PART TWO - COUNTRY PAPERS

ALGERIA

Area: 2,381,700 km^2

Population: 20.5 million (United Nations estimate, 1983)

I. GEOGRAPHICAL SUMMARY

Algeria is both a Mediterranean country with the Tell and the steppe in the north covering only 280,000 km^2. and a desert country with the Sahara in the south covering nine-tenths of the territory. Northern Algeria, flanked by the Mediterranean coast, is a region of high land with an average altitude of 900 m made up of four separate zones: the high plateaus, the interior plains, the mountain zones and the coastal zone; from south to north first are found large lagoonal formations in a very dry region (*chotts*) and *zahres*), followed by alternating zones of mountains and interior plains, and finally the valleys of the watercourses and a narrow coastal strip running east to west for 1,000 km. The Sahara Desert, of which Algeria occupies about a half, has five types of relief: the crystalline or volcanic mountains, the *hammada* (a flat plateau at the foot of mountains), the *reg* (a stony and arid plain), the *erg* (sand dunes) and the closed basins, *sabkhas* or *dayas*.

Climate

There are six main climatic zones; from north to south:

- The coastal zone; the coastal zone itself and a subcoastal zone;
- The Tell Atlas: an east-west band between the coastal zone in the north and the high steppes in the south;
- The high plains of the Tell, mainly in the east of the country, and the high plains of Constantine and Aures;
- The high steppes, a zone of *chotts* and high plateaus between the Tell Atlas and the Saharan Atlas;
- The Saharan Atlas, the northern edge of the Sahara;
- The Saharan zones.

Temperatures

Apart from the coastal zone which is under the direct moderating influence of the sea, the daily and annual temperature ranges are high, especially in the plains of the Tell Atlas (El Asnam), only 50 km from the sea, where the climage is of the continental type with a harsh winter and a very hot dry summer; this is also the case in the high steppes, but here the altitude keeps the annual average temperature down.

The annual averages at several stations in each of the six climatic zones are given in the following table:

Climatic zone	Cold season average (centigrade)	Hot season average (centigrade	Annual average (centigrade)
	14	23	18.5
Tell Atlas (plains)	14	26	20
High plains of the Tell	12.5	25.5	19
High steppes	15.5	28	21.7
Saharan Atlas	15	28	21.7
Northern Sahara	15	29.5	22.3

The annual ranges, i.e. the differences between the averages of the coldest and the hottest months, also increase steadily from north to south:

	Degrees centigrade
- Coast	14
- Tell Atlas (20°C in the plain of Cheliff)	19
- High plains of the Tell	19
- High steppes	21
- Saharan Atlas	22
- Northern Sahara	24

Rainfall

The average annual rainfall also follows in general terms the north-south zonal system, but with big discrepancies between east and west in each zone, the Oran region (west) being generally less wet than the Constantine region (east). The annual rainfall in Algeria ranges from 2,000 mm in the high mountains bordering the Mediterranean to less than 100 mm in the northern Sahara.

The lowest rainfall is found in the Saharan regions where the notion of an annual average has little meaning, given the very large variations from year to year and the total lack of rain in some years. Thus, the average rainfall over thirty years at Bechar is 91 mm. This represents the arithmetical average of a series of values between 30 and 180 mm.

This phenomenon is even more marked in the Sahara: at Timimoun the annual rainfall ranges between zero and 140 mm.

Average rainfall
(mm/year)

Climatic zone	West	Central	East
Coast	400	700	900
Tell Atlas (plains)	500	450	700
Tell Atlas (mountains)	600	700 - 1,000	800 - 1,600
High plains of the Tell	-	-	400
High steppes	250	250	
Saharan Atlas	200	200	400 - 700
Northern Sahara	50	50	150

The wettest regions are in the northern part of the Tell Atlas, a zone of mountains rising directly from the sea (Atlas of Blida, Djurjura, Petite Kabylie).

Almost everywhere the dry season is from May to September inclusive. It becomes increasingly less distinguishable as the annual rainfall declines. In an average year Algeria receives about 65 billion m^3 of rainfall.

