

Water resources of GCC countries

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Background

The Gulf Cooperation Council (GCC) contains six countries: the kingdom of Saudi Arabia, Oman, UAE, Kuwait, Bahrain, and Qatar. In general, The GCC countries have a similar socio-economic situation in terms of features and development with the discovering of oil industry and high revenues during the last 40 years. The economy is dominated by oil, which accounts for 90% of merchandise export earnings and the relation between them so strength due to the same history, language, the religion and relatives relations. Natural water resources are in short supply and lack of renewable water resources, while demand for water is growing. The dilemma arises from continuing growth in demand, which is the result of population increase and other social factors, in conjunction with the fact that the region is already exploiting all its annual surface water resources, while its aquifers are becoming depleted in some countries. Desalination plants play a great role in modifying the fresh water shortage. The Gulf countries demonstrates that desalination and wastewater treatment plants technology have developed to a level where it can serve as continuous and reliable source of water with also groundwater at all the time comparable to water source of countries that have natural water resources like rivers and lakes. This region is arid and its countries are already passing the scarcity line that defined by WHO (having renewable water resources $<1000 \text{ m}^3/\text{y}/\text{capita}$). The total area of GCC countries is 2.55 Million Km^2 and they have the same climate with no surface water except south of Saudi Arabia and south of Oman.

Water resources availability situation and demand

Water in the GCC countries is very scarce resource while water is ultimately precious and it situated in one of the most water-stressed regions of the world, have an extremely poor endowment of water resources. From this point, since 1950 all of these countries began develop and built desalination plants and later on wastewater treatment plants to help and sustain the groundwater resources to meet their demand. The GCC countries receive only

scanty rainfall and infrequent with average annual volume of rainfall is 209.93 billion m³ (varies between 75 and 140 mm on the average) while the precipitation is remarkable higher and intensive that reaching about 500 mm at Oman Mountains to the east and Asir Mountains to the southwest of Saudi Arabia whereas average evaporation exceeds 300 mm per year which the rate between 2.5 mm day⁻¹ in winter season to reach the maximum 17 mm day⁻¹ in summer season. In the coastal areas the yearly annual 2500 mm yr⁻¹ and dramatically increase to center of Saudi Arabia to about 4500 mm. The runoff that accumulated from precipitation in winter almost evaporated due to high temperature and the rest of water (less than 20%) recharge the groundwater resources. The total runoff is estimated as 4.83 billion m³ yr⁻¹. Currently, The critical challenge is minimizing the gap between the growth demand and supply which the supply depend on one natural water resources (groundwater) and two artificial water resources (desalination plants and wastewater treatment plants). During the last decade, extensive development rapid population growth and substantial improvement in the standard of living have all led to present imbalance between available water resources and water demands in the GCC and is expected to increase in the future due to development of this region. The estimated

country	Area Km ²	Population (million)	surface runoff (MCM)	Rainwater (BCM)	Annual Evaporation mm	Consumption per capita L/d
Saudi arabia	2149690	28.5	3210	158.47	3500-4500	252
Kuwait	17818	3	0.1	2.27	1900-3500	476
Bahrain	695	0.5514	0.2	0.4	1650-2050	455
Qatar	11610	1.4	1.4	0.47	2000-2700	407
UAE	77700	2.444	150	6.72	3900-4050	770
Oman	300000	2.518	1470	37.6	1900-2700	146
TOTAL	2557513	38.4134	4831.7	205.93	avg. 2500 - 4500	avg. 400

