

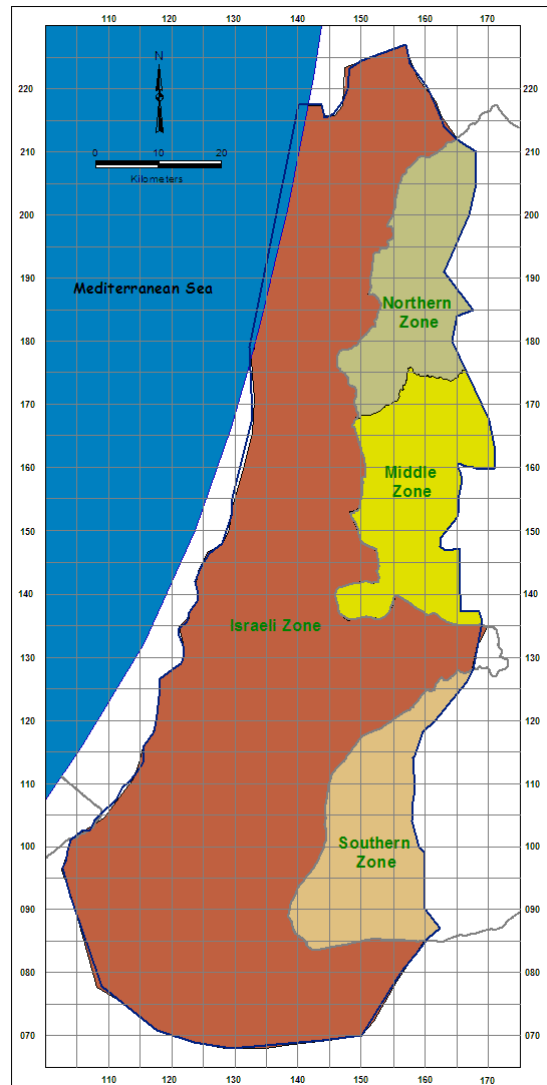


# Assessment of Sustainable Yields of WAB

Muath Abu Sadah



# Sustainable Yield of Palestinian Management Zones in WAB



Western Aquifer Basin is hydrogeologically a complex system due to:


- Confined/Unconfined Aquifer.
- Layered Aquifer
- Upper and Lower are connected in many places
- Shared aquifer

Therefore, Estimating the sustainable yield of WAB is mathematically very difficult.





# Maximum Abstractions from Palestinian Management Zones in WAB

## Aim:

-  To estimate the maximum possible abstractions in Palestinian management zones under different Israeli abstraction scenarios without creating adverse conditions in the whole Basin.

## Calculations based on:

-  Rainfall scenario (1998-2025).
-  30 % of the saturation thickness as the maximum drawdown in the aquifer.

## Calculations conducted by using the IMT (Iterative Method)



# Maximum Abstractions from Palestinian Management Zones in WAB

- Under each Israeli abstraction scenario, three Palestinian (maximum) abstraction scenarios are tested.
- This tells us that the shaded in red box is the number of abstraction that we can generate from specific Palestinian Management Zone under the particular Israeli abstraction scenario without causing the basin to reach adverse conditions.

| Scenario | Abstarction (Mcm) |               |             |               |                           |             |
|----------|-------------------|---------------|-------------|---------------|---------------------------|-------------|
|          | Israeli Zone      | Northern Zone | Middle Zone | Southern Zone | Palestinian Zones (Total) | WAB (Total) |
| Sc01     | 250               | 465           | 0.7         | 0.4           | 466.1                     | 716.1       |
|          |                   | 19.9          | 490         | 0.4           | 510.3                     | 760.3       |
|          |                   | 19.9          | 0.7         | 1.9           | 22.5                      | 272.5       |
| Sc02     | 317               | 385           | 0.7         | 0.4           | 386.1                     | 703.1       |
|          |                   | 19.9          | 420         | 0.4           | 440.3                     | 757.3       |
|          |                   | 19.9          | 0.7         | 1.8           | 22.4                      | 339.4       |
| Sc03     | 400               | 315           | 0.7         | 0.4           | 316.1                     | 716.1       |
|          |                   | 19.9          | 315         | 0.4           | 335.3                     | 735.3       |
|          |                   | 19.9          | 0.7         | 1.5           | 22.1                      | 422.1       |
| Sc04     | 500               | 230           | 0.7         | 0.4           | 231.1                     | 731.1       |
|          |                   | 19.9          | 235         | 0.4           | 255.3                     | 755.3       |
|          |                   | 19.9          | 0.7         | 1.4           | 21.8                      | 521.8       |
| Sc05     | 600               | 140           | 0.7         | 0.4           | 141.1                     | 741.1       |
|          |                   | 19.9          | 138         | 0.4           | 158.3                     | 758.3       |
|          |                   | 19.9          | 0.7         | 1.2           | 22                        | 622         |
| Sc06     | 700               | 54            | 0.7         | 0.4           | 55.1                      | 755.1       |
|          |                   | 19.9          | 38          | 0.4           | 58.3                      | 758.3       |
|          |                   | 19.9          | 0.7         | 1             | 21.6                      | 721.6       |

19.9, 0.7, 0.4 & 317 Mcm are the average abstraction (1986-1998) for Northern, Middle, Southern and Israeli zones respectively.

# Maximum Abstractions from Palestinian Management Zones in WAB

## Results and Conclusions

| Scenario | Abstarction (Mcm) |               |             |               |                           |             |
|----------|-------------------|---------------|-------------|---------------|---------------------------|-------------|
|          | Israeli Zone      | Northern Zone | Middle Zone | Southern Zone | Palestinian Zones (Total) | WAB (Total) |
| Sc01     | 250               | 19.9          | 0.7         | 1.9           | 22.5                      | 272.5       |
| Sc02     | 317               | 19.9          | 0.7         | 1.8           | 22.4                      | 339.4       |
| Sc03     | 400               | 19.9          | 0.7         | 1.5           | 22.1                      | 422.1       |
| Sc04     | 500               | 19.9          | 0.7         | 1.4           | 22                        | 522         |
| Sc05     | 600               | 19.9          | 0.7         | 1.2           | 21.8                      | 621.8       |
| Sc06     | 700               | 19.9          | 0.7         | 1             | 21.6                      | 721.6       |

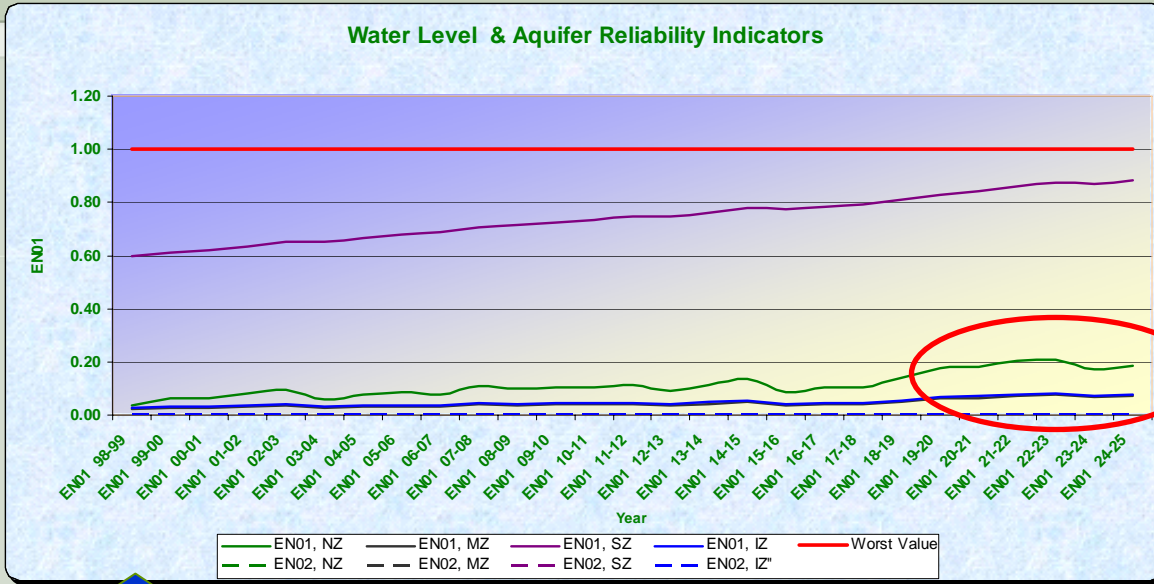
- ✚ The Palestinian management zone in the south is very limited in its recharge and productivity.
- ✚ The maximum abstraction from the southern zone did not increase more than 1.9 Mcm/yr whether regardless of abstraction scenarios in other zones
- ✚ This zone is not strong connected hydraulically with other zones
- ✚ The PWA is not advised to utilise the southern management zone of WAB beyond its current capacity (one or two wells only are recommended)

## Maximum Abstractions from Palestinian Management Zones in WAB

- Water availability in middle zone is much greater than the northern zone, this does not mean that the ability to extract water is easier; development costs should be prepared and a tradeoff between cost of development & drilling and quantity of extracted water should be made for the two zones.

