MULTIVARIATE STATISTICS AND NUMERICAL MODELING FOR OPTIMIZING WATER QUALITY MONITORING NETWORKS

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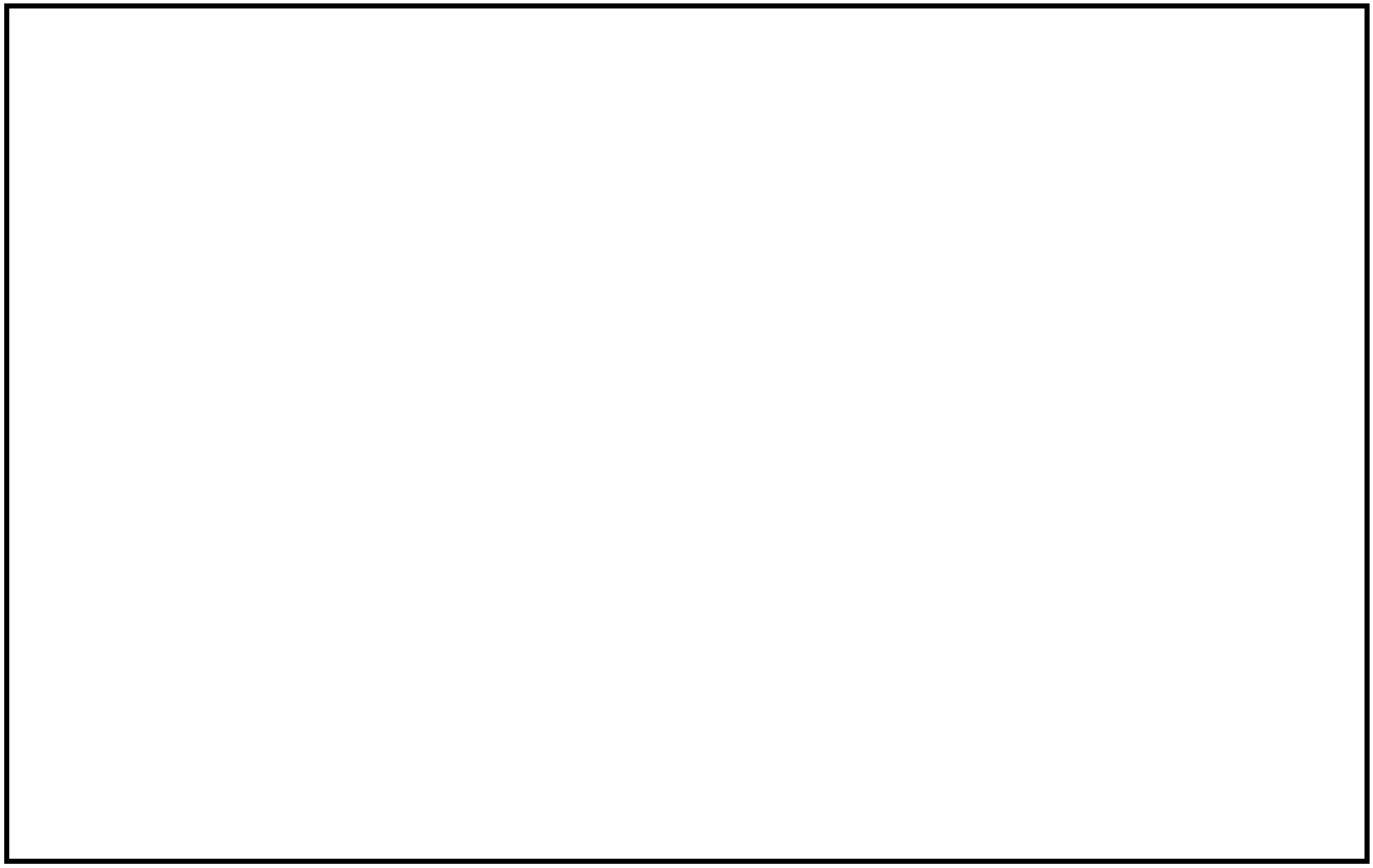
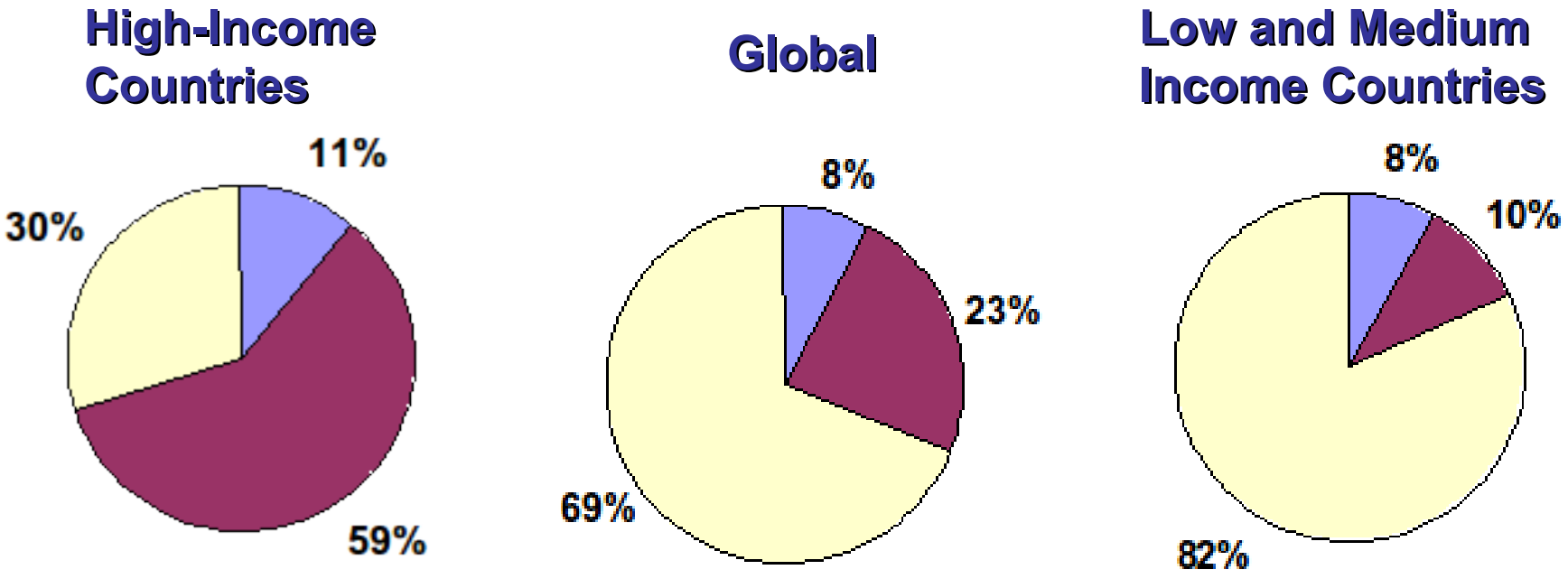
WATER SCARCITY