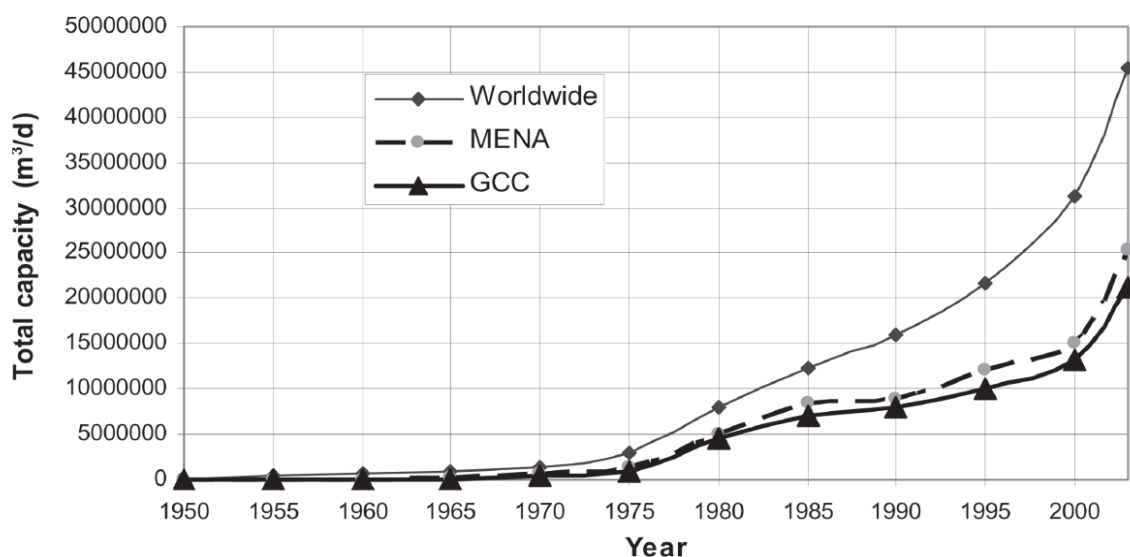
population is 38.4 million with an average growth rate of 3.73%. Population projection will reach 80.570 million in 2025. The total domestic demand for the water is 4070 MCM and the consumption per capita for all of them under 500 l/c/d except UAE above 700 l/c/d. Also, the consumption per capita increase due to expansion in industrial and development of tourism.

Water resources

The main sources of fresh water are groundwater, most of which is non renewable, and a limited amount of renewable near surface water. Non- conventional sources, including desalinated seawater and wastewater treatment.

Desalination seawater plants

It is a strategic option for fulfilling current and future domestic water supply requirements. Experience with desalination plants in many of the Gulf Countries, especially Saudi Arabia and Kuwait began since 1950s. From all the desalination plants in world, 50% of them are taking place in the GCC region.



The desalination technology processes by different way (MSF, MED and RO) and expected to increase in this region to satisfying the demand and drought condition. The use of natural gas as a fuel for desalination makes to be more efficient, less cost and more environmental safe than using the petroleum. In spite of natural gas better than petroleum but releasing a huge amount of gas such as CO₂ has some impact on the environment that might to accelerate the increase in temperature and decrease the precipitation. The potable water that is supplying for domestic is mixing by 90% from desalinated water and the rest from groundwater to be satisfying of TDS level (between 200 -1000 ppm). In order to meet domestic water demands, which is function of population, industrial and urbanization growth, the GCC governments are

going ahead with desalination plants, although their high budgets which range between 1-1.5\$/m³. Table 2 shows the data for the desalination plants in GCC countries.

country	No. Of plants	capacity (MCM)	production(MCM)	Capacity Mm3/day	production Mm3/day
Saudi arabia	23	1278	1063.28	3.50	2.91
Kuwait	6	525.125	478.1	1.44	1.31
Bahrain	3	138	122.7	0.38	0.34
Qatar	2	178	158	0.49	0.43
UAE	8	952	812.61	2.61	2.23
Oman	2	103	67.932	0.28	0.19
TOTAL	44	3174.125	2702.622	8.696232877	7.404443836

Wastewater treatment plants

The reuse of treated wastewater is considered one of the promising sources of water. The annual available water after treated (recycling) and has TDS lower than 1000 ppm is estimated at 0.75 billion m³ and just 34.33% it will use while the rest spill to the sea. The expectation for waste water treatment play important role in future to minimizing the demand with increasing the production to reach 1.57 Billion m³ in 2015. Treating WW for reuse becomes common practice worldwide due to low cost of plants comparing to desalination plants. Most of the water that recycled is using for highway landscaping, enhancement the green lands and recreational activities. In Kuwait and UAE, exists the artificial lakes and they use the treated water to feed them.

country	capacity (BCM)	production(BCM)
Saudi arabia	0.483	0.418
Kuwait	0.229585	0.16
Bahrain	0.058	0.056
Qatar	0.044	0.044
UAE	0.106	0.063
Oman	0.01	0.009
TOTAL	0.930585	0.75

