4 min. rate) copier. These concentration contours were of a much lower quality. Most of the maps were readable, but several copies lost the heading and therefore were rendered useless. The heading contains the observation time for the data used and valid time for the concentration isopleths.

- For the most part, testing of the system was done with minimal telephone communication. Several calls by ARF were necessary when the operator held the screen preventing the computer from going into the send/receive mode. This caused several aborts when ARF was trying to communicate or send over contours. Occasionally, these aborts caused a system malfunction, twice as I remember, which in turn led the mini to reboot the program. During a real incident, open communication lines (telephone) would prevent much of the time and data loss due to misinterpretation of the send/receive signal.

I was impressed with the system, its fast response, well documented outputs and also with the well informed operators. Having the capability to graphically display Gaussian model output from trial data is also a major plus for the system. As for the validity of the model output, that would be where the real test of ARAC lies.

COMMENT 3

The ARAC terminal at the NRC Incident Response Center can presently be used to simulate atmospheric releases from LLNL using a simple straight-line Gaussian diffusion model. Output from the MATHEW/ADPIC or PATRIC models can also be received if the release is assumed to be at LLNL. In order for any other sites to be simulated a "site tape" is needed. The "site tape" contains the site area topography, and mini-computer instructions. For demonstration purposes, the LLNL site tape in the IRC contains sample meteorological data. The terminal user can also input meteorological data for use in the simple model.

MATHEW/ADPIC files were received in the fall (1980) at the IRC ARAC terminal. There was initially some difficulty in establishing communication for the transmission. Three output files were transmitted, however, only two were retrievable due to what appeared to be transmission errors.

The terminal has no immediate utility if there is not an existing site tape. Site-specific transport diffusion estimates cannot be made or received without the site tape.

The NRC ARAC terminal is only a receiving point for and cannot initiate MATHEW/ADPIC simulations. No onsite meteorological data can be received through the terminal.

In the one year since the equipment has been installed the following equipment problems have been identified:

1. broken "joy stick"
2. light pen doesn't work well
3. tape drive is broken
4. site tape has been stretched.

COMMENT 4

In response to your request, we have prepared some comments directed toward improving the ARAC. These are as follows:

1. Site terminal tapes should be cassettes rather than open reel for easier handling.

2. Map scales should be provided on all outputs, perhaps to correspond to a standard USGS map scale (i.e., 1/25,000 or 7.5 minute) so that overlays can be prepared.

3. A method is needed whereby the ARAC system can transmit meteorological and terrain inputs as well as plume isopleths.

4. A dispersal model, consistent with the Class A model of NUREG-0654 (Rev. 1), should be developed to accept meteorological input from one location (and possibly supplemental locations), the gamut of release characteristics and terrain conditions.

5. Contour maps received at the site terminal should include latitude and longitude of the release point as well as (x,y) location from a local grid.

In summary, the improvements should provide enough versatility at the site terminal so that ARAC system products including the simple Gaussian model, an intermediate scale model (i.e., Class A model of NUREG-0654, Rev. 1) and the full scale particle-in-cell model can be received and be readily interpretable by the user, which may be federal or state agencies.

APPENDIX B. COMPUTER-TO-COMPUTER COMMUNICATIONS FOR ARAC AND OTHER EMERGENCY RESPONSE AGENCIES

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The purpose of this appendix is to outline a proposed standard for intercomputer communications. The main users of this mode will be the interim upgrade version of ARAC and the next generation ARAC system. The fundamental reasons for proposing this standard are as follows:

- Automated inter-computer data transfer.
- Error-free transmission using X.25 and X.29 CCITT standard protocols.
- High-speed transfers of data over direct-dial lines.

To speed the response to an emergency situation, it is desirable to provide an automated method for collecting all necessary meteorological data. The time involved in placing a manual call, requesting the data, returning the requested data, and then manually entering that data into the proper computer file for subsequent numerical calculations is both time-consuming and error-inducing. By providing a direct intercomputer link, it is possible to retrieve data without manual intervention. Such an approach was used during the TMI incident and again during the INEL exercise, both of which demonstrated the usefulness of direct computer links. Three major flaws came to light during both uses:

- A high initial start-up effort is needed.
- Error detection and correction is difficult to impossible.
- Low-speed links make collection slow and error correction even harder.

Because interface with the appropriate site personnel is necessary to work out the idiosyncracies of the system, the intial start-up of a link can take several days. This effort is not too difficult if a site was scheduled to be added to the network, but is almost impossible in an emergency. Both site and ARAC personnel are busy, and everything must be done immediately. ARAC and other agencies desperately need to access meteorological data directly from any site. With the large numbers of sites that may be using ARAC services, however, the task of accessing many different systems will become monumental. Therefore, a standard access method is essential if the ARAC system is to be utilized efficiently.

