Addendum Report to:

HYDROLOGIC EFFECTS OF CONTINUED 1980-2002 WATER SUPPLY AND USE CONDITIONS

(Base Case Scenario)

DATA AND PROGRAMS

November, 2004

by

Allan Wylie, Donna M. Cosgrove, Bryce A. Contor,

Nathan Rinehart, Gary Johnson

Idaho Water Resources Research Institute,

University of Idaho

for the

Idaho Department of Water Resources

with guidance from the

Eastern Snake Hydrologic Modeling Committee

Idaho Water Resources Research Institute

Technical Report 04-001 Addendum

Eastern Snake Plain Aquifer Model Enhancement Project

Scenario Document Number DDS-001-Addendum

Introduction

This addendum describes the process and software used to produce the scenario: *Hydrologic Effects of Continued 1980-2002 Water Supply and Use Conditions (Base Case Scenario).* It describes how to run the base case and contains a description of the required software in a Relevant Software Section toward the end of the document. There are three base case simulations: 1) a steady state base case in which the recharge for the 22 year model period is averaged and the model run to steady state, 2) a 22 year average transient base case in which the averaged recharge is run for 88 one year stress periods, and 3) the full model base case in which the full recharge set for the 22 year model calibration period is used and the model run repeatedly until it approaches equilibrium. All data sets are identified in a table and, along with the required software, provided in an accompanying set of computer files.

General Instructions

All executable files provided with this document are run from the DOS command line. Files are provided in a zipped format, and after being unzipped, they may be in a read-only format. The user should check the properties of the files to make sure that they are not read-only before attempting to use them. **All files, including MODFLOW and the other executables for a specific run, should be placed in the same directory prior to attempting to run.**

Steady State Base Case

The zip file *basess.zip*, contains all files necessary to run the 22 year steady state base case: the full recharge set, the average recharge set, the MODEFLOW executable and input files, and the utility programs and their input files. The recharge set, *fulltran.rch,* is averaged and saved as *avall.rch*. To run the model, type:

mf2k1

MODFLOW then asks for the name file. Type:

basss.nam

On a 1200MHz machine the run only takes about one second, however MODFLOW will let you know when it is done.

MODFLOW is set up so that it saves simulated aquifer head and volumetric water budget data to binary files. BUD2SMP is a utility program designed to extract this information. BUD2SMP requires input which is available in prepared files. To run BUD2SMP using the standard reaches, type:

bud2smp < bud2smpr.in

This will extract gains and losses for all the river reaches above Minidoka as identified in integer array *riv05.inf* and save the information in file *river.smp*. Column one in file *river.smp* contains the reach name and the last column contains the gains and losses in cubic feet per day. A flux from the aquifer to the river is negative.

To extract aquifer discharge from springs below Milner run BUD2SMP again using an input file designed for the spring reaches, type:

bud2smp < bud2smpd.in

This will extract and aggregate all the spring discharges as according to reaches identified in integer array *drnzon.in* and save the information in file *drain.smp*. Column one in file *drain.smp* contains the reach name and the last column contains the reach spring discharge in cubic feet per day. A flux from the aquifer to the spring is negative. Table 1 provides a list of the reach names used for all the Base Case simulations.

Table 1. Reach Identification

Reach Name	**Abbreviation**
Ashton to Rexburg	A-R
Heise to Shelley	H-S
Shelley to Near Blackfoot	S-B
Near Blackfoot to Neeley	B-N
Neeley to Minidoka	N-M
Devil's Washbowl to Buhl	DwbBul
Buhl to Thousand Springs	BulKsp
Thousand Springs	Ksp
Thousand Springs to Malad	KspMld
Malad	Mld
Malad to Bancroft	MldBan

<u>22 Year Average Transient Base Case</u>

The zip file *baseavtrn.zip* contains all files necessary to run the 22 year average transient base case scenario, the full recharge set, the MODFLOW executable, and input files: and the utility programs and their input files. To run the model type:

mf2k1

MODFLOW then asks for the name file, type:

bas22avtr.nam

On a 1200MHz machine this run takes about four minutes, however MODFLOW will let you know when it is done.

