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# Hydrogeological Assessment of Western Aquifer Basin


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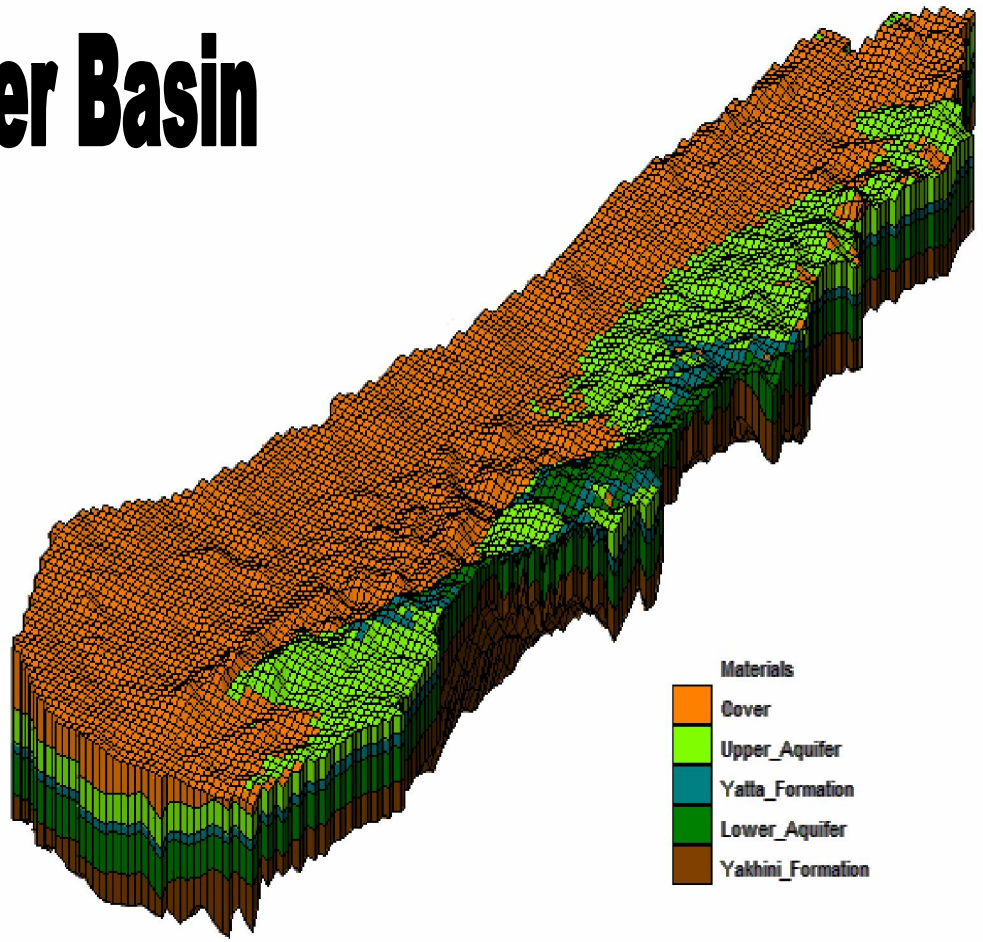
**Grand Park Hotel**

**8/12/2005**



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# Groundwater Hydrology of the West Bank & Gaza

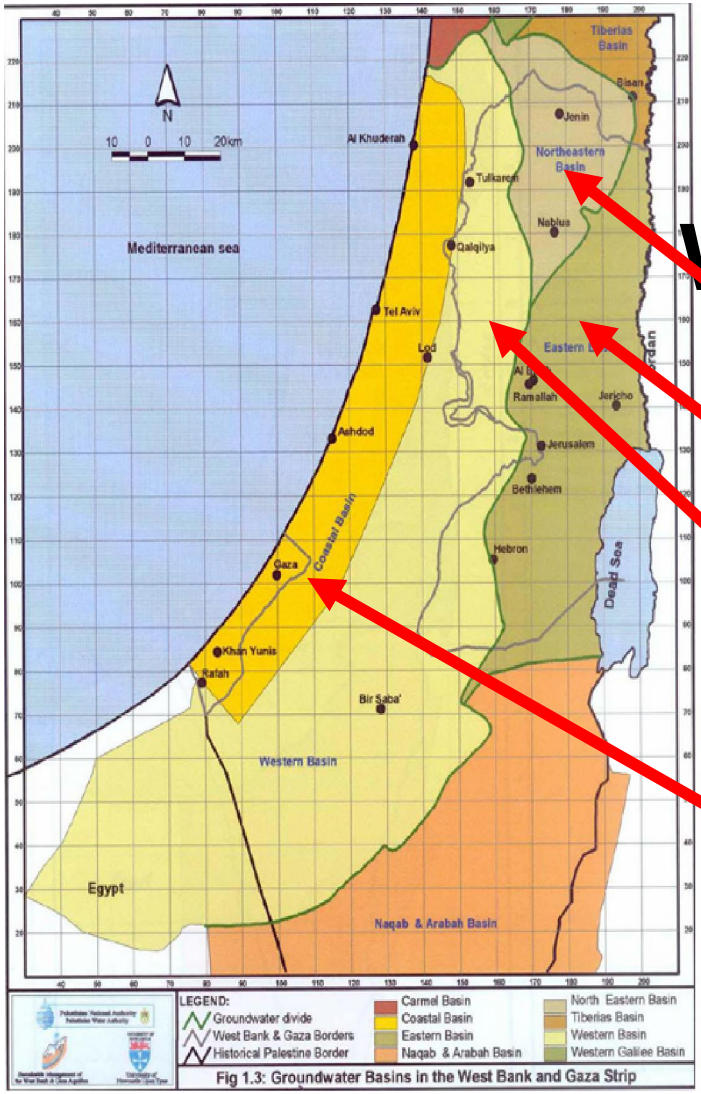

Fig 1.3: Groundwater Basins in the West Bank and Gaza Strip

Groundwater resources in the (WB) are :

- Northeastern Aquifer Basin (NEAB),
- Eastern Aquifer Basin (EAB),
- Western Aquifer Basin (WAB),
- Coastal Basin and

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# The Western Aquifer Basin

It extends over an area of 11,862 $Km^2$ :

1.Palestinian area: 2,232 $Km^2$

2.Israeli area is 7,390 $km^2$.

3.Egyptian 2,240 $Km^2$.


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# The presentation will cover:

Conceptual Model: To provide a reasonable understanding of the groundwater flow system of WAB.

Hydrogeological Investigation and Data acquisition




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# Conceptual Model:

- Boundaries
- Geology, Hydrogeology, Geography
- Geometry in 3D
  - Aquifer and non-aquifer units (Thickness and extension)
  - Connection between aquifers
  - Connection with the sea




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- Hydrological stresses
  - Recharge
  - Well abstractions
  - Spring discharges
- Flow system
  - Water levels
  - Flow patterns

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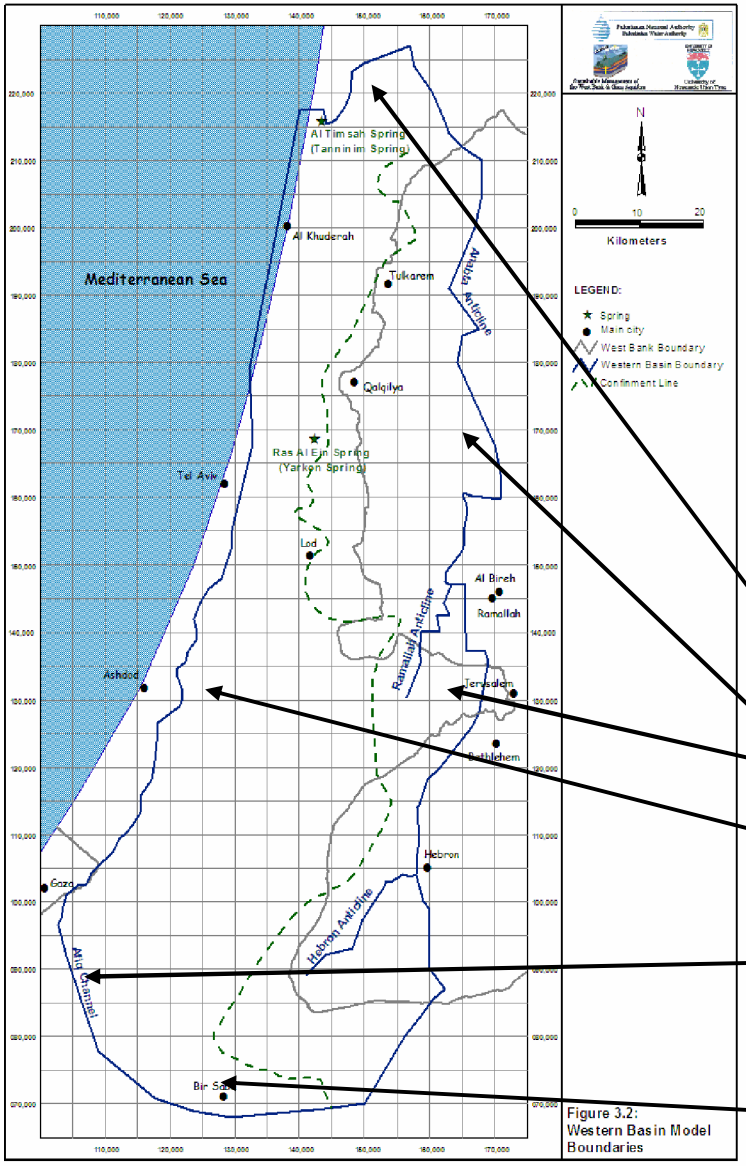

Figure 3.2: Western Basin Model Boundaries

# Boundaries (Model area)

§**Mainly no flow as an effect to ,Structure &Lithofacies,ets**

§**Model area equal 6036 km2**

§**System extensions**:

ØFoothills of the Carmel Mountains and Menache syncline in the north

ØMountains of the West Bank in the east

ØSeaward beneath the coastal plain in the west.

ØAffig channel extenstion, the southern boundary of study area.

ØBir-Saba in the south

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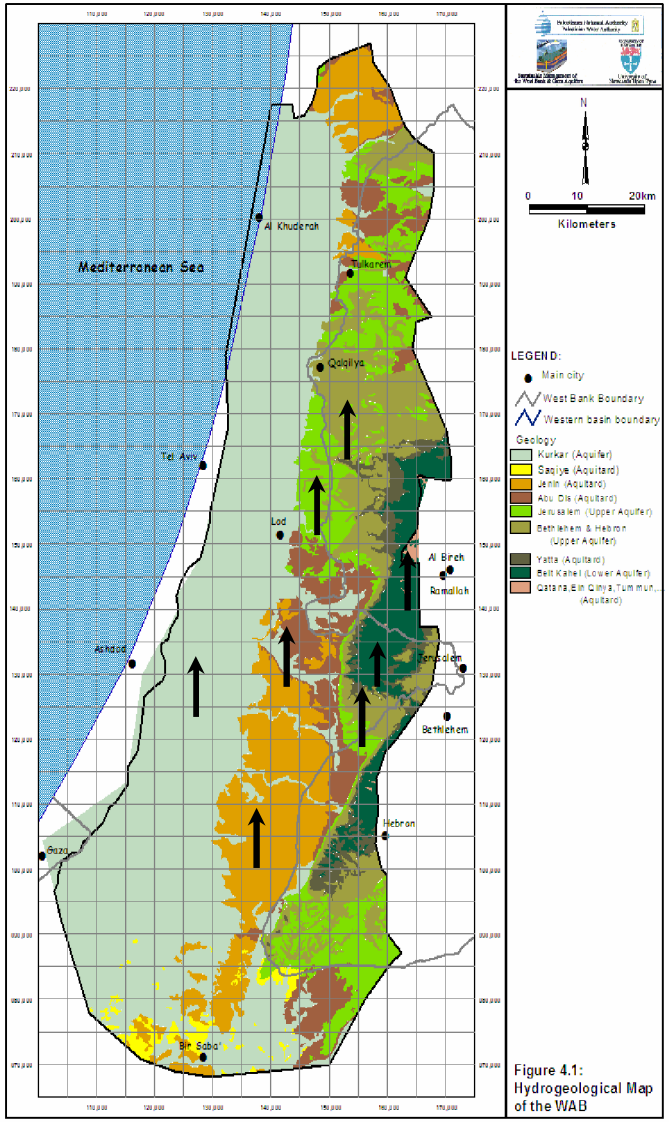

Figure 4.1: Hydrogeological Map of the WAB

Outcropping formations in the modelled area.

