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User's Guide for MAGIC—Meteorologic and Hydrologic GenScn (Generate Scenarios) Input Converter

Open-File Report 2010–1221

U.S. Department of the Interior
U.S. Geological Survey

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KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Flow rate	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Energy	
Langleys per day (Lg/d)	279.12	Watts per square meter (W/m^2)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8$$

User's Guide for MAGIC—Meteorologic and Hydrologic GenScn (Generate Scenarios) Input Converter

By Terry W. Ortel and Angel Martin, Jr.

Abstract

Meteorologic and hydrologic data used in watershed modeling studies are collected by various agencies and organizations, and stored in various formats. Data may be in a raw, un-processed format with little or no quality control, or may be checked for validity before being made available. Flood-simulation systems require data in near real-time so that adequate flood warnings can be made. Additionally, forecasted data are needed to operate flood-control structures to potentially mitigate flood damages. Because real-time data are of a provisional nature, missing data may need to be estimated for use in flood-simulation systems. The Meteorologic and Hydrologic GenScn (Generate Scenarios) Input Converter (MAGIC) can be used to convert data from selected formats into the Hydrologic Simulation System–Fortran hourly-observations format for input to a Watershed Data Management database, for use in hydrologic modeling studies. MAGIC also can reformat the data to the Full Equations model time-series format, for use in hydraulic modeling studies. Examples of the application of MAGIC for use in the flood-simulation system for Salt Creek in northeastern Illinois are presented in this report.

Introduction

Meteorologic and hydrologic data collected, processed, and stored by many organizations are used in watershed modeling studies. Near real-time processed data are needed for flood-simulation systems and operation of flood-control structures to potentially mitigate flood damages. To efficiently process these data, the Meteorologic and Hydrologic GenScn (Generation and Analysis of Model Simulation Scenarios for Watersheds, Kittle and others, 1998) Input Converter (MAGIC) program was written by the U.S. Geological Survey (USGS), Illinois Water Science Center in cooperation with the DuPage County, Illinois, Division of Stormwater Management, as part of the Salt Creek flood-simulation system (Vonnahme and others, 1999). Meteorologic and hydrologic data are used in the flood-simulation system to simulate the hydrologic and hydraulic processes of the Salt Creek to evaluate structure operations based on potential peak water-surface elevations. MAGIC was developed to convert data from various sources and formats to a common format for use in the flood-simulation system. Because much of the data are provisional, MAGIC also incorporates limited checking, estimating, and logging of the data values. MAGIC can be used to calculate potential evapotranspiration using Argonne National Laboratory (ANL) meteorologic data. It also can append National Weather Service (NWS) forecast data, for example Quantitative Precipitation Forecast (QPF) data, to the end of the real-time data. The simulation system utilizes input data that are processed by MAGIC to run the continuous simulation rainfall-runoff model, Hydrological Simulation Program–Fortran (HSPF; Bicknell and others, 1997), and the unsteady-flow hydraulic routing model, Full Equations (FEQ; Franz and Melching, 1997). The data are stored in a Watershed Data Management (WDM) database (Murphy and Ishii, 2006); and the simulation results are reviewed and analyzed using the Generation and Analysis of Model Simulation Scenarios for Watersheds (GenScn; Kittle and others, 1998) interface. MAGIC can be applied to other similar flood-simulation systems and watershed modeling studies.

The purpose of this report is to describe the use and application of the MAGIC program. Program functions and options are described and procedures for converting meteorologic and hydrologic data for input to specific databases are discussed with examples included.

Background

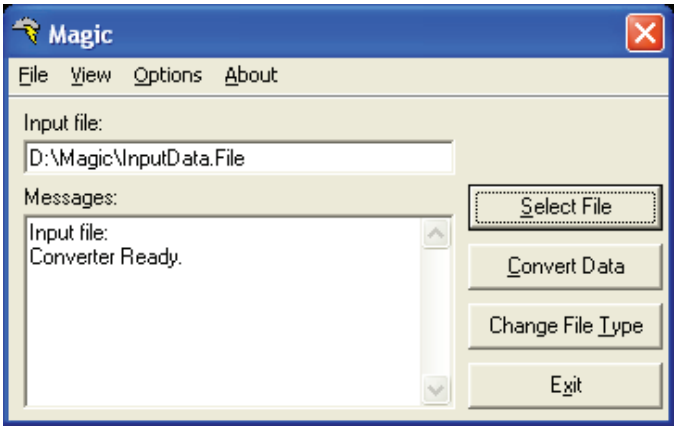
MAGIC is a file-format conversion program that runs on Microsoft Windows Operating Systems, for example Windows 2000 and XP. MAGIC converts meteorologic data in Argonne, DuPage, and Relational Data Base (RDB) formats to HSPF hourly-observations format (HYDHR). HSPF reads the HYDHR files and stores these data in a WDM database for use in hydrologic modeling and display in GenScn (Kittle and others, 1998). MAGIC also converts hydrologic data, such as stream stage and flow, in DuPage, OUTWAT, and RDB formats to HYDHR format and FEQ function-table type 7 format (Franz and Melching, 1997). FEQ is used in the flood-simulation system for dynamic wave routing of the streamflow.

Program Requirements and Installation

MAGIC is written in Visual Basic 6.0 and runs on Microsoft Windows Operating Systems. The program has been tested using Windows 2000 and XP. The MAGIC distribution includes a Microsoft Windows installation program; MAGIC can be installed by running the setup program. A digital version of the MAGIC distribution may be requested from the USGS Illinois Water Science Center.

