HYDROGEOLOGIC UNITS IN GIS AND MODFLOW AT PLACITAS,NEW MEXICO

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ABSTRACT

A GIS hydrogeologic database for Placitas, New Mexico is based on the geologic and hydrologic characteristics described by Johnson (2000) and on data derived from an exploratory drilling and aquifer-testing program. A MODFLOW model simulates groundwater flow through hydrogeologic units in three dimensions using the Hydrogeologic-Unit Flow Package. Geologic-solid models were produced using custom GIS data objects developed for ESRI ARCMAP.

The model simulates the hydrologic interaction of the Placitas aquifer system: natural recharge, evapotranspiration, spring discharge and routing through streams, agricultural operations, groundwater diversions by existing and future wells and return flows. The model calculates the impacts to the Placitas area hydrologic system from growth of water use during a historical period (1953 to 2002) and a projected 100-year future period (2003 to 2103). Water-level trends from groundwater withdrawal in the Middle Rio Grande Basin are applied as a boundary condition to the model of the Placitas area.

DOCUMENTATION OF THE HYDROGEOLOGIC-UNIT FLOW (HUF) PACKAGE

By Evan R. Anderman *and* Mary C. Hill

The HUF Package is an alternative internal flow package that allows the vertical geometry of the system hydrogeology to be defined explicitly within the model using hydrogeologic units that can be different than the definition of the model layers. The HUF Package works with all the processes of MODFLOW-2000. For the Ground Water Flow Process, the HUF Package calculates effective hydraulic properties for the model layers based on the hydraulic properties of the hydrogeologic units, which are defined by the user using parameters. The hydraulic properties are used to calculate the conductance coefficients and other terms needed to solve the ground-water flow equation. The sensitivity of the model to the parameters defined within the HUF Package input file can be calculated using the Sensitivity Process, using observations defined with the Observation Process. Optimal values of the parameters can be estimated by using the Parameter-Estimation Process. The HUF Package is nearly identical to the Layer-Property Flow (LPF) Package, the major difference being the definition of the vertical geometry of the system hydrogeology. Use of the HUF Package is illustrated in two test cases, which also serve to verify the performance of the package by showing that the Parameter-Estimation Process produces the true parameter values when exact observations are used.

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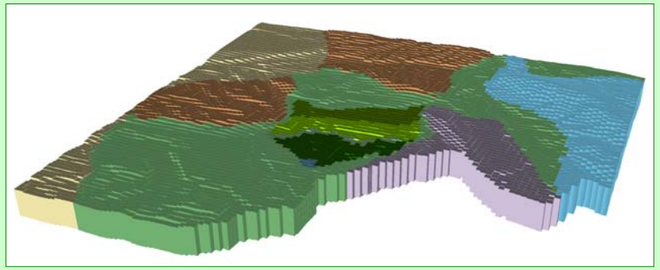
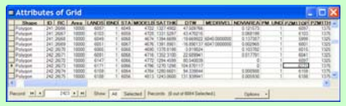
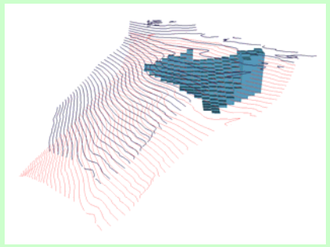
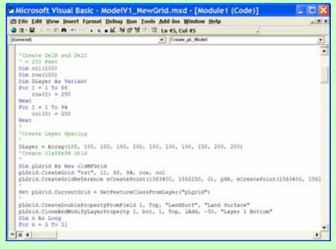