Freshwater availability per capita per year

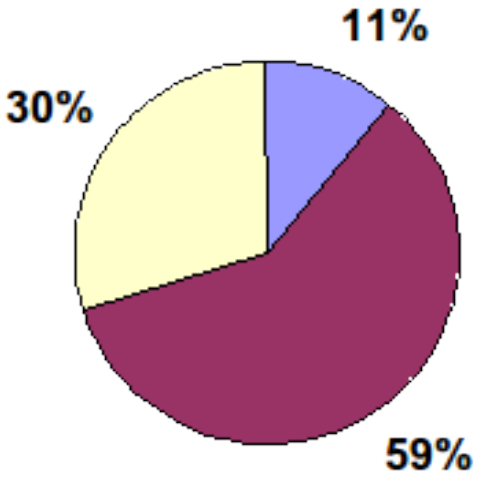
IRRIGATION WITHDRAWLS



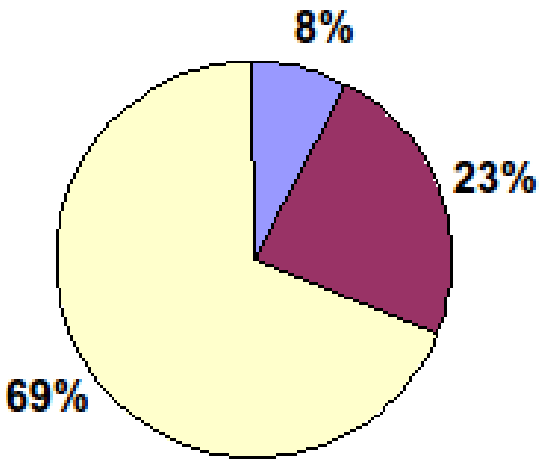
Variation in Sectoral water demand

IRRIGATION WITHDRAWLS

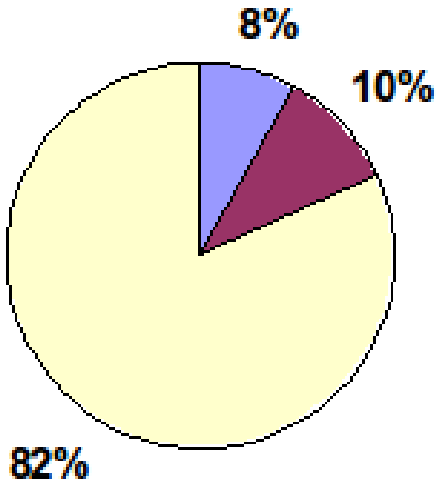
High-Income Countries



Global



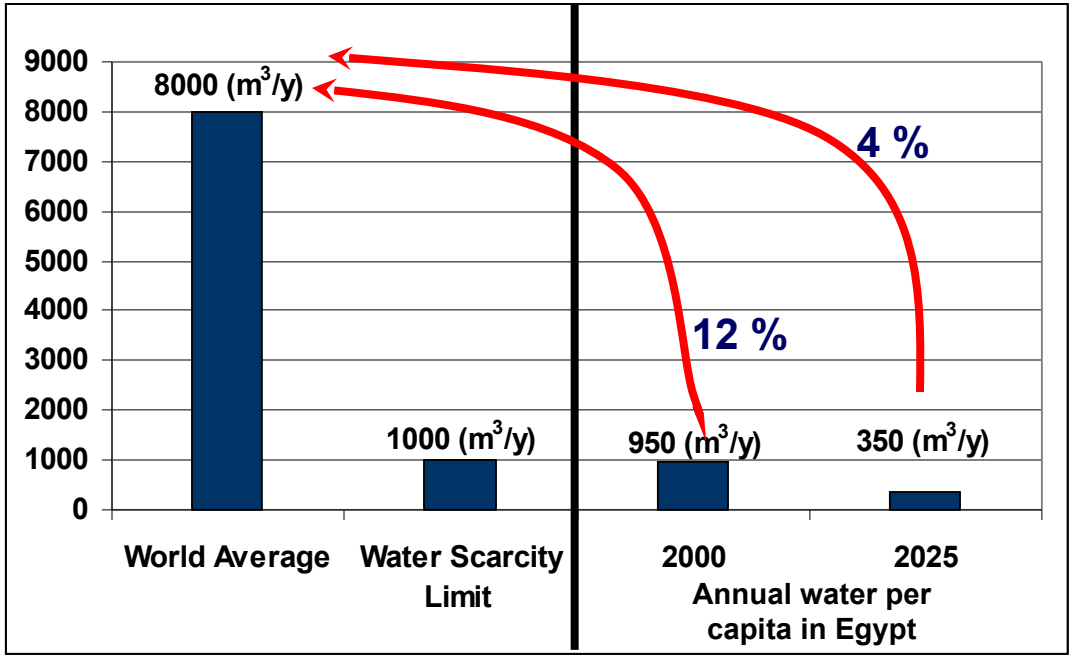
Low and Medium Income Countries



Irrigation sector is the largest water consumer and has the highest potential for saving water.

WATER SCARCITY IN EGYPT

The per capita share of fresh water resources



Population 68,359,979
Population growth rate 1.72%

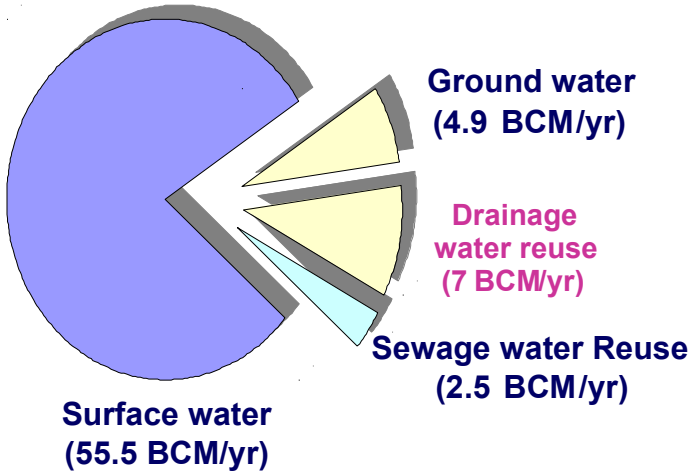
The per capita share of cultivated land is 500 m² only 12% of the world average

These statistics were estimated in the year 2000

DRAINAGE WATER REUSE

On the one hand ....

- Re-use of drainage water is one of the most promising, practical and economical means of increasing the Egyptian water budget.