User Interface

The MAGIC user interface contains three main components; the drop-down menus along the top, the command buttons along the right side, and the two text boxes. The drop-down menus and the command buttons access similar functions; however, the drop-down menus include additional capabilities. The "Input file" text box displays the path and name of the current input file, and the "Messages" text-box displays status messages and messages associated with processing.



Quick Start

To run MAGIC, double-click on the MAGIC icon on the Windows desktop. An example file can be converted using the command buttons along the right side. For example,

1. Click the "Select File" button.
2. Select a data file and click "Open".
3. Confirm the data file type and click "Okay".
4. Click the "Convert Data" button.
5. Repeat steps 1–4 to convert additional data files or click "Exit" to close the program.

Program Functions

The program functions are grouped under the "File", "View", "Options", and "About" drop-down menus.

File

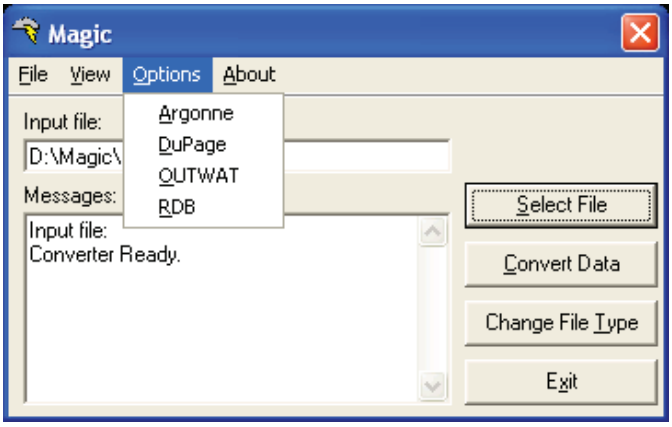
The "File" drop-down menu provides the user with four options. The "Select File" option allows the user to select the input data file. The "Convert Data" option allows the user to convert the input data file using the selected file-type conversion. The "Change File Type" option allows the user to change the input data file, and the "Exit" option allows the user to close the program.

View

The "View" drop-down menu allows the user to view the input file in the Microsoft Notepad text editor. To run "View", click on "Input File" in the "View" pull-down menu, and the input file is opened in Notepad.

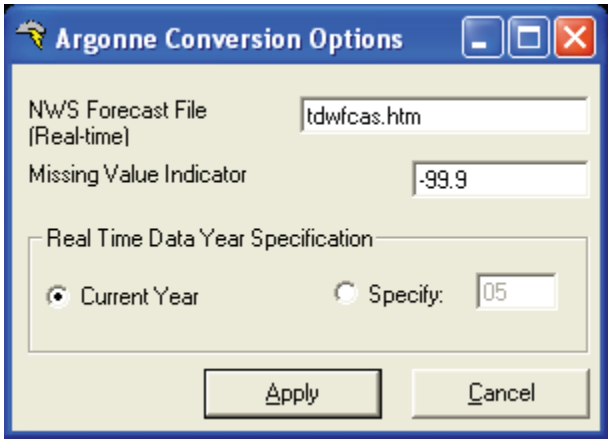
Options

The "Options" drop-down menu allows the user to change various settings for each data type. For example, the user can change the missing value indicator used in the HSPF HYDHR files. "Options" menus are available for the Argonne National Laboratory (Argonne), DuPage County, Illinois (DuPage), Automated Data Processing System (ADAPS) General Retrieval of Time-Series Data (OUTWAT), and Relational Data Base (RDB). The various options are stored in the Windows Registry and used in subsequent MAGIC runs.



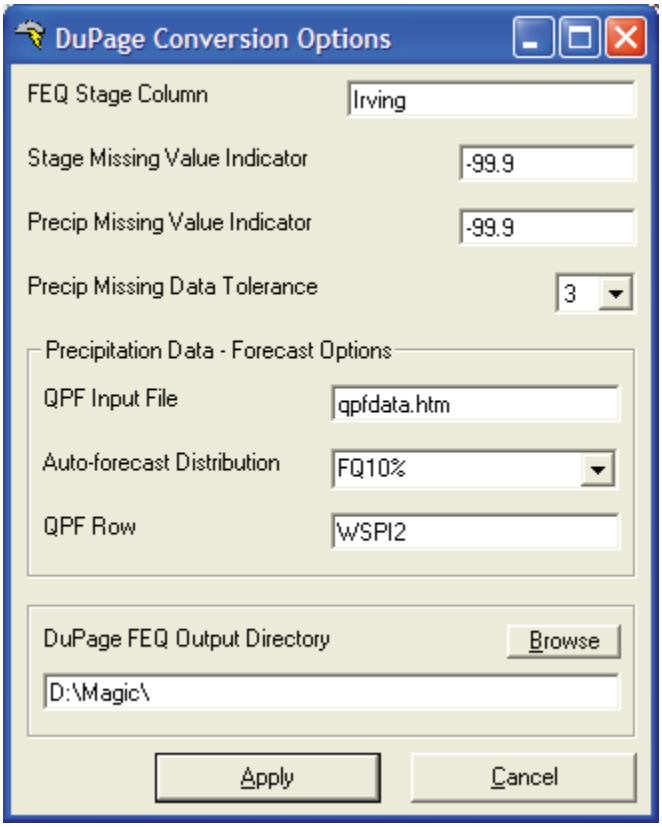
Argonne

The Argonne option refers to meteorologic data collected by the ANL in northeastern Illinois and published on the ANL Web site (*http://gonzalo.er.anl.gov/*). The Argonne Conversion Options form allows the user to specify the name of a NWS forecast-data file, the missing value indicator written to the HSPF HYDHR files, and the starting year of the real-time data input files. ANL real-time data files do not contain the year, and the default year for real-time data is the current year specified in Microsoft Windows. The year specification option allows the user to specify a different starting year for the data. The year specification option is set to the current year each time MAGIC is started, and the user must change this option before converting the data if a different year should be used. The default NWS forecast file name is tdwfcas.htm and the default missing value indicator is -99.9.