MODEL PREPARATION





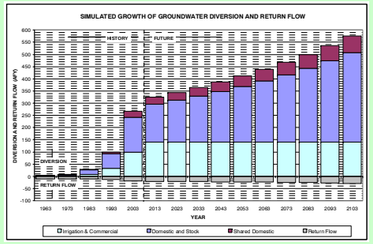


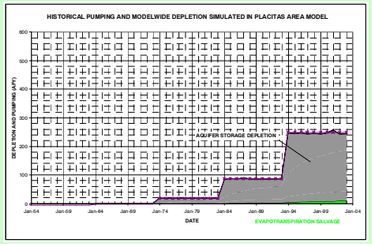
GROUNDWATER MODEL DESCRIPTION

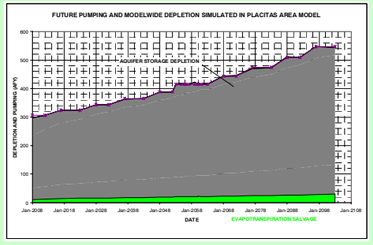
Balleau Groundwater, Inc. (BGW) prepared a digital finite-difference groundwater flow model of the aquifer system at and in the area of influence of Casas Montañés property. The model was constructed based upon the geologic and hydrologic characteristics described by Johnson (2000) and data derived from the BGW exploratory drilling and aquifer-testing program. The model simulates groundwater flow through defined hydrogeologic units in three dimensions using the program MODFLOW (2000) with the Hydrogeologic-Unit Flow Package (2000). The hydrogeologic units represented in the model are shown on Plate E1. Model grid dimensions are 250 feet square (horizontally) and 11 layers totaling a thickness of about 1,300 feet. Horizontal and vertical hydraulic conductivity, specific storage and specific yield for each simulated unit are listed on the table on Plate E1.

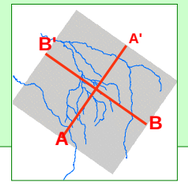
The model simulates the features that define the hydrologic interaction of the Placitas aquifer system: natural recharge, evapotranspiration, spring discharge and routing through streams, agricultural operations, groundwater diversions by existing and future wells and return flows. The model representation of these features is shown on Plate E2. Natural recharge includes subsurface recharge to the Placitas aquifer system from infiltrated snowmelt and rainfall in the Sandia Mountains and runoff onto Las Huertas Creek, Agua Zarca and Tunnel Spring. Evapotranspiration is simulated in areas where unmanaged riparian vegetation consumes groundwater. Areas where aquifers discharge to springs along the mountain front, the Village of Placitas, Cuchilla Lupe, Arroyo Oso and Las Huertas Creek, are simulated. Agricultural operations are simulated as net return flow to a water-table aquifer from irrigated lands supplied by Placitas Village Springs and acequia. Diversions from groundwater wells are simulated at locations where wells are on file with the New Mexico Office of the State Engineer (OSE) (Electronic communication, http://www.seo.state.nm.us/water-info/index.html, April 19, 2003). Return flow from septic tanks is simulated in areas where depth-to-water is shallow (less than about 30 feet).

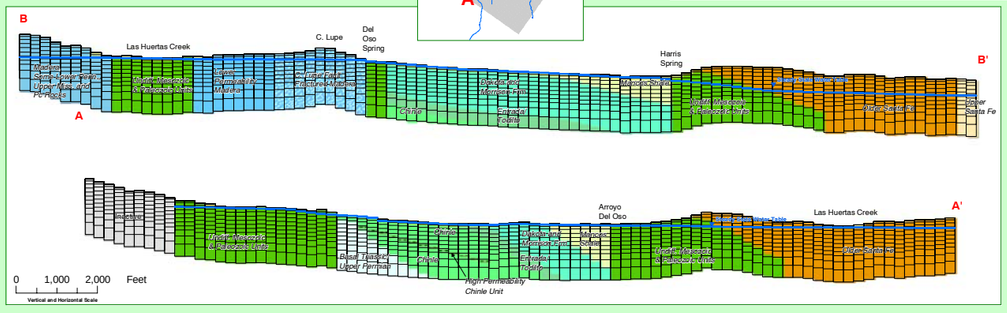
The model calculates the impacts to the Placitas area hydrologic system from growth of water use through a historical period (1953 to 2002) and a projected 100-year future period (2003 to 2103). Water use is based on the Water Administration Technical Engineering Resource System (WATERS) database compiled by the OSE. Categories of use include domestic, stock, commercial, and irrigation wells. The date that a well was drilled, indicated in the WATERS database, is the basis for developing a simulation of historical water use. Future water use in the Placitas area is projected by assuming one percent growth of domestic wells.







