

## MEMORANDUM

To: ESPAM Model Files  
Fr: Bryce Contor  
Date: 4 October 2003

Re: Applying Balancing Tools to output of Recharge Tools.

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This memo is intended as a follow-up to the 3 October 2005 memo on use of the GIS and FORTRAN recharge tools, and to the 4 October 2005 memo on use of the summary utilities. Its purpose is to describe the process of deriving a balanced water budget from the output of the recharge tools, in order to duplicate the MODFLOW input files used for model calibration.

In addition to files described in the earlier memos, the following files from the IDWR FTP site are referred to in this memo:

From zipped file "VB\_Utills.zip," files:

For\_Koreny\_Data\_Request\_Sept\_2005\Balancing\_Tools\Blank\_Spreadsheet.xls  
For\_Koreny\_Data\_Request\_Sept\_2005\Balancing\_Tools\Adjuster\_Only\_3.exe  
For\_Koreny\_Data\_Request\_Sept\_2005\Balancing\_Tools\Wrapper.exe

From zipped file "WaterBudgetData.zip," file:

New\_Balance1.xls  
T124\_ESPAM\_OUTPUT.zip

### **Overview of Budget Balancing**

This section is an overview of ideas presented to the ESHMC in May 2003.

In the modeling process, head-dependent components of the water budget (Snake River gains and losses and discharges to springs) were applied as model calibration targets along with aquifer water levels. Non-head-dependent components of the water budget were applied as specified flux components using the MODFLOW recharge package or the MODFLOW well package.

Given a specified-flux input and a suite of aquifer parameters, MODFLOW will use the ground-water flow equations to calculate aquifer heads and fluxes to or from head-dependent cells. It will by definition balance the water budget. However, since the goal in model calibration was to find a suite of aquifer parameters that reproduced measured or estimated aquifer heads, gains and losses, and spring discharges, the decision was made to provide a balanced set of specified-flux values that honored the water balance implied by target values for heads and head-dependent fluxes.

The balancing was performed by applying a least-squares algorithm (Jack C. McCormac, Surveying Fundamentals, 2nd Edition, Appendix B) with weighting for user confidence in various components. This was applied by a macro in a spreadsheet, which may be inspected in file "Blank\_Adjuster.xls." To avoid division by zero in matrix calculations, zero-value components of the water budget were replaced with an arbitrary very small number, which introduces a small imprecision in the results. The macro did not work well with the very large numbers in the native units of cubic feet, so all values were scaled.

## **Process of Balancing the Water Budget**

The specific process was as follows:

1. Calculate best estimates of all specified-flux water budget components.
2. Run *espam.exe*, *readinp.exe* and summary utilities.
3. Extract values for the steady-state balancing period and apply to a version of *Blank\_Adjuster.xls* with appropriate head-dependent flux and change in storage values.
4. Calculate adjusting multipliers. Be sure these are reasonable, given the confidence in the data or estimates that are proposed to be adjusted.
5. Use utilities "*Adjuster\_Only\_3.exe*" and "*Wrapper.exe*" to apply the multipliers to the intermediate files *output by espam.exe* and *used as input by readinp.exe*.
6. Re-run *readinp.exe* to obtain balanced MODFLOW input files. These are the values used in model calibration.

For the May 2004 training session, the decision was made to apply the balancing multipliers to the GIS and tabular input data for presentation to attendees. Therefore, the data on the CDs is balanced to match the input data used in ESPAM 1.0. Subsequently, in an archiving accident in the fall of 2004, many of the "raw" input files were lost.

## **Re-balancing the water budget for ESPAM 1.1**

Because of the loss of raw input files, the re-balancing of the water budget for ESPAM 1.1 was accomplished by calculating multipliers and applying the utilities to the *previously balanced* intermediate files. The balanced intermediate files actually used for ESPAM 1.1 may be viewed by opening *T124\_ESPAM\_OUTPUT.zip*. By applying *readinp.exe* to these files, one may obtain the actual MODFLOW input files used in ESPAM 1.1.

The calculation of the new multipliers is outlined in file *NEW\_BALANCE1.xls*, worksheet "FromSummry." References to "*briggs\_e\_balanced\_w*" and "*T119*" refer to data used in

ESPAM 1.0. References to T124 refer to data used in ESPAM 1.1. Cells B63 through F78 of that worksheet are reproduced below.