Groundwater resources

There are two types of aquifers in GCC region one is the top in shallow alluvial aquifers and is renewable resources while the below shallow aquifers is fossil aquifers (deep aquifers) and is non renewable. Shallow aquifers depend on the surface runoff and precipitation to recharge them and its thickness varies from about 20 to 200 m. the water quality of shallow aquifers is

good and most of them is potable with TDS between the ranges 200 and 4000 ppm. The other main source of groundwater is non renewable fossil stored in deep sedimentary formation, known as Arabian shelf. Huge amount of groundwater are stored in these deep aquifers with estimated at 2200 BCM out of which about 1920 BCM are located in Saudi Arabia. The bulk of these recourses are brackish quality with great variation in TDS (200 to 200000 ppm). Another feature of GW is quality degradation which the water table drops down due to excessive

country	Total demand MCM	Renewable groundwater MCM	surface runoff (MCM)	Total renewable	groundwater use MCM	% of renewable GW to total renewable water
Saudi arabia	2350	3850	3210	7060	14430	54.53
Kuwait	512	160	0.1	160.1	405	99.94
Bahrain	117	100	0.2	100.2	258	99.80
Qatar	190	85	1.4	86.4	185	98.38
UAE	750	130	150	280	2650	46.43
Oman	151	550	1470	2020	1644	27.23
TOTAL	4070	4875	4831.7	9706.7	19572	71.05

extraction, as a consequence the salinity increase and intrusion of seawater takes place in coastal areas. Several aquifers are already affected by this phenomenon for example Bahrain, Qatar and Oman. The artificial recharge processes are using for improvement the aquifers in GCC countries which can help the quality of the groundwater and recharge the fossil aquifers that are not non-renewable. Also, they are using the aquifers as storage instead using the surface storage by using the rest of the wastewater that spill it to the sea for recharge the aquifers Because problem facing the GCC countries is the vulnerability of desalination plants to pollution and emergency conditions. So, The surface storage at all GCC countries can supply for just maximum 2 days except Kuwait and Saudi Arabia which they can supply for a week and still this period of time do not enough for back the plants to work and the surface storages are not satisfied the demand. All GCC countries have a limited number of large deep aquifers that satisfy to pumping. These contain non-renewable supplies of fossil water. These fossil waters have two limitations: finite lifetime and quality limitations. World Bank estimates that this water resource availability will shrink by half of its current size by 2030 if it does not use the artificial recharge. At the appendix there are figures and gross section for the formation of soil and the groundwater of GCC countries.

Critical issues in GCC countries

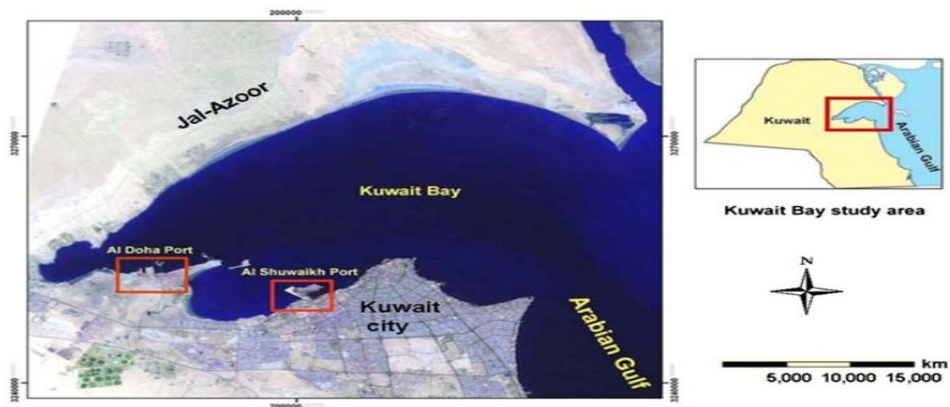
The slightly increase the demand that is consequence for high population growth, which it should consider the growth in demand and expand the capacity of the production by either natural or artificial water resources. Other issues that can be attributed are urbanization development, deficient institutional arrangements, and poor management practices and does not support and rely on the generation youths to solve these issues, water depletion, and deterioration of quality in shallow aquifers.