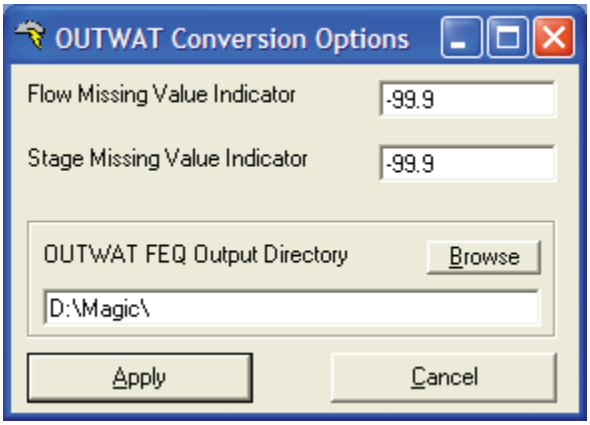
DuPage

The DuPage option refers to precipitation and stream stage data collected by DuPage County in northeastern Illinois, in cooperation with the USGS Illinois Water Science Center. The DuPage Conversion Options form contains entries for precipitation and stage data. The precipitation data options allow the user to specify the name of the NWS QPF data file, the automated forecast data distribution, the site in the NWS QPF data file, a missing data tolerance, and the missing value indicator written to the HSPF HYDHR files. The automated forecast distributions are described in Huff (1990) and are used to distribute the NWS 6 hour QPF total precipitation to hourly totals. The missing data tolerance represents the number of missing 5-minute periods that are allowed in 1 hour before the hourly total is assigned the missing value indicator. The stage data options allow the user to specify the directory to store the FEQ function-table files, the input data column to use in the FEQ function-table files, and the missing value indicator written to the HSPF HYDHR files. The default NWS QPF file name is qpfdata.htm and the default missing value indicator is -99.9.



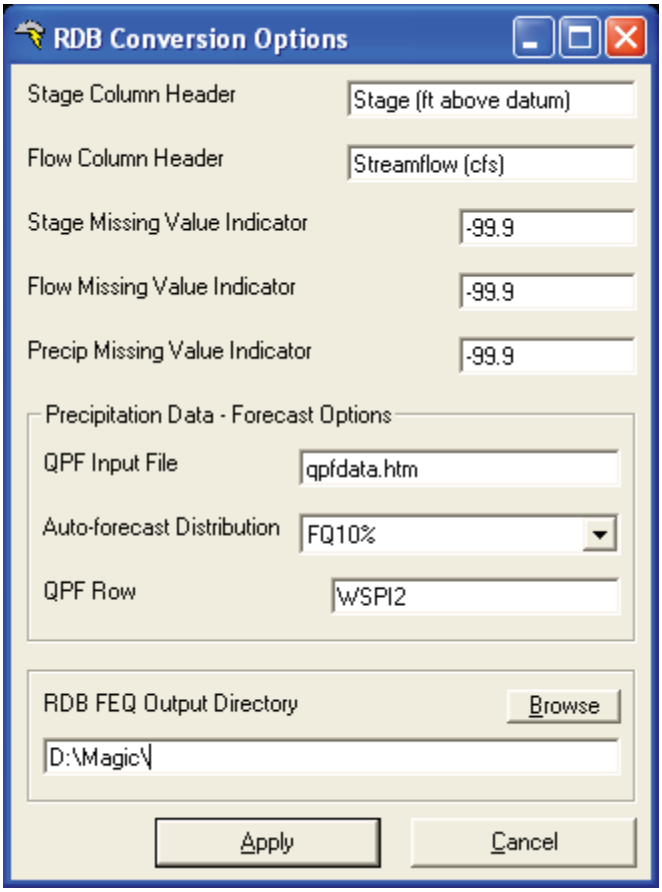
OUTWAT

The OUTWAT option refers to stream stage and flow data that are retrieved from the USGS National Water Information System (NWIS) database using the ADAPS OUTWAT time series retrieval program. The OUTWAT Conversion Options form in MAGIC allows the user to specify the missing value indicator written to the HSPF HYDHR files for stage and flow data, and the directory to store the FEQ function-table files. The default missing value indicator is -99.9.



RDB

The RDB option refers to precipitation, stream stage and flow data that have been downloaded in RDB format from the USGS Illinois Water Science Center Web site using the National Water Information System–Web (NWIS–W) data-retrieval program. The RDB options are for stage, flow, and precipitation data. The stage and flow options allow the user to specify the RDB column headers, the missing value indicator written to the HSPF HYDHR files, and the directory to store the FEQ function-table files. The precipitation options include the missing value indicator, the NWS QPF file name, the forecast distribution, and the name of the NWS forecast location. The default NWS QPF file name is qpfdata.htm and the default missing value indicator is -99.9.



About

"About" displays the program version number and an overview of the file conversion types.

Conversion of Meteorologic and Hydrologic Data

MAGIC creates two types of output files for use in the flood-simulation system; HSPF HYDHR files, and FEQ function-table files. MAGIC also creates various log and error files to document the conversion process. Generally, the output file names have the same prefix as the input file and have an extension of "hsp" for HSPF HYDHR files, "tab" for FEQ function-table files, and "log" for log files.

