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A review of regional groundwater flow model in Guarani Aquifer System outcrop region in Uruguay: consequences for integrated surface and groundwater management

Alberto Manganelli¹, Didier Gastmans², Lucas Vituri Santarosa³, Gerardo Veroslavsky^{4,5}, Natalie Aubet³, Lucía Samaniego^{1,5}, Roberto Carrión⁵, Lautaro Pochintesta⁴, Agostina Pedro⁴, Johnny Arteaga³

The Guarani Aquifer System (GAS) outcrop area in Uruguay develops as a N-NE strip of 165 km long and 30-55 km wide in the north-central region of the country. In this region, GAS is constituted by the Tacuarembó and Rivera formations (Upper Jurassic - Lower Cretaceous from Parana sedimentary basin), that encompass a succession of fine to medium siliciclastic sandstone strata, presenting good to the moderate selection, and good porosity. An extensive revision of the available wells data set (up to 1,100 wells) allowed a new interpretation of the GAS geometry and piezometry in the outcrop region in Uruguay. Based on the morpho-structural and stratigraphic features that it exhibits in the outcrop area, the GAS can be subdivided into 3 domains (South, Center, and North) and separated by strong NW lineaments: Arapey-Sopas-Tacuarembó Chico (ASTC) and Cuaró-Paguero-Isla Cristalina (CPIC), respectively. Despite these structures, GAS constituent units exhibit a homogeneous thickness about of 80-90 m.

Along the outcrop area GAS is a typical unconfined aquifer, despite some wells located in the western edge present basalts covering the sandstones, representing semi-confined conditions. According to the well depth two piezometric maps were constructed: one representing upper portions of the aquifer (well depth <70m), and another one for the lower aquifer (well depth >70m) (Figure 1).

Groundwater flow in the upper portion of GAS is directly related to the most outstanding relief and drainage features, associated with the main lineaments. Within the Northern Domain, the discharge occurs towards the depressed sector in the central portion of the outcropping area, represented by the Tacuarembó River, which develops in the NE direction. The groundwater flows to SE direction towards the Tacuarembó River in the Central Domain, strongly controlled by the morpho-structural features with NW direction, where the Tacuarembó Chico and Tres Cruces streams stand out. The Tacuarembó River initially runs under the NS direction to undergo a strong inflection under the NW direction. In the Southern Domain, the general discharge is towards the East, with a variation towards the SSE in the extreme south.

1 Centro Regional para la Gestión de Aguas Subterráneas en América Latina y el Caribe (CeReGAS), Uruguay, Av. Rondeau 1665 P1, Montevideo, Uruguay CP 11900

2 São Paulo State University (UNESP), Environmental Studies Center (CEA-Rio Claro)

3 UDELAR, Facultad de Ciencias

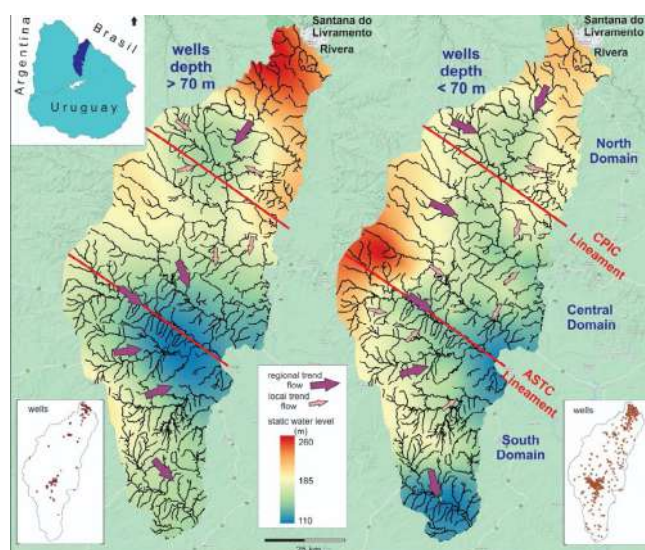
4 UTEC, Centro Sur

5 Centro Regional para la Gestión de Aguas Subterráneas en América Latina y el Caribe (CeReGAS)

Despite the fewer deeper wells, it was possible to construct a piezometric map for the lower portion of the GAS. In general way the regional directions are quite similar to the previous described, however some differences could be observed. Groundwater flow in the North Domain exhibits a SSW direction towards the Lunarejo Stream (PCIC Lineament) and its tributaries, while in the Central Domain the discharge and general flow direction is towards the SE, with the discharge being controlled by the Tacuarembó Chico River. In the Southern Domain, the regional discharge is towards the East with a slight variation towards the SE, observing that in this area the number of wells is very scarce.

Figure 1.

Left: Piezometric Map from the deep portion of GAS (>70m depth). Right: Piezometric Map from the shallow portion of GAS (<70m depth)



source: Open Street Maps, Own elaboration

The piezometric maps of the GAS outcrop area indicated a clear WE trend for the regional groundwater flow, strongly controlled by the relief elements, and the discharge is mainly directed towards the drainage network, which in turn, shows that morpho-structural features operate in its design. Despite the flow in the North Domain has a direction towards the SSW with a discharge towards the valley of the Tacuarembó River, in the other portion the flow is directed to the E, contributing to the baseflow of the Río Negro Basin. These findings are in opposite to the conceptual regional flow models for the GAS in Uruguay, that considers the outcrop area as a regional recharge area, and groundwater flows towards the West and Southwest.

The results presented, obtained using a geomorphological, geological, and hydrological database combined approach to evaluate the regional groundwater flow, open new perspectives for the water management in the GAS outcrop area, as well as opening the discussion about the recharge of GAS confined areas. Both the shallow and deep regional discharge of the GAS limits the original concept of considering the outcropping region as a natural recharge towards the W. At the transboundary level, the regional flow from north to south (from Brazil to Uruguay) remains in force, but the question remains about how the deepest area is recharged towards the Uruguay River (Argentina-Uruguay border). These aspects require that in both cross-border situations common criteria be adopted to evaluate and manage the resource, to propose actions for its coordinated management.