

## **SIMULATING CURTAILMENT WITH ESPAM2.0 TOOLS AND SUPERPOSITION VERSION OF ESPAM2.0**

### Software

ArcGIS10.0 (Service Pack 3)/Spatial Analyst Extension/Python 2.6/Numpy1.3.0

ESPAM2 Recharge Tools V1.5 (IDWR)

- Download and installation instructions:  
<http://www.idwr.idaho.gov/WaterInformation/Projects/espam/ESPAM-Web-Documentation/install.html>

MKMOD8.1 (ESHMC)

- Download code and executable file:  
[http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/model\\_tools/MKMOD/mkmod81.zip](http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/model_tools/MKMOD/mkmod81.zip)
- Download command line switches:  
[http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/model\\_tools/MKMOD/NOTES\\_MOD8.txt](http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/model_tools/MKMOD/NOTES_MOD8.txt)
- Download description of \*.mdl file format:  
[http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/model\\_files/Version\\_2.0\\_Development/Current\\_Documentation/Memo\\_MKMOD7\\_mdl.pdf](http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/model_files/Version_2.0_Development/Current_Documentation/Memo_MKMOD7_mdl.pdf)

MODFLOW (USGS)

- MODFLOW-2000 Version 1.18.01 used to calibrate ESPAM2.0 – no longer available on USGS website; posted on ESPAM2 website:  
[http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/MKMOD\\_MODFLOWTraining\\_ModflowTraining.zip/Aug9Modflow/software/mf2k18.exe](http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/MKMOD_MODFLOWTraining_ModflowTraining.zip/Aug9Modflow/software/mf2k18.exe); OR
- MODFLOW-2000 Version 1.19.01 download and installation instructions from USGS:  
<http://water.usgs.gov/nrp/gwsoftware/modflow2000/modflow2000.html>; OR
- MODFLOW-2005 gives very similar results

BUD2SMP (Watermark Numerical Computing)

- <http://www.pesthomepage.org/Downloads.php#hdr3>

### Input files

- Download settingsNULL.ini for ESPAM2 Recharge Tools from [http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/June15\\_2012\\_Training/RechargeToolInput/](http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/June15_2012_Training/RechargeToolInput/)
  - Copy file to %appdata%\ESPAM and rename to settings.ini
  - Create a Workspace directory at path listed in settings.ini file
- Download recharge input files for ESPAM2 Recharge Tools: [http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/June15\\_2012\\_Training/RechargeToolInput/](http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/June15_2012_Training/RechargeToolInput/)
  - Extract files in NULL.zip to D:\ESPAM2\RechargeTools\ (or edit settings.ini to match other path)
- Download input files for MKMOD: [http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/June15\\_2012\\_Training/MKMODInput/](http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/June15_2012_Training/MKMODInput/)
- Download ESPAM2.0 superposition model files (includes post-processing files): [http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/June15\\_2012\\_Training/MODFLOW/](http://www.idwr.idaho.gov/Browse/WaterInfo/ESPAM/meetings/June15_2012_Training/MODFLOW/)

### Curtailment Simulation Example 1.

This example simulates steady state curtailment of groundwater irrigation junior to January 1, 1949 within the ESPAM2.0 boundary using the superposition version of ESPAM2.0.

