

GSFLOW Input Instructions: A Supplement to Appendix 1 of the GSFLOW manual (USGS TM 6-D1)

Version 1.2.2 GSFLOW release, February 08, 2018

Introduction

Instructions for preparing input files for GSFLOW were provided with the first release of GSFLOW as Appendix 1 in Markstrom and others (2008). Since that time, new functionality has been added to the software; some of the original functionality has been removed; and individual parameters and variables have been added, modified, and deleted. As a result, it has been necessary to update the original input instructions with each new release of GSFLOW. Input instructions for preparing a GSFLOW input dataset are now provided in three formats: This file provides updated information for a few of the tables in Appendix 1 that relate directly to the GSFLOW software. This file is a supplement to Appendix 1 in Markstrom and others (2008; TM 6-D1), which provides a general discussion of the terminology, styles, and formats of GSFLOW inputs and the definitions of each of the GSFLOW input files. This file also replaces the ‘Appendix1_Tables.pdf’ file that was distributed with previous versions of the software.

Input instructions for the several PRMS modules and MODFLOW packages that are part of the GSFLOW software can be found in separate resources:

PRMS Data and Parameter Files: Up-to-date specifications for PRMS dimensions, parameters, and input and output variables were provided online in several tables on the PRMS-IV software distribution page:

ftp://brrftp.cr.usgs.gov/pub/mows/software/prms/4.0.3/PRMS_tableUpdates_4.0.3.pdf. Due to reorganization uncertainties, this webpage is currently unavailable, so, the file *PRMS_table_GSFLOW_1.2.2.pdf* is included in the ‘doc\Related reports (PRMS, MODFLOW, CRT)’ subdirectory of the GSFLOW distribution folder. In addition, documentation for the `nhru_summary` module and updates for the surface-depression storage simulation option can be found in this ‘Related reports’ subdirectory in the file *tm6b8_PRMS_enhancements.pdf*. PRMS-IV is documented in Markstrom, S.L., Regan, R.S., Hay, L.E., Viger, R.J., Webb, R.M.T., Payn, R.A., and LaFontaine, J.H., 2015, PRMS-IV, the precipitation-runoff modeling system, version 4: U.S. Geological Survey Techniques and Methods book 6, chap. B7, 158 p. The PRMS-distribution website is http://wwwbrr.cr.usgs.gov/projects/SW_MoWS/PRMS.html, accessed February 9, 2018.

MODFLOW Input Files: Up-to-date descriptions of the input requirements for all MODFLOW-2005 and MODFLOW-NWT Packages and Processes are provided in the *Online Guide to MODFLOW-2005* (<http://water.usgs.gov/ogw/modflow/MODFLOW-2005-Guide/>, accessed February 9, 2018) and *Online Guide to MODFLOW-NWT* (<http://water.usgs.gov/ogw/modflow-nwt/MODFLOW-NWT-Guide/>, accessed February 9, 2018). These guides supercede information given on pages 176-226 in TM 6-D1.

Information Related to GSFLOW Input Tables

Tables 1 and 2: Descriptions of PRMS and GSFLOW modules and MODFLOW packages supported in GSFLOW version 1.2.2

Brief descriptions of the modules and packages that are supported in GSFLOW version 1.2.2 are given in table 1; a list of the PRMS modules and MODFLOW packages not implemented in GSFLOW version 1.2.2 is given in table 2. These two tables update tables 1 and 2 provided in TM 6-D1 and TM 6-B7.

Table A1-1: Parameters specified in the GSFLOW Control File

This table supercedes table A1-1 on pages 135-136 of the GSFLOW manual (TM 6-D1) and Table 1-2 in TM6-B7. The GSFLOW Control File is described in detail on pages 134-139 of TM 6-D1. Additional notes follow:

1. Previous versions of GSFLOW required that a PRMS Parameter File be specified in the Control File for a MODFLOW-only simulation. The code has been updated so that the user no longer needs to specify a PRMS Parameter File for a MODFLOW-only simulation. Thus, for a MODFLOW-only simulation, the Control File could be as short as the following example for the Sagehen Creek GSFLOW model distributed with the software:

```
Control File for a MODFLOW-only simulation, Sagehen Creek Watershed
####
model_mode
1
4
MODFLOW
####
modflow_name
1
4
../input/modflow/sagehen.mf.nam
```

Note, however, that for restart simulations, the user also will need to specify control parameters **modflow_time_zero**, **init_vars_from_file**, **save_vars_to_file**, **start_time**, and **end_time**.

2. If default values shown for any input parameter are acceptable, the user does not need to enter those parameter blocks.

Table A1-3: Time-series data that can be specified in the PRMS Data File (supercedes table A1-3 in TM 6-D1, page 141)

1. This table is provided online (PRMS-IV table 1.4, Time-series input variables that may be included in the Data File for the Precipitation-Runoff Modeling System). Refer to that table for the current list of variables that can be specified in PRMS Data Files.

2. The Data File must have at least one column of input values (“data”) in addition to the 6 values that specify the date and time for the time series. Variables that do not have values do not need to be specified. For example **form_data**, **solrad**, and **pan_evap** as shown in figure A1-1 in TM D6-1 page 140 could be removed.

Table A1-4: Dimensions defined in PRMS Parameter Files (supercedes table A1-4 in TM 6-D1, page 145 and table 1-1 in TM 6-B7)

1. Dimensions defined in this table are only needed for the GSFLOW and PRMS-only simulation modes, and are not needed for MODFLOW-only simulation mode because Parameter Files are not needed for a MODFLOW-only simulation.

Tables A1-5 and A1-6 through A1-22: Parameters in the PRMS Parameter File and input parameters for each of the PRMS modules (pages 147-172 in TM 6-D1)

1. These tables have been superceded and are provided online (PRMS-IV table 1.3, Parameters listed by usage with the associated modules in which they are used for the Precipitation-Runoff Modeling System). Refer to that table for the current list of parameters that can be specified in PRMS Parameter Files. Also note that not all of the parameters listed in online table 1.3 are available in GSFLOW; those that are available are based on the PRMS modules available in GSFLOW (see table 1 below).

Table A1-23: Parameters specified for GSFLOW modules (supercedes tables 3 and 4, page 27, and tables A1-23 through A1-27, pages 173-175 in TM 6-D1)

1. This table replaces the seven tables previously used to define input parameters for each of the GSFLOW modules. In keeping with the new structure of the table used to define PRMS-IV input parameters, the parameters for all of the GSFLOW modules are now combined into a single table.

Table 1-5: Selected GSFLOW output variables for which values can be written to the PRMS Statistic Variables File and PRMS Animation Variables File(s) (supercedes Table A1-2 (p. 138-139) in TM 6-D1).

1. The variables shown in this table relate to GSFLOW simulation mode only; additional variables can be written for PRMS-only simulations depending on values in the Data File and active modules (see online PRMS-IV tables 2, 1-2, 1-3, and 1.4 and 1.5).

Table 1-6: GSFLOW output variables written to the GSFLOW Comma-Separated Values File (supercedes Table 12 (p. 88-89) in TM 6-D1).

1. The variables shown in this table have been substantially revised from previous versions of the software.

Table 1. Description of PRMS and GSFLOW modules and MODFLOW packages implemented in GSFLOW version 1.2.2. **[Module or package name:** Users select only one of the modules or packages in each group indicated by a number from 1 to 8. **Fortran or C programming language file:** C programming language file designated with a “.c” at end of file name. **Version:** Shows the GSFLOW release version number when the module or package was first added to GSFLOW. **Model mode:** G is GSFLOW coupled simulation, P is PRMS-only simulation, M is MODFLOW-only simulation; HRU: hydrologic response unit]

| Process | Fortran or C programming language file | Description | Version | Model mode |
|--|--|---|---------|------------|
| PRMS Modules | | | | |
| Basin Definition | basin | Defines shared watershed-wide and hydrologic response unit (HRU) physical parameters and variables | 1.0.00 | G,P |
| Cascading Flow | cascade | Determines computational order of the HRUs and groundwater reservoirs for routing flow downslope | 1.0.00 | G,P |
| Climate and Flow Parameter and Variable Definition | climateflow | Defines shared watershed-wide and hydrologic response unit (HRU) climate and flow parameters and variables | 1.1.5 | G,P |
| Potential Solar Radiation | soltab | Computes potential solar radiation and sunlight hours for each HRU for each day of year | 1.0.00 | G,P |
| Daily Time Step Definition | prms_time | Computes time related variables within the daily time step | 1.2.0 | G,P |
| Observed Data | obs | Reads and stores observed data from all specified measurement stations | 1.0.00 | G,P |
| Temperature Distribution (1) | temp_1sta | Distributes maximum and minimum temperatures to each HRU by using temperature data measured at one station and an estimated monthly lapse rate | 1.0.00 | G,P |
| | temp_laps | Distributes maximum and minimum temperatures to each HRU by computing a daily lapse rate with temperature data measured at a base station and lapse station with differing altitudes | 1.0.00 | G,P |
| | xyz_dist | Determines the form of precipitation and distributes precipitation and temperatures to each HRU by using a multiple linear regression of measured data from a group of measurement stations or from atmospheric model simulation; selection requires this module also be selected for precipitation | 1.0.00 | G,P |
| | temp_dist2 | Distributes maximum and minimum temperatures to each HRU by using a basin-wide lapse rate applied to the temperature data, adjusted for distance, measured at each station | 1.0.00 | G,P |
| | climate_hru | Reads distributed temperature values directly from files | 1.1.5 | G,P |
| | ide_dist | Determines the form of precipitation and distributes precipitation and temperatures to each HRU on the basis of measurements at stations with closest elevation or shortest distance to the respective HRU; selection requires this module also be selected for precipitation | 1.2.0 | G,P |
| Precipitation Distribution (2) | precip_1sta | Determines the form of precipitation and distributes it from one or more stations to each HRU by using monthly correction factors to account for differences in altitude, spatial variation, topography, | 1.0.00 | G,P |

