

NOT ENOUGH TO GO AROUND:

Battles Over Water Apportionment, Pollution and Replenishment in the Middle East

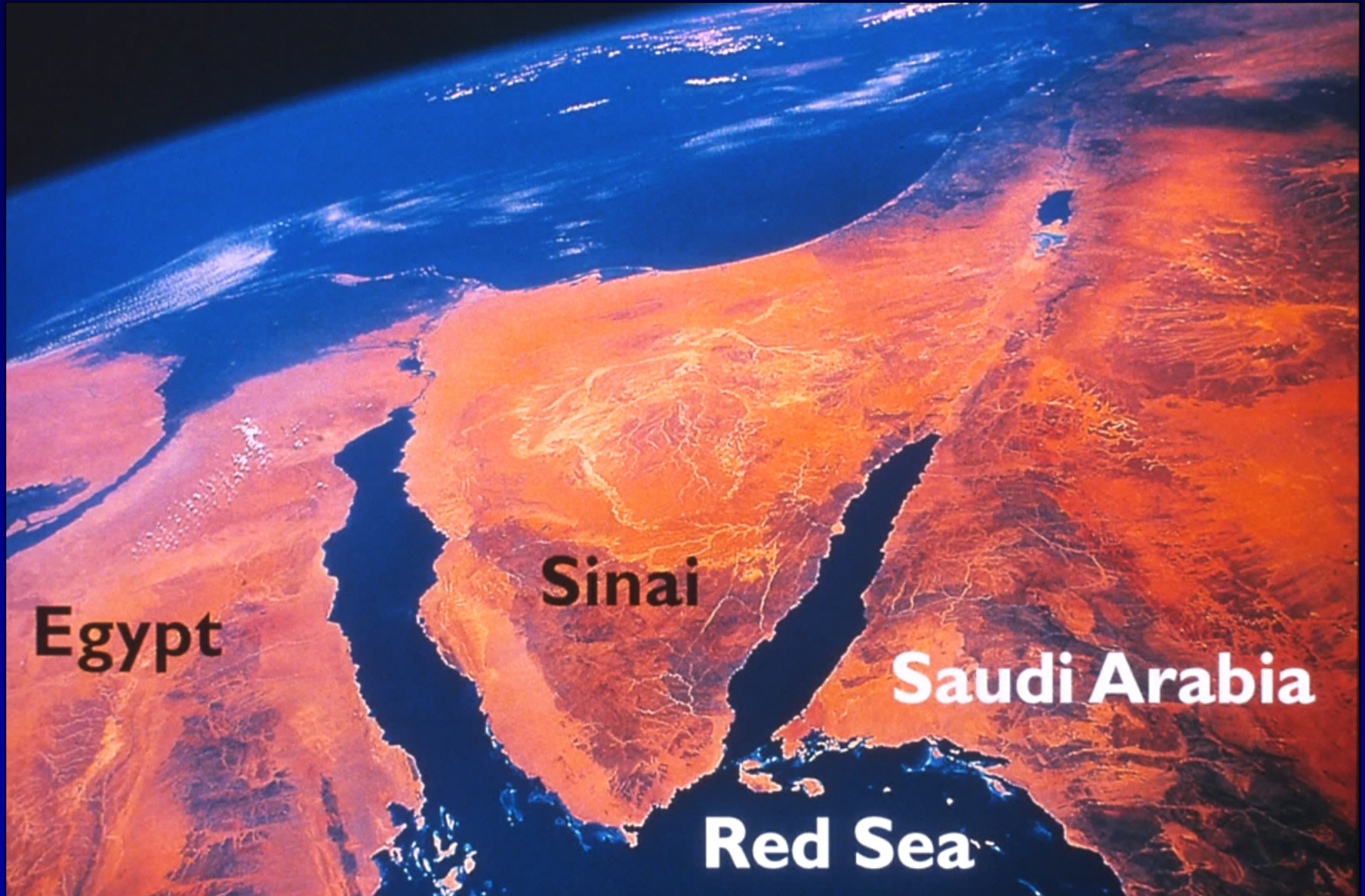
J. David Rogers, Ph.D., P.E., R.G.

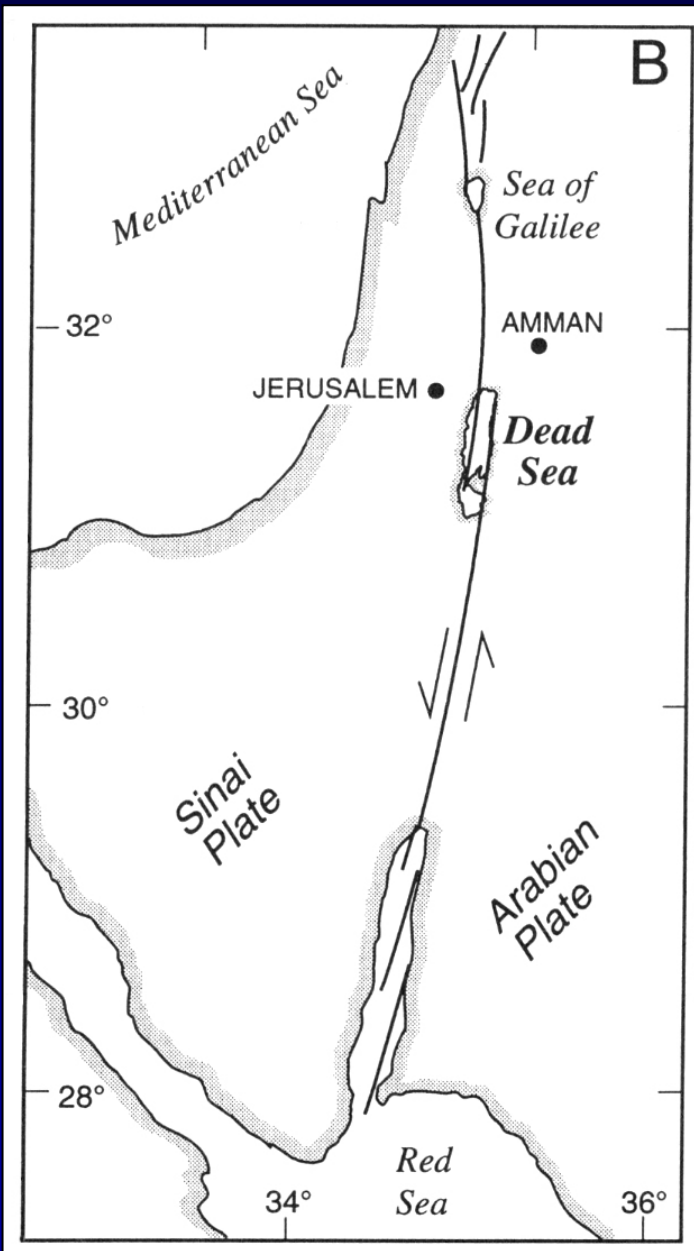
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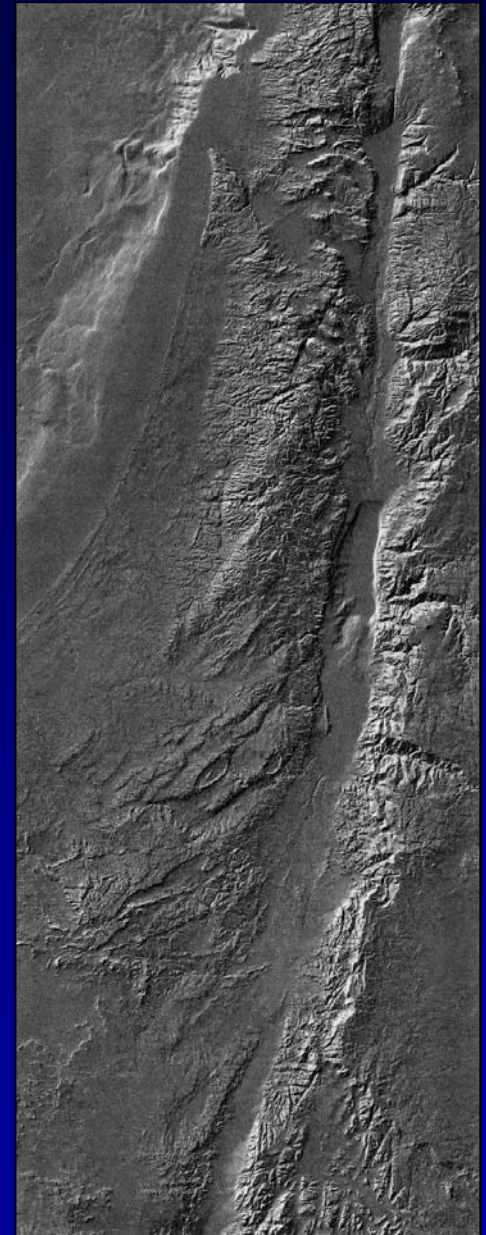
North End of East African Rift Zone





CROSSROADS BETWEEN TWO CONTINENTS

The Jordan River Valley/Dead Sea Transform lies between the Arabian and Sinai tectonic plates, at the north end of the East African-Syrian rift



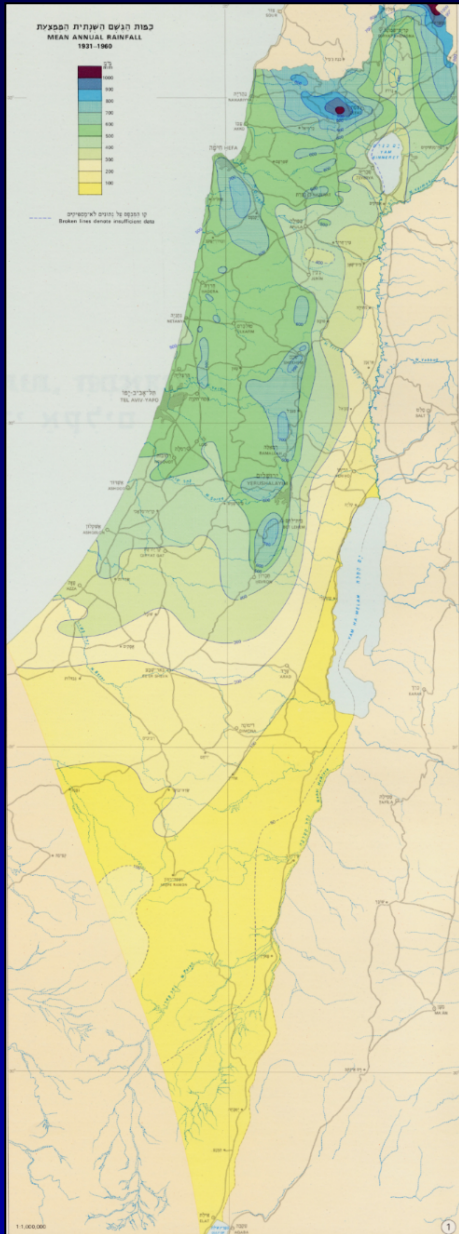
**WATER
RESOURCES AND
POLITICAL
BOUNDARIES**

Jordan River, Dead Sea and Wadi Arava Catchment Area



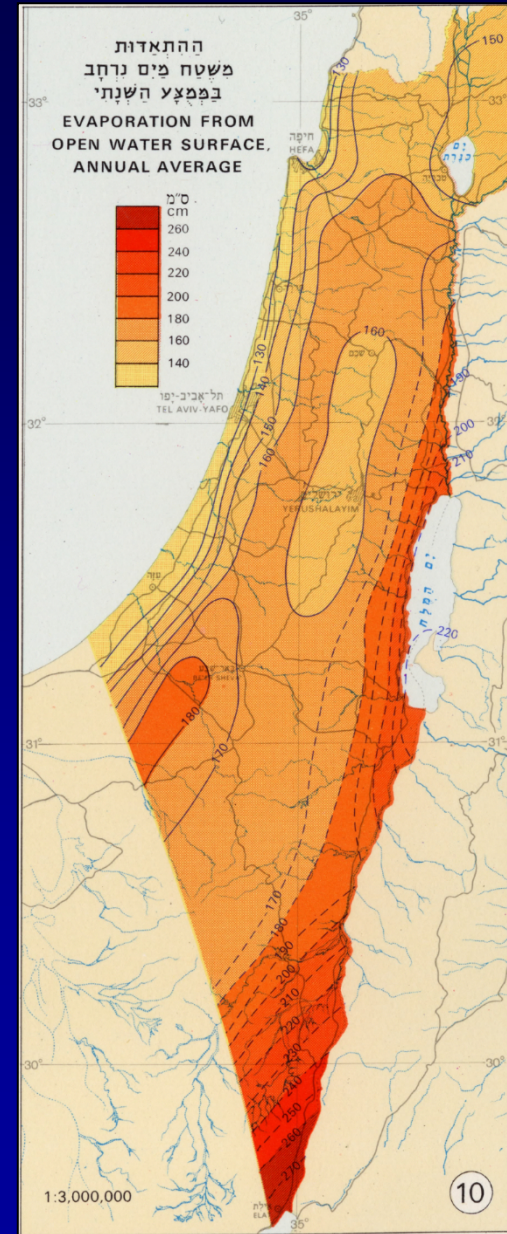
**ISRAEL, JORDAN,
SYRIA, LEBANON,
EGYPT and the
PALESTINIAN
AUTHORITY
are linked by
COMMON AQUIFERS
and
WATERSHEDS**