**Step 1.** Edit `%appdata%\ESPAM\settings.ini` file for ESPAM2 Recharge Tools for the following files used by the Curtailment IAR Tool.

```
[[wetlandmask]]
    type=raster
    path=D:\ESPAM2\RechargeTools\NULL\IAR\wet_urb_rsmp

[[groundwaterentity]]
    type=raster
    path=D:\ESPAM2\RechargeTools\NULL\IAR\gw_poly_snap
    entity=S_VALUE

[[surfacewaterentity]]
    type=raster
    path=D:\ESPAM2\RechargeTools\NULL\IAR\sw_poly_snap
    entity=S_VALUE

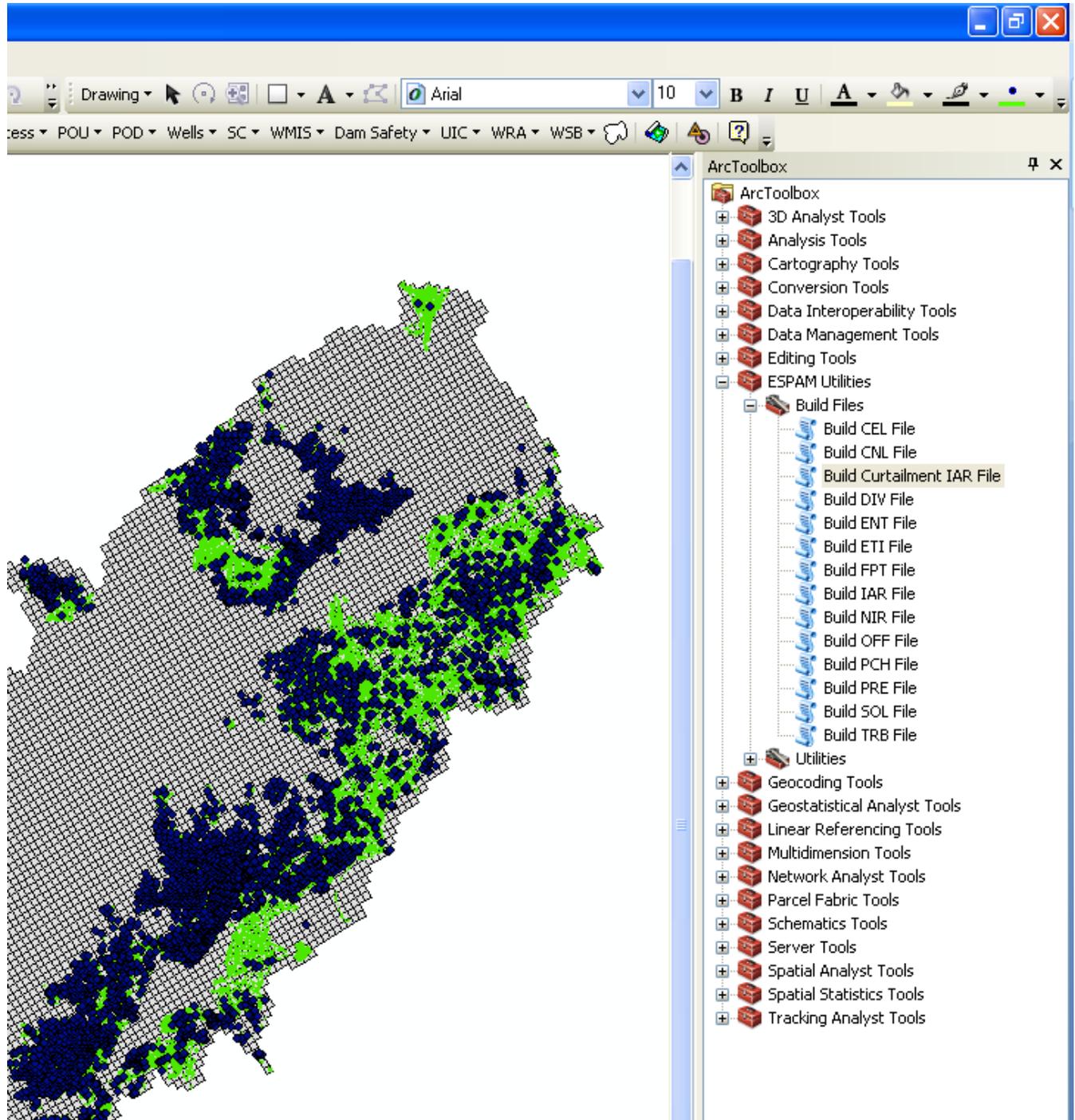
[[groundwaterfraction]]
    type=raster
    path=D:\ESPAM2\RechargeTools\NULL\IAR\avggwfrac

[[irrigation]]
    [[[2008]]]
        type=raster
        stressperiod=1
        path=D:\ESPAM2\RechargeTools\NULL\IAR\2008IrrigatedLandsRaster\irr2008plcrep

[[pointofdiversion]]
    type=table
    path = D:\ESPAM2\RechargeTools\NULL\IAR\POD_2012\POD_2012_ESPAM2_IDTM83.shp
    row = ROW_ID
    col = COL_ID
    rate = Irrcfs
    pnum = PNUM_E
```

**Step 2.** Calculate priority fractions and create IAR file with Curtailment IAR Tool

From ArcToolbox select **Build Curtailment IAR File**. If ESPAM Utilities do not appear in ArcToolbox, right click in the toolbox window to Add Toolbox.



Select default profile. Confirm POD Feature Class and field settings are correct, or edit if desired. Irrigated lands files can only be edited in the settings.ini file.

Enter the following values:

Number of Stress Periods: Enter 1 for steady state

Priority Date: Enter 1/1/1949 (month/day/year)

EST Flag: Enter A to use adjacent cells to calculate priority fraction for cells without PODs

Groundwater Multiplier: Enter -1 to model decrease in groundwater irrigation

Surface Water Multiplier: Enter zero to model no change in surface water irrigation

Select raster output directory. Output rasters will include (a) one raster showing the **junior priority fraction** by model cell, and (b) one raster for each irrigated lands input file showing irrigated lands with **junior source fraction**.

