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User's Guide for the Multiple Airshed (MASH) Model

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USER'S GUIDE FOR THE MULTIPLE AIRSHED (MASH) MODEL

By

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ACKNOWLEDGMENT

The Multiple Airshed (MASH) model was based on concepts originating within the Monitoring Data and Analysis Division (MDAD), and was initiated under the auspices of the Strategies and Air Standards Division (SASD). Both Divisions are within the Office of Air Quality Planning and Standards (OAQPS) of the U.S. Environmental Protection Agency (EPA). Special recognition is given to Dr. Edwin L. Meyer and Mr. Gerald P. Gipson of MDAD who specified methods to distinguish different airsheds and who provided detailed technical guidelines on allocating hourly ozone values at specific monitoring sites.

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SECTION 1

INTRODUCTION

The ozone (O_3) problem in the United States is sometimes characterized by long-range transport of 03 and/or its precursors. In such situations, observed high concentrations of O_3 are not necessarily attributable to nearby, obvious potential sources (i.e., cities). The most desirable way to determine cause/effect relationships is to perform a detailed case-by-case analysis. This is the procedure recommended and followed in O_3 modeling analyses performed as part of the State Implementation Planning (SIP) process. However, in regulatory impact analyses (RIA), it is often necessary to consider the impact of proposed regulations in or near dozens of cities. Under such circumstances detailed case-by-case analyses are not feasible. This document describes an automated procedure, the Multiple Airshed (MASH) model, in which wind data and time of occurrence of high O_3 values are used to identify the city (or SMSA) whose emissions are most likely associated with each observed high concentration of O_3. When an observed O_3 concentration is assigned to an SMSA, it is assumed that the particular monitoring site is located within an airshed whose source area consists of the city or SMSA to which the O_3 value has been assigned.

Multiple airshed (MASH) model calculates design values for each of a series of ozone monitoring sites in the U.S. Each monitor is assigned to various airsheds, depending on time of day and the resultant wind direction for each day. Using a list of high values for each airshed, one design value is selected for each airshed and monitor combination. The design value associated with a particular SMSA can be selected from the resulting list of site-specific design values which the program generates for each airshed. Input data for MASH are 1) hourly ozone values from monitors, 2) daily

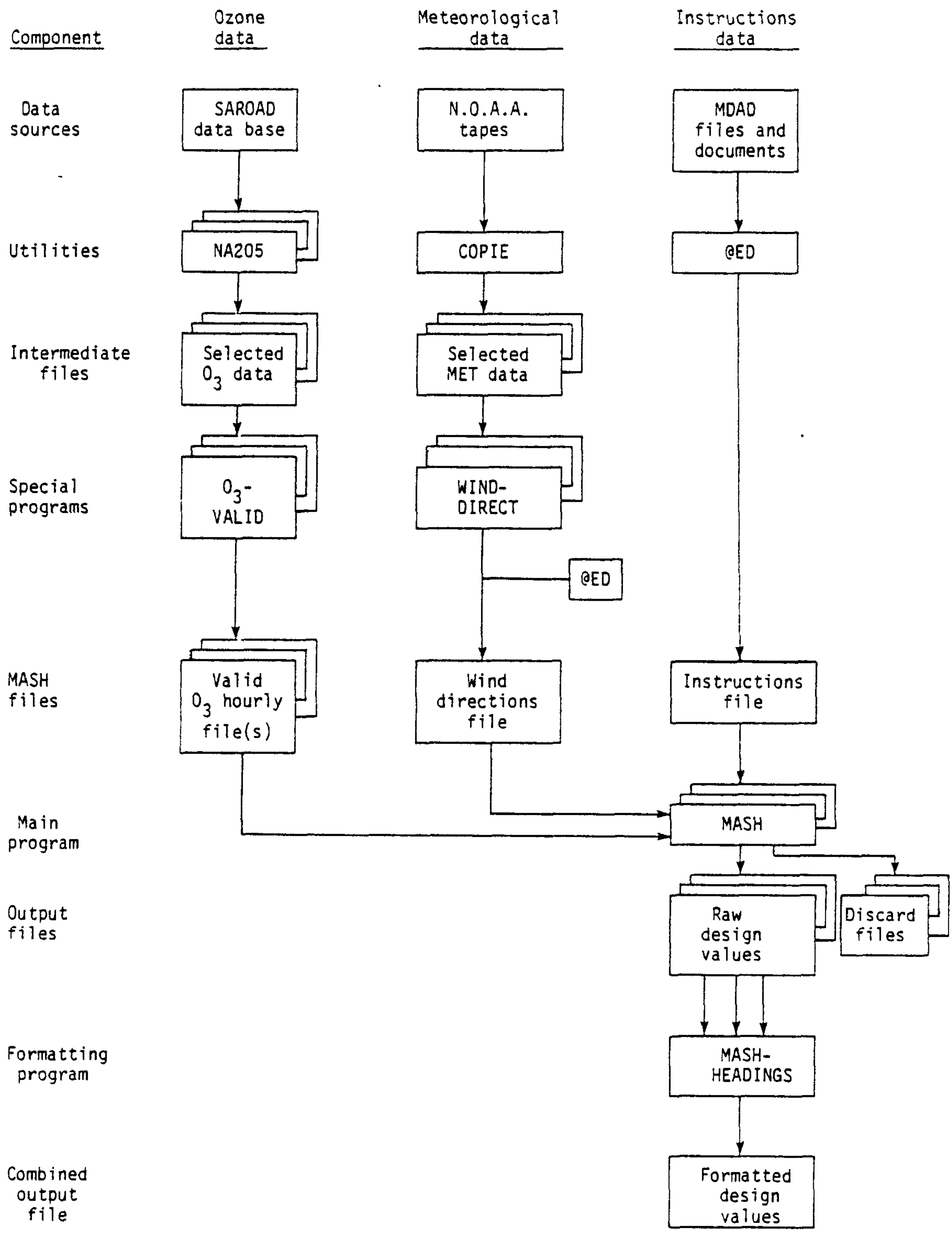

Figure 1. Flow of data processing for MASH analysis.

resultant wind directions at selected meteorological stations, and 3) a coded set of instructions telling how to allocate hourly ozone values to various airsheds based on wind direction.