ANNUAL RAINFALL vs EVAPORATION



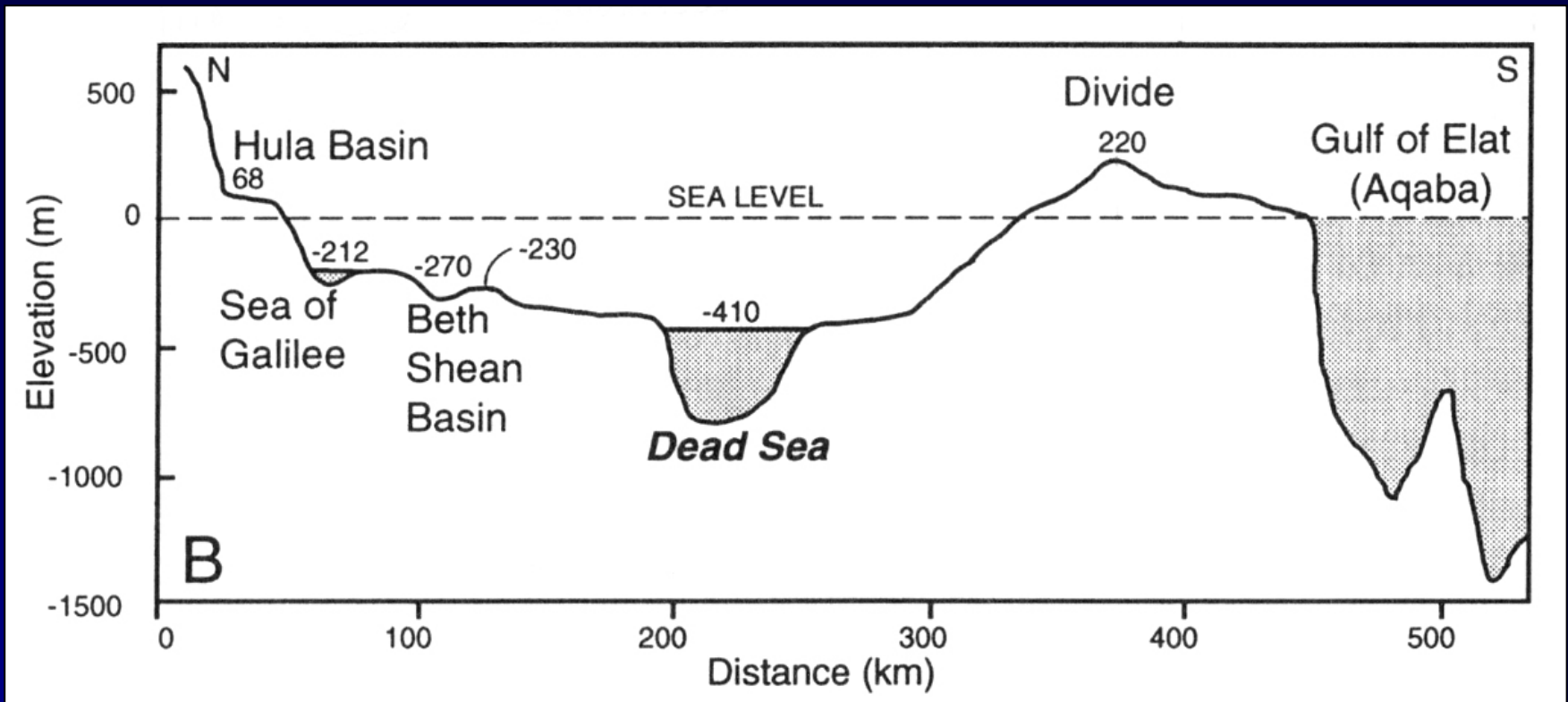
**abundant
water
in the
north**

**little rain
and
lots of
heat
in the
south**





- **The Jordan River is the only significant watercourse in the Holy Land. Born on the slopes of Mt. Hermon (el. 9232 ft).**
- **Three principal tributaries meet in Hula Valley, two from the Golan Heights secured by Israel from Syria in June '67 War**
- **Average annual flow of about 1.5 million acre-feet**



- The Jordan River follows the East Africa-Syrian Rift, flowing southward into the Dead Sea transform, now 417 m (1,368 ft) below sea level
- The dry Wadi Arava flows to the Dead Sea from a drainage divide 220 m (722 ft) above sea level



SEA OF GALILEE

- The Sea of Galilee lies in a down-faulted graben, about 700 feet below sea level
- It covers an area of 64 square miles
- Less than 145 ft deep
- The Sea contains 3,257,690 acre-feet of fresh water (about 70% capacity of California's Lake Shasta)

THE “NATIONAL RESERVOIR”

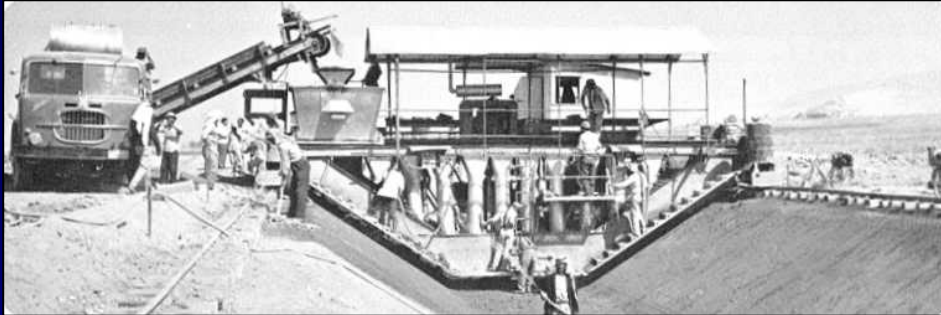


- **The Sea of Galilee [Sea of Kinneret] and Jordan River supply about 75% of Jordan’s and 30% of Israel’s annual water consumption**

THE JOHNSTON WATER PLAN

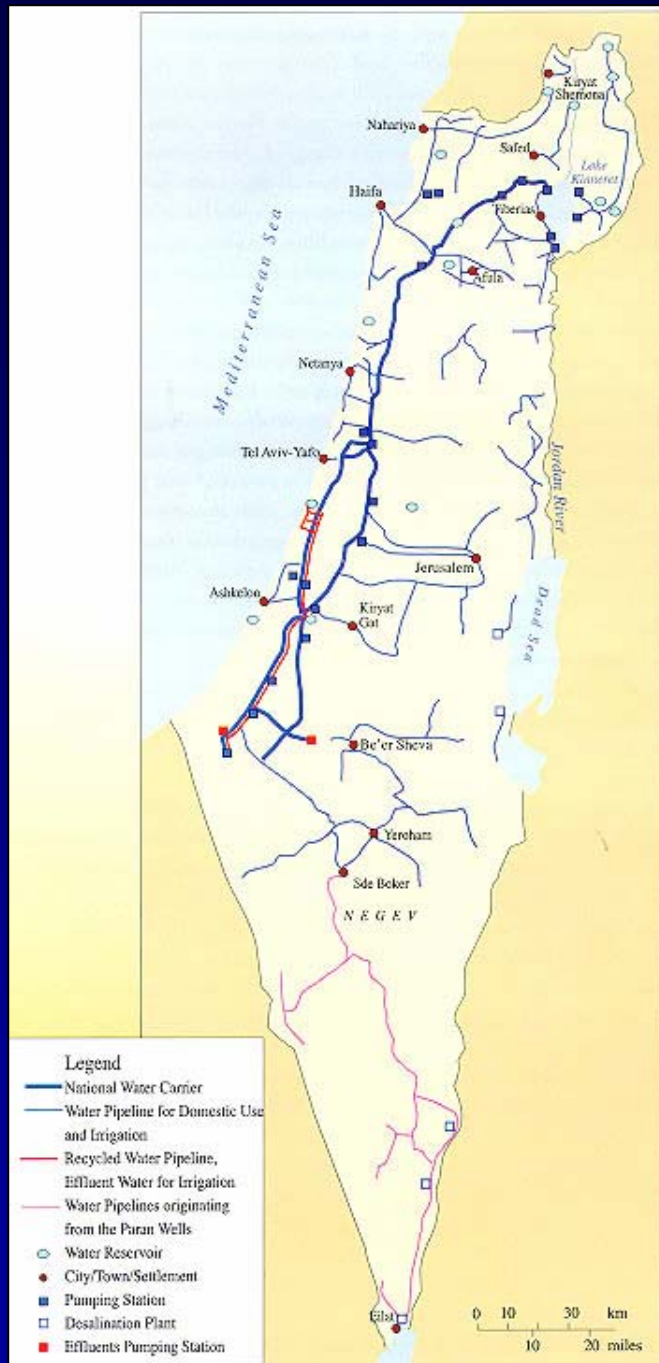
- In 1953-55 U.S. Special Envoy to the Middle East Eric Johnston hammered out a cooperative agreement for sharing the Jordan River system between Jordan, Lebanon, Syria, and Israel.
- The shares of each country were based on how much irrigable land it had, so Lebanon and Syria got the least, even though those two countries produce the most water.
- The agreement was honored for 12 years, from July 1955 until the June 1967 Arab-Israeli War

KING ABDULLAH CANAL



- **Between 1957-1961 the Jordanians built their 110-km long East Ghor Canal**
- **This brings water from the Sea of Galilee to the east side of the Jordan River Valley**
- **Recently renamed the King Abdullah Canal**

ISRAEL'S NATIONAL WATER CARRIER



- National Water Carrier canal is a conveyance and distribution system the Israelis began in 1958.
- Water is lifted 372 m from Sea of Galilee and conveyed southward, into populous areas along the coast and the Negev Desert
- Extended and connected to numerous pipelines since 1964, using intermediary pump stations
- 80% of conveyed water is used for agriculture

MIDDLE EAST IMPASS 1967-1994

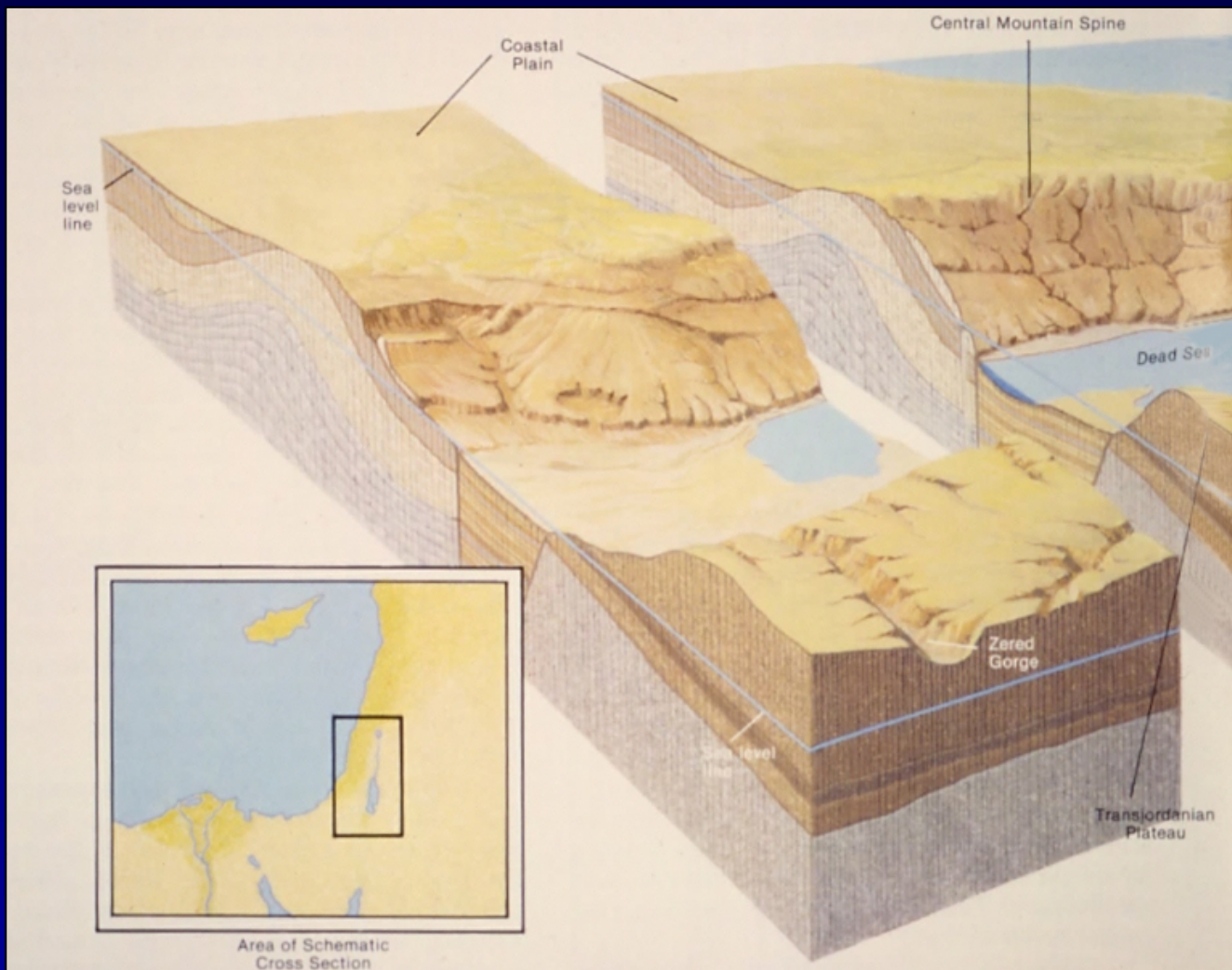


- **The World Bank will not fund water resources projects unless all entities in the watershed agree on a protocol spelling out management responsibilities and apportionment for such developments.**

