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AN AUTOMATED EMERGENCY METEOROLOGICAL RESPONSE SYSTEM

by

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SRL
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ABSTRACT

A sophisticated emergency response system has been developed to aid in the evaluation of accidental releases of hazardous materials from the Savannah River Plant to the environment. A minicomputer system collects and archives data from both onsite meteorological towers and the National Weather Service. In the event of an accidental release, the computer rapidly calculates the trajectory and dispersion of pollutants in the atmosphere. Computer codes have been developed which provide a graphic display of predicted concentration profiles downwind from the source, as functions of time and distance.

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INTRODUCTION

The Savannah River Plant (SRP) is the principal producer of radionuclides for the Department of Energy (DOE). The plant is the only producer of heavy water, ^{238}Pu, and tritium in the United States. SRP is located on a 777 km^2 site about 40 km southeast of Augusta, GA. The plant has facilities for fuel element fabrication, irradiation of fuel and targets in nuclear reactors, and chemical separation of the nuclear products.

Due to the nature of SRP's mission, the potential exists for the release of hazardous materials to the environment. These include tritium[1,2] (a site product), gaseous fission products (in the unlikely event of a fuel meltdown), and H_2S gas[3] (used in the production of heavy water).

The Savannah River Laboratory (SRL), built on the SRP site, provides research, development, and support to the SRP operation. As part of this support, SRL conducts environmental research programs to improve response and assessment capabilities in the event of an accidental release. Part of this research effort is aimed at developing and evaluating mathematical methods to predict the transport and effects of hazardous material in the environment. State-of-the-art models are used to predict the transport and dispersion of pollutants in the air, rivers and streams, and groundwater.

A sophisticated minicomputer system has been installed to aid in the realtime evaluation of atmospheric releases. The computer system is coupled with on-line instrumented towers, the National Weather Service (NWS), and other high quality meteorological sensors. This system, called the Weather Information and Display (WIND) system,[4] provides rapid graphical displays of the trajectories and ground level concentrations projected for times up to 12 hours following the release. The WIND system is located in the Weather Center Analysis Laboratory (WC-AL) within SRL. A staff of ten professionals, consisting of engineers, meteorologists, and chemists, conduct meteorological and environmental research, and maintain the operation of the WIND system.

METEOROLOGICAL DATA

Onsite wind information is obtained from seven meteorologically instrumented towers located adjacent to the seven production areas on SRP. These towers are 62 m in height, corresponding to the stack heights in each of the operating areas. A turbulence quality vector vane wind sensor is located at the top of each tower, and provides data on wind speeds, and horizontal and vertical wind fluctuations. The response time of a vector vane is approximately one second.

In addition to the seven-tower system, a 330 m television tower (WJBF-TV) located approximately 15 km northwest of the plant boundary is instrumented to collect meteorological data. The tower is equipped with bivanes (to measure horizontal and vertical wind fluctuations), fast response cup anemometers (to measure wind speeds), and platinum resistance thermometers (to measure air temperatures). These instruments are located on booms attached to the television tower at seven levels between 10 and 304 m above the ground. The location of the TV tower and seven towers on the SRP site are shown in Figure 1. A meteorological wind tunnel, pitot probe, and hot-wire anemometer are used to calibrate the instruments.

Two acoustic sounders are used to provide continuous realtime measurements of the vertical mixing occurring within the lowest 1 km of the atmosphere. A conventional acoustic sounder is centrally located on the plant site (Figure 1), and is linked to the WIND system to monitor buoyant plumes (thermals), temperature inversions, and mixed-layer heights. A doppler acoustic sounder is located at the television tower site, and provides horizontal and vertical velocity measurements using acoustic doppler shift analysis, in addition to the measurements obtained with the conventional sounder. The doppler acoustic sounder is currently undergoing validation and calibration tests, and will eventually be moved to one of the production areas at SRP. Instrumented balloons, which transmit information to a Beukers LO-CATE minicomputer for trajectory plotting, are used in combination with a tethered boundary layer profiler to provide meteorological information within the mixed-layer.

Synoptic weather data are received in the WC-AL over three different circuits. These are: a National Facsimile Circuit (for surface observations and forecast maps from the NWS), an FAA Teletype Service A (for hourly surface observations), and an NWS Teletype C circuit (for upper air and surface information). The A and C circuits are fed directly to the WIND system, where the information for the southeastern states region can be archived on a continuous basis. A radar drop is also used in the weather center to analyze current weather conditions within the Central Savannah River area. Specific stations are dialed by telephone, and the latest radar images are transmitted over the telephone line. The system is used to forecast weather conditions during severe weather (Hurricane David passed within 50 miles of SRP).

WEATHER INFORMATION AND DISPLAY (WIND) SYSTEM

The WIND system consists of the data acquisition systems linked together to provide meteorological assessment in the event of an accidental atmospheric release. The heart of the WIND system is a PDP 11/40 (Digital Equipment Corporation) minicomputer located within the WC-AL, shown in Figure 2. The PDP computer is used to archive the meteorological data in a summarized form, to perform research and development, and to provide a realtime emergency response system for the SRP site. The minicomputer consists of a central processor, a 128,000 word high-speed memory, two 1.2 million word disk drives, two 20 million word disk drives, two 126,000 word floppy disk drives, and a magnetic tape drive compatible with the SRL IBM-360/195 computer. Input channels collect meteorological data from the TV tower, the seven-tower system, both teletype circuits, and the acoustic sounders. The minicomputer drives graphical display units in the WC-AL, the SRP Emergency Operating Center (EOC), and the seven production areas. The EOC is activated when an emergency situation develops, and is staffed by SRP, SRL, and DOE personnel. The system is shown schematically in Figure 3.

Each production area computer terminal linked to the WIND system has access to the system data and emergency response codes. In the event of an accident within a specific area, Health Protection personnel can activate the system. Each area terminal is tailored to meet the area's needs, and provide information pertinent for consequence-limiting decisions.

A backup system, called the Atmospheric Release Advisory Capability (ARAC)[5], has been obtained from the Lawrence Livermore National Laboratory (LLNL). The ARAC system provides predictions of the consequences of atmospheric releases from SRP in the event of a WIND system failure. The ARAC system was used during the Three Mile Island accident to provide graphical displays of the release trajectories during the incident. The system has been undergoing evaluation by the SRL meteorology staff; preliminary studies show that the system is effective in situations where there are complex meteorological conditions, long periods of release time, and long travel distances.

WIND System Models

The dispersion models used in the WIND system are based on Gaussian assumptions for the diffusion of a pollutant. Both puff and plume models reside in the system and are used, depending upon the type of release. The plume transport and diffusion are calculated by the relation

$$\chi = \frac{Q}{\pi \bar{u} \sigma_y \sigma_z} \exp\left(-\frac{\lambda x}{\bar{u}}\right) \exp\left[-\frac{(z-h)^2}{2\sigma_z^2} - \frac{y^2}{2\sigma_y^2}\right] \qquad (1)$$

where

χ is downwind concentration, pCi/m^3
Q is source term, pCi/s
$\bar{u}$ is averaged wind speed, m/s
λ is radioactive decay constant, s^{-1}
x is downwind distance, m
h is release height, m
y is horizontal distance from plume centerline, m
σ_y is horizontal Gaussian dispersion coefficient, m
σ_z is vertical Gaussian dispersion coefficient, m
z is height above ground, m

The values of σ_y and σ_z are calculated from the TV tower and seven tower wind turbulence measurements; values at distances offsite are obtained using the correlations suggested by Pasquill.[6]

A segmented Gaussian plume model[7,8] based on equation (1) is used to account for the variability in atmospheric conditions and trajectory due to wind direction changes over long distances.

