NORTH WESTERN SAHARA AQUIFER SYSTEM

BASSIN AWARNESS

DATA BASE AND GIS

(Synthesis)

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INTRODUCTION

The structuring of data is an indispensable operation for the NWSAS project whose set up target is to capitalise the whole of the information collected as of today in the region. The collection of these information constitutes a prerequisite in order to update the evaluation of the acknowledges on the basin resources.

The project has initially provided for a collection and homogenisation mission of the data, supposed to be available within the administration of the three countries, in charge of the management of the water resources.

A first diagnostic of the situation, at the start up of the project, had shown that one had to go much further, for the following reasons :

- the countries were already faced with structuring problems of their respective data bases,
- the collected data within the framework of several studies conducted in the region, are produced in the shape of manual files,

The elaboration of a data base must be preceded by a prior work of designing the data architecture which allows the integration and the matching up of all the inventoried information.

But the NWSAS project had also as objectives to develop a permanent system of collection in order to facilitate the future updatings and to progressively implement a device which allows a common management of the basin waters through a concertation structure. This requires therefore that the national data bases must in their turn be improved and updated so that the future updatings can be easily implemented, namely :

- Homogenous data structures and codification,
- the existence of an identical common core inside the three countries. This can be completed by specific data,
- Interfacing with GIS,
- Elaboration of a liaison module with the digital pattern.

The achievement of these objectives has given to the project another dimension because we are talking, as a matter of fact, about the design and the achievement of a real, integrated and durable information system which complies with the requirements of the NWSAS project and which brings forward to the three concerned countries a significant contribution in the management and processing field of hydrogeological information.

This system hinges on three main components which are :

- the data base (DB)
- the Geographic Information System (GIS)
- the DB – GIS – pattern liaison interfaces.

The achievement of this sub-project required four main stages :

- the diagnostic of the existing data inside the three countries and defining the development options
- the designing of an information system and the implementation of an adequate organisation and technical solution.

- the implementation of a system which includes a common data base, a GIS and DB-GIS- pattern liaison modules
- and finally an entry phase of the data and their validation

1. DIAGNOSTIC AND DEVELOPMENT GUIDELINES

1.1 Situation at the project start up

1.1.1 At the level of the DB architecture

The data base is a central element in the global information system. It is meant to group all the existing information in the NWSAS zone in a relation structure, of an easy access and authorising the processings contemplated by the study.

A first diagnosis took place in order to make an inventory of the available data inside the three administrations, both at the architecture and contents levels.

This diagnosis allowed to notice that the countries had launched their works for the improvement and even for the reorganization of their information system in order to group the dissimilar data and to install some tools for the automatic processing of these data.

- the GWA, (Libya) has elaborated a new architecture for a bilingual data base under *ACCESS* (English – Arabic) with the collaboration of the *ACSAD*.

- the DGRE (Tunisia) has listed up a project for a total reorganization of its hydrogeological information system according to a customer-server approach. The NWSAS project was therefore an opportunity to structure the existing data inside a unique and same relation DB.

- the ANRH (Algeria) which had an ACCESS data base developed in collaboration with the BRGM, wished to dispose of tools that allow the conducting of elaborated applications difficult to achieve as of today. A project for a hydrogeological data base under SQL/SERVER has just been initiated.

The detailed analysis of the present and future organisation of the hydrogeological information inside the three administrations has given the summarised results listed in the following chart :

Summary Chart for the situation in terms of information organization

Country	Constraints and Shortcomings
ANRH (Algeria)	- The structure of the DB does not integrate all the data necessary for the required processings - The relation pattern is not standardized - The existing tools do not allow synthesis applications - Links with GIS are not provided for
GWA (Libya)	- The data pattern includes some shortcomings and needs to be improved - Certain information were not provided for - Inexistence of tools for processing and synthesis applications - Links with the GIS were not taken into account
DGRE (Tunisia)	- Existence of several DB => difficulty to secure a global coherence - Non harmonized codification - Synthesis processing and complex applications difficult to execute - Inexistence of links with the GIS.

There is therefore a need for the structuring of the data which the NWSAS project must take into account. One has, starting from the existing situation, to work out an architecture which covers the needs of NWSAS and which complies with the global objectives of each country

among the three, in this field. The structure of the base contemplated for the NWSAS will show a common core, issued from the three DB which must be completed and harmonized.

1.1.2 At the level of the contents

At the level of the contents, the situation is clearly more complex : the data files which were listed show heterogeneities because of the diversity of the tools and procedures for collection. The main reason for this situation is that the collected data for the pattern processings are often considered as dissociated from the data base since the studies, conducted as of today, have not taken the information from relation structures.

A shaping work is necessary to make these information exploitable and liable to be integrated in the adequate data base in order to execute the processings provided for by the project.

- Merging the files in the shape of formats
- Adding the missing information
- Typical conversion and format.

A listing of the existing files has been made, it is summed up as follows :

Country	Available Information
ANRH (Algeria)	- The files of the water sources in the BADGE require a careful control (identification and positioning) - The EXCEL files used within the framework of BRL project - The EXCEL files containing inventory data (96 to 98) : require an important shaping work - Manual files concerning the earlier studies and which include exploitation and piezometry data : ERESS and RAB project, BRL study, …
GWA (Libya)	- EXCEL files containing the characteristics of the water sources - Manual files issued from the piezometric network - Study documents containing synthesis information about the intakes
DGRE (Tunisia)	- DBASE and EXCEL files containing all the information about the intakes and the piezometric levels in the zone : they require a slight shaping work - Manual files for the data prior to 1981 : earlier studies, directories.

1.2 Organization and technical solution

The NWSAS information system must not only group and organize these information, but also provide for all the automatic processing tools which enable to extract the data for the digital pattern and to restitute the results under various shapes (synthesis, graphic charts, thematic maps, …) .

At the organization level, a mechanism for the updating of the data, at different scales of intervention (regional departments, headquarters of the administration, NWSAS office) must be implemented. This device, based on formal procedures and a distribution of the tasks between the NWSAS team and those in the countries, makes up an important stage for the future creation of an active concerted management cell at the scale of the basin.

Three levels of processing have been defined :

The decentralized departments : they are in charge of controlling, within the framework of the NWSAS project, the existing data concerning their competence zone and proceeding with the collection of the eventual additional data. In the future, these departments which will dispose of developed tools within the framework of this project, could collect and enter new information.

The national hydrogeological departments : they run the data base of all the NWSAS zone and see to the overall coherence of the information. Data verification and analysis tools will serve to secure a reliable systematic control before forwarding any data to NWSAS.

The NWSAS team : it secures the matching and coherence of the data issued by the three countries and the processings as far as the whole basin is concerned. Within the framework of the project, this team has been asked to proceed with the entry of all the information which are not available at the level of the countries, on an electronic support :

- Old histories : ERESS, RAB, BRL, other local studies
- Reference maps : initial piezometry, hydrodynamic parameters, …
- Quality histories (essentially salinity),
- Geological data.

The selected organization relies on :

- the implementation of a common data base at the level of NWSAS (which may become the future DB of the concerted management structure) ,

- adapting national DB in order to make them be in conformity with the basic relation rules and to harmonize the data in order to facilitate their future updatings,

- defining clear procedures for the updating in both ways.

- Implementing data security mechanisms (access authorization, using levels, …)

The three countries can profit from these improvements at the design level and they are in a position to continue the expected extensions in order to use this system as a management tool of the data at the regional or central level (headquarters of the three administrations).

At the technical level, the hardware and software tools have been defined according to several criteria :

- objectives and requirements of the NWSAS project
- technological trends of the moment
- control level by the national experts
- compatibility with the existing equipment and softwares inside the countries

A simple solution was adopted in order to allow a perfect control by the national experts and the permanent team of the project. The only requirement is that this solution must be capable of satisfying the project present needs and that it can evolve in case of need :

- SGBD « *ACCESS* » already widely spread inside the three administrations
- GIS « *ARCVIEW* » software which is equally very used in the field of the natural resources and offers a good interface with ACCESS

- A utility facility allowing to develop the links DB - GIS – PM5 in order to automate the tasks for the preparation of the data for the patternization process

The following equipment and softwares were therefore acquired :

Organization	Equipement and Softwares
ANRH	1 Pentium III : 256 Mo, HD 8Go, 19“ screen, ZIP 250 reader, Windows NT Office 200 professional (SGBD ACCESS) GIS Arcview 3.2 soft Spatial Analyst Extension for Arcview Image Analysis Extension for Arcview 1 additional Pentium III
DGRE	1 Pentium III : 256 Mo, HD 8Go, 19“ screen, ZIP 250 Reader, Windows 98 Office 200 professional (SGBD ACCESS) GIS Arcview 3.2 soft Spatial Analyst Extension for Arcview Image Analysis Extension for Arcview ARCINFO network version (for specific needs)
GWA	1 Pentium III : 256 Mo, HD 8Go, 19“ screen, ZIP 250 reader, Windows 98 Office 200 professional (SGBD ACCESS) GIS Arcview 3.2 soft Spatial Analyst Extension for Arcview Image Analysis Extension for Arcview Extension for the Arabic language under Arcview
NWSAS Headquarters (Tunis)	2 Pentium III : 256 Mo, HD 8Go, 19“ screen, ZIP 250 reader, Windows 98 Office 200 professional (SGBD ACCESS) GIS Arcview 3.2 soft Spatial Analyst Extension for Arcview Image Analysis Extension for Arcview ArcPress Extension for Arcview