They were lumped into 5 layers.

Ø**Cover:** Quaternary, Oligocene, Miocene, Pliocene, Eocene, Senoian

**Upper Aquifer**:Turonian-Upper Cenomanian

Ø**Yatta**: Lower Cenomanian

Ø**Lower Aquifer**:Upper Albian

Ø**Base:** Lower Cretaceous

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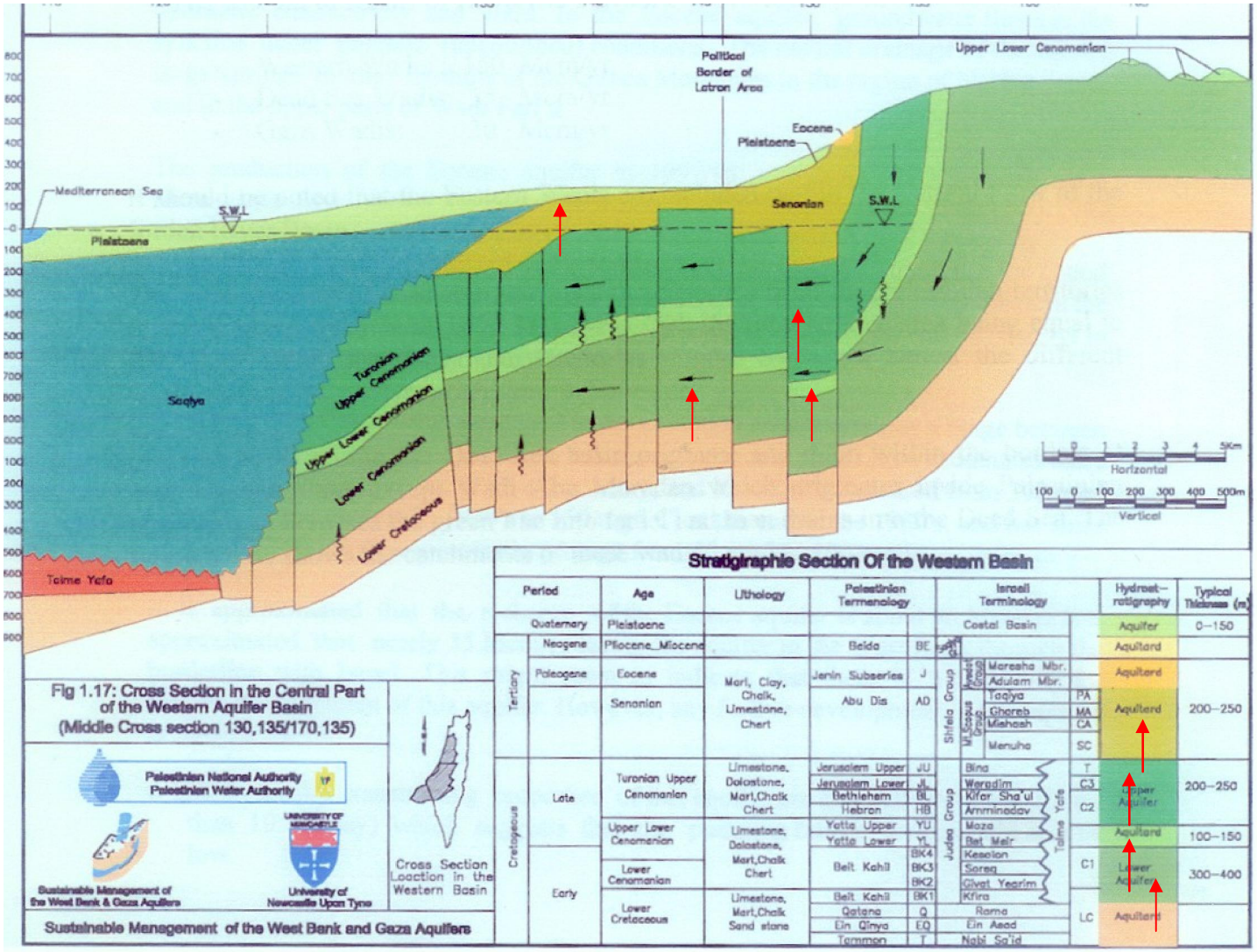

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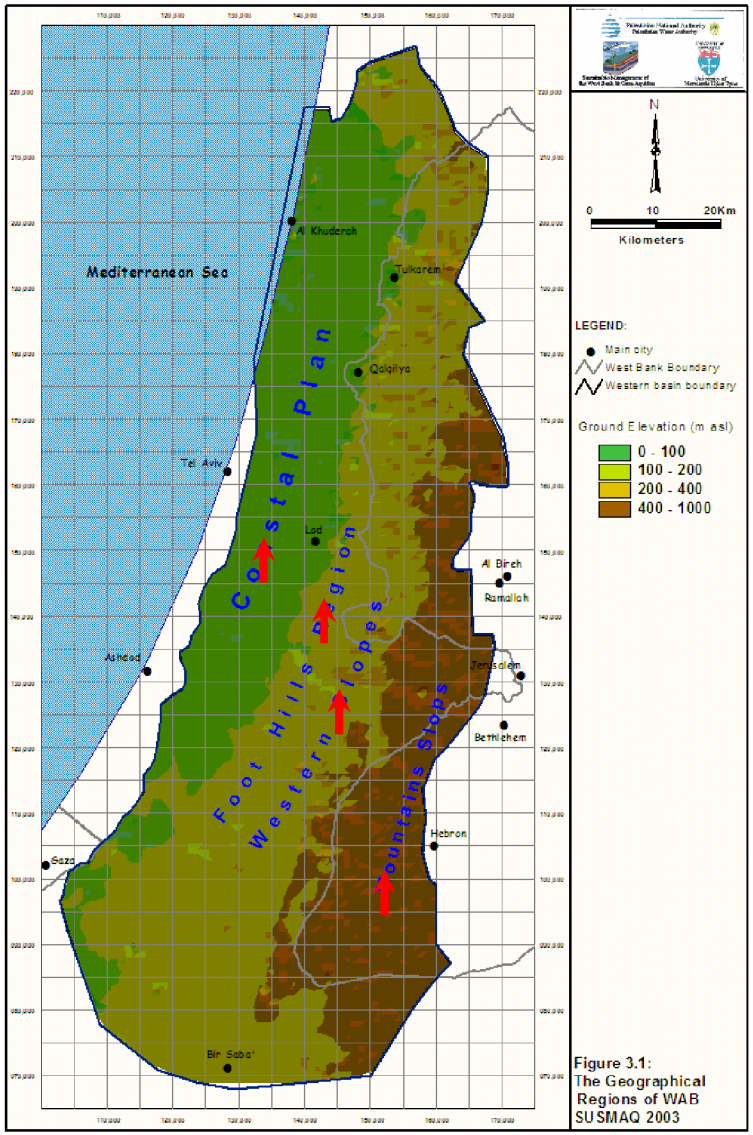


Figure 3.1:
The Geographical Regions of WAB
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# Geographical Regions

- Mountains Slopes
  - Ø400-1000 m asl
- Western Slopes
  - Ø200-400 m asl
- Foothills
  - Ø100-200 m asl
- Coastel Plain
  - Ø0-100 m asl

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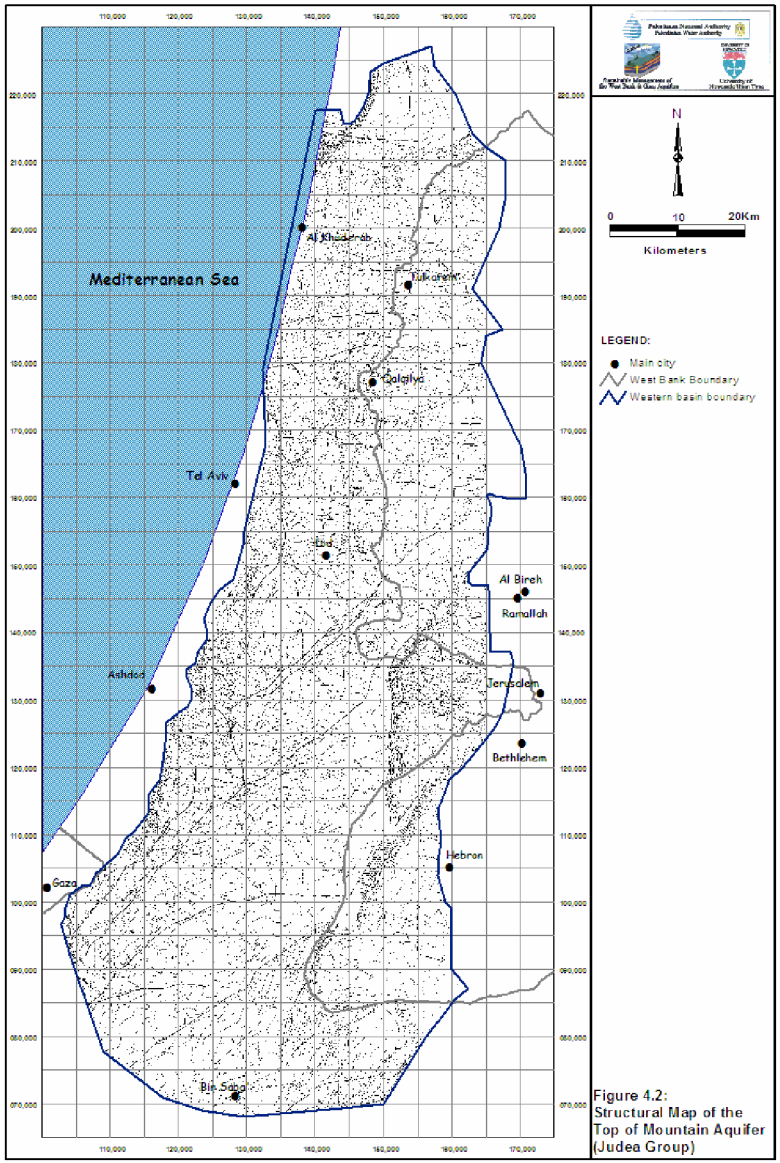


Figure 4.2:
Structural Map of the Top of Mountain Aquifer (Judea Group)

# Basin Geometry

## *Layer thicknesses*

Ø Total thickness of MA was determined from structural contour maps.

ØFormation thickness maps were used (from geological maps, wells lithological data and cross sections )to develop thicknesses of UA , Yatta, LA and Yakhini.