A Gaussian puff (instantaneous release) is dispersed according to the basic relation

$$\chi = \frac{Q}{\sqrt{2\pi}\ \pi\sigma_x\sigma_y\sigma_x} \exp\left[-\frac{(x-\bar{u}t)^2}{2\sigma_x^2} - \frac{y^2}{2\sigma_y^2} - \frac{(z-h)^2}{2\sigma_z^2}\right] \qquad (2)$$

where σ_x is the downwind (horizontal) diffusion coefficient (usually assumed to equal σ_y). Both Gaussian models can be used quickly, and have been tested and validated extensively with field data; their limitations and accuracies are well known. For an emergency response system, both models provide reliable first guess estimates using realtime, on-site data. Multi-dimensional models are also being developed at SRL to be run on the WIND system, allowing complex terrain and the three-dimensional nature of the wind field to be more realistically simulated.[9,10]

An analytical atmospheric deposition model has also been developed, using estimates for turbulent time scales, deposition velocities, and mixed-layer depths.[11] The governing equations are solved with an analytical marching technique. One equation governs turbulent transfer of pollutants to the surface layer; the other equation governs the deposition rate. Pollutant concentration profiles are assumed to be Gaussian in the horizontal plane. Calculations of particle and gas deposition velocities are based on site- specific canopy and aerodynamic resistance models.

Heavier-than-air releases are modeled using the relationships established by Yih,[12] Fryer and Kaiser,[13] Cox and Roe,[14] and Weber.[15] The model assumes a rate for radial pollutant cloud growth as a function of the growth equation for a density current. The entrained air is governed by an equation which accounts for top and edge entrainment. The dense gas cloud is slowly heated by the ground and by the addition of the warmer ambient air. The model is used to provide the initial size distribution and growth rate of a heavier-than-air release until the gas becomes passive. A more detailed description of the model is given by Weber.[15]

Validation tests of the atmospheric dispersion models residing in the WIND system, as well as a set of multi-dimensional numerical models, have been conducted using field measurements at SRP. SRL, in cooperation with the Air Resources Laboratory (NOAA), have compiled a data base consisting of hourly release rates of ^{85}Kr from SRP. Included in this data base are turbulence quality meteorological data from the tower network at SRP, and 10-hour averaged ^{85}Kr air concentrations at 13 sites surrounding SRP at distances ranging between 30 and 143 km.[16]

Model results were evaluated by calculating the daily, weekly, monthly, and annual average air concentration at each sampler location for comparison with the measurements. In using annual average concentrations, the effects of day-to-day variations in plume trajectories were minimized. (Long-term average concentration estimates are generally dependent upon diffusion properties.) For short-term average concentrations, such as from an accidental release, the transport of the plume is frequently more important than its expansion (because of diffusion).

The series of models, utilizing a gridded wind field, were used to calculate the transport of ^{85}Kr from the center of SRP. Wind fields were calculated at one-hour intervals, using an objective analysis routine based on successive corrections to a first guess wind field. Out of approximately 167 observations of ^{85}Kr at the 13 locations, the Gaussian plume model agreed 72% of the time within a factor of two, and agreed 90% of the time within a factor of ten.[16]

A model validation workshop is being hosted by SRL on November 19-21, 1980 using the 2 1/2 year ^{85}Kr data base. The workshop involves nine DOE funded laboratories, and includes observers from the Environmental Protection Agency and the Nuclear Regulatory Commission. Model sophistication ranges from simple wind rose to three-dimensional finite element and pseudospectral techniques.[9] Results of the workshop, including a statistical analysis of all models' responses and accuracies, will be published in early 1981.

The WIND system also provides automatic forecasts of wind and turbulence for periods up to 30 hours.[17] The wind forecasts originate at the NWS in Suitland, MD, and are transmitted to the WIND system by telephone (modem) twice daily. These forecasts are based on Model Output Statistics (MOS), which is a forecast technique that statistically relates the output of numerical weather prediction models to the meteorology of a particular site. This work was done in collaboration with the Techniques Development Laboratory (NOAA) using three years of data from the WJBF-TV tower. The MOS forecasts provide wind direction, wind speed, and horizontal and vertical turbulence intensities at the 10, 91, and 243 m levels of the WJBF-TV tower.

The MOS forecast technique has been compared with persistence, i.e., the assumption that meteorological conditions in the future will be the same as the latest observation. Validation studies over the past year[17] have shown that the MOS forecasts for wind speed and turbulence are better than persistence for times greater than 2 hours; wind direction forecasts are generally better than persistence for times greater than 4 hours.

EMERGENCY RESPONSE OUTPUT

In the event of an accidental release from SRP, personnel working in the affected area can activate the WIND system using their area terminal. In addition, the Emergency Operating Center is notified, and the meteorology staff in SRL is alerted for assistance, if needed. The response time to activate the system and execute programs by an operator is less than one minute. Program selection by the operator is done quickly by chosing the appropriate function from a menu list, shown in Figure 4. Shift personnel with only a brief period of training can run the programs.

Function No. 1

Function No. 1 is used as a terminal and system check. This program generates a graphical display at the request of the user when the system is operating correctly.

Functions No. 2 and 3

Functions No. 2 and 3 give up-to-date displays of the data from the instrumented seven tower system at SRP and the seven levels of the WJBF-TV tower located offsite. Function No. 2 displays the latest 15 minute (averaged) data in metric units; Function No. 3 displays the data in English units. Figure 5 shows a typical output from Function No. 2. Wind speeds, directions, and temperatures at all seven levels are depicted in the

first two profiles; wind speeds and directions from the seven tower system, plus a 62 m value (interpolated) from the TV tower data (SAM), are shown on the right hand side. The table under the graph lists the data from each sensor in tabular form.

Quality control of the meteorological data is required to meet DOE standards. The question marks immediately adjacent to the tabulated tower data (Figure 5) denote those values flagged as inaccurate or suspicious.

Quality control is achieved by routine inspection of the data summaries. These summaries are generated automatically by the PDP-11/40 computer; hard copies are printed hourly. A computer code calculates an expected value of each variable of the SRP tower data based upon boundary layer theory and observed data. These expected values are used to identify and replace the suspect data to make it consistent with the overall meteorological data.[18] A display of the data (Function 7) permits judgments to be made on the acceptability of the replaced data.

If malfunctions in the sensors are detected, maintenance crews are scheduled. Problems on the WJBF-TV tower are fixed by hired tower climbers; on the average, tower climbers are used at six-month intervals.

Function No. 4

Function No. 4 is an example of the output generated for each operating area. This function issues a map centered on each area. Figure 6 shows concentration isopleths for a continuous release (plume) of H_2S in D Area. Maps are sent to each area hourly via a Tektronix Display Terminal. The latest meteorology for each specific site is used to compute the travel time and direction of a hypothetical release from the site. This function is used to provide a quick assessment of the current release behavior in the site vicinity.