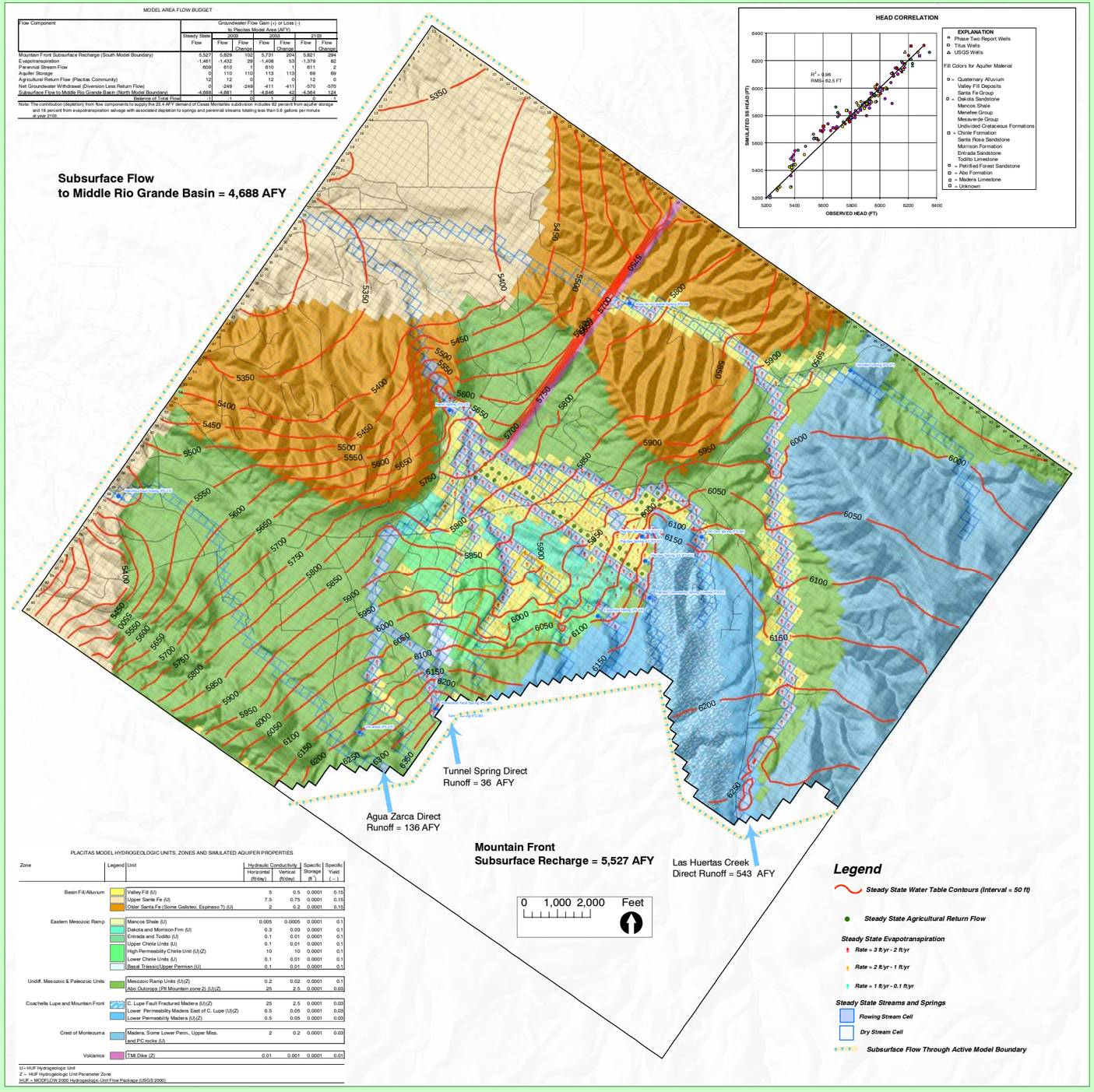




MODEL AREA FLOW BUDGET

Flow Component	Steady State Flow	2003 Flow	2003 Flow Change	2053 Flow	2053 Flow Change	2103 Flow	2103 Flow Change
	Groundwater Flow Gain (+) or Loss (-) to Placitas Model Area (AFY)						
Mountain Front Subsurface Recharge (South Model Boundary)	5,527	5,629	102	5,731	204	5,821	294
Evapotranspiration	-1,461	-1,432	29	-1,408	53	-1,379	82
Perennial Stream Flow	609	610	1	610	1	611	2
Aquifer Storage	0	110	110	113	113	69	69
Agricultural Return Flow (Placitas Community)	12	12	0	12	0	12	0
Net Groundwater Withdrawal (Diversion Less Return Flow)	0	-249	-249	-411	-411	-570	-570
Subsurface Flow to Middle Rio Grande Basin (North Model Boundary)	-4,688	-4,681	7	-4,646	42	-4,564	124
Balance of Total Flows	-1	-1	0	1	2	6	7

Note: The contribution (depletion) from flow components to supply the 23.4 AFY demand of Casas Montañés subdivision includes 82 percent from aquifer storage and 18 percent from evapotranspiration salvage with associated depletion to springs and perennial streams totaling less than 5.6 gallons per minute at year 2103.



PLACITAS MODEL HYDROGEOLOGIC UNITS, ZONES AND SIMULATED AQUIFER PROPERTIES