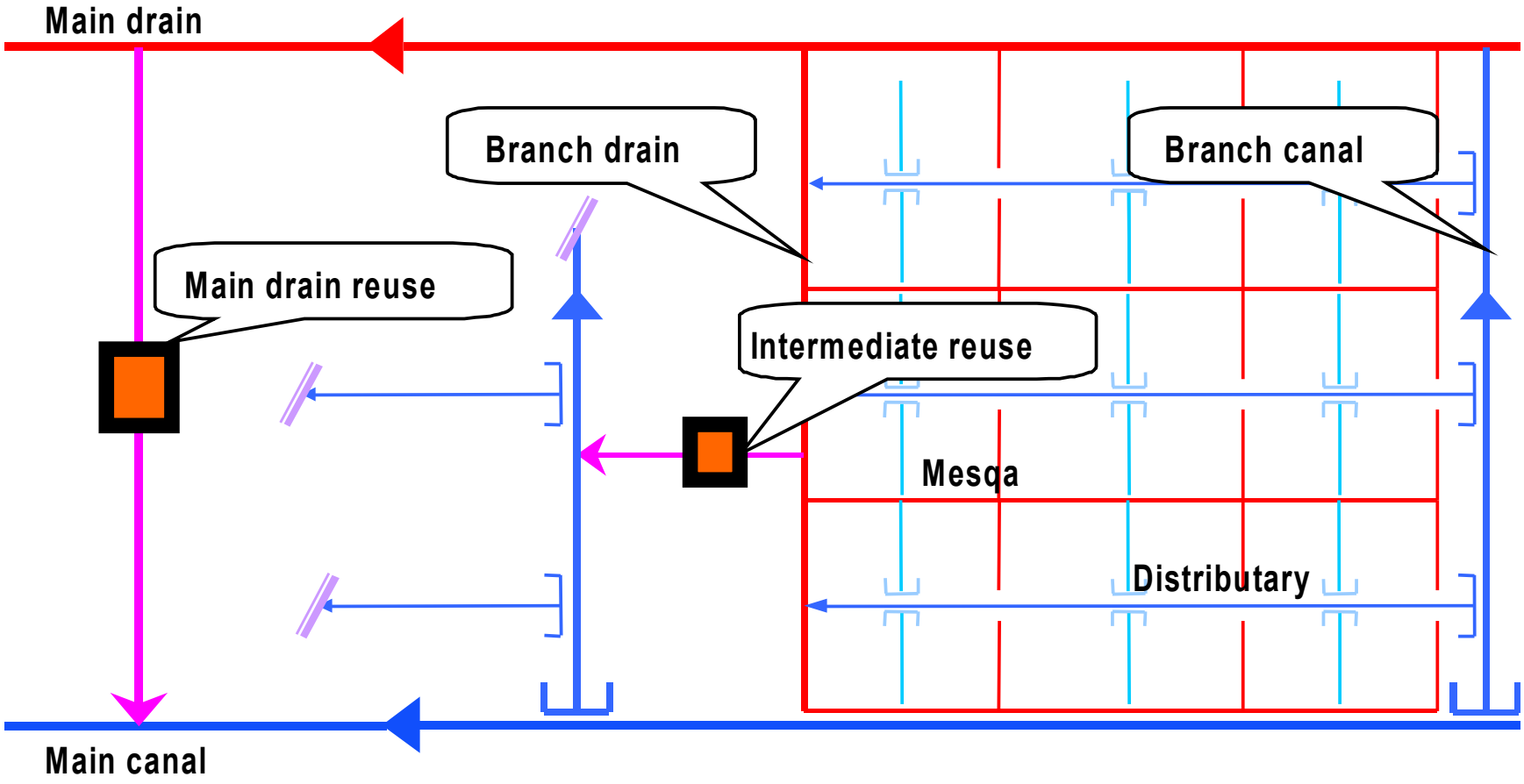


.....on the other

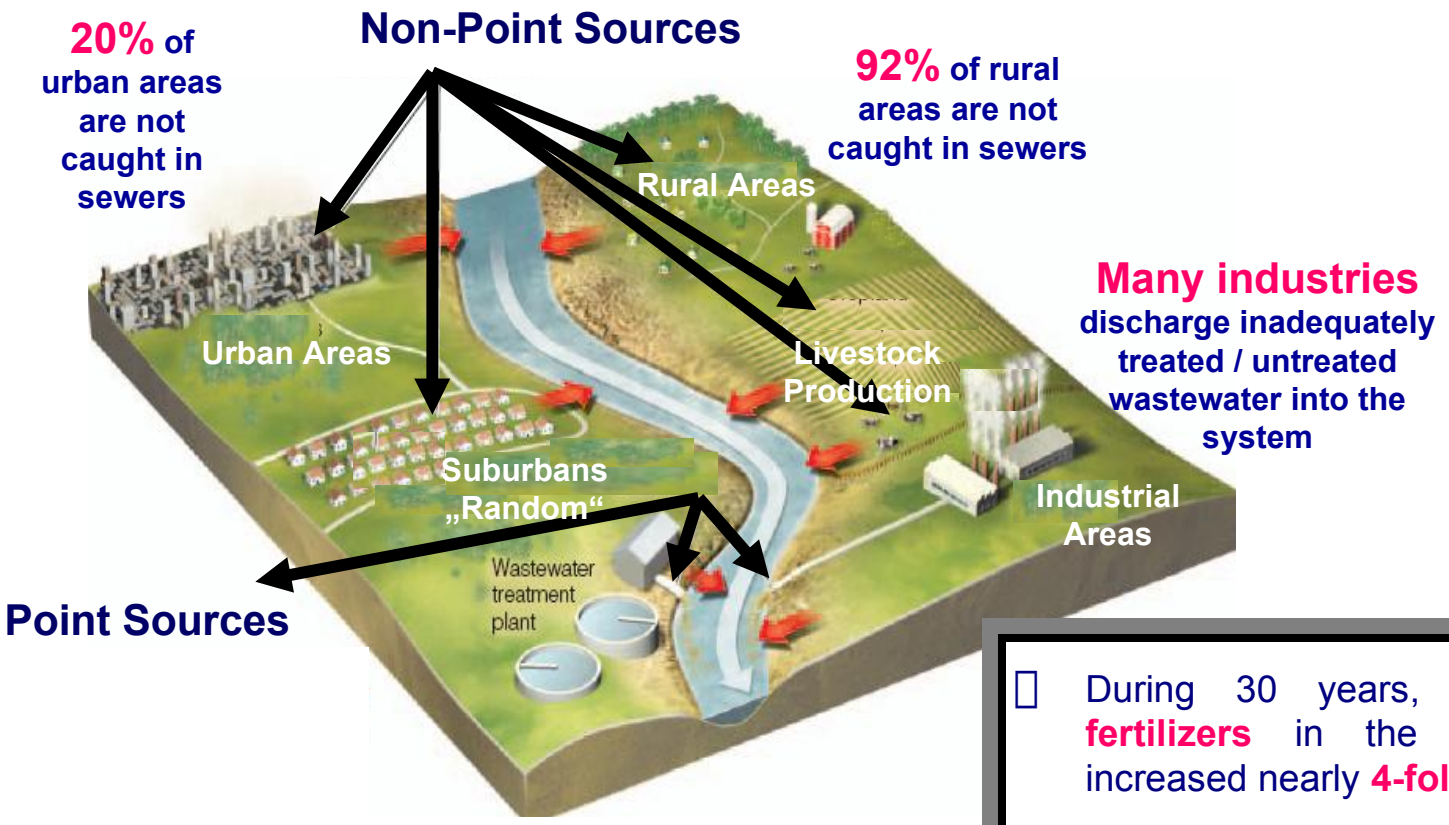
- Available information shows that the drainage system particularly is receiving the heaviest pollution loads.