MODFLOW is set up so that it saves simulated aquifer head and volumetric water budget data to binary files. BUD2SMP is a utility program designed to extract this information.

BUD2SMP requires input which is available in prepared files. To run BUD2SMP using the standard reaches, type:

bud2smp < bud2smpr.in

This will extract gains and losses for all the river reaches as identified in integer array *riv05.inf* and save the information in file *river.smp*. Column one in file *river.smp* contains the reach name and the last column contains the gains and losses in cubic feet per day for a specific time step (approximately 35 days). A flux from the aquifer to the river is negative.

To extract aquifer discharge from springs below Milner, run BUD2SMP again using an input file designed for the spring reaches. Type:

bud2smp < bud2smpd.in

This will extract and aggregate all the spring discharges according to reaches identified in integer array *drnzon.inf* and save the information in file *drain.smp*. Column one in file *drain.smp* contains the reach name and the last column contains the gains and losses in cubic feet per day for a specific timestep. A flux from the aquifer to the springs is negative.

Full Model Base Case

The zip file *baseFull.zip* contains all files necessary to run the full model base case, the full recharge set, the MODFLOW executable and input files, the utility programs and their input files. The recharge data set, *fulltran.rch* is read in and the model run repeatedly until it approaches equilibrium. To run the model type:

mf2k1

MODFLOW then asks for the name file, type:

basrep22.nam

On a 1200MHz machine the model will take about two and a half minutes to run. MODFLOW will inform you when it has finished.

MODFLOW is set up so that it saves simulated aquifer head and volumetric water budget data to binary files. BUD2SMP is a utility program designed to extract this information. BUD2SMP requires input which is available in prepared files. To run BUDWSMP using the standard reaches, type:

bud2smp < basrivb2s.in

This will extract gains and losses for all the river reaches as identified in integer array *riv05.inf* and save the information in file *river.smp*. Column one in file *river.smp* contains the reach name and the last column contains the gains and losses in cubic feet per day for a specific timestep. A flux from the aquifer to the river is negative.

To extract spring discharges along the Snake River below Milner, run BUD2SMP again using an input file designed for the river reaches. Type:

bud2smp < basdrnb2s.in

This will extract and aggregate all the spring discharges according to reaches identified in integer array *drnzon.inf.* and save the information in file *drain.smp*. Column one in file *drain.smp* contains the reach name and the last column contains the reach spring discharge in cubic feet per day for a specific timestep. A flux from the aquifer to the river is negative.

The ending heads from the just completed model run need to be extracted. MODFLOW saved aquifer head information at the end of each time step. There are a total of 440 time steps in this run, the aquifer head at the end of the last time step needs to be extracted. To extract the 440th aquifer head array and save it as starting heads for the next run use the utility program MANY2ONE. Type

many2one < many2one.in

MANY2ONE reads the binary head file created by MODFLOW and saves the last head array in a separate file *new1.hds.*

The model is now prepared for the second run. It will run using the just created starting heads with the exact same recharge set as the first run. This run estimates what river gains and losses would be like if the next 22 years had exactly the same recharge as the previous 22. Type:

mf2k1

MODFLOW then asks for the name file, type:

basrep22_1.nam

On a 1200MHz machine the run will take about two and a half minutes to run. MODFLOW will inform you when it has finished.

To extract aquifer gains and losses for the Snake River above Milner, run BUD2SMP again using an input file designed for the river reaches. Type:

bud2smp < basrivb2s1.in

This will extract all the river reaches as identified in integer array *riv05.inf* and save the information in file *river1.smp*.

To extract aquifer discharge from springs below Milner run BUD2SMP again using an input file designed for the spring reaches, type:

bud2smp < basdrnb2s1.in

This will extract and aggregate all the spring discharges according to reaches identified in integer array *drnzon.inf* and save the information in file *drain1.smp*.