HSPF HYDHR files are used to input hourly observations to the WDM database. HSPF HYDHR is a Fortran fixed format consisting of 8X, I4, 1X, I2, 1X, I2, 1X, I1, 12F5.0 (Bicknell and others, 1997). The data fields are:

1. 8X – eight character alpha-numeric station number or identifier (this field is not read);
2. I4 – four character numeric field for either the full calendar year, or the last two digits of the calendar year;
3. 1X – a space;
4. I2 – two character numeric field for the month;
5. 1X – a space;
6. I2 – two character numeric field for the day;
7. 1X – a space;
8. I1 – "1" is for a.m. hours, and "2" is for p.m. hours; and
9. 12F5.0 – 12 fields that are 5 characters wide for the hourly data, card 1 is for the a.m. hours, and card 2 is for the p.m. hours.

Generally, if an existing HSPF HYDHR file with the same name is present in the output directory, MAGIC will overwrite the existing file. However, the DuPage County data conversion will append new data to existing HSPF HYDHR files, starting with the first value in the file being converted.

The FEQ function-table files contain time-series data for use in FEQ modeling. The files generally contain hourly values of stage or flow data. MAGIC uses the type 7 function-table file format (Franz and Melching, 1997). The type 7 function-table format is I4, 1X, I2, 1X, I2, 1X, 3F10.0, where the data fields are:

1. I4 – four character numeric field for the full calendar year;
2. 1X – a space;

3. I2 – two character numeric field for the month;
4. 1X – a space;
5. I2 – two character numeric field for the day;
6. 1X – a space; and
7. 3F10.0 – a 10 character numeric field for the hour of the day, includes the fractional hour; followed by 2 fields that are 10 characters wide to contain the stage or flow data for the corresponding date/time.

If a FEQ function-table file with the same file name exists in the output directory, MAGIC will append new data to the existing file, starting with the first value in the file being converted. If an existing file is not found, a new file is created and MAGIC will write the FEQ function-table header lines and a hypothetical event for 1925 to the file. Missing data in the input file are not noted or flagged in the FEQ function-table file because FEQ will interpolate linearly for missing time steps at runtime.

Argonne

Argonne data files contain meteorological data collected at the U.S. Department of Energy Argonne National Laboratory in northeastern Illinois. Currently (2009), these data are retrieved from the ANL weather data Web site, *http://gonzalo.er.anl.gov/ANLMET/*. ANL has available real-time data that are not quality controlled, and historical data that are quality controlled.

The ANL real-time files that MAGIC will convert have a file name prefix of anltower and an extension of either .48 or .not_qc (for example, anltower.48 or anltower.not_qc). The anltower.48 file contains the most recent 48 hours of data. The anltower.not_qc file contains all the recent data that have not been quality controlled.

The real-time data files contain two header lines, the data lines, and one footer line. The header consists of a note regarding the data quality, "Note that these data are generally raw non-QC'd values", and a listing of the data elements. The data lines typically are between 189 and 200 characters long and consist of 25 space-separated values. The footer line is a repeat of the data-element listing.

Each data line contains a single 15-minute entry for each data element. The first column is three characters wide and contains the Julian Date (JDA). The second column is five characters wide and contains the time. Generally, the time interval is 15 minutes but it may be longer if data are missing. The data elements are space delimited and generally are a minimum of seven characters. The last two data elements in a data line are a repeat of the time and JDA, respectively.

The real-time data elements that are processed by MAGIC are:

1. Dew point temperature at 10 meters in degrees Celsius, column 10 (Tdp_10m);
2. Ambient temperature at 10 meters in degrees Celsius, column 11 (TaC_10m);
3. Wind speed at 10 meters in meters per second, column 12 (spd_10m);
4. Solar radiation in Watts per meter squared, column 17 (radW/m2); and
5. Precipitation in millimeters, column 23 (precpmm).

For each 15-minute value, the ambient and dew point temperatures are converted to degrees Fahrenheit from Celsius, wind speed to total miles of movement from meters per second, solar radiation to total Langleys from Watts per meter squared, and precipitation to hundredths of an inch from millimeters. After conversion, MAGIC checks each value using the following bounds:

- Dew point [-50 to 130];
- Ambient temperature [-50 to 130];
- Wind movement [0 to 200];
- Solar radiation [0 to 200]; and
- Precipitation [0 to 5,000].

The 15-minute values within bounds are used to compute hourly values; values outside these bounds are discarded. Hourly ambient and dew point temperatures are average values, and hourly wind, solar radiation, and precipitation are cumulative values. The data are processed as follows.

1. If there are not any 15-minute readings for a given hour, the missing value indicator (-99.9) is stored for that hour.
2. If there are one to four 15-minute values for a given hour, the values are summed and the number of 15-minute readings (1–4) is stored. Any bad or missing 15-minute value is excluded from the sum.
3. The hourly average temperature and dew point values are calculated by dividing the sum by the number of 15-minute readings in the hour.
4. The hourly cumulative precipitation is calculated by summing all of the 15-minute values within the hour. If there are any bad or missing 15-minute values, the cumulative value is set to the missing value indicator.
5. The hourly cumulative wind and solar radiation are calculated by summing all of the 15-minute values within the hour, multiplying the sum by 4, and then dividing by the total number of valid 15-minute readings in the hour.

MAGIC automatically will estimate and fill hourly values of ambient temperature, dew point temperature, wind

movement, and solar radiation that are missing; missing hourly values of precipitation are set to the missing value indicator. If there are less than 3 hours of missing data in a day, or if this is the first day, the missing values are filled with the hourly value that precedes the missing period. If there are three or more hours of missing data in a day and this is not the first day, the hourly data are filled with data for the corresponding hour of the previous day. If the missing period extends to the end of the current day and continues into the next day, and if the number of missing values from the last good value to the end of the day is less than three, then the values for these hours are filled with the valid hourly value preceding the missing period. If the number of missing hours from the last good value to the end of the day is greater than three, then the values are filled with values for the corresponding hour of the previous day. The log file lists the missing values contained in the input file.

