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Organising information related to groundwater hydrology

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Abstract

A relational data base has been designed to cover the hydrological and meteorological information of Greece on a nationwide basis. This paper deals with the part concering Groundwater Hydrology and Hydrogeology. A system is presented for the search and retrieval of this information. The software has been developed using the W4GL of the Ingres DBMS and runs in workstations under Unix X-Windows. The ultimate goal of developing the data base is to acquire a tool for groundwater management. However, there are no specific defined policies in that area, although the nature of the problems is known. Therefore, the system was designed in a sufficiently general and flexible manner, so as to accomodate future needs. The information related to groundwater is organised on the basis of a classification into spatial and temporal categories. Subsequent groups and subgroups of information emanate from this basic division and the whole scheme is depicted in frames logically inter-connected and reflecting an hierarchy in data access. These frames provide a visual overview of all information categories and a suitable environment for the processes of data entry, search, retrieval, query formulation and report production. The data management software depends heavily on SQL search codes. Alternatives of such code commands are applied and discussed.

1. Introduction

A relational data base system has been designed to cover the hydrological and meteorological information of Greece. This task has been carried out within the framework of the project HYDROSCOPE, which is currently underway at a national scale. Details of this project have been given by Tolikas et al[5]. This paper deals with the part concerning Groundwater Hydrology and Hydrogeology.

Traditionally, hydrological data are for the most part collected in relation to surface water resources. Rainfall and runoff data, as well as river elevations and discharges are to be found in considerably large amounts and

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in the form of long time series in the archives and registers of the responsible data collecting agencies.

In contrast, Groundwater Hydrology can only exhibit relatively small amounts of data. Time series essentially do not exist in the form of regularly registered values. Rather, they appear as isolated events at irregular time intervals. However, in comparison to Surface Hydrology, Groundwater Hydrology entails a larger variety of data (Finch et al.[3]) and this may have been one of the reasons why more emphasis has been put to the collection of surface water data.

Groundwater data collection is indeed a very old practice, but it has been exercised in a rather fragmentary and not particularly systematic fashion. It was only through the water pollution experiences of the past few decades, that the need was recognised for definite limits on the use of groundwater. It has also been realised that management studies and policies are truly indispensable.

The term management in the context of designing this data base is considerably wide and does not refer to a concrete, pre-specified and well defined problem or group of problems. For this reason, the question of the amount and the types of data to be collected and stored cannot be answered in a unique and specific way. The problem becomes more undetermined by the fact that the data base extends to the whole country thus adding to the variety and the number of the regional problems to be faced.

The design of any groundwater data base is determined by a two-way relationship between water management and data collection policies. Indeed, data collection and existing data registers determine simulation models to be used and, subsequently, management strategies to be followed. On the other hand, management goals and plans dictate selection of data and data collection procedures (Maimone et al.[4]).

In view of this inherent vagueness in prospective utilisation plans for the data base, it was thought hardly possible to specify in a definitive manner hierarchies and priorities in the data to be entered, both from the point of view of INGRES table design and from the point of view of user interface. For this reason, the data base system had to be designed in a flexible fashion, so as to correspond to evolving future needs. A first step toward this end was to define fundamental data categories, in order to classify and group all information under a sufficiently general scheme (Georgiadis et al.[1,2]).

The data categories are presented in a series of successive frames, which constitute the user interface. Proper manipulation of these frames permits both data entry and data recovery. The response of the system to user queries takes the form of reports easily adapting to particular needs.

The entire system is based on the INGRES relational data base software and the programming code consists of SQL commands. Certain questions arise as to the use of SELECT commands, which affect the efficiency of the searches. Alternative formulations of SELECT commands are, therefore, tried and compared.

2. Classification scheme

The two basic, broad categories defined are labelled as spatial and temporal respectively (Fig. 1). Spatial information refers to those data associated to the

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measuring station and to its location, that are not subject to additional entries or changes with time. Spatial information is further subdivided into two large subcategories. The first one, labelled as general, refers to station identification, as well as to its geographical, administrative and hydrological location. The data contained in this category are independent of the fact that they refer to groundwater. They describe and characterise the measuring station itself. The same data category may apply equally well to a surface water station. This classification has been adopted in order to achieve unification with the surface water part of the data base system.

The second, so-called specific, subcategory comprises purely hydrogeological information, such as water well construction details, history of well drilling, land use and lithological section data.