Table 1.  
Summary of Adjustments  
for ESPAM 1.1

Water Budget Component	T119 values (balanced to old reach gain targets)	Planned Multipliers (balancing to new targets)	Summary after operation of balancing and processing through READINP.EXE	Actual Effective Multipliers
NIR	517,391	1.016	518,225	1.001612
IRR_PCP	1,720,474	1.002	1,723,916	1.002001
IRR_ET	-5,489,695	0.997	-5,473,229	0.997000
SW_DIV	7,010,954	1.002	7,024,674	1.001957
OFF	-68,087	0.998	-67,950	0.997999
FPT	-138,873	0.998	-138,595	0.997998
SPT	0	NA	0	NA
PCH	293,599	1.003	294,480	1.003002
CNL	472,067	1.002	473,005	1.001987
TRB	919,198	1.016	933,918	1.016014
Sub Total	5,237,029		5,288,447	
River Gains (new)	-5,294,424		-5,294,424	
Change in Storage	0		0	
Imbalance	-57,395		-5,978	
Imbalance (%)	1.08%		0.11%	

Values in column "Planned Multipliers" are the multipliers that were indicated by the balancing spreadsheet. These were to have been applied to the previously-balanced budget to obtain the budget balanced to new reach gains. Column "Actual Effective Multipliers" back-calculates the actual multipliers implied by dividing the values in column "Summary after operation..." by the values in column "T119 Values...."<sup>1</sup>

These multipliers were applied to the intermediate files used in ESPAM 1.0. Those files had been obtained by scaling the intermediate files that resulted from applying `espam.exe` to the raw GIS and tabular data (which are no longer available). The GIS and tabular data available today were obtained by scaling the raw input directly (using identical multipliers), prior to operation of `espam.exe`. Therefore, the order of operations was different; T124 applied the first set of scalars *after* GIS operation and the results that will be obtained from the process outlined below will have had the first set of scalars applied *before* GIS operation. It is expected that results will differ insignificantly at the last few decimal places.

<sup>1</sup> Note that a typographical error was made in inputting the multiplier for the NIR component; "1.0016" was input instead of "1.016." The very small imbalance of 0.11%, however, is calculated from the actual output values.

One can compare the balancing required for ESPAM 1.1 and ESPAM 1.0 by looking at cells B21 through K24 in worksheet "FromSummry."

### **Using "Adjuster\_Only\_3.exe" and "Wrapper.exe"**

To obtain a reasonable facsimile of T124, one needs to complete the operation of the GIS tool as outlined in the 3 October 2004 memo. Then, open Adjuster\_Only\_3.exe and input desired multipliers, as illustrated in Figure 1. The software runs for several minutes and creates a new suite of intermediate files with the value from input box "Adjustment ID" appended to the file names. It also outputs a summary text file that contains a record of the multipliers used, as illustrated in Figure 2.

The adjuster utility sometimes generates lines too long to be read by FORTRAN. Consequently, utility Wrapper.exe must be run before applying readinp.exe. The wrapper utility is illustrated in Figure 3. It appends "W" to the output file names. Both Adjuster\_Only\_3.exe and Wrapper.exe leave the original files unchanged as an archive.

At this point, the filenames are quite unwieldy. It may be well to use a DOS window to rename all the files, as was done to data set "T124." Readinp.exe may now be run on the balanced intermediate files as described in the 3 October 2005 memo.