For the flood-simulation system, the effect of deviations from true values in the real-time meteorologic time-series estimations generally is expected to be small, except in the case of temperatures near freezing, on short-term rainfall-runoff simulations (Whitbeck, 2005). The amount of missing precipitation data should always be reviewed before use in a flood-simulation system, because precipitation is the primary input for rainfall-runoff modeling.

The hourly meteorologic values are then used internally to compute daily values. The daily ambient and dew point temperatures are average values, and daily wind, solar radiation, and precipitation are cumulative values. Daily potential evapotranspiration is then calculated by the Lamoreux Potential Evapotranspiration (LXPET) method (Murphy, 2005) using the daily average ambient and dew point temperatures, and the daily cumulative wind and solar radiation. After the daily evapotranspiration has been calculated, the hourly values are computed using the distribution in the LXPET program (Murphy, 2005). If the computed potential evapotranspiration for a day is less than zero, the daily value is set equal to zero.

After all the data in the Argonne real-time file are processed, a forecast can be added to extend the values in the HSPF HYDHR file out by two days. For the flood-forecast system, the forecast data are retrieved from the NWS Web site, *http://forecast.weather.gov/MapClick.php?w0=t&w1=td&w3=sfcwind&Submit=Submit&FcstType=digital&textField1=41.9124755859375&textField2=-87.9663619995&site=lot*. A tabular forecast is downloaded and stored in the file given in the Argonne Conversion Options form, for example "tdwfcas.htm". The tabular forecast contains forecasted values for each hour. These values are used for the hour preceding the reading. For example, the reading at hour 10 is stored in the place of the hourly reading from 9–10. The temperature, wind, and dew point forecast data are read from the file, and the solar radiation data are copied forward from the last day of real-time data because solar radiation is not forecasted. The daily potential evaporation for the forecasted days is calculated from the values. The precipitation forecast from this NWS Web site is not used in the flood-simulation system for Salt Creek. The flood-simulation system for Salt Creek uses other sources of real-time precipitation data that are closer to the watershed, and NWS QPF precipitation forecast data.

Currently (2009), the ANL historical data files that MAGIC will convert are retrieved from the ANL Weather Data Web site, *http://gonzalo.er.anl.gov/ANLMET/numeric/*. The files have a file name consisting of the first three letters of the month, followed by the last two digits of the year, followed by "met", and a file name extension of .data (for example, jun07met.data). The files contain hourly data for 1 month, and the month and year are given in the file name. MAGIC lists the Argonne historical data conversion type as "Argonne, Monthly".

The historical data files contain only the data; a separate Readme.data file on the ANL Web site describes the various fields. Each data line consists of 24 columns, and contains the hourly values for each data element. The first four columns consist of the day, month, year, and hour, followed by the data columns. The data elements are space delimited and generally are seven characters wide. The historical data elements used in MAGIC are:

1. Average dew point temperature at 10 meters in degrees Celsius, column 14;
2. Average ambient temperature at 10 meters in degrees Celsius, column 13;
3. Average wind speed at 10 meters in meters per second, column 11;
4. Average solar radiation in Watts per meter squared, column 18; and
5. Total precipitation in millimeters, column 17.

The ambient and dew point temperatures are converted to degrees Fahrenheit from Celsius, wind speed to total miles of movement from meters per second, solar radiation to total Langleys from Watts per meter squared, and precipitation to hundredths of an inch from millimeters. The values also are checked using the same bounds as the real-time data conversion.

MAGIC automatically will estimate and fill missing hourly values of ambient temperature, dew point temperature, wind movement, and total Langleys if there are less than three missing hours in a day. The first missing value is filled with the hourly value that precedes it, and the second missing value is filled with the hourly value that follows it. If there are three or more values missing in a day, no data filling is done and the missing value indicator is stored for all of the hours. If the first missing value is the first hour of the day, or if the second missing value is the last hour of the day, then the missing value indicator is stored for that hour. The log file lists the missing values contained in the input file and any data filling that was done.

The hourly meteorologic values are used internally to compute daily values. Daily ambient and dew point temperatures are average values, and daily wind, solar radiation

and precipitation are cumulative values. The daily potential evapotranspiration is then calculated by the LXPET method (Murphy, 2005) using the daily average temperature and dew point, and the daily cumulative wind and solar radiation. After the daily evapotranspiration has been calculated, the hourly values are computed using the distribution in the LXPET program (Murphy, 2005). If the computed potential evapotranspiration for a day is less than zero, the daily value is set equal to zero. If any of the hourly meteorologic data on a given day are missing, then the daily potential evapotranspiration is not computed for that day.

The HSPF HYDHR file names use the same prefix as the input file, followed by an underscore, the parameter name, hr for hourly, and hsp is the extension. Six output files are created for each input file; the separate output files contain dew point temperature, evapotranspiration, precipitation, solar radiation, ambient temperature, and wind data.

