THESIS FOR A DEGREE OF DOCTOR OF PHILOSOPHY

AT

KINGSTON UNIVERSITY

WATER SUPPLY
TO
PORTUGUESE REGIONAL HOSPITALS

A CONTRIBUTION FOR THE KNOWLEDGE OF THE WATER CONSUMPTION PATTERNS IN PORTUGUESE REGIONAL HOSPITALS

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The undersigned, Carlos Alberto Gassmann Rodrigues Oliveira, of Rua de Damao, 9, 2760-041 Caxias, Portugal, hereby declares solemnly that, except where referred, he did personally all the investigations and other work required for the making of this Thesis.

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WATER SUPPLY
TO
PORTUGUESE REGIONAL HOSPITALS

A CONTRIBUTION FOR WATER SUSTAINABILITY IN THE DESIGN AND OPERATION OF PORTUGUESE REGIONAL HOSPITALS

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ACRONYMS

ADP	"Águas de Portugal", the Portuguese National Water Authority
AWWARF	American Water Works Association Research Foundation
EPAL	Empresa Portuguesa das Águas Livres, SA, the Water Authority for the Greater Lisbon
EU	European Union
FFL	Finished floor level
GNP	Gross National Product
HVAC	Heating, ventilation and air conditioning
IRR	Internal Rate of Return
IWA	International Water Association
NB	Nominal bore (of pipes)
NTS	Not to scale
PI	Performance Indicator
PROV	Provisional
WC	Water closet

SYMBOLS

A	regression coefficient for trigonometric harmonic analysis
a	regression coefficient
B	regression coefficient for trigonometric harmonic analysis
b	regression coefficient
C	regression coefficient for trigonometric harmonic analysis
c	coefficient of correlation
c^2	coefficient of determination
CMA or **cma**	centred moving average
D	deseasonalised data
e	Euler number
f	frequency
Ha	hectar (10,000 m^2)
i, j	order of a variable in season **i** of period **j**
$\Im$	The set of integers
k	numeric constant, or order of a period
km^3	Cubic Kilometre, or 10^9 m^3

kPa	KiloPascal
kWh	KiloWatthour
L	Total number of seasons in any returning period
LN or **ln**	natural logarithm
ℓ	litre
ℓ**/s**	litre per second
m	meter, or order of the "dummy" variable
m^3	cubic meter
mm	millimetre
N	Number of periods of records
n	number of available records
p_i or p_i	most probable value of a dependent variable at time period t_i as produced by the mathematical model (if existing)
Pm^3	Peta cubic meter (or 10^{15} m^3)
p_{mean}	mean of the most probable values
q_i	most probable value for the dependent variable at time period t_i, or temperature at time period t_i
$\Re$	the set of real numbers

$r_i,\dots,z_i$	recorded value of the dependent variables, at time period t_i
r_{mean}	mean value of variable **r**
S	sum of the squared residuals
T	Period of an oscillation
t_{ij}	time period of order i in season of order j
t_{mean}	mean value of time period variable **t**
TR_i	Trend
SN_i	seasonal component
CL_i	cyclic component
IR_i	irregular component
ω	natural circular frequency of harmonic oscillations
Φ	Pipe diameter

WATER SUPPLY
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1. INTRODUCTION

1.1 Foreword

This Thesis was motivated by an ongoing idea regarding possible improvements in the water and energy usage in Portuguese hospitals, and was kindly encouraged and supported

i. by the two hospitals investigated, namely the Hospital de Santa Maria and the Hospital Amadora Sintra,

ii. by EPAL, Empresa Portuguesa das Águas Livres SA, the Portuguese Water Authority for the Greater Lisbon Region and

iii. by my School, the Instituto Superior de Engenharia de Lisboa.

The work was done without interruptions but at a part time pace. In general, I had the support of all parties that I had to contact for information or for other purposes. I am truelly indebted to them all.

The overall conclusion is that poor designs are prevalent and there are at times also operational malpractices. It is the combination of these two factors that were responsible in the past for increased water and energy costs and wastage.

Several pertinent conclusions were arrived at. This Thesis includes a list of recommendations that is based on these conclusions. I hope that, in the future, they will contribute to better designs and for improved operations of hospitals in Portugal.

1.2 Global description

a) This work starts with a broad description of the main features to be addressed and the Aims and expected Contribution to Knowledge.

b) Follow the literature reviews

   i. of the environmental concerns related to the Resource Water, and

   ii. of the water sustainability concepts applicable to domestic water usages (because water usages in hospitals are basically of a domestic nature).

c) The various surveys made for this Thesis are then presented.

   i. The first was a general survey of the Hospital Amadora Sintra, a regional hospital in the North-Western suburbs of Lisbon.

      A physical description of this hospital was done in terms of its localization, accesses, buildings and landscaped areas, services rendered to the community, and internal and external water supply systems.