Air quality data are obtained from the Storage and Retrieval of Aerometric Data (SAROAD) data base maintained on UNIVAC by the National Air Data Branch (NADB) within Monitoring Data and Analysis Division (MDAD). A utility program developed by NADB called NA205 is used to select hourly ozone data from selected monitors over a selected 3-year period (Figure 1). These hourly data are placed in a mass storage file. Program O3-VALID, developed by PEI Associates, Inc. (PEI) reads this file and applies certain validity criteria specified by MDAD. The screened and validated data are placed into a second mass storage file in a format suitable for MASH. Limits on the number of monitors that can be specified for NA205 and practical limits on the size of mass storage files require that a series of validation runs and MASH runs be executed to process all ozone monitoring sites in the U.S. Further information on air quality processing may be found in Section 2.

Meteorological data are obtained from a historical data tape produced by the National Climatic Center (NCC) in Asheville, North Carolina (Figure 1). A standard utility program developed by the U.S. Environmental Protection Agency (EPA) National Computer Center (NCC) called COPIE may be used to select 3 years of data from each station during a 3-year period (the same time period used for air quality data). Each 3-year set of meteorological data is placed into a separate mass storage file. Program WIND-DIRECT, developed by PEI, is used to read each of these files and calculate a resultant wind direction for each day of the year. A resultant wind direction is the weighted average of each hourly wind vector (wind direction and speed) over the 9-hour time period 8:00 a.m. to 4:00 p.m. If the meteorological stations only takes measurements every 3 hours, then these observations occurring within the same 8-hour period are used. The UNIVAC Editor is used to combine output files from several runs of WIND-DIRECT into one wind direction file for use in MASH. Further information on meteorological data may be found in Section 3.

The instructions file used in MASH is created by the UNIVAC Editor using information from various documents, guidelines, and analyses produced by MDAD (Figure 1). The file containing current instructions for all qualified ozone monitors in the U.S. is MDAD*INSTRUCT-USA. More information on the instructions file may be found in Section 4.

The main MASH program processes air quality data by (a) determining which airshed is associated with each hourly value, (b) saving the highest value associated with each airshed during each day, and (c) determining whether each saved value is one of the four highest values for the airshed (Figure 1). The particular value selected as the design value for the monitor-airshed combination depends upon whether the monitor is located in the source area of the airshed (locally generated ozone) or in an impact area of the airshed (transported ozone). If the ozone is locally generated, then the design value is the N + 1 highest observation, where n is the number of valid site-years of data according to Guidelines for the Interpretation of Ozone Air Quality Standards, EPA-430/4-79-003. If an observed ozone concentration is attributable to transport of emissions from a distant source area, it is assumed that it is that source area's responsibility to reduce the observed concentration to the level of the NAAQS. This assumption holds, even if the observed concentration is the highest concentration recorded at the particular site. Ordinarily such a procedure has little effect on the design value associated with the distant source area. This follows, because usually the higest O_3 concentrations (recorded anywhere) which are associated with a source area occur in relatively close proximity to the source area. As such, they are regarded as locally generated, and the "N + 1" rule described above governs selection of a design value. However, occasionally, the highest O_3 concentration attributed to a source area at a remote site may exceed the N + 1 highest concentration at a local site attributed to the same area. Under these circumstances, the highest O_3 concentration at the remote site which is attributable to the source area is assumed to be the design value.

Design values for monitor-airshed combinations are placed into an output file. Outputs from a series of MASH runs may be combined into one file using the Editor, sorted using the utility @SORT, and placed into an easy-to-read table using program MASH/HEADINGS. Further information is found in Section 6.

For the convenience of users, all program source codes pertaining to MASH have been placed in program file MDAD*PROG. This file has a write-key to protect the programs from unauthorized changes. Runstreams to implement MASH programs are located in file MDAD*RUN, and elements of this file are described in the following section. These descriptions assume a working knowledge of the UNIVAC computer, executive control language (ECL), and the principal utilities available at the NCC.

SECTION 2

PROCESSING OZONE DATA

Processing of ozone data begins by retrieving selected data from the SAROAD data base and then reviewing these data for validity. Retrieval of hourly data is carried out by program NA205 and validity checks are performed by program 03-VALID. Both programs may be executed by a single runstream, exemplified by element NA205-VALID/TEST1 of file MDAD*RUN, shown in Figure 2. This runstream is annotated by comments that follow the symbol ƀ.ƀ on most lines of the runstream. Explanation of this runstream follows:

- Line 1: The run card, identified by @RUN, should contain an appropriate run-id and account number authorized for the user. In the example, bin number 06, user initials RP, and run series 1A are shown on the run ID. Run series 1A matches the last two characters on the alternate print file 03RP1A and the output file TEST1A used in this run. Note that run series 1B (a different runstream) will execute a MASH analysis that uses the ozone data file TEST1A produced by this run. Run elements following the account number should be specified as shown in the example.

  Lines 2-7: An alternate print file, 03RP1A, is established which can be maintained in the computer after the run is completed. Additional copies may be obtained by submitting the command shown on line 7 at a demand terminal, substituting the number of copies desired for '1' and substituting PR for RM95PR if better quality printing is desired.