Forging cooperation between stake holders

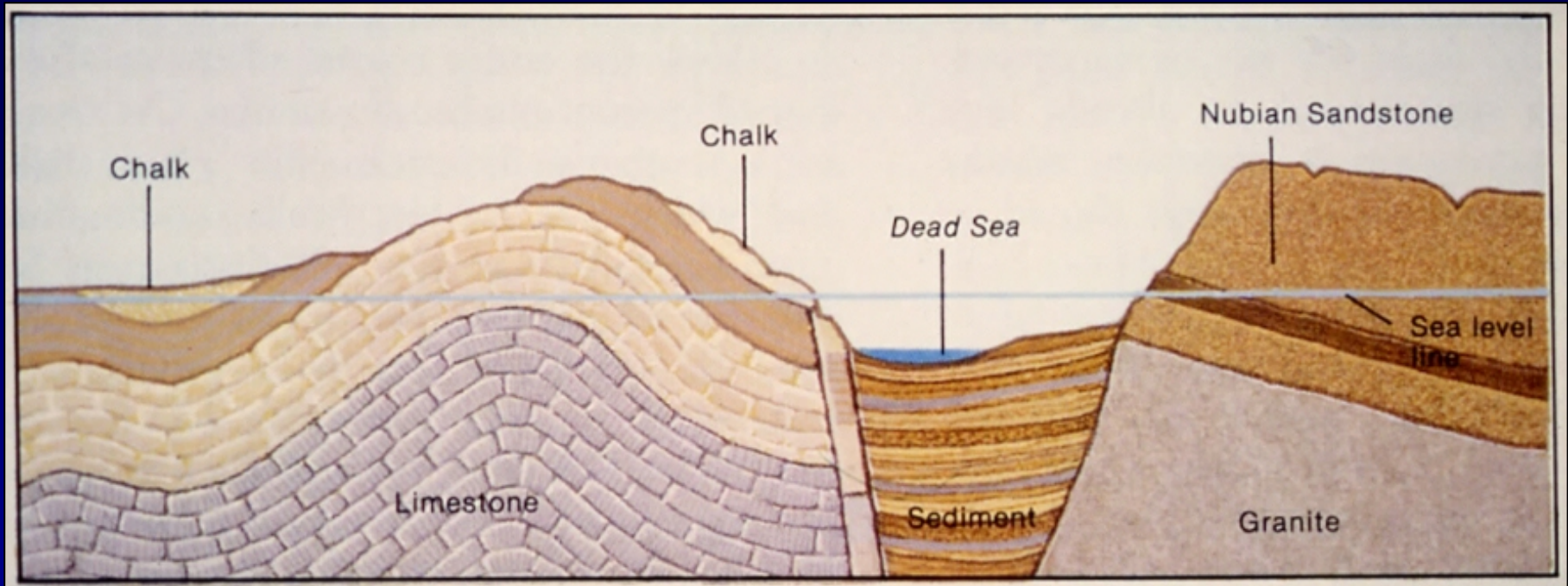


- The Jordanians have been attempting to build the **al-Wahda Dam** on the upper Yarmouk River since 1955. Israel has been able to withhold cooperation because it controls 3% of the watershed.
- In 1999 Jordan and Syria agreed to build the dam using the Arab Fund for Economic and Social Development and the Islamic Development Bank.
- A condition is 40% of the contract monies must go to Syrian and Jordanian subcontractors. As a consequence, the project has stalled.

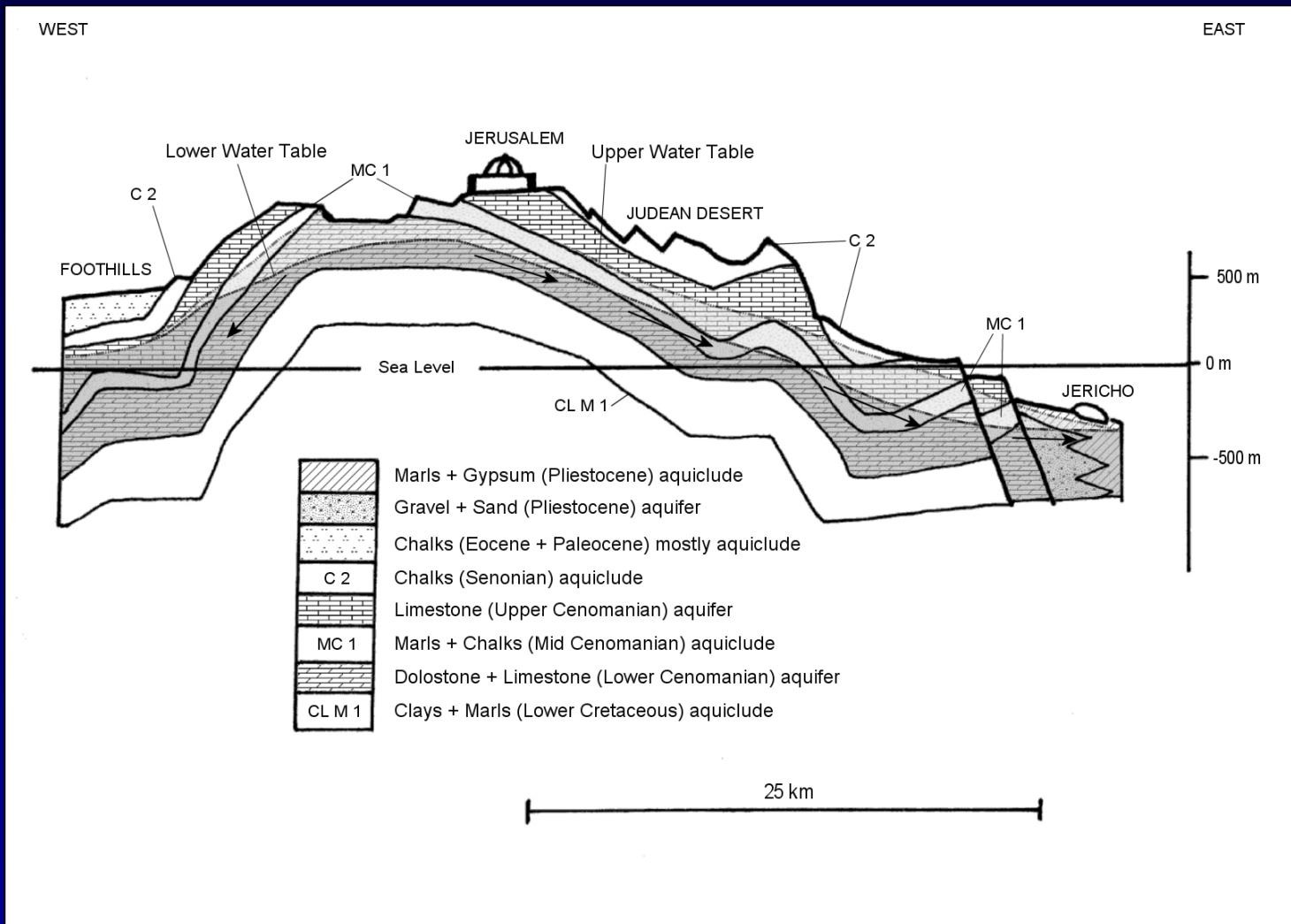


- **Block diagram of Israel, West Bank and Jordan showing the coastal plain, central mountain range, Dead Sea transform, and the Transjordan Plateau.**

GEOLOGIC CROSS SECTION

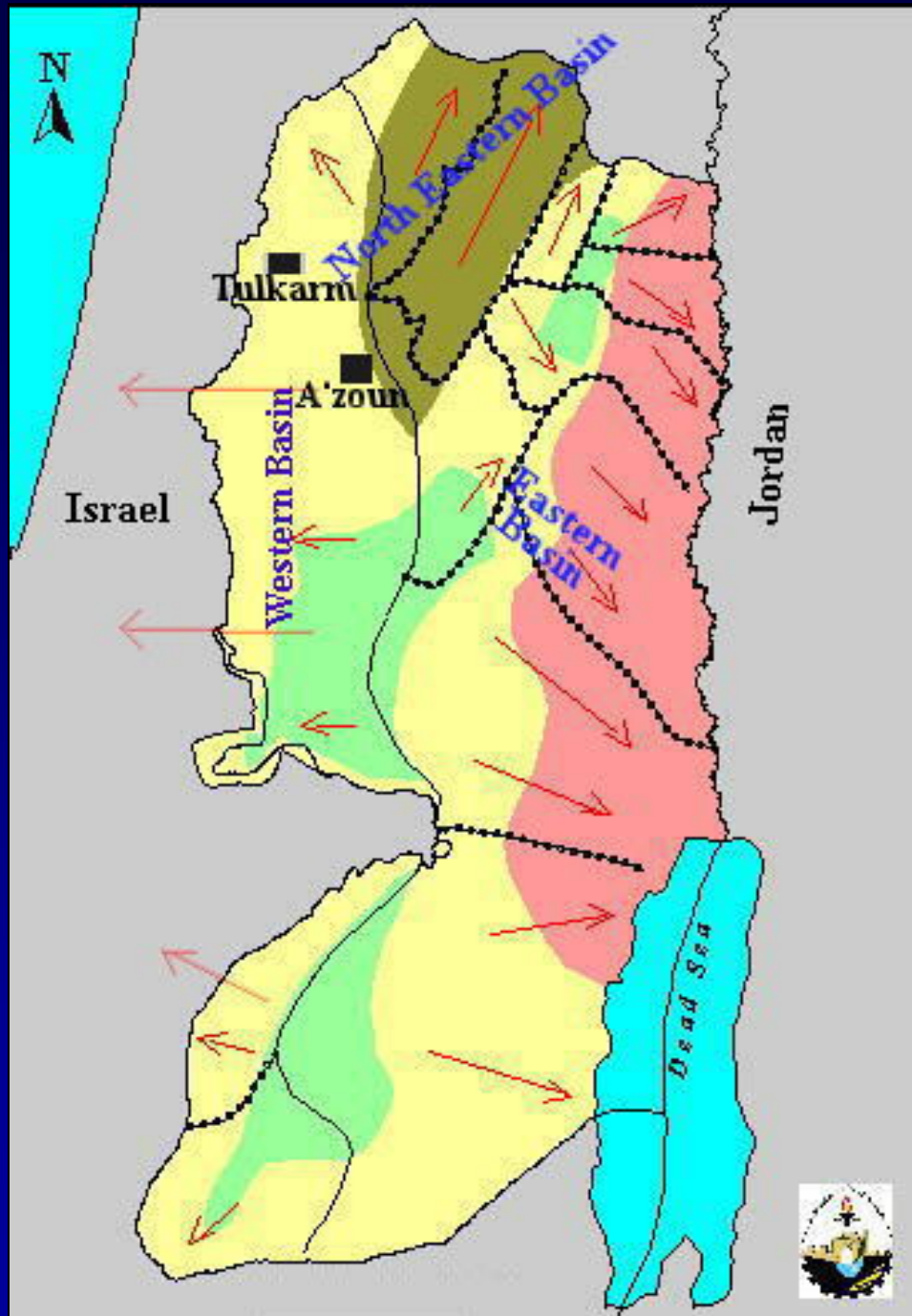


- **Cross section through Israel, the Palestinian Autonomous Authority (West Bank) and Jordan, along the tectonic boundary between the Sinai and Arabian Plates on the Syrian-African Rift. This is the deepest graben on the Earth.**