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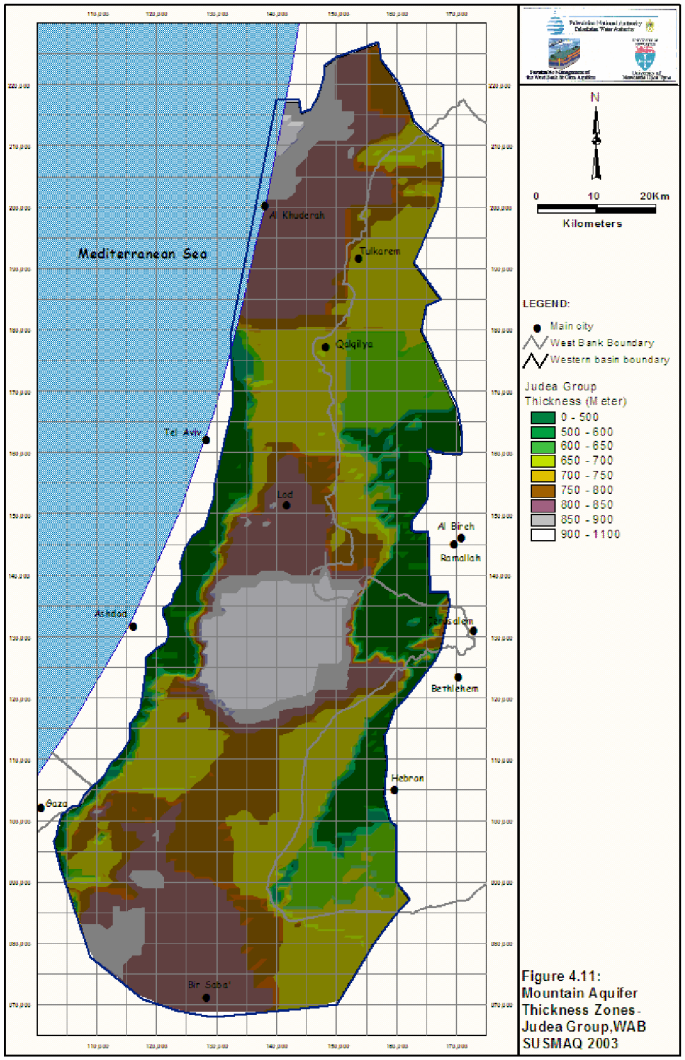


Figure 4.11:
Mountain Aquifer
Thickness Zones-
Judea Group,WAB
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# MA Thickness Zones

(650m-900m)

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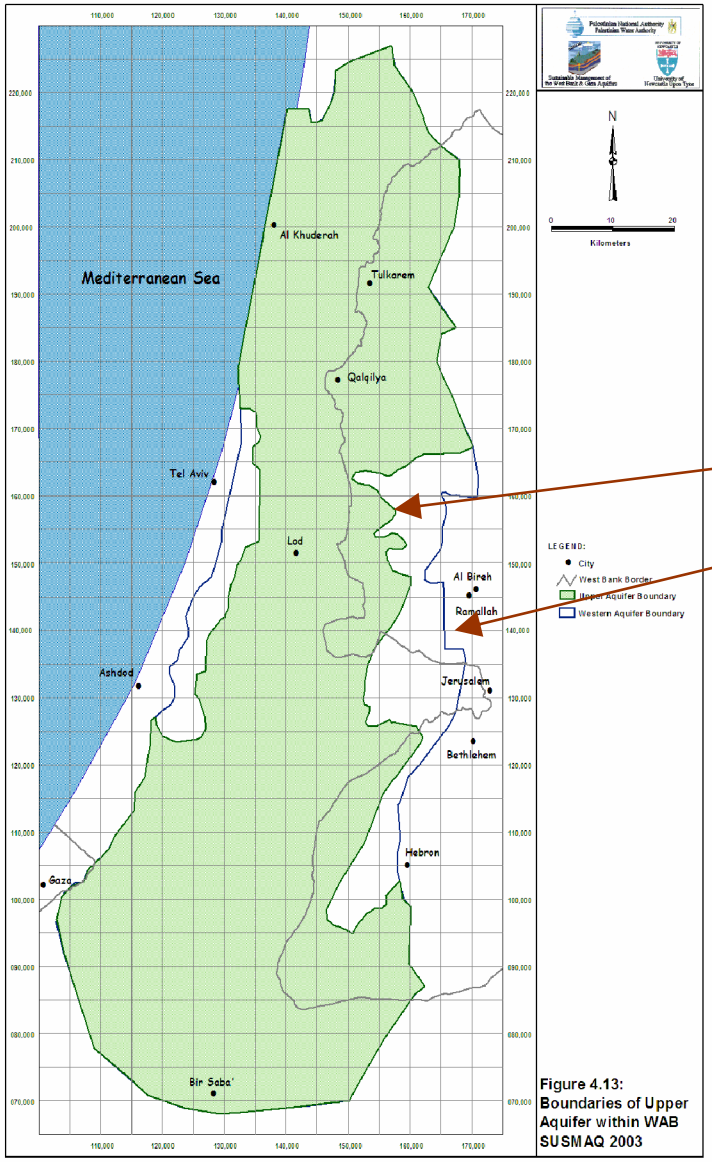


Figure 4.13:
Boundaries of Upper Aquifer within WAB
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# *Aquifers Extension*

ØExtension of UA and LA

ØNote the UA is truncated in the West and eroded in the east.

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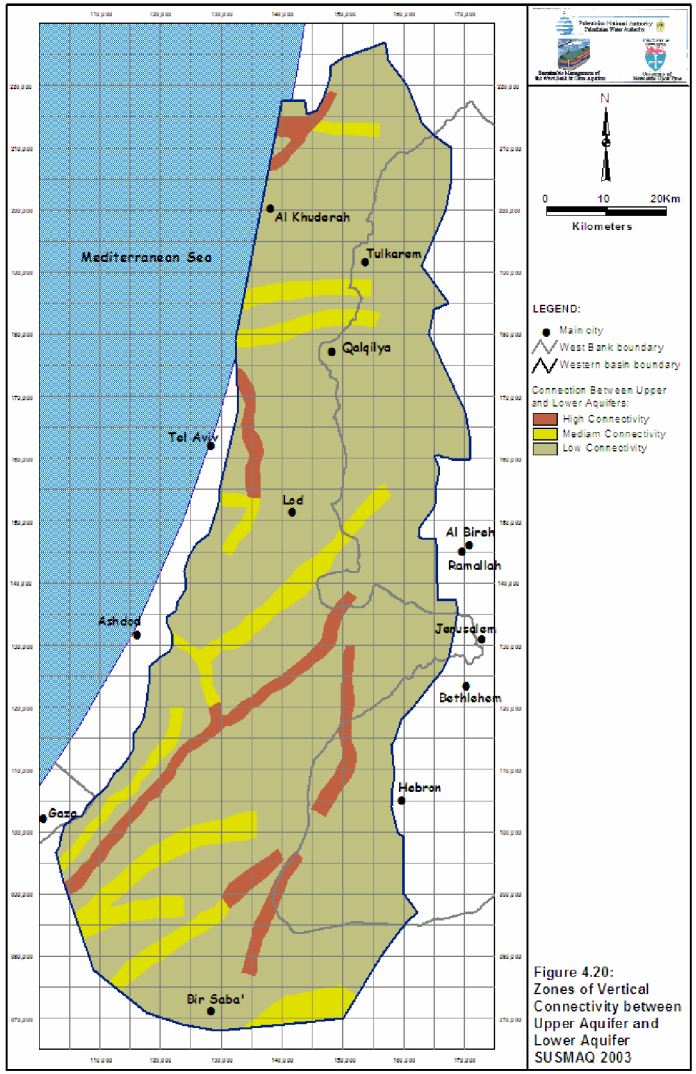


Figure 4.20: Zones of Vertical Connectivity between Upper Aquifer and Lower Aquifer SUSMAQ 2003

# *Connection between Aquifer Units*

The UA and LA are connected where:

- The throw of the faults is greater than the thickness of Yatta
- Lithology of Yatta changes to make a continuation of UA into the LA


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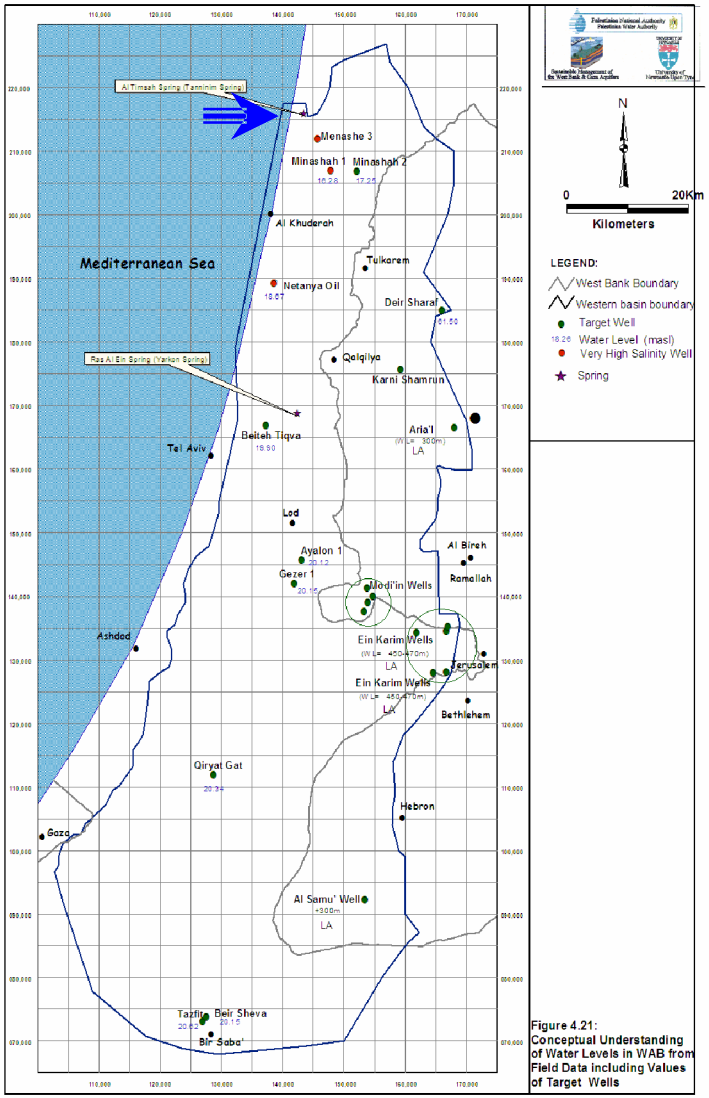


Figure 4.21: Conceptual Understanding of Water Levels in WAB from Field Data including Values of Target Wells

# *Connection with the Sea*

It is believed that Binyamina fault and other salinisation processes allow *3-4* Mcm/yr from the sea to intrude into the UA, mix with fresh water and leaves through Tanninim spring [average salinity ≈ 2000 mg/l]

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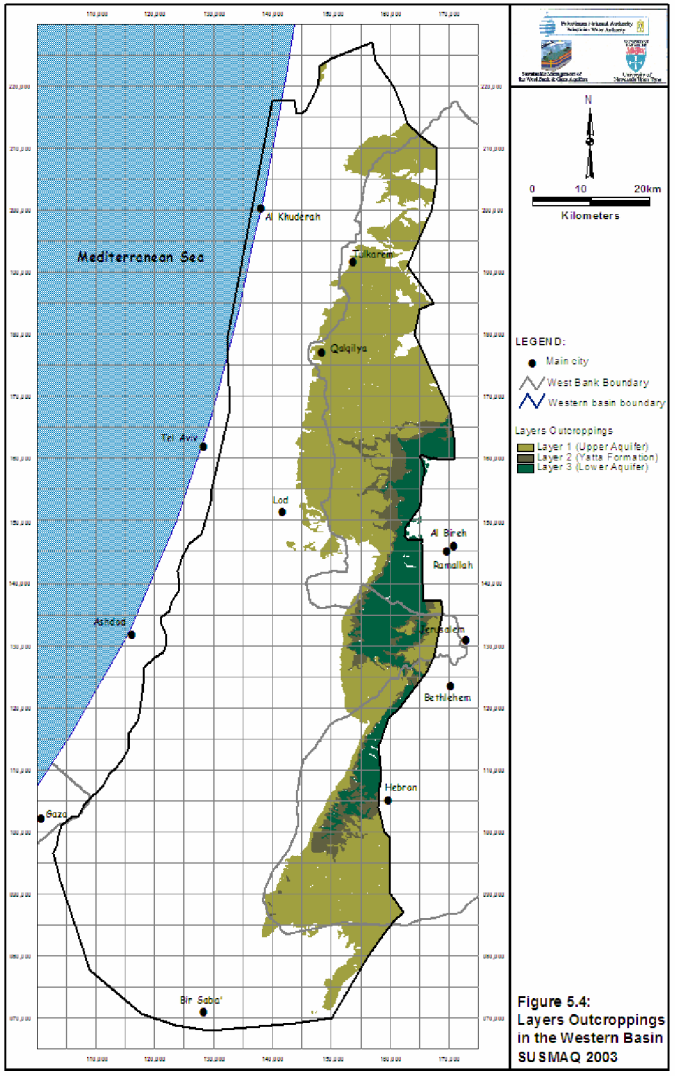