      It must be referred that a previous survey was also done. It was the survey of the of the water supply system to Hospital de Santa Maria, a regional hospital with 1100 beds in the heart of Lisbon, inaugurated in 1953. However, it had to be abandoned because of the lack of available records, which were not sufficient for reliable analyses. Nevertheless, some of the conclusions of this initial work are very valid and are consequently incorporated in this Thesis.

   ii. The second survey was of the existing internal hot and cold conduits and fittings of the Hospital Amadora Sintra, to allow for the "isolation" of each of its internal sections.

      It was then possible to plan the exact position of the temporary cold and hot water meters and valves required for the simultaneous records of their individual water consumptions. This, in turn, allowed for the evaluation of their unit water consumptions.

The connecting fittings and the "temporary" isolating valves will be left permanently installed, as they will be instrumental not only for the temporary installation and the subsequent removal of the meters required for the purposes of this Thesis, but also for future random checks to detect abnormal water consumptions.

In this respect, and already at this early stage, it is convenient to clarify the credibility of the extension of the conclusions of this Thesis to other hospitals with different physical characteristics, be they already in service or still to be constructed.

The question may seem pertinent, because this work is not based on data from several hospitals. In fact, it is based mainly on the information gathered from the Hospital Amadora Sintra in terms of installations, services rendered, sources of water, water consumption routines and global volumes of water consumed.

However, the undisputable conclusion is that guidelines derived from the operation of a single hospital may be judiciously applicable to other hospitals.

In fact, it is evident that the total volume of water consumed in a hospital is directly dependent on the number of beds installed therein, on its characteristics and on the extension of the involving landscaped areas, but the individual unit water consumptions of the various internal sections should, in essence, be similar (i.e., the consumption of water in a haemodialysis process should be very much the same in all hospitals, as should be the use of water per exam of the electronic microscope, or the unit consumption of water per kilogram of washed hospital linen).

Therefore, some of the conclusions of this Thesis can be generalised to other similar hospitals, notwithstanding the fact that only the Hospital Amadora Sintra was used as supplier of numeric data for the analyses of the internal unit water consumptions in hospitals.

Thus, some of the conclusions arrived at in paragraph 4 below are in effect valid only for Hospital Amadora Sintra. However, others can equally be applicable to other Portuguese regional hospitals, as the case is, for example, of the peak factors and the philosophy behind the abstraction of water from different sources.

iii. The third survey was of the global volumes of water consumed by the Hospital Amadora Sintra from its two sources of water, namely the Municipal Water Supply System and a borehole sunk in the hospital's premises.

These records range from January, 2004 to April, 2008 but, are, unfortunately, intermittent and at times show unrealistic values.

iv. The forth survey was of the smoothing methodologies available to improve the existing time series of water consumption data into series of working data, required for all the mathematical analyses to be done for the definition of the global water consumption patterns at the Hospital Amadora Sintra.

These smoothing techniques will also be used to process the data recorded for the unit water consumptions of the individual internal sections (to be done subsequently, as a continuation of this Thesis).

v. Finally, the last survey done was of the analyses and modelling methodologies to process water consumption data.

d) The following chapter deals with the actual case study, namely

i. the processing of the recorded data into working data,

ii. the analyses of that working data, the resulting models and outputs, and the conclusions of those outputs,

iii. the factual conclusions, and

v. based on the above, the recommendations emanating from this Thesis.

1.3 Aims

The aims of this Thesis are

a) to identify and critically evaluate existing global water supply trends at the Hospital Amadora Sintra, namely in terms of the total volumes of water required and their periodic fluctuations over the days of the week and the weeks and the months of the year,

b) to analyse the effectiveness of the strategies adopted by that hospital to address environmental concerns and the financial issues related to their water usage, and

c) to perform the detailed planning for the measurement of the individual unit water consumption requirements of each one of the forty internal sections of the Hospital Amadora Sintra, expected to be implemented as a continuation of this Thesis.

As no recent comprehensive research is known in this area and there is ample evidence that the hospital design procedures used in the past in Portugal have produced poor and expensive water supply systems, it is expected that, when concluded, both the analyses of the global volumes of water consumed at the Hospital Amadora Sintra (to be done in this Thesis), and the quantification of the internal unit water consumptions (to be done subsequently), will allow for improved designs of hospitals in terms of their pipe diameters, and heating and pumping systems.

Savings may then be achieved in their installation, maintenance and operation costs.

1.4 Contribution to knowledge

This Thesis will propose mathematical models for the global water usage at the Hospital Amadora Sintra, as well as universal conclusions applicable to the design, construction and operation of other similar hospitals, existing or to be constructed in the future.

It is expected that these general recommendations will contribute to better hospitals, by improving indoor and outdoor water supply systems, reducing both construction and operation costs, and requiring less water and energy to operate.

2. LITERATURE REVIEWS

2.1 Environment Concerns and the Water Resource

2.1.1 Introduction

This chapter introduces the concept of "Sustainability, or "Sustainable Development" as the basis for the wellbeing and progress of the present and future generations, and refers briefly the difficulties of its implementation into the exploitation of the natural resources.