Northern Algeria has a Mediterranean climate, but with continental features in the areas far from the sea and protected from its influence by the coastal mountains. There is almost no rainfall in summer and it is unevenly distributed in time and space during the rest of the year. The eastern Tell, with its fairly high elevations, is very wet. The Tell of Oran, in contrast, is hot and dry. The high plains of Constantine are well watered and surrounded by mountains from which the waters flow towards the plains. The high plains of Algier and Oran have a relatively low and irregular rainfall. The Sahara is extremely arid. It is situated entirely to the south of the 200 mm isohyet. Of the whole of the territory of Algeria, only the central and eastern coastal zones and a few very mountainous areas in the interior receive more than 600 mm of rainfall per year.

Surface water

Algeria's flow systems are determined by the abrupt and fragmented nature of the relief, the narrowness of the Tell band, and the climate; the watercourses are irregular, the commonest type being the wadi, a succession of streams rather than rivers, which are rarely perennial. In winter the flood waters are violent and carry down large quantities of solid material; in summer the majority of the wadis are difficult to regulate.

Dams are expensive and they accumulate a lot of sedimentation. Surface-water flows occur mainly in the northern part of the country over an area of about 300,000 km^2 north of the line Bechar-Laghouat-Biskra. Typical features of these flows are:

- The extreme irregularity of the inflows from season to season and year to year;

- The violence and swiftness of the flood waters;

- The large amount of solid material carried down.

These characteristics make it difficult to exploit the hydrometric network and to interpret the measures taken, so that there are big gaps in the series of observations.

Hydrographic network - made up of 17 drainage basins which can be placed in three categories:

i) The basins flowing into the Mediterranean

These are the basins of the wadis which drain the Tell Atlas and the Sahelian coastal basins. They cover 130,000 km^2 and receive an annual rainfall of between 400 and 1,500 mm.

They deliver to the Mediterranean about 12 billion m^3/year.

From west to east they are: the Tafna, the Macta, the coastal basins of Constantine ,the Kebir Rhumel, the Seybouse and the Medjerda.

ii) The endorheic basins of the high plains

They cover some 100,000 km^2 and receive an average annual rainfall of 300 mm. Much of the surface water of these basins is lost through evaporation in the chotts.

From west to east they are: the basins of Chott Chergui, Chott Zahrez and Chott Hodna and of the high plateaus of Constantine.

Their potential is estimated at 750 hm^3/year.

iii) The Saharan basins

The surface water found in the Sahara comes from the wadis which drain the Saharan slopes and the Great Atlas in Morocco (Chott Melrhir, southern slopes of Mts. Ksour and Guir). The basins cover 100,000 km^2, receive between 100 and 300 mm of rainfall and deliver to the Sahara an annual average of about 700 hm^3 in the form of very irregular floodwaters.

Hydrometric network - The first stations in Algeria's hydrometric network were established in 1924.

This network has been steadily developed:

- In 1950 it had 40 stations operated by four hydrological teams;

- In 1968 immediately before the three-year plan it had 77 stations operated by seven teams.

In 1982 the hydrometric network had 220 stations operated by 25 teams which unfortunately provided somewhat imprecise data for a long series of annual observations.

Surface-water potential - The figures given in the table below are based on analysis of data taken from the hydrometric data bank established by DEMRH (Department of Environmental Studies and Hydraulic Research) and they constitute a stock of information equal to 3,000 station-years.

For the tributary basins of the Mediterranean which are controlled before they reach the sea DEMRH has tried as far as possible to reconstitute the natural discharges by adding to the observed yields the amounts held back by the reservoir dams.

However, low-water river intakes have not been included.

ALGERIA

SURFACE-WATER POTENTIAL

Drainage basin	Sub-basins	Millions of m^3/year	Drainage basin total in millions of m^3/year
Tafna			315
Macta			250
Oran coastal			50
Cheliff	Above Boughzoul	240	
	Below Boughzoul	1,400	1640
Algiers coastal	Mazafran	350	
	Harrach	280	
	Sebaou	980	1610
Isser			495
Soummam			684
Constantine coastal	East Kebir	800	
	West Kebir	330	
	Saf Saf	240	
	Guébli	500	
	Jijel coastal	1,400	3270
Kebir Rhumel			550
Seybouse			496
Medjerda	Medjerda	190	
	Mellegue	80	270
Chott Cheroui			240
Zarhez			60
Chott Hodna			250
High plains of Constantine			200
Chott Melrhir	W. Djedi	100	
	South Aures	180	280
Saharan Atlas			150
Guir			200
TOTAL:			11,010