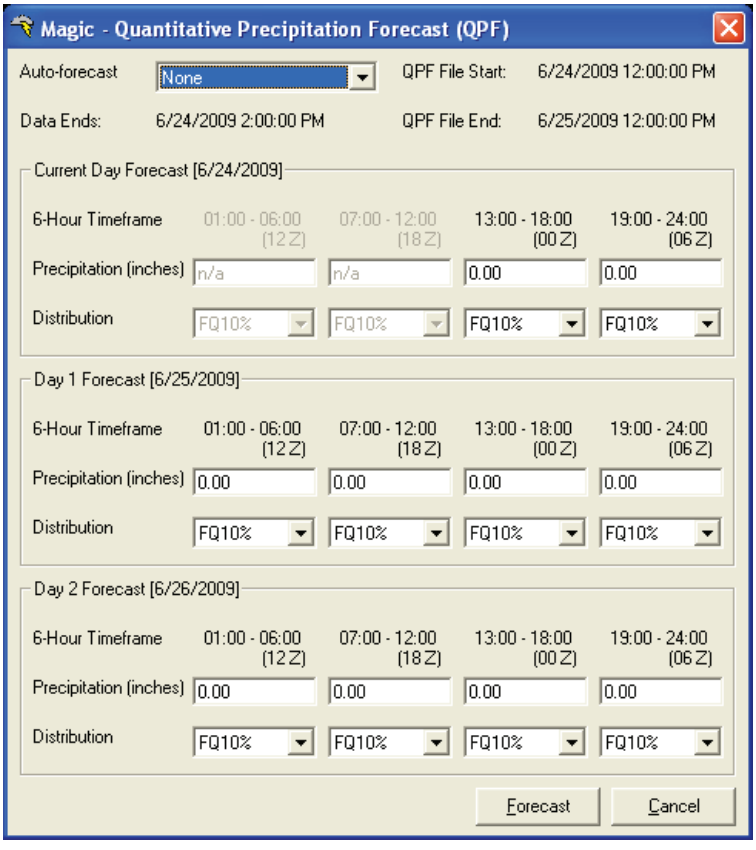
DuPage

DuPage County data consists of precipitation data collected at 28 rain gages within and near DuPage County, Illinois, and stage data collected at 4 sites on Salt Creek in DuPage County. The rain-gage sites are operated in cooperation with the USGS Illinois Water Science Center, and the four stage sites are operated by DuPage County. The stage sites record data from two different sensors; an ultrasonic sensor and an admittance sensor, and data from both sensors can be converted by MAGIC. The data-recording interval is 5 minutes, and the values are either 5-minute cumulative precipitation in inches, or creek stage in feet. The data files contain data for the last 7 days, and as of June 2009, the USGS Illinois Water Science Center retrieves the files from an ftp server operated by DuPage County.

The DuPage County precipitation data and stage data are converted to HSPF HYDHR format, and stage data for selected locations also can be converted to FEQ function-table format. If the HSPF HYDHR or FEQ function-table file exists, the new data are appended to the existing files; otherwise, new output files are created. DuPage County data are recorded in Central Daylight Time, when applicable, and MAGIC adjusts the time to Central Standard Time for use in the Salt Creek flood-simulation system.

The DuPage precipitation data are stored in files named RG_##.000, where ## is the DuPage County rain-gage number. Generally, the data files have four header lines, followed by the data lines. The exception is RG_8.000, which has three header lines. MAGIC reads and discards the header lines, and the data lines are then read one line at a time until valid data are found or the end-of-file has been reached. A valid data line will contain a date value in MM/DD/YY format, followed by the time in HH:MM:SS, followed by the cumulative 5-minute precipitation value. Erroneous and missing values are denoted by either a “100” or a “?” in the data file. The user can allow up to four bad or missing 5-minute values before the hourly total is marked as missing (-99.9). The number of allowed values is set in the DuPage Options form, and any allowed values are assumed to be zero inches of precipitation. The 5-minute values are summed to hourly cumulative values, and then multiplied by 100 to convert to hundredths of an inch. If the end of the data file is reached and no valid data are found, the message “Data format type mismatch in the input file” is displayed in the Messages window.

A precipitation forecast can be appended to the end of the precipitation data by selecting “Auto” or “Manual” on the MAGIC Forecast Options form that appears after the data are converted. Selecting “None” on the MAGIC Forecast Options form does not append a forecast. The forecast can be entered automatically using data in the NWS QPF data file listed in the DuPage Options form, or entered manually by the user. Currently (2009), the NWS QPF file used in the flood-simulation system is downloaded from *http://www.crh.noaa.gov/ncrfc/content/water/fmap_multi_req.php?Product=QPF&Wfo=LOT&Day=0* and contains the forecasted 6-hour precipitation totals in Standard Hydrometeorological Exchange Format (SHEF) for a 24-hour period. If the user decides to manually enter a forecast, the MAGIC QPF form is displayed for entering the values and selecting the precipitation distribution. The distributions are based on the 10-, 50-, and 90-percent probability distributions developed by Huff (1990). The forecast 6-hour precipitation totals are then distributed into hourly values using the selected distribution.