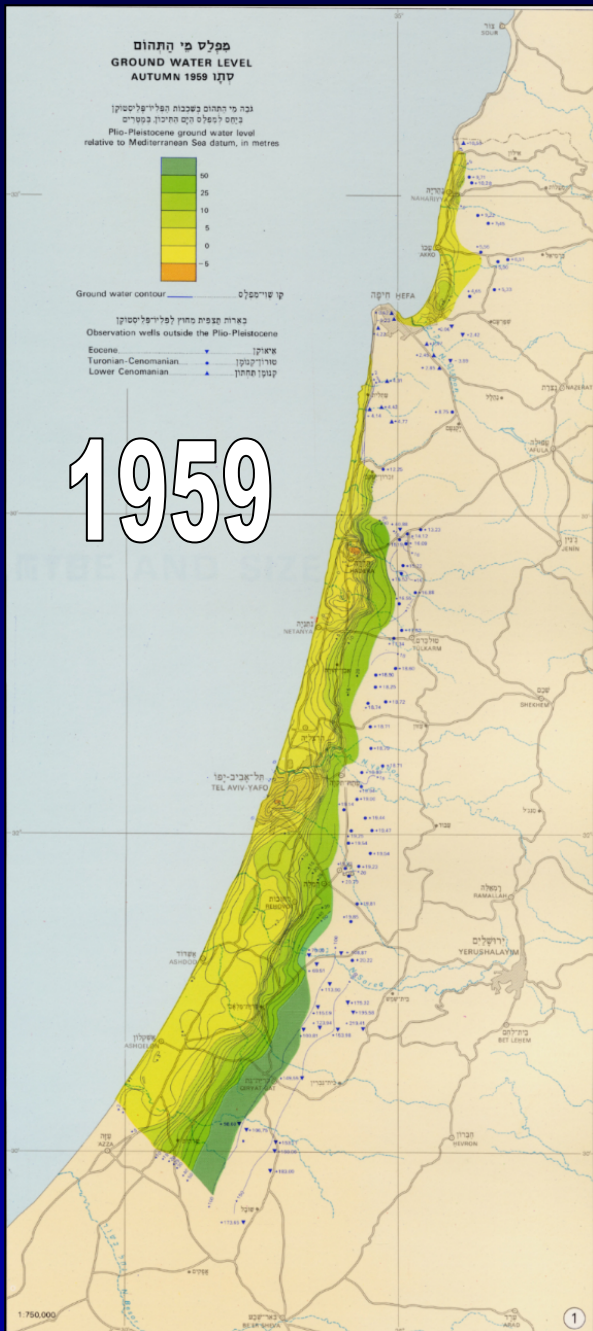
- **Section through the Mountain Aquifer in central Israel. This aquifer has been steadily depleted since 1949. The Israelis have not been able to recharge this area as easily as the units underlying the Mediterranean Coast.**

ISRAEL'S MOUNTAIN AQUIFERS



- These aquifers are formed in fractured limestones along a major anticlinal axis parallel to the Dead Sea Transform
- Groundwater flows away from the axis of the anticline (red arrows)
- Management boundaries for the mountain aquifers area shown at left

**SQUEEZING OUT
EVERY LAST
DROP; AND THE
CONSEQUENCES
THEREOF**



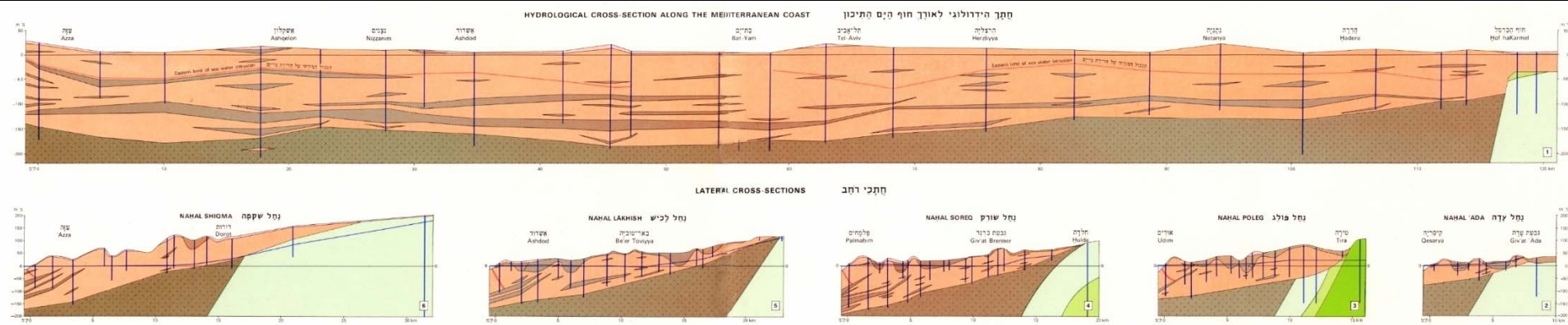
ISRAEL'S COASTAL AQUIFER

Plot at left
shows gwt
above sea
level in 1959

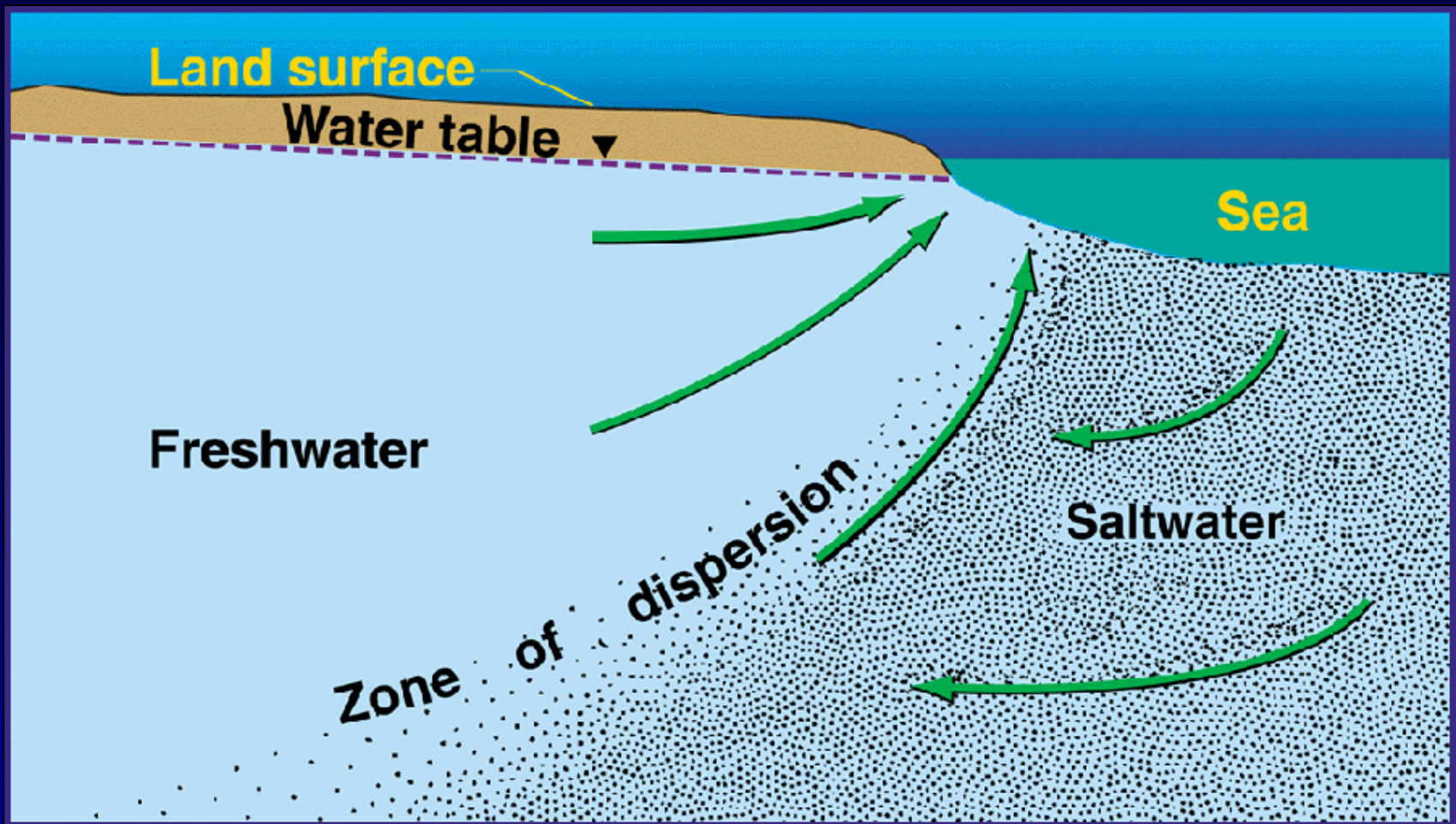
Plot at right
shows levels
dropped
markedly by
1973 due to
overdrafting



MANAGING ISRAEL'S COASTAL AQUIFER



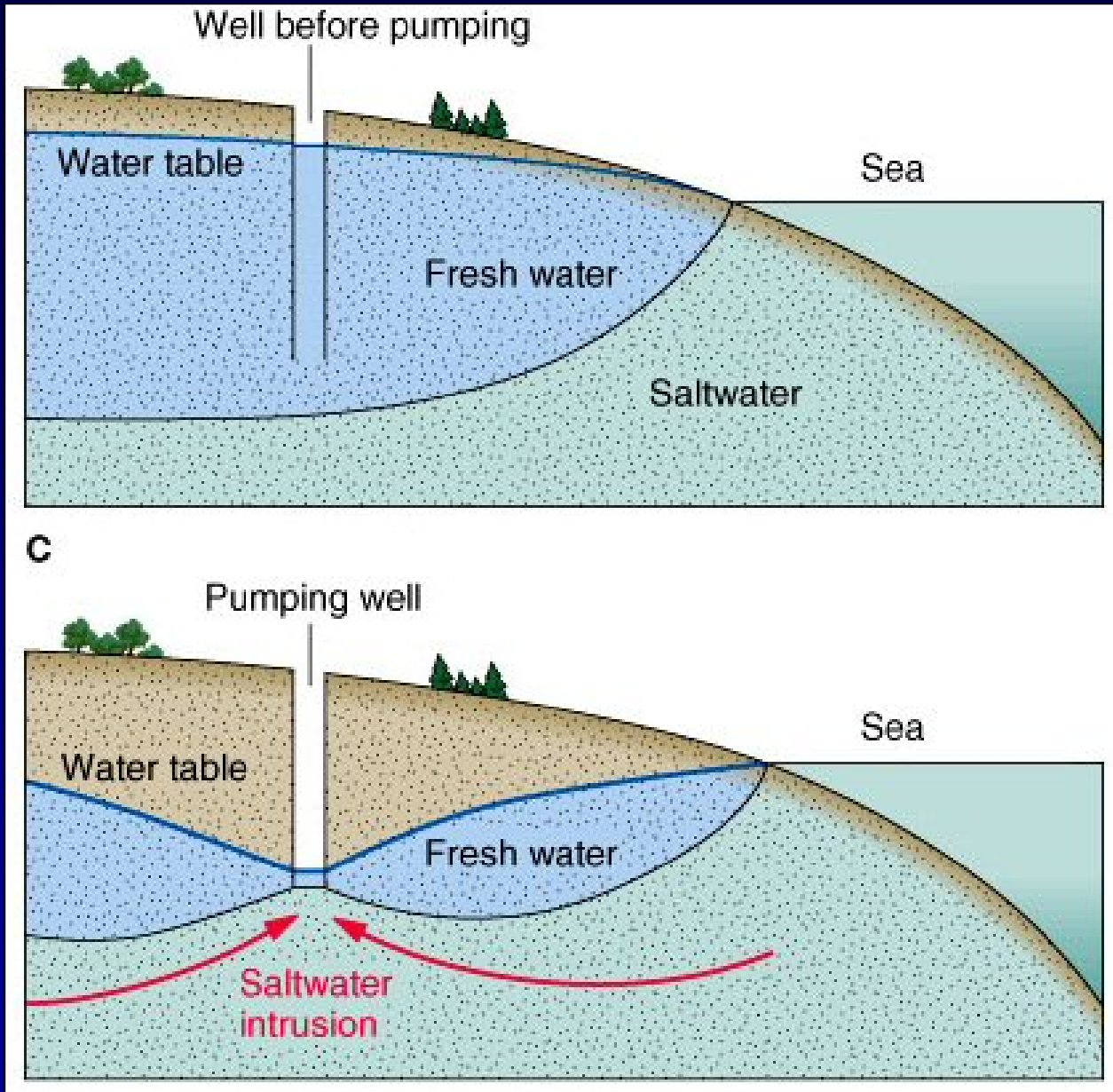
- The coastal aquifer has been depleted, allowing saltwater intrusion along the coast.
- The coastal aquifer has also been polluted by pesticides in the Gaza Strip
- The Israelis are now using brackish water to recharge the southern limits of this aquifer



- The boundary between fresh and brackish groundwater along shorelines is determined by the balance between recharge and discharge. Saltwater is more dense than freshwater.

