# Agricultural Water Use Options for MODFLOW-NWT Packages

Agricultural Water use Options (AgOptions) have been added to several MODFLOW-NWT Packages, including the Streamflow-Routing (SFR2), Well (WEL), and Unsaturated Flow (UZF1) Packages. These options include the ability to 1) apply water in a SFR2 diversion segment to a specified number of UZF1 cells to represent irrigation; 2) supplement a SFR2 diversion shortfall caused by limited surface water supply by pumping from specified groundwater wells; and, 3) apply pumped water to a specified number of UZF1 cells to represent supplemental irrigation by groundwater.

AgOptions can be used to simulate agricultural water use using three different configurations: 1) surface water and supplemental groundwater used for irrigation can be removed from the model, assuming all water is consumed by plants; 2) surface water and groundwater can be applied to UZF1 cells to simulate groundwater return flows using user-specified irrigation efficiency factors, and surface water return flow using the UZF1 IRUNBND option to route water to receiving SFR2 reaches or LAK surface reservoirs; and, 3) surface water and groundwater are applied to UZF1 cells while the unsaturated and saturated zone ET option is active in order to simulate plant water consumption and return flows.

AgOptions are activated by inputting character variables in the options block of the SFR2, WELL, and **UZF1 Packages**. These AgOptions key words include specification of additional external input files used for inputting required input data for simulating these options. A separate input file is required for each separate package, and the name and unit number of these separate AgOptions input files must be included within the MODFLOW-NWT Name file. AgOptions can be added to one or more of the SFR2, WELL, and UZF1 Packages for a simulation.

FOR EACH SIMULATION

# Streamflow Routing AgOption

An AgOptions character variable can be specified in the SFR2 Package within the Options block in item 1a.

OPTIONS

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[IRRIGATE Numirrsegmax Unitirs Maxells]

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END

IRRIGATE An optional character variable. When IRRIGATE is specified, the option to add water flowing in SFR2 diversion segments to UZF1 cells is activated.

Numirrsegmax An optional integer variable. When IRRIGATE is specified, the integer variable Numirrsegmax also is specified. Numirrsegmax is the maximum number of diversion segments that will apply water to UZF1 cells during a simulation.

Unitirs An optional integer variable. When IRRIGATE is specified, the integer variable Unitirs also is specified. Unitirs is the file unit number for the SFR2 Irrigation (IRS) input file.

Maxells An optional integer variable. When IRRIGATE is specified, the integer variable Maxells also is specified. Maxells is the maximum amount of UZF1 cells associated with any single SFR2 diversion segment.

If optional character variable “IRRIGATE” is specified then the following additional input is read from an external file of Type data specified in the MODFLOW Name file. The integer variable Unitirr must match the corresponding file unit number specified in the Name file.

**Input for the SFR2 Irrigation (IRS) Input File**

FOR EACH STRESS PERIOD

Item 1a

NUMIRRSEG

NUMIRRSEG An integer variable equal to the number of SFR2 segments that will be designated as irrigation diversion segments for this stress period.

Note: A segment that is designated as an irrigation diversion will remain an irrigation diversion for the remainder of the simulation. Applied irrigation from a diversion segment can be set to zero by setting the SFR2 input file variable FLOW to zero, or by setting FIELD\_FACT to zero.

Item 1b

SEGNUM NUMCELLS EFF\_FACT1 FIELD\_FACT1  IRRROW1 IRRCOL1…. EFF\_FACTnumcells FIELD\_FACTnumcells IRRROWnumcells IRRCOLnumcells

Note: Item 1b is repeated NUMIRRSEG times.

Note: Variables EFF\_FACT, FIELD\_FACT, IRRROW, IRRCOLare repeated NUMCELLS times for each record in item 1b.

SEGNUM An integer variable equal to the SFR2 segment number for the diversion used to divert surface water for irrigation.

NUMCELLS An integer variable equal to the total number of UZF2 cells that water diverted from SEGNUM will be applied for irrigation.

EFF\_FACT A real variable equal to the fraction of the water applied to a cell, defined by IRROW and IRRCOL that is removed from the model before being applied to cell due to crop evapotranspiration and other field evaporation losses. If evapotranspiration is being simulated explicitly by UZF1 then set EFF\_FACT to zero.

FIELD\_FACT A real variable equal to the fraction of the diverted water applied to a cell, for example, FIELD\_FACT1 is the fraction of the diversion amount multiplied by EFF\_FACT that is applied to cell IRROW1 and IRRCOL1. The sum of all FIELD\_FACT values specified in each item should sum to one.

IRRROW An integer variable equal to the UZF1 cell row number to which diverted water will be applied as irrigation.

IRRCOL An integer variable equal to the UZF1 cell column number to which diverted water will be applied as irrigation.

Note: Variables EFF\_FACT, FIELD\_FACT, IRRROW, and IRRCOL are repeated NUMCELLS times for each record.

# WELL AgOption

FOR EACH SIMULATION

Two AgOptions character variables can be specified in the WELL Package within the Options block in item 1a.