Example: D:\ESPAM2\SteadyState1949\CurtailmentIAR\IAR\_Rasters

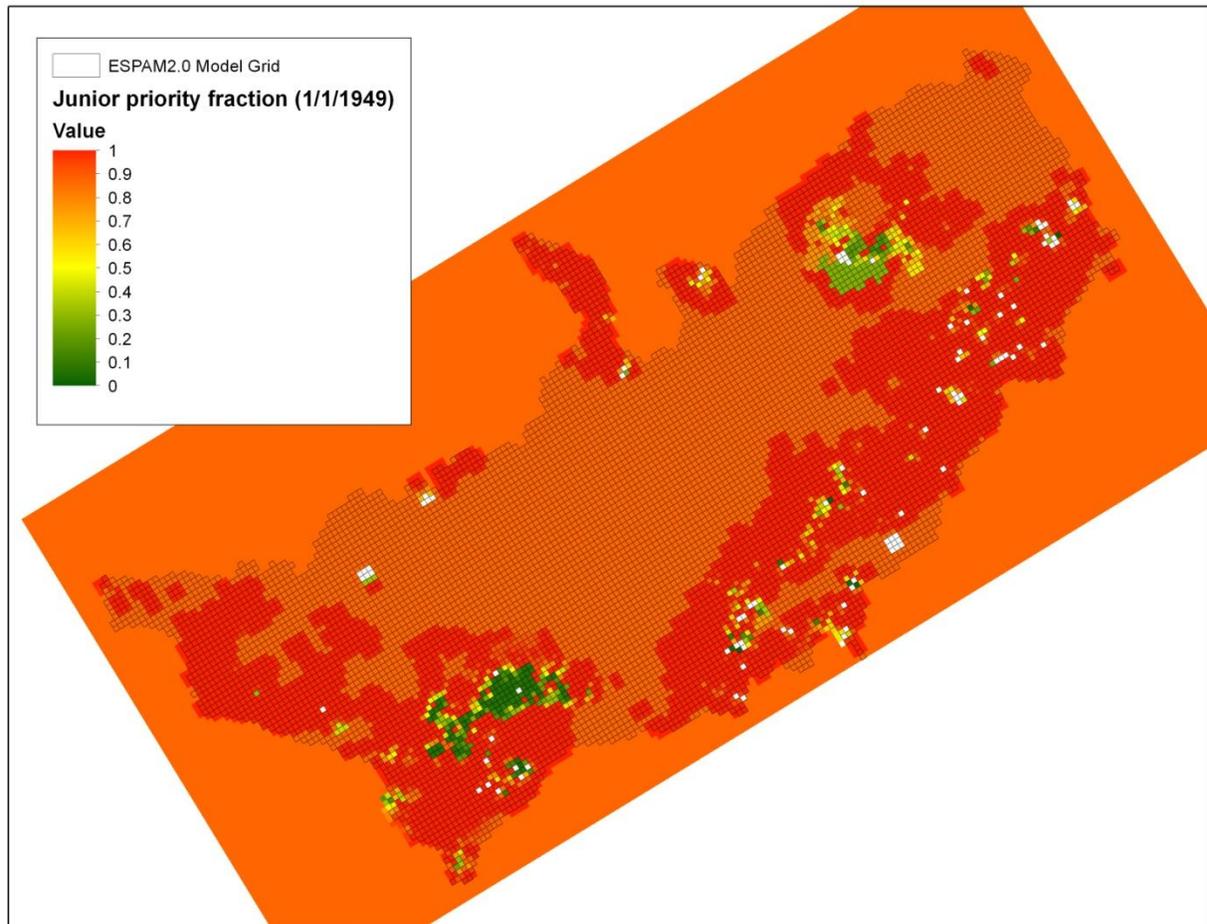
Selection location and name for the output file (include IAR extension).

Inspect IAR file. Input files and user-specified priority date are listed in comments at the top of the file. Areas applied to groundwater entities should be negative. Areas applied to surface water entities should be zero.

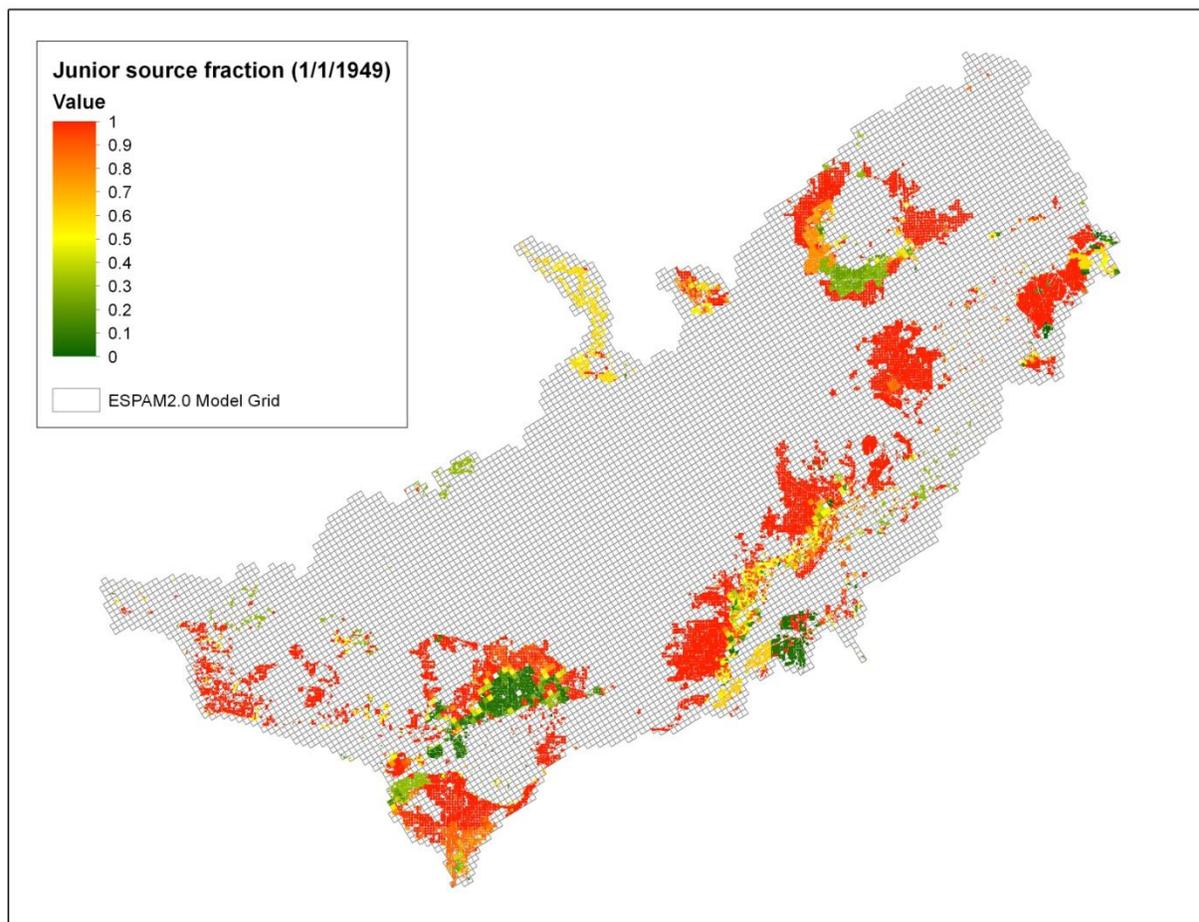
```
#ESPAM2_ModelGrid_06092011.shp
#sw_poly_snap
#gw_poly_snap
#wet_urb_rsmp
#avggwfrac
#irr2008plcrep
#POD_2012_ESPAM2_IDTM83.shp
#1949-01-01
STRESS PERIOD 1
1
5337
81 128 2
IEGW506 IESW034
-15996000 0
81 129 2
IEGW506 IESW034
-5557730 0
50 42 2
IEGW507 IESW059
-678126 0
50 43 2
IEGW507 IESW059
-4249920 0
50 40 3
IEGW507 IESW059 IESW058
-12873700 0 0
50 41 3
IEGW507 IESW059 IESW058
-431095 0 0
...
```