Reuse Water is 12% of the Egyptian water quata from The Nile River

IRRIGATION AND DRAINAGE LAYOUT



CHALLENGES

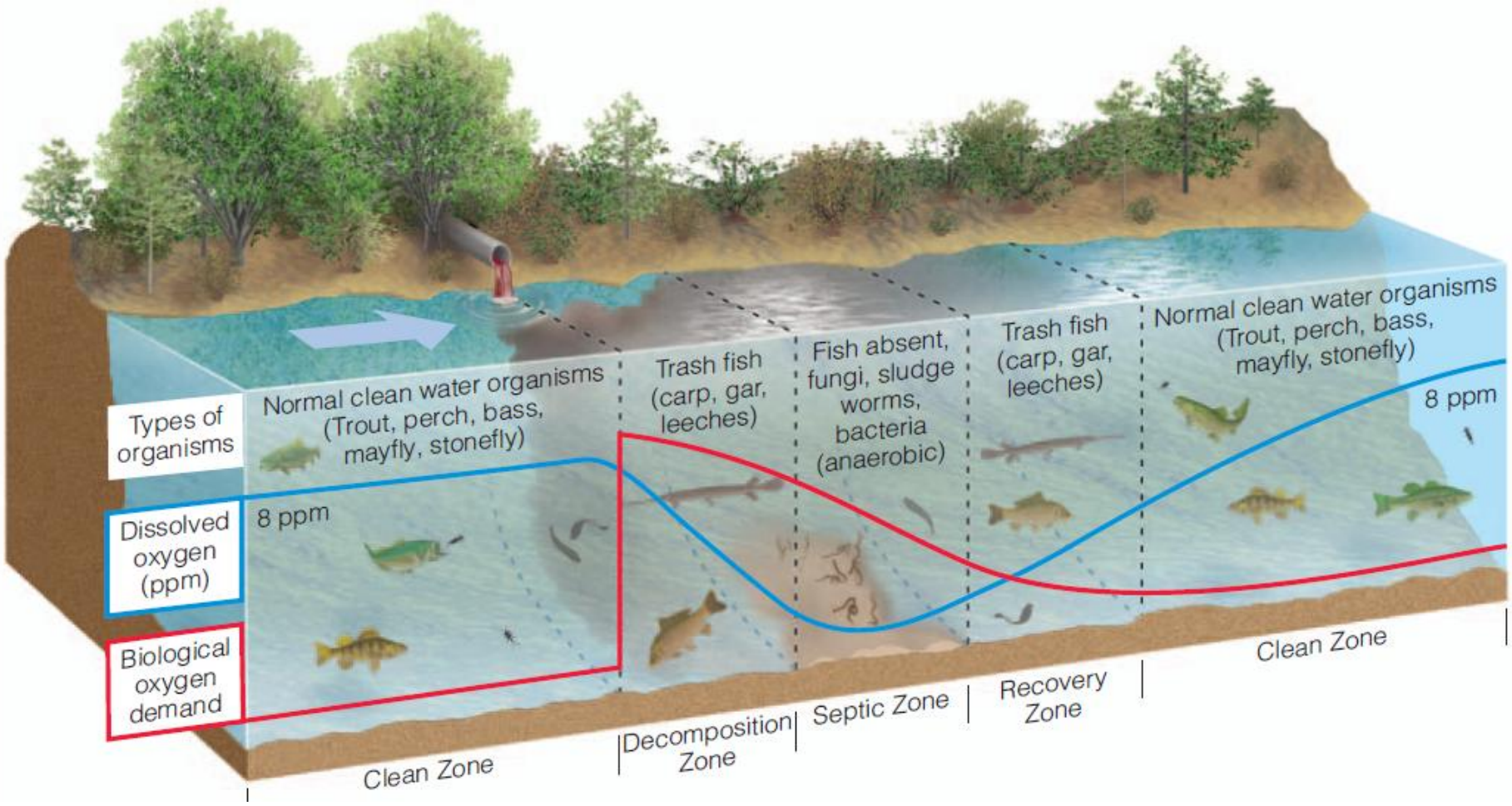


Many industries discharge inadequately treated / untreated wastewater into the system

- During 30 years, the applications of **fertilizers** in the Egyptian agriculture increased nearly **4-fold**.
- Pesticides use has increased as well, but not at the same rate of fertilizers.
- **Salinity** affects **35%** of agricultural land.

7 out of 23 reuse P.S. in the Delta had to be closed due to serious biological pollution.