| Scenario | Abstarction (Mcm) |               |             |               |                           | WAB (Total) |
|----------|-------------------|---------------|-------------|---------------|---------------------------|-------------|
|          | Israeli Zone      | Northern Zone | Middle Zone | Southern Zone | Palestinian Zones (Total) |             |
| Sc01     | 250               | 465           | 0.7         | 0.4           | 466.1                     | 716.1       |
|          |                   | 19.9          | 490         | 0.4           | 510.3                     | 760.3       |
| Sc02     | 317               | 385           | 0.7         | 0.4           | 386.1                     | 703.1       |
|          |                   | 19.9          | 420         | 0.4           | 440.3                     | 757.3       |
| Sc03     | 400               | 315           | 0.7         | 0.4           | 316.1                     | 716.1       |
|          |                   | 19.9          | 315         | 0.4           | 335.3                     | 735.3       |
| Sc04     | 500               | 230           | 0.7         | 0.4           | 231.1                     | 731.1       |
|          |                   | 19.9          | 235         | 0.4           | 255.3                     | 755.3       |
| Sc05     | 600               | 140           | 0.7         | 0.4           | 141.1                     | 741.1       |
|          |                   | 19.9          | 138         | 0.4           | 158.3                     | 758.3       |
| Sc06     | 700               | 54            | 0.7         | 0.4           | 55.1                      | 755.1       |
|          |                   | 19.9          | 38          | 0.4           | 58.3                      | 758.3       |

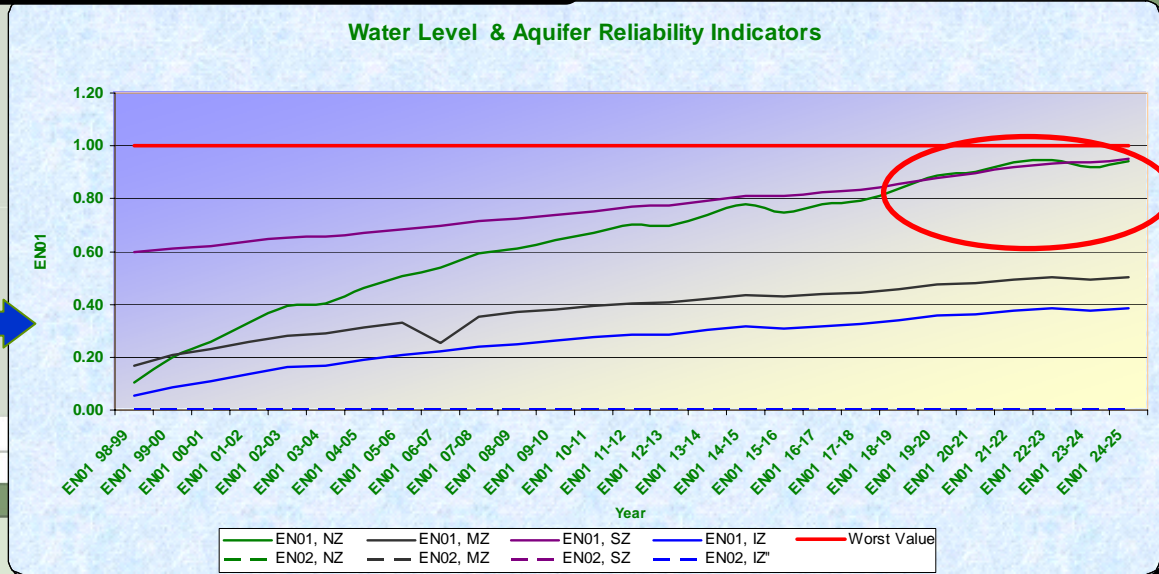
# Maximum Abstractions from Palestinian Management Zones in WAB



However, The negative impacts of abstracting water from Israeli zone or Palestinian Middle zone are larger on the water levels of the Northern zone.

**Abstractions (Mcm):**  
 NZ= 19.9  
 MZ=0.7  
 SZ=0.4  
 IZ=317

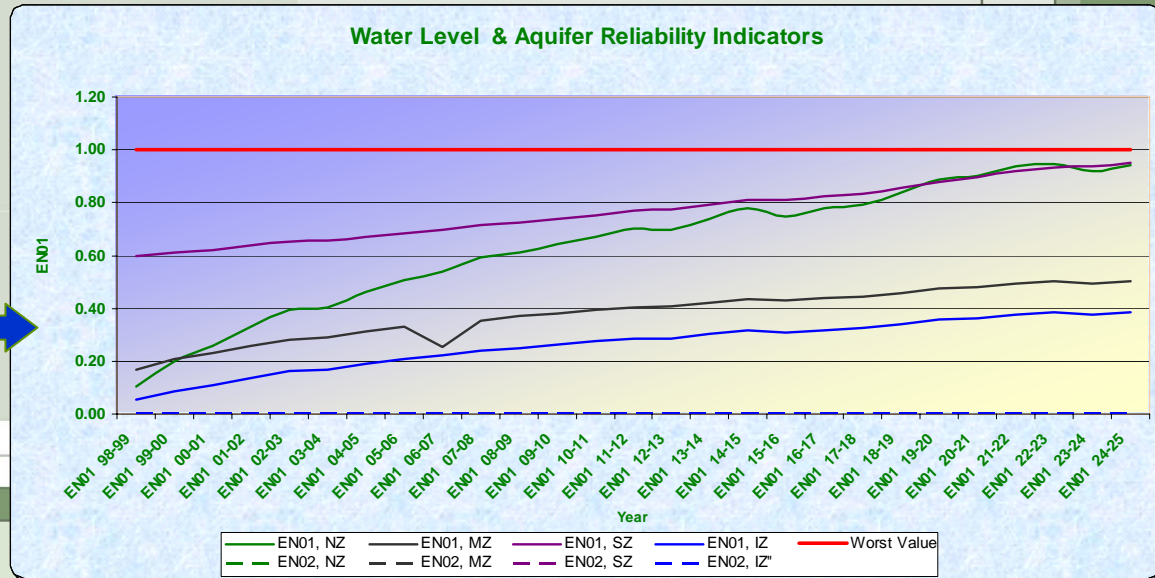
**Abstractions (Mcm):**  
 NZ= 19.9  
 MZ=315  
 SZ=0.4  
 IZ=400



# Maximum Abstractions from Palestinian Management Zones in WAB

- ✚ Middle Zone and Northern Zone are strongly connected
- ✚ Even we increased the abstraction in middle zone from 0.7 Mcm/yr to 315 Mcm/yr, the water levels of the middle zone deteriorates only to some extent while those of Northern Zone (even their abstraction remain low at 19.9 Mcm/yr) deteriorates to almost reach the worst condition.

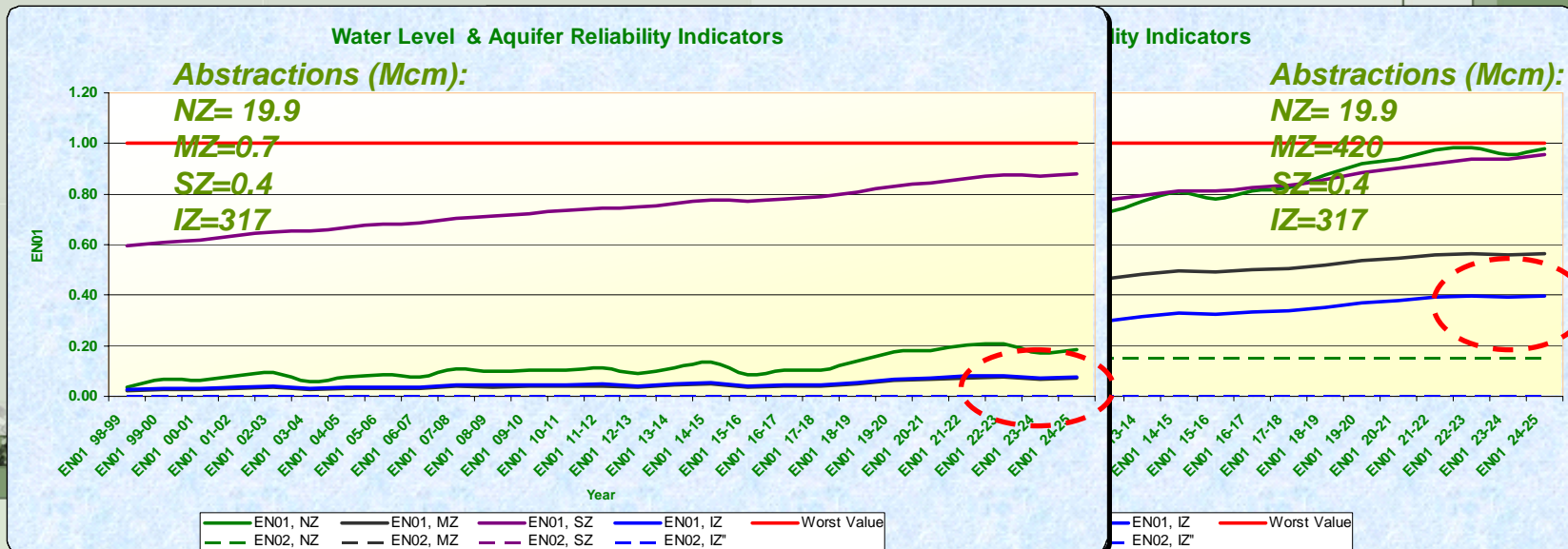
Abstractions (Mcm):  
 NZ= 19.9  
 MZ=315  
 SZ=0.4  
 IZ=400





# Maximum Abstractions from Palestinian Management Zones in WAB

- ✚ It is shown that the Palestinians can abstract 420 Mcm/yr from middle zone without causing significant harm to the Israeli wells.
- ✚ In conclusion the Palestinian can abstract the difference between the Sustainable Yield of the basin (443 Mcm) and the current Israeli abstraction (317 Mcm), i.e. the Palestinian can now abstract 126 Mcm/yr from their management zones without causing any harm to any Israeli well.