Inspect junior priority fraction and source fraction rasters in ArcMap. If more than one irrigated lands raster was input into the Curtailment IAR Tool, there will be one source fraction file for each irrigated lands file.

Junior Priority Fration: Fraction of groundwater irrigation junior to 1/1/1949 by model cell (jfr\_111949).



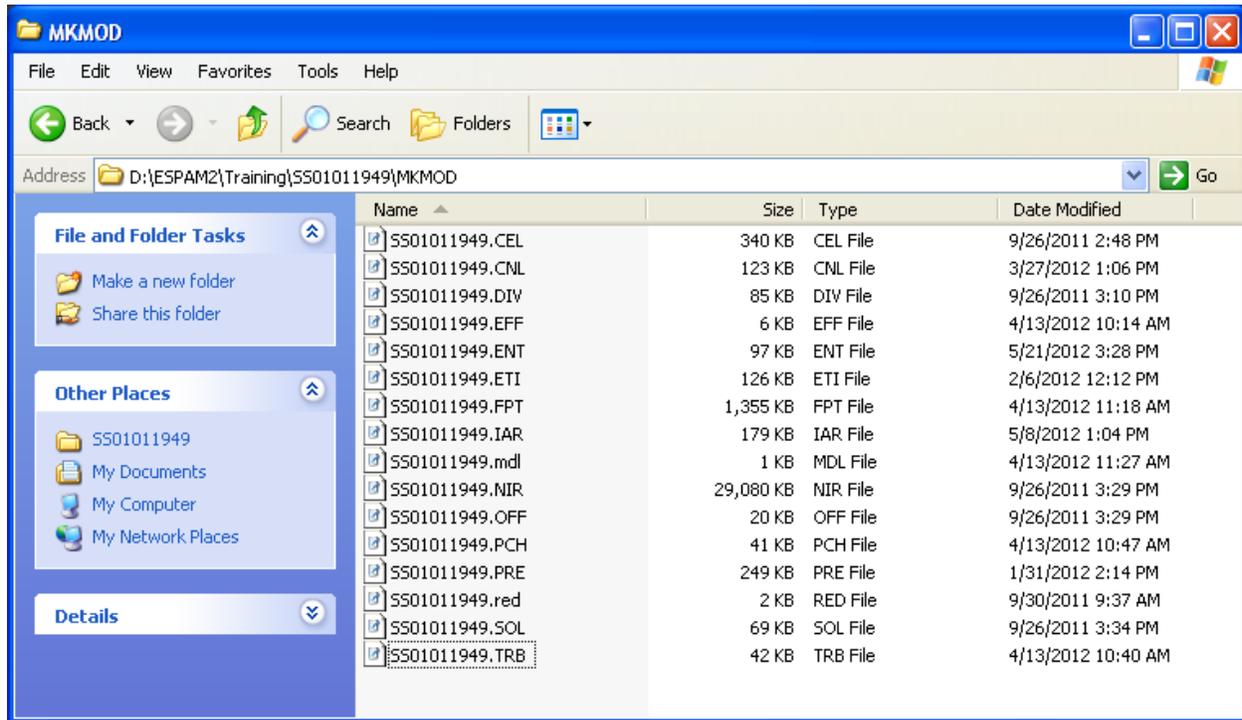
Junior Source Fraction: Fraction of land area irrigated with a groundwater source junior to 1/1/1949 based on 2008 irrigated lands data set (jsrcfr\_1).