OPTIONS

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[IRRIGATE Numirrwells Unitirr Maxcells]

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[SUPPLEMENTAL Numsupwells Unitsupwells Maxsegs]

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END

IRRIGATE An optional character variable. When IRRIGATE is specified, the option to add groundwater pumped by a well to UZF1 cells is activated.

Numirrwells An optional integer variable. When IRRIGATE is specified, the integer variable Numirrwells also is specified. Numirrwells is the maximum number of wells in any stress period that will apply water to UZF1 cells.

Unitirr An optional integer variable. When IRRIGATE is specified, the integer variable Unitirr also is specified. Unitirr is the file unit number for the Well irrigation (IRR) input file.

Maxells An optional integer variable. When IRRIGATE is specified, the integer variable Maxells also is specified. Maxells is the maximum number of UZF1 cells associated with any single supplemental well.

SUPPLEMENTAL An optional character variable. When SUPPLEMENTAL is specified, the option to automatically pump water to supplement the difference between a specified SFR2 diversion and the actual diversion when there is a surface water shortfall.

Numsupwellsmax An optional integer variable. When SUPPLEMENTAL is specified, the integer variable Numsupwellsmax also is specified. Numsupwellsmax is the maximum number of supplemental wells during a simulation.

Unitsup An optional integer variable. When SUPPLEMENTAL is specified, the integer variable Unitsup also is specified. Unitsup is the file unit number for the Supplemental Pumping (SUP) input file.

Maxsegs An optional integer variable. When SUPPLEMENTAL is specified, the integer variable Maxsegs also is specified. Maxsegs is the maximum number of SFR2 segments that are supplemented by a SUP well.

**Input for the WELL Irrigation (IRR) Input File**

FOR EACH STRESS PERIOD

Item 1a

NUMIRRWELL

NUMIRRWELL An integer variable equal to the number of wells that will be designated as irrigation wells during the stress period.

Note: If a well is designated as an irrigation well during a stress period then this well will remain an irrigation well for the remainder of the simulation. An irrigation well can be made inactive by specifying the pumping rate to zero or by setting the SUP input variable SUB\_FACT to zero for a supplemental well (see below).

Item 1b

WELLNUM NUMCELLS EFF\_FACT1 FIELD\_FACT1  IRRROW1 IRRCOL1…. EFF\_FACTnumcells FIELD\_FACTnumcells IRRROWnumcells IRRCOLnumcells

Note: item 1b is repeated Numirrwells times.

Note: for each record variables EFF\_FACT, FIELD\_FACT, IRRROW, IRRCOLare repeated NUMCELLS times.

WELLNUM An integer variable equal to the SFR2 segment number for the diversion used to divert surface water for irrigation.

NUMCELLS An integer variable equal to the total number of UZF1 cells that water pumped by WELLNUM will be applied for irrigation.

EFF\_FACT A real variable equal to the fraction of the water applied to a cell, defined by IRROW and IRRCOL that is removed from the model before being applied to cell due to crop evapotranspiration and other field evaporation losses. If evapotranspiration is being simulated explicitly by UZF1 then set EFF\_FACT to zero.

FIELD\_FACT A real variable equal to the fraction of the diverted water applied to a cell, for example, FIELD\_FACT1 is the fraction of the diversion amount multiplied by EFF\_FACT1 that is applied to cell IRROW1 and IRRCOL1. The sum of all FIELD\_FACT values specified in each item should sum to one.

IRRROW An integer variable equal to the UZF1 cell row number to which pumped water will be applied as irrigation.

IRRCOL An integer variable equal to the UZF1 cell column number to which pumped water will be applied as irrigation.

Note: Variables EFF\_FACT, FIELD\_FACT, IRRROW, and IRRCOL are repeated NUMCELLS times for each record.

**Input for the Supplementary WELL (SUP) Input File**

FOR EACH STRESS PERIOD

NUMSUPWELL An integer variable equal to the number of wells that will be designated as supplemental wells during the stress period.

Note: If a well is designated as a supplemental well during a stress period then this well will remain a supplemental well for the remainder of the simulation. A supplemental well can be made inactive by setting the SUP input variable SUP\_FACT to zero for a supplemental well (see below).

Item 1 is repeated Numsupwells times, resulting in Numsupwells records for each stress period. If WELLNUM is specified as -1 after the first stress period then values from previous stress period will be used.

WELLNUM NUMSEGS SUP\_FACT1 SEG1… SUP\_FACTNUMSEGS SEGNUMSEGS

Note: for each record variables SUP\_FACT, and SEGare repeated NUMSEGS times.

WELLNUM An integer variable equal to the well number, as defined by its order in the Well Package input file.

NUMSEGS An integer variable equal to the total number of SFR2 diversion segments supplemented by well number WELLNUM.

SUP\_FACT A real variable equal to the fraction of the surface water diversion shortfall that will be supplemented by well number WELLNUM. The diversion shortfall is calculated by SFR2 as the difference between the specified and actual diversion amounts.

SEG An integer variable equal to the SFR2 diversion segment number.

Note: Variables SUP\_FACT and SEG are repeated NUMSEGS times for each record.