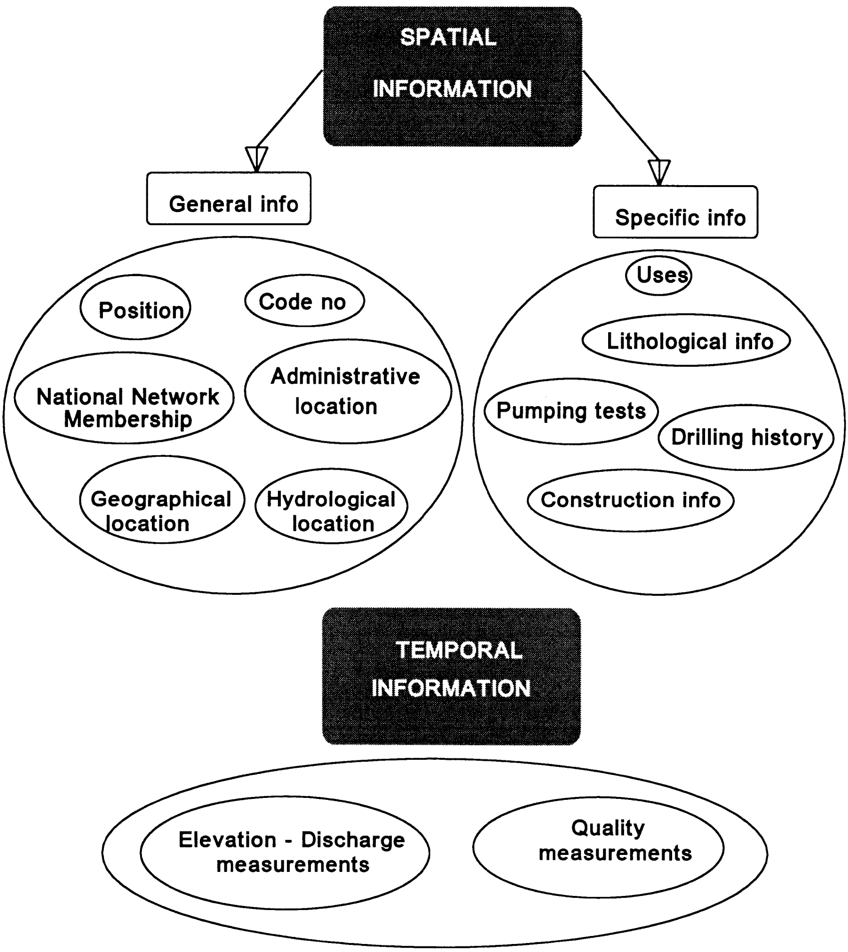

Figure 1: General classification scheme.

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The temporal category, on the other hand, includes measurement data. Such may be elevation and discharge data, as well as various water quality measurements. The data registers have the form of time series, which in the case of groundwater data are not dense. The broad classification scheme oulined above is depicted in Fig. 1.

The general scheme just presented is made more specific in the logical diagram of Fig.2, which shows the actual categorisation and hierarchy of information as implemented in the data base and in the user interface.

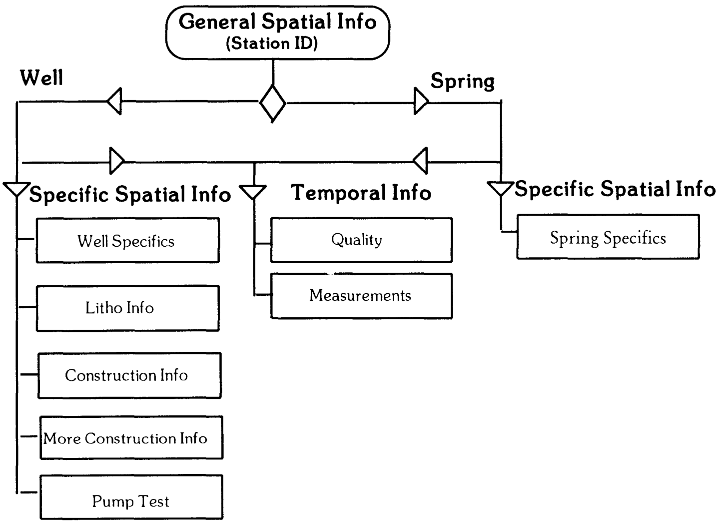

Figure. 2: Logical diagram of information categories.

3. Data entry

The process of data introduction is naturally performed within an environment of successive frames, that materialises the logical diagram of Figure 2. The first of these frames, which may be called "front page" (Fig. 3), presents an overview of the already defined data groups and categories. For data entry the "front page" may be used for the selection of category, and, subsequently, for directing control to the proper succeeding frame and to the selection of the desired field.