| | | | | |
|----------------------------------|--------------|---|--------|-----|
| | | and measurement gage efficiency. | | |
| | precip_laps | Determines the form of precipitation and distributes it to each HRU by using monthly lapse rates | 1.0.00 | G,P |
| | xyz_dist | Distributes precipitation and maximum and minimum temperatures to each HRU using a multiple linear regression of measured data from a group of measurement stations or from atmospheric model results; selection requires this module also be selected for temperature | 1.0.00 | G,P |
| | precip_dist2 | Determines the form of precipitation and distributes it to each HRU by using an inverse distance weighting scheme | 1.0.00 | G,P |
| | climate_hru | Reads distributed precipitation values directly from files | 1.1.5 | G,P |
| | ide_dist | Determines the form of precipitation and distributes precipitation and temperatures to each HRU on the basis of measurements at stations with closest elevation or shortest distance to the respective HRU; selection requires this module also be selected for temperature | 1.2.0 | G,P |
| Solar Radiation (3) | ddsolrad | Distributes solar radiation to each HRU and estimates missing solar radiation data using a maximum temperature per degree-day relation | 1.0.00 | G,P |
| | ccsolrad | Distributes solar radiation to each HRU and estimates missing solar radiation data using a relation between solar radiation and cloud cover | 1.0.00 | G,P |
| | climate_hru | Reads distributed solar radiation values directly from files | 1.1.5 | G,P |
| Potential Evapotranspiration (4) | potet_jh | Computes the potential evapotranspiration by using the Jensen-Haise formulation (Jensen and Haise, 1963) | 1.0.00 | G,P |
| | potet_hamon | Computes the potential evapotranspiration by using the Hamon formulation (Hamon, 1961) | 1.0.00 | G,P |
| | potet_pan | Computes the potential evapotranspiration for each HRU by using pan-evaporation data | 1.0.00 | G,P |
| | potet_hs | Computes the potential evapotranspiration by using the Hargreaves-Samani formulation (Hargreaves and Samani, 1982) | 1.2.0 | G,P |
| | potet_pm | Computes the potential evapotranspiration by using the Penman-Monteith formulation (Penman, 1948; Monteith, 1965) using specified windspeed and humidity in CBH files | 1.2.0 | G,P |
| | potet_pm_sta | Computes the potential evapotranspiration by using the Penman-Monteith formulation (Penman, 1948; Monteith, 1965) using specified windspeed and humidity in the PRMS Data File | 1.2.1 | G,P |
| | potet_pt | Computes the potential evapotranspiration by using the Priestley-Taylor formulation (Priestley and Taylor, 1972) | 1.2.0 | G,P |
| | climate_hru | Reads distributed potential evapotranspiration values directly from files | 1.1.5 | G,P |
| Transpiration Period (8) | transp_frost | Determines whether the current time step is in a period of active transpiration by the killing frost method | 1.2.0 | G,P |

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|--------------------|------------------|---|--------|-----|
| | transp_tindex | Determines whether the current time step is in a period of active transpiration by the temperature index method | 1.0.00 | G,P |
| | climate_hru | Reads distributed transpiration values directly from files | 1.1.5 | G,P |
| | frost_date | Computes the last spring frost and first fall frost for each HRU based on the simulation time period and distributed temperature; processes after precipitation distribution are not computed | 1.2.0 | P |
| Interception | intcp | Computes volume of intercepted precipitation, evaporation from intercepted precipitation, and throughfall that reaches the soil or snowpack | 1.0.00 | G,P |
| Snow | snowcomp | Initiates development of a snowpack and simulates snow accumulation and depletion processes by using an energy-budget approach | 1.0.00 | G,P |
| Surface Runoff (5) | srunoff_smidx | Computes surface runoff and infiltration for each HRU by using a nonlinear variable-source-area method allowing for cascading flow | 1.0.00 | G,P |
| | srunoff_carea | Computes surface runoff and infiltration for each HRU by using a linear variable-source-area method allowing for cascading flow | 1.0.00 | G,P |
| Soil Zone | soilzone | Computes inflows to and outflows from soil zone of each HRU and includes inflows from infiltration, groundwater, and upslope HRUs, and outflows to gravity drainage, interflow, and surface runoff to down-slope HRUs | 1.0.00 | G,P |
| Groundwater | gwflow | Sums inflow to and outflow from PRMS groundwater reservoirs; outflow can be routed to downslope groundwater reservoirs and stream segments | 1.0.00 | P |
| Streamflow | strmflow | Computes daily streamflow as the sum of surface runoff, shallow-subsurface flow (interflow), detention reservoir flow, and groundwater flow | 1.0.00 | P |
| | routing | Computes common segment routing flows for modules strmflow_in_out and muskingum | 1.2.0 | P |
| | strmflow_in_out | Routes water between segments in the system by setting the outflow to the inflow | 1.2.0 | P |
| | muskingum | Computes basin on-channel reservoir storage and outflows | 1.2.0 | P |
| Summary | basin_sum | Sums values for daily, monthly, yearly, and total flow summaries of volumes and flows for all HRUs | 1.0.00 | P |
| | map_results | Writes HRU summaries to a user specified target map at weekly, monthly, yearly, and total time steps (initially named grid_report) | 1.1.3 | G,P |
| | subbasin | Computes streamflow at internal basin nodes and variables by subbasin | 1.1.00 | G,P |
| | nhru_summary | Writes selected user-selected results dimensioned by the value of dimension nhru as daily, monthly, mean-monthly, mean yearly, and yearly total time-series as Comma-Separated-Values (CSV) files | 1.2.0 | G,P |
| | nsegment_summary | Writes selected user-selected results dimensioned by the value of dimension nsegment as daily, monthly, mean-monthly, mean yearly, and yearly total time-series as Comma-Separated-Values (CSV) files | 1.2.2 | G,P |

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|--|-------------------|--|--------|-----|
| | nsub_summary | Writes selected user-selected results dimensioned by the value of dimension nsub as daily, monthly, mean-monthly, mean yearly, and yearly total time-series as Comma-Separated-Values (CSV) files | 1.2.2 | G,P |
| | basin_summary | Writes selected user-selected results dimensioned by the value of dimension one as daily, monthly, mean-monthly, mean yearly, and yearly total time-series as Comma-Separated-Values (CSV) files | 1.2.2 | G,P |
| | water_balance | Computes daily HRU and basin-wide water balances for selected hydrologic processes when control parameter print_debug is specified equal to 1. | 1.2.0 | P |
| | write_climate_hru | Computes user-selected climate values for each HRU based on the simulation time period and distributed climate; processes after transpiration period are not computed | 1.1.6 | P |
| MODFLOW Packages | | | | |
| Basic | gwf2bas7_NWT | BAS: Handles a number of basic administrative tasks; modification of gwf2bas7 | 1.0.00 | G,M |
| Block Centered Flow (6) | gwf2bcf7 | BCF: Calculates conductance coefficients for groundwater-flow equations using a block-centered flow package | 1.0.00 | G,M |
| Layer Property Flow (6) | gwf2lpf7 | LPF: Calculates conductance coefficients for groundwater-flow equations using a layer-property flow package | 1.0.00 | G,M |
| Hydrogeologic-Unit Flow (6) | gwf2huf7 | HUF: Calculates effective hydraulic properties for model layers using hydrostratigraphic units | 1.0.00 | G,M |
| Upstream-Weighting Package (6) | gwf2upw1 | UPW: Calculates conductance coefficients for groundwater-flow equations using an upstream-weighting package. The package is used with the NWT solver | 1.1.5 | G,M |
| Horizontal Flow Barrier | gwf2hfb7_NWT | HFB: Simulates flow barriers by reducing horizontal conductance | 1.0.00 | G,M |
| Well | gwf2wel7_NWT | WEL: Adds terms to flow equation to represent wells | 1.0.00 | G,M |
| Multi-Node Well | gwf2mnw17_NWT | MNW, version 1: Adds terms to flow equation for wells that extract or inject water in more than one cell | 1.0.00 | G,M |
| | gwf2mnw27_NWT | MNW, version 2: Adds terms to flow equation for wells that extract or inject water in more than one cell | 1.1.1 | G,M |
| General Head Boundary | gwf2ghb7_NWT | GHB: Adds terms to flow equation to represent general head-dependent boundaries | 1.0.00 | G,M |
| Constant Head Boundary | gwf2chd7 | CHD: Adds terms to flow equation to represent constant-head boundaries | 1.0.00 | G,M |
| Flow and Head Boundary | gwf2fhb7 | FHB: Adds terms to flow equation to represent flow and head boundaries | 1.0.00 | G,M |
| Sea Water Intrusion | gwf2swi27 | SWI: Allows three-dimensional vertically integrated variable-density groundwater flow and seawater intrusion in coastal multiaquifer systems to be simulated | 1.2.2 | M |
| Subsidence and Aquifer-System Compaction for Water-Table | gwf2swt7 | SWT: Simulates vertical compaction in models of regional groundwater flow. The program simulates groundwater storage changes and compaction in discontinuous interbeds or in extensive confining | 1.2.2 | M |