2 DESIGNING AND IMPLEMENTING THE INFORMATION SYSTEM (IS)

2.1 Data Pattern

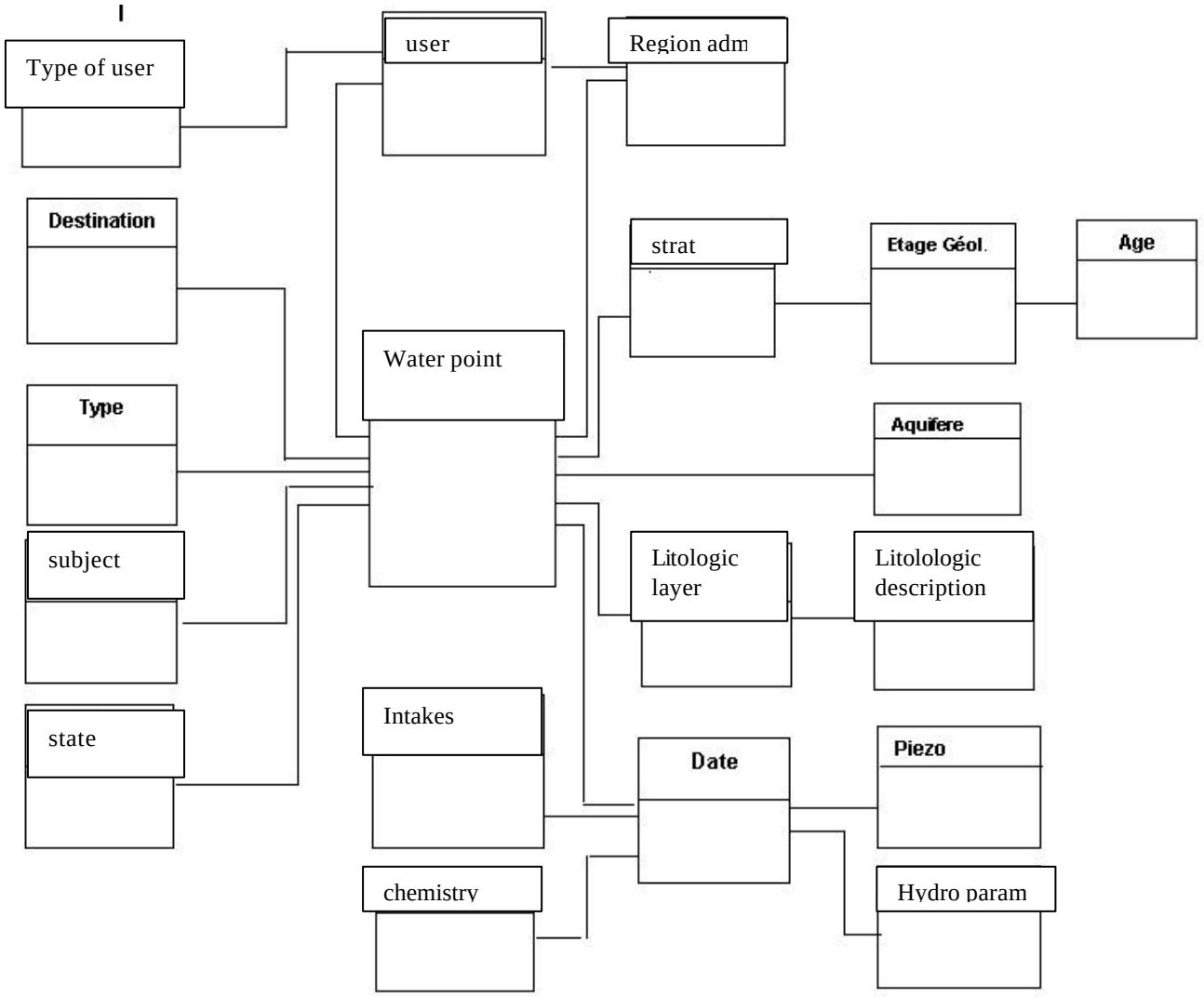
In order to secure the perenniality and the evolution of the IS, the adopted designing procedure rests essentially on the data, that is to say a clear identification of the entities managed by this system and the logical relations existing between these entities

The first and most important task consists in the elaboration of a data pattern integrating all the information that can be managed by a hydrogeological department. Starting from this pattern (MCD), the most complete and to which the experts of the countries largely contributed, a core was extracted to constitute the common data base of NWSAS.

Hence, the countries concerned by the project could profit from this relational architecture to improve their respective DB.

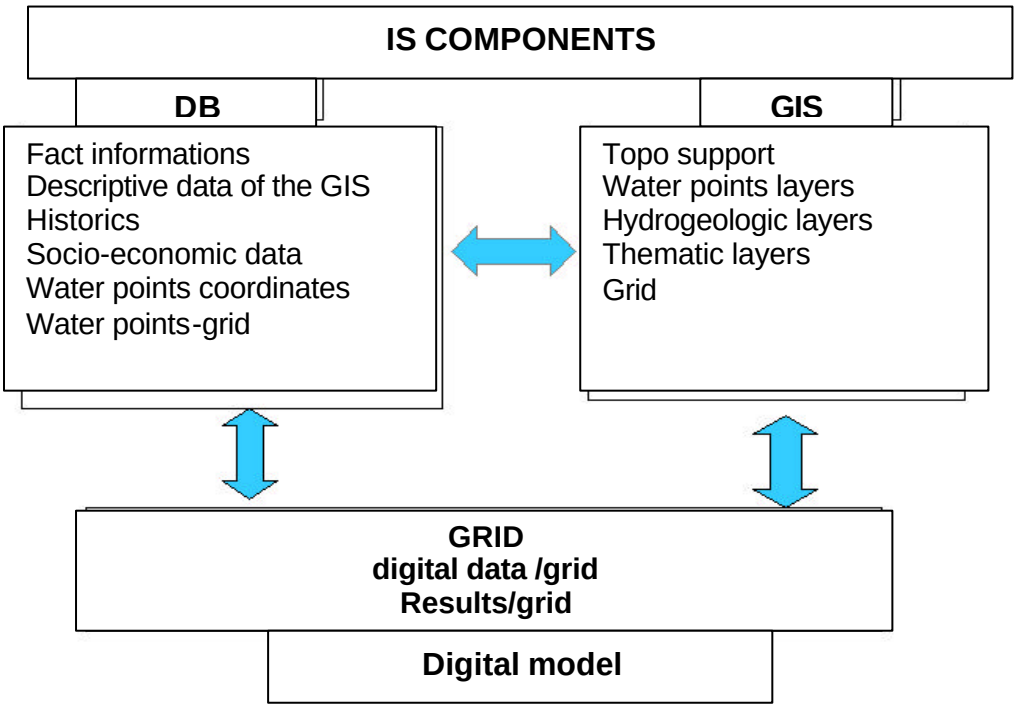
The second advantage lies in the integration, in the IS, of the information describing the spatial entities, allowing likewise a non redundant management of the data and offering the possibility for their spatial analysis, without going through transfer or conversion operations towards the GIS.

Scheme of the MCD for the project



2.2 The Information System Components

The information system includes thus three main elements which are : the DB, the GIS and the digital pattern. The meshing of the pattern, which is at the same time a table of the DB and a layer of the GIS, allows to secure these links, as shown by the following scheme :



The links DB – GIS are translated by :

- the integration of the data, describing the geophysical layers in the DB in order to be able to use them in the applications, even outside the GIS. The redundancies are avoided, the information is stored only in one single place.

- the creation of GIS layers for the whole data liable to be translated on maps or to make the object of spatial applications; when designing the DB, an inventory of these entities was worked out (intake zone, aquifer, administrative units ….).

Thus any application made on the DB can, without difficulty, make the object of a thematic mapping.

These links are achieved thanks to a specific utility device acquired within the framework of the project. It is a «MapObjectsLT » developed and marketed by ESRI. This module can elaborate all the basic operations of a GIS software while remaining in the data base environment : viewing of the map, spatial applications, specific programmes, …

The implementation of the system includes therefore three components :

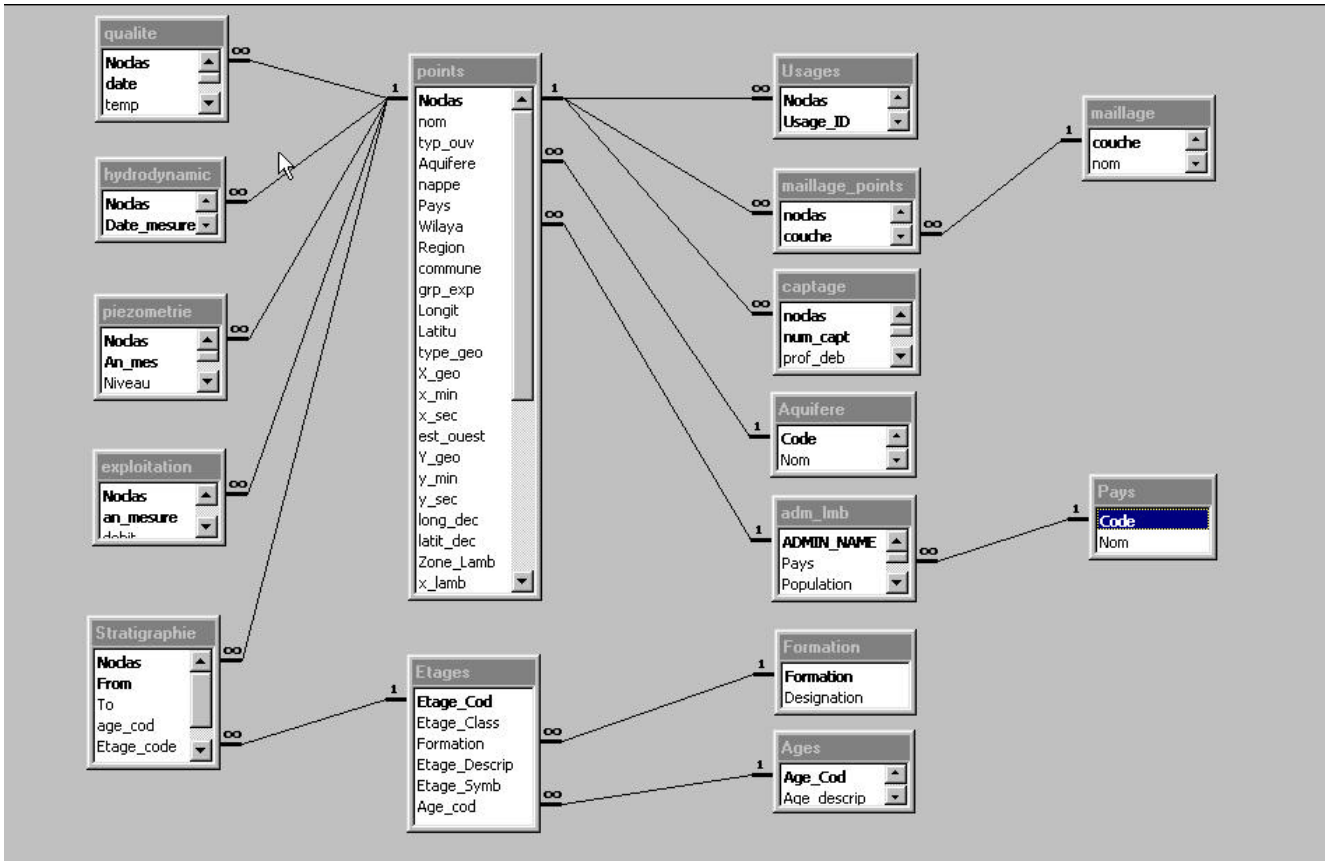
- a common data base integrating also the data describing the spatial entities
- a GIS made up by all the cartographic layers necessary for the project in the same projection system
- a set of specific modules, allowing to execute the expected processings by the project (data preparation for the digital module, data viewing and analysing tools, devices for the entry and the control of the data ….)