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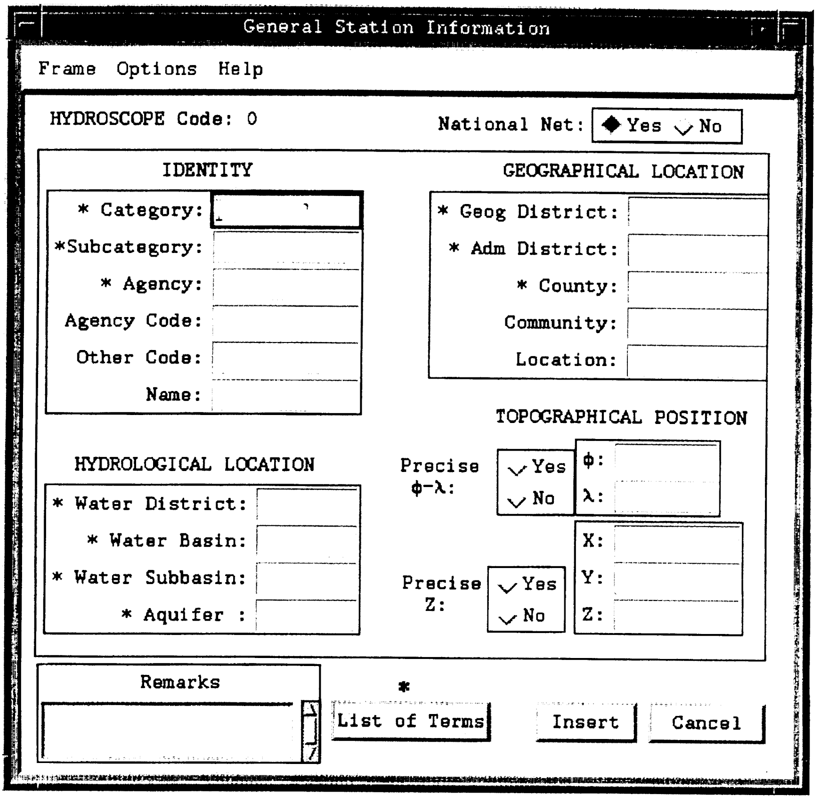

Figure 3: Front page frame.

The system is designed in such a way that, in order to introduce any particular data item or group of items, priority is given to the station identification information, to which the data to be entered is associated.

A number of hydrogeological data concerning construction details and history of drilling are introduced via the relevant specific Spatial Information Frames (Fig. 2). Data of this group can be presented in table form, or even better, they can be shown pictorially as in Fig. 4. The data on this picture represent a common practice example.

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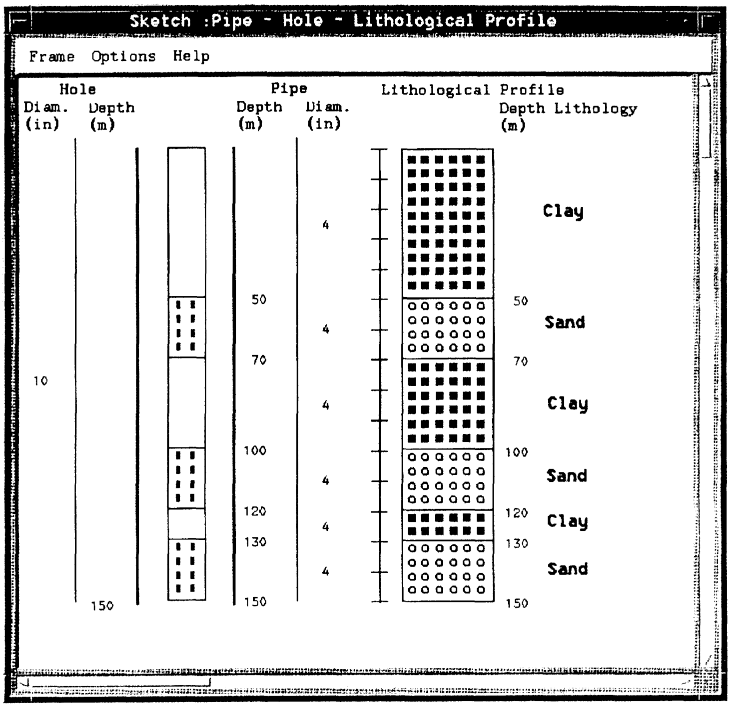

Figure 4: Lithological profile

4. Search procedure and data retrieval.

The classification scheme and the system of successive frames form the basis and the environment within which search conditions are defined and searches are performed.