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|--|------------------------------|--|--------|-------|
| Aquifers | | units, accounting for stress-dependent changes in storage properties. | | |
| Streamflow Routing | gwf2sfr7_NWT | SFR: Adds terms to flow equation to represent groundwater and stream interactions; modification of gwf1sfr2 | 1.0.00 | G,M |
| Lake | gwf2lak7 | LAK: Adds terms to flow equation to represent groundwater and lake interactions; modification of gwf1lak3 | 1.0.00 | G,M |
| Unsaturated Zone Flow | gwf2uzf1_NWT | UZF: Adds terms to flow equation to represent recharge from the unsaturated zone, evapotranspiration, and groundwater discharge to land surface | 1.0.00 | G,M |
| Gage | gwf2gag7 | GAG: Prints time series gage output for selected stream reaches and lakes; modification of gwf1gag5 | 1.0.00 | G,M |
| Link to the MT3DMS contaminant-transport model | lmt8_NWT | LMT: Records flow information from MODFLOW for use by MT3DMS or MT3D-USGS | 1.2.2 | M |
| Observation | obs2bas7, obs2chd7, obs2ghb7 | OBS: Compares model-generated values of heads and flows to observed values for the BAS, CHD, and GHB Packages | 1.0.00 | G,M |
| Solver (7) | sip7_NWT | SIP: Solves simultaneous equations resulting from finite-difference approximations using the strongly implicit procedure | 1.0.00 | G,M |
| | pcg7_NWT | PCG: Solves simultaneous equations resulting from finite-difference approximations using a preconditioned conjugate-gradient procedure | 1.0.00 | G,M |
| | de47_NWT | DE4: Solves simultaneous equations resulting from finite-difference approximations using a direct solution procedure | 1.0.00 | G,M |
| | NWT1 (various files) | NWT: Solves simultaneous equations resulting from finite-difference approximations using a Newton formulation | 1.1.5 | G,M |
| GSFLOW modules | | | | |
| Computation Order | gsflow_prms | Controls model mode, the GSFLOW and PRMS daily time-step loop, and computational sequence order of GSFLOW and PRMS modules—PRMS equivalent file call_modules.f90 | 1.0.00 | G,P,M |
| | gsflow_modflow | Controls sequence order for reading MODFLOW time-dependent input data and controls the computational sequence of calculations in the time-step and iteration loops for MODFLOW packages and defines variables used for converting between PRMS and MODFLOW units—MODFLOW equivalent MF_NWT.f | 1.0.00 | G,M |
| Integration | gsflow_prms2mf | Distributes the PRMS soilzone module computed gravity drainage and unsatisfied potential evaporation from HRUs to MODFLOW cells for input to the UZF Package and the PRMS surface-runoff and soilzone computed Hortonian and Dunnian surface runoff and interflow from HRUs to stream segments and lakes and precipitation and evaporation to lakes for input to the SFR and LAK Packages at the end of each time step | 1.0.00 | G |
| | gsflow_mf2prms | Distributes computed groundwater discharge from | 1.0.00 | G |

| | | | | |
|---------|---------------|---|--------|---|
| | | MODFLOW cells to HRUs for input to the PRMS soilzone module at the end of each time step | | |
| Summary | gsflow_budget | Computes watershed budget for GSFLOW and adjusts PRMS gravity reservoir storage using the flows to and from MODFLOW cells after the MODFLOW budget procedure and writes to the GSFLOW output file at the end of each timestep | 1.0.00 | G |
| | gsflow_sum | Computes detailed watershed water budgets for flow and storage components and writes these to the GSFLOW CSV file at the end of each timestep | 1.0.00 | G |

Table 2. PRMS version 4.0.2 modules and MODFLOW-NWT version 1.1.2 packages not implemented in GSFLOW version 1.2.1.[HRU: hydrologic response unit]

| Module or package name | Fortran file | Description |
|----------------------------------|------------------------------|---|
| PRMS modules | | |
| Streamflow with On-channel Lakes | strmflow_lake | Computes daily streamflow as the sum of surface, subsurface, and ground-water flow contributions to each stream segment and routes flow through lakes |
| Summary | prms_summary | Computes select watershed-wide variables to a Comma-Separated Values (CSV) file |
| MODFLOW-NWT packages | | |
| Recharge | gwf2rch7 | RCH: Adds terms to groundwater flow equation to represent areal recharge to groundwater system |
| Evapotranspiration | gwf2evt7 | EVT: Adds terms to groundwater flow equation to represent head-dependent evapotranspiration from groundwater system |
| Segmented Evapotranspiration | gwf2ets7 | ETS Adds terms to groundwater flow equation to represent segmented head-dependent evapotranspiration from groundwater system |
| Interbed Storage | gwf2ibs7 | IBS: Adds terms to groundwater flow equation to represent inelastic compaction of fine-grained sediments |
| Subsidence | gwf2sub7_NWT | SUB: Simulates aquifer-system compaction and land subsidence |
| Tile Drain | gwf2drt7 | DRT: Adds terms to groundwater flow equation to represent groundwater discharge to drains while accounting for irrigation return flows |
| River | gwf2riv7_NWT | RIV: Adds terms to groundwater flow equation to represent rivers to represent head-dependent flow between a surface water body and a groundwater system |
| Drain | gwf2drn7_NWT | DRN: Adds terms to groundwater flow equation to represent ground-water discharge to drains |
| Reservoir | gwf2res7 | RES: Adds terms to groundwater flow equation to represent leakage from reservoirs |
| Stream | gwf2str7 | STR: Adds terms to flow equation to represent groundwater and stream interactions; predecessor to SFR2 Package |
| Surface-Water Routing | gwf2swr7_NWT | SWR: Surface-water routing process is designed to simulated surface-water routing in one- and two-dimensional surface-water features and surface-water/groundwater interactions |
| Hydrograph capability | gwf2hydmod7.f | HYDMOD: Records time-series data for selected data types |
| Observation | obs2drn7, obs2riv7, obs2str7 | OBS: Compares model-generated values of heads and flows to observed values for the DRN, RIV, and STR Packages |

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Table A1-1. Parameters specified in the GSFLOW Control File.

[Pathnames for all files can have a maximum of 256 characters, variable names a maximum of 32 characters; Data Type: 1=integer, 2=single precision floating point (real), 3=double precision floating point (double); 4=character string; HRU, hydrologic response unit; GWR, groundwater reservoir; CBH, climate-by-HRU; ET, evapotranspiration; >, greater than; dimensions **ncascade**, **ncascdgw**, and **nsub** defined in table A1-4 of this document; the first two blocks of control parameters listed in the table are recommended for every simulation, although all parameters are optional depending on the appropriateness of the default values]