### **Step 3.** Prepare input for MKMOD

Copy NULL\_BASE files to a working directory. For this steady state example copy all NULL.\* files except NULL.IAR. Rename files to scenario name SS01011949.\*

Copy SS01011949.IAR, created in Step 2, to working directory.

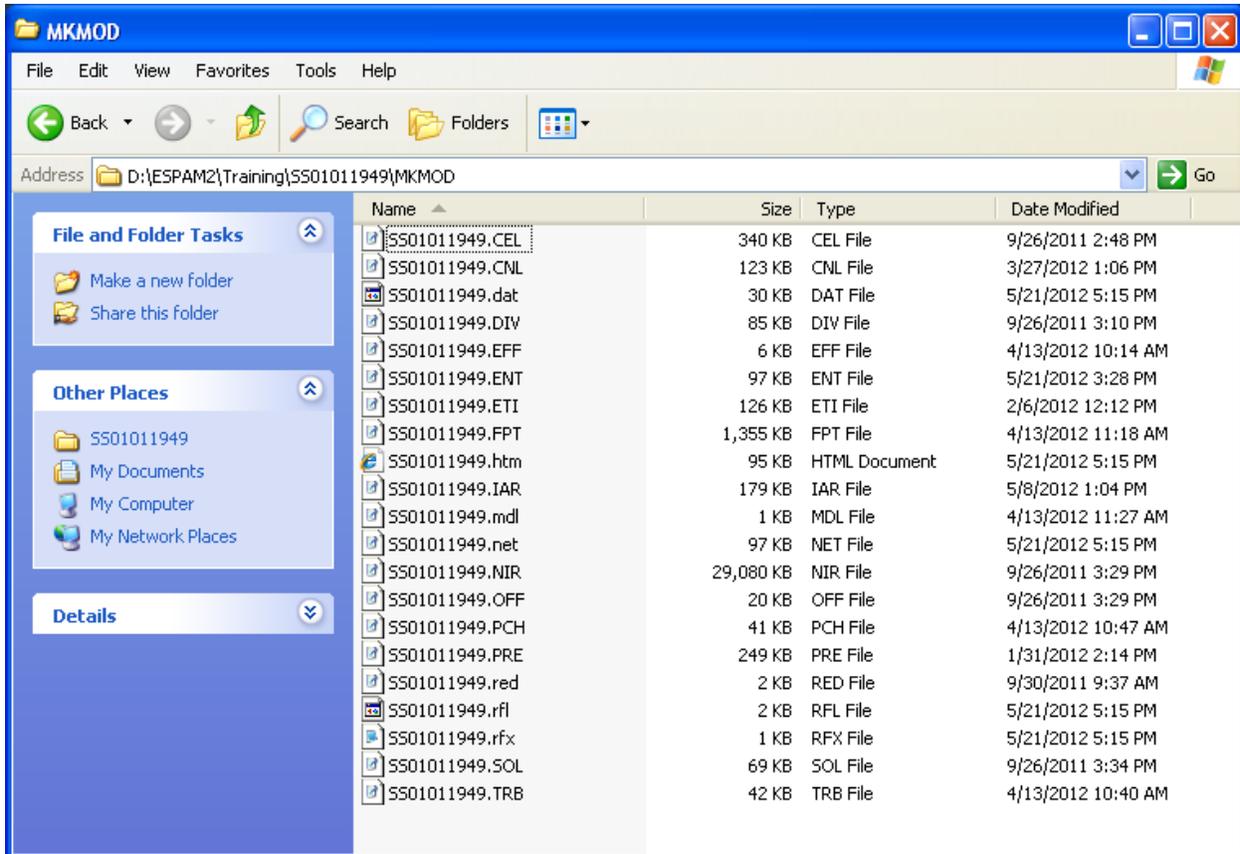


All 16 files are required to run MKMOD.

**Step 4.** Create well file using MKMOD.

Open Command Prompt and navigate to the working directory from Step 3.

