Chapter 1

Introduction

1.1 Motivation. Project description

Groundwater can be used for cooling buildings. In summer, groundwater is cooler than the temperature of the atmosphere. Then, this water can be either circulated through a piping circuit in the building or used to dissipate thermal energy through heat exchangers. This is an environmentally friendly system that may also be reversed and use groundwater for heating purposes during winter.

Barcelona Regional (BR) is the organization responsible of controlling the urbanism developing of the city of Barcelona. Both the local council and BR have promoted a rational exploitation of underground resources. Within the development and investment in the Sagrera area the possibility of using groundwater resources as thermal interchanger has become an important matter for politicians and institutions.

In this context, water table is rising beneath the city of Barcelona. The process started in the last quarter of the twentieth century. It was caused by changes in the hydrogeological cycle that resulted from a steady increase in the urbanization degree and the soil and groundwater uses.

As a result, important leakage problems have arisen in underground public and private structures linked to an important economical cost. In order to deal with this problems, the local council of Barcelona is carrying out a series of projects to take advantage of this amount of raw groundwater with three main goals:

1. To find an alternative supply for specific uses that do not require first quality water
2. To decrease first quality water demand
3. To mitigate the local problems following the increase in water table levels in recent years.

1.2 Background

Two items are required to design a cooling system with groundwater. First, local hydrogeology must be known. Second, we must understand the physical
principles governing heat flow and transport.

The hydrogeology of Barcelona has been widely studied. In 1996 the UPC wrote a project called "The study of groundwater in the Barcelona" funded by the local council of the city. This work granted the GHS-UPC a broad knowledge of the hydrogeology setting of the area, specially near the Besos river and the coast. It constituted a fantastic data base that has been completed and revised later.

The Hydrogeology Group wrote an initial report on the possibility of using the Besos river aquifer with energetic goals [9]. This project consisted of the adaptation and improvement of the existing hydrogeological model of the area and the creation of a heat transport model capable of foreseeing the possible effects of the future use of the aquifer as a thermal pole.

A number of articles and studies concerning heat transfer processes in aquifers have been published. While dissipating heat by injecting warm water into the aquifer has been a traditional procedure for important industries and homes since the 40s[5], alternative methods like ground heat exchangers (GHE) have been broadly studied in north-European countries. The main advantage is that these are environmental friendly systems since no water is pumped or injected into the aquifer. In case of piles or other foundation structures, polyethylene piping forming closed circuits is incorporated in the concrete. This is used to circulate the heat transfer medium (water or mixture of water and antifreeze) and transport the thermal energy to the aquifer.

Basic principles governing heat transport in aquifers are well known. It is widely accepted that heat is transported by advection and conduction [2]. One would expect dispersion to be also a relevant mechanism for heat transport [6]. Surprisingly, this mechanism is rarely accounted for in cooling studies[8] [11] [4].

This may reflect uncertainties in how to represent dispersion, which is known to grow with the scale of the problem. If one adopts a large dispersivity (typical of large scale problems), then unrealistically too much heat is dispersed into the aquifer. On the other hand, if dispersion is neglected then one would not simulate accurately heat dissipation.

In summary, uncertainties remain about both the use of Barcelona groundwater for cooling and about the simulation of heat transport in aquifers.

1.3 Objectives and Methodology

The objective of this thesis are two fold:

- analyze the feasibility of the implementation of cooling systems of buildings by means of groundwater in the area of la Sagrera, Barcelona.
- study the effect of dispersion on the efficiency of the cooling system.

So as to fulfill the objectives described above, a number of tasks has been carried out:

1. Quantification of the efficiency of the ground heat exchanger systems with the hydrogeological medium:

2. Application to the study area: Once the local behavior of the systems is understood and quantified, a global integration of the system will be done to determine the potential energetic capability of the aquifer.
1.3. OBJECTIVES AND METHODOLOGY

The main tasks of the project will be divided into:

- Describe a hydrogeological setting of the area and give a detailed description of the hydraulic parameters and temperatures measured in the aquifer (Chapter 2).

- To give a wide explanation of the equations and processes taking part in the modelling of the phenomenon. In addition to this, a detailed description of the parameters used in the input of the numerical code is also included (Chapter 3).

- Entirely describe the modelling of close loop systems and a series of numerical models in terms of boundary conditions, spatial and time discretization and results (Chapter 4).

- To deal with the modelling of open loop systems and its potential regional impacts in the aquifer. Different scenarios are analyzed according to the power demand studies carried out by Barcelona Regional (Chapter 5).

- Finally, conclusions and discussion about the results obtained in the modelling are considered in chapter 6. An evaluation of the most suitable system for the area, potential thermal capability of the aquifer, possible further applications and optimization of the system are the main points discussed.