2.3 The executed final products

2.3.1 Description of the NWSAS DB

The ACCESS base was implemented based on the MCD and including the specific data, linked to the selection of the pattern.

Sketch of the ACCESS base



The managed information are grouped into five categories :

- Identification – localisation of the water sources
- Spatial units (administrative and physical)
- Histories (exploitation, piezometry, quality, hydraulic parameters)
- Geological and lithological data
- Liaison with the digital pattern.

It is possible to incorporate other information. One has only, in order to do so, to respect the basic rules of the relation bases. The national experts were trained on these concepts and in the handling of SGBD ACCESS 2000 to enable them to execute extensions for their own needs.

2.3.2 Description of the GIS

All the layers in the GIS elaborated within the framework of the project are in the Lambert Sud projection system which offers the following features :

- Ellipsoïd : Clarke 1880
- Central meridian. : 2.7
- Reference parallel : 33.3
- South latitude : 31.733928
- North latitude : 36.866072
- False easting : 500135
- False northing : 300090

The maps were drawn out in the SHP ARCVIEW 3.2 format. The following layers are concerned :

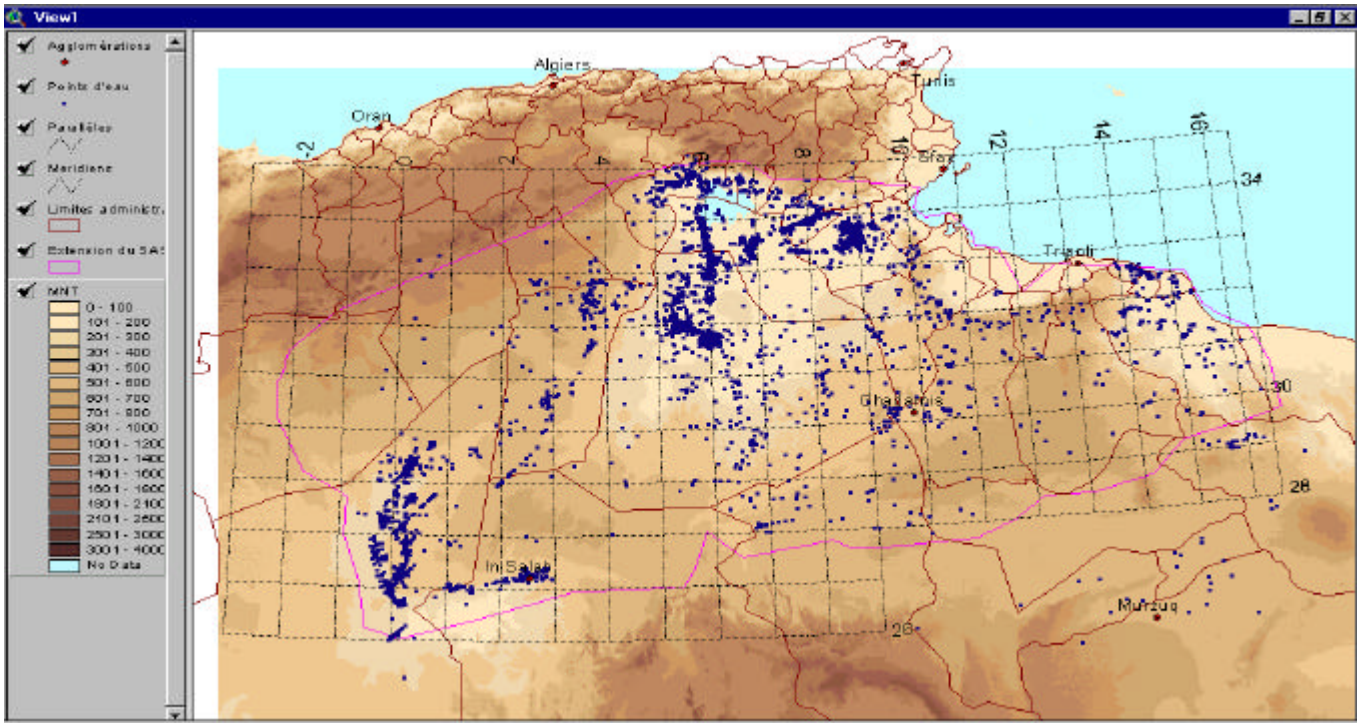
The topographical background : made up with heterogeneous sources and requiring a harmonization work (scales and codifications)

- Digital Chart of the World map (DCW)
- The field digital pattern issued from the GTOP030
- The world hydragraphical network map HYDRO1k
- The maps produced by the ERESS study
- The maps supplied by the organizations in the countries in charge of the mapping information.

This background includes, among others, the following Arcview coverages :

- Curves of the equidistance level at 100 metres
- The main hydrographical network
- Important agglomerations and localities
- Communication channels
- Administrative limits
- The limits of the study zone and the extensions of the main aquifers

Some superposed layers in the GIS at the MNT, scale 1/1000000



The thematic layers

On this background, all the other layers necessary for the study were superposed

- Geological coverages : outcropping of the main formations, faults, litho-stratigraphic sections
- Hydraulic parameters : horizontal and vertical limits of the aquifers, transmissivities, storage coefficients.
- Hydrogeological parameters
- Pattern meshings.

The water sources make up a dynamic layer because they come directly from the data base, so much so that any modification made at the level of this base will be translated on this layer of the water sources (automatic updating).

This organization of the geographical information combined with various spatial processing patterns allows to multiply the possibilities for the production of thematic maps: applications inside the data base or values calculated by the digital pattern such as :

- The intakes by spatial entity or by proportional symbol
- Piezometry
- The draw downs
- The water quality
- Various indicators related to the spatial entities,
- …

Finally, the GIS thus constituted was of a big contribution during the analysis and validation phase of the collected data : several anomalies would not have been detected without the mapping viewing and without the spatial applications on the data in the DB.

2.3.3 Data Management Tool « SAGESSE »

The constitution of the NWSAS data base resulted in the implementation of a considerable number of tools which served to :

- transfer the data made available by the countries for the project and introduce new data
- proceed with the checkings and corrections per forms and in an interactive way
- elaborate statistic and synthesis applications allowing the control at any moment of the reliability of the collected data
- execute the interface with the PM5 pattern and automate thus the preparation of the data for this pattern.
- secure the connections DB-GIS through specific functions.

These tools developed in the ACCESS environment as the compiling of the contents of the data base proceeded along, were grouped in a unique package called « ***SAGESSE*** » (**S**ystème d'**a**ide à la **g**estion des **e**aux du **S**ahara **Se**ptentrional – Northern Sahara Waters Management Assistance System).

The idea to elaborate such a package complies with the wish to progressively implement a device allowing the collection and the management of the information relating to the NWSAS basin.
Indeed, « ***SAGESSE*** » includes all the basic elements to make up a real panel control for the follow up of the exploitation of the basin waters.

Meant essentially for the NWSAS users (decision makers, teams in charge of the digital pattern, DB administration), SAGESSE is designed as an explorer which displays the information collected during the project under charts or in a geographical form. The shifting from one mode to the other, as well as the control of GIS layers are made by a simple click, without leaving the ACCESS environment.

It has been achieved to group and enhance all the works executed in the field of organizing and managing the collected data and the various processings which were developed within the framework of the project.

This product which had initially as a unique objective the interfacing with the PM5 pattern, was enriched and progressively converted into a real instrument for management which can be precious both for the countries and the concertation structures which will be laid down.

2.3.3.1 General features

SAGESSE was elaborated for the applications, the data updating, the preparation of the entries for the PM5 pattern and also to view the synthesis charts.

Its open architecture allows the exploration guided by the software and gives the possibility to develop applications and additional processings, not scheduled, directly in the ACCESS environment.

Among the innovating functionalities of the system, we can list :

- The information necessary for the digital pattern come directly from the data base, which offers the following advantages :
    - the collected data can be reused by the future updating studies
    - the developed system is used both for the patternization (main purpose) and to satisfy the needs of the decision makers : statistics, synthetic charts, thematic maps
    - the user will not have to worry about the format of the entry files for the "pattern"' software, or the format of the results = less depending on the patternization softwares
    - the information are not introduced by mesh but by water source, which guarantees a better flexibility. The meshing is dynamic
- The GIS integrates wisely in the data base , allowing thus :
    - cartographic viewings of the essential themes without leaving ACCESS,
    - an automatic updating of the layer "water source" every time that the coordinates are changed or after the introduction of new water sources

- the automatic assignment, through a spatial application, of one mesh number to the water sources.