The ending heads from the just completed model run need to be extracted. To extract the 440th aquifer head array and save it as starting heads for the next run use the utility program MANY2ONE. Type

many2one < many2one1.in

MANY2ONE reads the head file created by MODFLOW and saves the last head array in a separate file *new2.hds*.

The model is now prepared for the third run. It will run using the just created starting heads with the exact same recharge set as the first run. This run estimates what river gains and losses would be like if the next 22 years had exactly the same recharge as the original 22 years. Type:

mf2k1

MODFLOW then asks for the name file, type:

basrep22_2.nam

On a 1200MHz machine the model will take about two and a half minutes to run. MODFLOW will inform you when it has finished.

To extract aquifer gains and losses through the Snake River above Milner, run BUD2SMP again using an input file designed for the river reaches. Type:

bud2smp < basrivb2s2.in

This will extract all the river reaches as identified in integer array *riv05.inf* and save the information in file *river2.smp*.

To extract aquifer discharge from springs below Milner, run BUD2SMP again using an input file designed for the spring reaches. Type:

bud2smp < basdrnb2s2.in

This will extract all the spring discharges and aggregate according to reaches identified in integer array *drnzon.inf* and save the information in file *drain2.smp*.

The ending heads from the just completed model run need to be extracted. To extract the 440th aquifer head array and save it as starting heads for the next run use the utility program MANY2ONE. Type

many2one < many2one2.in

MANY2ONE reads the head file created by MODFLOW and saves the last head array in a separate file *new3.hds*.

The model is now prepared for the fourth run. It will run using the just created starting heads with the exact same recharge set as the first run. This run estimates what river gains and losses would be like if the next 22 years had exactly the same recharge as the original 22 years. Type:

mf2k1

MODFLOW then asks for the name file, type:

basrep22_3.nam

On a 1200MHz machine the model will take about two and a half minutes to run. MODFLOW will inform you when it has finished.

To extract aquifer gains and losses for the Snake River above Milner, run BUD2SMP again using an input file designed for the river reaches.. Type:

bud2smp < basrivb2s3.in

This will extract all the river reaches as identified in integer array *riv05.inf* and save the information in file *river3.smp*.

To extract aquifer discharge from springs below Milner, run BUD2SMP again using an input file designed for the spring reaches. Type:

bud2smp < basdrnb2s3.in

This will extract all the spring discharges and aggregate according to reaches identified in integer array *drnzon.inf.* and save the information in file *drain3.smp*.

<u>Relevant Software</u>

MF2K1.EXE

MF2K1 is version 1.10 of MODFLOW-2000. Documentation as well as a more recent version is available for download on the USGS website http://water.usgs.gov/software/ground_water.html. MF2K1 is included here because it is the version used to calibrate the model. This version includes the LMG solver which is not available in the more recent versions. All MODFLOW data sets provided with this scenario utilize the LMG solver, but could be modified to invoke the PCG solver.

BUD2SMP.EXE

BUD2SMP uses an integer array (such as riv05.inf or drnzon.inf) and sums the river and drain cells into reaches. Output is reach gain for ever time step. Documentation and the most recent version of BUD2SMP is freely available for download at www.sspa.com/pest. Figure 1 contains an example of BUD2SMP output for a transient run.

```
NAME  DATE_AND_TIME_AT_END_OF_TIME_STEP   REACH_GAIN
 A-R          05/19/1980   04:48:00     -2.9385342E+07
 A-R          06/06/1980   09:36:00     -3.8292456E+07
 A-R          06/24/1980   14:24:00     -4.5587712E+07
 A-R          07/12/1980   19:12:00     -5.1884660E+07
 A-R          07/31/1980   00:00:00     -5.7442664E+07
 A-R          08/18/1980   04:48:00     -6.2408864E+07
 A-R          09/05/1980   09:35:59     -6.6884952E+07
 A-R          09/23/1980   14:23:59     -7.0943288E+07
 A-R          10/11/1980   19:11:59     -7.4641472E+07
 A-R          10/29/1980   23:59:59     -7.8027216E+07
 A-R          11/17/1980   07:11:59     -5.6941512E+07
 A-R          12/05/1980   14:23:59     -4.4848256E+07
 A-R          12/23/1980   21:35:59     -3.5896924E+07
 A-R          01/11/1981   04:48:00     -2.8485682E+07
 A-R          01/29/1981   12:00:00     -2.2081548E+07
 A-R          02/16/1981   19:11:59     -1.6437493E+07
 A-R          03/07/1981   02:23:58     -1.1411472E+07
```

Figure 1. Example BUD2SMP output.