II. GEOLOGY

Summary geological background

Algeria has two main geological regions. The African tableland of the Sahara and the Mediterranean fold region: the Atlas Mountains. The geology of the Atlas has evolved through the following phases:

In the Paleozoic era, during the period from the Ordovician to the Middle Carboniferous, the land was covered by the sea. Then, especially in the Permian-Triassic era, it passed through alternate continental and lagoonal phases. A process of marine sedimentation began at the beginning of the Jurassic and lasted until the end of the Cretaceous period. The banks of the sea were displaced north-south and south-north, and the depths of the sea declined from north to south. The sedimentation processes in the Cenozoic era underwent many changes.

The main tectonic phases were as follows:

The beginning of the Mesozoic era saw the formation of the marginal trench of the southern Atlas which separates the northern and southern parts; geosynclinal development began in the north, and platform conditions persisted in the south.

During the Mesozoic and Cenozoic eras the Algerian Atlas was subject to the influence of Hercynian (two phases) and Alpine (five phases) tectogenesis.

The last phase of Alpine folding, of Astian age, played an important role in the rejuvenation of the relief and the development of fissuration and karstic phenomena, as well as in the creation of saliferous domes and lodes. These processes have left their imprint on the present geological structure.

Stratigraphy

The Precambrian granitogneiss basement rock outcrops in the western Sahara (Eglab) and central Sahara (Hoggar). It is overlain with Paleozoic sedimentary formations, mainly of marine origin and Cambrian to Carboniferous age, which are characterized by Hercynian orogeny. These formations outcrop: in the west, at the periphery of the Tindouf basin; in the centre, north of Hoggar, in the "Tassili enclosure"; in the south-west, at the eastern edges of the Taoudenit basin; in the north-west, in the basins of the Saoura and the Bechar.

In the most depressed parts of these basins the Paleozoic sediments are overlain by three sedimentary systems: "intercalcated continental", Cretaceous and Tertiary. The intercalcated continental is a complete thick series (up to 1,000 m) of Post-Carboniferous to Precenomanian age. These are detrital formations of sand, sandstone and conglomerate with lenticular intercalations of marl. These facies are similar to those of the nearby Albian continental formations in the Saharan Atlas and on the high plateaus, with a thickness of 50 to 1,000 m. Cretaceous (marine) and Tertiary formations occupy the centre of the basins; they constitute enormous tablelands - the hammadas - and they are often totally covered by the sandy formations of the ergs.

A major accident separates the African tableland of the Sahara from the fold area of the Maghreb (or Mediterranean), which is also called "Berbérie" by geologists. The Berbérie is a geosyncline affected by two orogenic phases in the Eocene and Miocene periods. The geological formations found there are mainly of Jurassic age in the western part of the Atlas and of Cretaceous age in the east. Bordering the Mediterranean small crystalline and Paleozoic massifs are found in the Kabylies on the edge of the geosyncline.

Here the Jurassic formations can be 3,000 to 4,000 m thick. They include deep-sea clay sediments and dolomitic limestones which form thick tablelands and folds in the region of Tlemcen and the Saida mountains.

Three-quarters of the mountains are composed of Cretaceous formations - limestones, schistoid marls, red sandstones, clays; they reach their maximum thickness (3,000 to 6,000 m) in Hodna. The high plateaus are generally covered by continental formations of Cretaceous age.

The Tertiary period (thickness 1,000 to 3,000 m) is represented by phosphated limestones and paleogenic sandstones and marl-schists and by various neogenic formations of lacustrine and continental origin which border the depressions, especially the interior plains (Chéliff, Mitidja).

The tectonics of the Berberie is complex: the fols, drifts and warps are very numerous and closely packed, especially in the Tell Atlas.

III. GROUND WATER

All types of aquifer are found in Algeria by virtue of the diversity of the geological formations and structures.

A trial classification of these aquifers based primarily on geological, lithological and morphological criteria is given below. First it is necessary to describe one of the dominant features of the country's groundwater resources: the great potential which allows intensive exploitation by groups of boreholes is associated with two main types of aquifer which are, in order of importance:

- A number of extensive limestone formations, unconfined or confined (Chott Chergui, Saida platea, Tolga aquifer);

- The great subsided plains covered with a thick layer of alluvial fill which are wellfed both by precipitation and infiltration of water from the wadis which cross them (plains of Algiers, Bel Abbes, Mascara, Maghnia, Annaba and Chéliff).