"Sustainable Construction" is then mentioned, due to the huge amounts of resources and energy consumed by this sector.

Regarding the water resource, a general description is made of its characteristics and availability. The special care required for the evaluation of water projects for developing regions is also mentioned, as well as the need to evaluate and compare these projects at a global level, having in consideration the different regional water practices and water requirements.

The dramatic social and environmental consequences of water scarcity are then described, followed by an overall introduction to the main domestic water usages in Portugal as, at least partially, they influence the water usages in Portuguese hospitals.

2.1.2 Sustainability

2.1.2.1 The Bruntland Report

The over-usage of natural resources was detected and preliminary advised in 1972 and was formally denounced in 1987, when the Bruntland Report "Our Common Future" [1] introduced the new concept of "Sustainability", or "Sustainable Development".

In general, Sustainable Development (translated to several other Languages as "Durable Development"), is nothing other than a controlled form of development, trying to fully satisfy all present day needs without compromising the right of future generations to fully satisfy theirs. Therefore, Sustainability is the basis for Humans' wellbeing and prosperity, for both the present and future generations.

Sustainable Construction is a paramount component of Sustainable Development, because of the huge amounts of energy and materials consumed with the construction and with the operation of all types of buildings and other structures.

In fact, and as indicated in "Agenda 21 on Sustainable Development" [2], buildings alone were responsible in the EU for:

a) the consumption of approximately 40% of the total energy consumed,

b) approximately 30% of all CO_2 emissions, and

c) the production of some 40% of all kinds of man-made waste.

Notwithstanding these undeniable figures, it must also be noted that the construction industry was by then the largest industrial sector in the EU, employing some 25 Million people and being responsible for about 11% of its Gross National Product (GNP). That means that the implementation of Sustainability at large, although fundamental for Man, requires a rather delicate and progressive process of implementation.

This Thesis deals with sustainability in water usages within regional Portuguese hospitals.

2.1.2.2 <u>Difficulties in the implementation of Sustainability</u>

The implementation of Sustainability is often difficult, notwithstanding the acceptance at large of its need and worthiness.

Regarding the private sector, "Agenda 21 on Sustainable Development" [2] refers that, comprehensively at first, developers and investors often consider it a burden, because of the extra costs and work involved. Moreover, even the populations show a generalized lack of interest in Sustainability, mainly when it forces them to dig deeper into their pockets.

As indicated in "Foreign Direct Investment and Development - The New Policy Agenda for Developing Countries" [35], and confirmed entirely by the candidate's professional experience in Africa, the same tends to occur in Developing Countries, namely in smaller municipalities and even in some Public Departments of Developed Countries with limited budgets, whose investment programs are also affected by the extra work and costs involved with the implementation of Sustainability.

These extra costs result mainly from

a) at times, the need to use more expensive materials and construction processes, to meet Sustainability requirements in new buildings,

b) the added costs frequently involved with the operation of sustainable buildings, and

c) the much higher costs involved with selective de-construction and the transport for recycling of the materials thus recovered.

In general, it can be said that most of the natural resources have been incorrectly processed and over exploited over the years, and that this malpractice is already jeopardising the quality of life in many instances.
It can also be said that Sustainability is fundamental for Man and for the Earth but, at least for the private sector, the costs involved often meet with the resistance of some of its agents, including the populations ("Agenda 21 on Sustainable Development" [2]).
Accordingly, only the promulgation of adequate legislation and the implementation of environmental education can put an end to this situation.
All the basic sustainable philosophical concepts are vital for the reasoning and definition of the correct behaviour of Man with respect to the natural resources. However, in practical terms it has to be admitted that only a few of the technologies at Man's disposition contribute decisively, even if indirectly, for the good implementation of sound sustainable practices.
"Global Warming" is an important threat to climate change, which accounts for approximately 20% of the increase in global water scarcity, as indicated in "World Water Assessment Program, Water for People, Water for Life" [37]).

The major impact that the Global Warming has on water usage, is also a threat to the implementation of water sustainability.

Although all anticipated Global Warming harmful impacts are subjective and nothing other than predictions, it cannot be ignored that those predictions coincide in the forecast of harmful effects to the hydrological cycle and to the future of the dichotomy water supply and water demand.

2.1.3 The Water Resource

2.1.3.1 Characteristics and influences

Water is vital for the basic development of life, and is directly or indirectly involved in all kinds of human activities and requirements, from the very basic needs to the development of the most sophisticated forms of technology and well-being.

In fact, water is used for human consumption and sanitation, for the production of food and energy, for the transport of goods and people, for sports and recreation, etc.

It is also the most common and widely distributed resource for Man on Earth.

Although outside the scope of this work, it has to be emphasised that the importance of water for life is not only derived from its abundance and distribution. In fact, some of its particular physical properties further enhance the importance of water for mankind and for life.

For example, with the exception of ammonia, water is the substance with the highest specific heat and with the highest heat of fusion of all known substances.

