AHYMO-S4 User Information
(Release Rel 2) - April 2018

Program Features and Functions

The following summarizes major differences between AHYMO-97 and the new AHYMO-S4 Arid-Land Hydrologic Model computer program (Release R2a) and describes the new functions of the AHYMO-S4 program.

Number of Hydrograph Data Values

The program can now use 4000 data values for hydrographs and rainfall distributions instead of the 600 value limit with the AHYMO_97 program. This means that the computation time step (DT) can be specified as small as 0.01 or 0.005 hours. This small time step results in very minor changes to individual watershed peak flow rates, but has a major impact on channel routing computations using the Muskingum-Cunge method. The need for small time steps depends on the channel configurations and shapes of the inflow hydrographs. For arid and semi-arid watersheds common in the western US, computation time steps of 0.01 or 0.005 hours appear to be needed when the Muskingum-Cunge channel routing procedure is used in the AHYMO program. The AHYMO program also contains a "variable storage coefficient" (VSC) channel routing procedure, but studies show that this procedure should not be used for natural or lined channels in New Mexico and similar arid or semi-arid areas.

AHYMO-S4 Command Revisions

START Command:

Default Values are specified by using:

```
        START
or
        START           0  0  0  0  0
or
        START           TIME=0.0    PUNCH=0.0   UH=0   MC CODE=0   PRINT CODE=0
```

The default value of MC CODE (MC CODE=0) specifies the Ponce formulation for Muskingum-Cunge routing when the computation time step (DT) specified with the RAINFALL command is 0.015 hours or smaller, and the dual mode Ponce then Fread formulations will be used when the DT is larger than 0.015 hours. The dual mode Ponce then Fread formulation was generally used with the AHYMO_97 program, although either formulation could be specified with the ROUTE MCUNGE command. If MC CODE=1 only the Ponce formulation will be

used. If MC CODE=2 the dual mode formulation (Ponce then Fread) that was in AHYMO-97 will be restored for all computation time steps, but this function is only recommended for comparison purposes. For most applications, it is recommended that a DT of 0.015 hours or smaller be used and that MC CODE=0 or 1 be specified.

For most applications the following is recommended:

```
START       TIME=0.0
```

LOCATION Command:

The location command specifies the location for the watershed and establishes special watershed parameters for some of these areas. The LOCATION command recognizes the following names:

> AHYMO OLD, AHYMO194, AHYMO97, ALBUQUERQUE, AMAFCA, ARIZONA, ARTESIA, BERNALILLO COUNTY, CARLSBAD, CLOVIS, COLORADO, EL PASO, ESCAFCA, FARMINGTON, FLAGSTAFF, GALLUP, LOS CRUCES, NEW MEXICO, PHOENIX, RIO RANCHO, ROSWELL, SANDOVAL COUNTY, SANTA FE, SSCAFCA, TUCSON.

The program will use default parameters if no LOCATION command is specified or if the location name is not recognized. The LOCATION command is normally placed immediately after the START command. For most of the locations identified, the program will use default parameters because no special program parameters have been specified. The following locations have exceptions to the default parameters:

> SANTA FE - Special infiltration values (initial abstraction and uniform infiltration) developed for the Santa Fe area will be used.

> AHYMO OLD, AHYMO97, SSCAFCA, or RIO RANCHO - When the TYPE=1 and TYPE=2 distributions are specified in the RAINFALL command, the rainfall distribution based on the equations in the Albuquerque DPM (NOAA Atlas 2) will be used. This is the same equation used in the AHYMO-97 program.

> AHYMO194 - the Muskingum-Cunge procedure from the AHYMO194 program will be used with the ROUTE MCUNGE command. This should only be used to make comparisons with an earlier analysis.

> For all other locations - When the TYPE=1 and TYPE=2 distributions are specified in the RAINFALL command, the rainfall distribution based on the equations in NOAA Atlas 14 for convective storm areas in Arizona and New Mexico will be used.