Table illustrates the Water resources problems and issues in GCC countries.

Problems	Evidence	Causes	Importance
Limited water resources	Depletion of water per capita over the time	-Arid region with infrequent rainfall -Growing population	Socio-economic development slows down
Inefficient water use	-Irrigation losses up to 40 % -Excessive leakage from supply networks -Wasteful water use	-Lack of awareness -Lack of realistic price -Lack of strict regulation -growing water demand	Excessive losses of available water Increasing water scarcity
Deteriorating water quality	-Contamination infiltrate to subsurface -Sea water intrusion -Groundwater depletion	-Discharge of untreated domestic and industrial effluent into subsurface -Over-extraction of groundwater -Lack of strict penalties -Insufficient studies for all the GCC countries	Soil damage Complicated groundwater problems Negative impact on environment
Weak institution	-Duplication of effort -inefficient water management	-Undefined responsibilities -Inadequate technical capacity and training the human resource	Poor water development Lack of decision makers

Climate change in Kuwait Bay

Kuwait relies on the Arabian Gulf to produce the fresh water to meet the demand since 1950s. With all the negative impact that released from the desalination plants to Arabian Gulf but it is still should consider that the desalination plants represent high percentage from the water supply which cannot stop them and just depend on the fresh groundwater that in North of Kuwait. There is study done recently measure the sea surface temperature (SST) for the Arabian Gulf, especially Kuwait Bay by Global, regional and local factors between 1985 and 2002. The Arabian Gulf is a semi-enclosed, shallow body of water. There are three factors affecting mixing of the water column that are tides, winds, evaporation and waves. In the north of the Arabian Gulf is located Kuwait Bay that is a semi enclosed basin with all urban development has been concentrated long the coastal line. It is the most attraction point for all different activity and most the desalination plant located on the south of Kuwait Bay. The data collected by AVHR (NOAA) satellite data in that area, SST in Kuwait bay reaches the maximum in August (36°C) and the minimum in January (11.9°C).



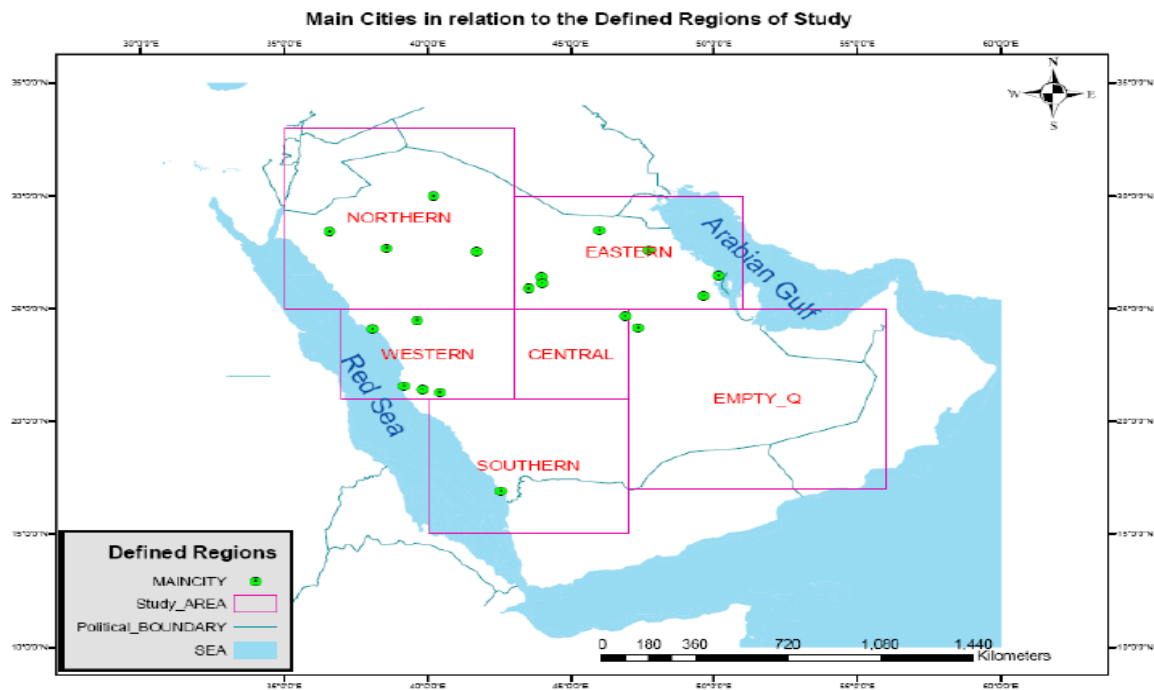
As a result from the three drivers that measures their affected to the SST in Kuwait Bay, The global drivers the more affective on SST of Kuwait bay while the others lead to impact to the environmental and the ecosystem of Kuwait Bay. SST has a rate of $0.6 (+/- 0.3)^{\circ}\text{C}/\text{decade}$ and this increase is three times greater than the global average for SST estimated by the IPCC.