  Lines 9-15: A temporary file called "cards" is established which contains data selection specifications for program NA205. Letter 's' on line 10 indicates the type of output desired, in this case a standard data file (SDF) on mass storage. Lines 11 through 14 are SAROAD select cards wherein specific fields (columns) give different specifications. These cards MUST be in ascending order by SAROAD code so that subsequent files will be in proper order. Columns 1 through 12 indicate the SAROAD code for a monitoring site. Columns 13 through 17 indicate the pollutant code (44201 = ozone). Columns 18 and 19 indicate the method code (** = all methods). Column 20 indicates the interval code (1 = 1 hour averages). Columns 21 through 32 indicate the beginning and ending dates of a 3-year period from which data is to be selected. In the example, data from the period January 1, 1981 through December 31, 1983, are to be selected. Columns 33 through 43 are used only if particular AQCR's, counties, or States are to be selected. The user is advised to select certain

```
@RUN,R/R     06RP1A,ACCOUNT,MDAD/SASDP,9,200
@SYM,D       PRINT$.                   . DELETE FIRST PRINT FILE.
@CAT,P       $03$RP1A(+1).             . NEW CYCLE OF ALT. PRINT FILE.
@COND                                  . PROCESS IN ORDER.
@BRKPT       PRINT$/$03$RP1A           . USE ALTERNATE PRINT FILE.
@TIME                                  . RECORD RUN DATE & TIME.
@SYM,U       $03$RP1A.,1,RM95PR        . 1 PRINTOUT TO MUTUAL BLDG.
@ . THE FOLLOWING CARDS SELECT SAMPLE DATA FROM CALIFORNIA:
@ELT,IL      CARDS                     . TEMPORARY DATA FILE
S
052460002I0144201**1810101831231***********
055320003I0144201**1810101831231***********
056820006I0144201**1810101831231***********
057690001I0144201**1810101831231***********
@EOF
@DELETE,C    SDF-FILE.                 . REUSABLE OUTPUT FILE.
@COND                                  . PROCESS IN ORDER.
@CAT,P       SDF-FILE.,F///999         . LARGE FILE SOMETIMES NEEDED.
@COND                                  . PROCESS IN ORDER.
@ASG,A       SDF-FILE.                 . OUTPUT FILE FOR NA205
@ASG,A       NADB*NADB-ND-INDX.        . SAROAD INDEX FILE - 1980+
@ASG,A       NADB*NADB-ND-BULK.        . SAROAD DATA FILE -- 1980+
@ASG,A       NADB*NADB-RUN/SDS.        . FILE OF NADB RUNSTREAMS.
@COPY,S      NADB*NADB-RUN.NAR205      . COPY ONE RUNSTREAM.
@FREE        NADB*NADB-RUN.            . FREE FILE FOR OTHER USERS.
@ADD,PL      NAR205                    . START NA205 RUNSTREAM.
@ASG,A       PROG.                     . FILE FOR MASH SOURCE CODES.
@PL1,S       PROG.O3-VALID,O3-VALID     . COMPILE PROGRAM.
@FREE        PROG.                     . FREE FILE FOR OTHER USERS.
@MAP,N      ,TPF$.O3-VALID             . CREATE AN ABSOLUTE IN TPF$.
IN           TPF$.O3-VALID             . COMPILED RELATIVE ELEMENT.
LIB          LIB*PL1.                  . PL1 LIBRARY SUBROUTINES.
END                                    . END OF MAPPING INSTRUCTIONS.
@ASG,A       SDF-FILE.                 . OZONE DATA FROM PROGRAM NA205.
@USE         VALIDO3,SDF-FILE.         . INTERNAL NAME USED IN O3-VALID.
@DELETE,C    TEST1A.                   . CLEAR OUTPUT FILE NAME.
@COND                                  . PROCESS IN ORDER.
@CAT,P       TEST1A.,F///999           . LARGE FILE NEEDED SOMETIMES.
@COND                                  . PROCESS IN ORDER.
@ASG,A       TEST1A.                   . OUTPUT FOR PROGRAM O3-VALID.
@USE         VALIDO3,TEST1A.           . INTERNAL NAME USED IN PROGRAM.
@XQT         O3-VALID                  . EXECUTE PROGRAM O3-VALID.
@BRKPT       PRINT$                    . END ALTERNATE FILE PRINTING.
@FIN                                   . END OF ALL PROCESSING.
```

Figure 2. A runstream for processing ozone data.

monitoring sites rather than certain areas because airshed allocation instructions are only available for urban or downwind sites. Limit the number of selection cards to 50 or less. Since hundreds of ozone monitors have been established, a series of runs are required to process all ozone data in the U.S.

Lines 16-20: An output data file for NA205. The file name is deleted in case it was used by a previous run, then recatalogued. If the current run bombs, the output file may still be examined.

Lines 21-22: The SAROAD files containing recent air quality data are assigned. Historical data (prior to 1980) may be obtained from an analagous set of files (NADB*NADB-HD-INDX and NADB*NADB-HD-BULK). If needed, two lines should be added to assign these two files to the run.

Lines 23-26: A runstream is copied from an NADB file and is dynamically started (including execution of program NA205).

Lines 27-29: The source code for program O3-VALID is compiled into assembly code and a relative element is created in TPF$.

Lines 30-33: The assembly code routines, including PL1 library routines, are mapped so they can be executed. The resulting absolute element is placed into temporary file TPF$. O3-VALID is a program that is executed infrequently; therefore, computer storage costs can be reduced by saving only the source code element between executions.

Lines 34-35: The ozone file from NA205 is reassigned and given an alternate name used in program O3-VALID.

Lines 36-41: An output file is established for program O3-VALID and an equivalent internal name is provided.

Line 42: Program O3-VALID is executed using files named in this runstream.

Line 43: End of printing to alternate print file.

Line 44: End of run.

Use of the Runstream:

1. Use the UNIVAC editor to copy this runstream to a new element of the file, e.g., MDAD*RUN.NA205-VALID/GIPSON3A.

2. In this new runstream, change the run card to show the desired bin number, user initials, and run series.

3. Change the name of the alternate print file, $O3$RP1A, to reflect the correct user initials and run series (e.g., $O3$JG3A).

4. Change the name of the valid hourly ozone file, TEST1A, to reflect the run series (e.g, OZONE-3A).

5. Change the SAROAD select cards to reflect the monitors and years of data desired. A limit of 50 cards is recommended for a single run.

6. Free file MDAD*RUN and start the runstream (e.g., @START MDAD*RUN.NA205-VALID/GIPSON3A).

SECTION 3

PROCESSING METEOROLOGICAL DATA

Processing meteorological (met) data involves mounting tapes on UNIVAC, copying data from tapes to mass storage files, and calculating daily wind directions. Table 1 lists cities and dates for which meteorological data were obtained from the National Climatological Center in 1984. When the tapes were delivered to EPA's National Computer Center at Research Triangle Park, a foreign tape number was assigned to each one (e.g., B10107).

The second stage is to read data from tape to mass storage by means of the COPIE processor. The following statements show how the data may be read in demand mode:

```
@ASG,TJ   TAPE1.,36N,B10107,0
@ASG,UP   MET-LA.,F///1800
@US*ER.COPIE,S   CONVER/ANSIF/SDFSEQ.,TAPE1/80/10.192836/131472,MET-LA.
```

In the first statement, a met tape is assigned to the run, stating as equivalent tape name (TAPE1), a tape reading device (36N), and the foreign tape name (B10107). In the second statement, a new mass storage file is assigned with maximum space of 1800 tracks. In the third statement, the COPIE processor is used to copy selected data from tape to mass storage. Three directions separated by commas specify the type of operation, the input format, and the output format. The type of operation specified is a conversion (CONVER) from a tape in fixed block format of the American National Standards Institute (ANSIF) to a sequential standard data file (SDFSEQ). The input format for TAPE1 is 80 characters per record with a blocking factor of 10. The number of records to be read is 131,472 starting at record 192,836. The output file is SDF file MET-LA.