RAINFALL Command:

The following 18 rainfall types (TYPE=1 to 17, 20 and 21) are now defined by the AHYMO_S4 program:

TYPE	Description
0	Input mass rainfall table. (with format changed from AHYMO_97.)
1	A 6-hour distribution that uses the TYPE=20 or TYPE=12 distribution depending on the name specified in the LOCATION command. When AHYMO97, SSCAFCA, or RIO RANCHO are specified, the TYPE=12 distribution (based on NOAA Atlas 2) is used. For the program default and at all other locations the TYPE=20 distribution (based on NOAA Atlas 14) is used.
2	A 24-hour distribution that uses the TYPE=21 or TYPE=13 distribution depending on the name specified in the LOCATION command. When AHYMO97, SSCAFCA, or RIO RANCHO are specified, TYPE=13 (based NOAA Atlas 2) is used. For the program default and at all other locations TYPE=21 (based on NOAA Atlas 14) is used.
3	PMP 6-hour distribution based on the local storm in HMR 55a. (Not changed from AHYMO_97.)
4	PMP 24-hour based on the general storm in HMR 55a. (Not changed from AHYMO_97.)
5	NRCS (formerly the SCS) Type II-a distribution for New Mexico with peak at 6-hours. (Not changed from AHYMO_97.)
6	A 6-hour based on the power formula in the 1981 *Albuquerque Master Drainage Study*. This distribution is used for comparison with existing studies only and not for new projects. (Not changed from AHYMO_97.)
7	A 35-minute distribution used in the *Far Northwest Drainage Management Plan*. This distribution is used for comparison with existing studies only and not for new projects. (Not changed from AHYMO_97.)
8	A 24-hour NRCS (formerly the SCS) Type II distribution with a peak at 12.0 hours. This distribution is not generally applicable to the arid southwest where NOAA Atlas 2 or NOAA Atlas 14 values are applicable. (Not changed from AHYMO_97.)
9	A 24-hour distribution based on NOAA Atlas 2 for New Mexico with a peak at 6.0 hours. (Not changed from AHYMO_97.)
10	A 6-hour distribution based on NOAA Atlas 2 for New Mexico with a peak at 0.4 hours. This distribution is used for comparison with existing studies only and not for new projects. (Not changed from AHYMO_97.)
11	A 24-hour distribution based on NOAA Atlas 2 for New Mexico with a peak at 0.4 hours. This distribution is used for comparison with existing studies only and not for new projects. (Not changed from AHYMO_97.)
12	A 6-hour distribution based on NOAA Atlas 2 for New Mexico with a peak at 1.40 hours. (This was distribution TYPE=1 in AHYMO_97.)

13   A 24-hour distribution based on NOAA Atlas 2 for New Mexico with a peak at 1.40 hours. (This was distribution TYPE=2 in AHYMO_97.)

14   A 6-hour distribution based on NOAA Atlas 2 for New Mexico with a peak at 1.40 hours and 5-minute incremental time steps. This distribution uses the same equations as the TYPE=12 distribution, except that only 5-minute incremental values are computed. Linear interpolation is used to compute intermediate values when the DT is not equal to 5 minutes.

15   A 24-hour distribution based on NOAA Atlas 2 for New Mexico with a peak at 1.40 hours and 5-minute incremental time steps. This distribution uses the same equations as the TYPE=13 distribution, except that only 5-minute incremental values are computed. Linear interpolation is used to compute intermediate values when the DT is not equal to 5 minutes.

16   A 6-hour distribution based on NOAA Atlas 14 for convective storm areas in Arizona and New Mexico. The distribution has a peak at 1.4 hours, with the peak 1-hour precipitation placed between 60 and 120 minutes. The distribution uses the following 5-minute peak precipitation sequence: 48, 45, 42, 39, 36, 33, 30, 27, 24, 21, 18, 15, 12, 9, 6, 3, 1, 2, 4, 5, 7, 8, 10, 11, 13, 14, 16, 17, 19, 20, 22, 23, 25, 26, 28, 29, 31, 32, 34, 35, 37, 38, 40, 41, 43, 44, 46, 47, 49, 50, 51, 52 to 72.