It also has the highest heat of vaporisation.

It is for these reasons that, for example, air temperatures rise in rainy periods, and masses of water in contact with land have a "buffer" effect on their air temperatures, causing milder variations of temperature (both daily and annually) than those registered in regions of the interior.

By way of example, reference is made to a megalomaniac project contemplated in the former Soviet Union (Alexander Soljenitzin was involved as an engineer) to try to improve the extreme continental weather conditions of parts of Siberia, by constructing a network of man made lakes and canals in those regions.

It is for the same basic reasons that ocean currents have a direct incidence on the prevailing temperatures along their coastal regions.

2.1.3.2 Global availability of water

As indicated in "Agenda 21 on Sustainable Development" [2], it is estimated that the total volume of water on Earth is 1,400 x 10^6 km^3 (or 1,400 x 10^{15} m^3, or 1,400 Pm^3).

However, "Construção Sustentável e Inovação Tecnológica" [7] indicates that the major part is the salt water of the oceans (96.5% of the total existing water, or 1,351 Pm^3).
A further 0.97% of that total (or 13.6 Pm^3) is brackish water, and only the remaining 2.53% (or 35.4 Pm^3) is the freshwater of glaciers, lakes, rivers and aquifers.
Some 68.7% (or 24.3 Pm^3) of the total volume of freshwater is permanently frozen and retained as such in glaciers. A further 31.01% (or 11.0 Pm^3) is in aquifers that are inaccessible with the existing technology. Only the remaining 0.29% of fresh water (or approximately 0.10 Pm^3, or 10^5 km^3, or 10^{14} m^3) is, in practical terms, the overall volume of freshwater available to Man. Furthermore, this fresh water is, in general, scarcely distributed and may even be of difficult access.
The oceans are wide, unevenly distributed, and constitute an immense reserve of water and other vital resources. They are of extreme importance for Man (notwithstanding the fact that most of Man's direct water needs are for freshwater).
As indicated in "Trabalhos Fluviais e Marítimos" [36], the abovementioned 1,351 Pm^3 of salt water occupy some 70% of the Northern and 90% of the Southern Hemispheres.
It is therefore fair to say that the oceans are accessible in many instances.
Hence, the candidate believes that it can be expected that the development of new, non nuclear technologies, will allow for the desalination of salt water at affordable prices. This is a much needed development for some Countries and Regions, as it will significantly improve the sanitation and the quality of life of desert and semi-desert populations located close to the sea, as well as their capacity of food production.
The candidate was professionally involved in one of such instances, in a project financed by the European Bank for Cooperation and Development for the recovery of several infrastructures in a formerly secret nuclear armament production settlement of 140,000 people in the desert area of Aktau, in Kazakhstan, former Soviet Union. There the water supply was entirely dependant on the desalination of water from the Caspian Sea, by reverse osmosis and using nuclear energy.
Although not involving desalination of sea water, the candidate can also refer another of this type of projects in which he was professionally involved. It was the Great Man Made River, in Libya, and involved the abstraction of

underground water from depths in excess of 2000 m, using the petrol produced by that Country.

Furthermore, it should be emphasised that the total volume of 0.10 Pm^3 of freshwater available to Man is renewable and remains constant throughout the whole global hydrological cycle. However, this does not always apply to short to medium term periods of time, when the availability of fresh water depends on seasonal and multi-annual cycles. It is for these reasons that droughts and floods occur at times, bringing much human privation and suffering.

To conclude, it must also be noted that Nature's limited capacity to recover the water quality from the ever increasing levels of degradation imposed on it by Man, may also be attenuated with the development of new technologies.

This enhances the importance of water research, further to the constant implementation of good and sustainable water usage practices.

2.1.3.3 Global water sustainability

Water is a scarce resource. As such, it has to be wisely used, all forms of avoidable deterioration and waste must be prevented, and unavoidable degradations of its quality must always receive adequate treatment before being returned to Nature.

In real terms, however, the situation is somewhat different. If and when available, water has often been (and still is!) used and degraded at alarming levels and in all sectors.

To counteract this situation, Sustainability must be addressed systematically along all the stages of the contact between Man and Water. This is without doubt a *sine qua non* condition to guarantee that the generations to come will continue to benefit, as we do today, from the Water Resource.

In addition, and as indicated in "Water - A Key to Sustainable Development" [3], all strategies on water Sustainability should be based on

a) the fact that water is a key to Human development, and even more to sustainable development,

b) the right of all human beings to have access to water,

c) the fact that the provision of water is a key to poverty reduction,

d) the fact that water should be allocated in equitable and sustainable processes, first to basic human needs, second for the functioning of ecosystems and, only after that, to economic activities (including some of the food productions),

e) the fact that pollution prevention should be prioritised, because it is normally more cost effective than the restoration of polluted waters,

f) the technologies available for the reduction of water consumption (including the re-use of water) without lowering neither the pre-existing levels of hygiene and comfort of the populations served, nor the profitability of the services and industries supplied, and also

g) the technologies available for the improvement of the quality of effluents of all types.