	Kuwait Bay	North Arabian Gulf	Arabian Sea (North Indian Ocean)
SST ($^{\circ}\text{C}/\text{decade}$)	+0.6 (± 0.3) $^{\circ}\text{C}$	+0.5 (± 0.3) $^{\circ}\text{C}$	+0.3 (± 0.2) $^{\circ}\text{C}$
Global drivers	50%	60%	100%
Regional drivers	33%	40%	0
Local drivers	17%	0	0

Source: (Al-rashidi et al. 2008)

Climate change in Saudi Arabia

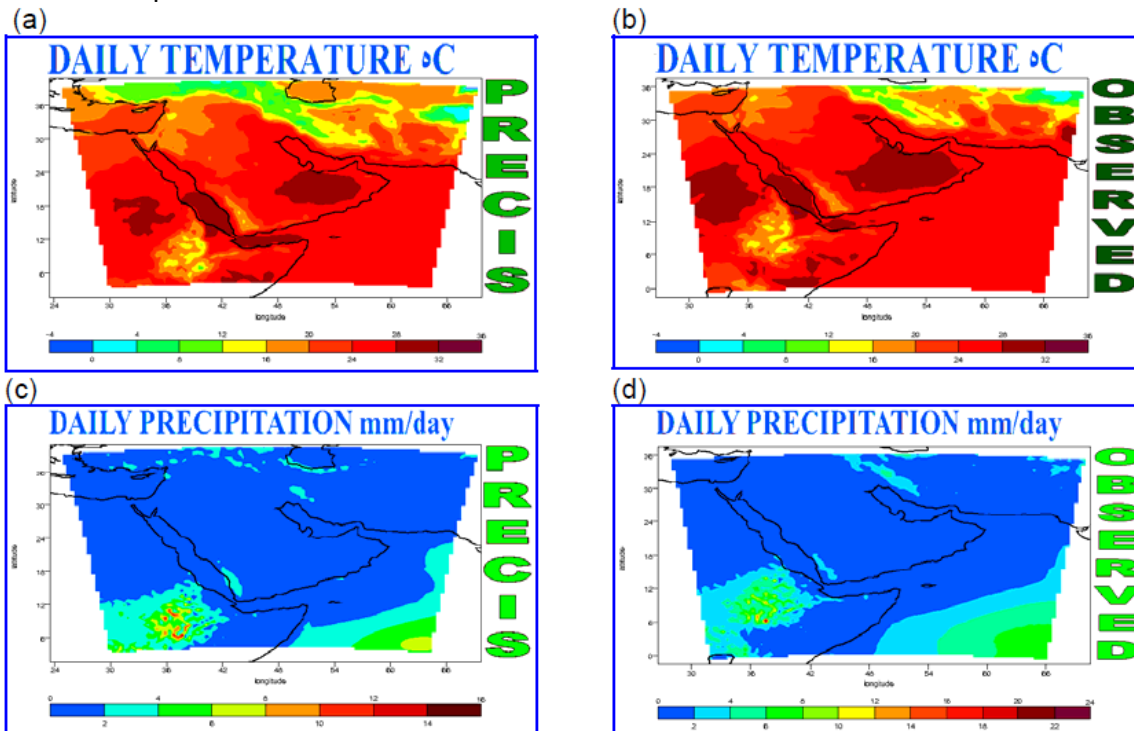
Another study is done in the GCC region for Saudi Arabia which is representing most of land area in this region. The study was assessed and measures the impact of climate change over 6 regions using PRECIS system that is abbreviation for “Providing Regional Climates for Impacts Studies” and there were two scenario designed “ A2 & B2” for evaluate and analysis to determine the impact of climate change on this region at the end of the 21st century.