D:\ESPAM2\Training\SS01011949\MKMOD>**MKMOD81 -ss SS01011949**



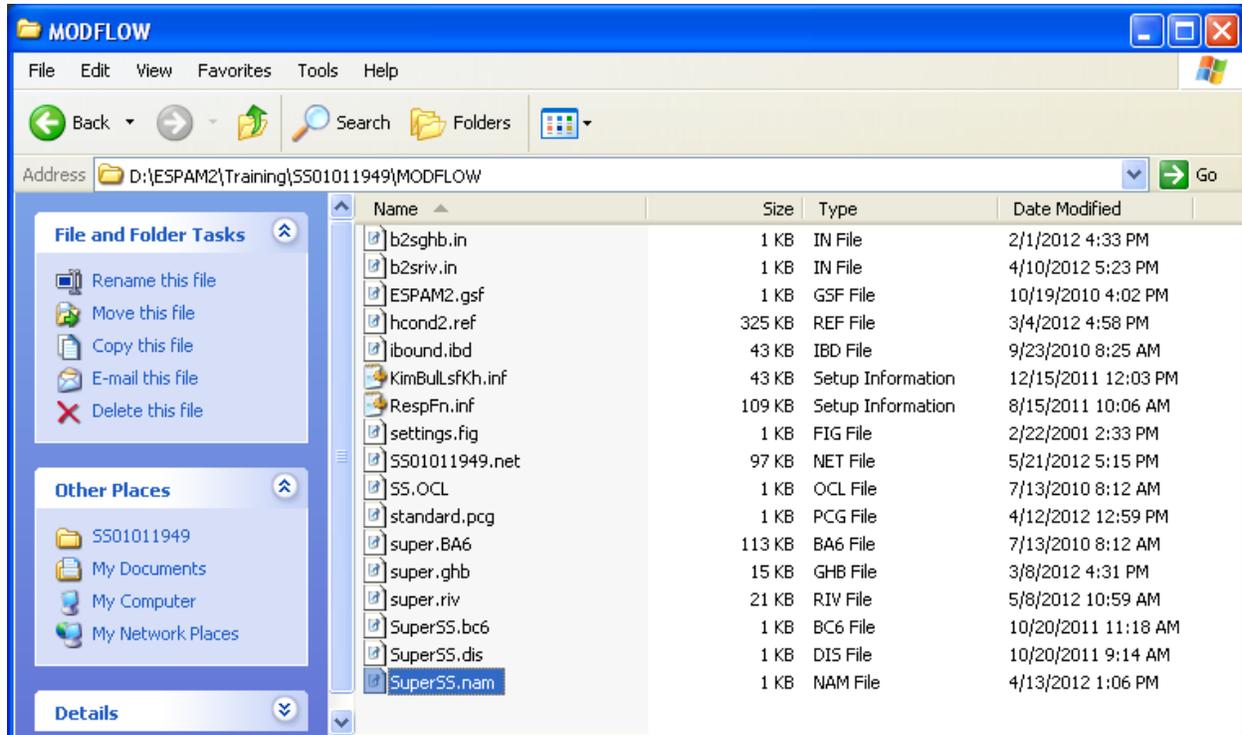
Inspect groundwater acreage and net recharge in **SS01011949.htm** output file, values should be negative. Confirm non-irrigated recharge volume, surface water acreage, and other recharge components are zero.

Inspect well file **SS01011949.net**, values should be positive.

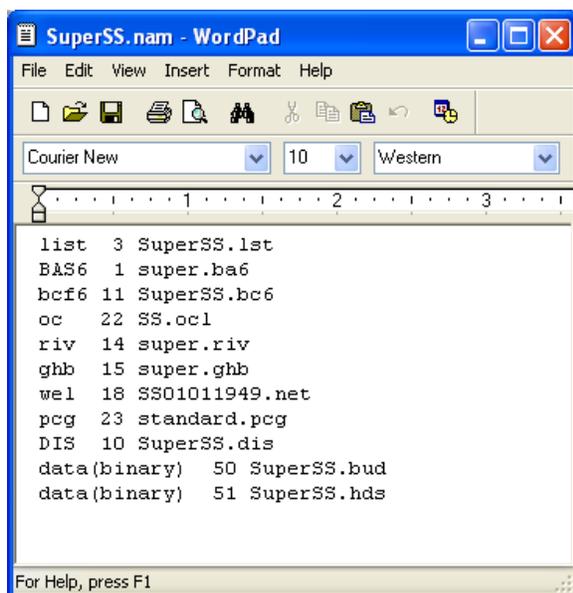
## Step 5. Prepare input for MODFLOW

Copy ESPAM2.0 superposition steady state files to a working directory.

Copy **SS01011949.net** to the working directory.



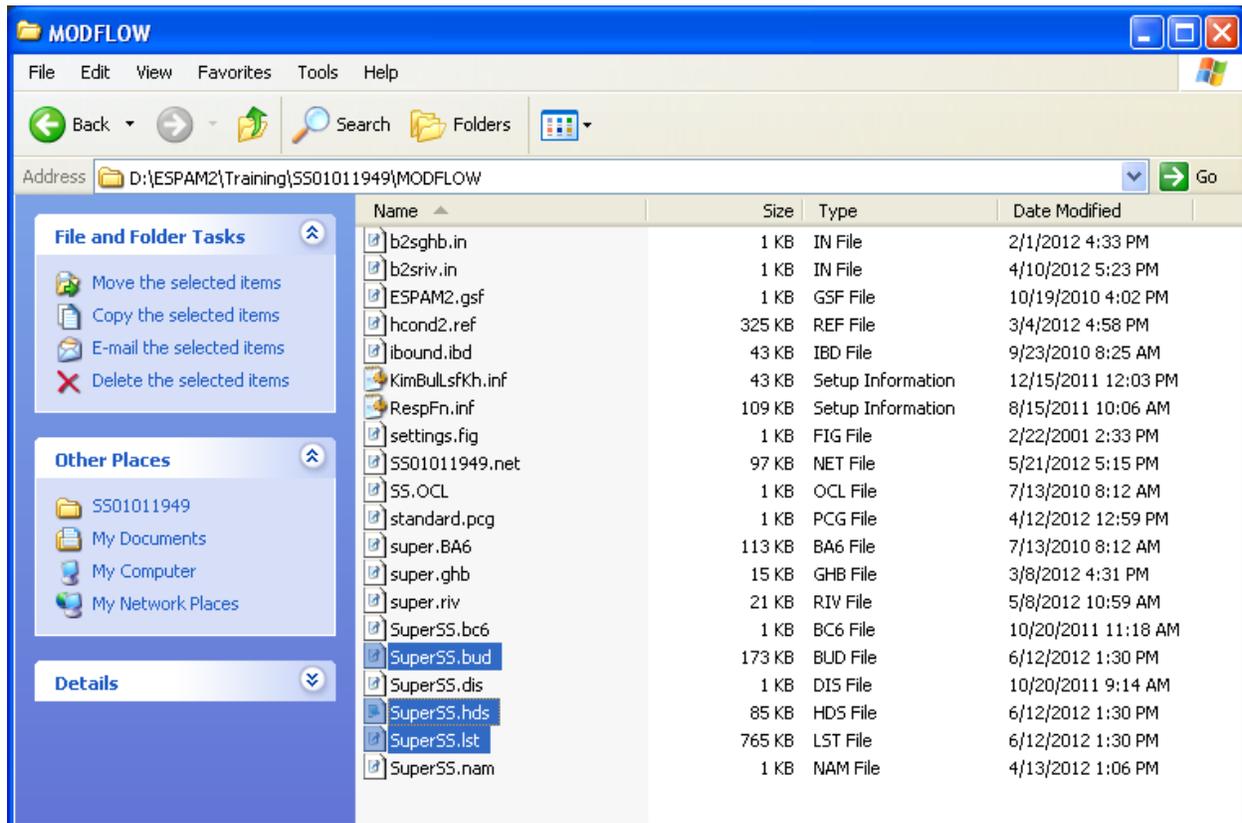
Edit well file name in **SuperSS.nam** to **SS01011949.net**