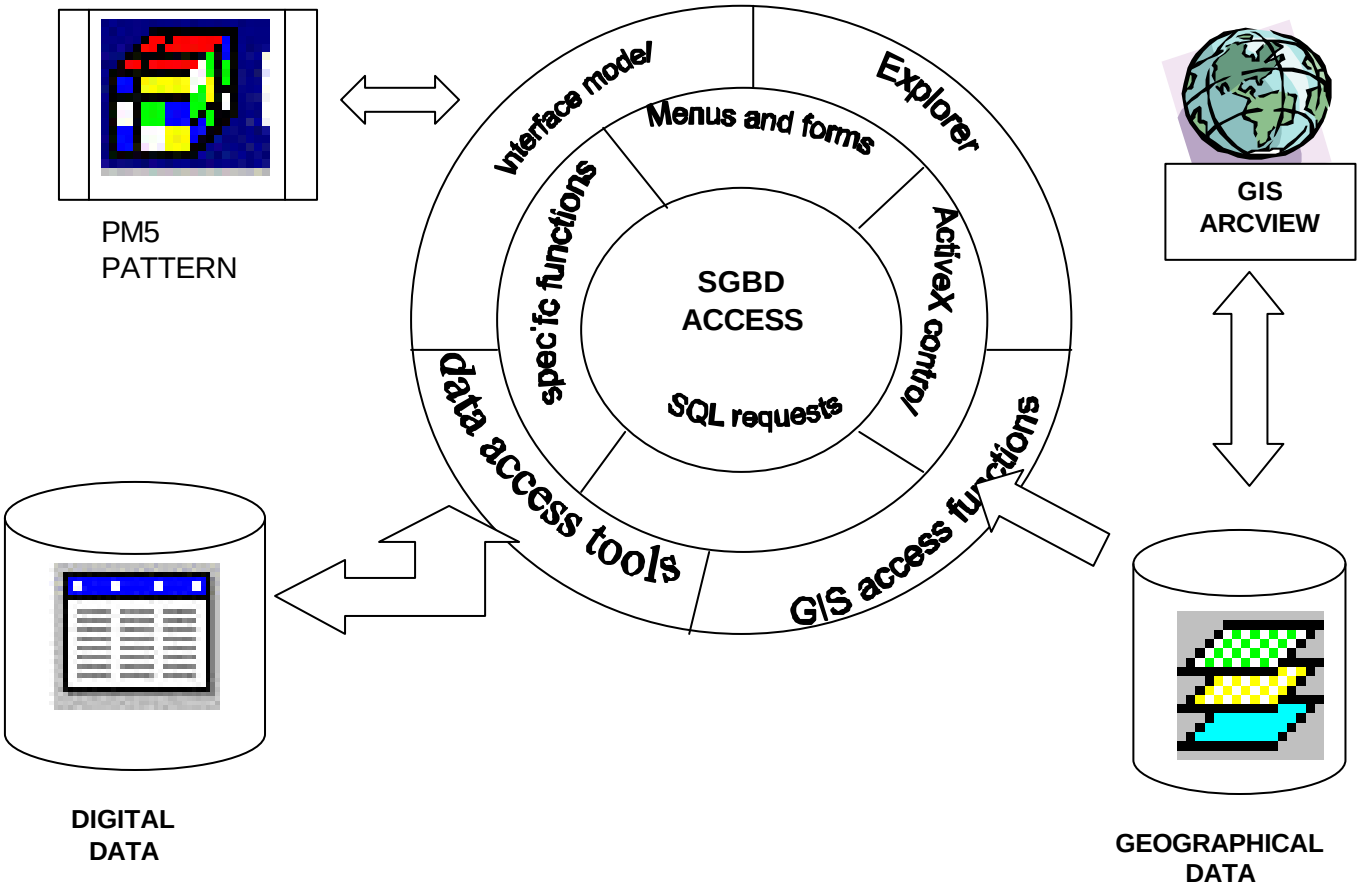
2.3.3.2 Structure of the system

It is an open and upgradable system elaborated thanks to standard tools under an ACCESS environment : ACTIVEX components developed by Microsoft and ESRI, VBA programming language. This offers the advantages of a low cost management of the system and a relatively easy corrective and evolving maintenance.

Around the cores, making up the SGBD, a certain number of developments was achieved by the VBA language and thanks to dedicated components (dialogue boxes, GIS access functions).

These functions allow, in particular :

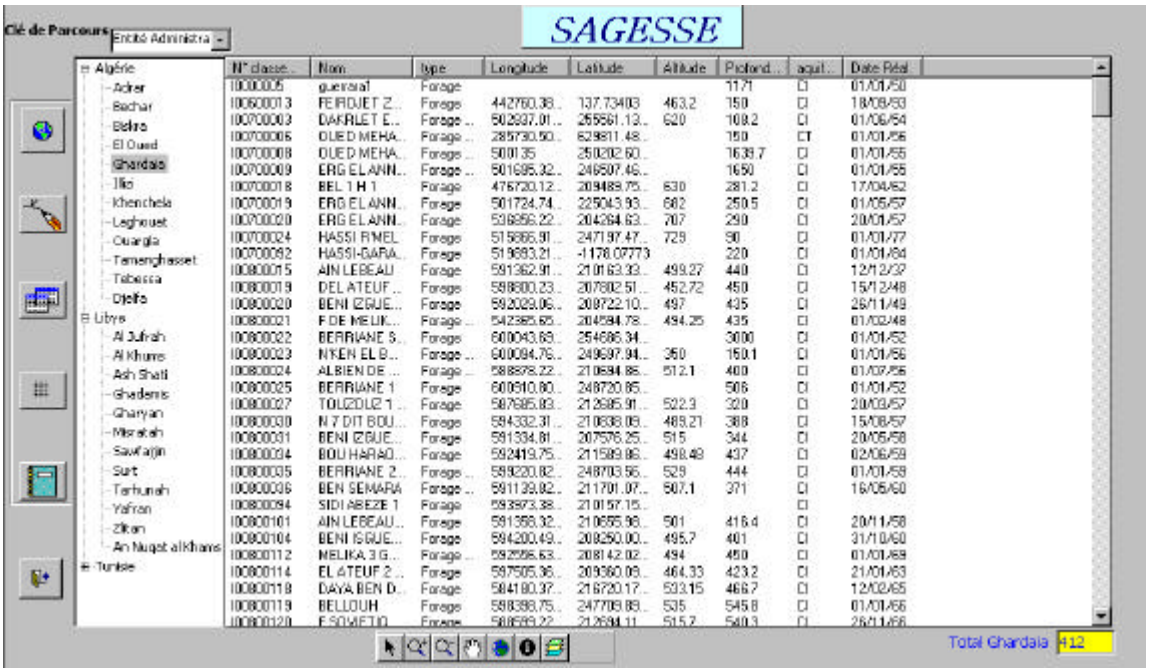
- to have access to the GIS functionalities in order to carry out almost all the cartographic viewing operations, without leaving the DB environment
- to explore the DB contents with several entry keys (by aquifer, by administrative entity, etc…)
- to prepare easily the necessary data for the PM5 pattern
- to control the entered data and to help analysing them through statistic and synthesis applications



Some examples of the possibilities offered by « ***SAGESSE*** »

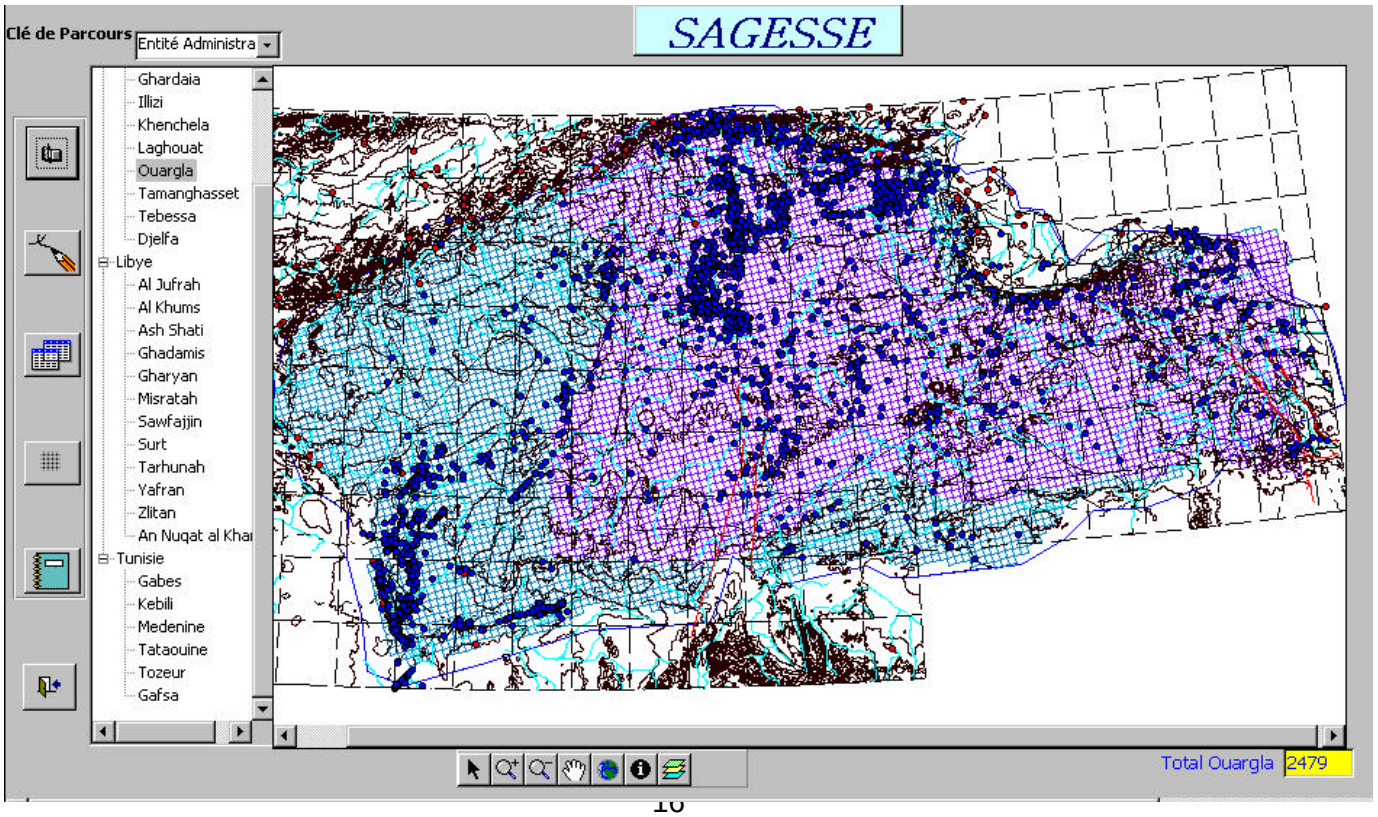
- **The explorer (navigation and data research tool)**

Digital tabular list



The data exploration window is at the same time the main menu from which we can have access to all the software functions. The tabular exploration is for the time being carried out in two ways : by administrative entity (country, wilaya (governorate)) and by aquifer (layer and type of water source). Additional keys can be incorporated through minor modifications in the programmes.