## Maximum Abstractions from Palestinian Management Zones in WAB

- ✚ *Technically, the Palestinians can abstract an equal amount of water to the Israelis'.*

| Scenario | Abstarction (Mcm) |                           |             |
|----------|-------------------|---------------------------|-------------|
|          | Israeli Zone      | Palestinian Zones (Total) | WAB (Total) |
| Sc01     | 60                | 670                       | 730         |
| Sc02     | 250               | 510.3                     | 760.3       |
| Sc03     | 317               | 440.3                     | 757.3       |
| Sc04     | 400               | 335.3                     | 735.3       |
| Sc05     | 500               | 255.3                     | 755.3       |
| Sc06     | 600               | 158.3                     | 758.3       |
| Sc07     | 700               | 58.3                      | 758.3       |




# Calculations

# Baseline (Year 1999)

- Northern Zone- Current Abstraction Year 1999

Existing Wells Abstraction Scenario - Northern Zone

|                   |                   |                   |
|-------------------|-------------------|-------------------|
| Year 98-99 : 19.9 | Year 07-08 : 19.9 | Year 16-17 : 19.9 |
| Year 99-00 : 19.9 | Year 08-09 : 19.9 | Year 17-18 : 19.9 |
| Year 00-01 : 19.9 | Year 09-10 : 19.9 | Year 18-19 : 19.9 |
| Year 01-02 : 19.9 | Year 10-11 : 19.9 | Year 19-20 : 19.9 |
| Year 02-03 : 19.9 | Year 11-12 : 19.9 | Year 20-21 : 19.9 |
| Year 03-04 : 19.9 | Year 12-13 : 19.9 | Year 21-22 : 19.9 |
| Year 04-05 : 19.9 | Year 13-14 : 19.9 | Year 22-23 : 19.9 |
| Year 05-06 : 19.9 | Year 14-15 : 19.9 | Year 23-24 : 19.9 |
| Year 06-07 : 19.9 | Year 15-16 : 19.9 | Year 24-25 : 19.9 |



Set abstraction to : 19.9 Mcm

Increase abstraction by : 100 %

Unit: Mcm

Submit View Abstraction Chart Reset

# Baseline (Year 1999)

- Middle Zone- Current Abstraction Year 1999

Existing Wells Abstraction Scenario -Middle Zone

|                  |                  |                  |
|------------------|------------------|------------------|
| Year 98-99 : 0.7 | Year 07-08 : 0.7 | Year 16-17 : 0.7 |
| Year 99-00 : 0.7 | Year 08-09 : 0.7 | Year 17-18 : 0.7 |
| Year 00-01 : 0.7 | Year 09-10 : 0.7 | Year 18-19 : 0.7 |
| Year 01-02 : 0.7 | Year 10-11 : 0.7 | Year 19-20 : 0.7 |
| Year 02-03 : 0.7 | Year 11-12 : 0.7 | Year 20-21 : 0.7 |
| Year 03-04 : 0.7 | Year 12-13 : 0.7 | Year 21-22 : 0.7 |
| Year 04-05 : 0.7 | Year 13-14 : 0.7 | Year 22-23 : 0.7 |
| Year 05-06 : 0.7 | Year 14-15 : 0.7 | Year 23-24 : 0.7 |
| Year 06-07 : 0.7 | Year 15-16 : 0.7 | Year 24-25 : 0.7 |



Set abstraction to : 0.7 Mcm

Increase abstraction by : 100 %

Submit

View Abstraction Chart

Reset

Unit: Mcm

# Baseline (Year 1999)

- Southern Zone- Current Abstraction Year 1999

Existing Wells Abstraction Scenario - Southern Zone

|                  |                  |                  |
|------------------|------------------|------------------|
| Year 98-99 : 0.4 | Year 07-08 : 0.4 | Year 16-17 : 0.4 |
| Year 99-00 : 0.4 | Year 08-09 : 0.4 | Year 17-18 : 0.4 |
| Year 00-01 : 0.4 | Year 09-10 : 0.4 | Year 18-19 : 0.4 |
| Year 01-02 : 0.4 | Year 10-11 : 0.4 | Year 19-20 : 0.4 |
| Year 02-03 : 0.4 | Year 11-12 : 0.4 | Year 20-21 : 0.4 |
| Year 03-04 : 0.4 | Year 12-13 : 0.4 | Year 21-22 : 0.4 |
| Year 04-05 : 0.4 | Year 13-14 : 0.4 | Year 22-23 : 0.4 |
| Year 05-06 : 0.4 | Year 14-15 : 0.4 | Year 23-24 : 0.4 |
| Year 06-07 : 0.4 | Year 15-16 : 0.4 | Year 24-25 : 0.4 |



Set abstraction to : 0.4 Mcm

Increase abstraction by : 100 %

Submit

View Abstraction Chart

Reset

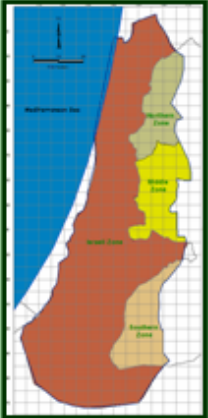
Unit: Mcm

# Baseline (Year 1999)

- Israeli Zone- Current Abstraction Year 1999

Israeli Abstraction Scenario

|                  |                  |                  |
|------------------|------------------|------------------|
| Year 98-99 : 317 | Year 07-08 : 317 | Year 16-17 : 317 |
| Year 99-00 : 317 | Year 08-09 : 317 | Year 17-18 : 317 |
| Year 00-01 : 317 | Year 09-10 : 317 | Year 18-19 : 317 |
| Year 01-02 : 317 | Year 10-11 : 317 | Year 19-20 : 317 |
| Year 02-03 : 317 | Year 11-12 : 317 | Year 20-21 : 317 |
| Year 03-04 : 317 | Year 12-13 : 317 | Year 21-22 : 317 |
| Year 04-05 : 317 | Year 13-14 : 317 | Year 22-23 : 317 |
| Year 05-06 : 317 | Year 14-15 : 317 | Year 23-24 : 317 |
| Year 06-07 : 317 | Year 15-16 : 317 | Year 24-25 : 317 |



Set abstraction to : 317 Mcm

Increase abstraction by : 100 %

Unit: Mcm

Submit View Abstraction Chart Reset

# Rainfall Scenario (1999-2025)

- Rainfall Accumulation

% From Average Recharge

|                  |                  |                  |
|------------------|------------------|------------------|
| Year 98-99 : 971 | Year 07-08 : 404 | Year 16-17 : 524 |
| Year 99-00 : 502 | Year 08-09 : 636 | Year 17-18 : 598 |
| Year 00-01 : 653 | Year 09-10 : 576 | Year 18-19 : 321 |
| Year 01-02 : 516 | Year 10-11 : 581 | Year 19-20 : 237 |
| Year 02-03 : 503 | Year 11-12 : 538 | Year 20-21 : 497 |
| Year 03-04 : 827 | Year 12-13 : 758 | Year 21-22 : 337 |
| Year 04-05 : 520 | Year 13-14 : 461 | Year 22-23 : 490 |
| Year 05-06 : 556 | Year 14-15 : 435 | Year 23-24 : 765 |
| Year 06-07 : 652 | Year 15-16 : 827 | Year 24-25 : 494 |