Function No. 5

Function No. 5 is a query response program and is the principal code used to assess environmental effects. The user interacts with the system, supplying information as requested by the program, or defaulting to specific values in cases where the information is unknown. The dispersion is based on a Gaussian puff and a segmented plume model, as described by Equations 1 and 2. The terminal operator decides whether to use manual, canned (test), forecast (MOS), or latest (persistence) winds; the program output projects the concentration values and trajectories out to 12 hours from the time of the release. The program asks whether the release is chemical or radioactive; the seven different radioisotopes produced at SRP and listed in the program

have the dose conversion constants and half-lives automatically incorporated. Chemical releases are entered by their molecular weight; chlorine, hydrogen sulfide (H_2S) and sulfur dioxide are entered as default releases. A heavier-than-air model is used to calculate the initial dispersion pattern for H_2S. Questions are also asked regarding location, source strength, height of release, inversion height, plume rise, etc. In the event of a radioactive accident involving core meltdown, the user can request the integral gamma dose from the noble gases that would be released.

A simulated puff release of 1 Ci of tritium from F Area is used to illustrate Function 5 output. Figure 7a lists the input data summary and forecast meteorology for a 2 PM release. Tabular centerline calculations and graphical displays, including values at two-sigma distances from the centerline are also listed by the program. ($\pm 2\sigma_y$ values contain 90% of the material in a puff.) Dose calculations for radioactive releases are given in rem, and air concentrations are listed in parts per million. Three maps are drawn automatically (Figures 7b, c, d). Figure 7b shows the dispersion pattern for the simulated puff with the circle centered on the location at the end of each hour of travel of the puff. The circle radius represents the two-sigma deviation from the centerline concentration. The next map shows a larger area, 630 km on a side, centered about the source location (Figure 7c). Figure 7d shows the area of responsibility of the DOE Savannah River Operations Office (1600 km on a side). The entire program sequence takes less than two minutes from the start of the program to the production of a hard copy of the final calculations.

The system is capable of responding to offsite accidents. On several occasions, the DOE Savannah River Operations Office has requested activation of the system for offsite incidents in the United States. State officials normally request assistance from DOE under the Radiological Assistance Program. A list of the nuclear sites in the southeast, Figure 8, is stored in the WIND system. The operator selects the location number corresponding to the specific site in question; output is then produced similar to that shown in Figure 7. However, a meteorologist in the WC-AL has to enter the approximate meteorological data for that site following an analysis of the NWS data in the WC-AL. Figure 9 shows a hypothetical radioactive puff release from the Brown's Ferry Nuclear Station near Huntsville, Alabama. The system is capable of responding to an incident anywhere in the Southeast, providing the latitude and longitude are known, and meteorological data are available.

Function No. 6

Function No. 6 is similar to Function No. 5 except that deposition is calculated. Particulate size, gas composition, and rainfall are querried, in addition to the set of questions asked in Function 5.

Function No. 7

Function No. 7 displays the corrected meteorological values from the tower network, as described in Function 2 (Figure 5). The flagged (question mark) values are readjusted according to the realtime quality control code (see asterisks) as shown in Figure 10. This function is used primarily to monitor the quality assurance calculations.

May 19-30, 1980 H_2S Incident

On May 19, 1980, hydrogen sulfide was detected leaking from a crack on a three inch diameter pipe spool piece in the heavy water production area. The spool piece was connected to the bottom flange of a storage tank containing 85 tons of H_2S. Attempts to seal the leak were unsuccessful. Transfer of the H_2S to an adjacent tank was undertaken. Observations of the crack on May 21 indicated that the leak rate was increasing significantly, creating the potential for a large release of H_2S. A partial area evacuation and closing of both river and area traffic were carried out. The EOC and WIND system were activated, and the meteorology group manned the weather center and EOC around the clock from May 21 to 29. Transfer of nearly all the H_2S was completed on May 29. A small amount of gas was burned and released from the 400' flare tower, and the tank was purged with steam.[3] The area and all traffic were reopened on May 30. The potential was high for a large release of H_2S (heavier-than-air), or an explosion with air to form SO_2. The WIND system was invaluable in aiding management to assess the effects to the surrounding populace of potentially large discharges.

Future Plans

Additional equipment is being obtained to improve the WIND system emergency response capabilities and research needs. An Automated Field Operations and Service (AFOS) minicomputer system is currently being installed within the WC-AL and will replace the facsimile circuit and the NWS teletype receivers. The AFOS system will be linked to the WIND system allowing meteorological information to be automatically entered in the dispersion codes for any location in the United States serviced by an NWS Station. A picture of the AFOS system is shown in Figure 11.

An additional minicomputer system is planned to augment the PDP 11/40 in early 1981. The new system will be linked to the PDP to provide time-share terminal control, program development, and a computational front-end system, freeing the PDP 11/40 to act as a realtime data acquisition processor.

Solar-powered gamma detectors will be installed on the SRP site by 1982 (forty eight detectors will be arranged in two concentric rings). Stack monitors in the reactor areas will be connected to the WIND system in 1981.

Both systems will be used to automatically trigger the WIND system and provide source term data. The additional computing capacity of these enhanced systems will permit more sophisticated meteorological models to be used to predict atmospheric behavior.[4,9,15] The enhanced system is schematically shown in dotted lines in Figure 3.

Software improvements to the emergency response codes are continually being undertaken. A program to forecast three-dimensional winds over complex terrain will be added along with a model to forecast mixed-layer heights. A program which calculates the dispersion of pollutants in rivers and streams has been added to the current menu list and will be used to provide quick estimates of concentration values in aquatic systems.[19] Tests using field tracers released from SRP will also be conducted throughout 1981 to validate the current and improved models.

SUMMARY

The Weather Information and Display (WIND) system is unique to the nuclear and chemical industries. The WIND system uses meteorological forecasts to provide realtime estimates of the downwind concentrations from accidental releases to the atmosphere, including dose and exposure to the population surrounding the SRP site. The meteorological data used is quality assured in realtime. The system is capable of responding to off-site accidents as well. The system provides not only emergency response information, but also serves as a research computational system for developing new and improved dispersion models. By coupling individual site meteorology into a single system, the larger mesoscale nature of the winds can be analyzed, as well as the various onsite conditions. It is the mesoscale flow which steers the advection of pollutants; this is particularly important when releases are hazardous over long periods of time or long travel distance. The WIND system is currently being enhanced with the addition of another minicomputer and automated weather system. The WIND system is designed for further expansion to meet the needs of emergency response as well as the research scientist. A computer program which calculates dispersion in streams and rivers has also been incorporated into the program files.

The WIND system response is quick and the results are reliable. Minicomputers can generally be repaired quickly if component failures occur. Use of the realtime system in actual incidents at SRP has shown the need and importance of predicting the effects of accidents both on and offsite.