Figure 5.4:
Layers Outcroppings in the Western Basin
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# Recharge Estimation

- Recharge from rainfall
  - § On aquifer outcrops
  - §Through Shallow aquifer to UA
  - §Runoff from rainfall wadis
- Recharge from runoff sewage wadis
- Leakage from conveyance systems
- Artificial recharge
- Influx from sea

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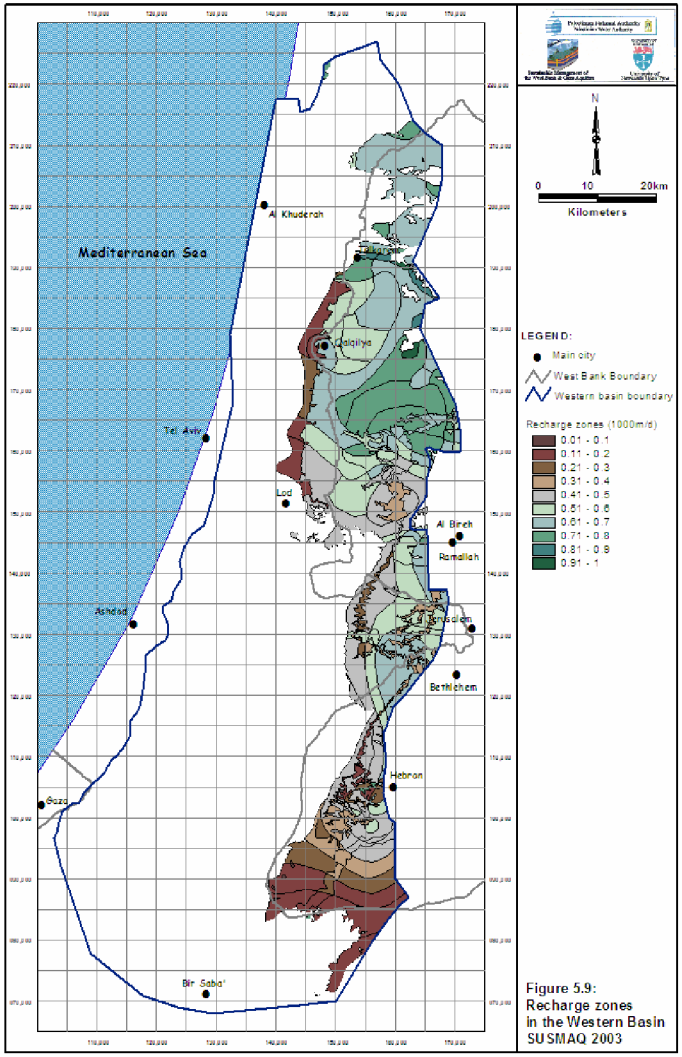


Figure 5.9:
Recharge zones
in the Western Basin
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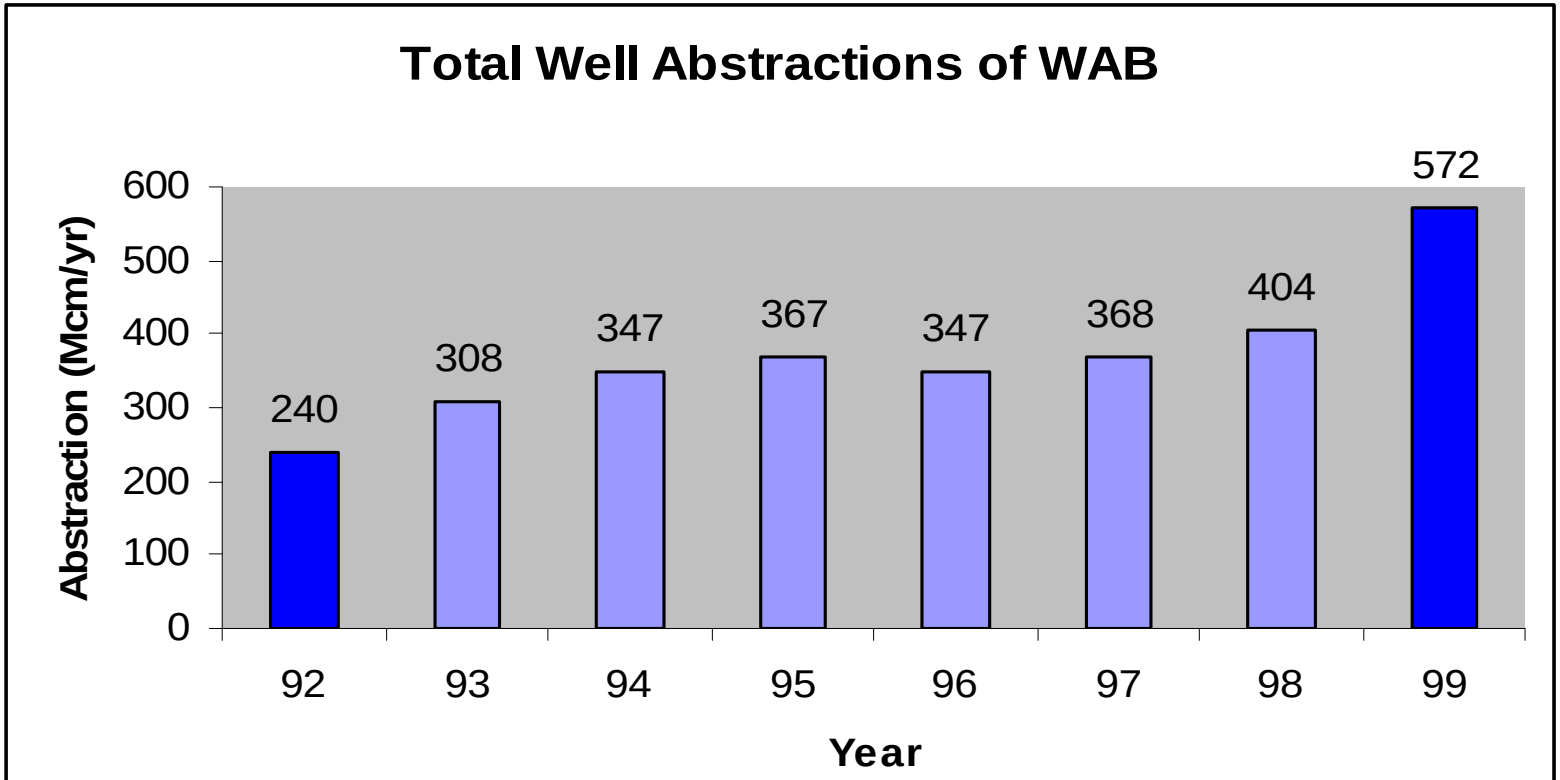
## Total Recharge (Mcm/yr)

| Aquifer | Direct Rainfall | Rainfall Runoff | Sewage | Leakage | Sea | Total |
|---|---|---|---|---|---|---|
| UA | 244.92 | 16.99 | 1.55 | 5.47 | 3.6 | 272.53 |
| Yatta | 21.1 | 1.45 | 0.02 | 0.25 | | 22.82 |
| LA | 55.4 | 3.75 | 0.29 | 0.71 | | 60.15 |
| Total | 321.42 | 22.19 | 1.86 | 6.43 | 3.6 | 355.5 |




- The period 93-98 gives no anomalies
- Average of 357 Mcm/yr over 93-98

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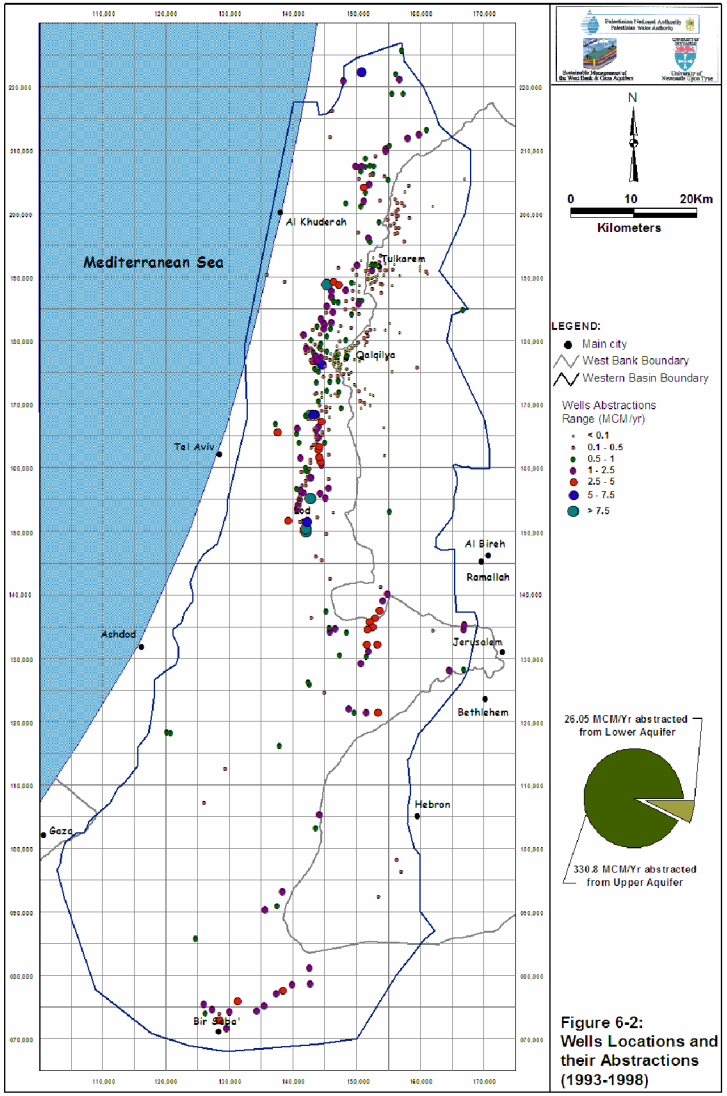


Figure 6-2:
Wells Locations and their Abstractions (1993-1998)

# Well Abstractions

- Most wells are located N-S line to the west of the foothills
- Most of the wells tap UA (90-92%)


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# Spring Discharges

| | Rase El Ain(Yarkon) | Al Temsah (Tanninim) |
|---|---|---|
| Historical Q | 254.5 Mcm/yr | 101.3 Mcm/yr |
| Now | Almost Dry | 52 Mcm/yr |
| TDS | 625 mg/l | ≈ 2000 mg/l |
| Water Level | Pool at 16.5 m asl. *The Israelis dried up the spring by drilling wells that extract almost the same volume of spring discharge* | Water level varies 4.5 -11 m asl<br>*Spring dos not issue if water level is less than 4.5 m.* |