Therefore, the implementation of the concept of Water Sustainability is of paramount importance, to counteract the already generalized alarming levels of water wastage and water degradation.

2.1.3.4 Social effects of water scarcity

A special reference has to be made to this major predicament, because water scarcity is the cause of much human suffering in many Developing Countries and Regions.

Often, water shortages are caused, or at least worsened, by common water malpractices such as inefficient water usage, uncontrolled or excessive pollution, overexploitation of aquifers, excessive leakage, etc.

As indicated in "Integrated Urban Resources Management Strategy - Water" [6], the result is that, in extreme situations,

a) child deaths can happen in those Countries and Regions at the rate of one every 8 seconds,

b) up to 50% of the populations suffer from one or more water-related diseases,

c) 80% of all diseases are caused by contaminated water, and

d) 50% of people on earth lack adequate sanitation, and

e) even 20% of the fresh water fish species have been pushed to the edge of extinction from contaminated water.

2.1.3.5 Economic evaluation of water supply projects for Developing Countries and Regions

In view of the unacceptable situations of human suffering and social degradation referred to above, it should be statutorily accepted that the economic evaluation of basic water supply projects for developing regions (IRR, for example) should consider with equal importance:

a) the direct social and economic benefits of the capital investment, and also

b) the indirect economic gains fostered by the project, such as healthier human conditions, less absenteeism at work and at schools, improved productivity from individuals, improved school results, etc.

2.1.3.6 "Performance Indicators"

Performance Indicators (PI) are a powerful tool for the evaluation of the efficiency of all water services, and for the establishment of global comparisons among them, as indicated in "Performance Indicators for Water Supply Services" [4]).

PI's pretend to be a universal approach to those evaluations, and are proposed for practically all stages of the various water services.

By this, it is meant that, from the abstraction of raw water until the tap of the end user, or from the discharge of a toilet to the return of the effluent to Nature, the monitoring and the evaluation of all steps of any water process can, and must be made in a unique way, using the same definitions, the same parameters and the same technologies as everybody else. Only in this manner, it is possible to establish direct comparisons between different systems, in different Countries and in different Regions.

PI's quantify the efficiency of the various stages of water systems, establishing unequivocal numeric relations between two or more characteristics and data values recorded in the processes. This is indicated in “Performance Indicators for Water Supply Services” [4]), a comprehensive International Water Association (IWA) publication on PI's for water supply services, which will not be referred to again in this report because it is outside of the scope of this Thesis.

Nevertheless, the concept of PI's for overall efficiencies of water supply systems is introduced here, as ratios between “useful” and “gross” volumes of water demanded by the system:

$$\textbf{PI for water usage efficiency} = \frac{\textbf{Useful volume}}{\textbf{Gross volume}} \times \textbf{100\%} \qquad (2.1)$$

2.1.4 Global Water demand and costs in Portugal

2.1.4.1 Water demand and costs in the year 2000

According to the “Programa Nacional para o Uso Eficiente da Água” [8], the official figures for the total water demand in Portugal in the year 2000 amounted to 7,505 x 10^6 m^3, and the total overall cost of that water was €1,883 Million.

In the same year, and still in accordance with “Programa Nacional para o Uso Eficiente da Água” [8], the Portuguese GNP amounted to €114,000 Million.

Therefore, in that year, the Portuguese paid 1.65% of their GNP for their water.

The volumes of water used in that year in the sectors of agriculture, domestic supply and industry, and their total and unit costs, are indicated in Table 2.1.

TABLE 2.1

Water demand and costs in Portugal in 2000,
as per “Programa Nacional para o Uso Eficiente da Água” [8]

Types of usage	Volumes (x 10^6 m^3)	Volumes (% of total)	Total Costs (€x 10^6)	Unit Costs (€/m^3)
Agriculture	6,550	87.3	524	0.080
Domestic	570	7.6	875	1.535
Industry	385	5.1	484	1.257
Total	7,505	100.0	1,883	0.251

It is therefore concluded that in the year 2000, in Portugal, the domestic sector supported the heaviest burden of the cost of water, having paid over 6 times the overall average unit cost. Industry paid some 5 times that value and, at the other extreme, agricultural sector paid less than 32% of the same average unit cost!

It is estimated that those figures remained largely unchanged to the present day, meaning that in Portugal there is still a serious discrepancy in water costs.

However, it must also be noted that water for agriculture is raw water, not requiring the sophisticated physical and chemical purification processes to attain the standards for human consumption, nor the intricate distribution networks and services to distribute water for domestic and industrial purposes.

2.1.4.2 Water losses and possible improvements

Not all the water actually supplied is effectively used.

In fact, the abovementioned volumes include significant losses, resulting not only from straight water losses in the supply system, but also from inefficiencies and malpractices in water usage.