The next step in processing meteorological data is to use the met data established on mass storage files to calculate daily resultant wind directions. A special program, WIND-DIRECT, was written to perform these calculations. Figure 3 shows a runstream, located in MDAD*RUN.WIND-DIRECT/SAMPLE, that builds a single file of resultant wind directions from a series of run

TABLE 1. HOURLY METEOROLOGICAL DATA RECEIVED IN 1984 FROM NATIONAL CLIMATIC CENTER

Tape number	Station number	City	Begin date	End date
1	14739	Boston, MA	1/1/45	12/31/83
2	94746	Worcester, MA	1/1/49	12/31/83
3	14765	Providence, RI	1/1/48	12/31/83
4	14764	Portland, ME	1/1/48	12/31/83
5	14740	Hartford, CT	1/1/49	12/31/83
6	14745	Concord, NH	1/1/48	12/31/83
7	93730	Atlantic City, NJ	6/1/58	12/31/83
8	14734	Newark, NJ	1/1/48	12/31/83
9	13739	Philadelphia, PA	1/1/41	12/31/83
10	14737	Allentown, PA	1/1/48	12/31/83
11	14751	Harrisburg, PA	1/1/48	12/31/83
12	13781	Wilmington, DE	1/1/48	12/31/83
13	93814	Cincinnati, OH	1/1/48	12/31/83
14	93815	Dayton, OH	1/1/48	12/31/83
15	94846	Chicago, IL	11/1/58	12/31/83
16	94822	Rockford, IL	1/1/51	12/31/83
17	14839	Milwaukee, WI	1/1/48	12/31/83
18	14837	Madison, WI	1/1/48	12/31/83
19	23174	Los Angeles, CA	1/1/47	12/31/83
20	23188	San Diego, CA	1/1/48	12/31/83

```
@RUN,D/R       06RP00/75,ACCOUNT,MDAD/SASDD,60,500
@SYM,D         PRINT$                      . DELETE FIRST PRINT FILE.
@CAT,P         $03$RP00(+1).               . NEW CYCLE OF ALT. PRINT FILE.
@COND                                      . PROCESS IN ORDER.
@BRKPT         PRINT$/$03$RP00             . USE ALTERNATE PRINT FILE.
@TIME                                      . RECORD RUN DATE & TIME.
@SYM,U         $03$RP00.,1,RM95PR          . 1 PRINTOUT TO MUTUAL BLDG.
@ASG,A         PROG.                       . FILE OF SOURCE CODES.
@PL1,S         PROG.WIND-DIRECT,WIND-DIRECT  . COMPILE INTO TPF$.
@MAP,N         ,TPF$.WIND-DIRECT           . CREATE ABSOLUTE IN TPF$.
IN             TPF$.WIND-DIRECT            . RELOCATABLE IS IN TPF$.
LIB            LIB*PL1.                    . LIBRARY OF PL1 ROUTINES.
END                                        . END MAPPING INSTRUCTIONS.
@ADD,PL        RUN.MET-FILES               . STATS ON ALL MET FILES.
@ . REPEAT THE FOLLOWING SECTION FOR EACH MET STATION:
@ASG,A         STDS*MET-ALLEN.             . HOURLY MET DATA FILE.
@USE           METDATA,STDS*MET-ALLEN      . NAME USED BY WIND-DIRECT.
@DELETE,C      WINDS-ALLEN.                . CLEAR THIS FILE NAME.
@COND                                      . PROCESS IN ORDER.
@CAT,P         WINDS-ALLEN.                . RECREATE SAME FILE NAME.
@COND                                      . PROCESS IN ORDER.
@ASG,A         WINDS-ALLEN.,F///999        . ASSIGN MORE FILE SPACE.
@USE           RESULTS,WINDS-ALLEN         . NAME USED BY WIND-DIRECT.
@XQT           WIND-DIRECT                 . EXECUTE PROGRAM.
YEARS=1981,1982,1983          N_STATIONS=01      . INPUT DATA
ALLENTOWN               14737                    . INPUT DATA
@ED,U          WINDS-NE2.                  . FILE ALREADY CATALOGUED.
ADD            WINDS-ALLEN.                . ADD OUTPUTS FROM THIS RUN.
EXIT                                       . END OF EDITING.
@ . REPEAT THE FOLLOWING SECTION FOR EACH MET STATION:
@ASG,A         STDS*MET-SANDI.             . HOURLY MET DATA FILE.
@USE           METDATA,STDS*MET-SANDI      . NAME USED BY WIND-DIRECT.
@DELETE,C      WINDS-SANDI.                . CLEAR THIS FILE NAME.
@COND                                      . PROCESS IN ORDER.
@CAT,P         WINDS-SANDI.                . RECREATE SAME FILE NAME.
@COND                                      . PROCESS IN ORDER.
@ASG,A         WINDS-SANDI.,F///999        . ASSIGN MORE FILE SPACE.
@USE           RESULTS,WINDS-SANDI         . NAME USED BY WIND-DIRECT.
@XQT           WIND-DIRECT                 . EXECUTE PROGRAM.
YEARS=1981,1982,1983          N_STATIONS=01      . INPUT DATA
SAN DIEGO               14737                    . INPUT DATA
@ED,U          WINDS-NE2.                  . FILE ALREADY CATALOGUED.
ADD            WINDS-SANDI.                . ADD OUTPUTS FROM THIS RUN.
EXIT                                       . END OF EDITING.
@BRKPT         PRINT$                      . END PRINTING TO ALT. FILE.
@SYM           PRINT$,1,PR                 . NEXT FILE PRINTED AT RTP.
@ED,R          WINDS-NE2.                  . REVIEW OUTPUTS CREATED.
LNP'                                       . PRINT ALL LINES.
@FIN                                       . END OF RUN.
```

Figure 3. A runstream for calculating daily resultant wind directions.

executions. Each run execution uses one data file from one met station. Explanation of the runstream follows:

Line 1: The @RUN card is similar to the cards used previously, with bin number and user's initials shown in the run-ID.

Lines 2-7: Establishes an alternate print file and causes one copy to be printed at the Mutual building.

Lines 8-13: Compiles and maps the program (WIND-DIRECT) into an element of the temporary file for the run (TPF$).

Line 14: Prints statistics (e.g., file size, data created, and disc usage) for each meteorological data file created in 1984.