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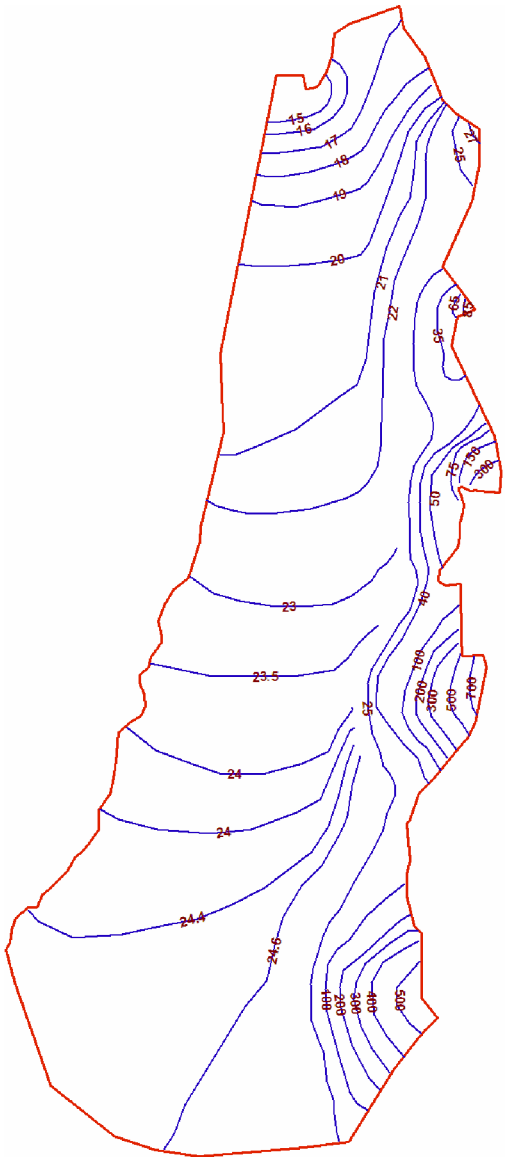

# Water levels

## *Lower aquifer (BK)*

ØIn the recharge areas: WL are generally high (300- 470 m asl)

ØFoothills & Coastal areas:(15 - 24m asl)

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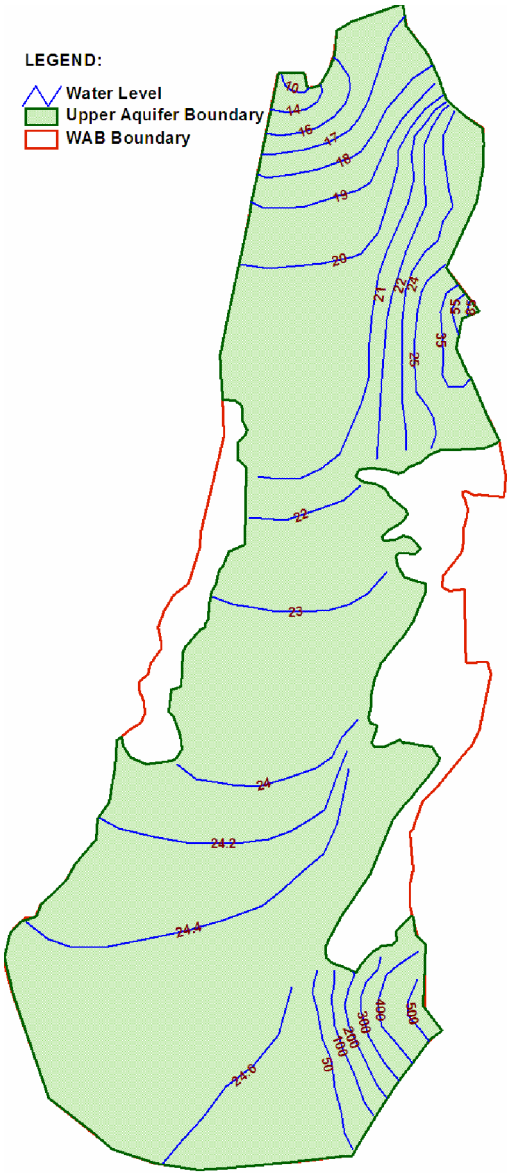


# Water level

## *For Upper Aquifer (JE,BL&HB)*

ØIn the recharge areas: WL are generally high (30- 500 m asl)

ØFoothills & Coastal areas:(15 - 24m asl)

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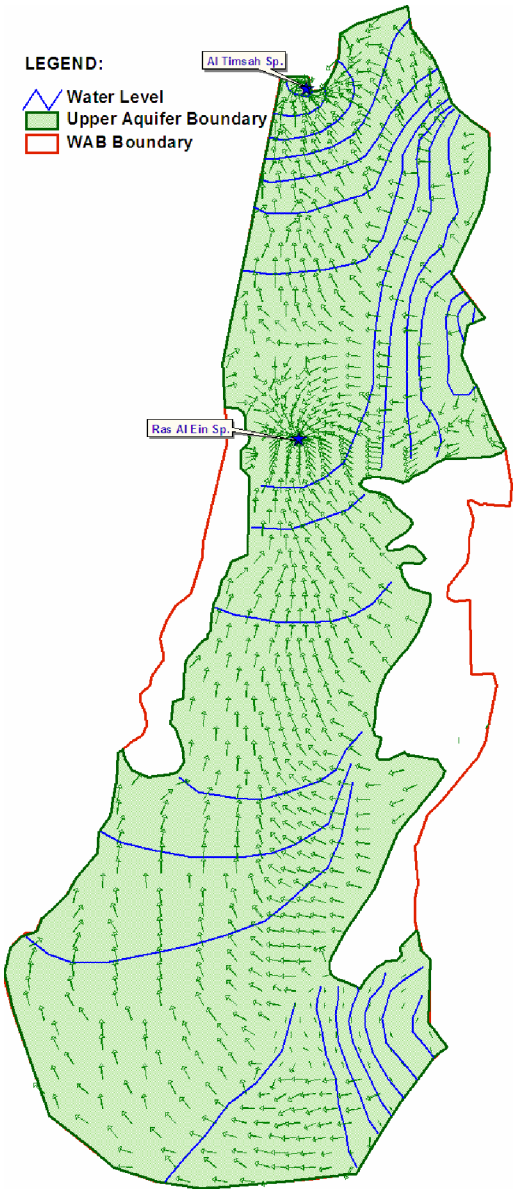


# Flow Patterns /*Upper Aquifer*

- The flow lines originate mainly from the recharge zones
- In general the direction is east-west and south-north:
  - Lithological facies changes and truncation of Judea Group prevent the groundwater flow to the west.
  - As a result, the flow direction will be diverted to the natural outlets of the basin in the north.

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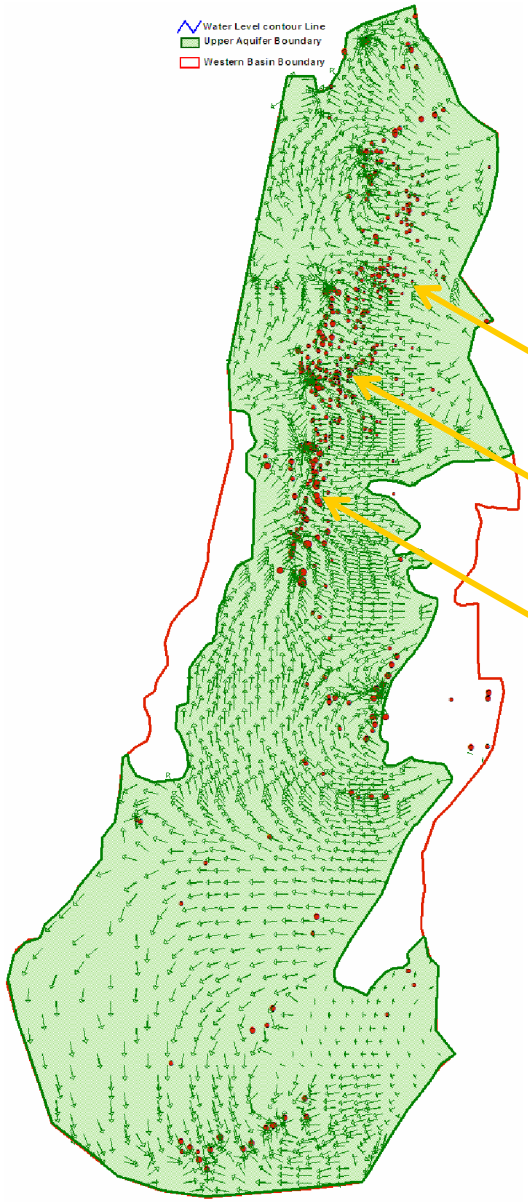


ØThe flow lines are affected by pumping and due to the changing abstraction rates.

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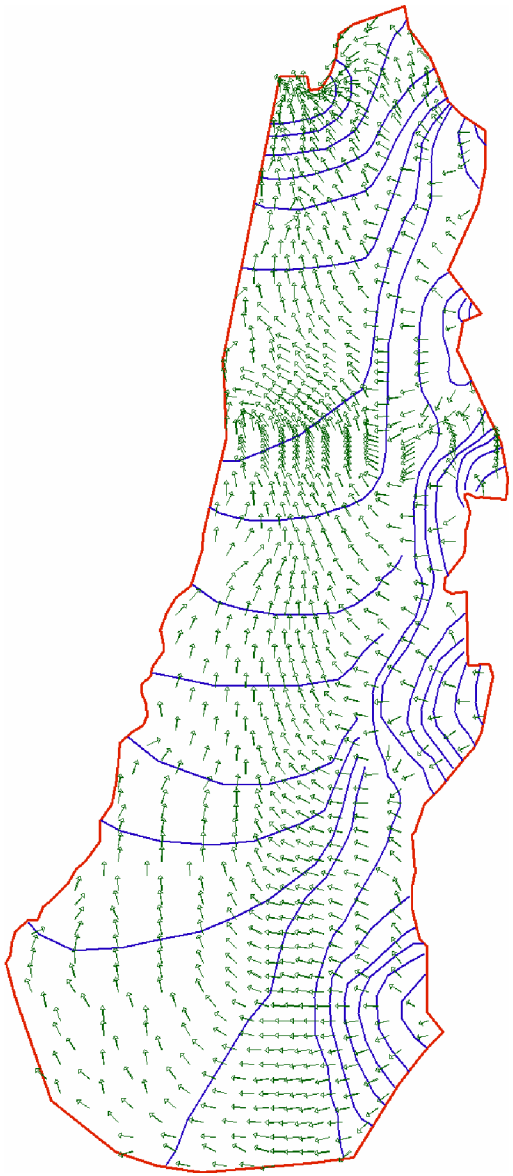

# Flow Patterns /*Lower Aquifer*

- The flow lines originate mainly from the recharge zones
- In general the direction is west-east and south-north.

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# Hydrogeological Investigation and Data acquisition


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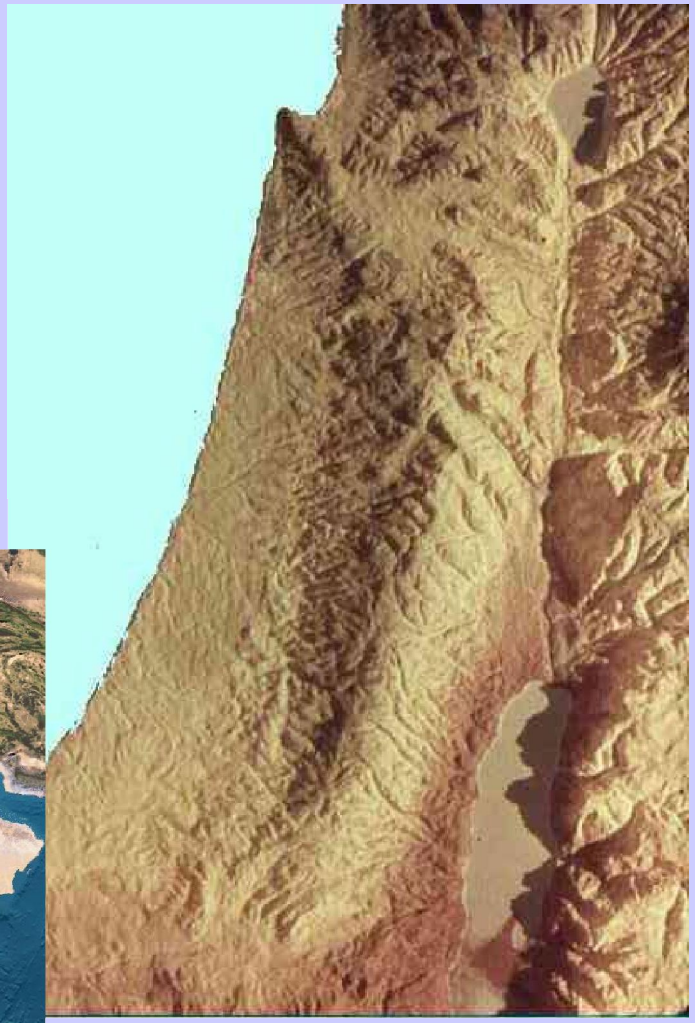
# 1)Production of three dimensional representations of the main hydrological units of the aquifers