SALTWATER INTRUSION

- When freshwater is overdrafted in coastal areas, brackish water will intrude upward, as shown here



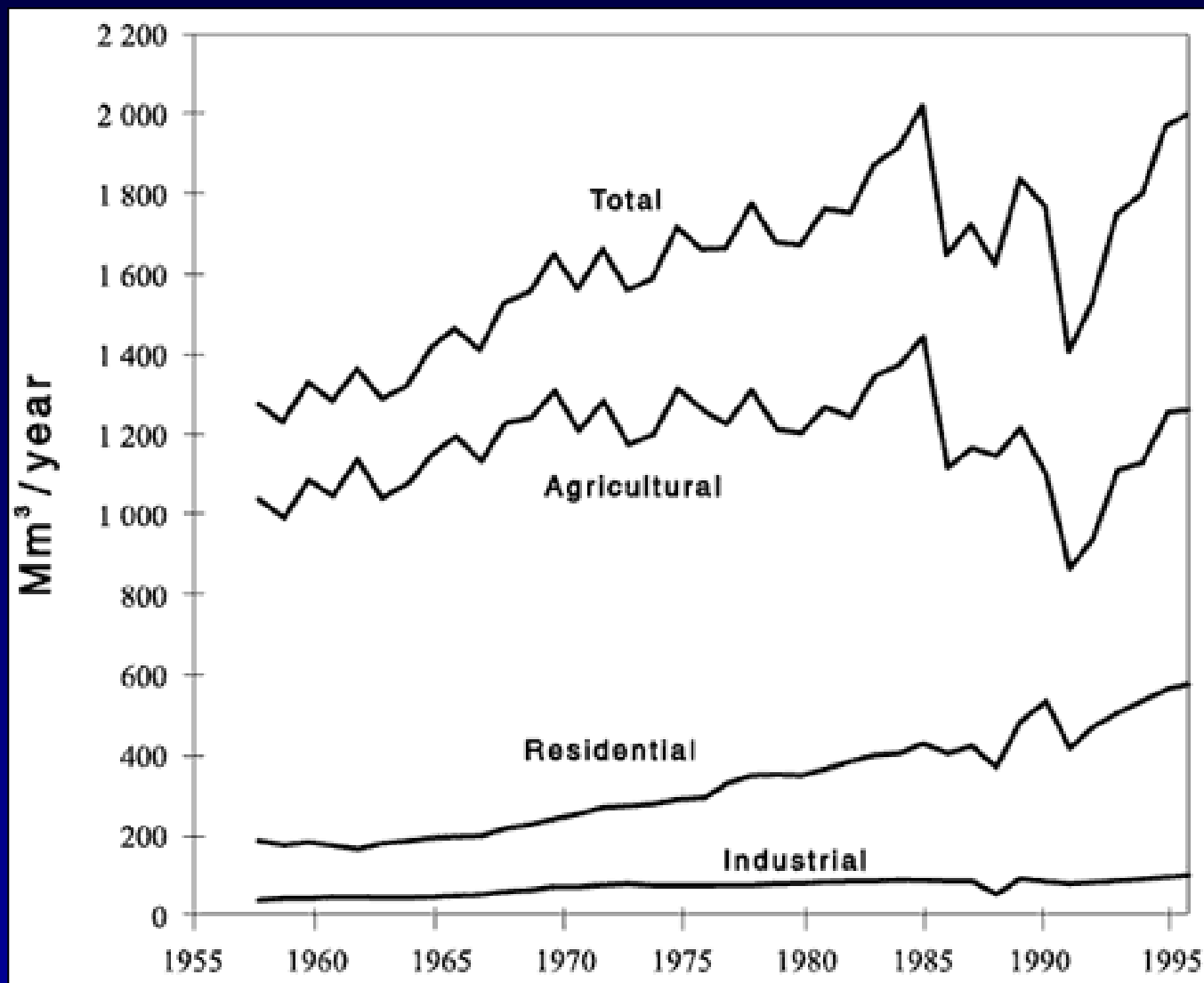
**THE CHALLENGES
OF AN
EXPANDING
POPULATION
BASE**

WORLD POPULATION TRENDS

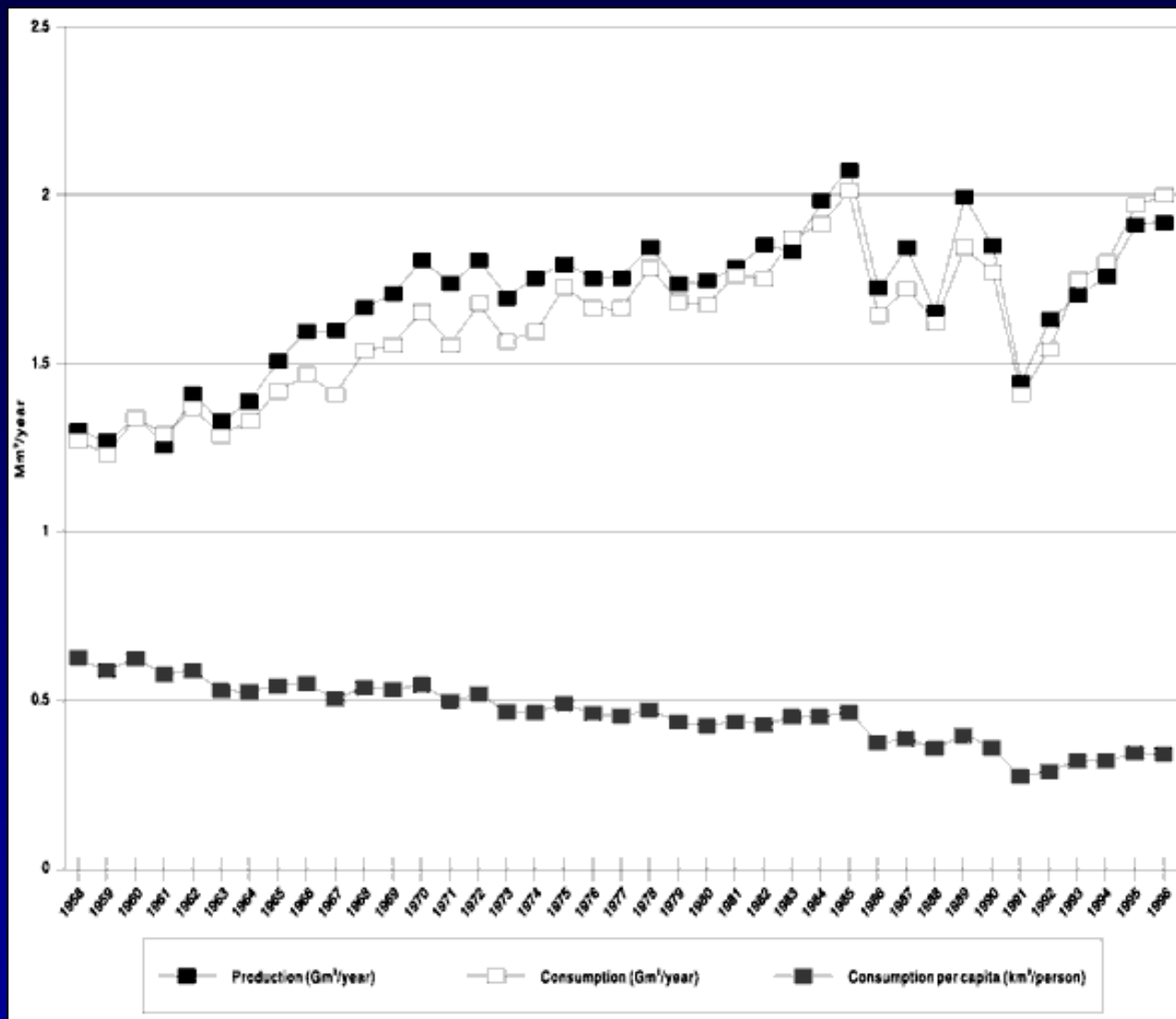
- The world's population reached 6 billion in 1999.
- Global population growth stands at approximately 81 million/year, compared to 53 million/year in the 1960s.
- It is estimated that over the next 30 years, 98 per cent of the world's population growth will take place in developing countries.
- In developing countries, the population doubles every 30 years, and young people will still account for as much as 40 per cent of the total population in 2025.
- By the same token, about 77 per cent of the increase in older populations is taking place in developing regions. In sub-Saharan Africa, the number of people 65 and older will grow from 22.7 million to 61.2 million by the year 2025, according to a U.N. population study.

ISRAELI POPULATION TRENDS

- **About 6.1 million people (2003 estimate)**
- **Annual growth rate about 1.5%**
- **At present, there are 5 million Jews and 4.5 million Arabs and 500,000 non-Jewish immigrants, mainly from the former Soviet Union.**
- **Israeli experts forecast that by 2020 Israel will swell to about 6.4 million Jews, assuming current growth trends and 50,000 Jewish immigrants a year.**
- **The Arab population inside Israel is expected to reach around 8.5 million, in addition to 1 million non-Jews of other origins**
- **If the non-Jewish population continues to outpace Jewish population growth, some Israelis fear their nation could become an underdeveloped Third World country by 2020**



- Historically, 80% of Israeli water consumption has been for agricultural use. Residential use is increasing at average rate of 14.3 Mm³ per year.

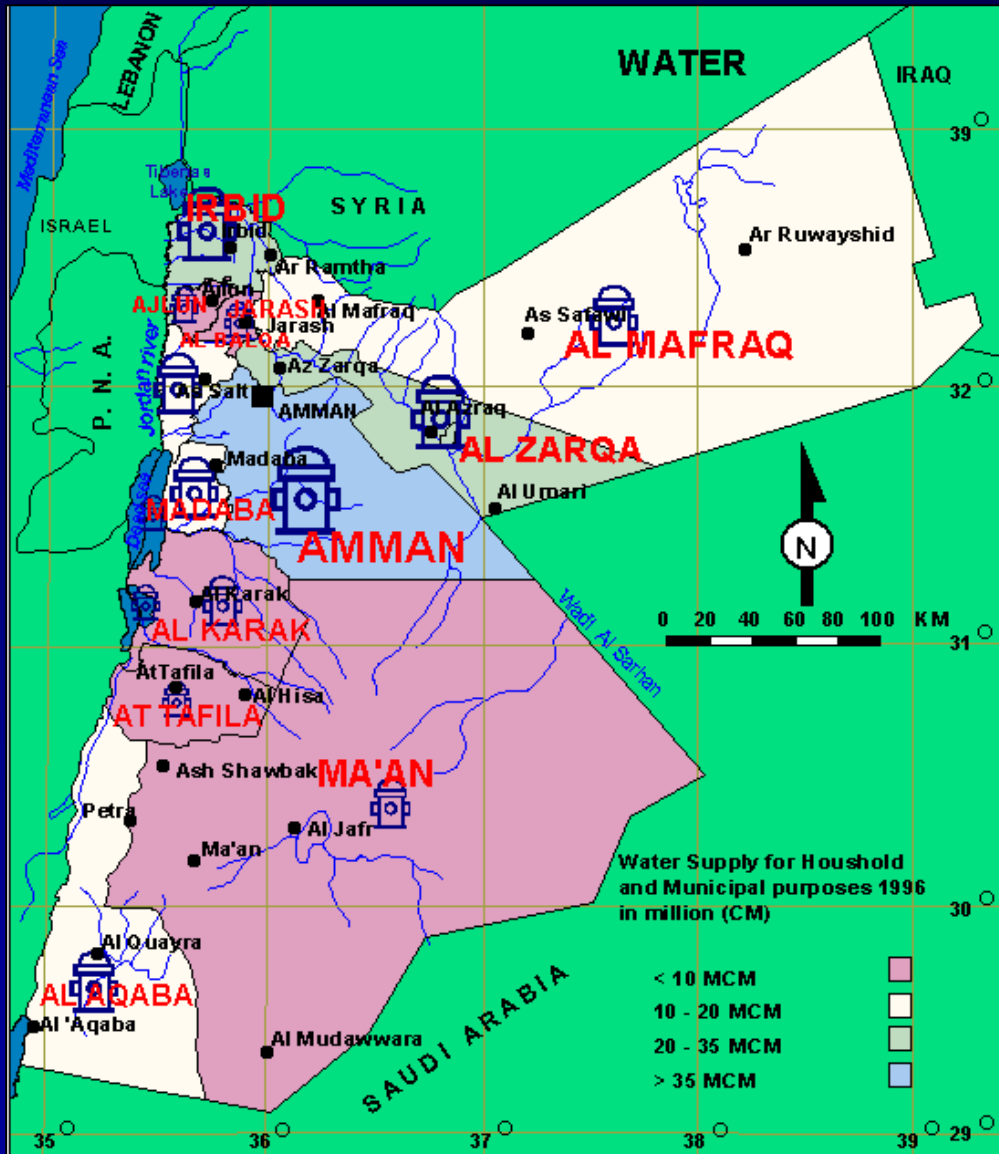


- Upper plot shows Israeli water production vs consumption. Lower plot is per capita usage; which is gradually decreasing each year.