The table shows Average calculation of the climate change over all Saudi Arabia.

	A2_Scenario	Historical	B2_Scenario	A2_Change	B2_Change	A2_%	B2_%
Temperature (°C)	29.891	25.676	28.709	4.216	3.033	16.419	11.813
Wind Speeds (m/s)	4.274	4.264	4.129	0.01	-0.135	0.234	-3.158
Precipitation (mm/y)	156.148	118.408	128.193	37.74	9.785	31.873	8.264
Evaporation (mm/y)	341.319	320.531	369.401	20.788	48.87	6.486	15.247
Run Off (mm/y)	1.643	0.497	0.964	1.147	0.467	230.823	94.051

PRECIS were used to downscale four types of boundary data 1) from 1960 to 1990 historical data 2) from 2070 to 2100 for A2 scenario 3) from 2070 to 2100 for A2 scenario 4) from 1960 to 1990 reanalysis data. As a result from the high resolution indicates that A2 scenario tends to force high temperature, increasing the precipitation, decreasing the evaporation and more runoff than B2 scenario. The simulated and observed are compared for the selected climate fields for the period 1961 to 1990 for entire Saudi Arabia.



Required Readings

Dawoud, Strategic Water Reserve: New Approach for Old Concept in GCC Countries.

Background Report to Seminar on Water and Energy Linkages in the Middle East, August 2009, Stockholm International Water Institute.

Al Zawad, 2008, Impacts of Climate Change on Water Resources in Saudi Arabia.

AL-RASHED, 2000. Water Resources in the GCC Countries: An Overview.

M.J. Abdulrazzak, Water supplies versus demand in countries of Arabian Peninsula, J. Water Resources Planning Management ASCE, 121(3) (1995) 227–234

Al-Rashidi, 2008. Sea surface temperature trends in Kuwait Bay, Arabian Gulf

Appendix

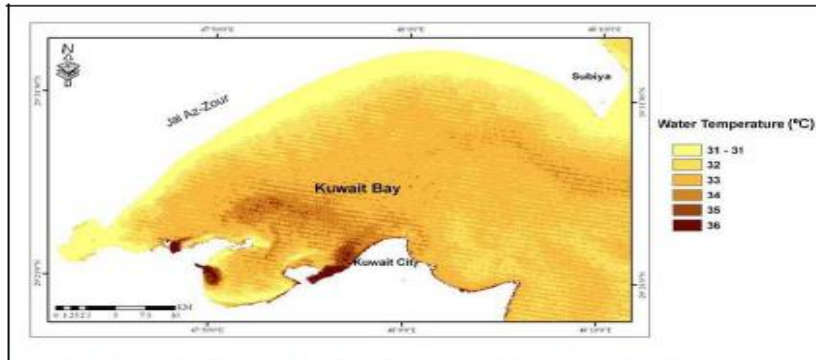


Fig. 5: The predicted SST from Landsat image dated June 22, 1985.

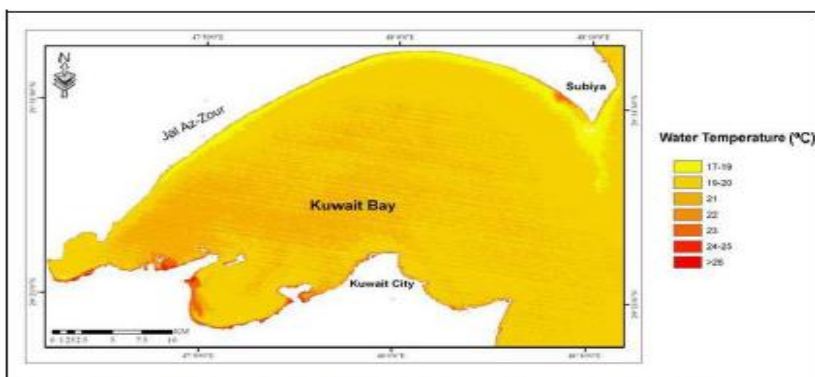


Fig. 6: The predicted SST from Landsat image dated April 29, 2003.