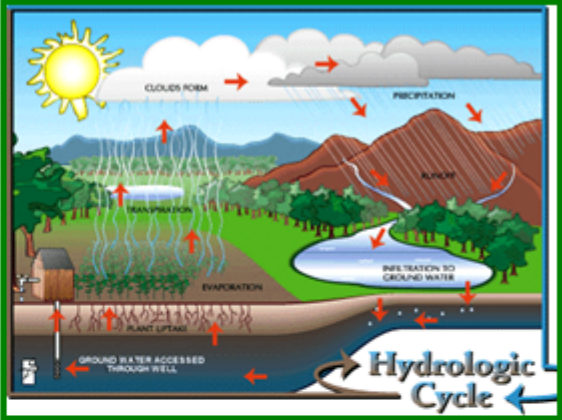
Unit: mm/yr

Multiply Rainfall by : 100 %

View Rainfall Time Series

View Recharge Time Series

Save & Exit      Exit without Save      High Emission      Low Emission

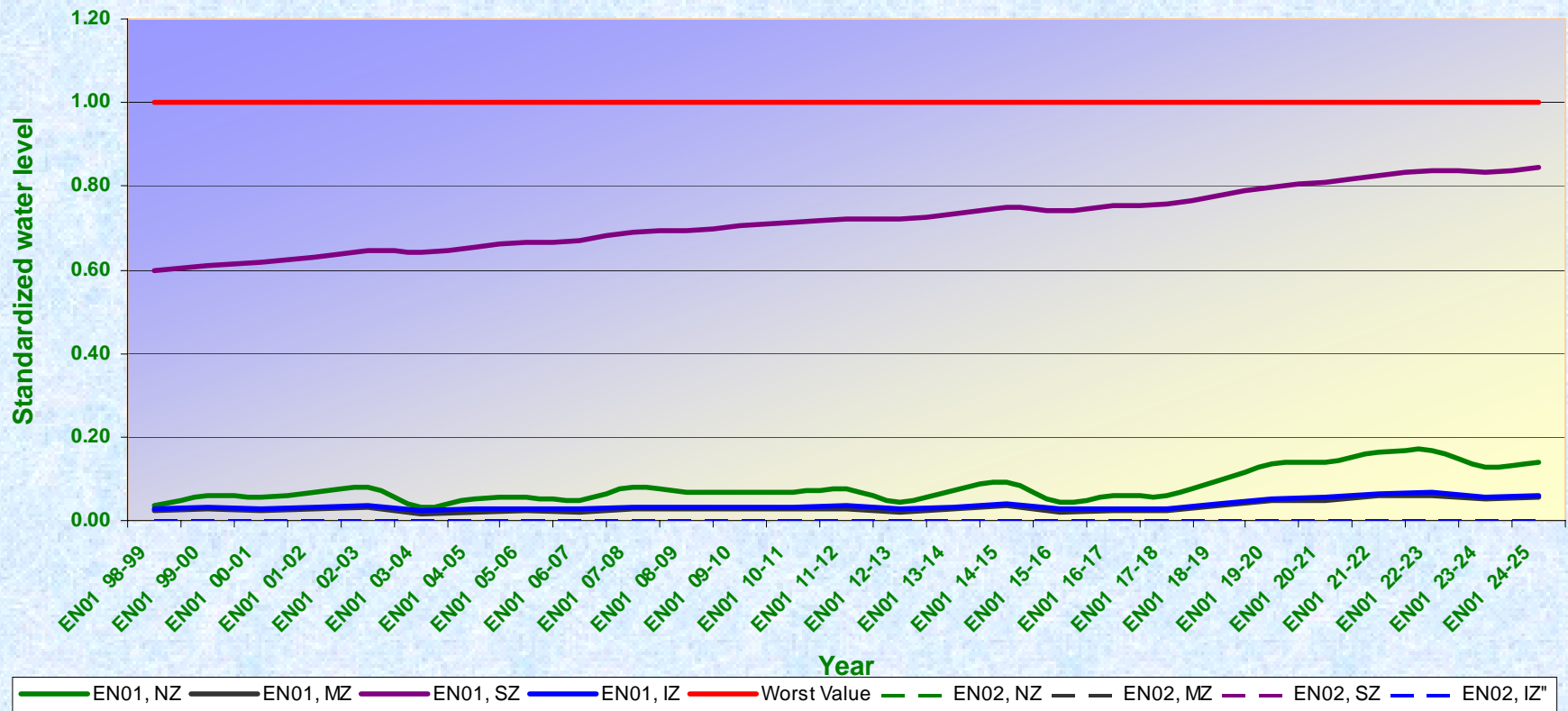


The diagram illustrates the hydrologic cycle with various processes labeled: CLOUDS FORM, PRECIPITATION, ALBINO, INFILTRATION TO GROUND WATER, EVAPORATION, PLANT UPTAKE, and GROUND WATER ACCESSED THROUGH WELL. It shows water moving between the atmosphere, land, and subsurface.



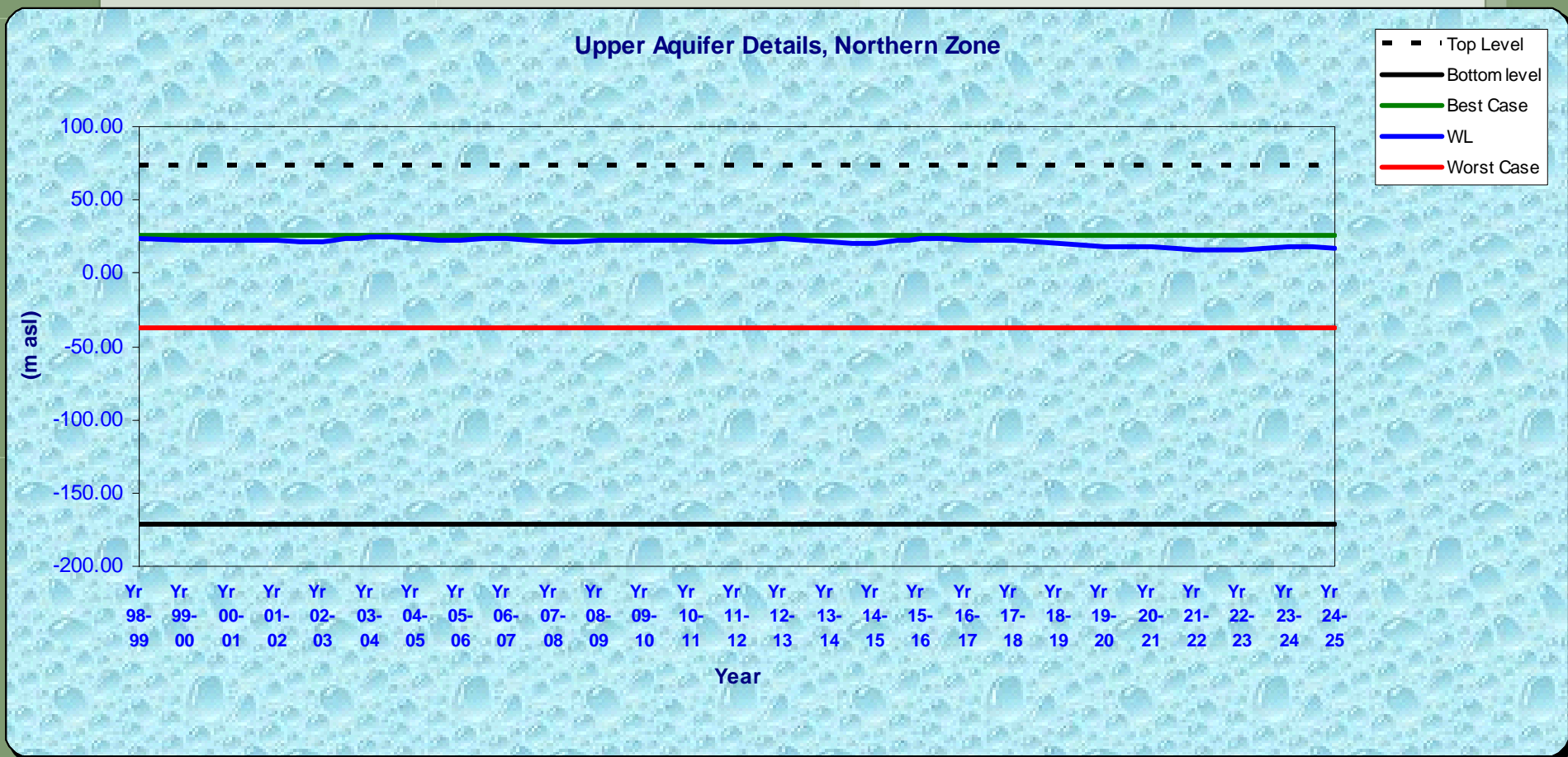
# Baseline (Year 1999)

- Standardized Water Levels for the Four Management Zones



# Baseline (Year 1999)

- Schematic diagram of Northern Zone.

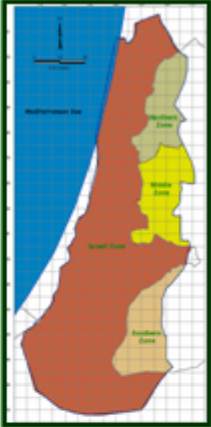


# Scenario 1: ( $Abst_{NZ} = 220 \text{ Mcm/Yr}$ )

- Increase the abstraction of northern zone from 20 Mcm/yr to 220 Mcm/yr, while the other zones, the abstractions do not change.

Existing Wells Abstraction Scenario - Northern Zone

|                  |                  |                  |
|------------------|------------------|------------------|
| Year 98-99 : 220 | Year 07-08 : 220 | Year 16-17 : 220 |
| Year 99-00 : 220 | Year 08-09 : 220 | Year 17-18 : 220 |
| Year 00-01 : 220 | Year 09-10 : 220 | Year 18-19 : 220 |
| Year 01-02 : 220 | Year 10-11 : 220 | Year 19-20 : 220 |
| Year 02-03 : 220 | Year 11-12 : 220 | Year 20-21 : 220 |
| Year 03-04 : 220 | Year 12-13 : 220 | Year 21-22 : 220 |
| Year 04-05 : 220 | Year 13-14 : 220 | Year 22-23 : 220 |
| Year 05-06 : 220 | Year 14-15 : 220 | Year 23-24 : 220 |
| Year 06-07 : 220 | Year 15-16 : 220 | Year 24-25 : 220 |