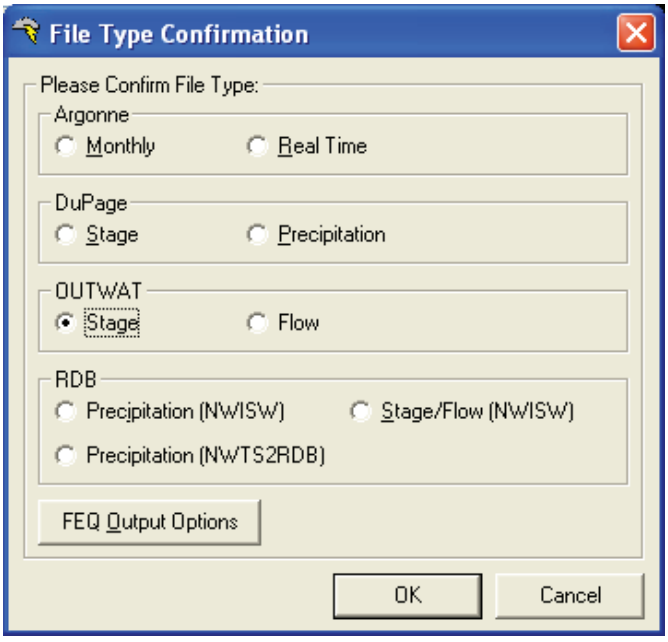


The DuPage stage data from the four sites with ultrasonic sensors are stored in a file named creek.000, and the stage data from two sites with admittance sensors are stored in a file named creeka.000. The data files have three header lines, followed by the data lines. A valid data line should contain a date in MM/DD/YY format, followed by time in HH:MM:SS, followed by the stage values. The data are recorded every 5 minutes, and MAGIC writes the value that is closest to the hour to the output files; the other values are discarded. HSPF HYDHR files are created for all locations, and FEQ function-table files are created for the location given in the DuPage Conversion Options form. If the end of the input file is reached and no valid data are found, the message "Data format type mismatch in the input file" is displayed.

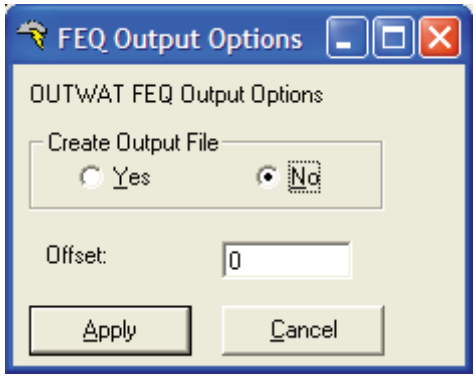
After processing the available data, MAGIC automatically appends a 2-day stage forecast to the FEQ function-table file by repeating the last value. The users are then asked if they would like to modify the forecast. If so, the FEQ function-table file is opened in Microsoft Notepad for editing.

OUTWAT

The OUTWAT data files contain stream stage or flow data that are retrieved from the USGS NWIS database using the ADAPS OUTWAT program. The OUTWAT file names are specified by the user creating the file, and the file should contain either stream stage or flow data, but not both. The OUTWAT files contain four header lines, then the data lines. The data lines consist of four 13-character wide fields that contain the year, the month, the day, and the minute of the day, followed by a field that contains the data value. To convert the data in MAGIC, the input data type should be set to OUTWAT stage or OUTWAT flow by clicking on the corresponding button on the File Type Confirmation form.



The FEQ Output Options button can be used to set additional options for the FEQ function-table file. Additionally, a datum offset can be added to the FEQ function-table data by entering an offset value.



The OUTWAT data should have a 5-, 15-, or 60-minute time interval, and contain a value on the hour. If the data have a different time interval, MAGIC will stop processing the data and generate an error message. MAGIC determines the time interval by subtracting consecutive values. When the time difference is equal for three consecutive readings, MAGIC assumes the time interval is equal to that value for the remainder of the file. Because MAGIC assumes a constant time interval for the data in the input file, MAGIC should not be used to convert files that contain a variable time step.

If the data interval is either 5 or 15 minutes, the value on the hour is converted and written to the HSPF HYDHR file, and the other values are discarded. A data value of "-1.23456E+25" in the input file denotes a missing value in ADAPS, and the missing value indicator is written to the HSPF HYDHR file.

The FEQ function-table files contain the stage or flow values that are closest to the hour. If the input file contains stage data, then the datum offset is added to the stage value. After all of the data have been processed, one can correct missing values or append a forecast to the FEQ function table. Missing data in the input file are not automatically noted or flagged in the FEQ function-table file because FEQ will linearly interpolate missing time steps at runtime. For a forecast, the last valid value is repeated for the next 2 days in the future. The FEQ function table is terminated by entering a date/time that is less than the previous date/time. MAGIC will decrement the year by one, and then write this date/time and the last valid value to the FEQ function-table file. If the user selects to correct missing values or modify the forecast, the FEQ function-table file is opened in Microsoft Notepad for editing.

RDB

RDB data files consist of precipitation, stage, and flow data downloaded from the USGS Illinois Water Science Center

Web site at *http://il.water.usgs.gov/nwis-w/IL/* using the NWIS-W web software, and also precipitation data downloaded from an USGS Water Science Center's NWIS database using the NWTS2RDB program available in ADAPS. The files are converted to HSPF HYDHR format. Optionally, stage and flow data also can be converted to FEQ function-table format. After conversion, the user can append forecast data, if desired.

Generally, the NWIS–W RDB data files contain 21 header lines followed by the data lines. MAGIC searches the header lines to determine if the file contains stage data, flow data, or both. The first 19 characters of each data line should contain the date in YYYY.MM.DD format, one space, then the time in HH:MM:SS format. A tab character separates the date and time from the data value. MAGIC checks each data line for a valid date. If the date is invalid, the line is discarded and MAGIC reads the next line from the file; if the date is valid, the data line is processed.

For the flood-simulation system, the stage data should be in feet and the flow data in cubic feet per second. Stage and flow values recorded on the hour are written to the HSPF HYDHR files, the other values are discarded. If there is not a value on the hour, the missing value indicator is written to the HSPF HYDHR file for that hour. The FEQ function-table files contain the values that are either on the hour or, if there are no values on the hour, the values that are closest to the hour. The FEQ function-table file stores times in fractions of an hour, so the values do not have to be on the hour. As the data are read, each line is scanned for an entry that is on the hour. If an on-the-hour entry is found, the line is parsed to get the date, time, and stage or flow values. If the data type is stage, then the optional datum value is added, if required. Missing data in the input file are not noted or flagged in the FEQ function-table file because FEQ will linearly interpolate for missing time steps at run time.