Lines 15-29: Executes program WIND-DIRECT for a sample meteorological station, Allentown, Pennsylvania. First the met file for Allentown is assigned to the run and given an internal name used by the program. Then an output file is established and given an internal name. The program is executed using these files and the input data following the @XQT statement. Years of data to use in calculations are indicated by three 2-digit numbers in line 25, columns 9-10, 14-15, and 19-20. Number of met stations (columns 40-41) should always be '1'. Other characters in the line are to help the user, but are not read by the program. The next line shows the name of the city (columns 1-12) and the ZIP code (columns 20-24) in which the met station is located (Table 1). After the execution, an already catalogued data file is edited by adding to it the data file from this run.

Lines 30-44. Executes program WIND-DIRECT for a second sample meteorological station, San Diego, California.

Lines 45-49. Ends the alternate print file, then lists the contents of the combined output file in a standard print file. This standard file is printed at a high quality printer, then the run is ended.

To Use the Runstream:

1. Catalogue a file to receive all daily resultant wind directions over a 3-year period. Use of a removable disk pack should ensure that it is retained on the system rather than being automatically removed after 60 days (e.g, @CAT,P RESULTS-USA.,F33,NCC075).

2. Copy the runstream to a new file element (e.g., WIND-DIRECT/1985).

3. Use the editor to change the run card to reflect the desired bin number and user's initials. Change the name of the alternate print file to reflect user's initials.

4. Delete this line or create an analagous file element (other than MET-FILES) that shows actual input files to be used.

5. Change the name of input and output files in lines 15-29 to indicate the correct met stations. Indicate the correct 3-year period following @XQT, maintaining column alignment. Indicate the correct station name and ZIP code, maintaining column alignment.

6. Use the correct combined data file name in lines 27 and 47.

7. Delete lines 30-44, then ditto lines 15-29 one or more times. In each ditto'd section, name a different met file to use in each execution. Note that the present version of MASH is limited to 20 met stations.

8. Exit and free the file. Start the runstream (e.g., @START MDAD*RUN.WIND-DIRECT/1985).

SECTION 4

ESTABLISHING A FILE OF INSTRUCTIONS

The instructions file is used by the MASH program to allocate hourly ozone values to airsheds. This file consists of a series of records whereby each record shows a range of times of day and a range of resultant wind directions that associate a particular monitor with a particular airshed. The format of the instructions file, MDAD*INSTRUCT-USA, is shown in Figure 4.

The first item on each record is the SAROAD code for the monitor (columns 1 to 12). The second datum is the area name (county or city) in which the monitor is located. This is the name corresponding to the SAROAD 4-digit area code within the 12-digit monitor code. Columns 29-32 show the Federal Information Processing Standards (FIPS) code for the Standard Metropoliton Statistical AREA (SMSA) in which the monitor is located.

The next two items are the names of two meteorological stations (truncated to eight characters) from which wind data are to be used for this monitor. If data from only one station is to be used, then the second name is filled with asterisks. If no wind data are to be used, then both station names are filled with asterisks and all hourly ozone values will be allocated to one local airshed named on this record. Only one instruction (record) should exist for a monitor if no wind data are used.

Instructions for each monitor are given in two 2-digit integers and two 3-digit integers. The first pair of integers (columns 52-53 and 55-56) indicate the range of hours of the day (0 to 24). The second pair of integers (columns 58-60 and 62-64) indicate the resultant wind direction for the day in compass degrees (0 to 360). Note that the first integer must always be less than the second integer in order for the instructions to be processed properly. For example, a wind direction range from 270^o to 10^o should be represented by two different records with ranges 270^o to 360^o and 0^o to 10^o. In cases where allocation instructions do not cover all possible conditions, values not covered will be automatically allocated to a dummy airshed called "discard."

CODED INSTRUCTIONS FOR MONITORING SITES

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Monitor	Monitor City	Monitor SMSA	MET Station 1	MET Station 2	Hours	Wind Direct		Airshed SMSA
221210001F01	MEDFIELD	1120	HARTFORD	********	11-15	180-230	TRANS	6480
					16-24	180-270	TRANS	5600
					0-24	0-360	LOCAL	1120
221220003F01	MEDFORD	1120	********	********	0-24	0-360	LOCAL	1120
221392001A05	MONTAGUE	9999	HARTFORD	********	11-15	160-200	LOCAL	8000
221520003F01	NEWBURYPORT	9999	********	********	0-24	0-360	TRANS	1120
221792001F01	PEPPERELL	9999	********	********	0-24	0-360	LOCAL	1120
221800005F01	PITTSFIELD	6320	********	********	0-24	0-360	LOCAL	6320
221800007F01	PITTSFIELD	6320	********	********	0-24	0-360	LOCAL	6320
221880002F01	QUINCY	1120	BOSTON	PROVIDEN	18-24	180-250	TRANS	5600
					0-24	0-360	LOCAL	1120
222100003F01	SOMERVILLE	1120	BOSTON	PROVIDEN	18-24	180-250	TRANS	5600
					0-24	0-360	LOCAL	1120
222160014F01	SPRINGFIELD	8000	HARTFORD	********	14-18	180-270	TRANS	CONN
					18-24	180-270	TRANS	5600
					11-15	150-210	LOCAL	8000
222196001F01	SUDBURY	1120	BOSTON	PROVIDEN	11-15	180-230	TRANS	6480
					18-24	180-250	TRANS	5600
					0-24	0-360	LOCAL	1120
222252001F01	TEWKSBURY	4560	BOSTON	PROVIDEN	18-24	180-250	TRANS	5600
					0-24	0-360	LOCAL	1120
222360001F01	WARE	9999	HARTFORD	********	16-24	180-250	TRANS	5600
					11-15	230-260	LOCAL	8000
222380005F01	WATERTOWN	1120	BOSTON	PROVIDEN	18-24	180-250	TRANS	5600
					0-24	0-360	LOCAL	1120
222640012F01	WORCESTER	9240	WORCESTE	********	0-24	80-130	TRANS	1120
					16-24	180-250	TRANS	5600
					11-15	0-360	LOCAL	9240
222640015F01	WORCESTER	9240	WORCESTE	********	16-24	180-250	TRANS	5600
					0-24	80-130	TRANS	1120
					11-15	0-360	LOCAL	9240

Figure 4. Sample records (lines) from the instructions file.