ACKNOWLEDGEMENTS

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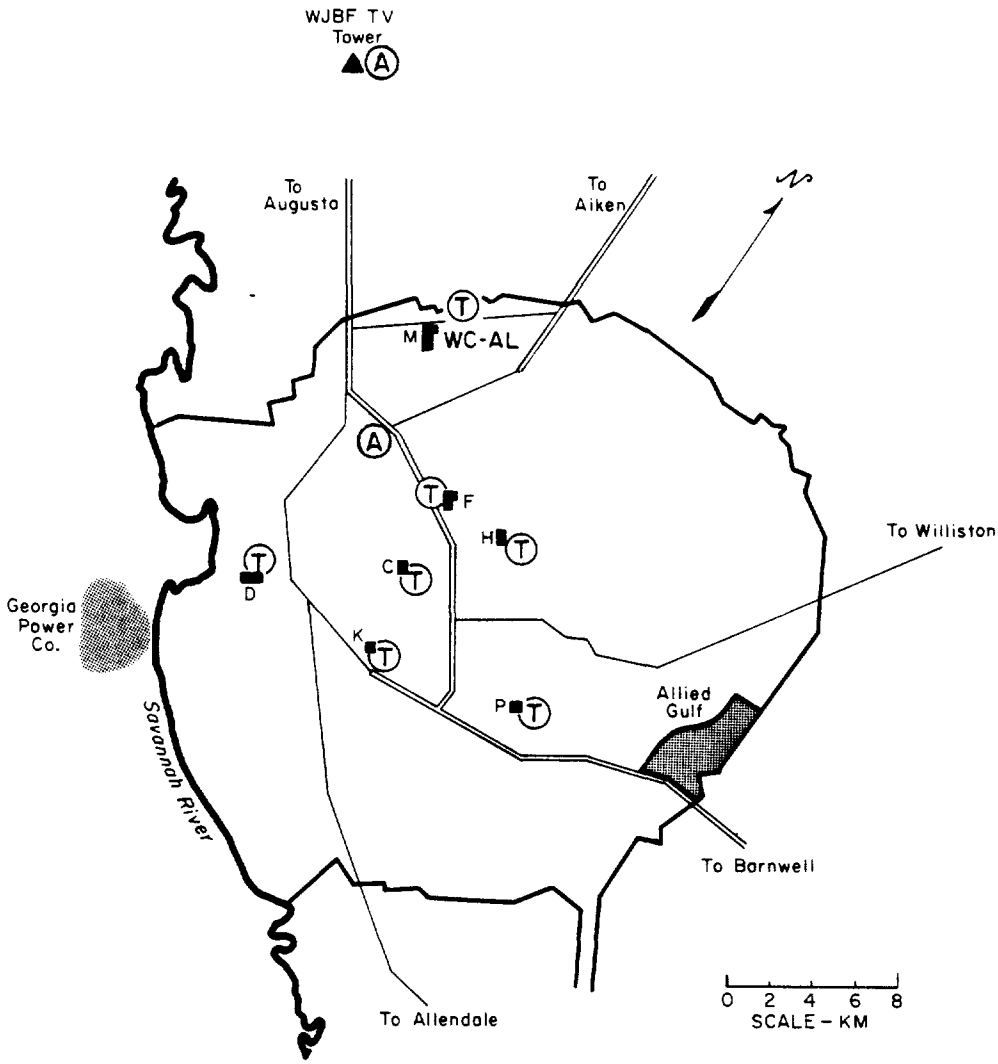

FIGURE 1. SRP Site Map; T Denotes 62 m Tower; A denotes Acoustic Sounder; WC-AL is the Weather Center Analysis Laboratory

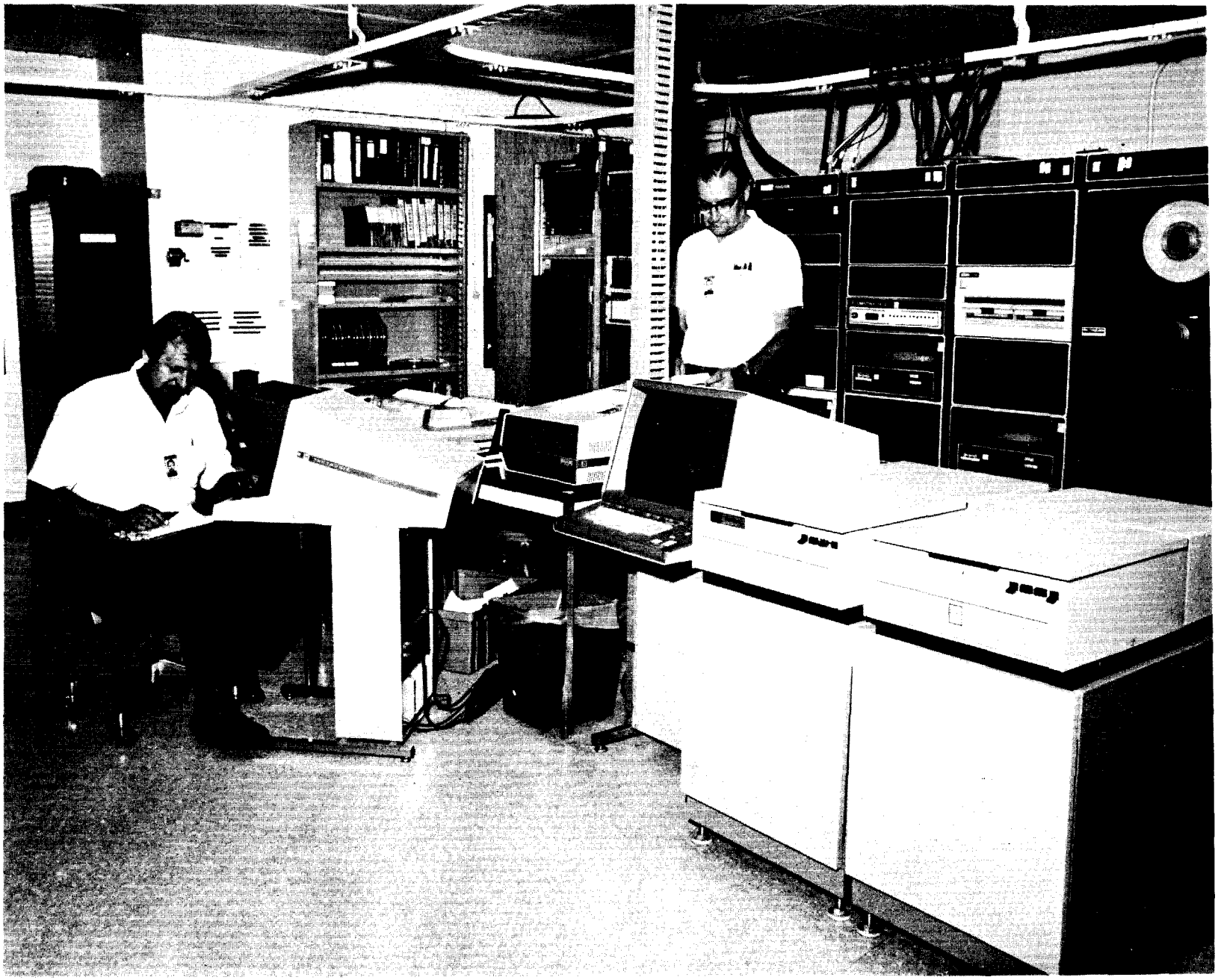

FIGURE 2. The Weather Information and Display (WIND) System - PDP 11/40 Minicomputer