**Step 6.** Run MODFLOW simulation.

Open Command Prompt and navigate to the working directory from Step 5.

D:\ESPAM2\Training\SS01011949\MKMOD>mf2k SuperSS



Inspect **SuperSS.lst** file for total depletions and water budget

**Step 7.** Post-processing MODFLOW output

Open Command Prompt and navigate to the working directory from Steps 5 and 6.

Run BUD2SMP utility to extract flow rates from **SuperSS.bud**

Files are provided to extract data in five formats:

- D:\ESPAM2\Training\SS01011949\MKMOD>**bud2smp<b2sriv.in** extracts data for the five Snake River reaches upstream of Minidoka and spring flow data for Group A, B, and C spring targets downstream of Kimberly. General head boundary flow is not included. Data are written to **River.smp**
- D:\ESPAM2\Training\SS01011949\MKMOD>**bud2smp<b2sghb.in** extracts general head boundary (baseflow) data for the five the three Snake River reaches downstream of Kimberly. Data are written to **mod\_GHB.smp**
- D:\ESPAM2\Training\SS01011949\MKMOD>**bud2smp<b2s\_RivGai.in** extracts data for the five Snake River reaches upstream of Minidoka. Data are written to **modRivGai.smp**
- D:\ESPAM2\Training\SS01011949\MKMOD>**bud2smp<b2s\_SpgRch.in** extracts spring flow data for the three Snake River reaches downstream of Kimberly. General head boundary flow is not included. Data are written to **mod\_SpgRch.smp**
- D:\ESPAM2\Training\SS01011949\MKMOD>**bud2smp<b2s\_GrpABSpgs.in** extracts spring flow data for the 14 Group A and B spring targets. General head boundary flow is not included. Data are written to **ABSprings.smp**

Negative values indicate discharge from the aquifer to the river or springs. Positive values indicate discharge from the river to the aquifer.

### Curtailment Simulation Example 2.

This example simulates the transient, monthly response to curtailment of groundwater irrigation junior to January 1, 1949 within the ESPAM2.0 boundary using the superposition version of ESPAM2.0. This simulation is for a period of 10 years.

**Step 1.** Edit **%appdata%\ESPAM\settings.ini** file for ESPAM2 Recharge Tools for the following files used by the Curtailment IAR Tool.

```
[[wetlandmask]]
    type=raster
    path=D:\ESPAM2\RechargeTools\NULL\IAR\wet_urb_rsmp

[[groundwaterentity]]
    type=raster
    path=D:\ESPAM2\RechargeTools\NULL\IAR\gw_poly_snap
    entity=S_VALUE

[[surfacewaterentity]]
    type=raster
    path=D:\ESPAM2\RechargeTools\NULL\IAR\sw_poly_snap
    entity=S_VALUE

[[groundwaterfraction]]
    type=raster
    path=D:\ESPAM2\RechargeTools\NULL\IAR\avggwfrac

[[irrigation]]
    [[[2008]]]
        type=raster
        stressperiod=1
        path=D:\ESPAM2\RechargeTools\NULL\IAR\2008IrrigatedLandsRaster\irr2008plcrep

[[pointofdiversion]]
    type=table
    path = D:\ESPAM2\RechargeTools\NULL\IAR\POD_2012\POD_2012_ESPAM2_IDTM83.shp
    row = ROW_ID
    col = COL_ID
    rate = Irrcfs
    pnum = PNUM_E
```

**Step 2.** Calculate priority fractions and create IAR file with Curtailment IAR Tool

From ArcToolbox select **Build Curtailment IAR File**. If ESPAM Utilities do not appear in ArcToolbox, right click in the toolbox window to Add Toolbox.