MANY2ONE.EXE

MANY2ONE reads a MODFLOW-2000 binary head file and extracts the array or arrays of interest representing the head distribution at a specific time step. Documentation and the most recent version of MANY2ONE is freely available for download at www.sspa.com/pest.

Data File Summary

Data files used in the simulations described above are identified in the following table. In some cases a single data file would be used for more than one of the simulations (specifications within that file apply equally to all of the Base Case simulations).

Table 2. Files used in Base Case simulations

File Name	Simulations Applied			File Type
Basss.bud	Steady State Base Case			Binary budget file output from steady state model using average recharge for the 17 year steady state period
Basss.hds	Steady State Base Case			Binary head file output from steady state model using average recharge for the 17 year steady state period
Basss.lst	Steady State Base Case			ASCII listing of MODFLOW processes and results
Basss.nam	Steady State Base Case			MODFLOW input file containing ASCII list of files used in the simulation
Basss.rch	Steady State Base Case			ASCII MODFLOW recharge file, calls avall.rch
Avall.rch	Steady State Base Case	22 Year Average Transient Base Case		Binary recharge file constructed by averaging the recharge for the entire 22 year calibration period
Bigrid.gsf	Steady State Base Case	22 Year Average Transient Base Case	Full Model Base Case	ASCII file containing information to map the model grid to the real world
Confss.bc6	Steady State Base Case			ASCII MODFLOW block centered flow file
Bud2smpd.in Bud2smpr.in	Steady State Base Case	22 Year Average Transient Base Case		ASCII input files containing prepared responses to BUD2SMP questions

Drain.smp River.smp	Steady State Base Case	22 Year Average Transient Base Case		ASCII BUD2SMP output containing modeled spring or river reach gain information
Drnsmp.rec Rivsmp.rec	Steady State Base Case	22 Year Average Transient Base Case		ASCII listing of BUD2SMP processes and results
Drnzon.inf Riv05.inf	Steady State Base Case	22 Year Average Transient Base Case	Full Model Base Case	ASCII 2D array identifying spring or river reaches
Full.drn	Steady State Base Case	22 Year Average Transient Base Case	Full Model Base Case	ASCII MODFLOW input file containing drain parameters
Full.riv	Steady State Base Case	22 Year Average Transient Base Case	Full Model Base Case	ASCII MODFLOW input file containing river parameters
Fullss.ba6	Steady State Base Case			ASCII MODFLOW basic package file
Fullss.dis	Steady State Base Case			ASCII MODFLOW discretization file
Fullss.ocl	Steady State Base Case			ASCII file containing output instructions for MODFLOW
Ibound.ibd	Steady State Base Case	22 Year Average Transient Base Case	Full Model Base Case	ASCII 2D array identifying active and inactive cells (MODFLOW IBOUND array)

Settings.fig	Steady State Base Case	22 Year Average Transient Base Case	Full Model Base Case	ASCII file necessary to run many PEST utility programs such as BUD2SMP
Standard.lmg	Steady State Base Case	22 Year Average Transient Base Case	Full Model Base Case	ASCII file stating parameters necessary for the MODFLOW LMG solver
Transm.ref	Steady State Base Case	22 Year Average Transient Base Case	Full Model Base Case	ASCII file containing 2D array of transmissivity values
Bas22avtr.bud		22 Year Average Transient Base Case		Binary budget file
Bas22avtr.dis		22 Year Average Transient Base Case		ASCII MODFLOW discretization file
Bas22avtr.hds		22 Year Average Transient Base Case		Binary head file output from MODFLOW
Bas22avtr.lst		22 Year Average Transient Base Case		ASCII listing of MODFLOW processes and results
Bas22avtr.nam		22 Year Average Transient Base Case		ASCII listing of files used in the simulation