In-depth investigations made by "Instituto da Água" in "Programa Nacional para o Uso Eficiente da Água" [8] suggest that at present it is possible to save in Portugal in excess of 40% of the present total annual water consumption of 7,505 x 10^6 m^3. More specifically, it is considered possible to save a total of up to 3,100 x 10^6 m^3 of water per annum, being about 2,750 x 10^6 m^3 in agriculture (corresponding to €220 million, or 0.19% of the GNP), 240 x 10^6 m^3 in the domestic sector (corresponding to €368.4 million, or 0.32% of the GNP), and 110 x 10^6 m^3 in industry (corresponding to €138.3 million, or 0.12% of the GNP).

Once again, it becomes clear that it is in the agricultural sector that most of the water savings can and should be investigated and implemented. In fact, agriculture is responsible for 89% of the total possible water savings, as opposed to just 8% in the domestic sector and only 4% in the industry.

According to the values indicated above for the present overall water demand and for the estimated overall losses, the PI for global water efficiency is (equation 2.1)

$$PI_{overall\ water\ usage} = \frac{7505 - 3100}{7505} = 58.7\%$$

For the case of the domestic water usage, the present value for the PI is 58%, and "Programa Nacional para o Uso Eficiente da Água" [8] anticipates that it can easily rise to 80% in the next 10 years. That means additional savings of about 126 x 10^6 m^3 of water per year, or about €193 million per annum, assuming that both the population and the *per capita* consumption will remain unchanged.

Following the same reasoning, the present PI for industrial usage is 71% and "Programa Nacional para o Uso Eficiente da Água" [8] anticipates that it can rise to 84% in the same horizon of 10 years. This would mean additional savings of about 48 x 10^6 m^3 of water per year, or about €60 million per annum. However, it does not seem to be really a very accurate prediction, because technological developments will certainly improve the terms of reference.

Still following the same reasoning, the present PI for the agricultural sector is 58 % and "Programa Nacional para o Uso Eficiente da Água" [8] anticipates that it can rise to 66% in the same horizon of 10 years. That would mean additional savings of about 523 x 10^6 m^3 of water per year, or about €42 million per annum. Again, it does not seem to be a very accurate projection, because the technological developments will certainly also improve the terms of reference.

In the cases of the domestic and the industrial sectors, it even seems that the envisaged aims (of, respectively, 80% and 84%) are conservative and easy to reach, because the losses in the underground pipe network have repeatedly been found to be in the region of 40% of the total volume of water fed into these same networks.

2.2 Domestic water sustainability in hospitals and other buildings

2.2.1 Domestic water sustainability

An analysis and description of the various types of domestic water usages in hospitals and other buildings is presented forthwith, as well as a description of good practices to improve the sustainability of those usages in terms of

a) the education of the water users,

b) the installation of correct water supply conduits, devices and fittings,

c) the eventual installation of improved internal and/or external domestic drainage systems,

d) the eventual retention and storage of rain waters for later use, and

e) the administrative and other technical and operational measures to improve internal and external water saving measures.

2.2.2 Water sustainability in hospitals

Hospitals are not exceptions to the general panorama of water wastage and misuse.

Therefore, rational alterations should, in general, be implemented.

However, it must be emphasized that these alterations have to be achieved without jeopardising the levels of hygiene and comfort of the populations served, the levels of water supply and water quality required by the actual medical services, and the levels of comfort of patients and hospital staff.

As indicated in "Water Use Case Study: Norwood Hospital" [5], regional hospitals in USA are normally within the top 10 water users in any water supply service, they have six main areas of water consumption, and water savings and improvements in the quality of the effluents are possible to attain in practically all of them.

Those six areas are

a) sanitary processes, responsible for approximately 40% to 45% of the hospital's total consumption,

b) Heating, ventilation and air conditioning, with approximately 20% to 25% of the hospital's total consumption,

c) medical processes, with approximately 15% of the hospital's total consumption,

d) kitchen and cafeteria services, with approximately 10% of the hospital's total consumption,

e) laundry services, with approximately 5% of the hospital's total consumption (if made at the hospital), and

f) other unaccounted services, with up to 10% of the hospital's total water consumption

Hospital Amadora Sintra is also within the ten major consumers of "Serviços Municipais de Água e Saneamento de Oeiras e Amadora", the local water authority, and shows also many cases where water savings are possible to achieve.

However, it seems that the relative percentages of consumption in the different services are not similar to those indicated in "Water Use Case Study: Norwood Hospital" [5]. In fact, and although still unknown the exact internal water consumptions at Hospital Amadora Sintra (or at any other Portuguese Regional Hospital!), it can at least be already said that the laundry at Amadora Sintra consumes some 25% of the total water consumption in the hospital.

Based on the detailed surveys done to the internal water supply systems of Hospital de Santa Maria and Hospital Amadora Sintra, it can also be said that significant reductions in the quantities of water consumed in hospitals can be achieved simply by the correct design and installation of all internal water supply pipes, plumbing fixtures and appliances, with their regular maintenance and, whenever possible, with the installation of special devices for increased efficiency.