Set abstraction to : 220 Mcm

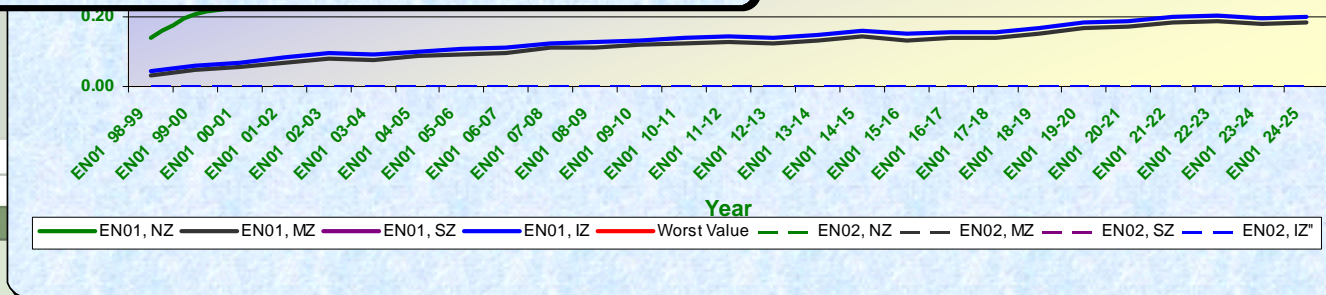
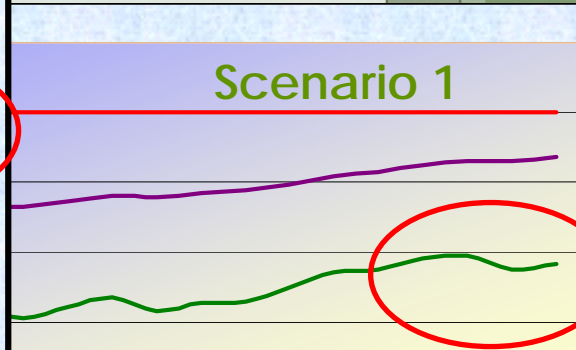
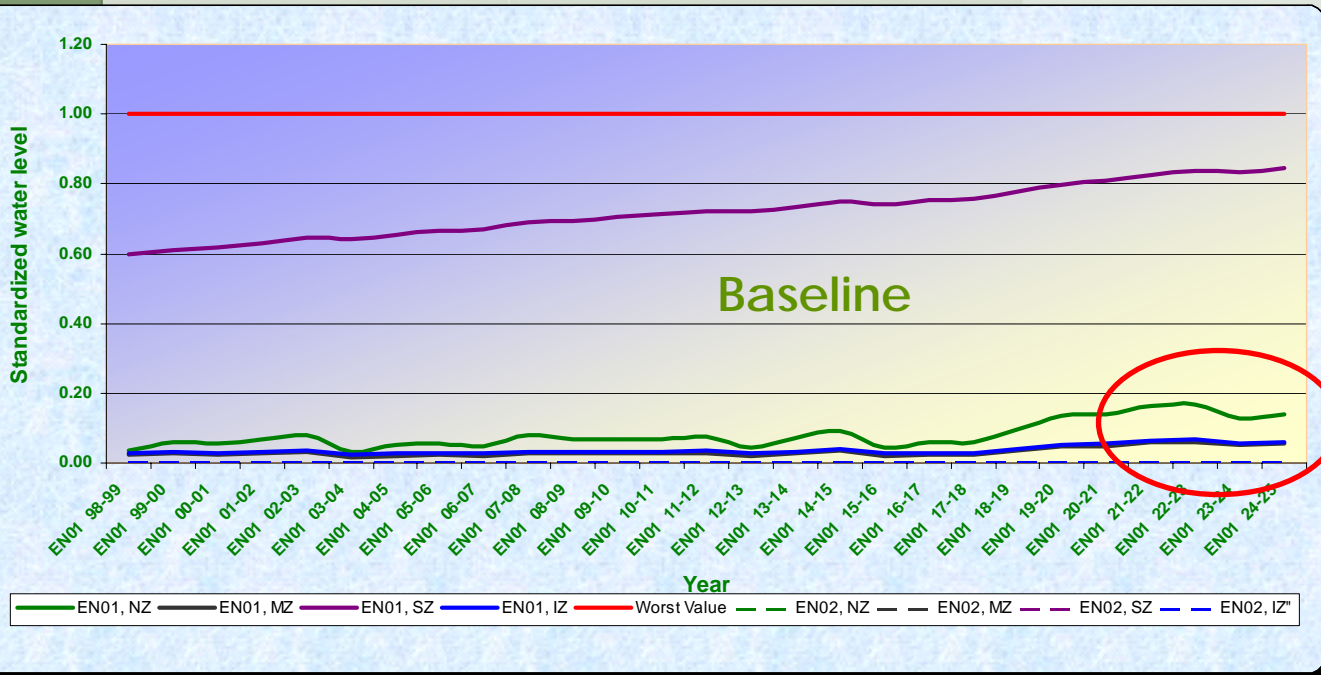
Increase abstraction by : 1106 %

Unit: Mcm

Submit View Abstraction Chart Reset

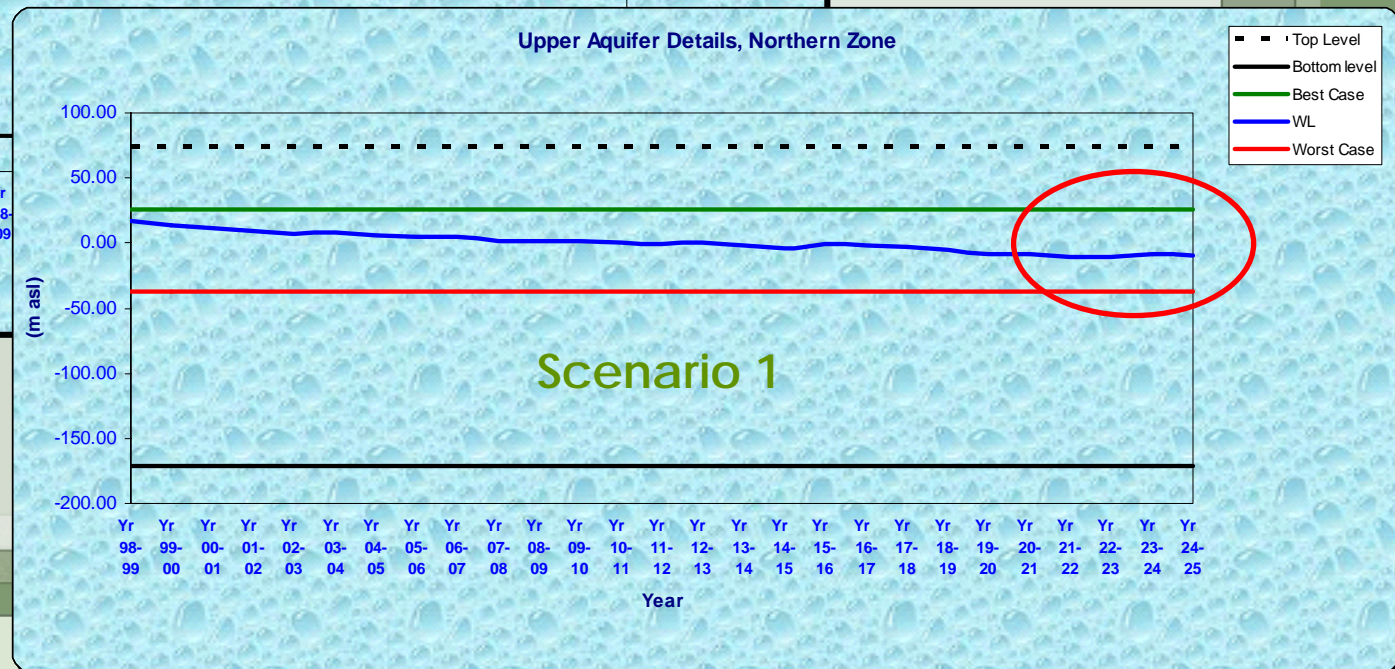
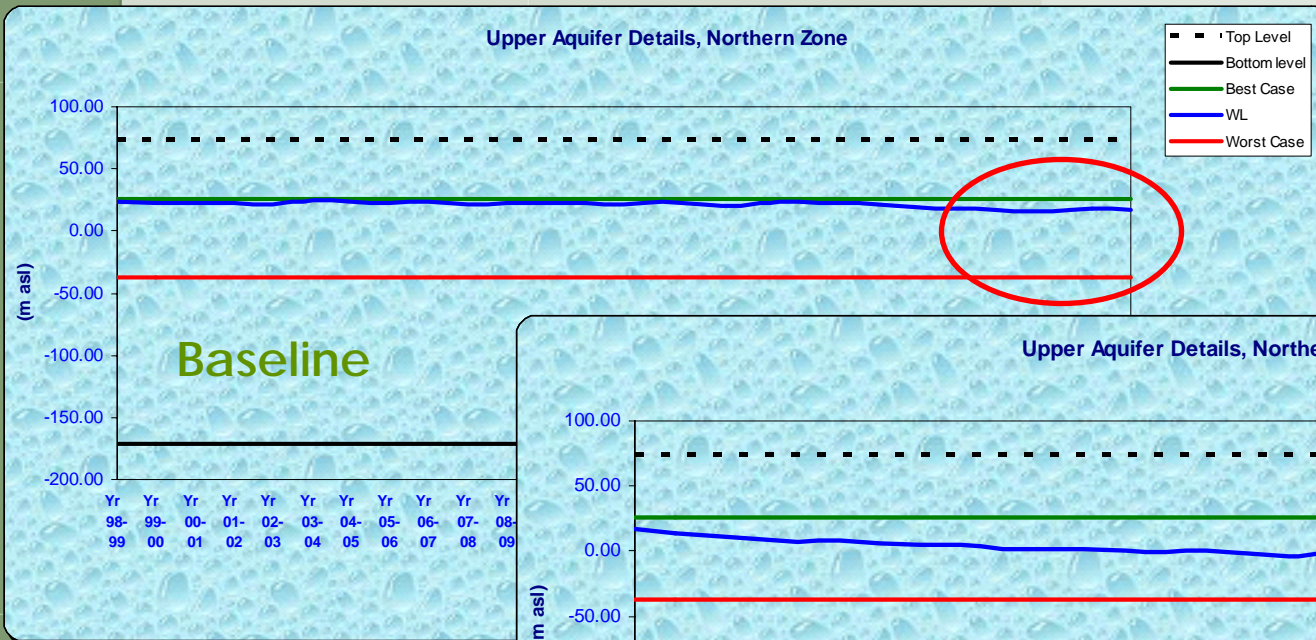
# Scenario 1: ( $Abst_{NZ} = 220 \text{ Mcm/Yr}$ )

- Standardized water level:



# Scenario 1: ( $Abst_{NZ} = 220 \text{ Mcm/Yr}$ )

- Schematic diagram of Northern Zone.




# Scenario 2: ( $Abst_{NZ} = 500 \text{ Mcm/Yr}$ )

- Increase the abstraction of northern zone to 500 Mcm/yr, while the other zones, the abstractions do not change.

