MF2005-FMP2 Example Problem "EX1"

The following description provides guidance to users that want to test FMP2 and to learn from the example model about the capabilities, features, use, and analysis with MF2005-FMP2. Please refer to the FMP2 user's guide for a complete description of input sets (Schmid and Hanson, 2009) in the doc folder.

Main Objectives of Exercise:

- Get familiar with the fundamental features of a MF2005-FMP2 model, when simulating supply and demand of irrigated agriculture as well as the physical water budget of water accounting regions (both "farm" and "non-farm," e.g., urban, native, and riparian);
- Show user how to be in control of changing simplistic to complex features, e.g.:,
  - change no water rights to equal appropriation water rights,
  - change manual surface-water routing to automatic routing options;
  - change single-node FMP wells to multi-node MNW wells,
  - change instant unconstrained deep percolation in FMP to delayed recharge in UZF.
- Illustrate the main categories of output data and some possible output options.

Main Features:

- Hypothetical example problem simulated with MF2005 using the FMP2 jointly with the SFR7, UZF1, and MNW7 packages;
- 8 "Farms" (water accounting regions) with associated farm wells, 6 crop types, 3 soil types;
- Root depth, crop coefficient, reference evapotranspiration, and precipitation lumped as constants over each 1 months stress period but variable from stress period to stress period (24 stress periods for 2 years);
- Calculation of crop transpiration under both unsaturated conditions and saturated conditions (e.g. riparian willows) by analytical solutions;
- Non-routed deliveries to irrigated farms (to be conceived as a priori known "water transfers" from outside model domain;
- Semi-routed surface-water deliveries to irrigated farms from reaches located outside the farm domain. The word "semi" is used in the sense of: (a) routed

along the stream network to a user-specified point of diversion, (b) non-routed delivery (e.g., pipe flow) from the point of diversion (perceived as ‘remote head-gate’) to the farm;

- Semi-routed runoff returnflow to either specified reaches or else to automatically found reaches within a farm or to the nearest reach outside a farm. For farms, where no returnflow locations are specified, runoff returnflow is either automatically prorated over all types of segment reaches if within a farm or, else, returned to the nearest reach outside a farm).
- Echo out the routing information for all farms by setting the optional ‘routing information print flag’ to 2 to print out the routing information to an ASCII file, ROUT.OUT, for the first stress period only.
- Equal appropriation height of surface-water deliveries to each farm. FMP2 divides this allotment [L] by the period length and multiplies by the area of each farm to get a farm-specific allotment rate [L^3/T] in MODFLOW-units chosen in the discretization file.
- Supplemental ground-water pumping from both FMP2-internal farm wells and MNW7 wells externally linked to FMP2 farm wells. The link between FMP2 and MNW7 enables the simulation of (a) the apportioning of FMP-calculated desired flow rates, (b) of actual flow rates, and (c) maximum capacities of multi-layer wells of Farm 5 and of the urban area (Farm 6):
    - In file WELLS.IN (opened by a command in item 4b of the FMP2 input file), a negative Farm Well ID indicates that the supplemental well pumpage of these wells should be simulated not by FMP2 but by the MNW package.
    - In the well list in WELLS.IN, a ‘zero layer number’ indicates that these wells should be simulated as multi-aquifer wells (3 FMP-wells of Farm 5 consist of 4 different MNW well-nodes across 4 layers, 2 FMP-wells of Farm 6 consist of 3 different MNW well-nodes across 3 layers).
    - A flag AUX QMAXRESET set in item 2c to tell the program to read an auxiliary variable in column 7 of the well list in WELLS.IN. If, for a particular MNW-well, a "1" is read in column 7 then the MNW-simulated maximum well capacity, QMAX, is reset to the QMAX rate specified in

WELLS.IN in the first iteration of each time-step. Without this option, simulated maximum well capacities of a particular time step can only be equal or less than QMAX values determined during the previous time step.

- In the MNW input file, all nodes belonging to each respective multi-layer well have the same head constraint (= top of the confining bed below layer 1).