The standard should be flexible enough to handle a variety of users but strict enough to allow easy access to the required data. The CCITT standard line and link protocols, X.25 and X.29, are available on almost every computer system. These protocols specify intercomputer communications up to the Interactive Terminal Interface.

The use of X.25 with the Interactive Terminal Interface would allow the user to retrieve meteorological data in 15 min. averages from the system. In addition to meteorological data transfers, an optional mode discussed later would allow ARAC products to be sent to the site. New software revisions could also be transferred from ARAC to the site.

Protocol X.25 answers the need for error-free communications. If an error is detected, then the system automatically retransmits the information. This ensures that the information sent from computer to computer is always received correctly.

Protocol X.25 also provides independence from the physical communications medium, allowing the computers to communicate via direct-dial telephone lines, leased lines, satellite transponders, or other mediums. This flexibility should allow communication with virtually any site. Besides providing independence from the medium, X.25 also allows a broad range of communication rates, which can be as high at 56,000 bits per second. A 212A-type modem and standard direct-dial telephone lines can be used to achieve rates up to 1200 bits per second. With current technology, this is probably the fastest speed that can be used reliably over commercial direct-dial lines. Higher rates may be used with other types of modems and/or lines. At 1200 bits per second, the data may be retrieved in one-fourth the time required for a terminal at 300 baud, which answers the need for higher speed retrieval of required data.

The meteorological data may be collected in a number of ways:

- Analog-to-Digital (A/D) convertors from sensors.
- Binary data bit-stream
- ASCII data bit-stream.
- Prompt for requested data.
- Parallel data path.

The A/D convertor would be used as the standard interfacing mechanism for most new and upgraded sites, allowing direct connection to the tower sensors and a great degree of control over data quality. For sites with existing or special telemetry systems, either the binary or ASCII bit-stream would be the best approach. In this mode, data from the sensors have already been converted, and the meteorological collection system needs only to listen for them. Although this mode would have to be customized for each site, the task would be fairly straightforward. For sites that have existing meteorological collection systems but are unable to communicate via X.25, this system could function as a protocol convertor. When a request for data is made, the convertor would format the proper request for the host and retrieve the data. The data would then be transmitted to ARAC, using X.25. This approach is also highly customized, but should not be too prohibitive. The last method, a parallel connection to some specialized meteorological collection network, is customized by nature and should only be considered as a last resort.

All meteorological collection systems should be able to support a local terminal(s) for site use, dial-in terminal(s) for other agencies, backup for computer communications, and an intercomputer communications link. To reduce training and confusion amoung users, user sites would have a similar data format. The system should maintain the last 12 hours of 15- min. averages for user retrieval. It should also provide a means by which meteorological data can be calibrated locally so that ARAC does not have to support the constantly varying parameters of each site.

A mode of operation that would allow ARAC products to be transmitted to the site, much like a telecopier, would be optional and add little cost to the system. Since the communications link and computer equipment would already be available, only a hardcopy device would have to be added. The X.25 packet switching protocol would then allow meteorological data to be retrieved and plot files to be transmitted to the sites. Although this feature would save the interim expense of a telecopier, it would not supplant the need for a new-generation site system at some future date. Some sites, however, may never have to upgrade to a full site-system capability. When operator times are counted, this option would be nearly as fast as a digital telecopier and would need no operator intervention.

In summary, this proposal answers a variety of needs for the sites, various agencies, and ARAC.

- Automated meteorological data collections.
- Standardized formats for all ARAC users.
- Error-free data transmission.
- Increased data transfer rate.
- Remote software distribution capabilities.
- On-site calibration of meteorological systems.
- Interim ARAC products distribution.

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16. ABSTRACT (200 words or less)

A Nuclear Regulatory Commission (NRC) sponsored project to examine and assess the potential of the Atmospheric Release Advisory Capability (ARAC) for contributing to the emergency response capabilities of the NRC staff is discussed herein. Preliminary planning, installation, and testing of the ARAC site facility at the NRC Incident Response Center are summarized. ARAC participation in two days of field testing at Idaho Falls, Idaho, in July 1981 is examined. The ARAC system is evaluated with emphasis on communications, meteorology, the suite of models contained within the ARAC system, and the staff. The implications of this project in designing the next-generation ARAC system to service federal and state needs are assessed.

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