Existing Wells Abstraction Scenario - Northern Zone

|                  |                  |                  |
|------------------|------------------|------------------|
| Year 98-99 : 500 | Year 07-08 : 500 | Year 16-17 : 500 |
| Year 99-00 : 500 | Year 08-09 : 500 | Year 17-18 : 500 |
| Year 00-01 : 500 | Year 09-10 : 500 | Year 18-19 : 500 |
| Year 01-02 : 500 | Year 10-11 : 500 | Year 19-20 : 500 |
| Year 02-03 : 500 | Year 11-12 : 500 | Year 20-21 : 500 |
| Year 03-04 : 500 | Year 12-13 : 500 | Year 21-22 : 500 |
| Year 04-05 : 500 | Year 13-14 : 500 | Year 22-23 : 500 |
| Year 05-06 : 500 | Year 14-15 : 500 | Year 23-24 : 500 |
| Year 06-07 : 500 | Year 15-16 : 500 | Year 24-25 : 500 |



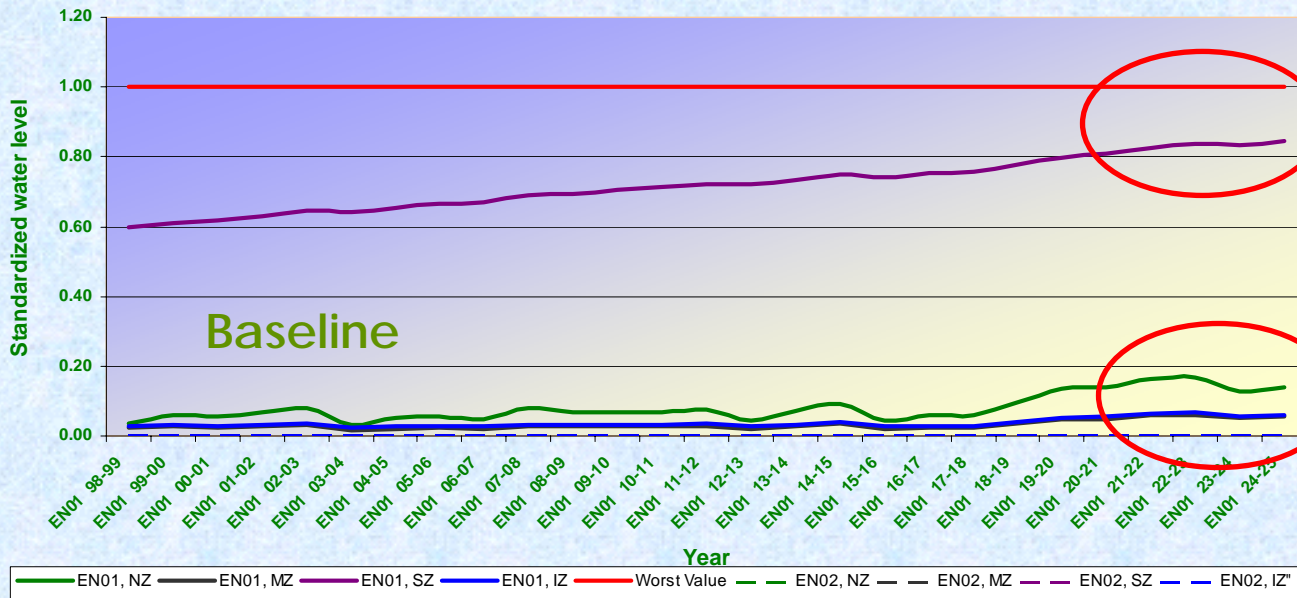
Set abstraction to : 500 Mcm

Increase abstraction by : 2513 %

Unit: Mcm

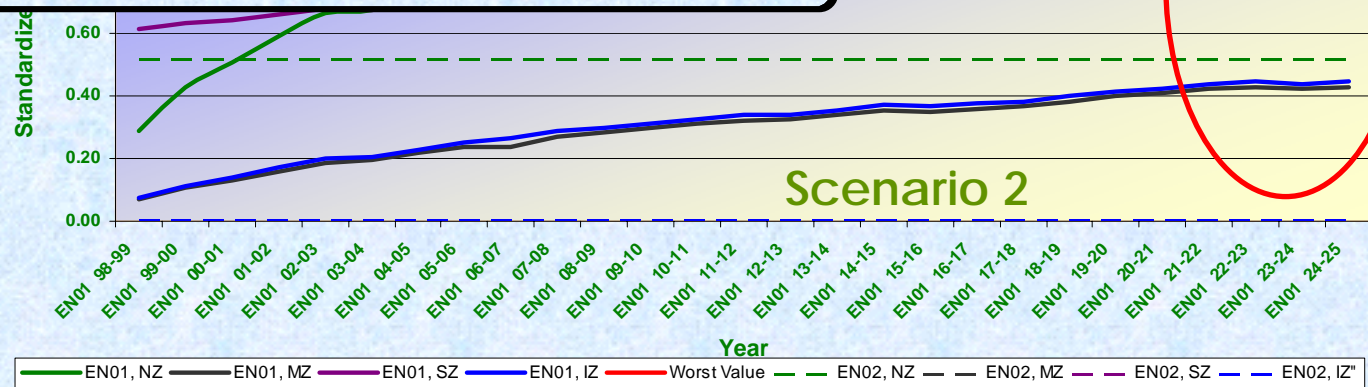
Submit View Abstraction Chart Reset

# Scenario 2: ( $Abst_{NZ} = 500 \text{ Mcm/Yr}$ )



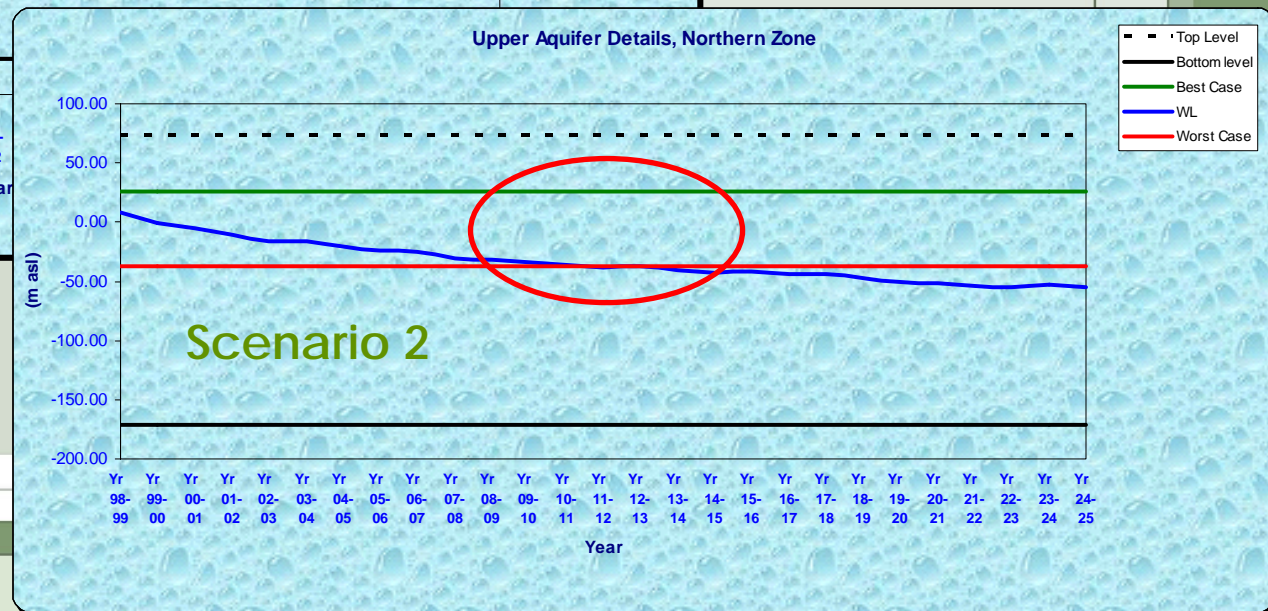
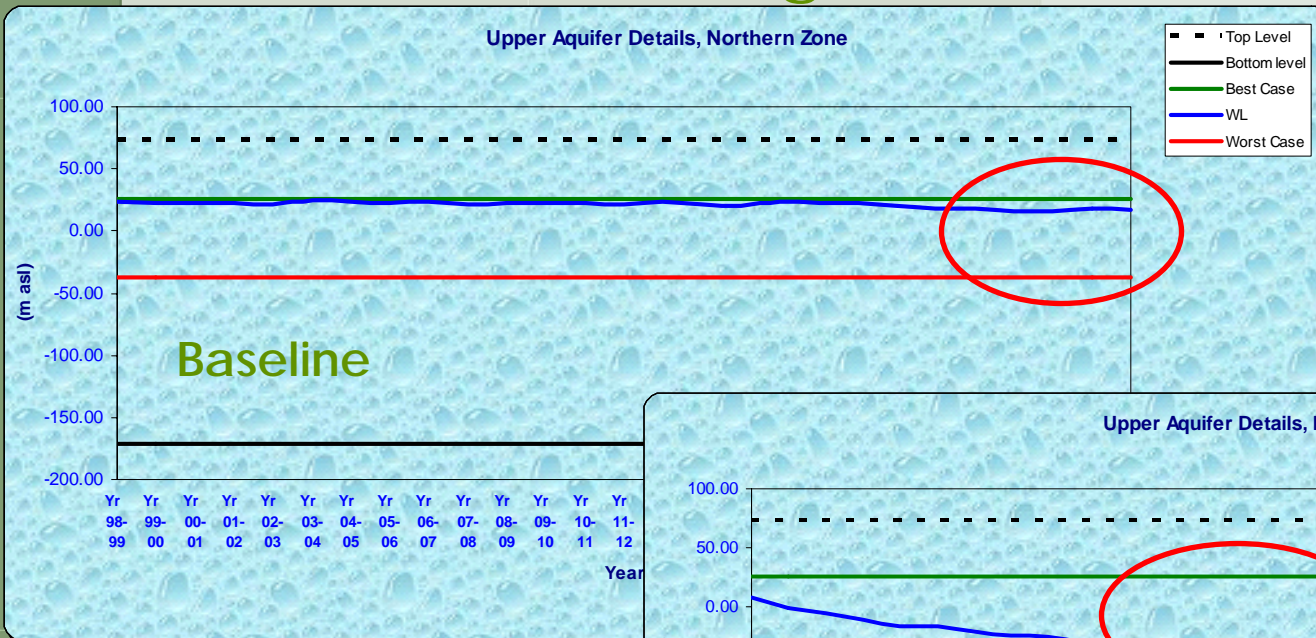
Standardized water level

Scenario 2 is not sustainable



# Scenario 2: ( $\text{Abst}_{\text{NZ}} = 500 \text{ Mcm/Yr}$ )

- Schematic diagram of Northern Zone.