Jordan's Population Growth

- In 1997, Jordan's population reached 4.6 million, doubling the figure from 1981 (an average growth rate of between 3.4 and 3.8%).
- 41% of Jordan's population are below the age of 15.
- Jordan's population is currently 5.6 million, but expected to reach 7.1 million by the year 2010, thanks to an annual growth rate of 4.4 %
- According to Jordan's Minister of Labour Mehdi Farhan, their average 4% growth rate is the highest in the Arab World.
- Refugees from the 1948 and 1967 Arab-Israeli wars accounted for a considerable part of Jordan's population, and, altogether, there are about one million registered Palestinian refugees in Jordan.

JORDAN'S WATER USEAGE



- 1996 water usage in Jordan in millions of cubic meters by district
- The Amman area consumes 35 million cubic meters of water annually, increasing 3% per annum
- The PAA population is increasing 4% annually

Palestinian Autonomous Authority



- **The Palestinian Autonomous Authority consist of the Gaza Strip and parts of the West Bank. These areas are scattered within the territory of Israel. Conflict has been a part of Palestinian-Israeli relations for more than half a century.**

Growth in the Palestinian Authority

- There are 3.64 million people in the PAA area
- Of late, annual growth has varied between 6% (1997) and 3.83% (2004).
- It is also very young, with roughly 49% estimated to be under 14 years of age.
- In addition, the Gaza Strip is one of the most crowded areas in the world with a population density of 2,888 per sq. km.

Israeli-Palestinian Accords

- **The Israel-PLO Declaration of Principles on Interim Self-Government Arrangements (the DOP) was signed in Washington, DC on 13 September 1993**
- **It provided for a transitional 5 year period of Palestinian interim self-government in the Gaza Strip and West Bank. Under the DOP, Israel agreed to transfer certain powers and responsibilities to the Palestinian Authority, which included the Palestinian Legislative Council elected in January 1996, as part of the interim self-governing arrangements in the West Bank and Gaza Strip.**
- **A transfer of powers and responsibilities for the Gaza Strip and Jericho took place pursuant to the Israel-PLO 4 May 1994 Cairo Agreement on the Gaza Strip and the Jericho Area and in additional areas of the West Bank pursuant to the Israel-PLO 28 September 1995 Interim Agreement, the Israel-PLO 15 January 1997 Protocol Concerning Redeployment in Hebron, the Israel-PLO 23 October 1998 Wye River Memorandum, and the 4 September 1999 Sharm el-Sheikh Agreement.**

Palestinian Infrastructure

- The scattered location of self-rule areas and Israeli security concerns pose immense problems to trade, travel and development.
- There are an estimated 2,000 km of roads in the West Bank and 168 km in the Gaza Strip, of which an estimated 40% require immediate repairs.
- There is no existing railway system.
- After prolonged negotiations with Israel, Gaza airport opened at the beginning of 1999.
- Construction of a port is envisaged south of Gaza, which would facilitate trade flows. UNDCP has incorporated an activity on port control which also targets this port in its new subregional program for the Middle East.

Lack of Foreign Investment

- **The Paris Protocol of 1994** governs economic relations between Israel and the Palestinian Authority (PA) for the interim period and provides the PA with a great deal of autonomy in establishing institutions and defining import policies.
- **The World Bank** reports that through the support of the international donor community, the PA has achieved respectable levels of service delivery and fiscal administration comparable with other developing countries of similar size.
- **Establishment of a sound regulatory environment for investment and transparent institutions** remains a challenge. Public sector corruption as well as the executive branch's unwillingness to protect private investments through the establishment of an independent judiciary has discouraged private sector investment.

TERRORISM AND IRREGULAR WARFARE

**Muslim acts of terror in the Middle East
against infidels is nothing new**

**Jewish zealots used terrorism against the
British from 1922 through 1948**

THE EXPANDING ARAB POPULATION IS PERCEIVED AS AN EFFECTIVE WEAPON

- Many Israelis have cited Arab propaganda that encourages women to bear more children; to foster manpower to fight the enemies of Islam
- *Intifada* terrorists are portrayed as martyred heroes; with their pictures prominently displayed in store fronts
- Their families are provided with pensions for life, which is attractive in a poor culture with 40% unemployment



The al-Aqsa INTIFADA

- **Speaking before Fatah youth in Ramallah, Yasser Arafat "*hinted that the Palestinian people are likely to turn to the Intifada option*" (*Al-Mujahid*, April 3, 2000).**

- **Arafat advisor Mamduh Nufal told the French *Nouvel Observateur* (March 1, 2001): "A few days before the Sharon visit to the Mosque, when Arafat requested that we be ready to initiate a clash, I supported mass demonstrations and opposed the use of firearms." Of course, Arafat ultimately adopted the use of firearms and bomb attacks against Israeli civilians and military personnel. On September 30, 2001, Nufal detailed in *al-Ayyam* that Arafat actually issued orders to field commanders for violent confrontations with Israel on September 28, 2000. This was the beginning of the current *Intifada* cycle of violence and unrest.**

A WAR OF PROPAGANDA AND IMAGES

القدس: هكذا أعدمت شرطة إسرائيل بدم بارد الشهيد محمود صلاح

1. يقتلون الشاب محمود وهو ملقى على الأرض

2. يملأون ثيابا ويصنعون سلاحهم منهم

3. يفتشون الشقة ويرهبون المواطنين بسلاحهم

4. يفتشون على الشاب محمود وهو ملقى على الأرض

5. يملأون ثيابا ويصنعون سلاحهم منهم

6. يقتلون الشاب محمود وهو ملقى على الأرض

7. يفتشون على الشاب محمود وهو ملقى على الأرض

القدس -عاجلة التغطية- ألقى أهال شهود حيان فلسطينيون أمن يان الطبو مخالف شهيداً الأقصى الذي قتل الجمعة يائدي الشرطة الإسرائيلية في بيت حنينا في القدس الشرقية -تم الاعتداء بدم بارد بعد أكثر من نصف ساعة على اعتقاله-

وإجماع أكثر من عشرة شهود على القول لوكالة فرانس برس أنهم شاهدوا عملية اعتقال الشاب محمود صلاح (23 عاماً) التي استمرت أكثر من نصف ساعة حتى اللحظات الأخيرة من تصفيته على حد قولهم لكن لفضل التلفزيون منهم، وما على أسئلة من أسئلة وعامة

فرانس برس: عدم الكشف عن اسمائهم. وقال يحيى الوعري (26 عاماً) لوكالة فرانس برس إن محمود صلاح (23 عاماً) الذي قتل يوم الجمعة برصاص الشرطة الإسرائيلية مع أختيه عندما بعد اعتقاله بنصف ساعة وبعد أن سيطرت عليه الشرطة سيطرة تامة.

وأيضاً يحيى الوعري عملية الاعتقال قائلا نحو إلى الرابعة والرابع بعد ظهر يوم الجمعة قدمت سيارة حرس الحدود (الشرطة الإسرائيلية) التي التفتة في (1)

- Modern electronic devices allow Arab deaths to be documented graphically to the extreme

Death Toll of the al-Aqsa Intafada



- **Over 1,000 Israelis since September 2000**
- **According to the PAA, somewhere between 2,000 and 3,400 Palestinian deaths, mostly from retaliatory strikes by Israeli Defense Forces**

The Ultimate Target - Americans



- The *Iraqi Intifada* has placed bounties on prominent American commanders and politicians, similar to those placed by the Palestinians on Israeli military commanders and officials

**SO, WHERE IS
THE WATER
GOING TO COME
FROM?**

DESALINATION PLANTS

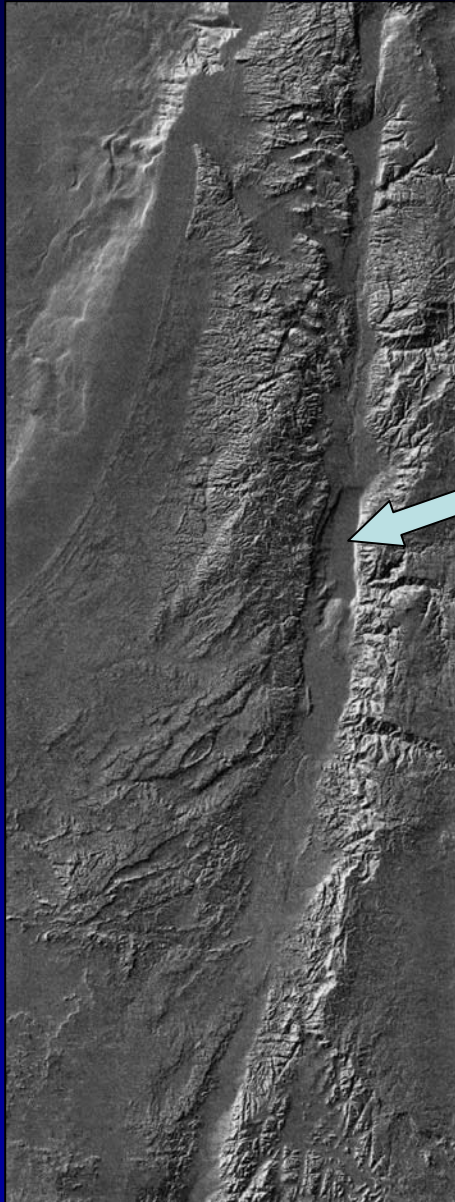


- The Israelis recently completed a reverse osmosis desalinization plant at Ashkelon which will produce 50 million cubic meters of fresh water per year.
- If a second pilot plant is successful, the Israelis hope to expand their desalinization capacity to between 500 to 600 million cubic meters per year by 2012.

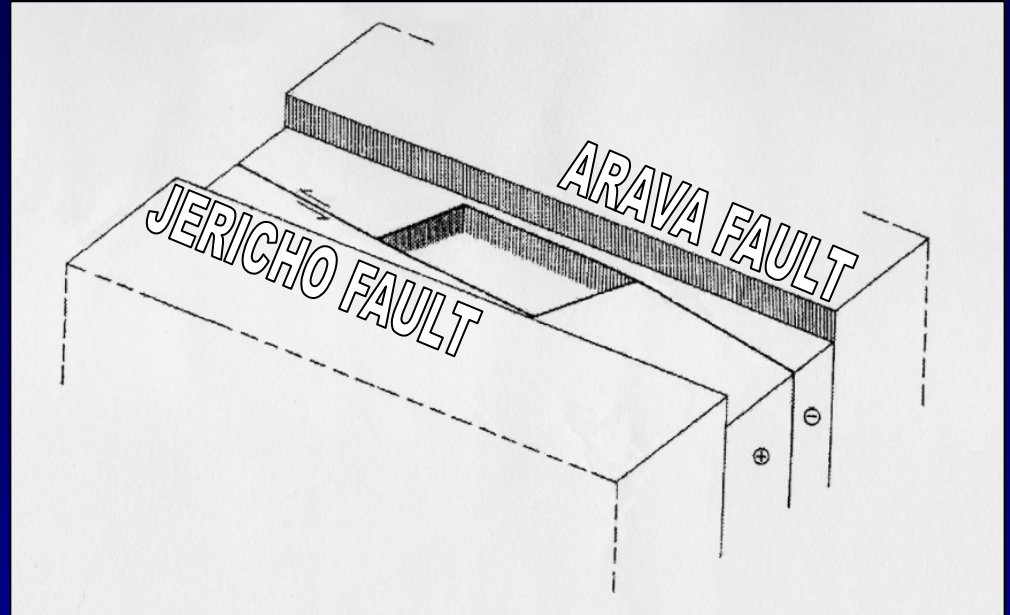


- One of the environmental concerns with desalination plants is the discharge of warm water, like that shown here in Kuwait.