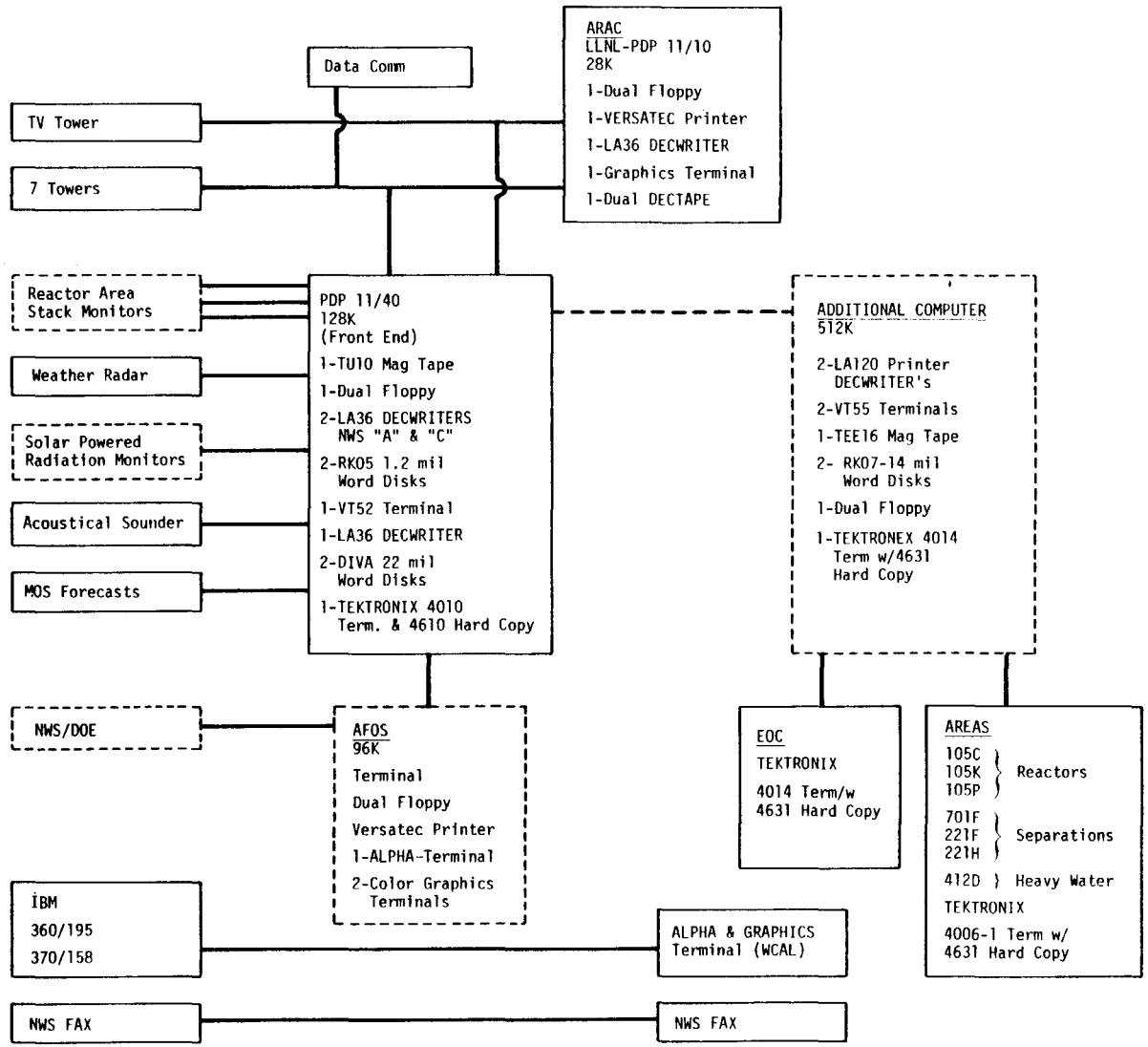

FIGURE 3. WIND System Schematic - (Dashed blocks indicate equipment to be installed in 1981)

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                HEALTH PROTECTION FUNCTION SELECTOR

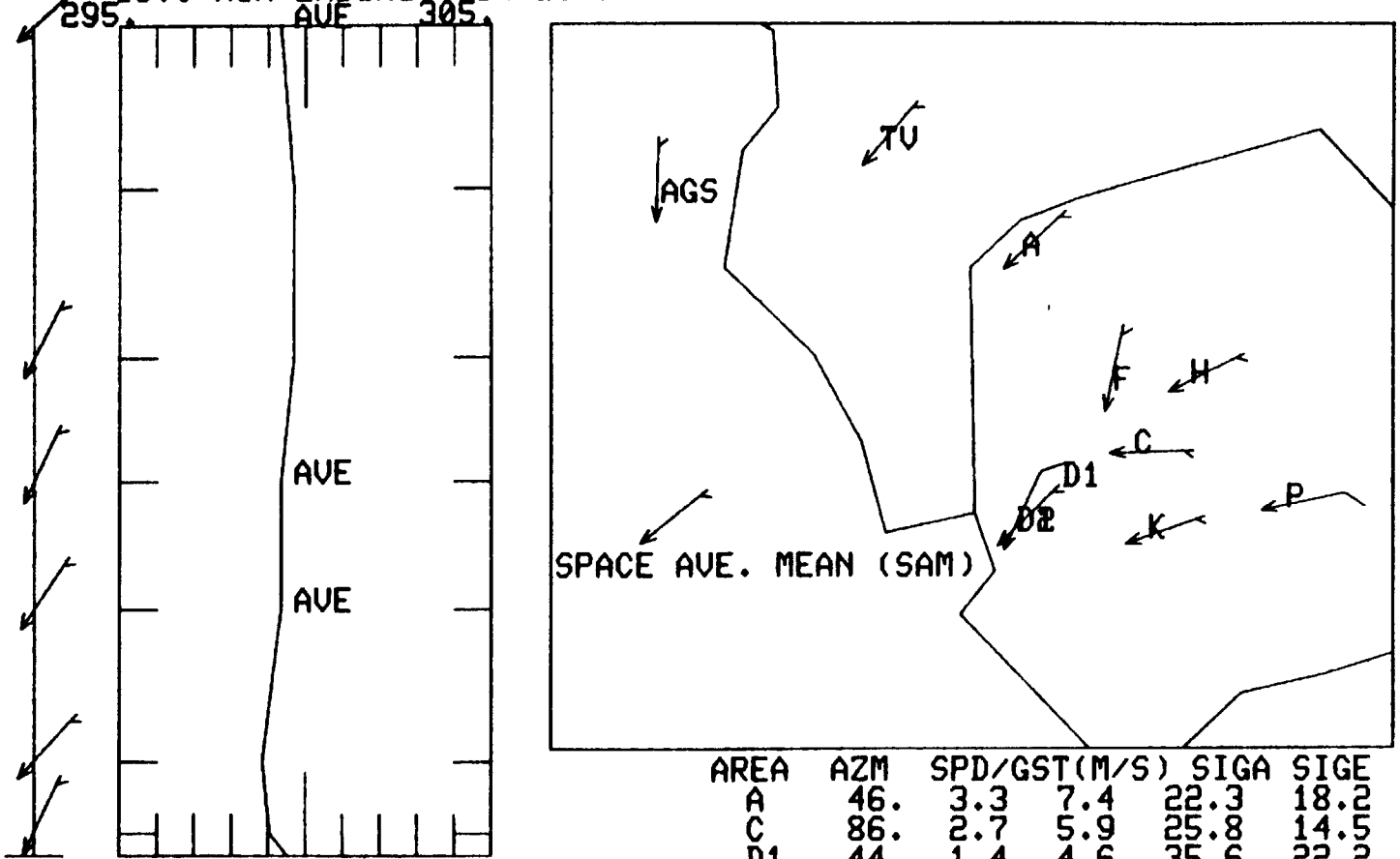
            THE FOLLOWING FUNCTIONS ARE AVAILABLE:

