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Department of Economic and Social Affairs

Natural Resources / Water Series No. 2

GROUND-WATER STORAGE AND ARTIFICIAL RECHARGE

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YARKON SPRING, ISRAEL*

The background information on Yarkon spring is as follows:

(a) Region: the Yarkon spring rises at the foot of the mountains north-east of Tel Aviv, at a distance of 15 km from the coast. It is a typical large karst spring;

(b) Geography: the spring is replenished by rainfall on an area of about 1,200 km^2 in the Judean mountains. These mountains form a chain running from south to north, with peaks of about 1,000 m elevation above sea level at a distance of about 50 km from the coast. Towards the west the mountains are succeeded by a belt of foot-hills and by the coastal plain. In the east, the mountains are limited sharply and abruptly by the deep Jordan depression;

(c) Climate: semi-arid, Mediterranean, with seasonal winter rainfall of about 600 mm/year;

(d) Reservoir type: folded carbonate rocks;

(e) Methods of investigation: geology is known in detail from outcrops and bore-holes; yield of spring and discharge of bore-holes are precisely gauged. Theoretical investigations conducted with the aid of decay-curve analysis and an electrical analogue model.

Ground-water reservoirs and utilization

The mountains of Judea are composed of folded Cretaceous limestones and dolomites underlain by shales, with strikes running generally north-north-east to south-south-west. The folds dip steeply towards the west and disappear below chalky and marly impervious rocks of Senonian-Eocene age and, finally, beneath Quaternary sediments of the coastal plain. A north-south line limits the reservoir on the east at the edge of the Jordan Depression.

The Cretaceous rocks composing the aquifer are subdivided into two major parts:

(1) An upper zone, consisting mainly of limestone with dolomitic limestone and a thick band of marl at the base;

(2) A lower zone, predominantly dolomitic, underlain by shales.

The upper zone of the reservoir is 370 m thick; the lower zone is 300 m thick. The outcrop area is about 1,200 km^2.

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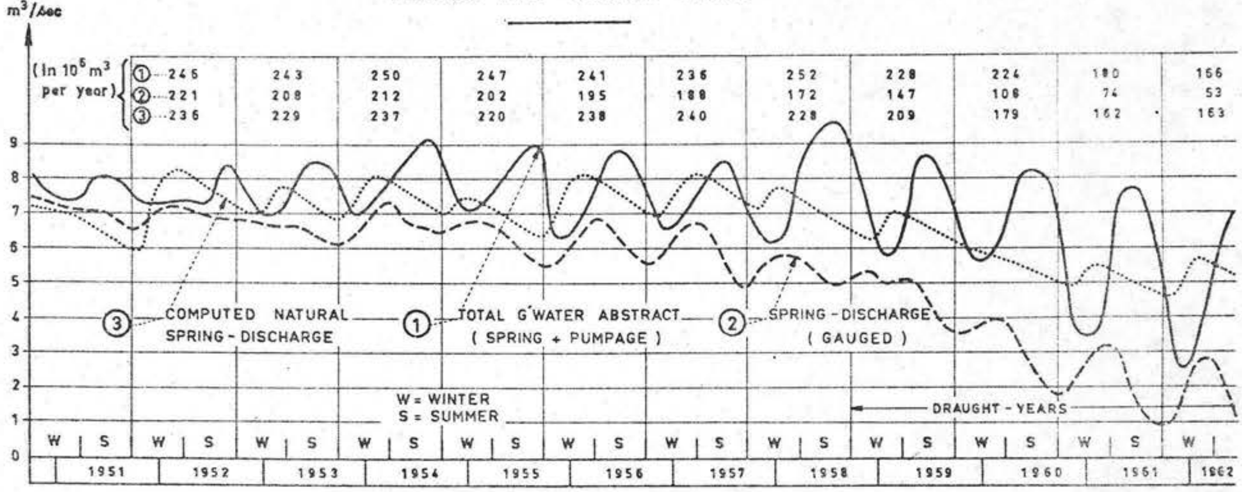
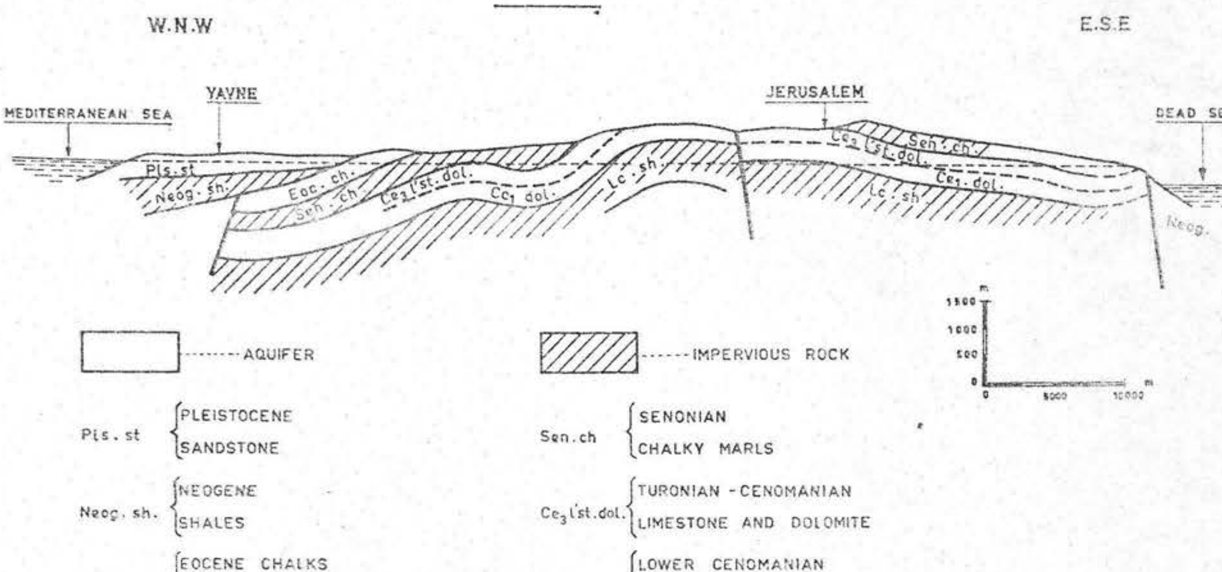
* Case study No. 31 prepared by S. Mandel (Israel).