DEAD SEA TRANSFORM



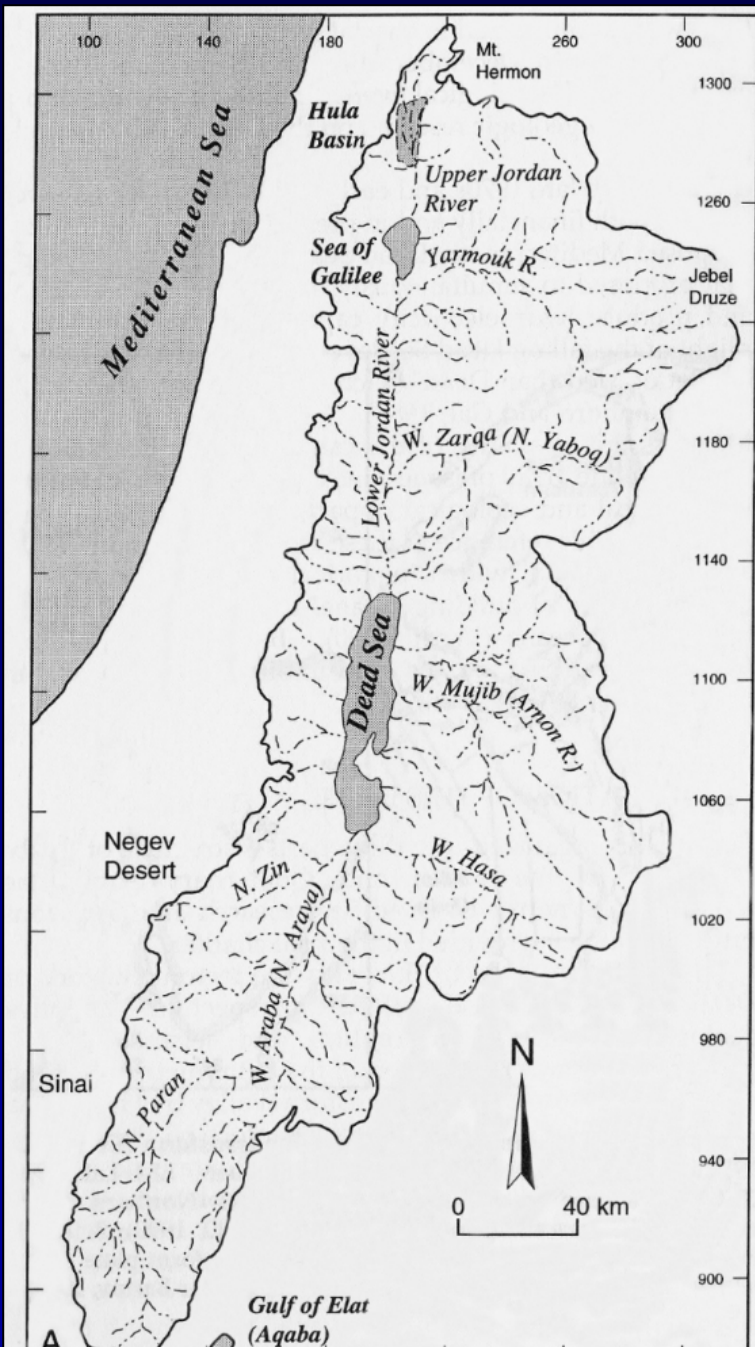
Dead
Sea



- The Dead Sea is a 14 km wide pull-apart basin formed between the Arava and Jericho faults
- It is the deepest land area above water, lying 1368 ft below sea level

DEAD SEA WATERSHED

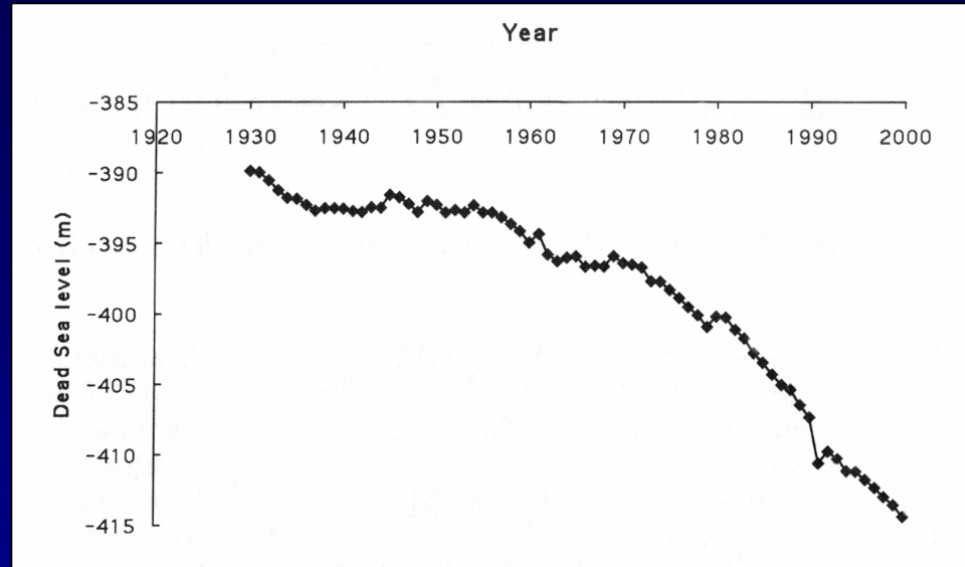
- 40,000 km² drainage basin
- Major sources are Mt Hermon range (in Syria and Lebanon) and Jebel Druze in Jordan
- One dam constructed on the lower Yarmouk River
- One dam on the Zarga River, which supplies 25% of Jordan's needs
- Wadi Hasa and Wadi Mujib convey perennial trickles from area south of the Dead Sea





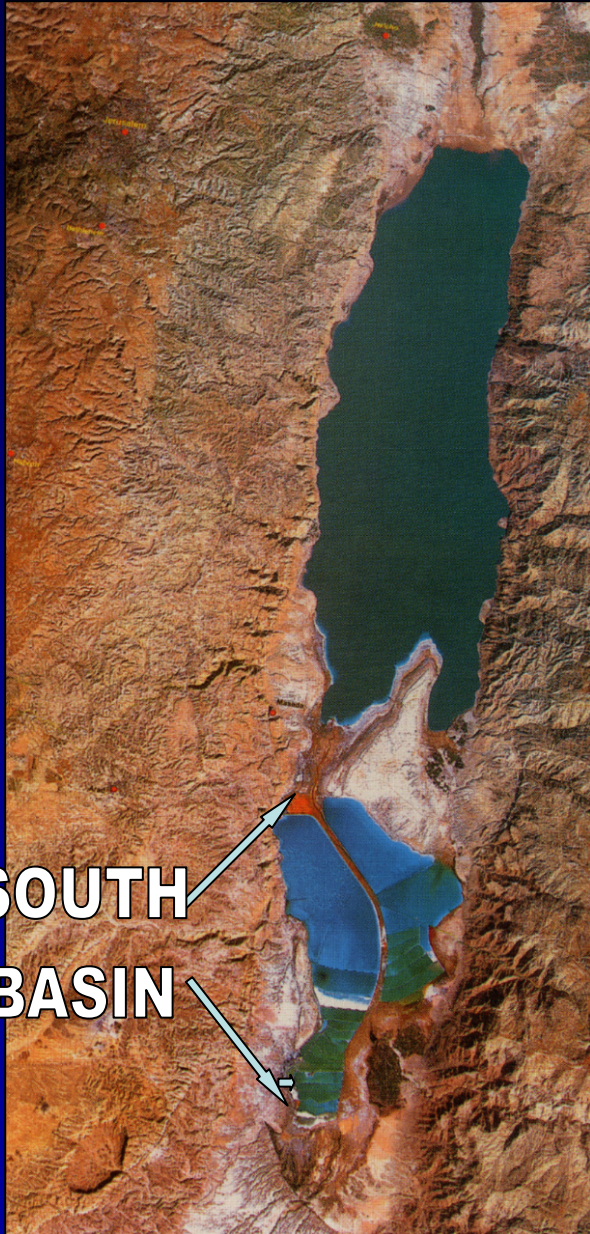
- **The level of the Dead Sea has been declining with increasing rate since 1930.**

THE DEAD SEA IS DISAPPEARING



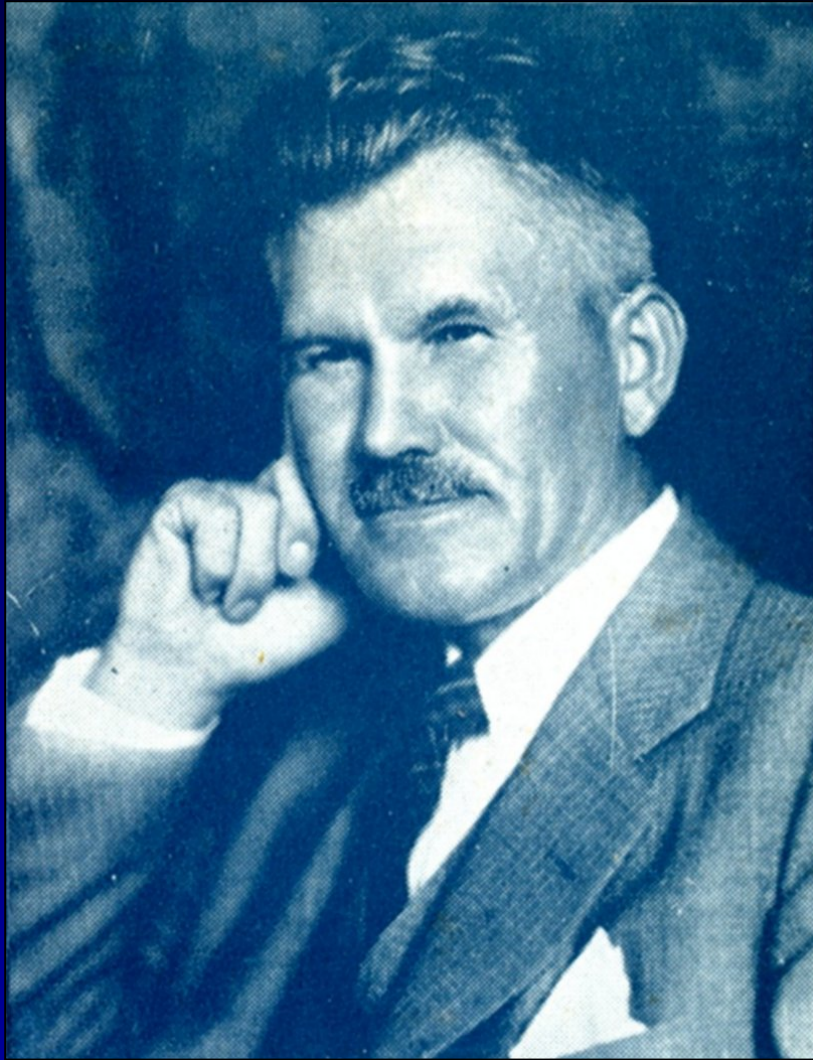
- The decline in Dead Sea water level is due to diversion of the Jordan River for irrigation and potash extraction. The Israelis began extracting potash from Dead Sea brine in 1949.

POTASH EXTRACTOR



- The Israelis and Jordanians have been extracting increasing quantities of potash from the South Basin of the Dead Sea since 1966/1977.
- Today, only 10% of the Jordan River's annual flow discharges into the Dead Sea

**MED-DEAD SEA
AND
RED-DEAD SEA
CANALS**



Walter Clay Lowdermilk 1888-1974

- **American conservationist Walter C. Lowdermilk was a Rhodes Scholar (1913), Army officer (1917-19), and missionary (1921-27) who took degrees in geology and forestry, including a PhD from Berkeley in 1928. He was appointed the first Asst Chief of the Soil Erosion Service in 1933. In 1938-39 he was dispatched to the Holy Land to study soil problems and offer advice.**