Select default profile. Confirm POD Feature Class and field settings are correct, or edit if desired. Irrigated lands files can only be edited in the settings.ini file.

Enter the following values:

Number of Stress Periods: Enter 120 for 10-year simulation with monthly stress periods

Priority Date: Enter 1/1/1949 (month/day/year)

EST Flag: Enter A to use adjacent cells to calculate priority fraction for cells without PODs

Groundwater Multiplier: Enter -1 to model decrease in groundwater irrigation

Surface Water Multiplier: Enter zero to model no change in surface water irrigation

Select raster output directory. Output rasters will include (a) one raster showing the **junior priority fraction** by model cell, and (b) one raster for each irrigated lands input file showing irrigated lands with **junior source fraction**.

Example: D:\ESPAM2\TransientSeasonal1949\CurtailmentIAR\IAR\_Rasters

Selection location and name for the output file (include IAR extension).

Example: D\ESPAM2\TransientSeasonal1949\CurtailmentIAR\TS01011949.IAR

Inspect IAR file. Input files and user-specified priority date are listed in comments at the top of the file. Areas applied to groundwater entities should be negative. Areas applied to surface water entities should be zero. The file should include 120 stress periods.

```
#ESPAM2_ModelGrid_06092011.shp
#sw_poly_snap
#gw_poly_snap
#wet_urb_rsmp
#avggwfrac
#irr2008plcrep
#POD_2012_ESPAM2_IDTM83.shp
#1949-01-01
STRESS PERIOD 1
1
5337
81 128 2
IEGW506 IESW034
-15996000 0
81 129 2
IEGW506 IESW034
-5557730 0
50 42 2
IEGW507 IESW059
-678126 0
50 43 2
IEGW507 IESW059
-4249920 0
50 40 3
IEGW507 IESW059 IESW058
-12873700 0 0
50 41 3
IEGW507 IESW059 IESW058
-431095 0 0
...
STRESS PERIOD 118
-1
STRESS PERIOD 119
-1
STRESS PERIOD 120
-1
```

Inspect junior priority fraction and source fraction rasters in ArcMap. If more than one irrigated lands raster was input into the Curtailment IAR Tool, there will be one source fraction file for each irrigated lands file.

**Step 3.** Prepare input for MKMOD

Copy NULL\_BASE files to a working directory. For this transient seasonal example copy all NULL.\* files except NULL.ETI, NULL.IAR, NULL.mdl, and NULL.PRE. Rename files to scenario name TS01011949.\*

Copy MONTHLY\_NULL.ETI, MONTHLY\_NULL.mdl, and MONTHLY\_NULL.PRE to working directory. Rename files to scenario name TS01011949.\*

Copy TS01011949.IAR, created in Step 2, to working directory.

**Step 4.** Create well file using MKMOD.

Open Command Prompt and navigate to the working directory from Step 3.

D:\ESPAM2\Training\SS01011949\MKMOD>MKMOD81 -ss TS01011949

Inspect groundwater acreage and net recharge in **TS01011949.htm** output file, values should be negative. Confirm non-irrigated recharge volume, surface water acreage, and other recharge components are zero.

Inspect well file **TS01011949.net**, values should be positive.

**Step 5.** Prepare input for MODFLOW

Copy ESPAM2.0 superposition monthly transient files to a working directory.

Copy **TS01011949.net** to the working directory.

Edit well file name in **SuperTR.nam** to **TS01011949.net**

**Step 6.** Run MODFLOW simulation.

Open Command Prompt and navigate to the working directory from Step 5.

D:\ESPAM2\Training\SS01011949\MKMOD>mf2k SuperTR

Inspect **SuperTR.lst** file for total depletions and water budget

**Step 7.** Post-processing MODFLOW output

Open Command Prompt and navigate to the working directory from Steps 5 and 6.

Run BUD2SMP utility to extract flow rates from **SuperTR.bud**

Files are provided to extract data in five formats:

- D:\ESPAM2\Training\SS01011949\MKMOD>**bud2smp<b2sriv.in** extracts data for the five Snake River reaches upstream of Minidoka and spring flow data for Group A, B, and C spring targets downstream of Kimberly. General head boundary flow is not included. Data are written to **River.smp**
- D:\ESPAM2\Training\SS01011949\MKMOD>**bud2smp<b2sghb.in** extracts general head boundary (baseflow) data for the five the three Snake River reaches downstream of Kimberly. Data are written to **mod\_GHB.smp**
- D:\ESPAM2\Training\SS01011949\MKMOD>**bud2smp<b2s\_RivGai.in** extracts data for the five Snake River reaches upstream of Minidoka. Data are written to **modRivGai.smp**
- D:\ESPAM2\Training\SS01011949\MKMOD>**bud2smp<b2s\_SpgRch.in** extracts spring flow data for the three Snake River reaches downstream of Kimberly. General head boundary flow is not included. Data are written to **mod\_SpgRch.smp**
- D:\ESPAM2\Training\SS01011949\MKMOD>**bud2smp<b2s\_GrpABSpgs.in** extracts spring flow data for the 14 Group A and B spring targets. General head boundary flow is not included. Data are written to **ABSprings.smp**

Negative values indicate discharge from the aquifer to the river or springs. Positive values indicate discharge from the river to the aquifer.