17   A 24-hour distribution based on NOAA Atlas 14 for convective storm areas in Arizona and New Mexico. The distribution has a peak at 1.4 hours, with the peak 1-hour precipitation placed between 60 and 120 minutes. The distribution uses the following 5-minute peak precipitation sequence: 48, 45, 42, 39, 36, 33, 30, 27, 24, 21, 18, 15, 12, 9, 6, 3, 1, 2, 4, 5, 7, 8, 10, 11, 13, 14, 16, 17, 19, 20, 22, 23, 25, 26, 28, 29, 31, 32, 34, 35, 37, 38, 40, 41, 43, 44, 46, 47, 49, 50, 51, 52 to 288.

18   Reserved for a future distribution.

19   Reserved for a future distribution.

20   A 6-hour distribution based on NOAA Atlas 14 for convective storm areas in Arizona and New Mexico. The distribution has a peak at 1.4 hours, and is similar to the TYPE=16 distribution. The distribution sequence is based on the sequence indicated with Table A.1.3 in NOAA Atlas 14. The distribution uses the following 5-minute peak precipitation sequence: 39, 35, 31, 27, 24, 21, 19, 18, 17, 15, 13, 11, 9, 7, 5, 3, 1, 2, 4, 6, 8, 10, 12, 14, 16, 20, 22, 23, 25, 26, 28, 29, 30, 32, 33, 34, 36, 37, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52 to 72.

21   A 24-hour distribution based on NOAA Atlas 14 for convective storm areas in Arizona and New Mexico. The distribution has a peak at 1.4 hours, and is similar to the TYPE=17 distribution. The distribution sequence is based on the sequence indicated with Table A.1.3 in NOAA Atlas 14. The distribution uses the following 5-minute peak precipitation sequence: 39, 35, 31, 27, 24, 21, 19, 18, 17, 15, 13, 11, 9, 7, 5, 3, 1, 2, 4, 6, 8, 10, 12, 14, 16, 20, 22, 23, 25, 26, 28, 29, 30, 32, 33, 34, 36, 37, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52 to 288.

The following table shows the required input values for the rainfall distributions. If input is not required for a given distribution, input a 0 value or other number as a place holder. Examples of all the rainfall types can be obtained by executing the RAINTEST.DAT data file. If the rainfall type is input as a negative number, the printing of the mass rainfall table will be suppressed on the AHYMO program output.

RAINFALL TYPE	QUARTER HOUR	ONE HOUR	SIX HOUR	DAILY RAIN
1	N	R	R	N
2	N	R	R	R
3	O	R	R	N
4	N	R	R	R
5	N	R	N	R
6	N	R	R	N
7	N	N	R	N
8	N	N	N	R
9	N	R	R	R
10	N	R	R	N
11	N	R	R	R
12	N	R	R	N
13	N	R	R	R
14	N	R	R	N
15	N	R	R	R
16	N	R	R	N
17	N	R	R	R
20	N	R	R	N
21	N	R	R	R

Legend	N	Not required or used - input as 0.0 or actual value
	R	Required
	O	Optional - input as 0.0 or actual value

The format for specifying the TYPE=0 RAINFALL has been revised to add the capability to specify an incremental computation time (DT) that is different from the time used to specify the rainfall. When RAINFALL TYPE=0, the mass rainfall table is directly input. The computation incremental time (DT) is first specified followed by the incremental time for the mass rainfall values (RDT). This is followed by the mass rainfall table with up to 4000 values.