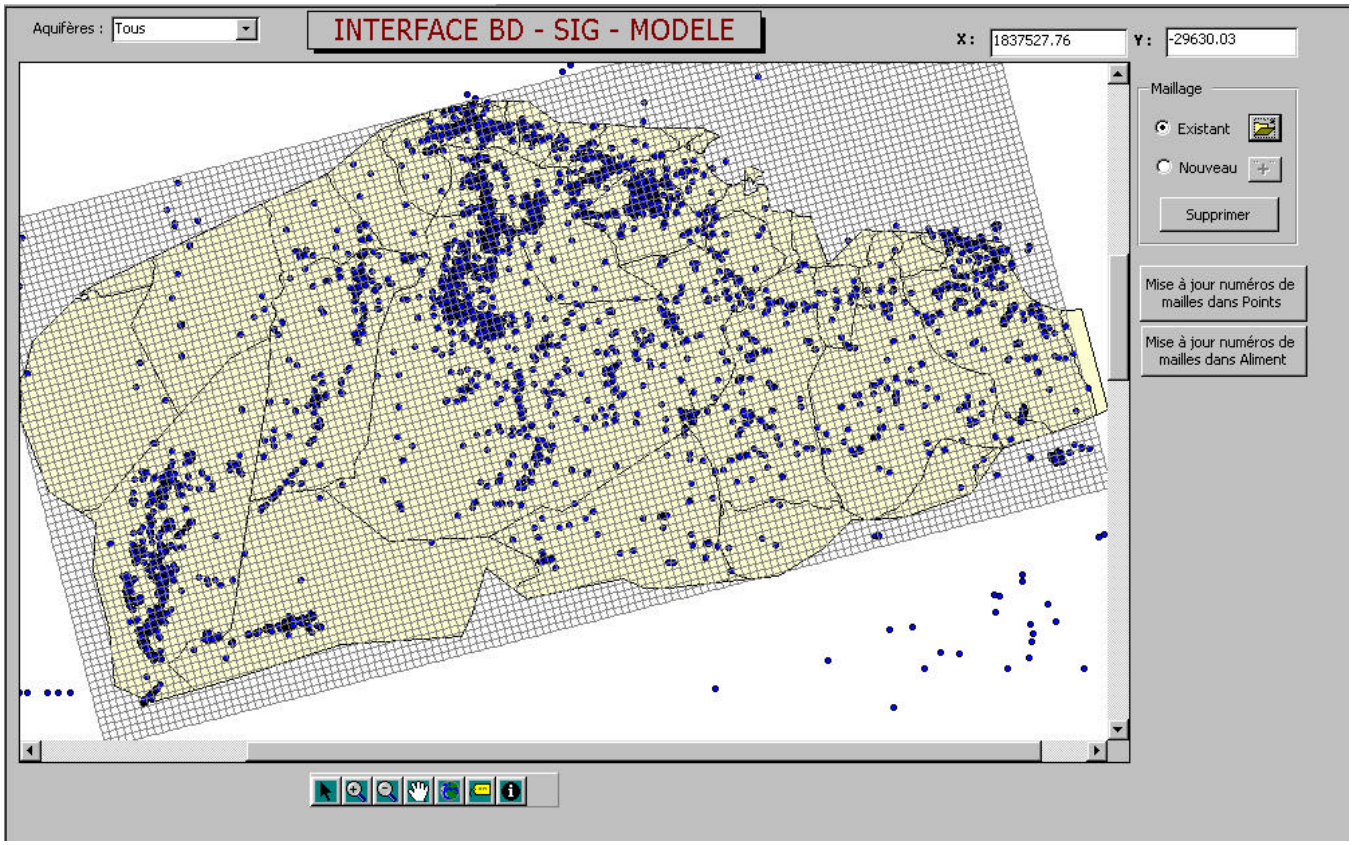
Geographical Exploration



- Window shifting
- Layers control
- Identification through the selection of a water source and the display of the corresponding information.
- Research by spatial criteria (inside a polygon, located at a distance of , …)

- **DB –GIS – PM5 Links**

Window of DB-GIS-PM5 Links



From this form, three fundamental tasks can be launched by the user :

- The generation for a meshing of the PM5 pattern
- The automatic assignment of a meshing number to all the water sources with Lambert coordinates
- The permanent DB–GIS synchronization in order to maintain a coherence between the "sources" table and the corresponding GIS layer.

The conversion of the geographic coordinates into Lambert is secured by an external module inside the *ARCVIEW* software. This module, achieved thanks to the «*Avenue* » language, allows an automatic conversion of the decimal degrees into Lambert while updating of the corresponding fields in the « *ACCESS* » data base.

3 SYNTHESIS OF THE INFORMATION COLLECTED DURING THE PROJECT

All the available information on the zone have been collected and entered in the data base. Many sources were exploited, which could be grouped into two categories :

- Already existing files in the countries and which were made available
- Reports on earlier studies conducted in the zone (ERESS, RAB, BRL, GEOMATH, …)

3.1 Data supplied by the countries

They concern, in general, recent data collected within the framework of the implementation of the respective data bases. They include :

- the water sources characteristics : identification – location
- the 1982 – 2000 exploitation histories
- the 1982 – 2000 level histories
- some useful information on the usages, the hydrodynamic parameters and the …. captured levels.

- **ANRH**

Three kinds of data were forwarded by the ANRH for the two main aquifers (ICS and TC) :

- Characteristics of the water sources : an EXCEL file per aquifer
- Inventory data and flow histories
- Piezometric histories.

These files come essentially from :

- the BADGE data base contents, managed at the level of the Ouargla regional unit,
- the inventories carried out in the 90's (91-98),
- the data supplied by the SONATRACH Company,
- the foggara inventory made in 99-2000.

These data were already processed to a large extent, within the framework of the BRL study carried out between 1997 and 1999, mainly with respect to the positioning and the histories of the intakes.

In order to include these information in the NWSAS DB, a preliminary processing was necessary : shaping and homogenisation of codes, transformations of the coordinates, reconstitution by means of the GIS, etc…

"Updated" applications were afterwards developed in order to transfer these files into the base and to distribute the data among the different tables.

The 1982-2000 intakes histories were made based on the inventories. Considering the absence of a regular follow up, the series had to be made up again. The value recorded on the inventory date was reproduced all over the period in the course of which the water source was exploited.

As for the reports on the levels, the measurements are even less numerous.

- **DGRE**

The data supplied by the DGRE include basic information on the water sources (identification, location, hydraulic parameters), the exploitation histories and the levels histories.
Concerning this Tunisian part, there is one single information source (the concerned DGRE and CRDA). The processing of the shaping has only affected the coordinates and the identification numbers (IRH n°).

DGRE data : distribution by governorate, by aquifer and by period of water sources having an intakes history.

Aquifer / Governorate	TC			ICS		
	1980	1982	2000	1980	1982	2000
Gabes				03	03	13
Gafsa	0	0	05			
Kebili	114	191	341	01	02	21
Medenine				0	01	11
Tataouine	0	01	02	29	30	55
Tozeur	88	98	151	01	01	01
Total Tunisia	**202**	**290**	**499**	**34**	**37**	**101**

The DGRE disposes of intakes histories coming from its measurement network. For the needs of this project, an annual value per water source was entered in the data base. One must point out that the values of 1999 were renewed for the year 2000.

- **GWA**

The unique computer file supplied by the GWA contained only the characteristics of the water sources. The histories of the intakes were reconstituted and the histories of the levels were entered by the NWSAS team. The other information were supplied on paper support because the GWA data base had just been delivered and was therefore empty.

GWA Data : distribution per administrative unit and per aquifer

Aquifer / Municipality (town hall)	TC		ICS	
	Before 1980	After 1980	Before 1980	After 1980
Al Jufrah			02	06
Al Khums				
Ghadamis	01	07	11	02
Gharyan			01	03
Misratah			02	01
Sawfajjin		01	04	47
Zlitan			01	07
Total Libya	**01**	**08**	**21**	**66**

The intakes histories were set up by the NWSAS team based on the information relating to the usages (irrigated areas)

3.2 Data collected by NWSAS

In order to complete the chronological series and integrate them in the data base, the old data used within the framework of former studies had been collected and entered in the data base, they were later on handed over to the teams of the countries in order to be checked and validated.

The data concern, in particular :

- the exploitation histories before 1982
- the piezometric series used in the ERESS, RAB, BRL, GEOMATH, ARMINES-ENIT studies,
- the salinity histories which were not managed by the countries' DB.

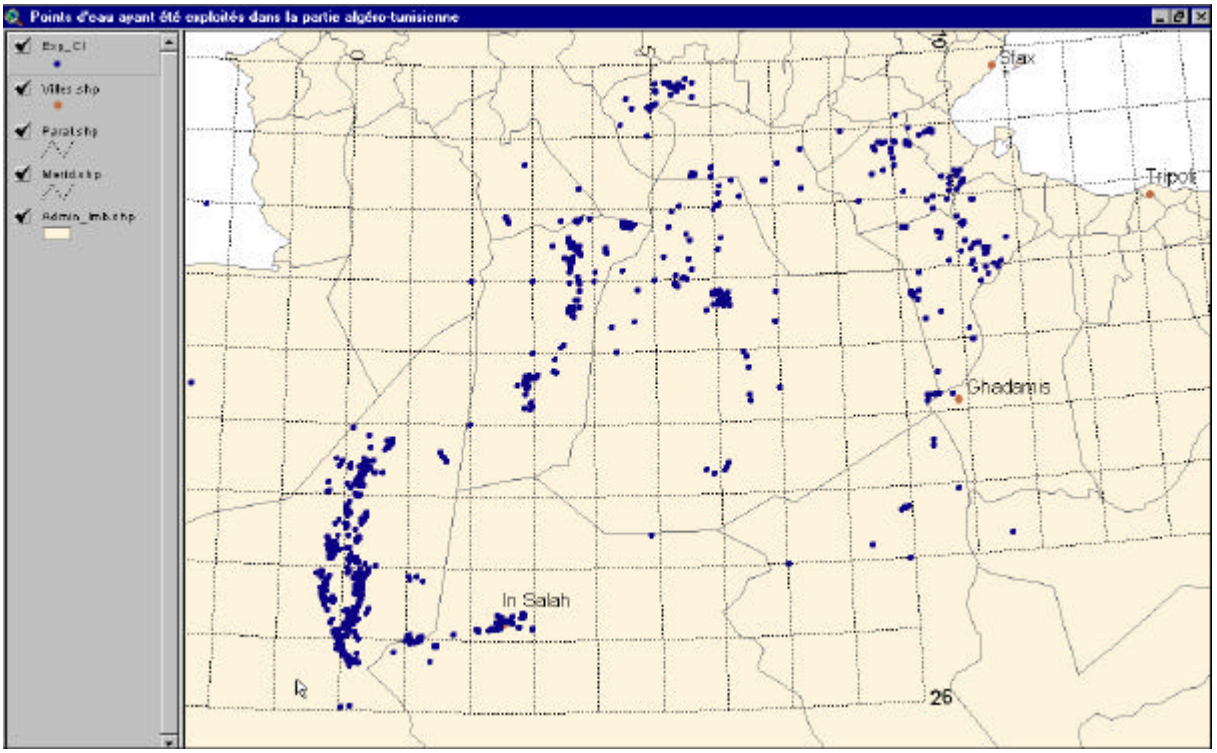
- **Intakes Histories**

For the Algerian and Tunisian parts, these histories (1950-1981) have been reconstituted in their majority, out of the studies carried out in the zone, namely : ERESS, RAB, ARMINES/ENIT