After all the stage and flow data have been processed, if the user has selected to create a FEQ function-table file, then MAGIC automatically will append a 2-day forecast to the FEQ function table by repeating the last valid value. The forecast can be modified by selecting "Yes" when prompted, and the FEQ function-table file is then opened in Microsoft Notepad for editing.

The NWIS–W RDB instantaneous precipitation data should be in inches and contain values that are on the hour. MAGIC uses these data to compute cumulative hourly precipitation data, which are written to the HSPF HYDHR files in units of hundredths of an inch. MAGIC uses three consecutive data values to compute the time interval of the input data. If the time step between the first and second values is the same as the time step between the second and third values, then the time step for the entire file is set equal to that interval. If the time steps are not the same, then the procedure is repeated until two consecutive time steps are equal. After determining the time step for the file, MAGIC will check if 60 is evenly divisible by the time step. If not, MAGIC stops processing the file and displays the following message: "Magic cannot handle [time step] time step." If a valid time step is found, then each data line is parsed to obtain the date, time, and value, and the cumulative hourly values are calculated.

A precipitation forecast can be appended to the end of the precipitation data by selecting "Auto" or "Manual" on the MAGIC Forecast Options form that appears after the data are converted. Selecting "None" on the MAGIC Forecast Options form does not append a forecast. The forecast can be entered automatically using data in the NWS QPF data file listed in the DuPage Options form, or entered manually by the user. If the user chooses an automatic forecast, MAGIC will use the NWS QPF data file given in the RDB Options form. If the user wants to manually enter a forecast, the MAGIC Quantitative Precipitation Forecast form is displayed for entering the values.

The NWTS2RDB RDB precipitation data files contain several header lines followed by data lines. The data values are tab-separated, and the first eight characters contain the date in YYYYMMDD format, followed by the time in HHMMSS format, the time zone code, the precipitation amount, the USGS precision specification, USGS remark codes, USGS data flags, and an USGS quality code. MAGIC checks each line for a valid date and time; if a valid date and time is found, the line is processed, if not, the line is discarded.

After the user selects a NWTS2RDB file and clicks "Convert Data," MAGIC will prompt the user to select a fixed or variable data-time interval, and whether the output data should be filtered using the USGS remark codes and flags. MAGIC supports 5-minute and 15-minute fixed data-time intervals, and will discard any data that are not in the fixed data-time interval when calculating hourly totals. If the data are missing for an hour, then the missing value indicator is stored for that hour. Variable time-interval data includes all data when calculating hourly totals. On days with a midnight AM value, MAGIC will set the hourly total to zero if there are no data for that hour. On days that are completely missing, MAGIC will set the hourly totals to the missing value indicator until the next valid data point.

MAGIC can filter the data using the USGS remark codes and flags. If a data point is associated with a remark code or flag that denotes affected data, MAGIC will not include that data in the hourly total. MAGIC uses for the following remark codes and flags, although some do not apply to precipitation data:

A – value is affected by backwater from ice at the measurement site;

B – value is affected by backwater at the measurement site;

R – rating is undefined for this value;

& – value is affected by unspecified causes;

K – value is affected by instrument calibration drift;

X – value is erroneous and will not be used;

U – unused for daily values;

< – value is known to be less than the reported value; and

> – value is known to be greater than the reported value.

Once the options for time interval and input flags are set, MAGIC processes each line of data. The HSPF HYDHR file is written after all the data are processed.

Summary

Meteorologic and hydrologic data collected by many organizations are used in watershed modeling studies. Near real-time data are needed for flood-simulation systems and operation of flood-control structures to potentially mitigate flood damages. To efficiently process these data, the Meteorologic and Hydrologic GenScn (Generate Scenarios) Input Converter (MAGIC) program was written by the U.S. Geological Survey Illinois Water Science Center in cooperation with the DuPage County, Illinois, Stormwater Management Division, as part of the Salt Creek flood-simulation system. Hydrologic and meteorologic data are used in the flood-simulation system to simulate the hydrologic and hydraulic processes of the Salt Creek to evaluate structure operations based on potential peak water-surface elevations. For the flood-simulation system, these data are collected by various agencies and stored in various formats. The data may be in a raw, un-processed format with little or no quality control, or may be checked for validity. MAGIC was developed to convert data from the various sources and formats to a common format for use in the flood-simulation system, and to provide limited checking, estimating, and logging of the data values.

The simulation system utilizes input data that are processed by MAGIC to run the continuous simulation rainfall-runoff model, Hydrologic Simulation Program–Fortran (HSPF) (Bicknell and others, 1997), and the dynamic wave routing model, Full Equations (FEQ) (Franz and Melching, 1997). Currently (2009), MAGIC can convert the following data types: Argonne National Laboratory, DuPage County, OUTWAT, and RDB. MAGIC will output files in either HSPF HYDHR format, for input to a Watershed Data Management database, or FEQ function-table format, for use in the FEQ hydraulic-routing model. This program and associated flood-simulation system can be applied to other similar studies.

Acknowledgments

Development of the MAGIC program began in 1997; since that time several developers and users have made significant contributions to it. Thomas Price, formerly with the Northeastern Illinois Planning Commission, provided FORTRAN source-code files that were used to develop the Argonne National Laboratory conversion routines and also reviewed an early version of the MAGIC program. Several current and former DuPage County, Illinois, Stormwater Management Division staff tested, reviewed, and provided comments on various versions of the MAGIC program. Bharath Krishnan and Luke Lim, former student employees of the USGS Illinois Water Science Center, worked on early versions of this report.

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