The following example shows a specified TYPE=0 RAINFALL with DT=0.01 hours and an RDT=0.083333 hours (5 minutes):

```
RAINFALL     TYPE=0    DT=0.01    RDT=0.083333
             MASS RAIN=  0.00   0.01   0.02   0.04   0.06
             0.09   0.12   0.15   0.21   0.27   0.34   0.42
             0.53   0.63   0.74   0.85   0.97   1.10   1.25
             1.40   1.58   1.79   1.88   2.00   2.10   2.18
             2.24
```

Designation of Input and Output Files

The file AHYMO-S4-R2.EXE, or shortcut file that calls AHYMO-S4-R2.EXE, must be locatable by Windows, to execute the program. To execute the program in Windows XP, double click on the shortcut AHYMO-S4 icon and specify the file name (including the directory location if needed) or drag the filename icon to the open window. As an alternative in Windows 7, 8, 8.1 and 10, you may drag the input data file to the shortcut AHYMO-S4 icon, and the AHYMO-S4 program will begin execution. When the program asks for the name of the input file, press the enter (return) key without typing a name, and the AHYMO program will use the input file that you specified by dragging. On some Windows systems, you may need to first open the AHYMO_S4 program by double-clicking the shortcut icon, then drag the data file to the program window that is opened, and hit "enter". Also, the AHYMO_IO.FIL file must be in the working directory or be locatable by Windows. The AHYMO_IO.FIL contains the input and output file names used by the program and the user identification code. The file AHYMO_IO.FIL should contain the following data:

D.1   First line (input file):
"PROMPT" - The program asks for the input file name during execution, or
name - a file name of a locatable data file.

D.2   Second line (output file):
"PROMPT" - The program asks for the output file name during execution, or
name - a file name to which the output is sent. If the file exists, it is overwritten.
If it does not exist, the file is created. A commonly used output file name is AHYMO.OUT.

D.3   Third line (simulated punch cards)
"PROMPT" - The program asks for the name of simulated punch card data during execution, or
name - a file name to which the simulated punch card output is sent. If the file exists, it is overwritten. If it does not exist, the file is created. A commonly used output file name is AHYMO.PUN.

D.4   Fourth Line (Hydrograph input/output file)
"PROMPT" - The program asks for the name of the HYDROGRAPH input/output file during execution,
name - a file name to which selected HYDROGRAPH output is sent. If the file exists, it is overwritten. If it does not exist, the file is created. A commonly used output file name is AHYMO.HYD.
"NONE" - If no hydrograph input/output file is needed. If the SAVE HYD command is used, a file name for HYDROGRAPH input/output is required. Note: The AHYMO program may require use of the Hydrograph input/output file to store hydrograph values if identification numbers (IDs)

with values above 20 are used extensively.

D.5   Fifth line (Summary Table output file)

"PROMPT" - The program asks for the name of the SUMMARY TABLE file during execution,

name - a file name to which the output summary is sent. If the file exists, it is overwritten. If it does not exist, the file is created. A commonly used output file name is AHYMO.SUM.

D.6   Sixth line (User Identification Code)

This line is reserved for the 24-character User Identification Code that is assigned to each licensed users and identifies the type of software license held by the program user (Single User, Site, Government Agency, Educational, or Temporary). Licensed program users may be assigned a User Identification Code by the City of Albuquerque, or the City may assign a User Identification ot a group of users. This code must be included in the AHYMO_IO.FIL for the program to function. The code may not be revised by the program user. A temporary User Identification Code may be available for testing and evaluation purposes.

D.7   Seventh line (Optional)

This optional line may be included to aid in the data entry of the User Identification Code on the Sixth line.

For general applications, it is recommended that the AHYMO_IO.FIL contain the following (on seven lines):

```
PROMPT
AHYMO.OUT
AHYMO.PUN
AHYMO.HYD
AHYMO.SUM
AHYMO_Temp_User:20122010
123456789012345678901234
```

When the AHYMO-S4 program is executed, the program will use the information in the AHYMO_IO.FIL to determine the location of the input and output files, and the license status of the User Identification Code. If you use the example AHYMO_IO.FIL format, you can later rename the AHYMO.OUT and AHYMO.SUM files for project archiving. Note that the sixth line in the example above uses a code for a Temporary license. Licensed program users should enter their assigned User Identification Code at this location. Note that the User Identification Code for licensed program users does not expire.