When the information relating to a specific water source is not found (one of the drawbacks of the old studies is their tendency to reduce everything to the mesh), a fictive water source is created with the centre of the mesh as its coordinates.

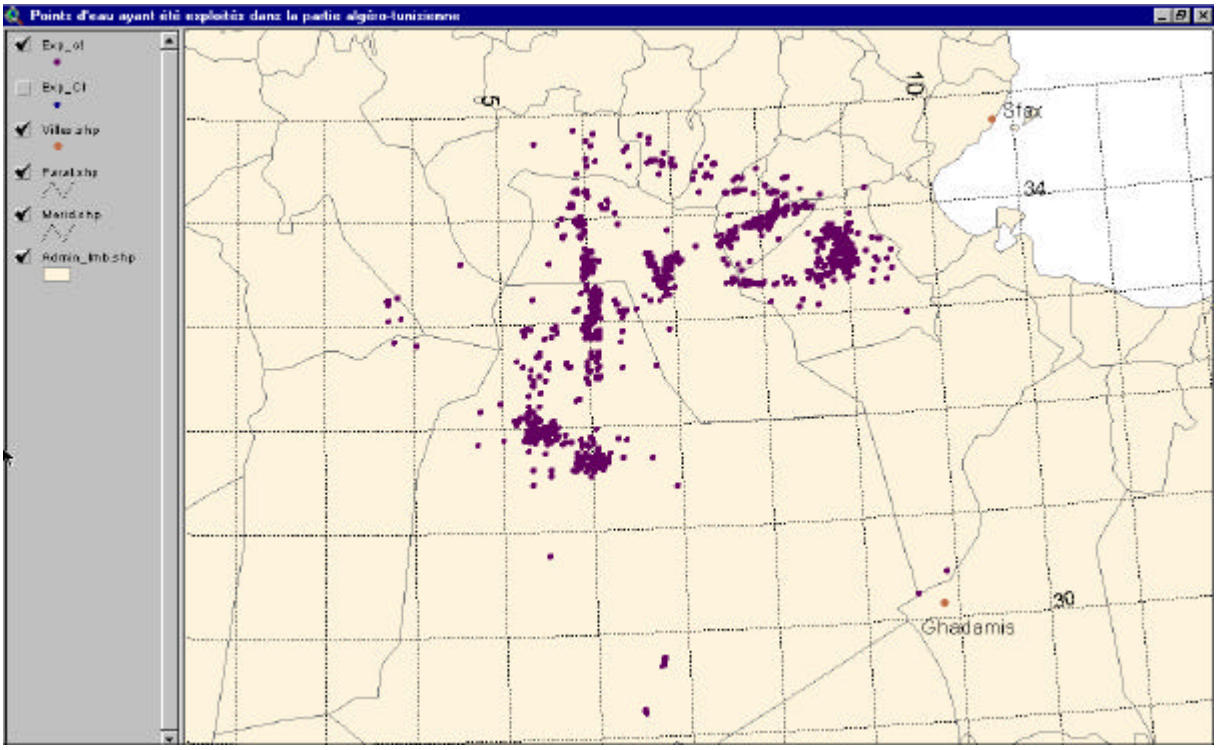
Distribution of the water sources now under exploitation (or which were formerly exploited) in the Algerian and Tunisian parts :

In the ICS



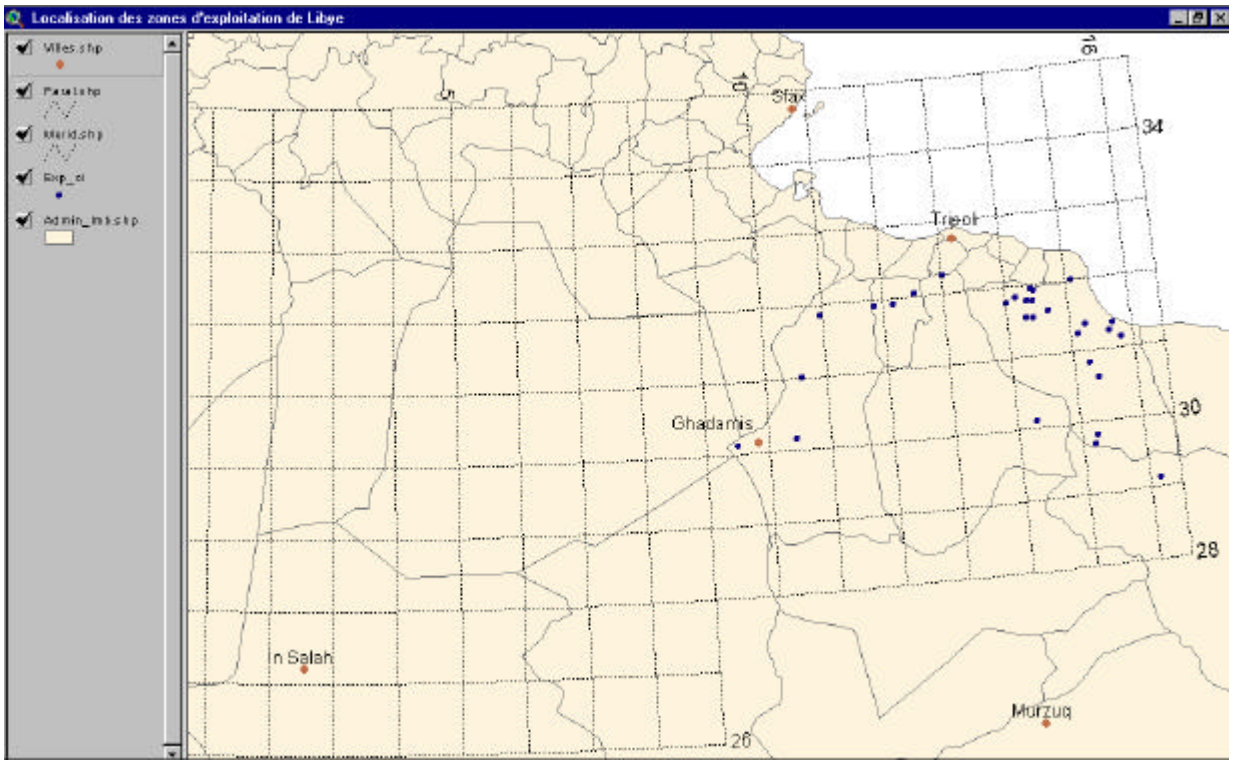
One must point out that the foggaras are also represented in groups (totalling 170 in the Adrar region).

And in the TC

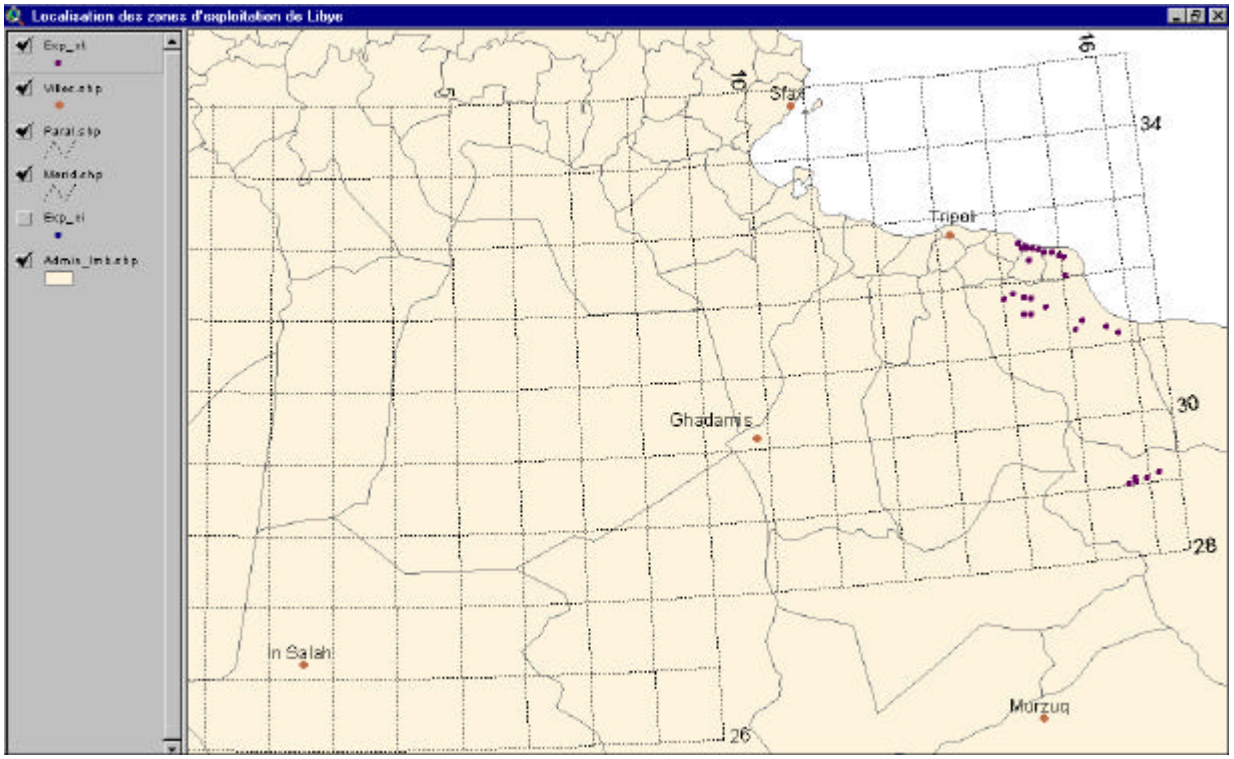


In the Libyan Part, the intakes are supplied per intake zone and they total 37. These centres were listed and localised by GPS. The following charts show their spatial distribution

In the ICS



And in the TC



- **Piezometric Histories**

Just like the case of the intakes, all the known springs were exploited for the elaboration of the histories of the levels. The following series were entered by the NWSAS team :

- 1950-1981 for the Algerian and Tunisian parts
- all the histories for the Libyan part.