The so-called "front page" serves for the choice of a data category, opening the way to a subsequent frame and to the selection of the field of interest. A relation in the sense of SQL is then defined by picking up the suitable operator "and", "or", "not" etc. The process returns to the "front page" to select, in the same way as before, another field needed to complete the definition of the search condition, as shown schematically below.

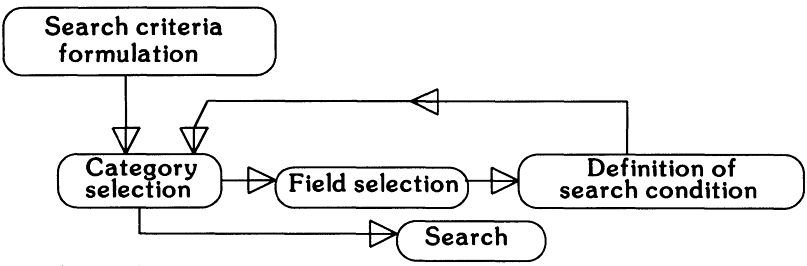

Figure 5: Search procedure

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5. Select commands.

The compilation of the SQL search code is largely based on the formulation of suitable select commands. The various searches are performed among three major INGRES tables, the table STATIONS, the table INSTRUMENTS and the table RAW__STD. The last table contains the measurements.

As an example, let us search and locate those stations, for which the elevation measurements after a certain date are larger than a certain value v0. Two alternative SELECT schemes are the ones shown in Figures 6 and 7. In Figure 6 the search starts with the table of measurements, returning a possibly large number of instruments with measurements other than those of interest. Another possibility is shown in Figure 7, where the selection is pushed downwards, so that, from the beginning, a smaller number of instruments is returned. It seems that this second formulation is more efficient. However, after several trials, it turned out that the time required for executing the set of commands of Figure 6 was less than that of Figure 7 by a ratio of 3 to 5. This may be attributed to the fact that a larger number of index files is used in the second formulation. More trials of this kind are needed, especially because, so far, only a small proportion of the whole final bulk of data has entered the base. Thus, the relative distribution of data among the various INGRES tables has not reached any representative level.

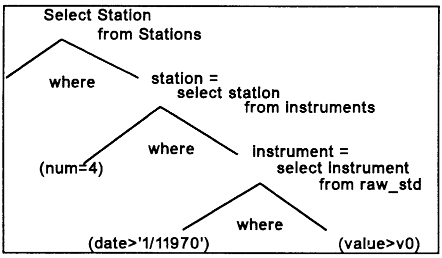

Figure.6: The search starts with the table of meaurements.

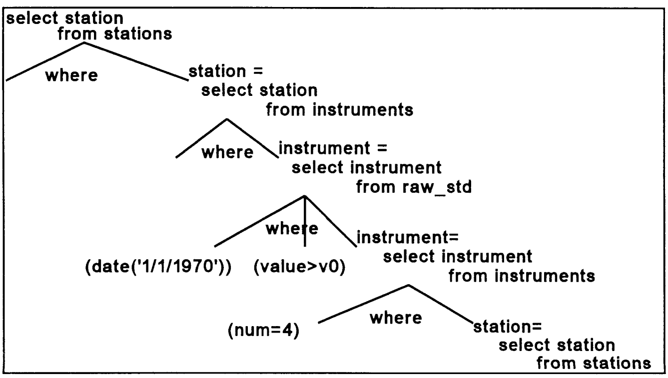

Figure 7: Search is pushed downwards

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6. Summary and conclusions

A nationwide relational database management system is being set up for the hydrological and meteorological information of Greece. Within this system hydrogeological information is organised with the view toward serving future management needs. The evolution of these needs and the formulation of specific problems not only influence the data base organisation, but they will also be affected by it.

Under these considerations, a general qualitative classification of hydrogeological information is presented, based on a distinction between the spatial and the temporal character of the data. Identification and characteristics of hydrogeological measuring stations form a separate subset of spatial information, as these stations are treated in the same way as other kinds of stations, such as Meteorology and Surface Hydrology stations, that are supported by the data base.

The above classification is made more specific through the introduction of suitable subcategories and the whole scheme is materialised in an environment of successive frames, which permit a controlled and structured access to the various data categories and fields. The fundamental processes of data entry and retrieval are naturally embedded within this environment.

The code underlying the search procedures is heavily dependent on SQL SELECT commands. Alternative formulations of such commands are presented and compared.

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