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Ground-Water Flow and Storage Concepts in the Edwards Aquifer, San Antonio Area, Texas

The Edwards aquifer in the San Antonio area is one of the most permeable and productive carbonate aquifers in the United States and has been designated a Sole Source Aquifer by the U.S. Environmental Protection Agency. The U.S. Geological Survey has been studying the hydrology of the Edwards aquifer for many years. Because of heightened interest in Edwards aquifer issues associated with the 1996 drought, the following information on ground-water flow and storage concepts in the aquifer is excerpted and reprinted from U.S. Geological Survey Water-Resources Investigations Report 95–4186, "Geology and hydrology of the Edwards aquifer in the San Antonio area, Texas," by Robert W. Maclay:

To investigate the effects of the faults on ground-water flow, a digital model of the ground-water-flow system of the Edwards aquifer in the San Antonio area was developed (Maclay and Land, 1988). The computer code for the digital model uses a two-dimensional, finite-difference approach. The hydrologic conditions for the simulations were based on data beginning in 1972, when recharge approximately equalled discharge. An assumption was made that steady-state conditions existed in the Edwards aquifer during 1972, thus allowing the use of a steady-state model. The modeled area, which was divided into grid cells based on rows and columns, was about 75 miles (mi) wide and 280 mi long and included all of the San Antonio area. Row widths ranged from 0.79 to 6.31 mi, and column widths ranged from 1.18 to 3.95 mi. Discharge from Comal and San Marcos Springs was simulated on the basis of specification of constant heads corresponding to ground-water levels in the area. The initial distribution of transmissivity was based on a delineation of relative transmissivities in 20 subareas by Maclay and Small (1984).

In northern Medina County, model results show that flow is diverted to the southwest by major barrier faults. The structural horst east of Uvalde diverts ground-water flow eastward from this area in Uvalde County. A rhomboid-shaped horst in the confined zone of the aquifer area in central Bexar County marks the location of two major intermittent artesian springs at a restriction along a flowpath. Where permeable strata on the upthrown side are opposite less permeable strata on the downthrown side, limited ground-water flow crosses the fault. The modelling analysis indicates that converging barrier faults "channel" water toward major springs, thereby affecting spring discharge.

Flow and Storage Units

Changes in water levels in the unconfined zone of the Edwards aquifer represent substantial changes in the volume of water stored in the total aquifer, whereas comparable changes in water levels in the confined zone represent only small changes. Because the area of the unconfined zone represents about 30 percent of the total aquifer, most of the water released from storage for a given water-level decline comes from this zone.

The quantity of water temporarily retained in storage in the unconfined zone is affected strongly by the barrier faults. These faults obstruct the flow of ground water from the unconfined zone to the confined zone. Because of the obstructions, water movement from the unconfined zone to the confined zone follows an extended flowpath causing water to remain in the unconfined zone for longer periods of time.

Simulation by the digital model indicated that four subareas of the unconfined zone tended to function as independent storage units because of faults. These storage units are referred to as western, western Medina, eastern Medina, and eastern. The division between these units is influenced strongly by major faults, narrowing of the recharge area, and stream-basin boundaries. These storage units are shown in figure 1 and described in table 1.

Simulation identified four generally independent ground-water-flow units—western-southern, south-central, north-central, and eastern. For purposes of this report, a flow unit of the Edwards aquifer is defined as an area of the aquifer that includes a storage unit and the area of the flowpaths that transmit water from this storage unit to major points of discharge. The flow units are shown in figure 1 and described in table 2. Some interchange of ground water from one flow unit to another probably occurs if the potentiometric surface fluctuates substantially. The flow units probably do not vary greatly when water levels remain within their historical range because of the internal boundaries of the aquifer and the fixed locations and stable rates of ground-water withdrawals.