| Parameter name | Description | Required/Simulation condition(s) | Number of Values | Data type | Default value |
|--|---|--|---------------------------|-----------|----------------------|
| Simulation execution and input and output files | | | | | |
| csv_output_file ² | Pathname of GSFLOW Comma-Separated-Values (CSV) output file for selected GSFLOW basin-area weighted flows and storages for each time step | model_mode = GSFLOW with gsf_rpt = 1 | 1 | 4 | prms_summary.csv |
| data_file | Pathname(s) for measured input Data File(s), typically a single Data File is specified | model_mode = GSFLOW or PRMS | number of Data Files | 4 | prms.data |
| end_time | Simulation end date and time specified in order in the control item as: year, month, day, hour, minute, second | model_mode = GSFLOW or PRMS | 6 | 1 | 2001, 9, 30, 0, 0, 0 |
| gsflow_output_file ² | Pathname for GSFLOW Water-Budget File of summaries of each component of the GSFLOW water budget | model_mode = GSFLOW | 1 | 4 | gsflow.out |
| gsf_rpt ² | Switch to specify whether or not the GSFLOW Comma-Separated-Values (CSV) output file is generated (0=no; 1=yes) | model_mode = GSFLOW | 1 | 4 | 1 |
| model_mode | Flag to indicate the simulation mode (GSFLOW=GSFLOW coupled model; PRMS=PRMS-only; MODFLOW=MODFLOW-only; FROST=growing season for each HRU; WRITE_CLIMATE=write CBH files of minimum and maximum air temperature (variables <i>tminf</i> and <i>tmaxf</i> -Fahrenheit), precipitation (variable <i>hru_ppt</i> -inches), solar radiation (variable <i>swrad</i> -Langley's), potential ET (variable <i>potet</i> -inches), and/or transpiration flag (variable <i>transp_on</i> -dimensionless) | required | 1 | 4 | PRMS |
| model_output_file | Pathname for Water-Budget File for results module <i>basin_sum</i> | model_mode = GSFLOW or PRMS | 1 | 4 | prms.out |
| modflow_name ² | Pathname for MODFLOW Name File | model_mode = GSFLOW or MODFLOW | 1 | 4 | modflow.nam |
| modflow_time_zero ² | Date and time for the first MODFLOW initial stress period in the control item as: year, month, day, hour, minute, second | model_mode = GSFLOW or MODFLOW and init_vars_from_file = 1 or save_vars_to_file = 1 | 6 | 1 | start_time |
| param_file | Pathname(s) for PRMS Parameter File(s) | model_mode = GSFLOW or PRMS | number of Parameter Files | 4 | prms.params |
| prms_warmup | Number of years to simulate before writing Basin, nsub , or nsegment Summary Output Files | basinOutON_OFF = 1, or nsegmentOutON_OFF = | 1 | 1 | 1 |

| Parameter name | Description | Required/Simulation condition(s) | Number of Values | Data type | Default value |
|--|--|---|------------------|-----------|----------------------|
| rpt_days² | Frequency with which summary tables are written to the GSFLOW Water-Budget File (0=none; >0=frequency in days, e.g., 1=daily, 7=every 7 th day) | 1 or nsubOutON_OFF = 1 model_mode = GSFLOW | 1 | 1 | 7 |
| start_time | Simulation start date and time specified in order in the control item as: year, month, day, hour, minute, second | model_mode = GSFLOW or PRMS | 6 | 1 | 2000, 10, 1, 0, 0, 0 |
| Module selection and simulation options (model_mode = GSFLOW or PRMS) | | | | | |
| cascade_flag | Flag to indicate if HRU cascades are computed (0=no; 1=yes) | ncascade > 0 | 1 | 1 | 1 |
| cascadegw_flag | Flag to indicate if GWR cascades are computed (0=no; 1 or 2=yes). If cascadegw_flag = 2, the GWR cascades are set equal to the HRU cascades, so gw_up_id , gw_strmseg_down_in , gw_down_id , and gw_pct_up do not need to be specified, which can decrease the size of the parameter files significantly. | ncascdgw > 0 | 1 | 1 | 1 |
| dprst_flag | Flag to indicate if depression-storage simulation is computed (0=no; 1=yes) | optional | 1 | 1 | 0 |
| et_module | Module name for potential-evapotranspiration method (climate_hru , potet_jh , potet_hamon , potet_hs , potet_pt , potet_pm , potet_pm_sta , or potet_pan) | required | 1 | 4 | potet_jh |
| gwr_swale_flag | Flag to indicate if GWR swales are allowed (0=no; 1=groundwater flow goes to groundwater sink; 3=groundwater flow goes to stream segment specified using parameter hru_segment) | optional | 1 | 1 | 0 |
| precip_module | Module name for precipitation-distribution method (climate_hru , ide_dist , precip_1sta , precip_dist2 , precip_laps , or xyz_dist) | required | 1 | 4 | precip_1sta |
| solrad_module | Module name for solar-radiation-distribution method (ccsolrad or ddsolrad) | required | 1 | 4 | ddsolrad |
| srunoff_module | Module name for surface-runoff/infiltration computation method (srunoff_carea or srunoff_smidx) | required | 1 | 4 | srunoff_smidx |
| strmflow_module | Module name for streamflow routing simulation method (strmflow , muskingum , or strmflow_in_out) | model_mode = PRMS | 1 | 4 | strmflow |
| subbasin_flag | Flag to indicate if internal subbasins are computed (0=no; 1=yes) | nsub > 0 | 1 | 1 | 1 |
| temp_module | Module name for temperature-distribution method (climate_hru , temp_1sta , temp_dist2 , temp_laps , ide_dist , or xyz_dist) | required | 1 | 4 | temp_1sta |
| transp_module | Module name for transpiration simulation method (climate_hru , transp_frost , or transp_tindex) | required | 1 | 4 | transp_tindex |

| Parameter name | Description | Required/Simulation condition(s) | Number of Values | Data type | Default value |
|---|---|--|------------------|-----------|---------------|
| Climate-by-HRU Files (model_mode = GSFLOW or PRMS) | | | | | |
| cbh_binary_flag | Flag to specify whether to input CBH files in a binary format using the same order of values as the text file version (0=no; 1=yes) | et_module , precip_module , temp_module , solrad_module , or transp_module = climate_hru | 1 | 1 | 0 |
| humidity_cbh_flag | Flag to specify whether to read a CBH file with humidity data (0=no; 1=yes) | et_module = potet_pm or potet_pt | 1 | 1 | 0 |
| humidity_day | Pathname of the CBH file of pre-processed humidity input data for each HRU to specify variable <i>humidity_hru</i> -decimal fraction | et_module = potet_pm, potet_pm_sta, or potet_pt | 1 | 4 | humidity.day |
| orad_flag | Flag to specify whether or not the variable <i>orad</i> is specified as the last column of the swrad_day CBH file (0=no; 1=yes) | solrad_module = climate_hru | 1 | 1 | 0 |
| potet_day | Pathname of the CBH file of pre-processed potential-ET input data for each HRU to specify variable <i>potet</i> -inches | et_module = climate_hru | 1 | 4 | potet.day |
| precip_day | Pathname of the CBH file of pre-processed precipitation input data for each HRU to specify variable <i>precip</i> -units based on value specified for parameter precip_units | precip_module = climate_hru | 1 | 4 | precip.day |
| swrad_day | Pathname of the CBH file of pre-processed solar-radiation input data for each HRU to specify variable <i>swrad</i> - units based on Langley's and value specified for parameter rad_conv | solrad_module = climate_hru | 1 | 4 | swrad.day |
| tmax_day | Pathname of the CBH file of pre-processed maximum air temperature input data for each HRU to specify variable <i>tmaxf</i> -units based on value specified for parameter temp_units | temp_module = climate_hru | 1 | 4 | tmax.day |
| tmin_day | Pathname of the CBH file of pre-processed minimum air temperature input data for each HRU to specify variable <i>tminf</i> -units based on value specified for parameter temp_units | temp_module = climate_hru | 1 | 4 | tmin.day |
| transp_day | Pathname of the CBH file of pre-processed transpiration on or off flag for each HRU file to specify variable <i>transp_on</i> -dimensionless | transp_module = climate_hru | 1 | 4 | transp.day |
| windspeed_cbh_flag | Flag to specify whether to read a CBH file with wind speed data (0=no; 1=yes) | et_module = potet_pm | 1 | 1 | 0 |
| windspeed_day | Pathname of the CBH file of pre-processed wind speed input data for each HRU to specify variable <i>windspeed_hru</i> -meters/second | et_module = potet_pm | 1 | 4 | windspeed.day |
| Debug options (model_mode = GSFLOW or PRMS) | | | | | |
| cbh_check_flag | Flag to indicate if CBH values are validated each time step (0=no; 1=yes) | optional | 1 | 1 | 1 |
| parameter_check_flag | Flag to indicate if selected parameter-values validation checks are treated as warnings or errors (0=warning; 1=errors; 2=check parameters and then stop execution) | optional | 1 | 1 | 1 |