The following chart shows the temporal distribution of the piezometric measurements collected for each of the two main aquifers :

Aquifer	1950	1960	1970	1981	1990	2000
ICS	04	13	77	20	56	202
TC	19	60	219	87	146	66

The DGRE and the GWA carry out a regular follow up of the levels by means of a network, which is not the case of the ANRH which collects the information on the occasion of the inventories or the studies.

- **Salinity Histories**

The files supplied by the countries include some values concerning the dry residues. They were transferred through a programme, into the data base.

Other information were taken from various documents and study reports and then entered by the NWSAS team.

The following chart summarises the evolution of the number of observations of dry residue per period :

Period Aquifer	Before 1972	Between 1972 and 1981	Between 1982 and 1990	After 1990
ICS	165	256	262	73
TC	803	1853	803	347

3.3 Origin of the data

- **Intakes**

Country	Origin of the data	Number of units	Entry Mode In the DB
Algeria	ERESS RAB ANRH inventories Foggaras inventories	120 298 2490 176	Entered by NWSAS Idem Transferred by programme Idem
Libya	NWSAS	36	Entered by NWSAS
Tunisia	ERESS RAB DGRE Network	290 280 964	Entered by NWSAS Idem Transferred by programme

- **Piezometry**

Country	Origin of the data	Number of units	Entry Mode In the DB
Algeria	ERESS RAB ANRH Files BRL 98	131 30 2050 22	Entered by NWSAS Idem Transferred by programme Entered by NWSAS
Libya	ERESS GEOMATH BRL GWA	1 119 45 26	Entered by NWSAS Idem Idem Automatic transfer
Tunisia	ERESS RAB ARMINES / ENIT DGRE Network Unpublished DGRE report	4 5 131 265 232	Entered by NWSAS Idem Idem Transferred by programme Entered by NWSAS

3.4 Synthesis of the data collected within the framework of the project

After various return trips between the NWSAS and the three administrations, necessary for the corrections and the making up of the deficiencies, the maximum level of reliability for the data was reached. All the possibilities were in fact exploited in order to do so, namely :

- Checking out and anomaly detection tools
- Manual corrections
- Cross examination of various types of data
- Visits paid by the national teams to the regional structures in order to validate certain information.

Distribution per country and per aquifer

Aquifer / Country	ICS	TC	Total
Algeria	2530	3979	**6509**
Libya	526	472	**998**
Tunisia	221	957	**1178**
Total	**3277**	**5408**	**8685**

Number of water sources per type

Aquifer / Type of source	CI	CT	GS	Total
Drilling	2034	4463	15	6512
Artesian drillings	335	469	26	830
Exploitation_grp	22	29		51
Oil drilling	37	174		211
Geology (sections)				238
Piezometer	8	3		11
Wells	3	129		132
Foggara	701	0		701
Spring	3	0	07	10
				8696

Number of sources with hydrodynamic characteristics

Country	Aquifer	Test Flow	Static level	Draw downs
Algeria	ICS	583	732	43
	TC	1316	1506	474
Libya	ICS	132	242	106
	TC	0	76	63
Tunisia	ICS	18	6	17
	TC	205	155	197

Number of water sources with histories (exploitation, piezometry and salinity)

Country	Exploitation		Piezometry		Salinity	
	ICS	TC	ICS	TC	ICS	TC
Algeria	1148	1343	676	1469	256	835
Libya	29	29	187	205	129	108
Tunisia	127	759	98	366	82	510
Total	**1304**	**2131**	**961**	**2040**	**467**	**1453**

4 DATA ANALYSIS AND VALIDATION

Considerable information from several sources were collected by the NWSAS project. This is the first time that such information are collected in order to serve in the future without having to collect them throughout dissimilar documents and files.

But the diversity of these sources ineluctably led to a risk of anomalies which had to be detected :

- First of all, for the needs of the study, in order to make available the most viable information to the pattern by making some corrections (making up for the deficiencies, cross-examination of these information by comparing them with other information sources …)
- Then, for future updatings, by providing for a careful control programme by the concerned administrations, using the tools and methods prepared during the NWSAS project.

An important part of these data and more particularly the histories of the intakes and of the piezometry were the subject matter of an analysis and a validity control.

This analysis covered several aspects :

- problems of localising the water sources
- errors in the measurement units
- harmony in the chronological series
- spatial distribution of the sources endowed with piezometric measurements or intakes histories.
- completion of the missing data.

Several stages were necessary for this analysis, correction and validation process

4.1 Preliminary Processing of the gross data

This processing consists in the identification and the most precise localization of the water sources. Priority was given to those endowed with an intake or a piezometric history.

- **Processing of the coordinates**

An important work of shaping, correction and transformation was achieved in order to allow a representation of the water sources on the same projection system. The errors, generally recorded, are due to the fact that information on the coordinates were never processed by the GIS, which resulted in :

- The absence of information concerning the projection system, the units (grades or degrees), the UTM zone,
- The bad transcription of the values which are not checked (as they are often unused)

The structures of the three national DB were improved in order to take these issues into account.

The following chart takes up the problems met in this field :

Country	Recorded Problems and Errors	Achieved Processings
Algeria	- absence of indication of the units (Grades or degrees) - Absence of indication on the position with respect to Greenwich meridian line - Inversion of the longitudes and latitudes - Total absence of coordinates - No indication of the Lambert zone (North or South)	- Correction of the anomalies by the ANRH team. - Correction, shaping and transformation into decimal degrees, then into Lambert South - Approximate reconstitution by the ANRH team according to other parameters (agglomeration, municipality, …)
Libya	- No indication of the type of coordinates and the UTM zone - Inversion of the longitudes and latitudes - Positioning errors	- Correction by the GWA - Shaping and transformation into decimal degrees, then in Lambert South
Tunisie	- absence of precision on the origin and the units (Paris grades or degrees) - sources without coordinates - positioning errors	- Corrections made by the DGRE team - Shaping and transformation into decimal degrees, then into Lambert South

- **Unique identification of the water sources**

In a data base, each record must be identified by a unique filing number : most of the times, this identification number is not found for various reasons. The recorded deficiencies are essentially due:

- To the data collected from study reports in which this number is not specified (often it is the name, the region or the mesh which are used)
- The files coming from the ANRH inventories,
- The files coming from the Libyan piezometric network.

In order to enter them in the data base, they had to be recorded under a fictive number in case it was found out, after a manual checking, that these sources do not exist in the DB. This situation may lead to the presence of duplicates because the sources entered likewise may have already been identified before. We however decided to take this risk in order to have the maximum data.

A systematic control programme was proposed to the teams in order to enable them to have a *"cleaner"* data base.

- **Making up for the deficiencies and homogenisation**

The available data within the three countries are presented in different ways : certain essential items are not always entered or do not have the same code.

These items being absolutely necessary for the project, have been reconstituted, for some of them, or completed, manually, for some others :

- type of water sources (drilling, piezometer, well, foggara, exploitation group)
- captured aquifer (ICS, TC, …)
- spatial entities (Wilaya (governorate), municipality, region, intake zone, ..)
- History dates

For the reconstitution of the spatial data a utility facility was developed with the help of the "Avenue" language in order to obtain the value of the attribute and to update automatically the data base.

4.2 Statistic Analysis of the data

Applications and crossed charts were elaborated in order to carry out probability controls, notably for the intakes histories, and to find out any eventual errors. The synthetic charts, per aquifer, per country and per administrative unit; allowed to check out the global coherence and the reliability degree.

These charts were completed by graphic and cartographic representations in order to make easier the detection of anomalies.

Evolution of the Intakes per administrative unit (in m3/s)

Aquifer	Country	Wilaya (governorate)	1950	1960	1970	1980	1990	2000
ICS	**Algeria**	Adrar		0	0	0	163	200.5
		Biskra		3.2	3.2	14.7	51.3	51.3
		El Oued	5.5	6.8	13.9	21.8	71.7	71.7
		Ghardaia	4.9		27.2	39.4	144.2	252.8
		Illizi					22.9	32.5
		Ouargla		0.3	34.9	54.5	145.6	148
		Tamanghasset	5			0.1	84.8	100.4
	Libya	Al Jufrah					5	14
		Ghadamis			0.1	4.3	4.3	4.3
		Gharyan				1.6	1.6	0
		Misratah				0	20	6
		Sawfajjin				45	117.6	64.7
	Tunisia	Gabes		2.2	7.5	3.4	14.8	24.9
		Kebili		2.8	5.4	2.1	26.6	38
		Medenine					0.1	0.1
		Tataouine	0.1	1.6	14.2	12.2	8	9.1
		Tozeur					8.4	9.3
		Total ICS	**15.5**	**16.9**	**106.4**	**199.1**	**889.9**	**1027.6**