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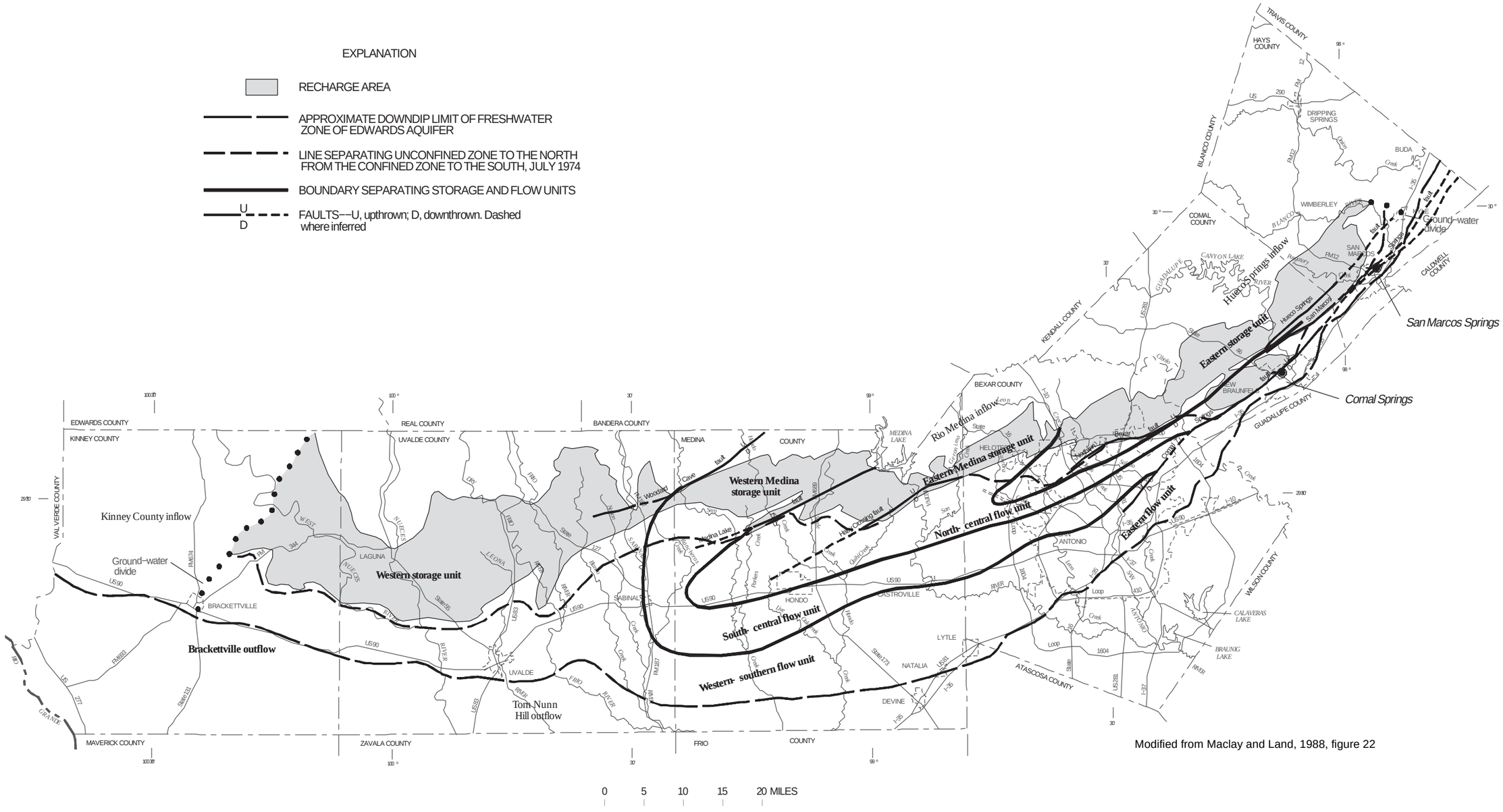

Modified from Maclay and Land, 1988, figure 22

Figure 1. Map showing storage and flow units of the Edwards aquifer in the San Antonio area, Texas.

Table 1. Major storage units of the Edwards aquifer in the San Antonio area, Texas[1]

Name	Description
Western	Includes the unconfined aquifer west of the Woodard Cave fault and the complex of faults in the Uvalde area that is an extension of the Medina Lake fault. Eastern limit is the topographic divide between Sabinal River and Seco Creek. Most of the recharge comes from losses of flow in the Nueces, West Nueces, Frio, Dry Frio, and Sabinal Rivers. Has the largest storage capacity of the four units. Is the most remote from the major discharge points. Yields water to the confined zone rather sluggishly.
Western Medina	Includes the unconfined aquifer between the western storage unit and the Medina Lake fault. Most of the recharge comes from Hondo and Seco Creeks and from Medina Lake.
Eastern Medina	Includes the unconfined aquifer between the western Medina storage unit and generally along the Haby Crossing fault. Receives most of its recharge from Medina River, Medina Lake, and several small creeks.
Eastern	Includes the unconfined aquifer east of the eastern Medina storage unit. The storage in this unit is strongly influenced by the Northern Bexar fault and the Hueco Springs fault. The recharge is primarily from several small streams, especially Cibolo Creek.

[1] Modified from Maclay and Land (1988).

Table 2. Major flow units of the Edwards aquifer in the San Antonio area, Texas[1]

Name	Description
Western-southern	Source of water is the western storage unit. Geometry of the aquifer causes the water to take the southernmost route from the area of recharge to points of discharge that extend to Comal Springs. Large portion of water moves through the western part of an opening (Knippa gap) in the Medina Lake fault-Uvalde horst complex near Sabinal and in a graben in the Uvalde area. Most or all of this flow is withdrawn by irrigation wells in Medina County and for the city of San Antonio water supply.
South-central	Source of water is the western Medina storage unit. The Medina Lake fault functions as a major barrier of ground-water flow and diverts the water to the southwest, where it moves through the eastern part of the Knippa gap near Sabinal that is described above. After the water moves past the opening, it turns sharply to the east. The major discharge points are irrigation wells in Medina County, public-supply wells in San Antonio, and Comal Springs.
North-central	Source of water is the eastern Medina storage unit. Much of the flow is diverted to the southwest by the Haby Crossing fault before it turns to the east. Major discharge points are public-supply wells in San Antonio and Comal and San Marcos Springs. Flow merges with the two southern flow units at Comal Springs.
Eastern	Source of water is the eastern storage unit. Water in the western part of the unit is diverted to the southwest by barrier faults, but in a short distance the water turns to the northeast. During normal water-level conditions, most of this flow discharges at San Marcos Springs.

[1] Modified from Maclay and Land (1988).

References

Maclay, R.W., and Land, L.F., 1988, Simulation and flow in the Edwards aquifer, San Antonio region, Texas, and refinement of storage and flow concepts: U.S. Geological Survey Water-Supply Paper 2336–A, 48 p.

Maclay, R.W., and Small, T.A., 1984, Carbonate geology and hydrology of the Edwards aquifer in the San Antonio area, Texas: U.S. Geological Survey Open-File Report 83–537, 72 p.

Information on technical reports and hydrologic data related to this and other studies can be obtained from:

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