              1  VERIFY SYSTEM STATUS
              2  DISPLAY CURRENT METEOROLOGICAL DATA-METC
              3  DISPLAY CURRENT METEOROLOGICAL DATA-ENGL
              4  AREA MAP REQUEST PROGRAM
              5  PUFF/PLUME REQUEST/QUERY PROGRAM
              6  PUFF/PLUME WITH DEPOSITION REQUEST QUERY
              7  CORRECTED CURRENT MET DATA-METC

PLEASE TYPE THE NUMBER OF THE FUNCTION YOU WANT,
THEN PRESS "RETURN" KEY.
YOU HAVE 30 SECONDS TO RESPOND
```

FIGURE 4. The Menu-Select Program

15.0 MIN ENDING: 14:29:59 Z 8/25/80 (10:29:59 AM EDT 8/25/80)



HT	AZM	SPD/GST(M/S)		SIGA	SIGE	TEMP C
304M	48.?	3.1	5.4	11.1?	17.1	0.00?
243M	0.	0.0?	0.0?	0.0	0.0?	24.15
182M	29.	3.2	6.8	12.8	15.3	24.74
137M	26.	3.2	5.0	14.6	13.4	0.00?
91M	35.	3.1	5.6	14.4	15.2	0.00?
36M	43.	3.0	5.5	19.8	13.6	25.33
10M	26.	2.1	4.5	27.4	20.4	25.77
2M						26.33

AREA	AZM	SPD/GST(M/S)		SIGA	SIGE
A	46.	3.3	7.4	22.3	18.2
C	86.	2.7	5.9	25.8	14.5
D1	44.	1.4	4.6	35.6	22.2
D2	24.	4.1	6.8	13.9	18.2
F	11.	3.4	5.4	7.8	7.3
H	62.	2.9	6.2	23.1	14.9
K	69.	3.1	5.7	20.1	15.8
P	76.	4.0	6.1	15.8	12.2
TV	39.	3.1	6.8	16.7	14.5
SAM	51.	3.3	7.4	20.1	15.3
AGS	360.	3.1	(23.3/	18.9	ST: 2)

FIGURE 5. SRP Tower Data, Latest 15 Minute Average - Function No. 2
(question mark denotes suspicious or erroneous data)

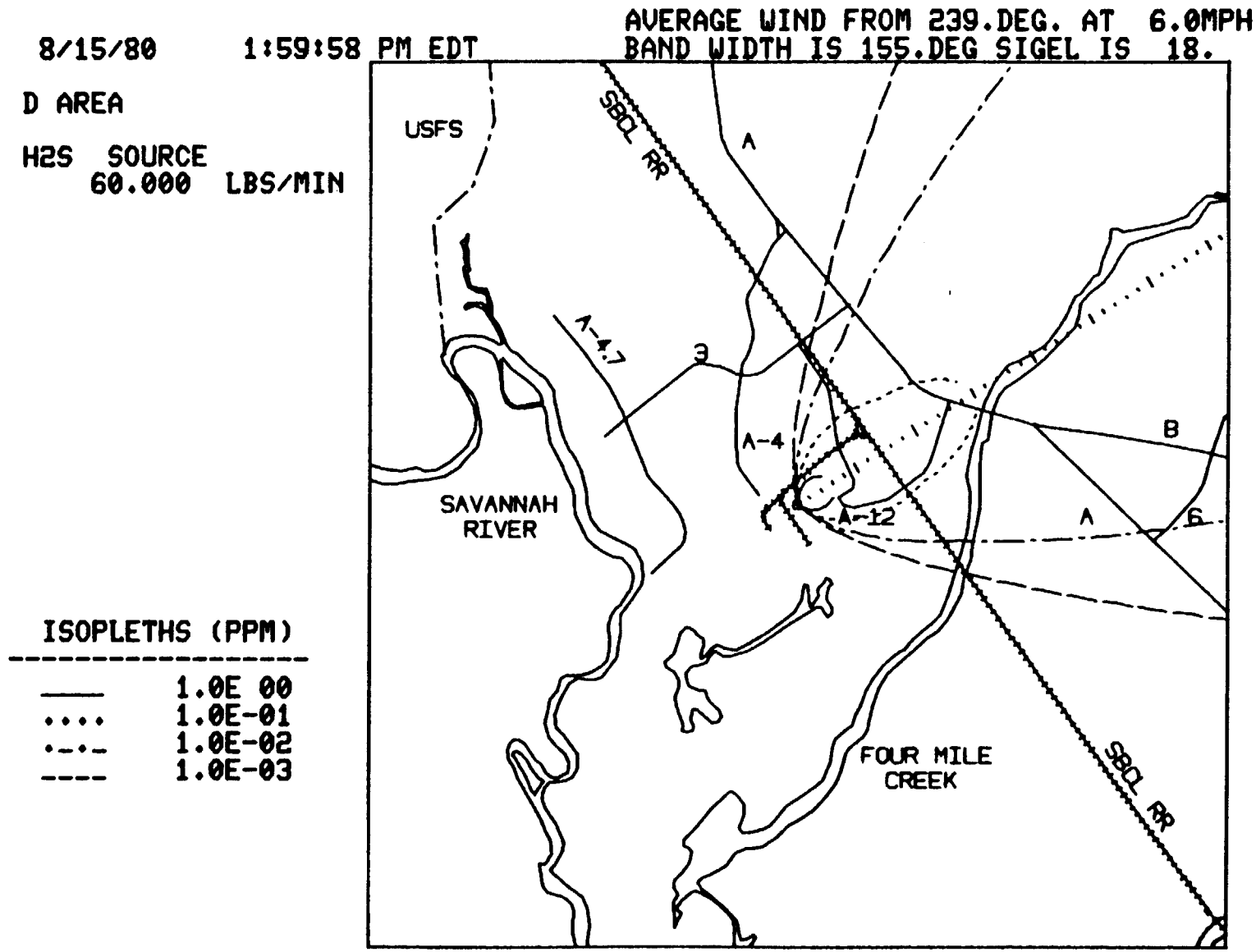


FIGURE 6. Area Map of the Heavy Water Facility - Function No. 4 (A hypothetical plume of H_2S (Q = 60 lb/min) is depicted by the isopleths. Latest meteorology is given at the top of the map)

THE FOLLOWING DATA DETERMINE GROUND LEVEL DOSES AND
CONCENTRATIONS AT CLOUD CENTERLINE AS A FUNCTION OF TIME
AND TRAVEL DISTANCE. ALSO PRESENTED IS THE DOSE
(CONCENTRATION FOR CHEMICAL RELEASES)