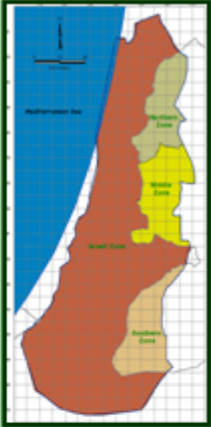


# Scenario 3: ( $Abst_{NZ} = 350 \text{ Mcm/Yr}$ )

- Increase the abstraction of northern zone to 350 Mcm/yr, while the other zones, the abstractions do not change.

Existing Wells Abstraction Scenario - Northern Zone

|                  |                  |                  |
|------------------|------------------|------------------|
| Year 98-99 : 350 | Year 07-08 : 350 | Year 16-17 : 350 |
| Year 99-00 : 350 | Year 08-09 : 350 | Year 17-18 : 350 |
| Year 00-01 : 350 | Year 09-10 : 350 | Year 18-19 : 350 |
| Year 01-02 : 350 | Year 10-11 : 350 | Year 19-20 : 350 |
| Year 02-03 : 350 | Year 11-12 : 350 | Year 20-21 : 350 |
| Year 03-04 : 350 | Year 12-13 : 350 | Year 21-22 : 350 |
| Year 04-05 : 350 | Year 13-14 : 350 | Year 22-23 : 350 |
| Year 05-06 : 350 | Year 14-15 : 350 | Year 23-24 : 350 |
| Year 06-07 : 350 | Year 15-16 : 350 | Year 24-25 : 350 |



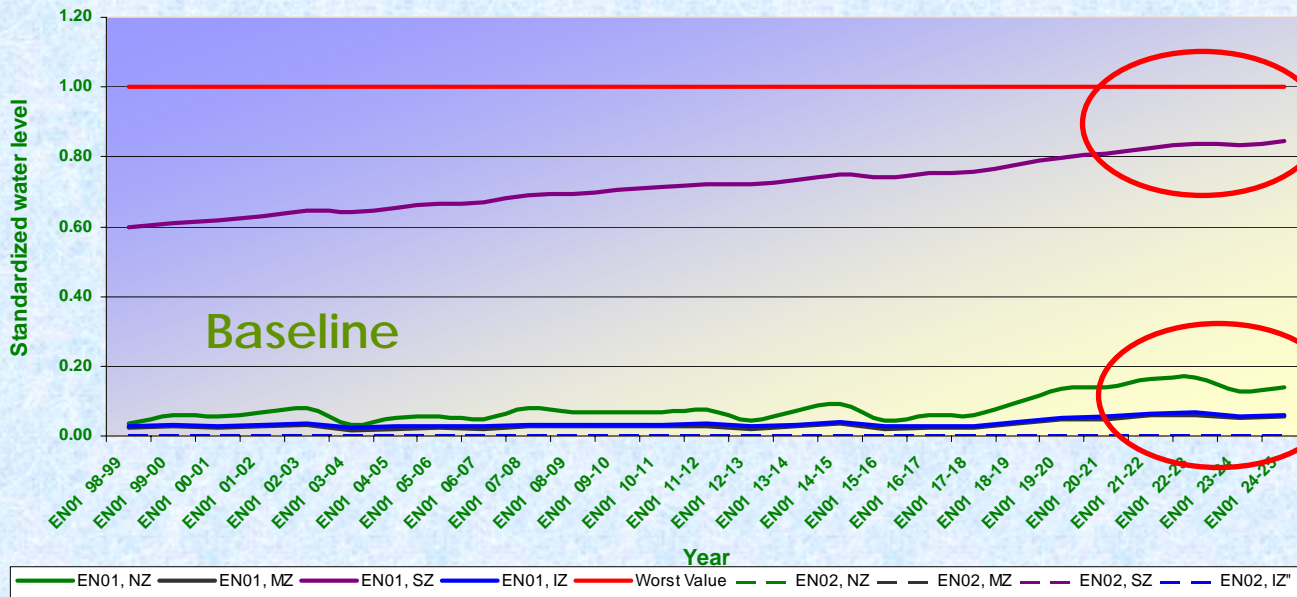
Set abstraction to : 350 Mcm

Increase abstraction by : 1759 %

Unit: Mcm

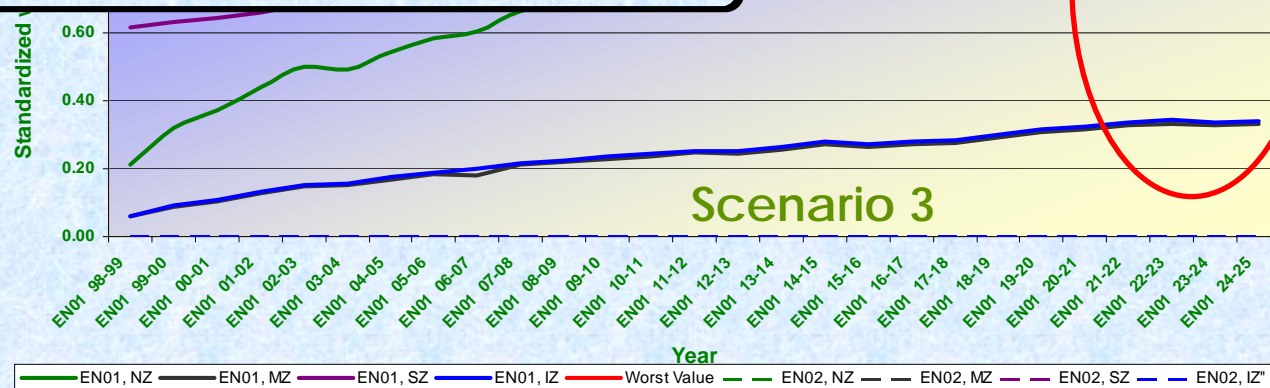
Submit View Abstraction Chart Reset

# Scenario 3: ( $Abst_{NZ} = 350 \text{ Mcm/Yr}$ )



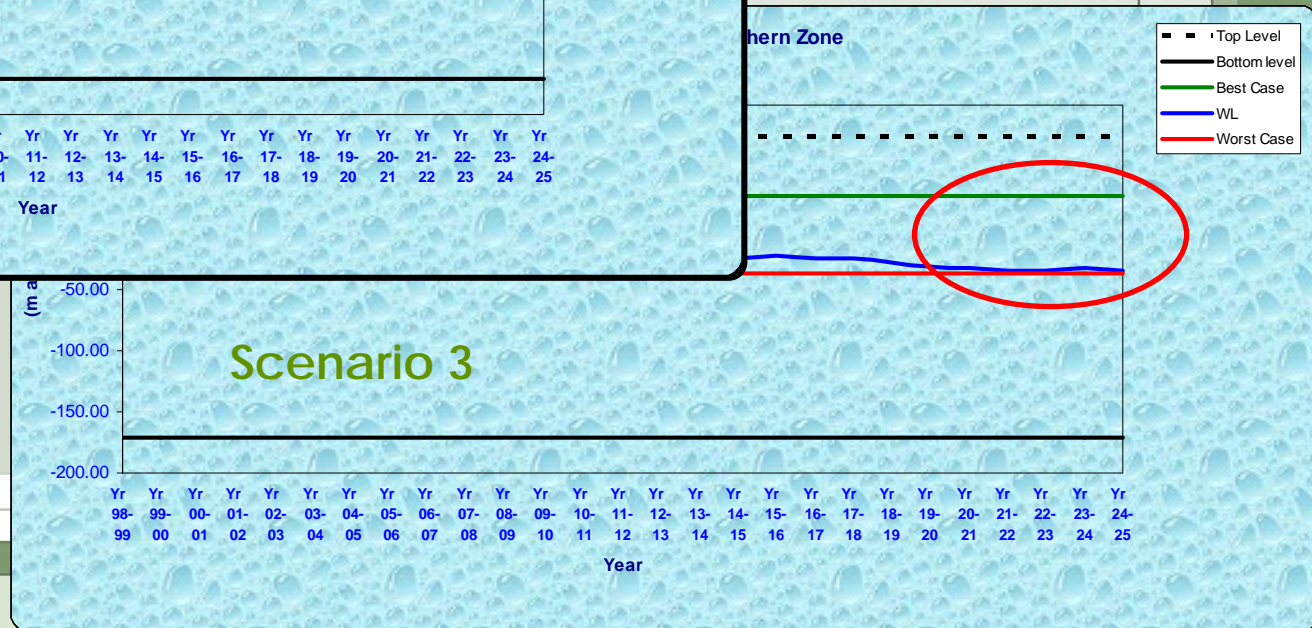
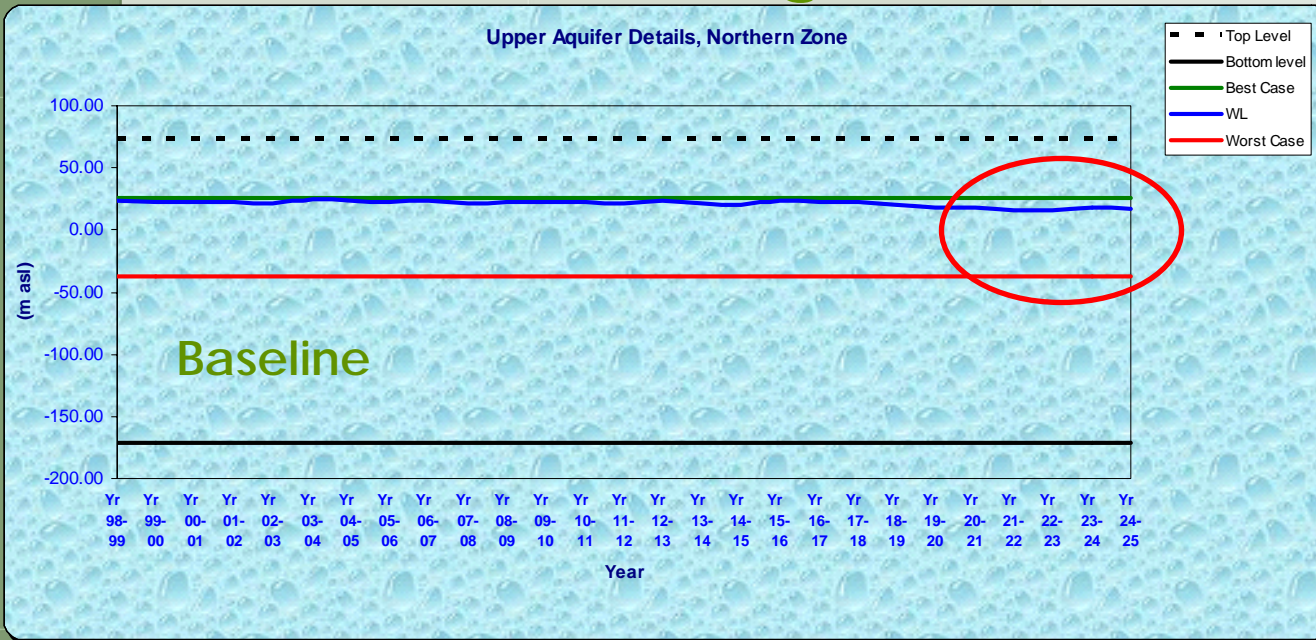
Standardized water level