It must also be said that considerable water savings can be achieved simply by the education of the water users.

This matter will be further discussed in the next paragraphs.

2.2.3 Metering, non-metering and sub-metering

Despite the existent general awareness of the need to save water, it is still very common to find that only one single water meter serves the whole of a hospital, or an office block, or a multifamily residential building or condominium, or even a shopping mall.

This practice of installing one single meter for those buildings tends to make the actual water users unaware of the amount of water they actually use professionally, for living, etc. This is so because, at the end of the month, they neither have to pay a water bill out of their pockets, nor are they even informed about the water costs involved with their jobs, or in the normal running of their lives.

Thus, single metering or non-metering tends to make water users unaware of the consequences that their water habits have on other fellow citizens, on the environment, and even on themselves. Water wastage is then indirectly facilitated, and that only because of the users' lack of awareness.

On the other hand, sub-metering consists of the separate metering of sections or parts of a whole building, be it residential, hospitalar, commercial, etc. Separated metering is then done in all individual wards and sections of a hospital, in all residential units of a multifamily residential complex, in all shops within a shopping mall, etc., and further meters are installed for the common water uses (be them internal or external).

In this way, all water users become more directly involved with the water management process and with the associated costs. They start feeling that they can have some control on the situation, and that they can even benefit from it. That, in turn, leads people to realise that their water habits have a direct impact on society, on themselves and, possibly, on their pockets.

The American Water Works Association Research Foundation (AWWARF) indicates in this respect that metering improves the awareness of water users about the efficiency of plumbing fixtures and water appliances, and that in the USA, the result of these combined actions can produce domestic water savings of some 10%.

Accordingly, water users' awareness of good water practices is an easy and efficient way to reduce water consumption within buildings.

Metering is therefore fundamental. Universal sub-metering enhances the advantages of metering, and the more intense is the sub-metering, the better are the expected results.

2.2.4 Metering in hospitals

As indicated above, hospitals are no exception to the situation described above. Accordingly, when individual metering is viable, it is a good practice to meter separately and control the consumptions of their heaviest internal water users. As briefly referred to in paragraph 2.2.2 above, they are

a) the HVAC and the laundry in the sector of the technical services,

b) the sanitary processes, the kitchen, cafeterias and change rooms for staff in the sector of the supporting services, and

c) some of the medical processes, such as the haemodialysis, the pathological services (mainly the electronic microscope, if the internal cooling system becomes out of order and the cooling has to be done by running water form the supply system), the magnetic resonance at the imagiology department, the physical medicine and rehabilitation installations, etc.

2.2.5 Metering in other buildings and situations

The best and most common practice, already implemented in many European Countries, is to sub-meter each individual dwelling (single and multifamily alike), as well as all independent units in buildings, be they shops, offices, etc.

In residential and office buildings, some water authorities are now starting to implement the mandatory installation of all the individual water meters in dedicated rooms at the main entrance of the buildings. This controversial decision facilitates the remote reading of meters and reduces the time required to meter visually the whole building, but increases significantly the installation costs and reduces the sustainability of the internal pipe networks.

Shopping malls are normally metered by a single water meter, installed at the main entrance of the building, and it is left to the building managers to install meters at each individual tenant, and include the cost of their water in their monthly statements of costs and rates.

Although outside the scope of this paragraph (water supply to buildings), it must be mentioned that in some rural water supply systems in Developing Countries, water is supplied and metered by the water authority and paid by the respective Tribes. The system consists of self-closing communal taps distant not more than 500 m from any hut, and the whole system is working well for years, without any vandalisms or malpractices.

It can be forthwith concluded that the awareness of developing populations for the advantage of having good water, combined with the water cost that they indirectly have to pay to the Tribe, contribute decisively for the generally good results of those projects.

2.2.6 Educational water saving awareness programs

2.2.6.1 Education of the populations at large

The excellent results obtained so far in domestic water savings simply by educating the population at large, lead to the present day belief that education alone can promote huge savings in all kinds of water usages, and amongst all kinds of users.

As verbally informed by Mr. Carlos Manuel Martins, President of "Associação Portuguesa de Distribuição e Drenagem de Águas" (a Portuguese association of water supply and water drainage authorities) and Vice President of "EUREAU - Federation of National Associations of Water and Waste Water Services", a clear example of the above is the present situation in Denmark where, due to education alone, since 1988 there has been a significant drop in water consumption, in all categories of consumers. This reduction is so important that their national standard design regulations are under review at present, in order to avoid long periods of water retention inside the distribution networks.

2.2.6.2 Education of water users in residential and other buildings

The control and the reduction of water consumption through public education in residential buildings, in hospitals and in all other types of buildings, can and must be permanently implemented at all possible levels.

However, these educational campaigns can only result in lasting water savings practices, if the quality of life of the end users is not jeopardised in any manner, specifically in terms of the quality of their services, health, hygiene, comfort, and economy.