## Figures

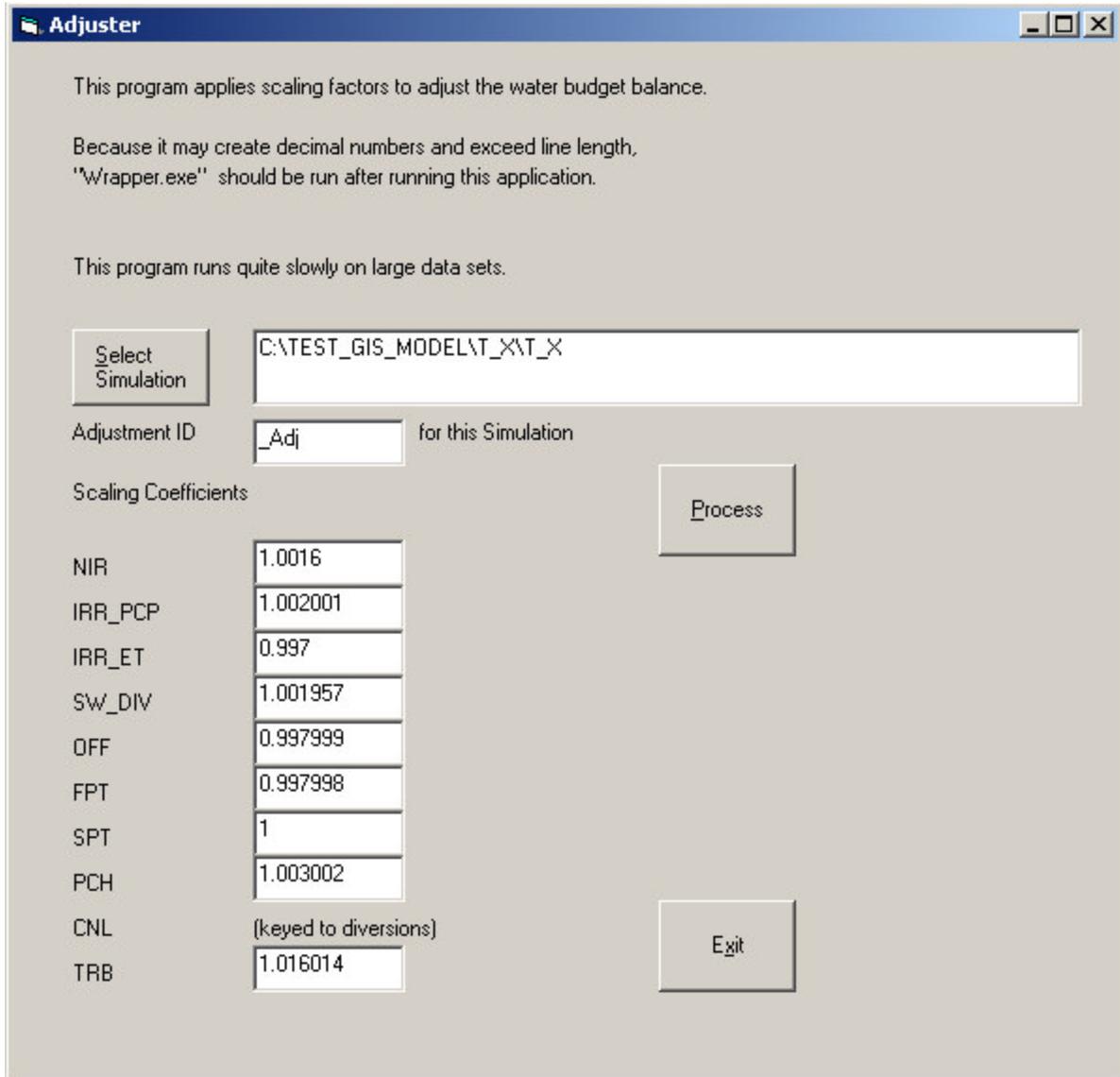


Figure 1. Input screen for Adjuster\_Only\_3.exe.

```
T_X_Adj.txt - Notepad
File Edit Format Help

Adjusted Input Files

Input File C:\TEST_GIS_MODEL\T_X\T_X.mdl
Adjusted Filenames: C:\TEST_GIS_MODEL\T_X\T_X_Adj.*

Adjustment coefficients:
NIR,1.0016
IRR_PCP,1.002001
IRR_ET,0.997
SW_DIV,1.001957
OFF,0.997999
FPT,0.997998
SPT,1
PCH,1.003002
TRB,1.016014

Note that line length may exceed 2048 characters.
If 'wrapper.exe' has been run, the directory will
contain files with similar filenames that have a 'w'
preceding the extension, where long lines have been wrapped.

10/4/2005
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Figure 2. Summary text file with details of adjustment.

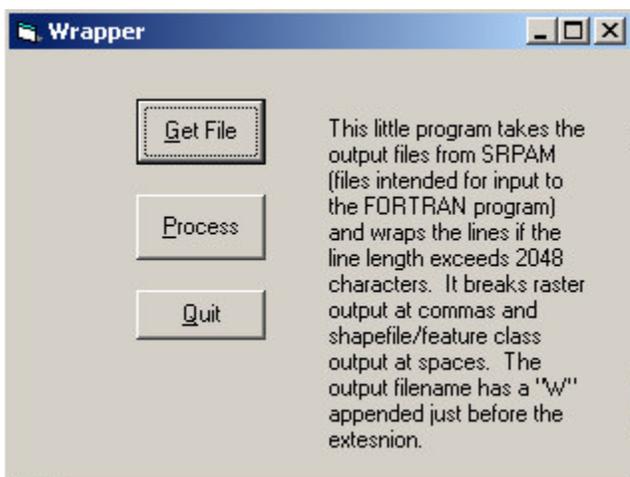


Figure 3. Input screen for Wrapper.exe