WELLS.IN:

Layer	Row	Column	Farm-Well ID	Farm ID	QMAXfact	QMAXRESET
1	5	6	1	1	5	
1	8	6	2	1	5	
1	8	9	3	1	5	
1	5	9	4	2	3	
1	6	10	5	2	2	
1	7	11	6	2	1	
1	18	3	7	3	2	
1	21	3	8	3	4	
1	18	19	9	4	3	
1	21	19	10	4	5	
0	6	2	-11	5	5	1
0	8	2	-12	5	5	1
0	10	2	-13	5	5	1
0	3	19	-14	6	10	1
0	6	17	-15	6	6	1

- Delayed recharge by linking the infiltration beyond the root zone to the UZF package, which simulates runoff in excess of the actual infiltration, recharge, and – for conditions of water levels rising above the surface – discharge of ground-water to surface water:
  - Infiltration of Farm 5 (deepest vadose zone of all farms) and ground-water discharge to surface water of Farm 8 (riparian area) are linked to the UZF package.
  - In the FMP input file, the UZF link is activated by setting the “consumptive use” flag, ICCFL, to 3. ICCFL=1 only calculates the analytical solution that simulates the actual transpiration in FMP. ICCFL=3 tells FMP in addition to simulate the delayed recharge by linking the FMP-simulated percolation beyond the root zone as a “quasi-infiltration” into the vadose zone by the UZF package.

Running MF2005_FMP2:

- Run batch file “example1.bat” to execute MF2005_fmp2.exe
- MF2005 produces the following output files: ex1.lst, ex1.hed, CBC.OUT.
- The FMP produces the following output files: FDS.OUT, FB_DETAILS.OUT, ROUT.OUT.
- The MNW package writes the following output files t.wl1, t.ByNode, and t.Qsum.
- The UZF package writes the following output files:
  - f5_r2c2.opt1 Output file for cell in row 2, col. 2 of farm 5 using IUZOPT=1
  - f5_r3c3.opt2 Output file for cell in row 3, col. 3 of farm 5 using IUZOPT=2
  - f5_r4c4.opt3 Output file for cell in row 4, col. 4 of farm 5 using IUZOPT=3
  - f5_r5c4.opt2 Output file for cell in row 5, col. 4 of farm 5 using IUZOPT=2
  - f8_r10c20.opt2 Output file for cell in row 10, col. 20 of farm 8 using IUZOPT=2
  - f5&8.uzfot Output file of times series of unsaturated-zone water budgets for both farms 5 and 8
- View the information written to the ASCII files FDS.OUT and FB_DETAILS.OUT for each time step for farm demand and supply flow rates and for the detailed farm budget of inflows and outflows.

Saving and viewing Farm Demand & Supply and Farm Budget flow rates:

- (a) Open FDS.OUT and from FB_DETAILS.OUT with a Text Editor and copy data from FDS.OUT and from FB_DETAILS.OUT into cell A1 of tab “data” of the respective Excel file FDS.XLS and FB_DETAILS.XLS in folder excel\post_process\.
- (b) Convert text to data with: Data > Text to columns… > Fixed with - …> Finish. With this task you will fill the empty spreadsheet with your data.
- View the time series of farm budget components (in and out of farm) and for farm demand and supply flow rates by clicking on the little down-arrow of field “FID” in column D and subsequently going to respective “time series” tabs.
- In FD_DETAILS.XLS, go to tab “pie charts” and enter a farm, stress period, and time step in row 4 of your choice to view the farm budget components of a particular farm at a particular time. Save the spreadsheet.