| Parameter name | Description | Required/Simulation condition(s) | Number of Values | Data type | Default value |
|--|---|--|--------------------|-----------|---------------|
| print_debug¹ | Flag to indicate type of debug output (-1=minimize screen output; 0=none; 1=water balances; 2=basin module; 4=basin_sum module; 5=soltab module; 7=soilzone module; 9=snowcomp module; 13=cascade module; 14=subbasin module) | optional | 1 | 1 | 0 |
| Statistic Variables (statvar) Files (model_mode = GSFLOW or PRMS) | | | | | |
| nstatVars | Number of variables to include in Statistics Variables File and names specified in statVar_names | statsON_OFF = 1 | 1 | 1 | 0 |
| stat_var_file | Pathname for Statistics Variables File | statsON_OFF = 1 | 1 | 4 | statvar.out |
| statsON_OFF | Switch to specify whether or not the Statistics Variables File is generated (0=no; 1=statvar text format; 2=CSV format) | statsON_OFF = 1 | 1 | 1 | 0 |
| statVar_element | List of identification numbers corresponding to variables specified in statVar_names list (1 to variable's dimension size) | statsON_OFF = 1 | nstatVars | 4 | none |
| statVar_names | List of variable names for which output is written to Statistics Variables File | statsON_OFF = 1 | nstatVars | 4 | none |
| Initial Condition Files | | | | | |
| init_vars_from_file | Flag to specify whether or not the Initial Conditions File is specified as an input file (0=no; 1=yes) | optional (available for all model modes) | 1 | 1 | 0 |
| save_vars_to_file | Flag to determine if an Initial Conditions File will be generated at the end of simulation (0=no; 1=yes) | optional (available for all model modes) | 1 | 1 | 0 |
| var_init_file | Pathname for Initial Conditions input file | model_mode = GSFLOW or PRMS and init_vars_from_file = 1 | 1 | 4 | prms_ic.in |
| var_save_file | Pathname for the Initial Conditions File to be generated at end of simulation | model_mode = GSFLOW or PRMS and save_vars_to_file = 1 | 1 | 4 | prms_ic.out |
| Animation Files (model_mode = GSFLOW or PRMS) | | | | | |
| ani_output_file | Root pathname for Animation Files(s) to which a filename suffix based on dimension name associated with selected variables is appended | aniOutON_OFF = 1 | 1 | 4 | animation.out |
| aniOutON_OFF | Switch to specify whether or not Animation File(s) are generated (0=no; 1=yes) | animation output | 1 | 1 | 0 |
| aniOutVar_names | List of variable names for which all values of the variable (that is, the entire dimension size) for each time step are written to Animation Files(s) | aniOutON_OFF = 1 | naniOutVars | 4 | none |
| naniOutVars | Number of output variables specified in the aniOutVar_names list | aniOutON_OFF = 1 | 1 | 1 | 0 |
| Mapped Results Files (model_mode = GSFLOW or PRMS) | | | | | |
| mapOutON_OFF | Switch to specify whether or not Mapped Output file(s) by a | optional | 1 | 1 | 0 |

| Parameter name | Description | Required/Simulation condition(s) | Number of Values | Data type | Default value |
|---|--|----------------------------------|------------------------|-----------|------------------|
| mapOutVar_names | specified number of columns (parameter ncol) of daily, monthly, yearly, or total simulation results is generated (0=no; 1=yes) List of variable names for which output is written to mapped output files(s) | map_resultsON_OFF = 1 | nmapOutVars | 4 | none |
| nmapOutVars | Number of variables to include in mapped output file(s) | map_resultsON_OFF = 1 | 1 | 1 | 0 |
| Nhru Summary Results Files (model_mode = GSFLOW or PRMS) | | | | | |
| nhruOutBaseFileName | Base pathname for each Nhru Summary Output File | nhruOutON_OFF = 1 | 1 | 4 | nhruout_path |
| nhruOutON_OFF | Switch to specify whether or not Nhru Summary Output File(s) are generated (0=no; 1=yes) | nhru summary results | 1 | 1 | 0 |
| nhruOutVar_names | List of variable names for which output is written to nhru Summary Comma Separated Values (CSV) Output Files(s). Each variable is written to a separate file with the prefix of each file equal to the value of nhruOutBaseFileName ; variables must be of type real or double. Each variable is written to a separate file with the prefix of each file equal to the value of nhruOutBaseFileName . The suffix of the files is based on the value of nhruOut_freq and will be .csv; _meanyearly.csv; _yearly.csv; _meanmonthly.csv; or _monthly.csv. Variables must be of type real or double | nhruOutON_OFF = 1 | nhruOutVars | 4 | none |
| nhruOutVars | Number of variables to include in Nhru Summary Output File(s) | nhruOutON_OFF = 1 | 1 | 1 | 0 |
| nhruOut_freq | Output frequency and type (1=daily; 2=monthly; 3=both; 4=mean monthly; 5=mean yearly; 6=yearly) | nhruOutON_OFF = 1 | 1 | 1 | 1 |
| nsegment Summary Files | | | | | |
| nsegmentOutBaseFileName | String to define the prefix for each nsegment Summary Output File. | nsegmentOutON_OFF = 1 | 1 | 4 | nsegmentout_path |
| nsegmentOutON_OFF | Switch to specify whether or not nsegment Summary Output Files are generated (0=no; 1=yes) | nsegment summary results | 1 | 1 | 0 |
| nsegmentOutVar_names | List of variable names for which output is written to nsegment Summary Comma Separated Values (CSV) Output Files(s). Each variable is written to a separate file with the prefix of each file equal to the value of nsegmentOutBaseFileName ; variables must be of type real or double. Each variable is written to a separate file with the prefix of each file equal to the value of nsegmentOutBaseFileName . The suffix of the files is based on the value of nsegmentOut_freq and will be .csv; _meanyearly.csv; _yearly.csv; _meanmonthly.csv; or _monthly.csv. Variables must be of type real or double | nsegmentOutON_OFF = 1 | nsegmentOutVars | 4 | none |
| nsegmentOutVars | Number of variables to include in nsegment Summary Output File(s) | nsegmentOutON_OFF = 1 | 1 | 1 | 0 |
| nsegmentOut_freq | Output frequency and type (1=daily; 2=monthly; 3=both; 4=mean | nsegmentOutON_OFF = | 1 | 1 | 1 |

| Parameter name | Description | Required/Simulation condition(s) | Number of Values | Data type | Default value |
|-----------------------------|---|----------------------------------|---------------------|-----------|---------------|
| | monthly; 5=mean yearly; 6=yearly) | 1 | | | |
| nsub Summary Files | | | | | |
| nsubOutBaseFileName | String to define the prefix for each nsub Summary Output File. | nsubOutON_OFF = 1 | 1 | 4 | nsubout_path |
| nsubOutON_OFF | Switch to specify whether or not nsub Summary Output Files are generated (0=no; 1=yes) | nsub summary results | 1 | 1 | 0 |
| nsubOutVar_names | List of variable names for which output is written to nsub Summary Comma Separated Values (CSV) Output File(s). Each variable is written to a separate file with the prefix of each file equal to the value of nsubOutBaseFileName ; variables must be of type real or double. Each variable is written to a separate file with the prefix of each file equal to the value of nsubOutBaseFileName . The suffix of the files is based on the value of nsubOut_freq and will be .csv; _meanyearly.csv; _yearly.csv; _meanmonthly.csv; or _monthly.csv. Variables must be of type real or double | nsubOutON_OFF = 1 | nsubOutVars | 4 | none |
| nsubOutVars | Number of variables to include in nsub Summary Output File(s) | nsubOutON_OFF = 1 | 1 | 1 | 0 |
| nsubOut_freq | Output frequency and type (1=daily; 2=monthly; 3=both; 4=mean monthly; 5=mean yearly; 6=yearly) | nsubOutON_OFF = 1 | 1 | 1 | 1 |
| Basin Summary Results Files | | | | | |
| basinOutBaseFileName | String to define the prefix for each Basin Summary Output File. | basinOutON_OFF = 1 | 1 | 4 | basinout_path |
| basinOutON_OFF | Switch to specify whether or not basin Summary Output Files are generated (0=no; 1=yes) | Basin summary results | 1 | 1 | 0 |
| basinOutVar_names | List of variable names for which output is written to Basin Summary Comma Separated Values (CSV) Output File(s). Each variable is written to a separate file with the prefix of each file equal to the value of basinOutBaseFileName ; variables must be of type real or double. Each variable is written to a separate file with the prefix of each file equal to the value of basinOutBaseFileName . The suffix of the files is based on the value of basinOut_freq and will be .csv; _meanyearly.csv; _yearly.csv; _meanmonthly.csv; or _monthly.csv. Variables must be of type real or double | basinOutON_OFF = 1 | basinOutVars | 4 | none |
| basinOutVars | Number of variables to include in Basin Summary Output File(s) | basinOutON_OFF = 1 | 1 | 1 | 0 |
| basinOut_freq | Output frequency and type (1=daily; 2=monthly; 3=both; 4=mean monthly; 5=mean yearly; 6=yearly) | basinOutON_OFF = 1 | 1 | 1 | 1 |

¹File and screen output options: 1=water balance output files written in current directory, for **intcp** module file **intcp.wbal**; for **snowcomp** module **snowcomp.wbal**; for **srunoff** module **srunoff_smidx.wbal** or **srunoff_carea.wbal**; for **soilzone** module **soilzone.wbal**; for **gwflow** module **gwflow.wbal**; 2=basin module output written to screen; 4=basin_sum debug information written to file **basin_sum.dbg** in current directory; 5=soltab module output written to the file **soltab_debug** in current directory; 7=soilzone debug information concerning input parameter consistency written to file **soilzone.dbg** in current directory; 9=arrays of *net_rain*, *net_snow*, and *snowmelt*

written to screen; 13=subbasin error and warning messages and cascade paths are written to the file cascade.msgs in current directory; 14=subbasin computation order written to file tree_structure in current directory.

²Parameter not needed for a PRMS-only simulation.

Table A1-4. Dimensions defined in the PRMS Parameter File.