Columns 66-70 indicate whether the airshed allocation in this record was based on ozone precursers transported from a distant SMSA (TRANS) or was generated within the local SMSA (LOCAL). Columns 72-75 indicate the FIPS code of the SMSA of the airshed.

The instructions file may be modified by changing one of the records, removing records, or adding new records. The user may need to review the contents of the file in a easy-to-read table with appropriate headings. Such a table may be generated by using the runstream MDAD*RUN.PRINT/INSTRUCT shown in Figure 5. Change the run - ID to reflect the correct bin number and user -ID, then submit an @START command at the terminal.

```
@RUN,R/R      06RP,ACCOUNT,MDAD/SASDP,2,100
@SYM,D        PRINT$                     . DELETE FIRST PRINT FILE.
@CAT,P        $03$RP(+1).                . NEW CYCLE OF ALT. PRINT FILE.
@COND                                    . PROCESS IN ORDER.
@BRKPT        PRINT$/$03$RP              . USE ALTERNATE PRINT FILE.
@TIME                                    . RECORD RUN DATE & TIME.
@SYM,U        $03$RP.,1,RM95PR           . 1 PRINTOUT TO MUTUAL BLDG.
@ASG,A        PROG.                      . PROGRAM SOURCE CODE FILE.
@PL1,S        PROG.PRINT/INSTRUCT,PRINT/INSTRUCT  . COMPILE PROGRAM.
@FREE         PROG.                      . FREE FILE FOR OTHER USERS.
@MAP,N       ,TPF$.PRINT/INSTRUCT        . CREATE ABSOLUTE IN TPF$.
IN            TPF$.PRINT/INSTRUCT        . RELATIVE LOCATED IN TPF$.
LIB           LIB*PL1.                   . PL1 SUBROUTINE LIBRARY.
END                                      . END MAPPING INSTRUCTIONS.
@ASG,A        INSTRUCT-USA.              . FILE TO BE PRINTED.
@USE          INSTRUCT,INSTRUCT-USA.      . NAME USED IN PRINT/INSTRUCT.
@XQT          PRINT/INSTRUCT             . EXECUTE PRINTING PROGRAM.
@BRKPT        PRINT$                     . END PRINTING TO ALT. PRINT FILE.
@FIN                                     . END OF RUN.
```

Figure 5. A runstream for printing the instuctions file.

Proper processing by MASH requires that records within the instructions file be in the proper order. MASH searches for an instruction with a monitor code matching a monitor in the ozone file. If the program finds a monitor code higher than the ozone file monitor, the search is stopped and a message is printed stating that no instruction was found for this monitor. This technique works only if records within the instruction file are sorted in ascending order of SAROAD code.

Within each SAROAD code, records should be sorted in descending order of transport value (TRANS, then LOCAL). Instructions allocating all transported ozone are read and used before any instructions for the local airshed. Once a value is allocated, no other instructions are used because only one airshed is allocated each hour. This protocol saves space in the file because fewer local records are required. For example, if wind directions 60° to 180° represent transported O_3 and all other directions are local, then only one local record is required for directions 0 to 360 rather than 0 to 59 and 181 to 360. Any wind direction 60° to 180° will cause the first instruction to be activated and the second one ignored. Any wind direction outside this range will cause the first instruction to be bypassed and the second instruction utilized.

The instructions file may be sorted in proper order by using the partial runstream MDAD*RUN.SORT/INSTRUCT, as shown in Figure 6. No change in the runstream is required; simply submit @ADD,PL MDAD*RUN.SORT/INSTRUCT in demand mode.

```
@ASG,A         INSTRUCT-USA.           . FILE TO BE SORTED.
@DELETE,C      $02$OUT.                . CLEAR OUTPUT FILE NAME.
@COND                                  . PROCESS IN ORDER.
@CAT,P         $02$OUT.                . NEW OUTPUT FILE.
@COND                                  . PROCESS IN ORDER.
@ASG,A         $02$OUT.                . TO BE USED BY @SORT.
@USE           INPUT.,INSTRUCT-USA.    . INTERNAL NAME FOR @SORT.
@USE           OUTPUT.,$02$OUT.        . INTERNAL NAME FOR @SORT.
@SORT,ES                               . CALL PROCESSOR.
FILEIN=INPUT                           . ANOTHER INTERNAL NAME.
FILEOUT=OUTPUT                         . ANOTHER INTERNAL NAME.
MODE=SDF                               . INPUT IS STANDARD FILE.
RSZ=132                                . RECORD SIZE = 132 CHAR.
DATA=ASCII                             . INPUT FILE CODING.
KEY=1,12,S,A:66,5,S,D    . COL 1-12, S=ALPHANUMERIC, A=ASCENDING.
RECORD=2                               . 2000 RECORDS (OR LESS).
@EOF                                   . END SORT INSTRUCTIONS.
```

Figure 6. A partial runstream for sorting the instructions file.

SECTION 5

OPERATING THE MAIN PROGRAM

Operation of the main program of MASH requires the assignment of four input data files and two output files.

Input files for MASH include a file of resultant daily wind directions from selected meteorological stations and a file of instructions on how to allocate hourly ozone values to various airsheds based on wind directions. Note that the meteorological stations named in the instructions file must match the stations in the wind directions file. As of this date, file MDAD*WINDS-USA contains wind data for 20 meteorological stations across the U.S. for all days from 1981 through 1983. These stations match the stations named in file MDAD*INSTRUCT-USA. Other input files include a small, temporary file of run options and a file of valid hourly ozone data from program O3-VALID.

Outputs are 1) a file of design values for each airshed monitor combination, and 2) a file of nonzero hourly values that were not allocated to any airshed (discards). The design value file is called a "raw" value file with one line of data for each design value. These outputs are to be combined with other files and sorted before being placed in a formal table (Section 6). The "discard" file lists hourly values from a monitor not assigned to a specific airshed. These discard values may be useful in expanding the instructions for future runs.