Scenario 3 is sustainable



# Scenario 3: ( $Abst_{NZ} = 350 \text{ Mcm/Yr}$ )

- Schematic diagram of Northern Zone.



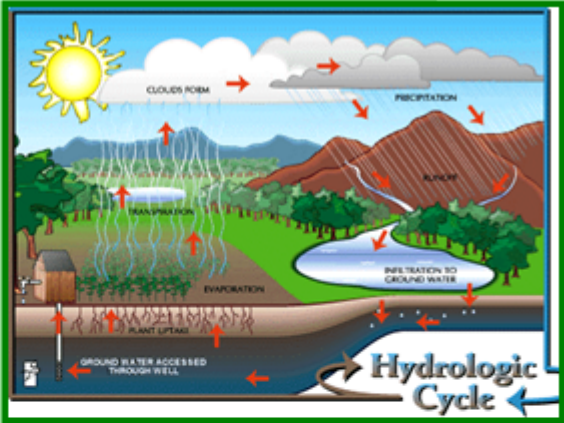
# Scenario 4: Reduce the Rainfall by 25%

- Keeping the abstraction as scenario 3 (sustainable yield of northern zone [350 Mcm/yr])

% From Average Recharge

|                  |                  |                  |
|------------------|------------------|------------------|
| Year 98-99 : 728 | Year 07-08 : 288 | Year 16-17 : 371 |
| Year 99-00 : 351 | Year 08-09 : 454 | Year 17-18 : 422 |
| Year 00-01 : 466 | Year 09-10 : 409 | Year 18-19 : 230 |
| Year 01-02 : 364 | Year 10-11 : 407 | Year 19-20 : 165 |
| Year 02-03 : 360 | Year 11-12 : 390 | Year 20-21 : 351 |
| Year 03-04 : 570 | Year 12-13 : 529 | Year 21-22 : 235 |
| Year 04-05 : 369 | Year 13-14 : 325 | Year 22-23 : 353 |
| Year 05-06 : 399 | Year 14-15 : 311 | Year 23-24 : 551 |
| Year 06-07 : 462 | Year 15-16 : 603 | Year 24-25 : 344 |

Unit: mm/yr



View Rainfall Time Series

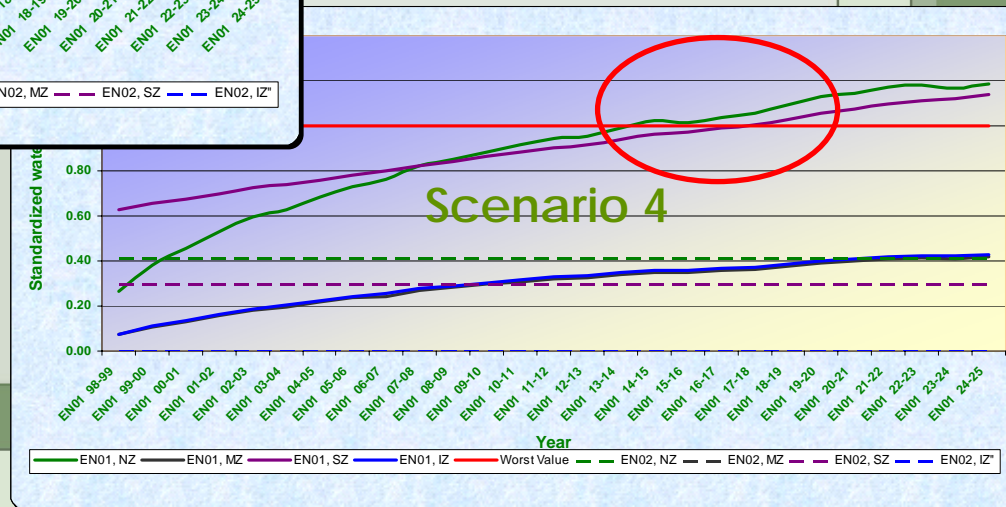
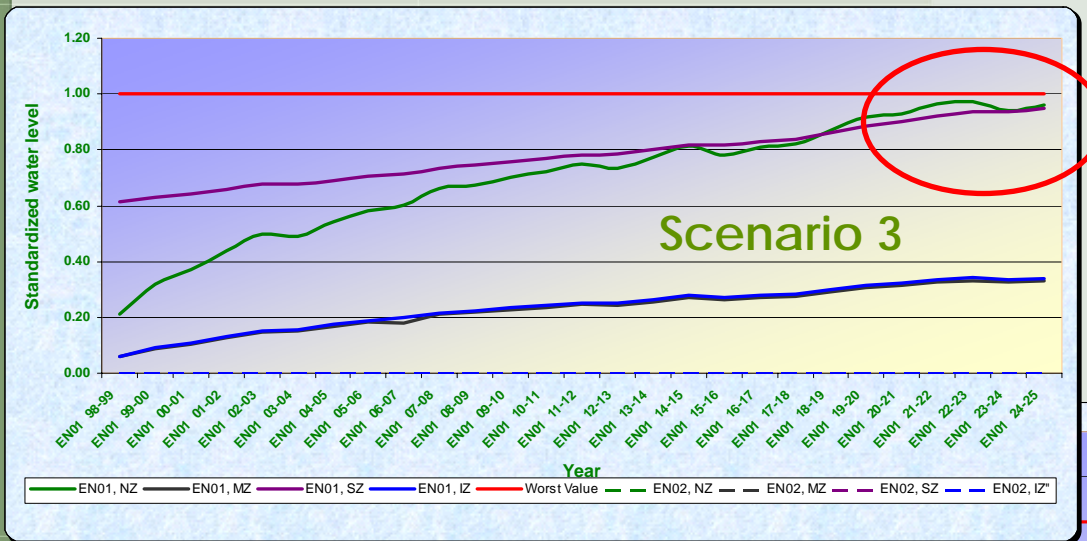
View Recharge Time Series

Multiply Rainfall by : 75 %

Save & Exit    Exit without Save    High Emission    Low Emission

# Scenario 4: Reduce the Rainfall by 25%

- Same abstractions but rainfall is reduced by 25%




# Scenario 5:

- The same as scenario 4 with reducing the abstractions of northern zone to 250 Mcm/yr

Existing Wells Abstraction Scenario - Northern Zone

|                  |                  |                  |
|------------------|------------------|------------------|
| Year 98-99 : 250 | Year 07-08 : 250 | Year 16-17 : 250 |
| Year 99-00 : 250 | Year 08-09 : 250 | Year 17-18 : 250 |
| Year 00-01 : 250 | Year 09-10 : 250 | Year 18-19 : 250 |
| Year 01-02 : 250 | Year 10-11 : 250 | Year 19-20 : 250 |
| Year 02-03 : 250 | Year 11-12 : 250 | Year 20-21 : 250 |
| Year 03-04 : 250 | Year 12-13 : 250 | Year 21-22 : 250 |
| Year 04-05 : 250 | Year 13-14 : 250 | Year 22-23 : 250 |
| Year 05-06 : 250 | Year 14-15 : 250 | Year 23-24 : 250 |
| Year 06-07 : 250 | Year 15-16 : 250 | Year 24-25 : 250 |



Set abstraction to : 250 Mcm

Increase abstraction by : 1256 %

Unit: Mcm

Submit View Abstraction Chart Reset

# Scenario 5:

- Under 25% reduction of rainfall, and decreasing the discharge of northern zone to 250, the northern zones is sustainable, but this situation will effect the southern zone. As an overall evaluation the WAB will not be sustainable under this conditions (i.e. abstraction must be reduced)