POLLUTION EFFECTS

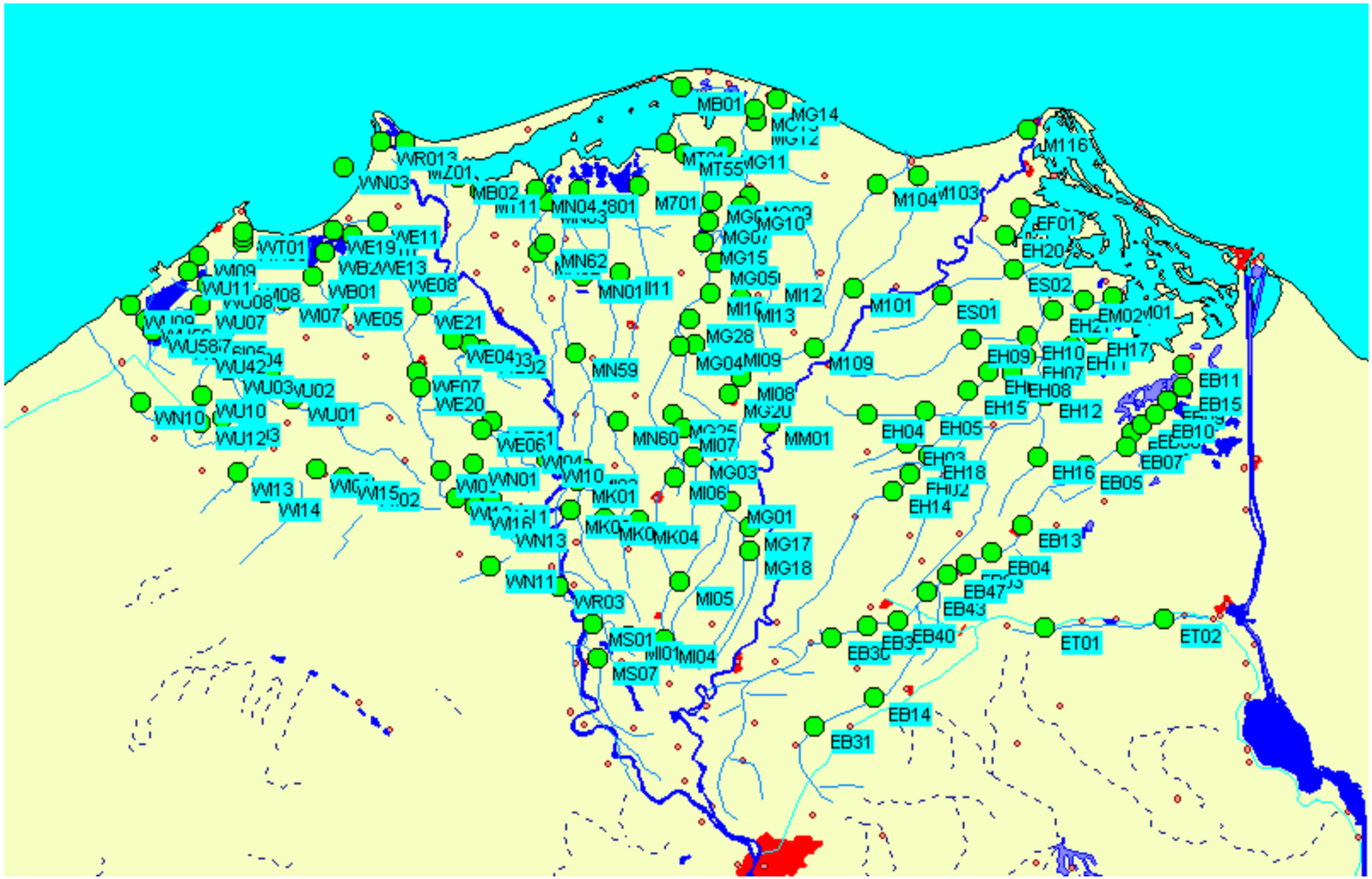


NEEDS FOR MONITORING

In General, water quality data are needed to delineate

- The general ***nature*** and ***trends*** in water quality ***characteristics***.
- The effects of ***natural*** and ***man-made*** factors upon the general trends in water quality processes.
- The effectiveness of water ***pollution control*** measures.
- The ***compliance*** of water quality characteristics with established quality standards.

MONITORING LOCATIONS



MONITORED PARAMETERS

Chemical

- EC , TDS, pH
- Na , K, Ca, Mg
- Cl,SO_4,HCO_3,CO_3

Physical Parameters

- Temperature
- Odor, Color
- Turbidity

Microbiology

- Total Coliform

Nutrients

- N - (NH_4,NO_3)
- P - (P_2O_5)