Geometry data

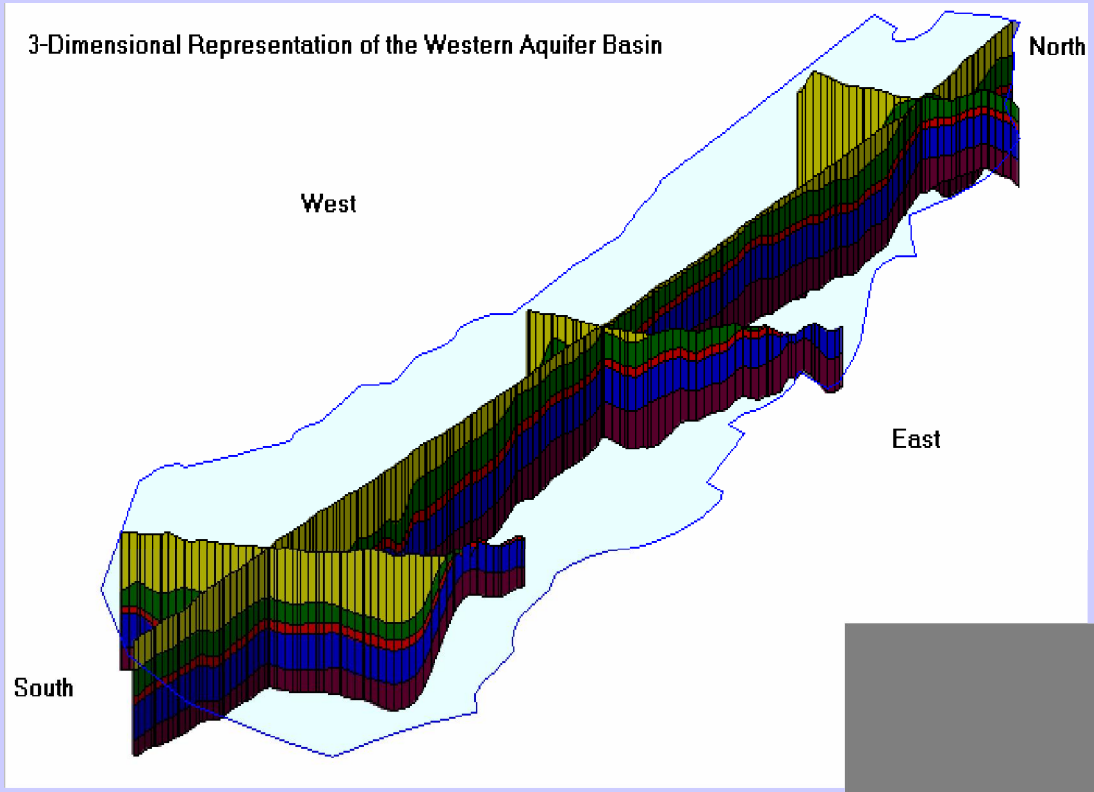
- ØTopography
- ØTop Upper Aquifer
- ØTop Yatta Aquifer
- ØTop Lower Aquifer
- ØBottom Lower Aquifer
- ØTop Telamim

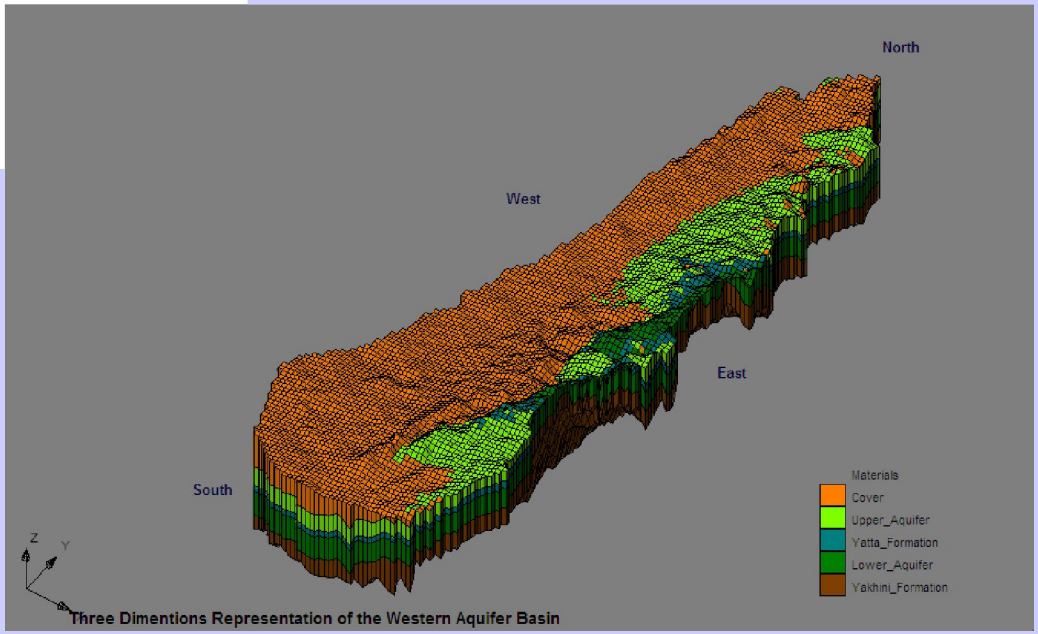
| PGE | PGN | Topography (m asl) | Top Upper Aquifer (Top Jer) (m asl) | Top Yatta Aquitard (Top Yat) (m asl) | Top Lower Aquifer (Top UBK) (m asl) | Bottom Lower Aquifer (Top Qat) (m asl) | Bottom Yakhini Aquiclude (Qat,EQ,T) (m asl) |
|---|---|---|---|---|---|---|---|
| 156740 | 226599 | 240 | 187 | -113 | -213 | -563 | -863 |
| 153521 | 225636 | 210 | 121 | -204 | -304 | -704 | -1004 |
| 154594 | 225636 | 200 | -19 | -344 | -444 | -844 | -1144 |
| 155667 | 225636 | 202 | -75 | -400 | -500 | -850 | -1150 |
| 156740 | 225636 | 233 | -54 | -379 | -479 | -829 | -1129 |
| 151375 | 224673 | 177 | -65 | -390 | -490 | -890 | -1190 |
| 152448 | 224673 | 136 | -63 | -388 | -488 | -888 | -1188 |
| 153521 | 224673 | 203 | -133 | -458 | -558 | -958 | -1258 |
| 154594 | 224673 | 183 | -218 | -543 | -643 | -1043 | -1343 |
| 155667 | 224673 | 200 | -222 | -547 | -647 | -997 | -1297 |
| 156740 | 224673 | 243 | -175 | -500 | -600 | -950 | -1250 |
| 149228 | 223710 | 98 | 98 | -249 | -349 | -799 | -1099 |
| 150301 | 223710 | 145 | -204 | -529 | -629 | -1029 | -1329 |
| 151375 | 223710 | 99 | -252 | -577 | -677 | -1077 | -1377 |
| 152448 | 223710 | 96 | -275 | -600 | -700 | -1100 | -1400 |
| 153521 | 223710 | 146 | -315 | -640 | -740 | -1140 | -1440 |
| 154594 | 223710 | 180 | -332 | -657 | -757 | -1157 | -1457 |
| 155667 | 223710 | 196 | -278 | -603 | -703 | -1053 | -1353 |
| 156740 | 223710 | 219 | -193 | -518 | -618 | -968 | -1268 |
| 148155 | 222747 | 112 | 112 | -188 | -288 | -738 | -1038 |
| 149228 | 222747 |  | -258 | -583 | -683 | -1133 | -1433 |
| 150301 | 222747 | 99 | -405 | -730 | -830 | -1230 | -1530 |
| 151375 | 222747 | 100 | -409 | -734 | -834 | -1234 | -1534 |
| 152448 | 222747 | 99 | -426 | -751 | -851 | -1251 | -1551 |
| 153521 | 222747 | 100 | -437 | -762 | -862 | -1262 | -1562 |
| 154594 | 222747 | 225 | -402 | -727 | -827 | -1227 | -1527 |
| 155667 | 222747 | 205 | -292 | -617 | -717 | -1067 | -1367 |
| 156740 | 222747 | 203 | -173 | -498 | -598 | -948 | -1248 |
| 157813 | 222747 | 236 | -117 | -442 | -542 | -892 | -1192 |
| 148155 | 221784 | 145 | 145 | -155 | -255 | -705 | -1005 |
| 149228 | 221784 | 102 | -504 | -829 | -929 | -1379 | -1679 |
| 150301 | 221784 | 154 | -545 | -870 | -970 | -1370 | -1670 |
| 151375 | 221784 | 92 | -502 | -827 | -927 | -1327 | -1627 |
| 152448 | 221784 | 92 | -498 | -823 | -923 | -1323 | -1623 |
| 153521 | 221784 | 167 | -482 | -807 | -907 | -1307 | -1607 |
| 154594 | 221784 | 253 | -407 | -732 | -832 | -1232 | -1532 |
| 155667 | 221784 | 248 | -264 | -589 | -689 | -1039 | -1339 |
| 156740 | 221784 | 207 | -137 | -462 | -562 | -912 | -1212 |