Apart from these two main types and the big aquifers of the continental formations of the Sahara, the exploitation of ground water is severely limited by several factors:

- The very abrupt relief of northern Algeria;
- The fragmentation and compartmentalization of the reservoirs due to erosion and tectonics;
- The aquifers' lack of depth;
- The low unit yield of the boreholes, which means that many must be drilled in one place, with the associated high costs (this is true of the Pliocene Quaternary fill of the high steppes);
- The risk of salination of the aquifers bordering the sea or in the vicinity of closed depressions (chotts and sabkhas).

Aquifers - trial classification

There are six standard categories, in order of increasing actual potential:

Type 1 - small isolated aquifers drained by weak contact and adjacent springs with their source in superficial alluvial or colluvial deposits, usually perched and eroded, dating from the Pliocene or Quaternary periods.

The discharges of the (isolated farm) wells are low, as is their total potential.

The reserve capacity is nil and the springs usually run dry in the dry season.

Type 2 - Aquifers in relatively thick alluvial plateau formations or in the fill of endorheic depressions in the high plains.

They are usually large in extent and thickness, especially in the high plains. However, with rare exceptions, the unit yields of the wells are low and they do not furnish large volumes at any one point. The water must therefore be exploited by a large number of scattered wells. The total potential is high owing to the large amount of rainfall. All these aquifers are drained either close to the soil or through the hydrographic network (the case in the coastal aquifers), or at deeper levels towards the evaporation surfaces of the closed depressions of the high plains of central Algeria known as chotts.

Type 3 - Narrow alluvial aquifers lying along major watercourses and in direct hydraulic contract with them.

The transmissivity, and therefore the yields of the installations, is high and the reserve stocks low. These aquifers can be intensively exploited, but the exact scale of their connections with the wadi must be known and the reserve capacity of the alluvial mass must be used to the maximum in the case of seasonal agricultural exploitation.

Particularly good examples of this type of aquifer are found in the valleys of Kabylie: Wadis Isser, Sebaou and Soumman.

Type 4 - Extensive limestone or dolomitic massifs with karstic circulation.

These aquifers usually receive heavy infiltration, in the order of 20 per cent of the rainfall, but their exploitation by boreholes is difficult owing to the heterogeneity of the fracturation which produces extremely variable unit yields. Thus they can be directly exploited only in favourable sites, in particular tectonized or subsided zones. Moreover, their unconfined part is often in a zone of abrupt relief and difficult access. The confined part, at the edges of outcrops, is usually worth exploiting. However, this exploitation is limited in practice, for tectonic accidents rapidly produce major displacements and, in view of the depths to be reached, the cost of the boreholes quickly becomes prohibitive.

In most cases this type of aquifer is well drained by powerful springs which can only very rarely be regulated by pumping. However, two aquifers are important exceptions to this general situation:

- The buried karst of the Ziban region west of Biskra which is exploited only in its confined part by artesian boreholes;

- The dolomitic aquifer of Chott Chergui, where all the resources can be exploited in one place in a favourable zone where the aquifer is overlain by a lens of extremely permeable limestone which serves as a drain for the whole of the dolomitic aquifer.

Type 5 - Aquifers based in the alluvial fill of the great subsided plains.

These are by far the most important aquifers in northern Algeria. The plain of Algiers where the sand and gravel fill reaches thicknesses of over 100 m is the best example. In general terms, these aquifers are unconfined for most of their extent. They are usually found in the Tell zone, where the rainfall is heavy, and are in constant hydraulic contact with major wadis.

The unit yields of the boreholes are variable owing to the heterogeneity of the fill. However, some zones can be tapped over a large area. For example, the two exploitation zones of Bas Mazagran should be supplying, through 35 boreholes, close to 2 m^3/s to the city of Algiers by 1990.

The reserve capacity of these aquifers is very high: their large stocks make it possible not only to control the dewatering rates over the year but also to compensate for the irregularity of recharge from year to year.

Type 6 - Very extensive and thick aquifers with extremely high geological reserves in comparison with the exploitation stocks.