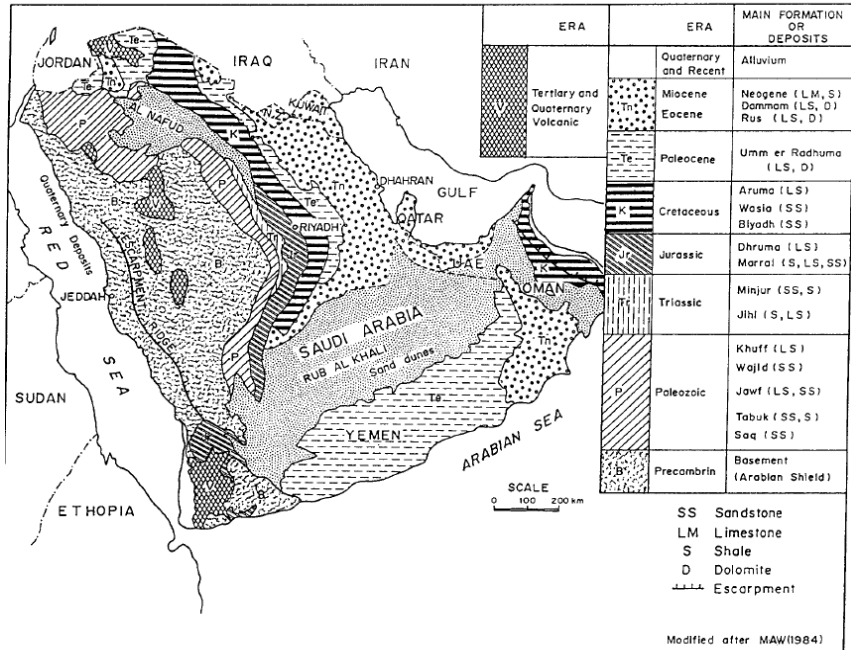


FIG. 2. General Geological Map and Aquifers of Arabian Peninsula

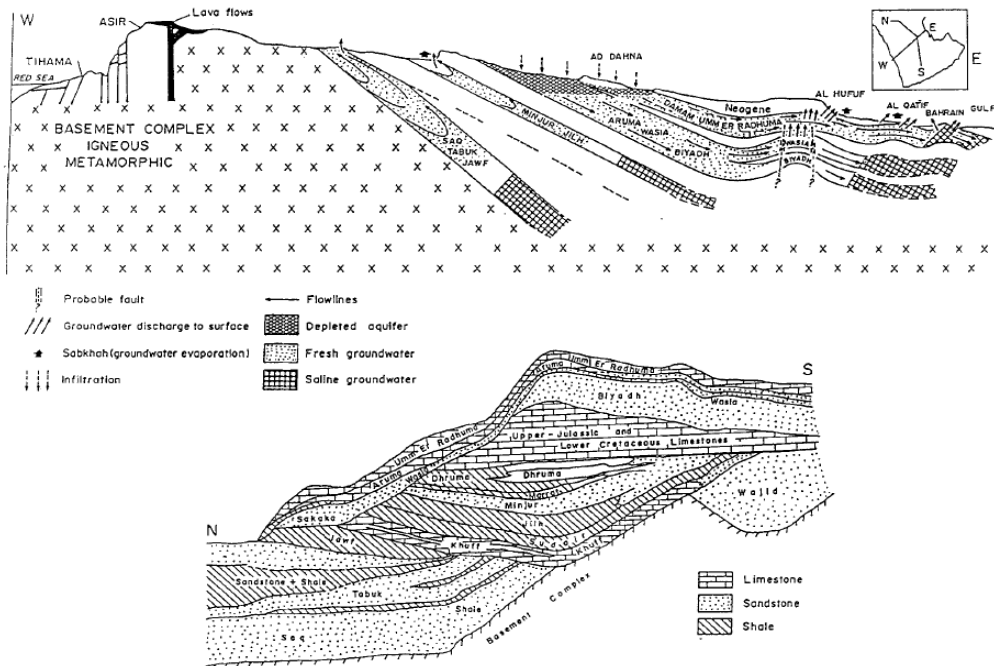


FIG. 3. Schematic Geological Section of Deep Aquifers