# q Satellite Images including the study area of the (WAB &NEAB)

# q Three Dimensional Presentation of (WAB)



# q Geological Cross Section and Maps

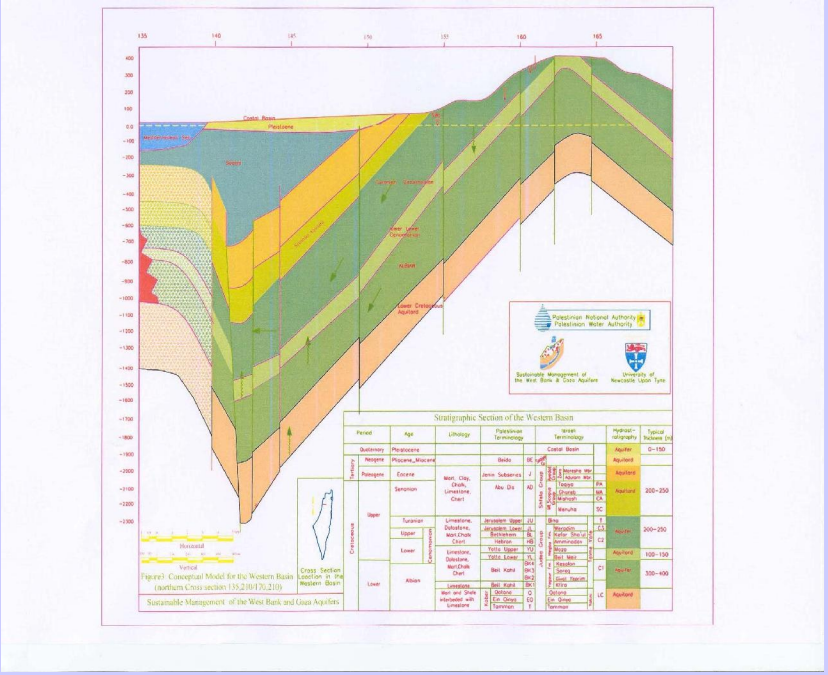
## ØStratigraphic Section

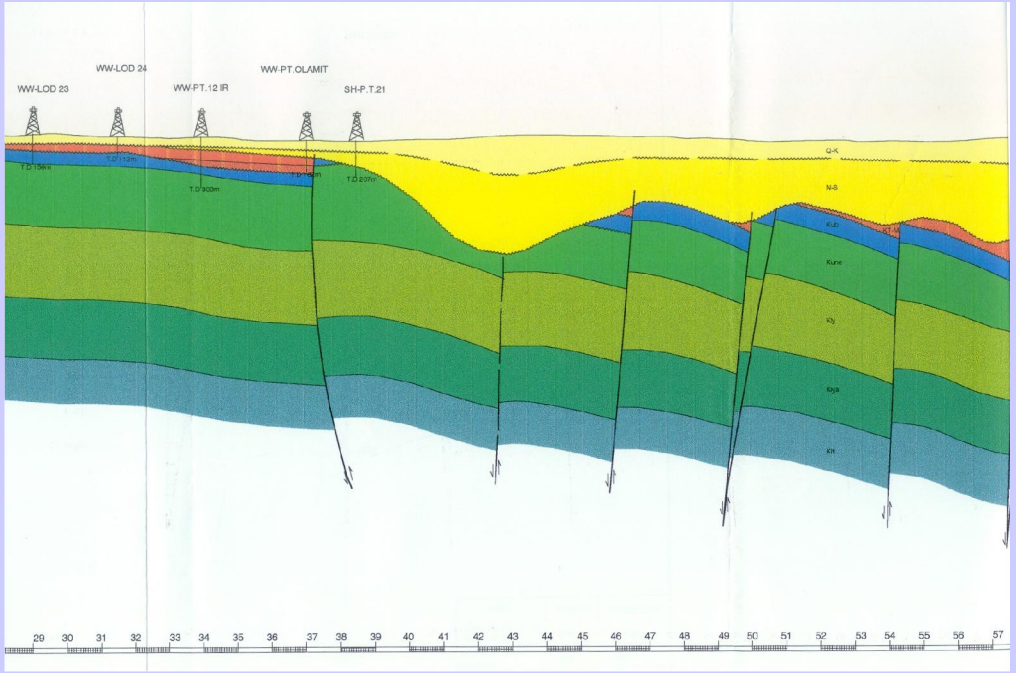
| Period | | Age | | Lithology | Palestinian Formation Terminology | | Israeli Formation Terminology | | | | | Symbol Israeli Map | Hydrostra-tigraphy | Typical Thickness (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quaternary | | Pleistocene\Holocene | | | | | Costal Basin | | | | | | Aquifer | 0–150 |
| Tertiary | Neogene | Pliocene\Oligocene | | Marl, Chalk, Clay and Limestone | Beida | BE | Saqiye Gr. | | | | | | Aquitard | |
| Tertiary | Paleogene | Eocene | | Marl, clay, chalk, limestone, chert | Jenin subseries | J | Shfela Group | Avedat Group | Zora | Maresha Mbr. | | | Aquitard | 200–250 |
| | | | | | | | | | | Adulam Mbr. | | | | |
| | | Paleocene | | | Abu Dis | AD | | Mt.Scopus Group | | Taqiya | | PA | Aquitard | |
| | | | | | | | | | | Ghareb | | MA | | |
| | | | | | | | | | | Mishash | | CA | | |
| Cretaceous | Upper | Senonian | | | | | | | | Menuha | | SC | | |
| | | Turonian | | Limestone, dolostone, marl,chalk chert | Jerusalem | J | Judea Group | Daliya Marl | | Bi'na | Undeferentiated Talme Yafe Group | T | Aquifer | 200–250 |
| | | Upper | Cenomanian | | Bethlehem Upper | BLU | | Negba Fm. | | Weradim | | C3 | | |
| | | | | | Bethlehem Lower | BLL | | | | Kefar Sha'ul | | | | |
| | | Lower | | | Hebron | HB | | | | Amminadav | | C2 | | |
| | | | | Limestone, dolostone, marl,chalk chert | Yatta Upper | YU | | | | Moza | | | Aquitard | 100–150 |
| | | | | | Yatta Lower | YL | | | | Beit Meir | | | | |
| | Lower | Albian | | | Upper Beit Kahil | BK4 BK3 | | Yagur Fm. | | Kesalon | | C1 | Aquifer | 300–400 |
| | | | | | Lower Beit Kahil | BK2 BK1 | | | | Soreq | | | | |
| | | | | Limestone | | | | | | Giv'at Ye'arim | | | | |
| | | | | | | | | | | Kefira | | | | |
| | | | | Marl and shale interbedded with limestone | Kobar Qatana | Q | Yakhini | | | Qatana | | LC | Aquitard | |
| | | | | | Kobar Ein Qinya | EQ | | | | Ein Qinya | | | | |
| | | | | | Kobar Tammun | T | | | | Tammun | | | | |

Figure 1.9: Stratigraphic Section of the Western Basin

# ØCross Sections

- v 13 Cross Sections (SUSMAQ/WAB)
- v 16 Cross Sections (Israeli Source/WAB



# 2)Production of an inventory of water table and piezometric surface elevation data

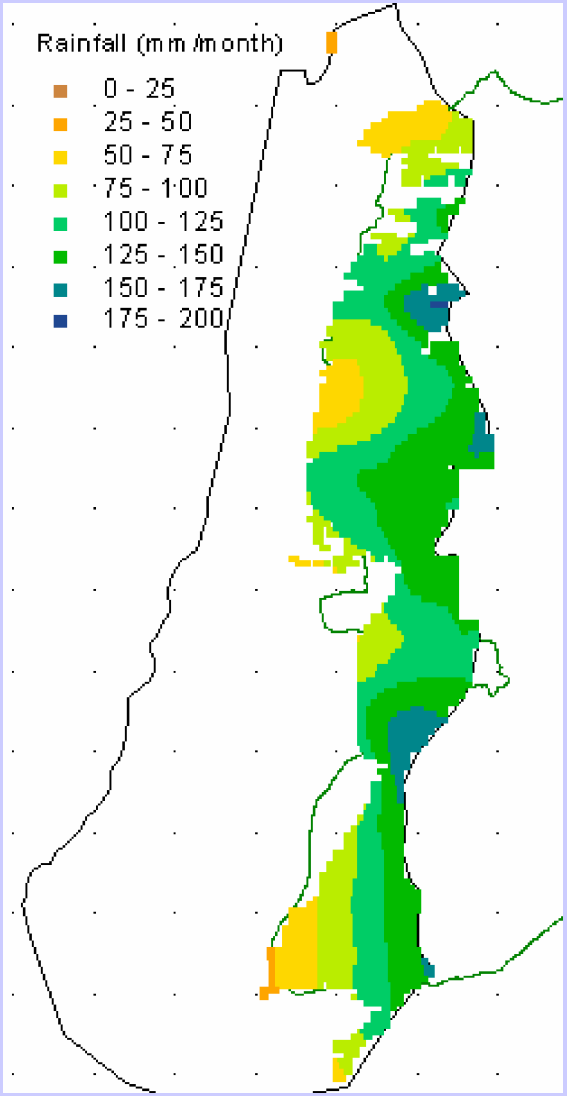
- q
  - ØAnnual data
  - ØBi annual
  - ØMonthly data
  - Øscattered
- q Sources of WL data
  - ØIsraelis
  - ØPWA
  - Øprojects

figure: 14 Water Level Contour Map-Western Basin (Year 1995)

# 3)Production of an atlas of initial estimates of mean monthly recharge from rainfall

Ø12 Monthly Values

ØMonthly Recharge maps for each month for each year (1968-1993)



# 4) Production of atlas of mean monthly recharge from irrigation, wastewater re-use and other artificial sources

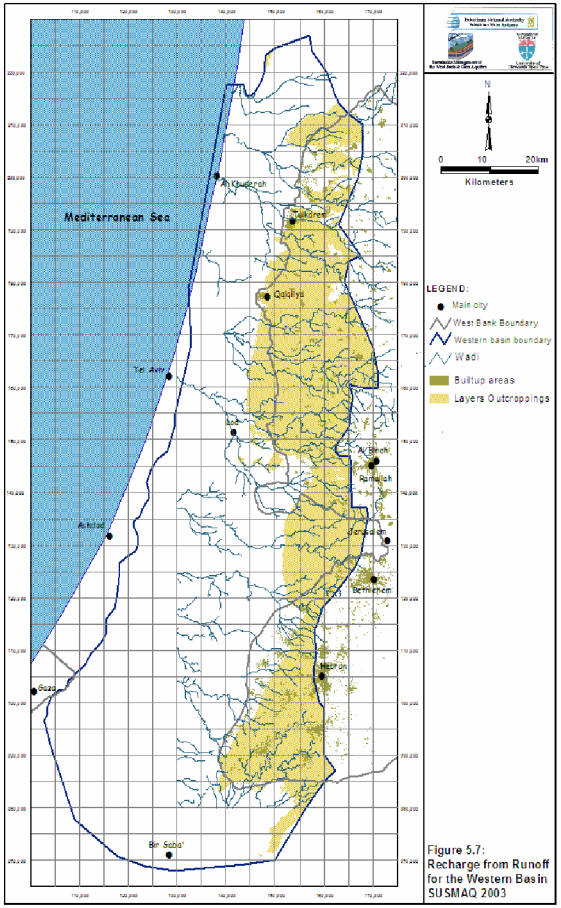



Figure 5.7:
Recharge from Runoff for the Western Basin
SUSMAQ 2003

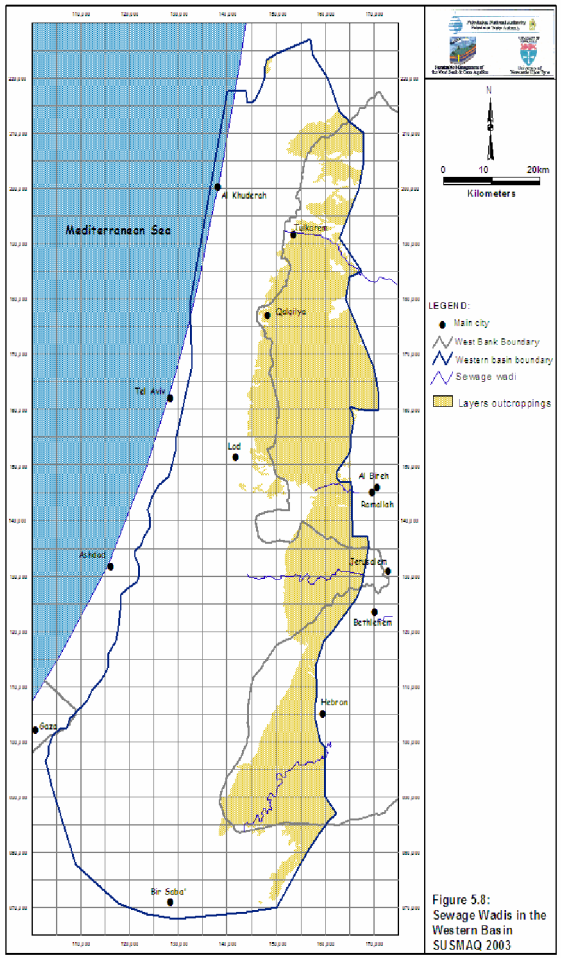
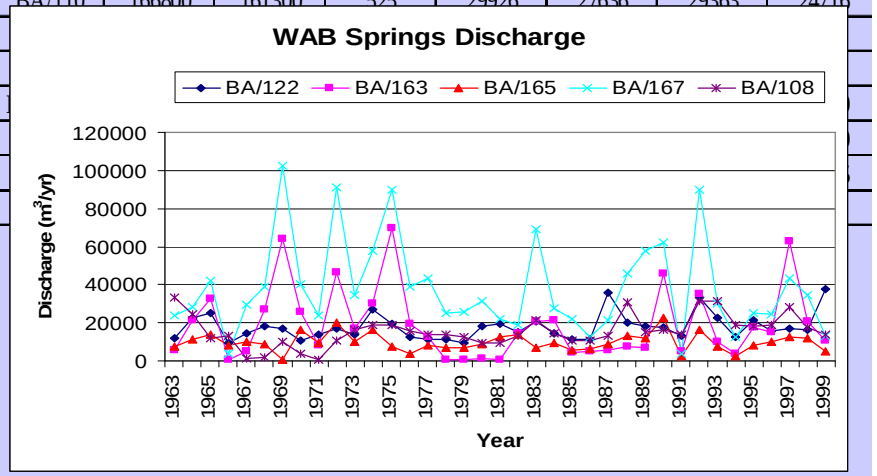