Recommendations for AHYMO-S4 Program Use

Recent testing of the ROUTE MCCUNGE command and comparisons with the US Army Coprs of Engineers HEC-HMS program indicates that the Muskingum-Cunge channel routing function is most accurately applied when only the Ponce formulation for solving the routing equations is applied. The AHYMO-97 program first applied the Ponce formulation, and then applied the Fread formulation if the routing computations showed numerical instability. If the incremental time (DT) for hydrograph routing is maintained at 0.015 hours or smaller, the Ponce formulation can be applied without experiencing numerical instability. Maintaining a hydrograph incremental time of 0.01 hours has little effect on hydrograph computed peaks from a single sub-basin, but the increased precision of channel routing computations can measurably effect computed hydrographs that result from routed and combined hydrographs. The 4000 hydrograph points allowable with the AHYMO-S4 program were implemented to address the need for greater computational precision with Muskingum-Cunge hydrograph channel routing.

> **Recommendation #1:** The ROUTE MCUNGE command should be specified for all natural and constructed open channels and the RAINFALL command should use a DT= 0.01 hours (or a small value) to restrict Muskingum-Cunge channel routing to the Ponce formulation..

The TYPE=1 and TYPE=2 distributions specified with the RAINFALL command in the AHYMO-97 program were based on NOAA Atlas 2 and the n-minute projected rainfall values within the peak hour derived from national averages. With the completion of NOAA Atlas 14 Volume I (QC 980.4.P7, 2004), revised rainfall values are provided including revised n-minute values. These values measurably change the n-minute percentages within the peak hour. Additionally, NOAA Atlas 14 contains data on the distribution of six-hour rainfall that was not available with NOAA Atlas 2. The TYPE=1 and TYPE = 20 distributions specified with the AHYMO-S4 program have been revised to revised to follow the numerical order of peak rainfall intensity for a 6-hour storm indicated with Figure A.1.3 in NOAA Atlas 14 (Page A.1.6). The TYPE=2 and TYPE=21 distributions have been revised to add 24-hour precipitation values to the TYPE=1 or TYPE=20 distributions.

> **Recommendation #2:** The TYPE=1 (6-hour) and TYPE=2 (24-hour) distributions with the RAINFALL command should be specified for Albuquerque and Bernalillo County, including the AMAFCA boundary, and for the ESCAFCA boundary. The LOCATION command should specify ALBUQUERQUE, AMAFCA, BERNALILLO COUNTY, or ESCAFCA. The TYPE=20 and TYPE=21 distributions may also be used.

Testing of the AHYMO-S4 program in the Rio Rancho area and applying a DT=0.01 hours, indicates that a rainfall distribution based on NOAA Atlas 2 (as used in AHYMO-97) will provide flow rates that are consistent with local peak runoff experience. The AHYMO-S4 program has been revised to use the rainfall distribution based on NOAA Atlas 2 (as used in AHYMO-97) for the TYPE=1 and TYPE=2 distributions in the RAINFALL command when AHYMO97, SSCAFCA, or RIO RANCHO are specified as the location. The TYPE=12 and TYPE=13 distributions also use the rainfall distribution based on NOAA Atlas 2.

> **Recommendation #3:** The TYPE=1 (6-hour) and TYPE=2 (24-hour) distributions with the RAINFALL command should be specified for Rio Rancho and the SSCAFCA boundary with the LOCATION command specifying RIO RANCHO, or SSCAFCA. The TYPE=12 and TYPE=13 distributions may also be used. This recommendation is only applicable to Rio Rancho and SSCAFCA.

The use of TYPE=1 and TYPE=2 distributions with the RAINFALL command along with the LOCATION command specifying ALBUQUERQUE, AMAFCA, BERNALILLO COUNTY, or ESCAFCA may result in higher peak flow rates than the values computed with the AHYMO-97 program. Additionally, the use of DT=0.01 hours or less and application of the Ponce formulation for Muskingum-Cunge routing may result in higher peak flow rates at routed and combined hydrographs. Program users may wish to compare model results with the values that would have been obtained with the AHYMO-97 program. Similar results to those obtained with the AHYMO-97 program can be obtained by specifying AHYMO97 with the LOCATION command, and using DT=0.033333 or DT=0.05 hours with the RAINFALL command.