[Dimensions only need to be defined for GSFLOW and PRMS-only simulation modes and are not needed for MODFLOW-only mode; HRU, hydrologic response unit; GWR, groundwater reservoir; >, greater than; control parameters **temp_module**, **precip_module**, **solrad_module**, **et_module**, **strmflow_module**, **subbasin_flag**, **cascade_flag**, **cascadegw_flag**, and **mapOutON_OFF** are defined in table A1-1 of this document; parameter **hru_solsta** defined in table 1-3 of online PRMS-IV documents; note that Dimensions that do not have an associated parameter specified in the Parameter File(s) or variable specified in the Data File are optional]

| Dimension | Description | Default | Required/Simulated Condition(s) |
|--|--|---------|---|
| Spatial dimensions | | | |
| ngw ¹ | Number of GWRs (used in PRMS-only simulations) | 1 | model_mode = GSFLOW or PRMS |
| ngwcell | Number of cells in the MODFLOW grid (includes active and inactive cells) | 0 | model_mode = GSFLOW or when mapOutON_OFF = 1 and model_mode = PRMS |
| nhru ¹ | Number of hydrologic response units | 1 | model_mode = GSFLOW or PRMS |
| nhrucell | Number of unique intersections between HRUs and spatial units of a target map for mapped results | 0 | model_mode = GSFLOW or when mapOutON_OFF = 1 and model_mode = PRMS |
| nlake | Number of lakes | 0 | model_mode = GSFLOW or PRMS when any HRU has hru_type specified equal to 2 |
| nreach | Number of reaches on all stream-channel segments | 0 | model_mode = GSFLOW |
| nsegment | Number of stream-channel segments | 0 | model_mode = GSFLOW or when HRU or GWR cascading flow is active or strmflow_module = strmflow_in_out or muskingum when model_mode = PRMS |
| nssr ¹ | Number of subsurface reservoirs | 1 | model_mode = GSFLOW or PRMS |
| nsub | Number of internal subbasins | 0 | model_mode = GSFLOW or PRMS and subbasin_flag = 1 or parameter subbasin_down is specified |
| Time-series input data dimensions (model_mode = GSFLOW or PRMS) | | | |
| nevap | Number of pan-evaporation data sets | 0 | et_module = potet_pan or when any HRU has hru_pansta specified > 0 |
| nhumid | Number of relative-humidity measurement stations | 0 | required if et_module = potet_pm_sta |
| nobs | Number of streamflow-measurement stations | 0 | optional in general and required when using the replacement flow option when strmflow_module = muskingum or strmflow_in_out and model_mode = PRMS |
| nrain | Number of precipitation-measurement stations | 0 | precip_module = precip_1sta , precip_laps , precip_dist2 , ide_dist , or xyz_dist |
| nsnow | Number of snow-depth measurement stations | 0 | optional |
| nsol | Number of solar-radiation measurement stations | 0 | solrad_module = ddsolrad or ccsolrad and when any HRU has hru_solsta specified > 0 |
| ntemp | Number of air-temperature-measurement stations | 0 | temp_module = temp_1sta , temp_laps , temp_dist2 , ide_dist , or xyz_dist |
| nwind | Number of wind-speed measurement stations | 0 | required if et_module = potet_pm_sta |
| Computation dimensions (model_mode = GSFLOW or PRMS) | | | |

| Dimension | Description | Default | Required/Simulated Condition(s) |
|---|---|---------|---------------------------------|
| ncascade | Number of HRU links for cascading flow | 0 | cascade_flag = 1 |
| ncascdgw | Number of GWR links for cascading flow | 0 | cascadegw_flag = 1 or 2 |
| ndepl | Number of snow-depletion curves | 1 | required |
| ndeplval | Number of values in all snow-depletion curves (set to ndepl *11) | 11 | required |
| Fixed dimensions (model_mode = GSFLOW or PRMS) | | | |
| ndays | Maximum number of days in a year | 366 | optional |
| nlapse | Number of lapse rates in X, Y, and Z directions | 3 | precip_module = xyz_dist |
| nmonths | Number of months in a year | 12 | optional |
| one | Dimension of scalar parameters and variables | 1 | optional |

¹Dimensions **ngw**, **nhru**, and **nssr** must be equal.

Table A1-23. Input parameters specified for GSFLOW modules in the PRMS Parameter File(s). [HRU, hydrologic response unit; Dimensions are defined in table A1-4 of this document]

| Parameter name | Description | Dimension | Type | Units | Range | Default | Required/Simulated condition(s) |
|------------------------------|--|-----------------|---------|------------------|--------------------------|--|--|
| gvr_cell_id | Index of the grid cell associated with each gravity reservoir | nhrucell | integer | none | 0 to ngwcell | 0 | model_mode = GSFLOW or when mapOutON_OFF = 1 and model_mode = PRMS |
| gvr_cell_pct | Proportion of the grid-cell area associated with each gravity reservoir | nhrucell | real | decimal fraction | 0.0 to 1.0 | 0.0 | model_mode = GSFLOW or when mapOutON_OFF = 1 and model_mode = PRMS and nhru not equal to nhrucell |
| gvr_hru_id | Index of the HRU associated with each gravity reservoir | nhrucell | integer | none | 1 to nhru | 1 | model_mode = GSFLOW or when mapOutON_OFF = 1 and model_mode = PRMS and nhru not equal to nhrucell |
| gvr_hru_pct | Proportion of the HRU area associated with each gravity reservoir | nhrucell | real | decimal fraction | 0.0 to 1.0 | 0.0 | model_mode = GSFLOW or when mapOutON_OFF = 1 and model_mode = PRMS and nhru not equal to nhrucell |
| id_obsrunoff | Index of measured streamflow station corresponding to the basin outlet | one | integer | none | 1 to nobs | 0 | required |
| lake_hru_id | Identification number of the lake associated with an HRU; more than one HRU can be associated with each lake | nhru | integer | none | 0 to nhru | 0 | model_mode = GSFLOW or PRMS and nlake is greater than 0 |
| mxsziter ¹ | Maximum number of iterations for which soil-zone states are computed | one | integer | none | mnsziter to 5,000 | MODFLOW convergence criterion ² | model_mode = GSFLOW |

¹Parameter is not required in MODFLOW-only simulations.

²MXITER, ITMX, or MAXITEROUT

Table 1-5. Selected GSFLOW output variables for which values can be written to the PRMS Statistic Variables File and PRMS Animation Variables File(s)
(supercedes Table A1-2 in Markstrom and others, 2008).[HRU, hydrologic response unit; ET, evapotranspiration; cfs: cubic feet per second; L3, cubic length units of MODFLOW; L3/T, cubic length units of MODFLOW per MODFLOW timestep; >, greater than; <, less than]

| Variable name | Description | Dimension ¹ | Units | Data type | Original Variable Name |
|---------------------------------|---|------------------------|--------|-----------|------------------------|
| <i>actet_gw</i> | Actual ET from each GW cell | one | inches | real | |
| <i>actet_tot_gwsz</i> | Total actual ET from each GW cell and PRMS soil zone | one | inches | real | |
| <i>ActualET_Q</i> | Volumetric flow rate of actual evapotranspiration from HRUs | one | L3/T | double | <i>basinactet</i> |
| <i>Ave_SoilDrainage2Unsat_Q</i> | Running average gravity drainage to the unsaturated and saturated zones | one | L3 | double | <i>ave_uzf_infil</i> |
| <i>basin_gw2sm</i> | Basin average water exfiltrated from unsaturated and saturated zones and added to soil zone | one | inches | double | |
| <i>basin_reach_latflow</i> | BasLateral flow into all reaches in basin | one | cfs | double | |
| <i>basingvr2sm</i> | Volumetric flow rate of flow from gravity reservoirs to capillary reservoirs | one | L3/T | double | |
| <i>basinrain</i> | Volumetric flow rate of rain | one | L3/T | double | |
| <i>basinseepout</i> | Volumetric flow rate of groundwater discharge from the saturated zone to the soil zone | one | L3/T | double | |
| <i>basinsm2gvr</i> | Volumetric flow rate of flow from capillary reservoirs to gravity reservoirs | one | L3/T | double | |
| <i>basinsnow</i> | Volumetric flow rate of snow | one | L3/T | double | |
| <i>basinsoilstor</i> | Volume of soil moisture storage | one | L3 | double | |
| <i>BoundaryStreamFlow_Q</i> | Volumetric flowrate of streamflow entering the model domain to SFR | one | L3/T | double | <i>new</i> |
| <i>Canopy_S</i> | Volume of intercepted precipitation in plant-canopy reservoirs | one | L3 | double | <i>basinintcpstor</i> |
| <i>CanopyEvap_Q</i> | Volumetric flow rate of evaporation of intercepted precipitation | one | L3/T | double | <i>basinintcpevap</i> |
| <i>Cap_S</i> | Volume of water in capillary reservoirs of the soil zone | one | L3 | double | <i>basinsoilmoist</i> |
| <i>CapDrainage2Sat_Q</i> | Volumetric flow rate of direct drainage from excess capillary water to the unsaturated zone | one | L3/T | double | <i>basinsoiltogw</i> |
| <i>CapET_Q</i> | Volumetric flow rate of evapotranspiration from pervious areas | one | L3/T | double | <i>basinpervet</i> |
| <i>cell_drain_rate</i> | Recharge rate for each cell | ngwcell | L/T | real | |
| <i>cum_pweqv</i> | Cumulative change in snowpack storage | one | L3 | double | |
| <i>cum_satstor</i> | Cumulative change in saturated storage | one | L3 | double | |
| <i>cum_soilstor</i> | Cumulative change in soil storage | one | L3 | double | |
| <i>cum_uzstor</i> | Cumulative change in unsaturated storage | one | L3 | double | |
| <i>Dprst_S</i> | Volume of water in surface dpressions | one | L3 | double | <i>new</i> |
| <i>DprstEvap_Q</i> | Volumetric flow rate of evaporation from surface depressions | one | L3/T | double | <i>new</i> |
| <i>DunnInterflow2Cap_Q</i> | Volumetric flow rate of cascading Dunnian runoff and interflow | one | L3/T | double | <i>basindnflow</i> |