Heavy Metals

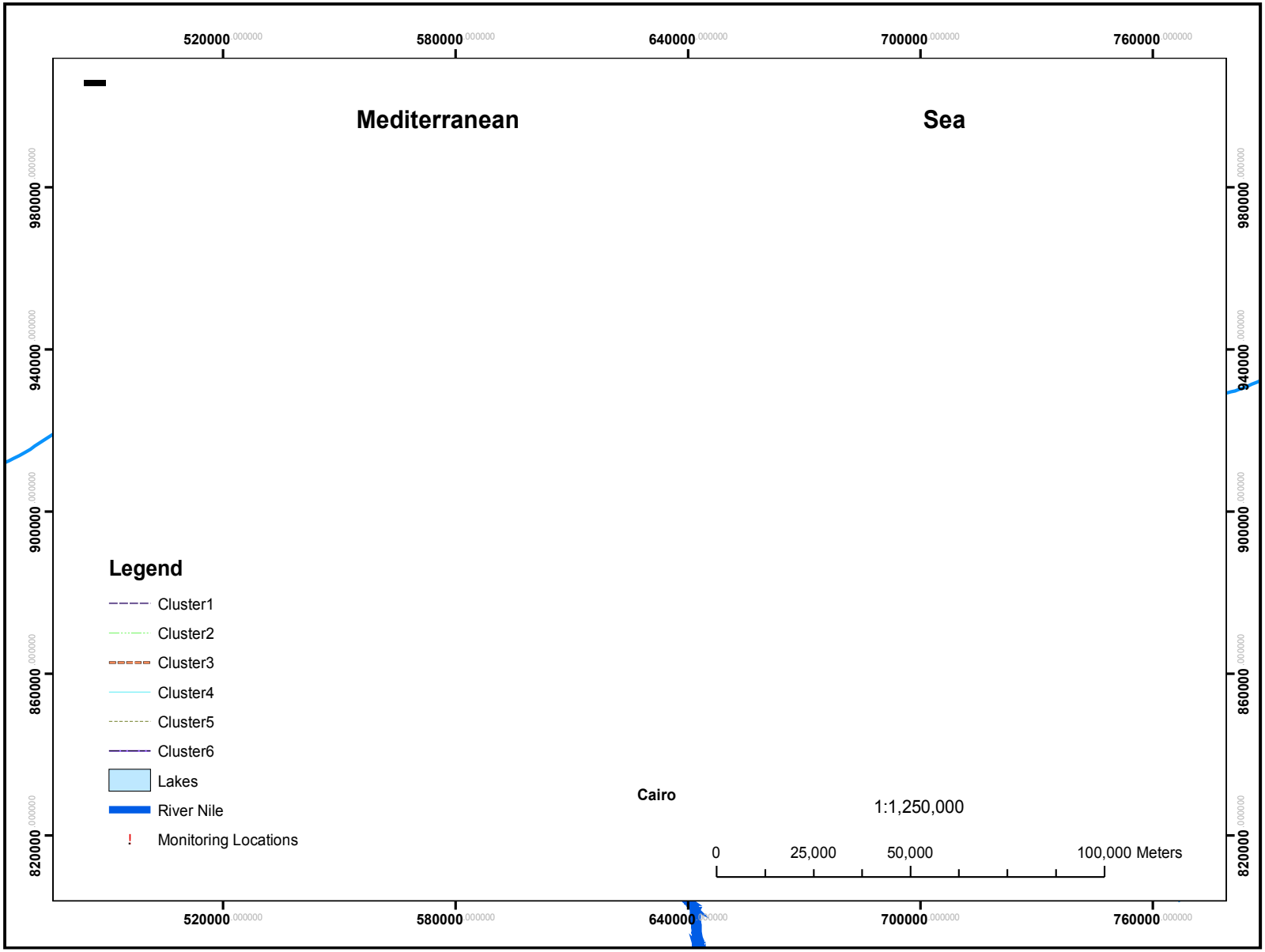
- Fe
- Mn
- Pb
- Cu
- Zn

Oxygen budget

- O_2
- BOD
- COD

The total number of measured parameters is 34

NWQMN OUTPUT



PROBLEM DEFINITION

- Already in 1977 Egypt had started to monitor quantity and some quality parameters (discharge and salinity) in some of the main drains in the Nile Delta.
- Since 1995, the Drainage Research Institute (DRI) continuously had to expand its monitoring activities to include an ever-increasing number of sampling locations and Water Quality parameters as requested by the water resources planners.
- Today, the network monitors too many parameters at too many locations at too high a frequency!

PROBLEM DEFINITION

- WQM is labored *intensive* and *costly*.
- Therefore, there is a *continuous* need to *optimize* the monitoring *activities* to minimize the *cost* without substantial effects on the *information* obtained.

OBJECTIVES

The overall objective is to introduce a **rationalization technique** for water quality monitoring (WQM) networks using multivariate statistics and numerical modeling .

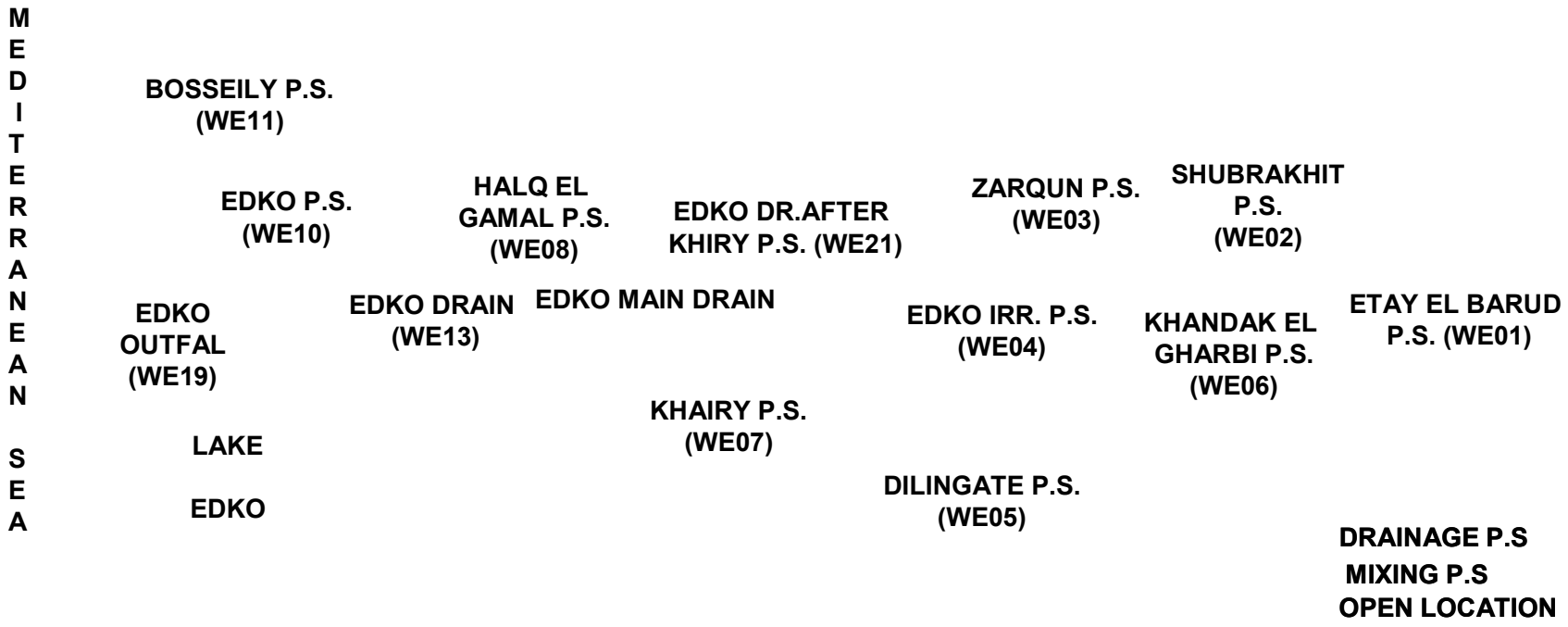
More specifically

To determine the ***location*** and ***number*** of **monitoring sites** in order to avoid redundant, insufficient or even useless water quality data.

STUDY AREA

- Although, *Lake Edko* is an important *fishing* area in Egypt, it receives significant amounts of *polluted* drainage water.
- The lake main water sources are *Kom Belag* , *Bersik* and *Edko* drains and seawater from Abu Qir Bay.

- The drainage system incorporates **ten** ***pump stations***. **Four** for official water reuse while the other **six** stations pump the drainage water into the main drain.
- **Three** other ***open locations*** in the main stream



METHODOLOGY

- **Spatial Analysis**
- **Multivariate Statistical Analysis**
- **QUAL2K Numerical Modeling**

METHODOLOGY

Spatial Analysis

- The monitoring locations were divided into ***four site groups*** based on the ***spatial*** characteristics of the drain system such as ***geographical*** position, surrounding ***environment*** and the direction of ***flow***.

- Within each ***site group***, if two sites are found to be statistically ***similar*** and produce similar information then one of them can be ***excluded***.

Spatial Analysis

The selected site groups are as following:

- ***Site Group 1***

  includes WE01, WE02, WE03 and WE04.

- ***Site Group 2***

  includes WE05, WE06, WE07 and WE21.

- ***Site Group 3***

  includes WE21, WE08 and WE13.