Operation of the main program is exemplified in element MASH/TEST1 of file MDAD*RUN as shown in Figure 7. Functions of this runstream are described in the comments on each line and in the following:

Line 1: The @RUN card indicates a routine batch run that can operate during normal operating times of the NCC. The run identification, O6RP1B, indicates bin number 6, user initials RP, and run series 1B. Note that run series 1B is intended to use the ozone date file TEST1 from O3-VALID created by runs series 1A (Section 2). The main program requires about 65,000 words in core, indicated by 65 on the run card. An appropriate account number may be inserted. Other elements of the run card must remain as shown, except that more than 9 minutes could be required for a very large ozone file.

```
@RUN,R/R        06RP1B/65,ACCOUNT,MDAD/SASDP,9,200
@SYM,D          PRINT$                       . DELETE FIRST PRINT FILE.
@CAT,P          $03$RP1B(+1).                . NEW CYCLE OF ALT. PRINT FILE.
@COND                                        . PROCESS IN ORDER.
@BRKPT          PRINT$/$03$RP1B              . USE ALTERNATE PRINT FILE.
@TIME                                        . RECORD RUN DATE & TIME.
@SYM,U          $03$RP1B.,1,RM95PR           . 1 PRINTOUT TO MUTUAL BLDG.
@ASG,A          PROG.                        . FILE FOR MASH SOURCE CODES.
@COPY,A         PROG.MASH,TPF$.MASH          . COPY ABSOLUTE TO TPF$.
@FREE           PROG.                        . FREE FILE FOR OTHER USERS.
@ASG,A          WINDS-USA.                   . WINDS @ 20 MET. STATIONS.
@USE            WIND,WINDS-USA.              . INTERNAL NAME USED IN MASH.
@ASG,A          TEST1.                       . O3 DATA FROM NA205.
@USE            VALIDO3,TEST1.               . INTERNAL NAME USED IN MASH.
@ASG,A          INSTRUCT-USA.                . AIRSHED ALLOCATION INSTRUCTIONS.
@USE            INSTRUCT,INSTRUCT-USA.   . INTERNAL NAME USED IN MASH.
@ASG,T          RUNINPUT.                    . TEMPORARY DATA FILE.
@ED,IQ          RUNINPUT.                    . PLACE DATA INTO TEMP. FILE.
N_STATIONS=20      N_MONITORS=050          PRINT_WINDS=YES
 YEAR1=1981   YEAR2=1982   YEAR3=1983     EOL
@EOF                                         . END OF TEMPORARY DATA FILE.
@DELETE,C       RAW-VALUES1.                 . CLEAR OUTPUT FILE NAME.
@COND                                        . PROCESS IN ORDER.
@CAT,P          RAW-VALUES1.                 . RECATALOGUE SAME NAME.
@COND                                        . PROCESS IN ORDER.
@ASG,A          RAW-VALUES1.                 . OUTPUT FILE ASSIGNED TO RUN.
@USE            DESIGNVALUES, RAW-VALUES1.   . INTERNAL FILE NAME.
@DELETE,C       TEST1-DISC.                  . CLEAR 2ND OUTPUT FILE NAME.
@COND                                        . PROCESS IN ORDER.
@CAT,P          TEST1-DISC.                  . RECATALOGUE SAME NAME.
@COND                                        . PROCESS IN ORDER.
@ASG,A          TEST1-DISC.,F///999          . ASSIGN WITH LARGER SPACE.
@USE            DISCARDS,TEST1-DISC.         . INTERNAL NAME USED IN MASH.
@SETC,O                                      . SET CORE ACCOUNTING FOR MASH.
@XQT            MASH                         . EXECUTE PROGRAM MASH.
@ED,R           RAW-VALUES1.                 . REVIEW OUTPUT FILE #1.
P'                                           . PRINT ALL LINES.
@ED,R           TEST1-DISC.                  . REVIEW OUTPUT FILE #2.
LNP             1 50                         . PRINT SAMPLE -- 50 LINES.
@BRKPT          PRINT$                       . END PRINTING TO ALT. PRINT FILE.
@FIN                                         . END OF RUN.
```

Figure 7. A runstream for executing the main MASH program.

Lines 2-5: Establishes an alternate print file so that results of the run may be reviewed after run completion, even if an error is encountered.

Line 6: The first data printed in the alternate print file will be the date and time of the run.

Line 7: Causes one copy of the alternate print file to be printed at the Mutual Building printer.

Lines 8-10: Copies an absolute file element of MASH to the run's temporary file (TPF$) for execution.

Lines 11-16: Assigns three input files to the run and assigns internal names used by MASH.

Lines 17-21: Establishes a temporary data file giving certain run options to the program.

Lines 22-23: Establishes two output files and provides internal names for use in MASH.

Line 34: Sets a value in a portion of the condition word associated with each run in UNIVAC. Option O was established by NCC to turn on an accounting system during the execution of a program. At the end of the execution (either normal or error) a statement is printed showing the standard units of processing (SUPS) and core space used.

Line 35: Executes program MASH using the files named in this run.

Lines 36-39: Prints certain lines of the output files so the user may check the run's success.

Line 40: Signals end of printing to the alternate print file.

Line 41: End of run.

Use of the Runstream:

1. Copy this runstream to a new element of the file (e.g., MDAD*RUN.MASH/1985-1B).

2. Change the run card to show the desired bin number, user initials, and run series.

3. Change the name of the alternate print file, $O3$RP1B, to reflect the correct user initials and run series.

4. Change the name of the valid ozone data file, TEST1, to reflect the correct file to be used.

5. Check the name and contents of the instructions file, INSTRUCT-USA., to ensure that instructions exist for the monitors named in the valid ozone data file.

6. Check the name and contents of the wind directions file, WINDS-USA., to ensure that wind data exist for all stations referenced in the instructions file.

7. Change the runstream options in file RUNINPUT as follows:

   (a) Keep the maximum number of stations (columns 12-13) at 20, the present capacity of MASH.

   (b) Limit the maximum number of monitors to be processed (line 19, columns 30-32) in one run to 50, a limit that keeps file sizes and run costs to a reasonable level.

   (c) If a list of wind data is to be printed in the alternate print file, maintain the value of print-winds as "yes" in line 19, columns 55-57. Otherwise change to "no."

   (d) Indicate year No. 1, year No. 2, and year No. 3 of the hourly data file by entering three two-digit numbers beginning in line 20, columns 10, 22, and 34. Other characters on lines 19 and 20 are comments that help maintain column alignment.

8. Exit and free file MDAD*RUN. Start the runstream (e.g., @START MDAD*RUN.MASH/1985-1B).

SECTION 6

FORMATTING THE OUTPUTS

When using the MASH model, a series of valid ozone data files are created to incorporate all ozone monitors in the U.S. These valid ozone data are processed by a series of MASH runs that produce a series of design value files. The final step is to combine all design value files into one file, sort this file by design value within each airshed, and print design values in an easy-to-read table with column headings. A runstream for carrying out this process located in MDAD*RUN.MASH/HEADINGS, is shown in Figure 8.