| | | | | | |
|------------------------------|--|-------------|--------|---------|----------------------------|
| | to HRUs | | | | |
| <i>DunnInterflow2Lake_Q</i> | Volumetric flow rate of Dunnian runoff and interflow to lakes | one | L3/T | double | <i>basinlakeinsz</i> |
| <i>DunnSroff2Stream_Q</i> | Volumetric flow rate of Dunnian runoff to streams | one | L3/T | double | <i>basin_dunnian</i> |
| <i>Grav_S</i> | Volume of water in gravity reservoirs of the soil zone . | one | L3 | double | <i>basingravstor</i> |
| <i>gw_rejected_grav</i> | Recharge rejected by UZF for each gravity-flow reservoir | nhru | inches | real | |
| <i>gw2sm</i> | HRU average water exfiltrated from groundwater model and added back to soil zone | nhru | inches | real | |
| <i>HortSroff2Lake_Q</i> | Volumetric flow rate of Hortonian runoff to lakes | one | L3/T | double | <i>basinhortonianlakes</i> |
| <i>HortSroff2Stream_Q</i> | Volumetric flow rate of Hortonian runoff to streams | one | L3/T | double | <i>basinhortonian</i> |
| <i>Imperv_S</i> | Volume of water in impervious reservoirs | one | L3 | double | <i>basinimpervstor</i> |
| <i>ImpervEvap_Q</i> | Volumetric flow rate of evaporation from impervious areas | one | L3/T | double | <i>basinimpervevap</i> |
| <i>Infil2CapTotal_Q</i> | Volumetric flow rate of soil infiltration into capillary reservoirs (including precipitation, snowmelt, and cascading Hortonian and Dunnian runoff and interflow minus infiltration to preferential-flow reservoirs) | one | L3/T | double | <i>basininfil_tot</i> |
| <i>Infil2Pref_Q</i> | Volumetric flow rate of soil infiltration into preferential-flow reservoirs (including precipitation, snowmelt, and cascading surface runoff) | one | L3/T | double | <i>basininfil2pref</i> |
| <i>Infil2Soil_Q</i> | Volumetric flow rate of soil infiltration (including precipitation, snowmelt, and cascading Hortonian flow) | one | L3/T | double | <i>basininfil</i> |
| <i>Interflow2Stream_Q</i> | Volumetric flow rate of slow plus fast interflow to streams | one | L3/T | double | <i>basininterflow</i> |
| <i>KKITER</i> | Current iteration in GSFLOW simulation | one | none | integer | <i>KKITER</i> |
| <i>Lake_dS</i> | Change in lake storage | one | L3 | double | <i>lake_change_stor</i> |
| <i>Lake_S</i> | Volume of water in lakes | one | L3 | double | <i>lake_stor</i> |
| <i>Lake2Sat_Q</i> | Volumetric flow rate of lake leakage to the saturated zones | one | L3/T | double | <i>lakebed_loss</i> |
| <i>Lake2Unsat_Q</i> | Volumetric flow rate of lake leakage to the unsaturated zones | one | L3/T | double | <i>lakebed_loss</i> |
| <i>LakeEvap_Q</i> | Volumetric flow rate of evaporation from lakes | one | L3/T | double | <i>basinlakeevap</i> |
| <i>LakeExchng2Sat_Q</i> | Volumetric flow rate of exchange between lakes and the saturated zone (value is equal to <i>Lake2Sat_Q</i> minus <i>SatDisch2Lake_Q</i> , where a negative value indicates a net loss from lakes) | one | L3/T | double | <i>new</i> |
| <i>LakePrecip_Q</i> | Volumetric flow rate of precipitation on lakes | one | L3/T | double | <i>basinlakeprecip</i> |
| <i>net_sz2gw</i> | Net volumetric flow rate of gravity drainage from the soil zone to the unsaturated and saturated zones | one | L3/T | double | |
| <i>NetBoundaryFlow2Sat_Q</i> | Volumetric flow rate to the saturated zone along the external boundary (negative value is flow out of model domain) | one | L3/T | double | <i>gw_inout</i> |
| <i>NetWellFlow_Q</i> | Net volumetric flow rate of groundwater injection or removal from wells | one | L3/T | double | <i>basinnetgwwel</i> |
| <i>obs_strmflow</i> | Volumetric flow rate of streamflow measured at a gaging station | one | L3/T | double | |
| <i>PotGravDrn2Unsat</i> | Potential volumetric flow rate of gravity drainage from the soil zone to the unsaturated zone (before conditions of the unsaturated and saturated zones are applied) | one | L3/T | double | <i>basinsz2gw</i> |

| | | | | | |
|-----------------------------|--|-----------------|------|--------|------------------------|
| <i>Precip_Q</i> | Volumetric flow rate of precipitation | one | L3/T | double | <i>basinppt</i> |
| <i>Pref_S</i> | Volume of water stores in preferential-flow reservoirs of the soil zone | one | L3 | double | <i>basinprefstor</i> |
| <i>rate_pweqv</i> | Change in snow pack storage | one | L3 | double | |
| <i>rate_satstor</i> | Change in saturated storage | one | L3 | double | |
| <i>rate_soilstor</i> | Change in soil storage | one | L3 | double | |
| <i>rate_uzstor</i> | Change in unsaturated storage | one | L3 | double | |
| <i>reach_cfs</i> | Stream flow leaving each stream reach | nreach | cfs | real | |
| <i>reach_wse</i> | Water surface elevation in each stream reach | nreach | L | real | |
| <i>RechargeUnsat2Sat_Q</i> | Volumetric flow rate of recharge from the unsaturated zone to the saturated zone | one | L3/T | double | <i>uzf_recharge</i> |
| <i>Sat_dS</i> | Change in saturated-zone storage | one | L3 | double | <i>sat_change_stor</i> |
| <i>sat_recharge</i> | HRU total recharge to the saturated zone | nhru | L3 | real | <i>new</i> |
| <i>Sat_S</i> | Volume of water in the saturated zone | one | L3 | double | <i>sat_stor</i> |
| <i>Sat2Grav_Q</i> | Volumetric flow rate of groundwater discharge from the saturated zone to the soil zone | one | L3/T | double | <i>basingw2sz</i> |
| <i>SatDisch2Lake_Q</i> | Volumetric flow rate of groundwater discharge to lakes | one | L3/T | double | <i>gwwflow2lakes</i> |
| <i>SatDisch2Stream_Q</i> | Volumetric flow rate of groundwater discharge to streams | one | L3/T | double | <i>gwwflow2strms</i> |
| <i>SatET_Q</i> | Volumetric flow rate of evapotranspiration from the saturated zone | one | L3/T | double | <i>sat_et</i> |
| <i>SnowEvap_Q</i> | Volumetric flow rate of snowpack sublimation | one | L3/T | double | <i>basinsnowevap</i> |
| <i>SnowMelt_Q</i> | Volumetric flow rate of snowmelt | one | L3/T | double | <i>basinsnowmelt</i> |
| <i>SnowPweqv_S</i> | Volume of water in snowpack storage | one | L3 | double | <i>basinpweqv</i> |
| <i>SoilDrainage2Unsat_Q</i> | Volumetric flow rate of gravity drainage to the unsaturated and saturated zones | one | L3/T | double | <i>uzf_infil</i> |
| <i>Sroff2Stream_Q</i> | Volumetric flow rate of surface runoff to streams | one | L3/T | double | <i>basinsroff</i> |
| <i>stream_inflow</i> | Specified volumetric stream inflow into model | one | L3/T | double | |
| <i>Stream_S</i> | Volume of water in streams (non-zero only when transient routing option is used in SFR2) | one | L3 | double | <i>strm_stor</i> |
| <i>Stream2Sat_Q</i> | Volumetric flow rate of stream leakage to saturated zones | one | L3/T | double | <i>streambed_loss</i> |
| <i>Stream2Unsat_Q</i> | Volumetric flow rate of stream leakage to unsaturated zones | one | L3/T | double | |
| <i>StreamExchnng2Sat_Q</i> | Volumetric flow rate of exchange between streams and the unsaturated and saturated zones (value is equal to <i>Stream2Sat_Q</i> minus <i>SatDisch2Stream_Q</i> , where a negative value indicates a net loss from streams) | one | L3/T | double | <i>stream_leakage</i> |
| <i>streamflow_sfr</i> | Streamflow as computed by SFR for each segment | nsegment | cfs | real | |
| <i>StreamOut_Q</i> | Volumetric flow rate of streamflow leaving the model domain | one | L3/T | double | <i>basinstrmflow</i> |
| <i>SwaleEvap_Q</i> | Volumetric flow rate of evaporation from swale HRUs | one | L3/T | double | <i>basinswaleet</i> |
| <i>total_pump</i> | Total pumpage from all cells | one | L3 | double | |
| <i>total_pump_cfs</i> | Total pumpage from all cells | one | cfs | double | |
| <i>Unsat_dS</i> | Change in unsaturated-zone storage | one | L3 | double | <i>uzf_del_stor</i> |

