Affectation of urban structures by variation of phreatic level (natural and anthropic), Buenos Aires, Argentina

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Abstract: A great part of the urban zone in the Province of Buenos Aires shows a marked rise of phreatic level, which a problem not foreseen at the moment of planning and executing numerous works. To face actually this situation by means of pumping fields models, seems to result a factible, though expensive way, of lowering the ground level.

Key words: Hydrogeology, Phreatic ascent, Pumping field, Argentina.

Introduction

The greater Buenos Aires includes the city of Buenos Aires and 25 districts of the Province of Buenos Aires, forming an urban zone of 3800 km^2 (Fig. 1). The reconstruction of equipotential maps over the database of early 20th century shows clearly that the groundwater flow draining direction was SW-NE, towards the discharge in the Rio de la Plata. Between 1940 and 1980 the intense groundwater exploitation rate provoked the development of a great drawdown of the piezometric level (Hernández et al., 1989 and 1997). Since the eighties the use of groundwater was replaced by superficial water and, as a consequence, a rise of the water table took place, due to the incorporation of imported water to the system. To the factor previously indicated we must add as a natural factor, the increase of annual rains.

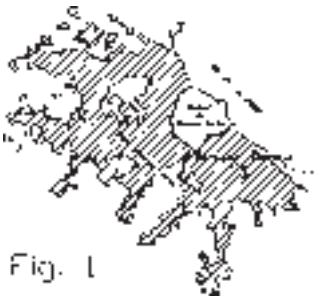

Fig. 1

During the period before the indicated process, numerous underground installations were planned and built, which was possible thanks to the wide unsaturated zone. At present the mentioned effects created potential risks related to the stability of foundations, now exposed to the contact with the phreatic level. This study evaluates the possibility of carrying the phreatic surface below the levels of second underground floors of the main building of the Central Market of Buenos Aires, by means of mathematical simulation of a drawdown system that brings the levels to the conditions existing at the moment when the building was built.

Scientific paper

HYDROGEOLOGICAL FRAMEWORK

In the Northeastern region of the Province of Buenos Aires exists a multilayered aquifer in sediments lying discordantly over marine sediments, which make up, then, the base of the usable groundwater in the region. This section responds directly to the hydrological cycle variables and it is formed by the following geological formations from top to bottom.
Postpampeano (Upper Pleistocene-Holocene) Clayey silts, partly sandy, laid in fluvial, marine and lacustrine environments. The Postpampeano is variable in thickness and from the hydraulical point of view, it acts as aquitard and aquiclude; **Pampeano** (middle to upper Pleistocene) formed by loess, partly sandy, from eolian origin, with calcrete levels and silt in its base. It constitutes a thick blanket with a great areal extension and contains the phreatic aquifer, while in its lower section exists some semiconfining (a clayey silt layer which acts as an aquitard and separates it from the Puelche); Puelches Sands (Pliocene). These are fluvial medium to fine sands. Their high porosity (between 20 and 31 %), average transmissivity of 500 m^2/day and the lack of chlorides and sulphates, make these sands an exceptional aquifer. They extend as a blanket. Their top is between 20 and 50 m depth and their thickness varies between 20 and 40 m, with a productivity of 40 to 150 m^3/hour.

HYDRODYNAMIC FRAMEWORK

Observation net: The Buenos Aires Central Market Corporation owns a property placed in a sector of La Matanza District next to the Riachuelo (Fig. 1). With the purpose of knowing the phreatic surface, a phreatimetric net composed by 40 wells was designed (BUCICH ET AL., 1988). In Figures 2 and 3 are shown the isodepths and isopieces.
The depths observed in phreatimeters (Fig. 2) showed a water table increase in the sectors near to Matanza River-Riachuelo, and a level depression was insinuated in the zone of the main building of the Market that surpasses 6 m. The groundwater general drainage (Fig. 3) agrees with the topographic slope using as the natural discharge level the Matanza-Riachuelo river. In the neighbourhood of the Administration Center, this is inverted due to the existence of a local watershed, originating a depression cone of the water table, provoked by the pumping of filtrated in the second underground floor.

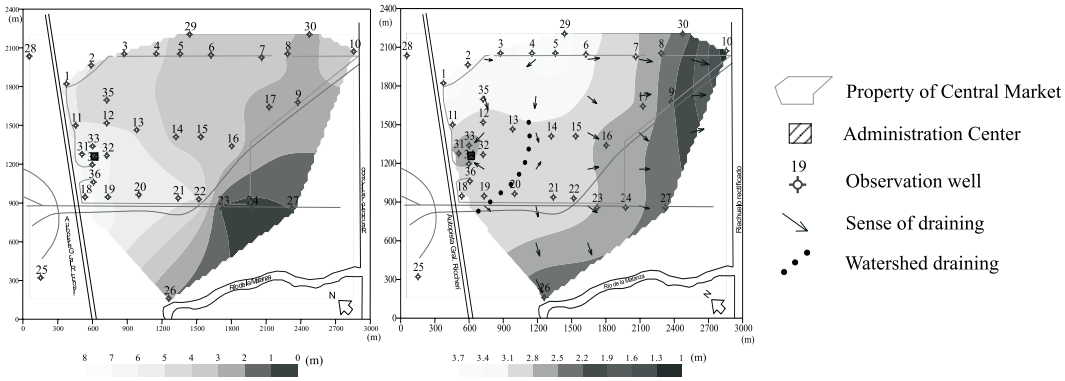

Figure 3. Isopieces (m)