Line 1 is a run card similar to other runs shown in this guideline. Lines 2-7 establish an alternate print file with one copy to be printed at the Mutual Building. Lines 9-13 establish a temporary file and add together all design values into the file. Lines 14-18 establish an output file for the UNIVAC sorting utility, @SORT. Lines 21-29 provide instructions to @SORT for sorting the input file by airshed and by design value. In lines 30-31 a sample of the output file, RAW-SORTED, is printed for quality assurance checking. In lines 32-37 a special program, MASH/HEADINGS, is compiled and mapped so it can be executed. Lines 38-43 establish an output file for this program. Lines 44-45 assign an input file consisting of FIPS codes and names for all SMSA's, including special names used only in this program. The SMSA file is needed because the design value table uses SMSA names as names of airsheds rather than using SMSA codes. Line 46 established a name used in MASH/HEADINGS. Line 47 turns on the accounting system. Line 48 executes the program. Lines 48-49 prints the output file for checking. Line 51 terminates printing to the alternate print file. Line 52 terminates the run.

<u>Use of the Runstream</u>:

1. Use the UNIVAC editor to change the bin number, initials, and account number in the run card as needed.

2. Change the name of the alternate print file to match the user's initials.

```
@RUN,R/R        06RP5,ACCOUNT,MDAD/SASDP,4,200
@SYM,D          PRINT$                     . DELETE FIRST PRINT FILE.
@CAT,P          $03$RP5(+1).               . NEW CYCLE OF ALT. PRINT FILE.
@COND                                      . PROCESS IN ORDER.
@BRKPT          PRINT$/$03$RP5             . USE ALTERNATE PRINT FILE.
@TIME                                      . DATE & TIME OF THIS RUN.
@SYM,U          $03$RP5.,,RM95PR           . 1 PRINTOUT TO MUTUAL BLDG.
@ASG,T          RAW-VALUES.                . TEMPORARY FILE FOR THIS RUN.
@ED,IQ          RAW-VALUES.                . PUT DATA INTO TEMP. FILE.

ADD             RAW-VALUES1.               . ADD DATA FROM A MASH RUN.
ADD             RAW-VALUES2.               . ADD DATA FROM A MASH RUN.
EXIT                                       . END OF NEW DATA.
@DELETE,C       RAW-SORTED.                . CLEAR THIS FILE NAME.
@COND                                      . PROCESS IN ORDER.
@CAT,P          RAW-SORTED.                . RECREATE SAME FILE NAME.
@COND                                      . PROCESS IN ORDER.
@ASG,A          RAW-SORTED.                . OUTPUT FILE FOR @SORT.
@USE            INPUT.,RAW-VALUES.         . INTERNAL NAME FOR @SORT.
@USE            OUTPUT.,RAW-SORTED.        . INTERNAL NAME FOR @SORT.
@SORT,ES                                   . CALL SORTING UTILITY PROGRAM.
FILEIN=INPUT                               . ANOTHER INTERNAL FILE NAME.
FILEOUT=OUTPUT                             . ANOTHER INTERNAL FILE NAME.
MODE=SDF                                   . INPUT IS STANDARD FILE.
RSZ=132                                    . RECORD SIZE = 132 CHAR.
DATA=ASCII                                 . FILE CODING IS ASCII.
KEY=1,4,S,A:49,5,S,D     . SORT BY AIRSHED SMSA, THEN DESIGN VALUE.
RECORD=4                                   . 4000 RECORDS (OR LESS)
@EOF                                       . END @SORT INSTRUCTIONS.
@ED,R           RAW-SORTED.                . CHECK SORTED FILE.
LNP 1 100                                  . PRINT 100 LINES.
@ASG,A          PROG.                      . FILE OF SOURCE CODES.
@PL1,SE         PROG.MASH/HEADINGS,MASH/HEADINGS  . COMPILE.
@MAP,N          ,TPF$.MASH/HEADINGS        . CREATE ABSOLUTE IN TPF$.
IN              TPF$.MASH/HEADINGS         . RELATIVE LOCATED IN TPF$.
LIB             LIB*PL1.                   . PL1 SUBROUTINE LIBRARY.
END                                        . END OF MAP INSTRUCTIONS.
@DELETE         DV-81-83.                  . CLEAR THIS FILE NAME.
@COND                                      . PROCESS IN ORDER.
@CAT,P          DV-81-83.                  . RECREATE THIS FILE NAME.
@COND                                      . PROCESS IN ORDER.
@ASG,A          DV-81-83.                  . OUTPUT FILE FOR MASH/HEADINGS.
@USE            DESIGNVALUES, DV-81-83.     . INTERNAL NAME USED.
@ASG,A          SMSA-NAMES.                . FILE OF SMSA CODES & NAMES.
@USE            SMSANAMES,SMSA-NAMES.      . NAME USED BY MASH/HEADINGS.
@USE            RAWSORTED,RAW-SORTED.      . NAME USED BY MASH/HEADINGS.
@SETC,0                                    . TURN ON CORE ACCOUNTING SYSTEM.
@XQT            MASH/HEADINGS              . EXECUTE HEADINGS PROGRAM.
@ED,R           DV-81-83.                  . CHECK OUTPUT FILE.
P'                                         . PRINT ENTIRE FILE.
@BRKPT          PRINT$                     . END PRINTING TO ALT. PRINT FILE.
@FIN                                       . END OF RUN.
```

Figure 8. A runstream for combining outputs into a formatted table.

3. Changes names of MASH files in lines 11-12 as needed to reflect actual file names that were created. Add more lines if needed.

4. Exit from the file and start the runstream (e.g., @START MDAD*RUN.MASH/HEADINGS).

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16. ABSTRACT

Multiple airshed (MASH) model calculates design values for each of a series of ozone monitoring sites in the U. S. Each monitor is assigned to various airsheds, depending on time of day and the resultant wind direction for each day. Using a list of high values for each airshed, one design value is selected for each airshed and monitor combination. The design value associated with a particular SMSA can be selected from the resulting list of site specific design values which the program generates for each airshed. Input data for MASH are 1) hourly ozone values from monitors, 2) daily resultant wind directions at selected meteorological stations, and 3) a coded set of instructions telling how to allocate hourly ozone values to various airsheds based on wind direction.

17. KEY WORDS AND DOCUMENT ANALYSIS

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