This type of aquifer is represented by the "terminal" and "intercalated" continental complexes of the Sahara. In this type of aquifer the only real problem of exploitation is the management of a stock which is very large in comparison with the annual rate of recharge and which must be exploited in a planned manner so as to ensure economically acceptable use at all points. A knowledge of the geometry of the reservoirs and the economic conditions of exploitation is essential for the determination of the various items in the water balance.

Ground-water resources

For the purposes of evaluation of ground-water resources, northern Algeria has been subdivided into 107 hydrogeologically homogeneous regions. These regions are usually drainage basins or sub-basins. Some isolated mountainous regions, such as small coastal basins where agricultural and urban development is insignificant, have been excluded.

It is rare for there to be no correlation between hydrographic and hydrogeological basins. Some notable exceptions are the upper Tafna basin, the aquifer of the dolomitic plateau of Saida, the upper Rhumel and the chott region.

Almost all the big alluvial plains and the extensive limestone massifs have been the subject of full hydrogeological studies. In terms of exploitable volume, this means almost 70 per cent of the total resources of northern Algeria.

For other zones with clearly lower potentials, the fragmentary information collected from isolated drilling and geophysical prospecting is still not sufficient for regional summaries to be made. For these zones and for the sparsely populated and little developed mountainous regions, global estimates have been made for a number of hydrogeological basins on the basis of rainfall-infiltration ratios. This method, whenever it has been possible to verify it by means of complete studies, has given good results in the determination of the total infiltration in a basin. It is based on the following principle: for a clearly delimited hydrological basin, without underground exchanges with neighbouring basins, the total flows measured at the downstream hydrometric station correspond closely to the total floodwater runoff and the base flows, which represent the volumes of water passing through the aquifers at any given moment. In the case of a basin subject to hydraulic exploitation, the figure includes the station's upstream withdrawals whether from surface water or from the aquifers.

In addition to a number of hydrological basins which have been properly studied, in their varied climatic, geological and geomorphological conditions, it is possible to draw experimental series of curves linking, for example, total infiltration (base flows) to rainfall for different permeability values of the basins.

Conversely, given knowledge of the average rainfall in a basin and taking into account the dominant lithological and morphological features, it is possible to estimate the basin's infiltration.

The ground-water potential is equal to the infiltration under the following conditions:

- Perfect hydrogeological shelf at the station (or at least knowledge of the leakage rates);

- Identity of underground and surface hydrological basins;

- Aquifers in balance (constant stocks);

- Negligible losses through evaporation.

This method gives the best results for the mountainous regions where there are no evaporation zones of any importance or where the aquifers are small in extent. Moreover it is in these regions where it is needed, for they rarely have hydrometric stations.

The exploitable potentials often represent only a small part of the total potentials, which are shown in the following tables:

GROUND-WATER RESOURCES

Northern Algeria

(hm^3/year)

Drainage basins	Resources	Uses	Remainder
Tafna	44	23	21
Oran coastal	60	47	13
Oran high plateaus	60	60	0
Cheliff (below Boughzoul)	121	73	48
Cheliff (above Boughzoul)	82	82	
Zarhez	20	20	
Algiers coastal	343	388	45
Constantine high plateaus	56	35	21
Isser	31	31	0
Sebaou	50	50	0
Soumam	100	100	
Hodna	133	133	
Kebir Rhumel	80	58	22
Seybouse	20	10	10
Constantine coastal	88	56	32
Chott Melrhir	233	215	18
Macta	182	100	82
Medjerda	25	15	10
TOTAL	1 728	1 496	322

Region	Drainage basins	Potential (hm^3/year)
NORTHERN ALGERIA	Tafna	44
	Macta	182
	Oran coastal	60
	Oran high plateaus	60
	Cheliff	203
	Zahrez	20
	Algiers coastal	343
	Isser	31
	Sebaou	50
	Soummam	100
	Hodna	133
	Constantine high plains	56
	Constantine coastal	88
	Kebir Rhumel	80
	Seybouse	20
	Chott Melrhir	215
	Medjerda	25
SAHARA	(Albian)	1032
	(Tertiary)	610
TOTAL		3352

The tables below show that Algeria's renewable ground-water resources amount to 3.3 billion m^3/year, distributed as follows:

Region	Resources (hm^3/year)	Use (hm^3/year)	Remainder (hm^3/year)	Date (estimage)
Northern Algeria	1 700	1 500	350	1974
Sahara	1 600	600	1 000	1970

Thus the rate of resource utilization is about 85 per cent for northern Algeria and 37 per cent for the Sahara. It has in fact increased since these last surveys were made.