AT A DISTANCE EQUAL TO 2-SIGY FROM THE PUFF CENTERLINE.
THE INPUT DATA CONSIST OF HOURLY AVERAGED WIND DATA, A
MAXIMUM OF TWELVE HOURS OF DATA IS INPUT BUT OUTPUT CAN
BE COMPUTED EVERY TEN MINUTES.

SOURCE TERM IS 1.000E 00 CI HALFLIFE IS 1.075E 05 HOURS
STACK HEIGHT IS 200.0 FT MAXIMUM MIXING DEPTH IS 1640.4 FT
START TIME (EST) IS 2 0 PM, DATE- 8 15 80 PUFF RELEASE
ISOTOPE BEING USED IS HTO
RELEASE LOCATION AT SRP, F AREA

TIME	W-SPD	W-DIR	SIGA	SIGE
2 PM	8.08	209.81	24.14	16.13
3 PM	8.33	199.88	21.80	16.48
4 PM	8.84	206.21	19.62	14.84
5 PM	9.32	211.90	17.55	13.22
6 PM	9.55	215.91	14.93	11.29
7 PM	9.73	219.28	12.42	9.40
8 PM	9.88	222.02	10.02	7.54
9 PM	10.11	227.85	10.57	8.71
10 PM	10.31	232.69	11.23	9.91
11 PM	10.47	236.59	12.01	11.14
0 AM	10.59	239.59	12.89	12.39
1 AM	10.68	241.72	13.89	13.68

FIGURE 7a. Summary of Release Data and Meteorological Information for a Hypothetical Release of Tritium - Output from Function No. 5. (12 hour forecast winds, release time 2 PM)

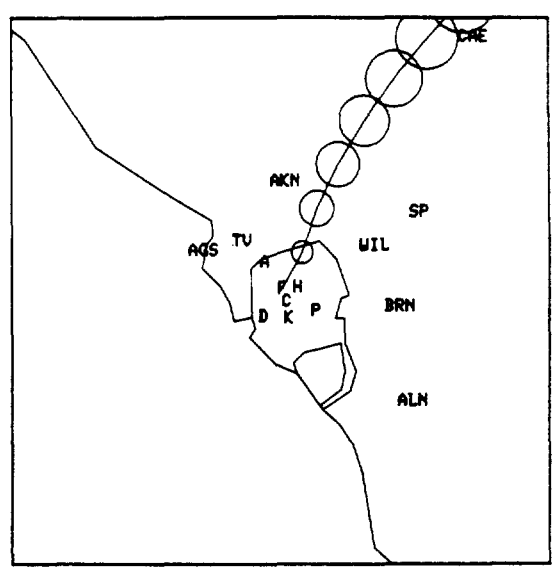


FIGURE 7b. Trajectory Plot for 6+ Hours After Time of Release (circles are located 1 hour apart and denote a radius of ±2 σ_y standard deviations)

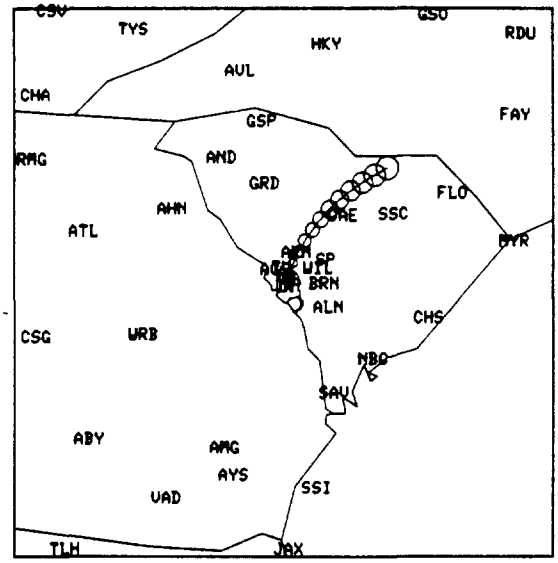


FIGURE 7c. Trajectory Plot of the Release Covering South Carolina and Adjoining States (12-hour forecast)

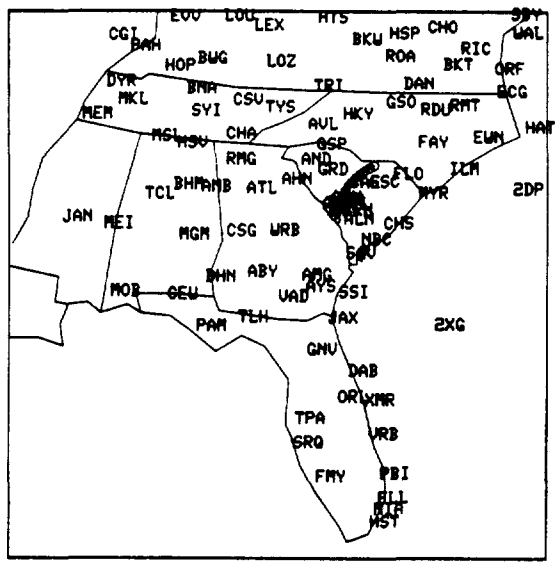


FIGURE 7d. Trajectory Plot Within the Area of Responsibility of the Savannah River Operations Office

LOC NO.	LOCATION	LATITUDE	LONGITUDE
1	704U	33D 17M	81D 43M
2	MEMPHIS,TENN.	35D 7M	90D 3M
3	LACOMBE, LA	30D 18M	89D 56M
5	BELLEFONTE	34D 43M	85D 55M
10	BROWNS FERRY	34D 42M	87D 7M
15	BRUNSWICK	33D 58M	78D 1M
20	CATAWBA	35D 3M	81D 4M
25	CHEROKEE	35D 2M	81D 32M