Figure 2. Isodepths (m)

Conceptual Model: The analysed scheme respond to a complex multiplayer system developed above the marine Tertiary sediments. The proposed drawdown system acts over the upper part, which comprises the Pampeano and Postpampeano, by pumping the strata with circulation of privileged water, in beds interbedded with the aquitard levels. The system functions with local, autochtonous recharge and the analysed sediments are within the pelites field, with a notorious heterogeneity in its uniformity coefficient and in the relative content of sand and silt. A saturated thickness of near 22 m was determined for the upper part, which totalises scarcely 40 m where it integrates the Puelche aquifer sandy interval. The hydrodynamic parameters were established through two pumping tests at depths of 21 and 24 m respectively, adopting the values kD = 100 m^2/day for transmissivity and S = 0,002 for storage coefficient.

Results and discussion

The observed levels respond to the underground water natural rise, typical of the periods with hydric excess in the surroundings of the Central Market, aggravated by the pumping interruption by the enterprise in charge of the supply of potable water. If the pumping of water infiltrated, the phreatic level would be nearly 2 meters above the floor of the second underground floor.

Mathematical model: In view of the need to bring the phreatic surface below the building foundation, a most convenient drawdown system was designed. It is intended to achieve the maximum depression in that pumping field with a minimum number of wells. To resolve this model was applied the program PRINCE (Bucich et al., 1994) which permits to know, not only the decreases in the piezometric surface, but also the drawdown produced in the exploitation wells submitted to intensive pumping including the charge losses produced by the pumping.

Project and construction of the dejection system: The lower level of the Administration Center building foundation is placed 11,00m below the ground surface and the water level at 6.70 m. The difference between these values shows the need to produce a drawdown of nearly 4.50 m of the piezometric level. By means of successive program runs the drawdown system was optimised. A distribution of eight wells was chosen, which were located in the yard of the first underground floor. In Fig. 4 the location of these wells is shown as well as the isodepression curves that show the evolution of the drawdown for 5 and 10 days of continuous pumping at a flow rate Q = 5 m^3/h per well.
In the next table the expected decreases of the piezometric level in a central control point are detailed, for the successive pass of time. So the depression considered as a working hypothesis (to surpass the 4,5 m) is obtained after 5 days pumping.

Conclusions

Unexpected facts in building projects related to the subsurface hydric resource characteristics bring as a consequence water infiltrations in the underground parts of buildings in ex-

tensive sectors of the urban zone of the greater Buenos Aires. The phreatic level rise is corrected punctually by drawdown systems, which, as in the cited example, work up to now. This problem should be taken in account in areas with low gradient plains, near their base level, where the natural water drainage is difficult. The installed drawdown system has allowed to bring the phreatic level back to the conditions existing at the moment of the building construction, by eliminating the consequences produced by the inundation of the underground floors.

Drawdown in control point x = 39m y = 42m

Time (days)	1	2	5	10	30	60	90	150	365	3650
Pumping well										
1	0.42	0.48	0.57	0.64	0.74	0.81	0.85	0.9	0.98	1.20
2	0.44	0.51	0.6	0.66	0.77	0.83	0.87	0.92	1.00	1.22
3	0.44	0.50	0.59	0.66	0.76	0.83	0.87	0.91	1.00	1.22
4	0.42	0.49	0.57	0.64	0.74	0.81	0.85	0.90	0.98	1.20
5	0.42	0.49	0.58	0.64	0.75	0.81	0.85	0.90	0.99	1.21
6	0.39	0.46	0.55	0.61	0.72	0.78	0.82	0.87	0.96	1.18
7	0.44	0.50	0.59	0.66	0.76	0.83	0.87	0.92	1.00	1.22
8	0.40	0.47	0.55	0.62	0.72	0.79	0.83	0.88	0.96	1.18
Decrease (m)	**3.37**	**3.9**	**4.6**	**5.13**	**5.96**	**6.49**	**6.8**	**7.19**	**7.87**	**9.63**

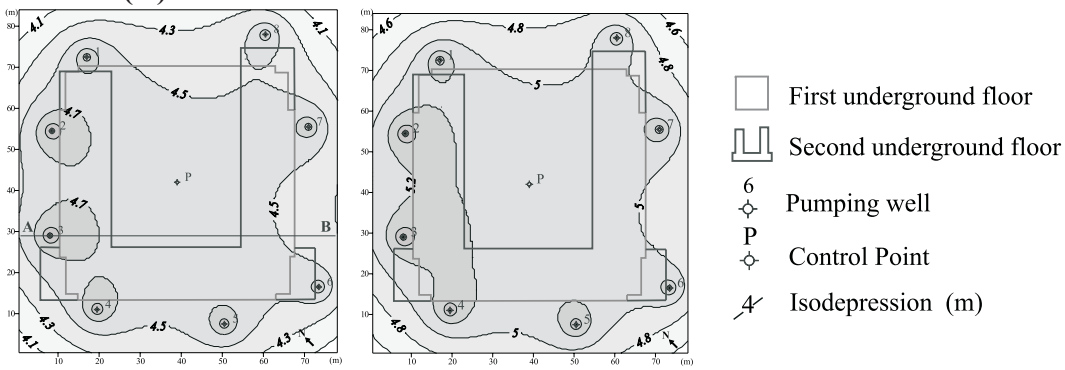

Figure 4. Evolution of the drawdown for 5 and 10 pumping days

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