EXPLOITATION OF THE AQUIFER FEEDING THE YARKON-SPRING



CROSS-SECTION THROUGH JUDEAN MOUNTAINS



AQUIFER

IMPERVIOUS ROCK

Pls. st	PLEISTOCENE SANDSTONE
Neog. sh.	NEOGENE SHALES
Eoc. ch.	EOCENE CHALKS SEMI - PERVIOUS
Sen. ch	SENONIAN CHALKY MARLS
Ce3 l'st. dol.	TURONIAN - CENOMANIAN LIMESTONE AND DOLOMITE
Ce1. dol.	LOWER CENOMANIAN DOLOMITE
Lc. sh.	LOWER CRETACEOUS SHALES

YARKON SPRING, ISRAEL

CASE STUDY Nº 31

The natural regulative reserves have been determined with the aid of the hydrograph-analysis method to average 900 x 10^6 m^3 at the end of the rainy season, under natural conditions. Approximately 31 per cent of the rainfall on the replenishment area is discharged by the Yarkon spring under natural conditions.

The Yarkon spring is the only major outlet of the regional ground-water reservoir. A thick layer of impervious shales (probably Neogene) separates the Cretaceous strata from the overlying Pleistocene sandstone in the coastal plain. At the shoreline, the top of the Cretaceous is more than 1,000 m below sea level; and at the prevailing hydraulic heads (maximum + 20 m under natural conditions), no outflow into the sea is possible.

Ground water in the carbonate rocks is separated from the overlying Pleistocene sediments by thick impervious strata. For these reasons, movement and discharge is, under natural conditions, to the Yarkon spring. The spring is situated at the lowest outcrop of the carbonate formations in the region, at about + 16 m elevation and, under natural conditions, the Yarkon spring yields on the average 220 x 10^6 m^3/year. Discharge varies from 5 to 8 m^3/sec, according to season.

Exploitation of ground water started in the early 1950s by holes drilled into the confined part of the aquifer all along the foot-hills of the Judean mountains. The number of bore-holes and exploitation of the aquifer increased rapidly. By 1959-1960 it reached 120 x 10^6 m^3, and it has now reached about 220 x 10^6 m^3, equal to the natural discharge of the spring. Until 1957, the aquifer was managed so that the total water supply by pumpage, plus residual spring flow, coincided with the demand curve. In 1957-1958 a series of dry years began and pumpage was increased. The dry years continued until 1963, during which period water supply was kept at a tolerable level by pumpage from bore-holes, but spring discharge declined and in 1963 stopped completely.

The Jordan River pipeline was put into operation in 1963. It would then have been possible to let the spring recover and revert to the mode of operation practised in 1958, i.e., pumpage for the seasonal modification of water-supply. However, it was found more advantageous to keep the water level in the reservoir low and to utilize the storage space thus created for seasonal and long-term ground-water storage from the Jordan River pipeline. These operations are now controlled with the aid of an electric analogue model.

Artificial recharge

The purpose of the project was to provide seasonal and long-term storage for the water of the Jordan River, in addition to the limited storage capacity of Lake Tiberias. Existing exploitation bore-holes are used for recharge, and they are connected to the National Water Carrier by a system of pipelines. Injection rates are between 500-1,000 m^3/h. During 1968-1969, injection was carried out in 12 bore-holes and a total of 31 x 10^6 m^3 of water from the Jordan River was injected.

During the first few years, 1965-1967, difficulties were encountered at high rates of injection because of air entrainment. These difficulties have now been eliminated by more careful supervision and improvements in the installations. Clogging by bacterial slimes considerably reduces injection capacities after about two months of continuous operation. Pumping for 2-4 hours quickly cleans the well-face and restores the capacity of the well. The foul water pumped during this period has to be rejected.

The cost of injecting water is about $0.015. This mainly reflects energy requirements and energy losses, since only small, inexpensive installations had to be installed for this purpose. The scheme is operated in conjunction with the National Water Carrier by Mekoroth Water Co., Ltd., under the water laws of Israel. Future operations are to continue.

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