30	CRYSTAL RIVER	28D 57M	82D 42M
35	FARLEY	31D 13M	85D 6M
40	GENERAL ELECTRIC	34D 19M	72D 56M
45	HATCH	31D 56M	82D 21M
50	MCQUIRE	35D 26M	80D 57M
55	OCONEE	34D 47M	82D 53M
60	PERKINS	35D 51M	80D 27M
65	HB ROBINSON	34D 24M	80D 10M
70	ST. LUCIE	27D 21M	80D 15M
75	SHERRON HARRIS	35D 38M	78D 57M
80	SUMMER	34D 18M	81D 19M
85	TURKEY POINT	25D 26M	80D 20M
90	VOGTLE	33D 9M	81D 46M
95	WESTINGHOUSE	33D 53M	80D 55M
99	CONTINENTAL CAN	33D 20M	81D 57M

ENTER DESIRED LOCATION NO. (HIT RETURN TO ENTER MANUAL COORDINATES)

FIGURE 8. Automated Location of All Nuclear Sites and Some Chemical Plants in the Southeastern United States - Function No. 5

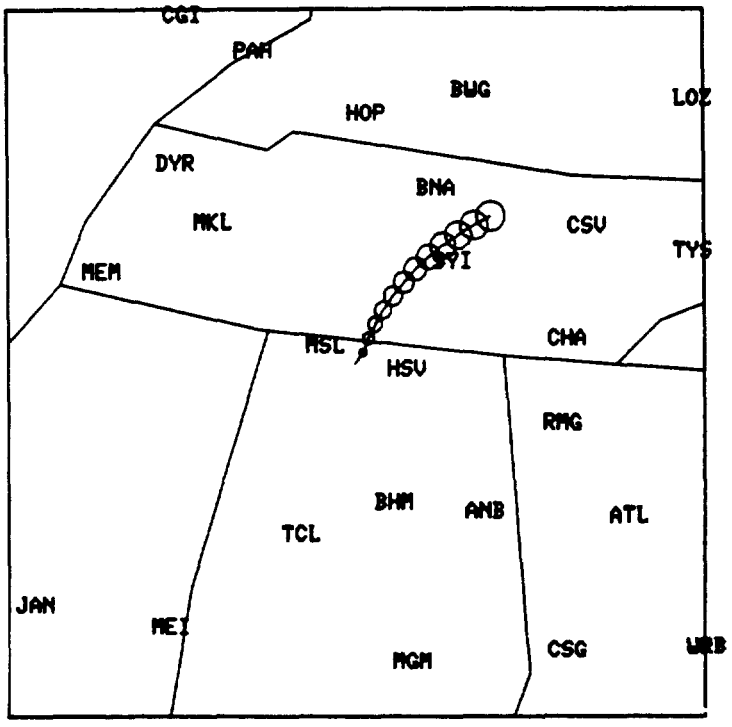
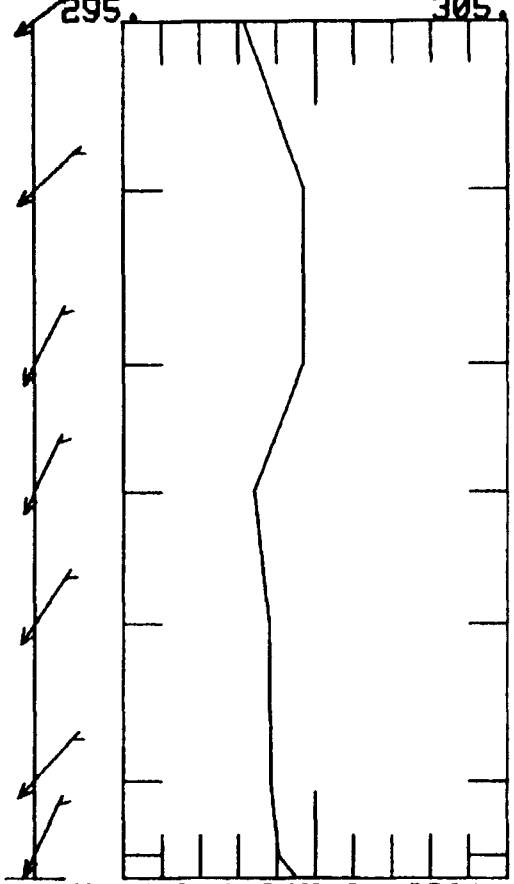
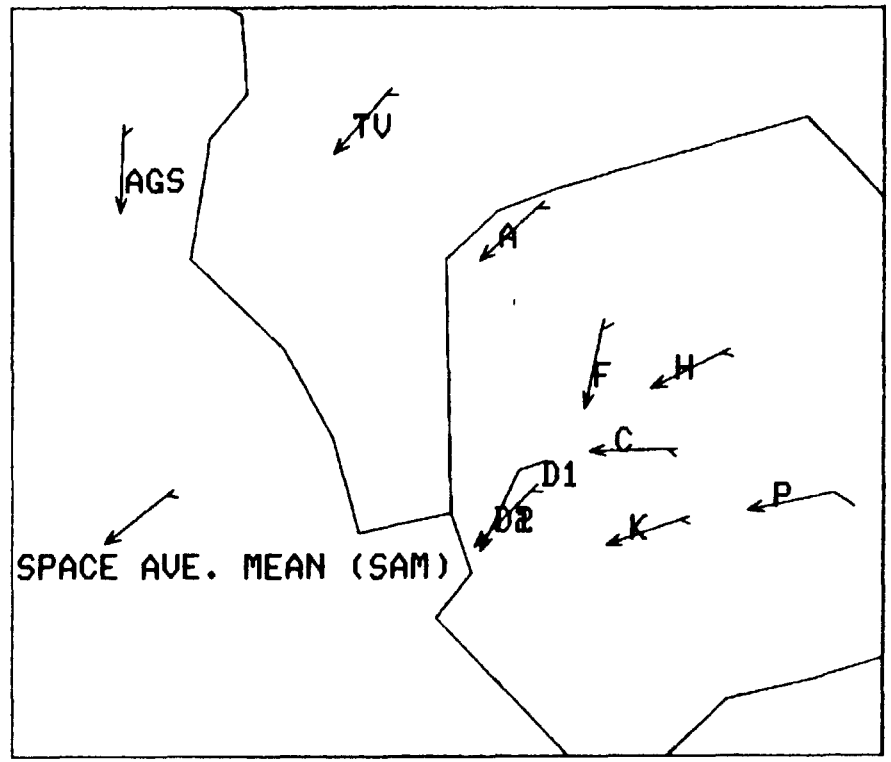


FIGURE 9. Hypothetical Radioactive Release From the Brown's Ferry Nuclear Plant Near Huntsville, Alabama (Location No. 10)

15.0 MIN ENDING: 14:29:59 Z 8/25/80 (10:29:59 AM EDT 8/25/80)





HT	AZM	SPD/GST(M/S)		SIGA	SIGE	TEMP C
304M	53.*	3.1	5.4	11.1	17.1	22.01*
243M	47.*	3.3*	0.0	13.6*	16.6*	24.15
182M	29.	3.2	6.8	12.8	15.3	24.74
137M	26.	3.2	5.0	14.6	13.4	23.92*
91M	35.	3.1	5.6	14.4	15.2	24.74*
36M	43.	3.0	5.5	19.8	13.6	25.33
10M	26.	2.1	4.5	27.4	20.4	25.77
2M						26.33

AREA	AZM	SPD/GST(M/S)		SIGA	SIGE
A	46.	3.3	7.4	22.3	18.2
C	86.	2.7	5.9	25.8	14.5
D1	44.	1.4	4.6	35.6	22.2
D2	24.	4.1	6.8	13.9	18.2
F	11.	3.4	5.4	7.8	7.3
H	62.	2.9	6.2	23.1	14.9
K	69.	3.1	5.7	20.1	15.8
P	76.	4.0	6.1	15.8	12.2
TV	39.	3.1	6.8	16.7	14.5
SAM	51.	3.3	7.4	20.1	15.3
AGS	360.	3.1	(23.3/	18.9	ST: 2)

FIGURE 10. Quality Control Corrected Meteorological Data

FIGURE 11. Automated Field Operations and Service (AFOS) Computer Systems (Photo by Ford Aerospace)