Walter Clay Lowdermilk

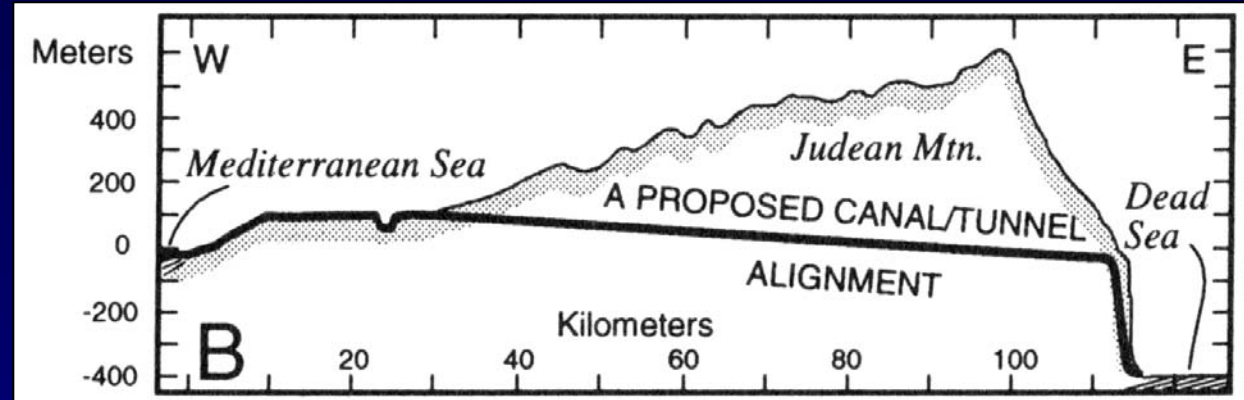
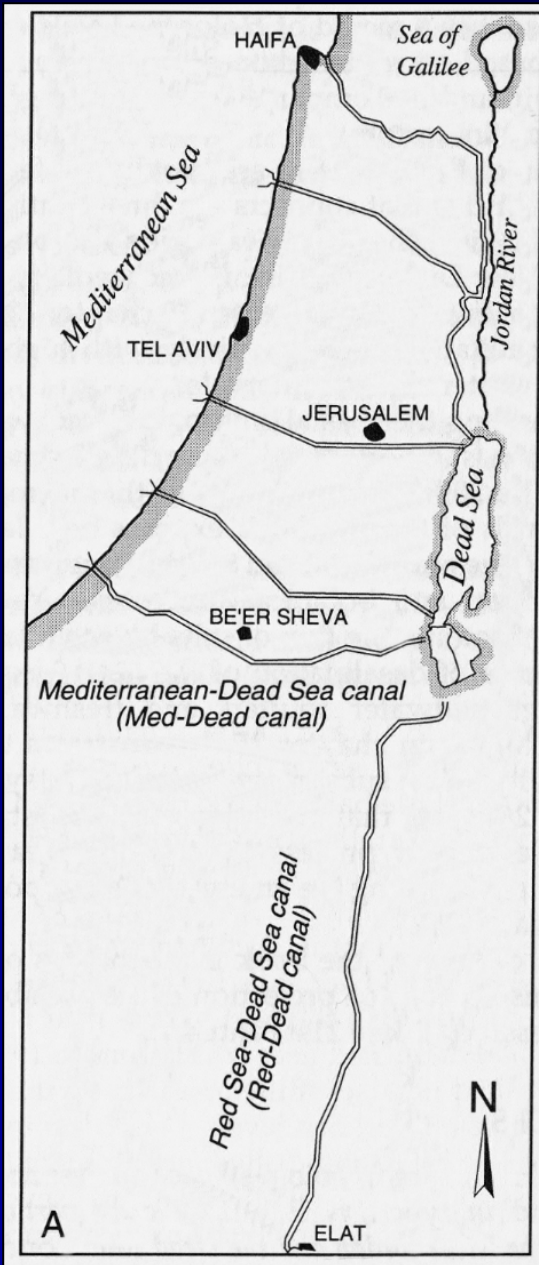
PALESTINE LAND OF PROMISE

An American soil expert presents a practical blueprint for reclaiming an ancient land and for revitalizing the whole Near East.

HARPER & BROTHERS ESTABLISHED 1817

- In 1944 Lowdermilk published *Palestine: Land of Promise*, which became a blueprint for the agricultural development of Israel and the Jordan Valley, suggesting that the Sea of Galilee be utilized as the national reservoir and constructing a series of irrigation aqueducts to areas with fertile soils

MED-DEAD SEA CANAL



- **Concept envisioned by American Walter C. Lowdermilk in the 1950s**
- **Between 1977-80 the Israelis considered four possible alignments**
- **Flow was to be 1.3 million acre-feet per year**
- **Israelis favored the southern route for security and environmental concerns**
- **Never constructed**

1994 ARAVA TREATY BETWEEN JORDAN and ISRAEL

- The treaty signed at Arava promised crucial allocations of water from Israel, cooperative efforts aimed at finding additional resources, establishing increased storage within Jordan, water quality and protection measures and protection of shared groundwater resources
- The treaty also mandates exchange of technical data for the first time between the two nations
- Fresh water began moving again through a pipeline from the Sea of Galilee to Jordan's King Abdullah Canal.

1994 TREATY BETWEEN ISRAEL AND THE PALESTINIAN AUTHORITY

- For first time since 1967, West Bank Palestinians are now permitted to drill water wells and may purchase additional water from Israel's National Water Carrier for a charge.
- The 1994 treaty failed to address Palestinian requests for additional water allotments, which would necessarily have come from Jordan or Israel.
- The subject of water allocation has become a non-negotiable agenda for the Palestinian Authority in its ongoing political strife with Israel.
- Desalination may emerge as the only practical long-term alternative

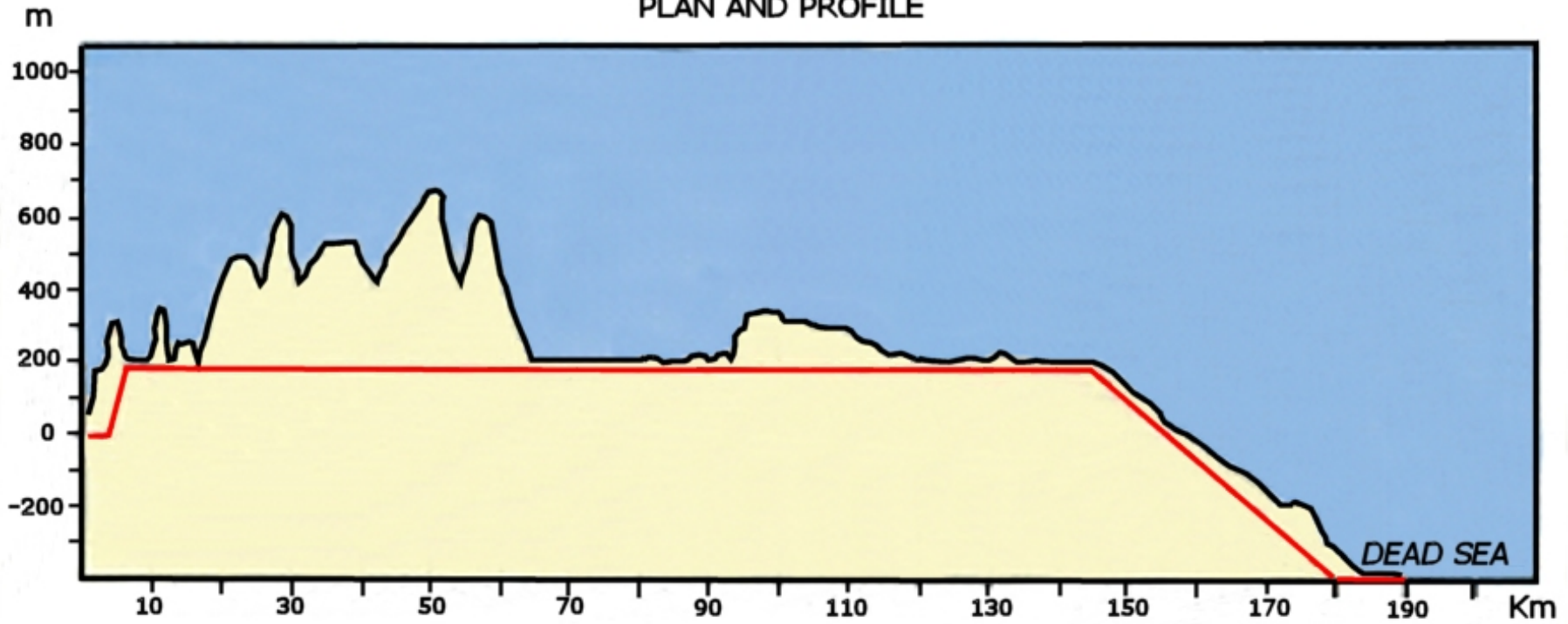
JRV - Red Sea - Dead Sea Canal Plan and Profile Alignment



RED-DEAD SEA CANAL

- Engineering feasibility studies by Harza Engineering Co. of Chicago in 1996-97 (paid for by the Italian government)
- The canal will extend from Aqaba 310 km north to the South Basin of the Dead Sea
- To provide desalination, hydropower, and raise level of the Dead Sea
- Cost will be about \$800 million
- Announced in September 2002 that project will be built and operated jointly by the Israelis and Jordanians

RED SEA - DEAD SEA CANAL - SAMPLE ALTERNATIVE LAYOUTS
PLAN AND PROFILE



- Red Sea water will be lifted 125 m (410 ft) and conveyed through two major tunnels, 45 and 24 km long
- Water will drop 533 m (1750 ft) into the Dead Sea, either through turbines for electricity or desalination for fresh water

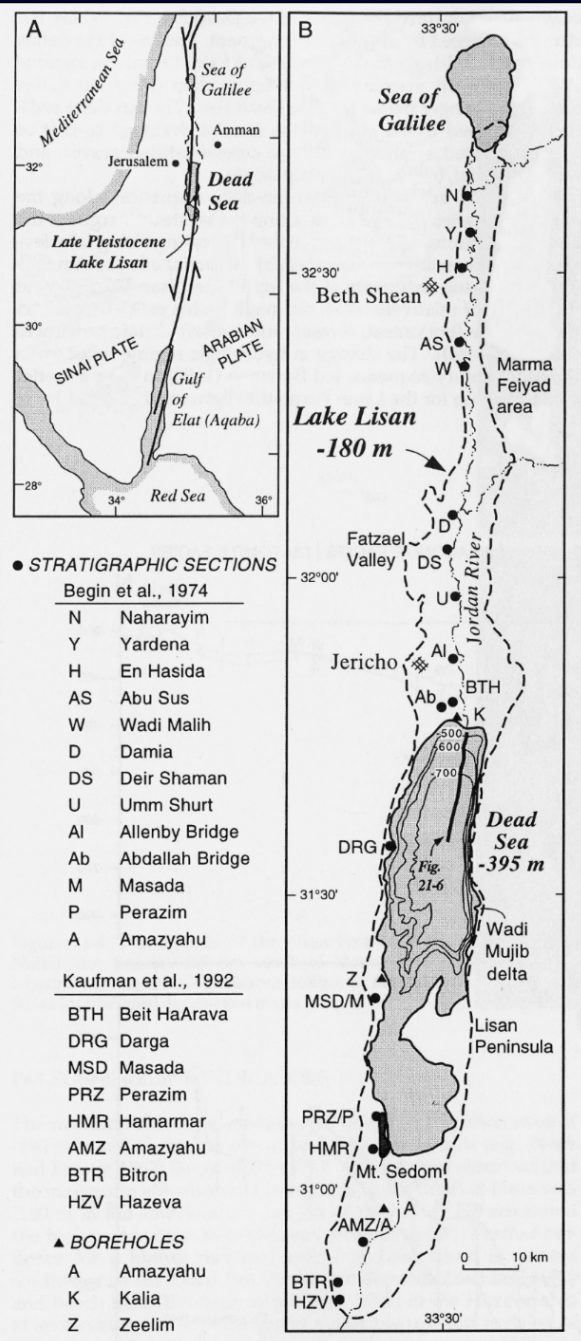


SWRO PLANTS

- Seawater Reverse Osmosis Filtration desalination plant under construction at Larnaca in Cypress.
- This plant uses spiral wound membranes in five RO treatment trains. Design capacity is 14.3 million gpd

**TECHNICAL
CHALLENGES
CONSTRUCTING
INFRASTRUCTURE
IN THE MIDDLE
EAST**

GLACIAL LAKE LISAN



- The Jordan River Valley (JRV) is typified by treacherous foundation conditions
- Glacial Lake Lisan filled the JRV between 63 and 14 ka
- Lake Lisan was up to 220 km long
- Lake level rose to -180 m, about 240 m deeper than present
- Lowest level was -700 m (280 m deeper than present)

DIATOMACEOUS SEDIMENTS



**THRUST FAULTS
COMMON OVER
RISING SALT
DIAPIRS**



- **The Jordan Valley contains soft compressible silts, clays and marls as well as collapsible diatomaceous soils deposited in glacial Lake Lisan**

HIGH VISIBILITY FAILURES



- In Late March 2000 2.5 km of a newly completed 22 m high dike on the Lisan Peninsula failed catastrophically upon its initial filling by the Jordanian Arab Potash Company.
- 30 million cubic meters of material washed away in 30 minutes.
- Very soft foundation materials developed excessively high pore water pressure, which caused a bearing capacity failure
- Israeli dikes are considerably smaller, but have experienced similar problems

CONCLUSIONS - 1

- **Three of the world's greatest religions emanate from Jerusalem**
- **This area will present some of the greatest challenges to technology and western culture in the 21st Century**
- **Conflicting ideologies and religious beliefs create a chasm in mutual trust and understanding**
- **Real need for partnering between factions to manage scarce water resources**

CONCLUSIONS - 2

- **Global Jihad or pragmatic co-existence are the two basic choices for Palestine and Jordan**
- **America and the European Union are perceived by Arab pragmatists as the only hope for economic development and partnership, because the Israelis wouldn't dare destroy western-financed infrastructure**
- **Israel and her Arab neighbors will likely pursue desalination as a primary means of augmenting their scarce water resources; and this will require substantive foreign investment**