- In FDS.XLS, go to tab “bar charts” and enter a farm, stress period, and time step in row 4 of your choice to view the farm budget components of a particular farm at a particular time. Save the spreadsheet.
- In FDS.XLS, compare how Farm 1 receives in the first year more routed surface water (R-SWD) than what was diverted from the main-stem river into the canal diversion-segment (> 10,000 m3/day) as a result of upstream runoff returnflows originating from Farm 5 being prorated over the diversion segment that passes through Farm 5.
- In FDS.XLS, observe that Farm 2 receives semi-routed deliveries over a longer period in year 2 than in year 1 as a result of the limited allotments that all farms receive in year 2. Farm 1’s allotment is curbed and at least some water is left in the canal and available downstream to Farm 2. Notice that without any allotment rules, Farm 1 would divert all the water from the diversion-segment and not allow Farm 2 hardly any semi-routed deliveries in both years. You can optionally test that by switching the IALLOT flag in item 2b to zero and by deleting the data entries for ALLOT in item 35.
- In file ROUT.OUT, observe how the runoff of Farm 5 is prorated as “fully-routed returnflow” over four reaches of a diversion segment leading to Farm 1. In reality, leveed canals simulated as diversion segments may not receive any returnflow: You can optionally test that by switching IRRFL from -1 to 1, which means that only non-diversion segments (non-canal segments) can now receive fully-routed returnflow from those farms, for which no semi-routed returnflow locations were specified manually.
- Copy data from file “t.ByNode” into cell A1 of tab “t.ByNode” of Excel file “MNW_FMP.xls” and from file “t.Qsum” into cell A1 of tab “t.Qsum” of the same Excel file “MNW_FMP.xls.”
- Convert text to data with: Data > Text to columns… > Delimited > Space > Finish. With this task you will fill the empty spreadsheets with your data.
- Compare time series of well discharge, Q, and, ground-water heads for individual MNW-well nodes, “t.ByNode,” by clicking on the little down-arrow of field “ENTRY” (e.g. for the entry 13, which is top node of well in row 3, column 19 of

farm 6) , and for cumulative net pumpage “t.Qsum” by clicking on the little down-arrow of field “ENTRY” (e.g. for entries 00013-00015, which are all the nodes belonging to the well in row 3, column 19 of farm).

- In tab “t.Qsum” of file “MNW_FMP.xls,” compare ENTRYs 00013-00015 and 00016-00018 and view how the head in the well, H-sum, and the net pumpage, Qsum, compare to each other in the second year. Both wells are pumping supplemental water supply to the urban area, Farm 6. The drawdown of the MNW-well 00013-00015, in row 3, column 19, is bound by the head-constraint of 205 meters. The pumping of the MNW-well 00016-00018, in row 6, column 17, is bound by the original maximum capacity of 6000 m^3/day set in file WELLS.IN that is opened from the FMP input file.
- Compare the red-dotted line, Q-FIN, for the final pumpage for Farm 6 in file FDS.XLS with the specified cumulative maximum capacity of all wells in Farm 6, QMAXF. Realize, how the MNW-head constraint lowered the possible pumping below the originally specified cumulative maximum capacity.
- Compare the black line, Q-ext-in, for external deliveries required to balance the farm budget of Farm 6 in file FB_DETAILS.XLS with the maroon line, Q-wells-in, for inflows into the farm from well pumping. Notice that by limiting the pumpage of Farm 6 by introducing head constraints through the MNW package, the external deliveries increase to compensate for the deficiencies.
- Copy data of one of the UZF output data files for a particular cell of Farm 5 (e.g., row 3, column 3, file f5_r3c3.opt2 – don’t copy first line!) into cell A1 of tab “Farm 5 (row 3, col 3)” of Excel file UZF_FMP.xls. Convert text to data with: Data > Text to columns… > Fixed with … > Finish (Do not copy the header line).

Running HYDMOD and ZONEBUDGET:

- Run the HYDMOD batch file “hydmod.bat” to execute hydfmt_32.exe and to produce the following HYDMOD output files: fmp2_ex1_hyd.inf, fmp2_ex1_hyd.otf, and fmp2_ex1_hyd.gwh, which contain time series of gage inflows and outflows as wells as ground-water heads of observation wells. The stream gages and observation wells are specified in the HYDMOD input file “hyd_all.hyd.”
- Run the ZONEBUDGET batch file “zone_budget.bat” to execute zonbud3.exe and to produce the following ZONEBUDGET output files:
  - FMP_waterbalance.out.2.csv — Boundary and Zone inflows and outflows
  - FMP_waterbalance.out.log — Log file
  - FMP_zone.out — Output file

Saving and viewing

- Copy the three HYDMOD output data files into cell A1 of each respective tab (*.gwh into ‘gwh data,’ *.inf into ‘inf data,’ and *.otf into ‘oft data’) of Excel file hydmod_graphs.xls. Convert text to data with: Data > Text to columns… > Fixed with … > Finish.
- Open the comma delimited ZONEBUDGET output file “FMP_waterbalance.out.2.csv”