- ***Site Group 4***

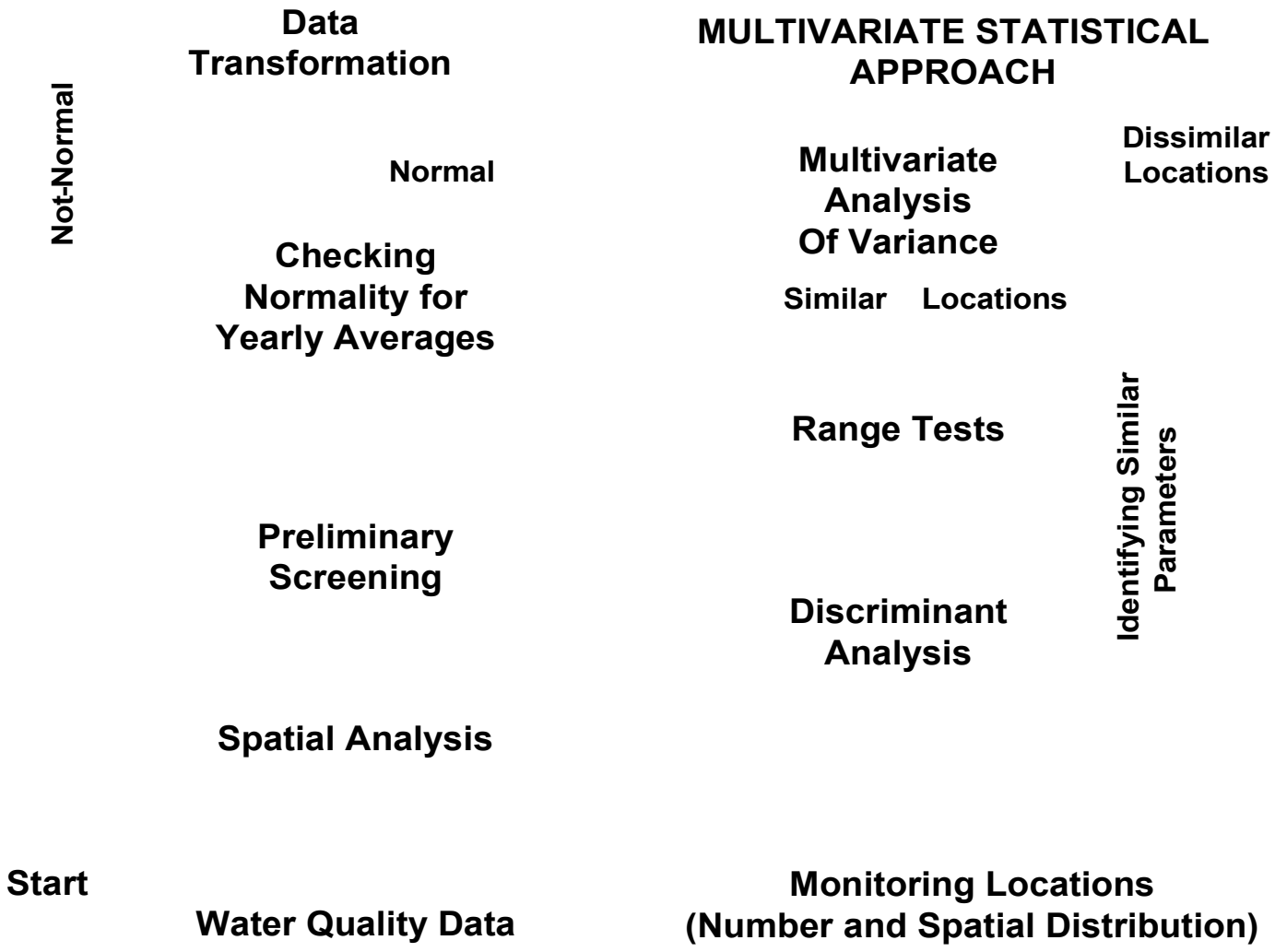
  includes WE13, WE10, WE11 and WE19.

METHODOLOGY

Multivariate Statistical Analysis

- The analysis started by checking the normality of the WQPs using ***Kolmogorov-Smirnov*** test.
- Data transformation was carried out if needed.
- Multivariate Analysis of Variance (***MANOVA***) followed by Multiple Comparisons (***MCs***) and then Discriminant Analysis (***DA***) were used for the purpose of this study.

METHODOLOGY



METHODOLOGY

QUAL2K Numerical Modeling

- ***QUAL2K*** model was used to model the water quality status of ***Edko*** drain in two cases (***A*** and ***B***).
- In ***Case A***, the information concerning the mean WQPs that were collected from the ***current*** (2010) network were introduced to the model.
- Based on the multivariate statistical analysis, ***similar*** monitored locations were ***identified***.

METHODOLOGY

QUAL2K Numerical Modelling

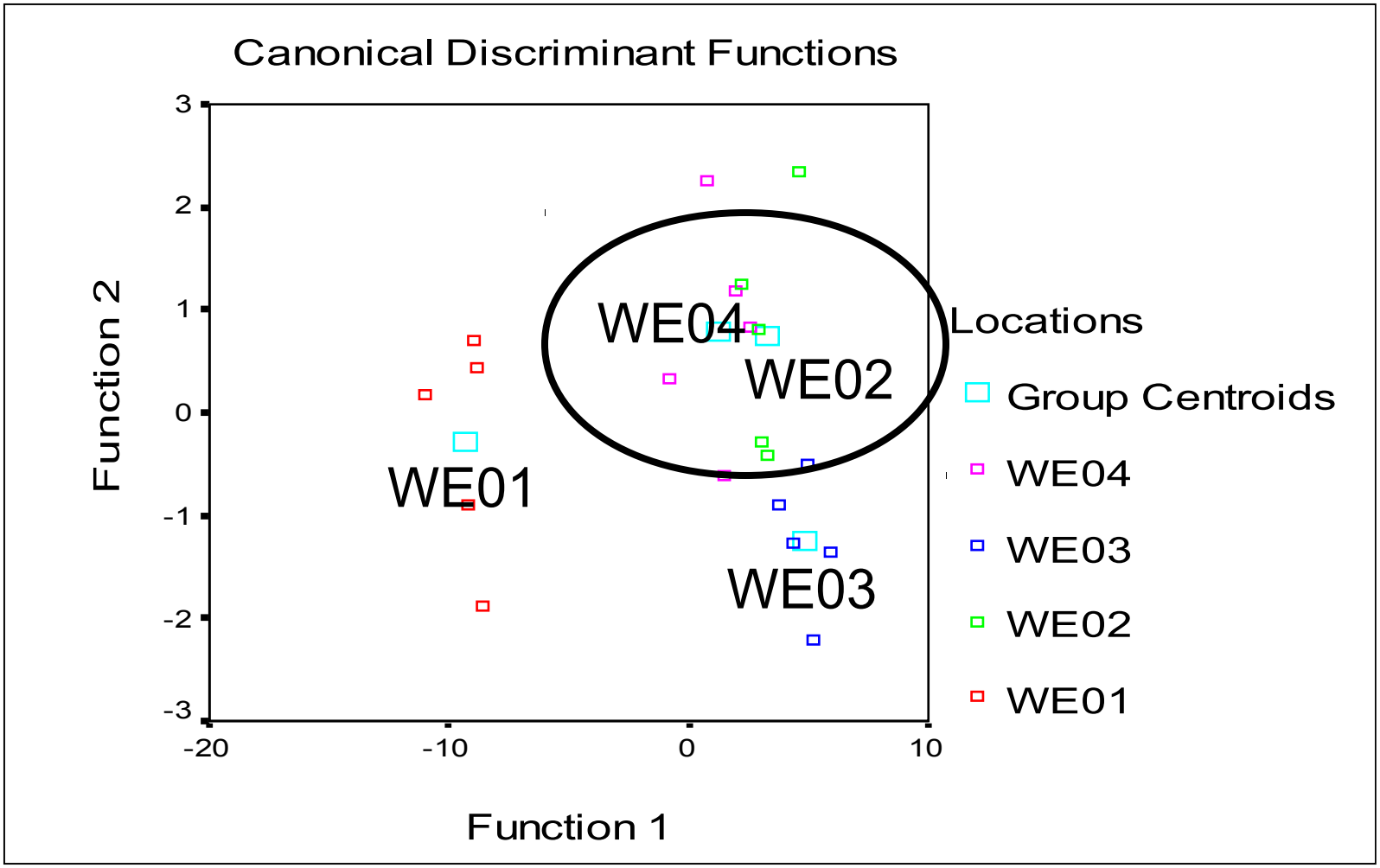
- Some of the similar locations were ***eliminated***.
- The WQ ***information*** for the ***eliminated*** locations was replaced by information related to their statistically ***similar*** sites.
- These new input conditions were used for a second run for QUAL2K (***Case B***).
- Finally, the ***cases A*** and ***B*** were then ***compared***.