Figure 5.8:
Sewage Wadis in the Western Basin
SUSMAQ 2003

# 5) Compilation of an inventory of spring discharges

- Spring general data
- Spring discharges

| No | Spring ID | PGE | PGN | Elev. (m asl) | 1963 | 1964 | 1965 | 1966 |
|---|---|---|---|---|---|---|---|---|
| 1 | BA/121 | 156880 | 160080 | 255 | 127322 | 399411 | 377696 | 150739 |
| 2 | BA/122 | 156960 | 158960 | 300 | 11674 | 22318 | 25203 | 9173 |
| 3 | BA/163 | 164380 | 147920 | 510 | 5403 | 21156 | 32626 | 380 |
| 4 | BA/165 | 164370 | 147800 | 560 | 7713 | 11160 | 13818 | 8005 |
| 5 | BA/167 | 164400 | 147800 | 525 | 23828 | 28450 | 42334 | 3889 |
| 6 | BA/170 | 163630 | 145880 | 535 | 76021 | 99940 | 95189 | 63299 |
| 7 | BA/171 | 163330 | 146120 | 515 | 2922 | 102421 | 125833 | 83686 |
| 8 | BA/085 | 162400 | 165500 | 375 | 59455 | 58841 | 100583 | 59462 |
| 9 | BA/108 | 169100 | 160300 | 570 | 33129 | 24348 | 12180 | 13504 |
| 10 | BA/111 | 166900 | 158900 | 430 | 30092 | 32689 | 29656 | 22933 |
| 11 | BA/164 | 165370 | 148700 | 500 | 31749 | 127831 | 209249 | 87441 |
| 12 | BB/020 | 163240 | 126080 | 655 | 3273 | 67353 | 41830 | 54976 |
| 13 | BB/021 | 162590 | 125470 | 630 | 2354 | 42037 | 43705 | 18379 |
| 14 | BB/022 | 162200 | 124400 | 710 | 2842 | 7575 | 12853 | 1117 |
| 15 | BB/077 | 154900 | 101500 | 810 | 9453 | 98766 | 28325 | 18366 |
| 16 | BB/086 | 154860 | 99140 | 770 | 10606 | 48742 | 38107 | 25612 |
| 17 | BA/137 | 161680 | 157420 | 500 | 3600 | 2954 | 631 | 1537 |
| 18 | BA/110 | 166800 | 161300 | 525 | 29926 | 27636 | 29363 | 24716 |
| 19 | | | | | | | | |
| 20 | | | | | | | | |
| 21 | | | | | | | | |
| 22 | | | | | | | | |
| 23 | | | | | | | | |
| 24 | | | | | | | | |

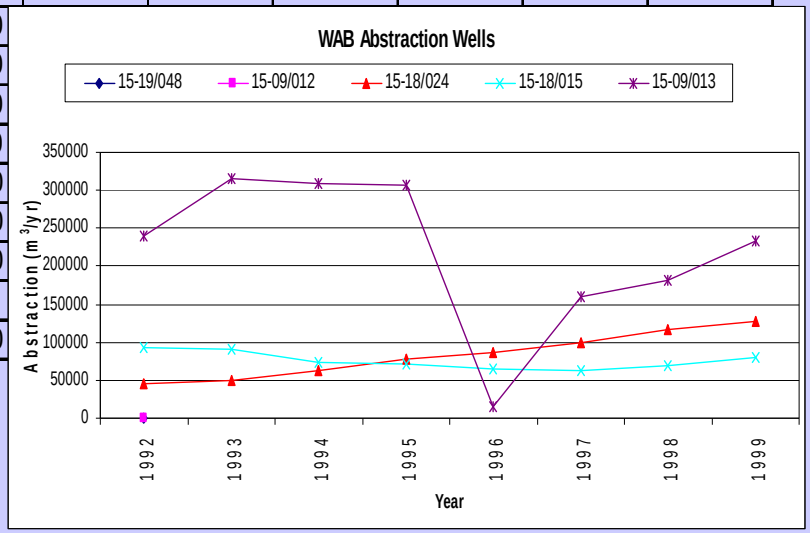


# 6) Compilation of an inventory of groundwater abstractions

ØWells general data

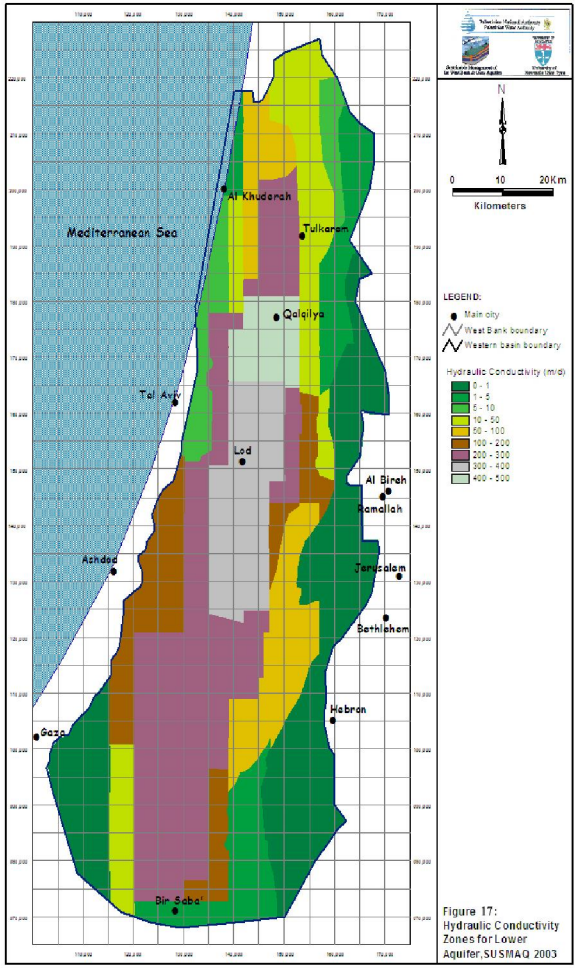
ØWells abstraction: annual and monthly

| PGN | Elev. (m asl) | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|
| 188500 | 100 | 44301 | 49762 | 63384 | 76867 | 86857 |
| 181200 | 270 | 92005 | 90258 | 74261 | 71199 | 64416 |
| 96200 | 700 | 238953 | 316253 | 309252 | 307225 | 15804 |
| 181600 | 142 | 108012 | 120808 | 126220 | 116755 | 112215 |
| 195450 | 195 | 132166 | 99299 | 189190 | 216130 | 251357 |
| 174640 | 75 | 184623 | 221571 | 215778 | 253751 | 254765 |
| 166150 | 200 | 1235 | 1779 | 717 | 875 | 649 |
| 198960 | 100 | 111503 | 131417 | 149507 | 160750 | 173747 |
| 177450 | 120 | 1030443 | 1006514 | 1076349 | 797560 | 1157241 |
| 204280 | 130 | 223531 | 254058 | 231788 | 257127 | 268424 |
| 179100 | 102 | 85209 | 91184 | 86600 | 122073 | 132175 |
| 188650 | 70 | 130229 | 240124 | 230562 | 227439 | 236399 |
| 177850 | 50 | 0 | 0 | 14729 | 9936 | |
| 153000 | 250 | 627095 | 628457 | 731803 | 675075 | 623785 |
| 175180 | | | | | | |
| 175960 | | | | | | |
| 177200 | | | | | | |
| 191950 | | | | | | |
| 190650 | | | | | | |
| 175000 | | | | | | |
| 200470 | | | | | | |
| 92260 | | | | | | |
| 193640 | | | | | | |

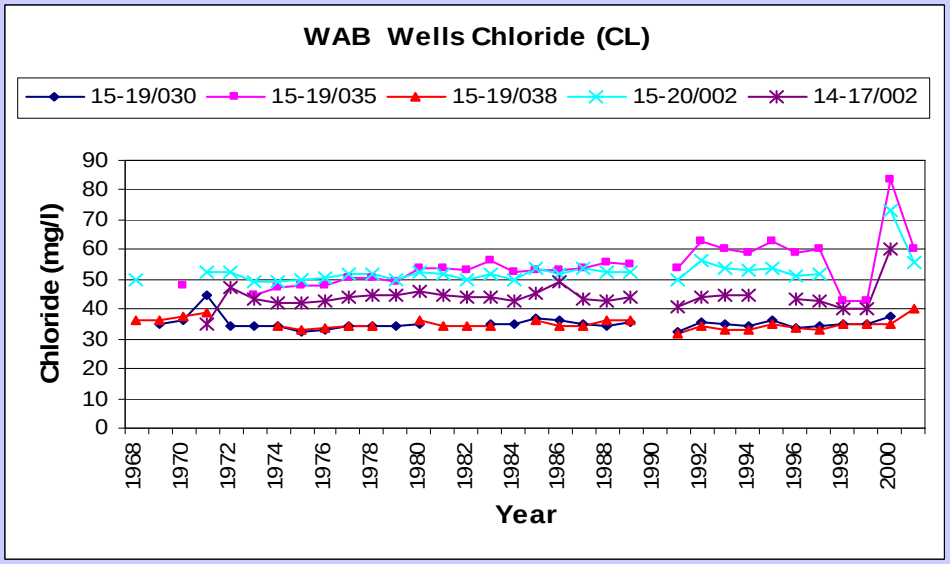


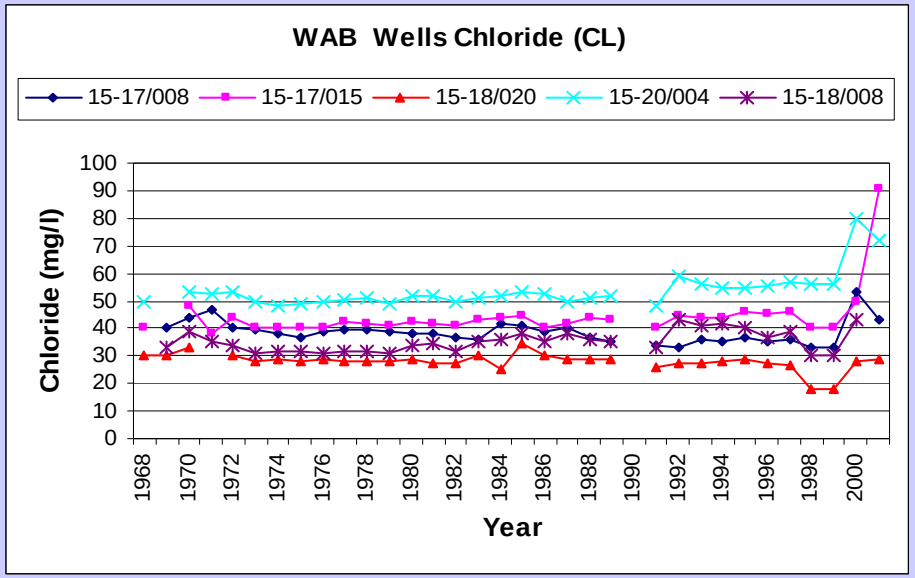
# 7) Compilation of an inventory of hydraulic conductivity storage coefficient and leakage estimates

ØMaps of hydraulic conductivity, T, S, n, etc



# 8) Compilation of an inventory of water chemistry data




ØYearly chloride content data

ØYearly Nitrate content data

Palestinian National Authority
Palestinian Water Authority

السلطة الوطنية الفلسطينية
سلطة المياه الفلسطينية


Sustainable Management of the West Bank and Gaza Aquifers

UNIVERSITY OF NEWCASTLE

NERC British Geological Survey

Department for International Development
DFID

# Thank You