Zone	Legend	Unit	Hydraulic Conductivity Horizontal (ft/day)	Hydraulic Conductivity Vertical (ft/day)	Specific Storage (ft⁻¹)	Specific Yield (–)
Basin Fill/Alluvium		Valley Fill (U)	5	0.5	0.0001	0.15
		Upper Santa Fe (U)	7.5	0.75	0.0001	0.15
		Older Santa Fe (Some Galisteo, Espinaso ?) (U)	2	0.2	0.0001	0.15
Eastern Mesozoic Ramp		Mancos Shale (U)	0.005	0.0005	0.0001	0.1
		Dakota and Morrison Fm (U)	0.3	0.03	0.0001	0.1
		Entrada and Todilto (U)	0.1	0.01	0.0001	0.1
		Upper Chinle Units (U)	0.1	0.01	0.0001	0.1
		High Permeability Chinle Unit (U)(Z)	10	10	0.0001	0.1
		Lower Chinle Units (U)	0.1	0.01	0.0001	0.1
		Basal Triassic/Upper Permian (U)	0.1	0.01	0.0001	0.1
Undiff. Mesozoic & Paleozoic Units		Mesozoic Ramp Units (U)(Z)	0.2	0.02	0.0001	0.1
		Abo Outcrops (Pil Mountain zone 2) (U)(Z)	25	2.5	0.0001	0.03
Coachella Lupe and Mountain Front		C. Lupe Fault Fractured Madera (U)(Z)	25	2.5	0.0001	0.03
		Lower Permeability Madera East of C. Lupe (U)(Z)	0.5	0.05	0.0001	0.03
		Lower Permeability Madera (U)(Z)	0.5	0.05	0.0001	0.03
Crest of Montezuma		Madera, Some Lower Penn., Upper Miss. and P.C.rocks (U)	2	0.2	0.0001	0.03
Volcanics		TMI Dike (Z)	0.01	0.001	0.0001	0.01

U = HUF Hydrogeologic Unit
Z = HUF Hydrogeologic Unit Parameter Zone
HUF = MODFLOW-2000 Hydrogeologic-Unit Flow Package (USGS 2000)