| | | | | | |
|------------------------------|---|-------------|------|--------|--------------------------|
| <i>Unsat_S</i> | Volume of water in the unsaturated zone | one | L3 | double | <i>unsat_stor</i> |
| <i>UnsatDrainageExcess_Q</i> | Volumetric flow rate of gravity drainage from the soil zone not accepted due to conditions in the unsaturated and saturated zones | one | L3/T | double | <i>basinszreject</i> |
| <i>UnsatET_Q</i> | Volumetric flow rate of evapotranspiration from the unsaturated zone | one | L3/T | double | <i>uzf_et</i> |
| <i>UnsatStream_dS</i> | Change in unsaturated-zone storage under streams | one | L3 | double | <i>sfruz_change_stor</i> |
| <i>UnsatStream_S</i> | Volume of water in the unsaturated zone under streams | one | L3 | double | <i>sfruz_tot_stor</i> |
| <i>uzf_et</i> | Volumetric flow rate of evapotranspiration from the unsaturated and saturated zones | one | L3/T | double | |
| <i>uzf_infil_map</i> | HRU total gravity drainage to UZF cells | nhru | L3 | double | |

¹Dimension variables defined in table 1-1.

Table 1-6. GSFLOW output variables written to the GSFLOW Comma-Separated-Values File (supercedes Table 12 in Markstrom and others, 2008).

[HRU, hydrologic response unit; ET, evapotranspiration; cfs: cubic feet per second; L3, cubic length units of MODFLOW; L3/T, cubic length units of MODFLOW per MODFLOW timestep; >, greater than; <, less than]

| Variable name | Description | Dimension ¹ | Units | Data type | Original Variable Name |
|------------------------------|---|------------------------|-------|-----------|----------------------------|
| <i>BoundaryStreamFlow_Q</i> | Volumetric flowrate of streamflow entering the model domain to SFR | one | L3/T | double | new |
| <i>Canopy_S</i> | Volume of intercepted precipitation in plant-canopy reservoirs | one | L3 | double | <i>basinintcpstor</i> |
| <i>CanopyEvap_Q</i> | Volumetric flow rate of evaporation of intercepted precipitation | one | L3/T | double | <i>basinintcpevap</i> |
| <i>Cap_S</i> | Volume of water in capillary reservoirs of the soil zone | one | L3 | double | <i>basinsoilmoist</i> |
| <i>CapET_Q</i> | Volumetric flow rate of evapotranspiration from pervious areas | one | L3/T | double | <i>basinpervet</i> |
| <i>Dprst_S</i> | Volume of water in surface dpressions | one | L3 | double | new |
| <i>DprstEvap_Q</i> | Volumetric flow rate of evaporation from surface depressions | one | L3/T | double | new |
| <i>DunnInterflow2Lake_Q</i> | Volumetric flow rate of Dunnian runoff and interflow to lakes | one | L3/T | double | <i>basinlakeinsz</i> |
| <i>DunnSroff2Stream_Q</i> | Volumetric flow rate of Dunnian runoff to streams | one | L3/T | double | <i>basin_dunnian</i> |
| <i>Grav_S</i> | Volume of water in gravity reservoirs of the soil zone . | one | L3 | double | <i>basingravstor</i> |
| <i>HortSroff2Lake_Q</i> | Volumetric flow rate of Hortonian runoff to lakes | one | L3/T | double | <i>basinhortonianlakes</i> |
| <i>HortSroff2Stream_Q</i> | Volumetric flow rate of Hortonian runoff to streams | one | L3/T | double | <i>basinhortonian</i> |
| <i>Imperv_S</i> | Volume of water in impervious reservoirs | one | L3 | double | <i>basinimpervstor</i> |
| <i>ImpervEvap_Q</i> | Volumetric flow rate of evaporation from impervious areas | one | L3/T | double | <i>basinimpervevap</i> |
| <i>Infil2Soil_Q</i> | Volumetric flow rate of soil infiltration (including precipitation, snowmelt, and cascading Hortonian flow) | one | L3/T | double | <i>basininfil</i> |
| <i>Interflow2Stream_Q</i> | Volumetric flow rate of slow plus fast interflow to streams | one | L3/T | double | <i>basininterflow</i> |
| <i>KKITER</i> | Current iteration in GSFLOW simulation | one | none | integer | <i>KKITER</i> |
| <i>Lake_S</i> | Volume of water in lakes | one | L3 | double | <i>lake_stor</i> |
| <i>Lake2Unsat_Q</i> | Volumetric flow rate of lake leakage to the unsaturated zones | one | L3/T | double | new |
| <i>LakeEvap_Q</i> | Volumetric flow rate of evaporation from lakes | one | L3/T | double | <i>basinlakeevap</i> |
| <i>LakeExchg2Sat_Q</i> | Volumetric flow rate of exchange between lakes and the saturated zone (value is equal to <i>Lake2Sat_Q</i> minus <i>SatDisch2Lake_Q</i> , where a negative value indicates a net loss from lakes) | one | L3/T | double | new |
| <i>NetBoundaryFlow2Sat_Q</i> | Volumetric flow rate to the saturated zone along the external boundary (negative value is flow out of model domain) | one | L3/T | double | <i>gw_inout</i> |
| <i>NetWellFlow_Q</i> | Net volumetric flow rate of groundwater injection or removal from wells | one | L3/T | double | <i>basinnetgwwel</i> |
| <i>Precip_Q</i> | Volumetric flow rate of precipitation | one | L3/T | double | <i>basinppt</i> |
| <i>RechargeUnsat2Sat_Q</i> | Volumetric flow rate of recharge from the unsaturated zone to the saturated zone | one | L3/T | double | <i>uzf_recharge</i> |

| | | | | | |
|-----------------------------|--|------------|------|--------|-----------------------|
| <i>Sat_S</i> | Volume of water in the saturated zone | one | L3 | double | <i>sat_stor</i> |
| <i>Sat2Grav_Q</i> | Volumetric flow rate of groundwater discharge from the saturated zone to the soil zone | one | L3/T | double | <i>basingw2sz</i> |
| <i>SatET_Q</i> | Volumetric flow rate of evapotranspiration from the saturated zone | one | L3/T | double | <i>sat_et</i> |
| <i>SnowEvap_Q</i> | Volumetric flow rate of snowpack sublimation | one | L3/T | double | <i>basinsnowevap</i> |
| <i>SnowPweqv_S</i> | Volume of water in snowpack storage | one | L3 | double | <i>basinpweqv</i> |
| <i>SoilDrainage2Unsat_Q</i> | Volumetric flow rate of gravity drainage to the unsaturated and saturated zones | one | L3/T | double | <i>uzf_infil</i> |
| <i>Stream_S</i> | Volume of water in streams (non-zero only when transient routing option is used in SFR2) | one | L3 | double | <i>strm_stor</i> |
| <i>Stream2Unsat_Q</i> | Volumetric flow rate of stream leakage to the unsaturated zones | one | L3/T | double | <i>new</i> |
| <i>StreamExchng2Sat_Q</i> | Volumetric flow rate of exchange between streams and the unsaturated and saturated zones (value is equal to <i>Stream2Sat_Q</i> minus <i>SatDisch2Stream_Q</i> , where a negative value indicates a net loss from streams) | one | L3/T | double | <i>stream_leakage</i> |
| <i>StreamOut_Q</i> | Volumetric flow rate of streamflow leaving the model domain | one | L3/T | double | <i>basinstrmflow</i> |
| <i>SwaleEvap_Q</i> | Volumetric flow rate of evaporation from swale HRUs | one | L3/T | double | <i>basinswaleet</i> |
| <i>Unsat_S</i> | Volume of water in the unsaturated zone | one | L3 | double | <i>unsat_stor</i> |
| <i>UnsatET_Q</i> | Volumetric flow rate of evapotranspiration from the unsaturated zone | one | L3/T | double | <i>uzf_et</i> |
| <i>UnsatStream_S</i> | Volume of water in the unsaturated zone under streams | one | L3 | double | <i>sfruz_tot_stor</i> |

¹Dimension variables defined in table 1-1