RESULTS

- **Statistical Evaluation**
- **Validation of Results Using QUAL2K**

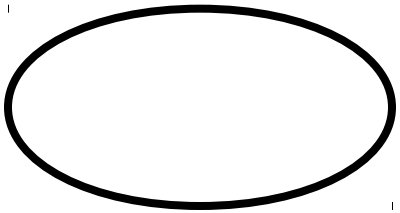
RESULTS

Statistical Evaluation



RESULTS

Statistical Evaluation



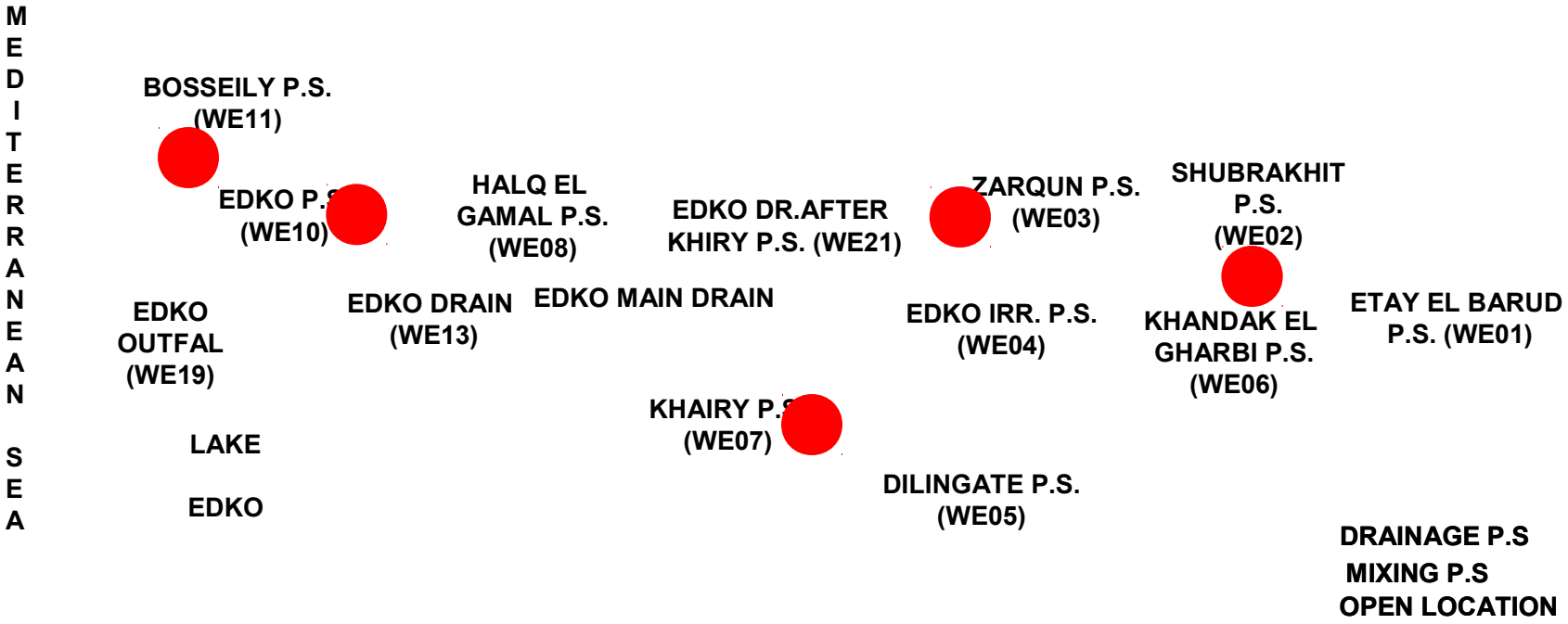
RESULTS

Validation of Results Using QUAL2K

Proposed for Termination	Information Replaced from	Remarks
WE02	WE04	All WQPs were replaced.
WE03	WE04	All WQPs were replaced except TDS that was obtained from regression analysis.
WE07	WE21	All WQPs were replaced.
WE10	WE19	All WQPss were replaced except SAR that was obtained from regression analysis.
WE11	WE19	All WQPs were replaced.

RESULTS

Terminated locations



QUAL2K Numerical Modelling

Conclusions
&
Recommendations

ACHIEVEMENTS

Monitoring sites

Proposed

Around 1200 Euros are required for one location per year

Edko: 6000 Euro per Year

Reduction

Data Load (No. of Records)

300 locations for surface water

230 locations for groundwater

?

Conclusions and Recommendations

- The approach used in this research can be ***adapted*** to other parts of the ***NWQMN***.
- It is based on ***multivariate*** parametric statistical tests, which may indicate ***powerful*** results and facilitates detailed information about the participated ***WQPs*** in relation with the monitoring ***locations***.

Conclusions and Recommendations

- It indicates the significant or insignificant ***differences*** between the locations based on these parameters.
- Then, it ***identifies*** which parameters are the reasons of the ***similarity*** or ***dissimilarity***.
- Finally, ***QUAL2K*** model can be ***effectively*** used to ***validate*** the network statistical assessment.

Thank You