Water resources of the Algerian Sahara

The ground-water resources of the Sahara are found in two big geological complexes.

- The intercalated continental clay-sandstone complex found throughout the northern Sahara; its very great extent and average thickness of several hundred metres make it a considerable reservoir. The annual recharge of this aquifer, although low in terms of the exploitable geological reserves, is evaluated at 8.5 m^3/s. It is effected through distribution from the wadis flowing down from the Saharan Atlas and through direct infiltration of rainfall on the Great Western Erg and the plateau of Tademait.

The natural outlets are, in the west and south-west, the springs of Touat-Gourara-Tidikelt, which explains the foggaras and the evaporation zones which mark these regions. In the north-east, towards the coastal zone of Tunisia, the outlets are in the fault areas of El Hamma and Medenine.

The artificial outlets are the foggaras of Touat-Gourara-Tidikelt in the west and south-west, and some one hundred boreholes, of which seven are very deep (about 1,500 m).

This aquifer's water balance has been studied on a mathematical model. The present exploitation is 6.5 m^3/s.

- The terminal continental complex which has several levels: Senonian Carbonic (especially Maestrichtian), Lower Carbonic Eocene, and sandy Miocene-Pliocene.

The corresponding aquifers are in more or less close hydraulic contact depending on the location and can be considered as a single recharging aquifer under the Miocene-Pliocene clays. The boreholes are artesian in the centre of the basin. The aquifer is unconfined at the edges. It is generally shallow or of moderate depth (100 to 400 m).

As in the "intercalated continental", the recharge is large in absolute terms but small in terms of the exploitable stocks. It is effected through infiltration of the runoff at the periphery of the basin (Saharan Atlas, Mzab, Dahar) and through direct infiltration of the exceptional rainfall on the Great Eastern Erg, which rests directly on the permeable horizons of the terminal complex.

This aquifer's natural outlets are the springs at the topographical low points, which have now mostly dried up as a result of intensive exploitation, and the evaporation zones represented by the chotts of Ouargla, Wadi Rhir, and Chott Melrhir.

The main artificial outlets are the more than 2,000 boreholes in Algerian territory.

The water balance of the terminal complex is as follows:

- Recharge: 18.5 m^3/s

- Total dewatering: 21.5 m^3/s

- Drawoffs from stocks: 3 m^3/s (between 1950 and 1970)

The water drawn off in the Algerian Sahara and actually used amounts to 8.5 m^3/s.

It thus appears that in 1970 a large part of the drawoff already came from aquifer stocks. These stocks are considerable. They are estimated at $6 \times 10^{13} m^3$, which in theory means continuous yield of 100 m^3/s for 2,000 years. However, overexploitation of this kind would lead to a steady lowering of the piezometric surface in amounts varying according to location, with the maximum amounts close to the big pumping centres and the minimum (possibly close to zero) in certain regions remote from the drawoff points.

From the economic standpoint this steady lowering of pumping levels will mean a growth in investments over time (increase in the number of boreholes and higher pumping costs) and a rise in the unit cost of the water.

The decision to exploit the water resources of these regions depends on economic criteria: the drawoff corresponding to an acceptable investment value and growth rate and acceptable operating costs for a given geographical distribution of present and future drawoff points. It was therefore essential to determine the evolution of the drawdowns at all points of the aquifers. This was the reason for the establishment of the two hydrodynamic models of the ERESS project (Study of the Water Resources of the Northern Sahara).

The exploitation assumptions have been determined on the basis of two different evaluations of the rates of agricultural development through irrigation:

	1971-1980	1981-1990	1991-2000
High assumption	600 ha/year	1,500 ha/year	2,400 ha/year
Low assumption	600 ha/year	900 ha/year	1,200 ha/year

The drawoff increases will be the following for these two assumptions:

Aquifer	Present yield (m^3/s)	Yield forecast for 2000 (m^3/s)	
		Low assumption	High assumption
Intercalated continental	6.5	23	33
Terminal continental	8.5	18	25
TOTAL	15	41	58

The drawoff increase between 1970 and 2000, a very large total amount has been simulated differently according to zone, so as not to cause drawdowns above 40 m, at least in the terminal continental aquifers. The amounts at present exploited in the region of Wadi Rhir have therefore been increased only a little as this zone is particularly sensitive. In contrast, the drawoffs in the El Hadjira region, which receives little attention at present, move from 0.1 m^3/s to 1.6 m^3/s (low assumption) and even to 2.5 m^3/s (high assumption) for the terminal continental aquifer alone.