Bas22avtr.ocl	22 Year Average Transient Base Case		ASCII file containing output instructions for MODFLOW
Bas22avtr.rch	22 Year Average Transient Base Case		ASCII MODFLOW recharge file that calls avall.rch
Conftr.bc6	22 Year Average Transient Base Case	Full Model Base Case	ASCII MODFLOW block centered flow file
Fulltr.ba6	22 Year Average Transient Base Case	Full Model Base Case	ASCII MODFLOW basic package file
Sy.ref	22 Year Average Transient Base Case	Full Model Base Case	ASCII file containing 2D array of specific yield values
Steady.hds	22 Year Average Transient Base Case		Binary head file produced in calibrated steady state run, used as starting heads
Basrep22.bud Basrep22_1.bud Basrep22_2.bud Basrep22_3.bud		Full Model Base Case	Binary budget file output from MODFLOW for the 1st 22, 2nd 22, 3rd 22, and 4th 22 years
Fulltr.dis		Full Model Base Case	ASCII MODFLOW discretization file

Basrep22.hds Basrep22_1.hds Basrep22_2.hds Basrep22_3.hds	Full Model Base Case	Binary head file output from MODFLOW for the 1^{st} 22, 2^{nd} 22, 3^{rd} 22, and 4^{th} 22 years
Many2one.in Many2one1.in Many2one2.in	Full Model Base Case	ASCII input files for MANY2ONE used to create starting head files for the 2^{nd}, 3^{rd}, and 4^{th} 22 years
Steady.hds New1.hds New2.hds New3.hds	Full Model Base Case	Binary head file containing starting heads for the 1^{st} 22, 2^{nd} 22, 3^{rd} 22, and 4^{th} 22 years
Basdrnb2s.in Basdrnb2s1.in Basdrnb2s2.in Basdrnb2s3.in	Full Model Base Case	ASCII input files containing prepared responses to BUD2SMP questions to create spring reach gain and loss files for the 1^{st} 22, 2^{nd} 22, 3^{rd} 22, and 4^{th} 22 years
Drain.smp Drain1.smp Drain2.smp Drain3.smp	Full Model Base Case	ASCII BUD2SMP output containing transient modeled spring reach gain information for the 1^{st} 22, 2^{nd} 22, 3^{rd} 22, and 4^{th} 22 years

Basrivb2s.in Basrivb2s1.in Basrivb2s2.in Basrivb2s3.in	Full Model Base Case	ASCII input files containing prepared responses to BUD2SMP questions to create river reach gain and loss files for the 1st 22, 2nd 22, 3rd 22, and 4th 22 years
River.smp River1.smp River2.smp River3.smp	Full Model Base Case	ASCII BUD2SMP output containing transient modeled river reach gain or loss information for the 1st 22, 2nd 22, 3rd 22, and 4th 22 years
Basrep22.lst Basrep22_1.lst Basrep22_2.lst Basrep22_3.lst	Full Model Base Case	ASCII listing of MODFLOW processes and results for the 1st 22, 2nd 22, 3rd 22, and 4th 22 years
Basrep22.nam Basrep22_1.nam Basrep22_2.nam Basrep22_3.nam	Full Model Base Case	MODFLOW input files containing ASCII listing of files used to simulate the 1st 22, 2nd 22, 3rd 22, and 4th 22 years
Fulltr.ocl	Full Model Base Case	ASCII file containing output instructions for MODFLOW
Fulltr.rch	Full Model Base Case	ASCII MODFLOW recharge file that calls fulltran.rch
Fulltran.rch	Full Model Base Case	Binary recharge file constructed to represent recharge for the 22 year calibration period