TC	Algeria	Biskra	3.7	10.1	13.1	10.5		
		El Oued	94.9	95.7	135.2	127.9	201.6	294.2
		Khenchela					9	9.6
		Ouargla	83.4	93.9	110.6	112.9	387.6	391.3
		Tebessa					8.1	7.2
	Libya	Al Jufrah	2	3	10	94	130	107.8
		Al Khums	0.5	0.5	1	12	13	14
		Misratah	28.9	24.7	16.9	58	55.9	57.4
		Sawfajjin				1	7	27
		Zlitan	2	3.1	4.6	6	21.2	26.2
	Tunisia	Gafsa					4.9	2.8
		Kebili	30.6	50.4	56.5	111.1	240.2	318.2
		Tataouine					1.4	1.5
		Tozeur	10.1	15.8	26.9	80	159.1	132.5
	TC Total		**256.1**	**297.2**	**374.8**	**613.4**	**1239**	**1389.8**
Grand Total			**271.6**	**314.1**	**481.2**	**812.5**	**2129**	**2417.4**

Graphic showing the evolution of the intakes in the two main aquifers (l/s)

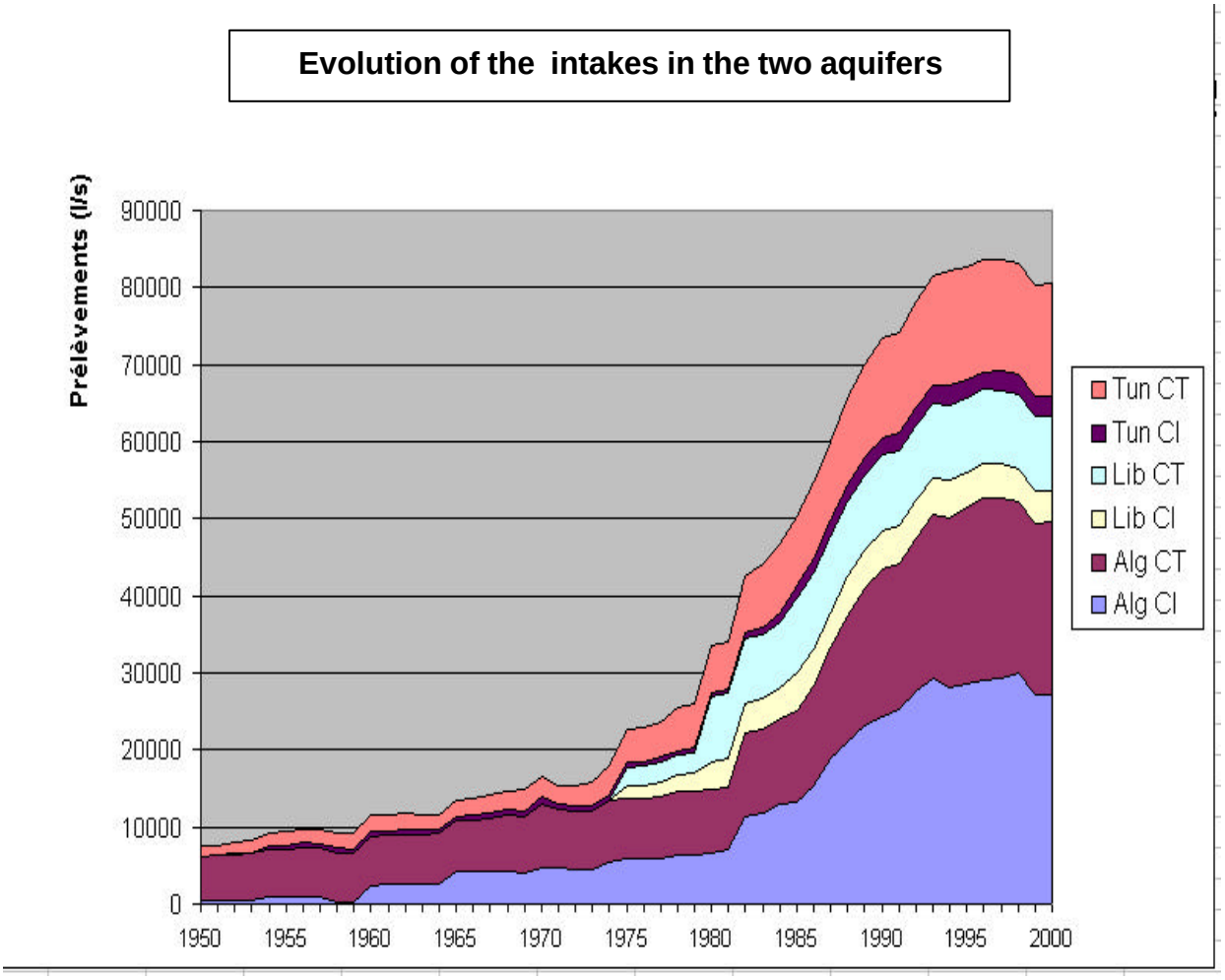
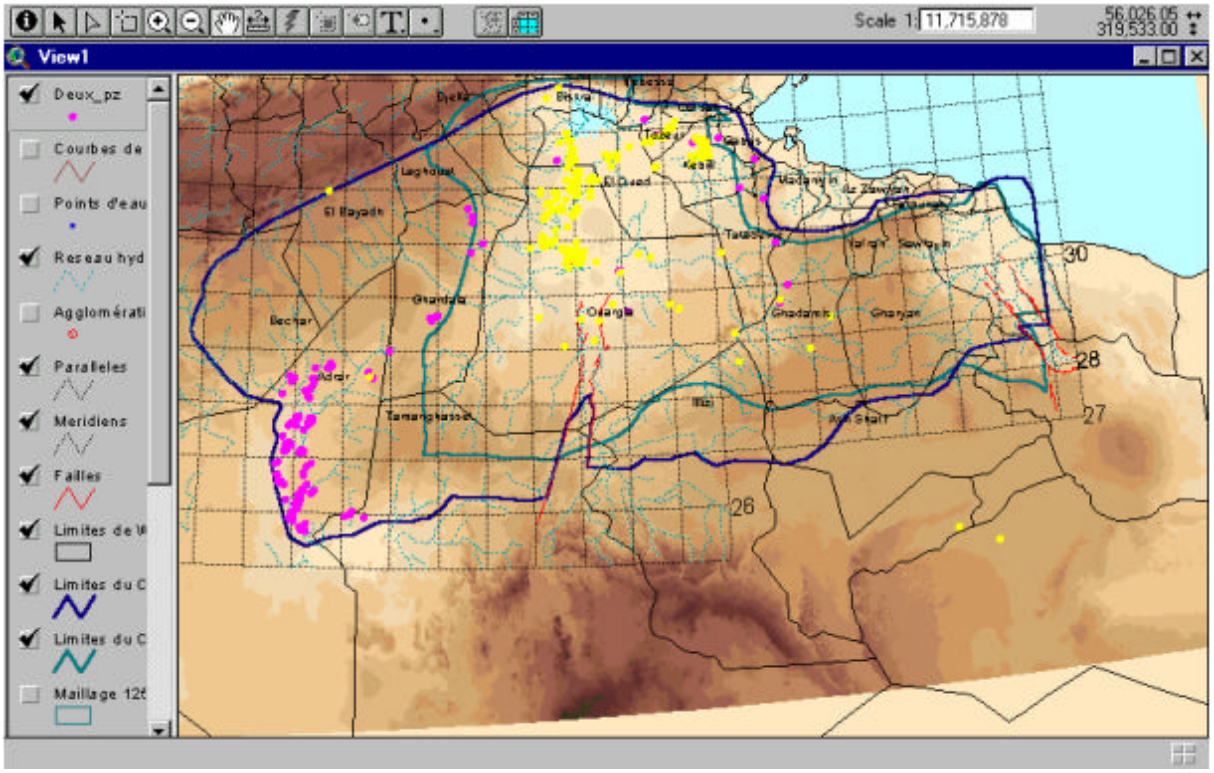


Chart of the water sources with three level measurements, at least, (the water sources complying with this criteria in yellow)



CONCLUSION AND RECOMMENDATIONS

The information collected during the project allowed for the first time, to have a uniform processing over the whole trans-border basin. The accuracy level required at this first stage is may be sufficient for a global representation of the aquifer systems, for an evaluation of the intakes at the level of the pattern meshes and the behaviour of the sheets level, according to various exploitation scenarii.

However, this reliability degree becomes insufficient if we want to have a deeper knowledge of certain zones and to reach a higher precision. For this end, we need collection modes based on a measurement network still to be defined, clear and uniform collection and processing procedures and an adequate organisational device for a regular updating of the information system.

But the most urgent measure would be to "*clean up*" the present DB in order to get as close as possible to the real situation. This operation which has to involve essentially the country teams, shall consist in the following tasks :

- searching for and identifying the eventual duplicates resulting from the multiplicity of data sources
- careful checking of the coordinates
- making up for the deficiencies which could not be made for all the fields
- checking the histories constituted within the framework of the project
- entry of data on the usages and precise assignment of the exploitation group to the water sources.

At the GIS level, a more precise digital cartography must be achieved with respect to the zones showing a particular hydrogeological interest : topographic background at a large scale, more precise MNT, limits of the agricultural zones and of the forecast extensions….

The tasks to be executed per country are summed up in the following chart

Country	Tasks
Algeria	- Checking the inventory data, assignment of an identification number and elimination of duplicates - Entering the missing information : coordinates, depth, captured formation, altitude, dates of achievement and interruption, status, …. - Confrontation of the intakes histories with the available information at the level of the users - Constitution of the exploitation group table and assigning it to the water sources - Checking the information on geology - Precise delimitatiuon of the exploitation zones and their cartography
Libya	- Confrontation of the entered data at the NWSAS level with the drilling which are really existing, elimination of duplicates and assignment of identification parameters - Constitution of intakes histories per drilling - Constitution of the exploitation group table and connecting it to the water sources - Checking the information on geology - Precise delimitation of the exploitation zones and their cartography
Tunisia	- Checking the water sources characteristics and completing the missing information - Constitution of the exploitation group table and assigning it to the water sources - Checking the information on geology - Precise delimitatiuon of the exploitation zones and making up their cartography

At a first stage, the achievements of the project and the dynamics resulting therefrom must be consolidated through the following actions :

- To continue the adaptations initiated on the national DB and to develop the management tools at the local level.
- To set up a data transmission device in order to achieve the updating of the common data base.

At a second stage, the organizational aspect must be taken care of in order to allow the technical tools to function properly:

- Creation of a management and administration cell for the data base and the GIS
- Setting up standard procedures and guides for the collection, the control and the validation of the data.