> **Recommendation #4:** The AHYMO-S4 program can be used to provide results similar to the AHYMO-97 program when the LOCATION command specifies AHYMO97 and the RAINFALL command specifies DT=0.033333 or DT=0.05 hours. The results obtained with this procedure may not represent a valid procedure when applying NOAA Atlas 14 rainfall and Muskingum-Cunge channel routing.

General AHYMO-S4 Program Information

The AHYMO-S4 program summary file output (AHYMO.SUM) with the 4000 time steps looks much like the output with the old 600 step AHYMO-97. The full output file (AHYMO.OUT) may be longer than the old version because of the smaller time steps. Depending on the codes used with the PRINT HYD and ROUTE RESERVOIR commands, the output file (AHYMO.OUT) and number of pages to be printed will be larger (more pages) than the output from the previous version. On most computer systems, less than 5-seconds of additional computation time is required to execute a very large data file. On some computer systems, users may find that the AHYMO-S4 program with 4000 hydrograph time steps executes faster than the AHYMO-97 program with 600 hydrograph time steps.

The program has been revised and recompiled using Intel Visual Fortran Version 11.1 (June 2009 version). The program will run on computers using MS Windows 7 (32 or 64-bit), Windows 8, 8.1 and 10. When running the program in Windows, it is recommend that the working directory be a subdirectory in C:\Users\Public. The AHYMO-S4 program is generally distributed as an AHYMO-S4_R2.zip file that contains the executable code for the computer program, files required for program execution, and examples of input and output data. You should un-zip the file and copy the information to a temporary directory or blank CD. The ZIP data file contains a set-up program (SETUP.EXE) that allows the AHYMO-S4 program to be installed on a computer with the Microsoft Windows 7 (32 or 64-bit), 8, 8.1 and 10 operating system. When you open the SETUP.EXE file, you will begin the Install Shield Wizard for the AHYMO-S4 program. The Install Shield Wizard will prompt you for the directory where the program files will be stored. If you accept the program default location, then:

- the program files will be stored at "C:\Program Files\AHYMO-S4", and
- the sample input and output files will be stored at:
  "C:\Program Files\AHYMO-S4\Samples."
  Note: On 64-bit computers with Windows 7, 8, 8.1 or 10 the AHYMO program files and sample files will be stored at "Program Files (x86)"
- The directory C:\Users\Public\AHYMOdata will be created for program shortcuts and will be the default directory for data input and output .

The C:\Users\Public\AHYMOdata directory will used as the default "starting" or "working" directory. The AHYMO-S4 Install Shield Wizard also asks if you want to have a "Typical", "Compact" or "Custom" installation. It is suggested that you use the "Typical" installation; this will install both the program files and the sample data files. If you place the program or data files in a different directory, you will need to change the properties in the shortcut file. You can copy the shortcut file to the desktop or another directory to execute the program from that location. Please see the "Procedures for Installing the AHYMO-S4 Program" for further information.

The "drag-and-drop" functionality to execute AHYMO remains in the AHYMO-S4 version. On Windows 7, 8, 8.1, or 10you should be able execute the program by dragging a data file an AHYMO_S4 shortcut icon. After the "drag-and-drop," the program file will open; hit the "enter" key and the program will execute the data file. On some Windows systems, you may need to first open the AHYMO_S4 program by double-clicking the shortcut icon, then drag the data file to the program window that is opened, and hit "enter". If you use "drag-and-drop" you will not need to type in the data file name to execute the program. Program output files (normally AHYMO.SUM and AHYMO.OUT) will be sent to the working directory that you specify.

Copyright and Grant of License

The program is copyrighted by the City of Albuquerque, 2018, all rights reserved.

The City of Albuquerque generally grants a Government Agency license for the AHYMO-S4 program to local, state and Federal government agencies at no cost. Other software licenses will be granted to individuals, companies and organizations based in policies established by the city of Albuquerque.

The AHYMO-S4 License Agreement is included at the end of this User Information file.

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