For the regions in which this aquifer has been extensively exploited, the amounts of water have been simulated on the basis of the intercalated continental.

GROUND-WATER RESOURCES

ALBANIAN SAHARA

Region	Resources m^3/s	Use $m/^3$/s	Remainder m^3/s
El Oued	1,275	0	
Bou Aroua	0,510	0	
El Meghaier	0,700	0,100	
Djamaa	1,659	0,442	
Touggourt	1,170	0,310	
El Hadjira	1,000	0,000	
Ouargla	1,200	0,450	
Hassi Messaoud	1,200	0,230	
Chardala	1,206	0,347	
Zelfana	1,200	0,290	
El Golea	2,900	0,500	
In Salah	3,935	1,123	
Gourar (foggara)	2,148	0,887	
Gourar (non-foggara)	3,840	0,000	
Touat (foggara)	4,363	2,085	
TOTALS m^3/s	28,300	6,760	26,500
hm^3/year	892	214	835

GROUND-WATER RESOURCES

TERTIARY SAHARA

Region	Resources	Use m^3/s	Remainder m^3/s
El Oued	1,313		
Bou Aroua	1,200		
El Meghaier	2,461		
Djamaa	3,755		
Touggourt	3,567		
El Hadjira	1,630		
Ouargla	1,095		
Hassi Messaoud	4,350		
TOTALS m^3/s	19,371	12,600	6,670
hm^3/year	610	390	220

IV. CONCLUSION - GROUND-WATER DEVELOPMENT

Ground water has been used in Algeria since time immemorial: chanelled spring waters (remnants of aqueducts from the Roman and later eras); hand-dug wells, sometimes very deep; underground galleries similar to the kanats of Central Asia, here called "foggaras" (periphery of the Tademait); and even earlier shallow wells in Wadi Rhir.

The exploitation of ground water by means of boreholes underwent great development after the Second World War. There has been rapid hydraulic development since Independence, especially since the Secretariat of State for Water was elevated to the rank of ministry in 1977. Regional study services and drilling enterprises have been established. A very large drilling programme is being carried out both in the north and in the Sahara. The exploitation of ground water is expected to reach 3.5 billion m^3 per year by 2000.

Hydrogeological studies in Algiers are carried out under the responsibility of a "Hydrogeological Service" which is a special unit of the Department of Environmental Studies and Hydraulic Research (DEMRH) attached to the Ministry of Water and Land and Environmental Development.

Hydrogeology was formerly the responsibility of the Service for Scientific Hydraulic Studies created in 1942.

There is a large amount of hydrogeological documentation on Algeria. It includes several hundred monographs and more than 2,000 reports and unpublished technical notes. Hydrogeological maps have also been published.

V. REFERENCES

Canteleev L.Y., Gouloubev, S. M.	Les eaux souterraines de l'Algérie, Ministry of Water Development of the USSR, Moscow "NEDRA", 1978.
Emsellem Y.	L'eau en Méditerranée - Rapport final. Plan Bleu, Expertise No. 2, June 1982.
DEMRH (Achi K.)	Water Resources in Algeria. The first Arab Symposium on Water Resources - Vol. I, Regional Hydrogeology in the Arab World - Part III ACSAD - Damascus 1980.
Cote M.	L'eau en Algérie. Mise en oeuvre et utilisation, in Colloque sur l'eau - University of Constantine, 10-13 April 1983.

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The following are also cited:

UNESCO	Etude des resources en eau du Sahara septentrional (Algérie-Tunisie) - final report of projet REG-100, Paris 1972.
Achi K.	Les ressources en eau souterraines de l'Algérie - 1979.
Margat J.	Les resources en eau du bassin méditerranéen, Aix-en-Provence, 1982, No. 2, pp. 15-19.