These practices have to be understood and accepted by the users at large. This, in turn, implies that each individual consumer has to be made well aware of the direct influence that his water habits have on the environment, on his wellbeing and on that of his family.

Many citizens have no idea about efficient ways to use water, both at home and in the surrounding landscaped areas. It is very common to discover that indoor and outdoor water usage practices are dictated solely by commercial interests.

However, successful experiences are showing that, after being made aware and involved in global water savings programs, the willingness of individuals to voluntarily comply with water conservation measures can have a significant reduction on the total water usage. So much so, that savings of some 2% to 5% of the total domestic water consumption can be achieved in multifamily residential buildings.

One of the most successful and cheapest public water awareness programs consists of the mailing of newsletters with the water bills. Such letters, in easy everyday language, must contain information concerning water conservation measures, other practical recommendations for the wise use of water, details of the water used in the individual dwellings and in the whole residential building, and notices of the purchasing of any communal equipment able to reduce their water and sewer bills.

In the USA, other important measures to promote the wise use of water are educational meetings about the best domestic water practices, in neighbourhood clubhouses, parish centres, etc. Such education of water users can and should be implemented in other fronts. For example, posters in the main circulation corridors of residential and working buildings (including hospitals), are good reminders of the need to save water.

In short, the successful implementation of any public water awareness program has to

a) Focus on the systematic education of all water users, including senior citizens and children,

b) Show how sustainable water practices can be permanently implemented,

c) Show how these practices can be beneficial for the individual and for the society at large, and

d) Involve as many citizens as possible in the whole process.

2.2.7 Administrative water saving measures

2.2.7.1 Sub-metering

The implementation of sub-metering programs, i.e., the installation and monitoring of water meters of an adequate calibre at each dwelling and other water users (shops, professional practices, etc.), is an important measure to save domestic water.

In this way, it is possible to know the exact quantity of water consumed by each user, which in turn makes it possible to inform residents of their individual water consumption and invoice them for the exact amounts of water consumed.

It goes without saying, that in those cases where hot water is generated centrally, the sub-metering process should cover both the cold and hot water supply lines.

2.2.7.2 Progressive rates

The use of progressive water rates is commonly practiced by the 301 Portuguese water authorities, as indicated in "Abastecimento de Água em Portugal – O Mercado e os Preços" [38], published in 2004 by the "Associação Portuguesa de Distribuição e Drenagem de Águas".

In line with "Directiva-Quadro da Água", the lowest water rates in Portugal must include all the actual costs involved with the supply of that same water, namely amortizations, operation, maintenance, administrative and modernization costs.

This directive is responsible for huge differences in the prices of water, of differences of 1 to 75, as concluded from the tables contained in "Abastecimento de Água em Portugal – O Mercado e os Preços" [38], where are indicated rates varying from €0,06/m^3 of water for the first echelon in some municipalities, to €4,49/m^3 for the last echelon in other municipalities.

To these unit prices, the drainage surcharge, which is nothing other but an additional cost of the water consumed, still has to be added.

The idea subjacent to the enforcement of progressive rates is to encourage conservation by charging higher rates for the volumes of water consumed in excess of reasonable quantities.

Progressive rates are easy to implement and may be socially correct at times, but they must be implemented with caution, to avoid forcing the users to reduce their normal living conditions because of the higher cost of the water.

Still in this regard, and based on his professional experience and available technology, the candidate believes that progressive rates should not be implemented without a previous detailed evaluation of the number and nature of the water users in each dwelling and/or in special building, so as to avoid unfair strains on large families, hospitals, old age homes, small residential *condominia*, etc., where no sub-metering is practiced.

2.2.7.3 Standard regulations

Standard Regulations for the design and construction of wet services (indoor and outdoor) of all types of buildings should be promulgated at national level. They should be comprehensive, and strictly implemented and supervised in all phases of the construction and operation of any building.

Town Councils should approve local regulations to complement and clarify the application of the national standard regulations to their particular local requirements and characteristics (for example, to exclude the need of storm water drainage systems in deserted areas, where the average annual precipitation is zero or near zero). Further reference to this matter will be done when dealing with indoor and outdoor water savings (respectively, paragraphs 2.2.8 and 2.2.9).

2.2.7.4 Abatement of water consumption peaks

Water consumption peaks can be reduced by enlarging their duration.

This can be done by distributing typical urban activities (office, school and business starting and closing times, for example) in up to 4 groups spaced in intervals of 10 to 15 minutes. The overall peaks of some common water consumption activities (mainly showers and baths) are therefore spread over an increased period, and reduced in their intensity.

As a matter of fact, this is already a usual measure in very high rise office buildings (for example, as the World Towers were), where the limited space to install lifts, forced different offices to have their starting and closing hours at slightly different times of the day.

2.2.7.5 Research of water consumption patterns in special buildings

Research should be promoted on the specific nature of water consumption of special buildings, in order to try to find means of improving their use of water. This is the case of shopping malls, hospitals, residential and mixed buildings, industries, etc.

2.2.7.6 Water audits

Water audits should be performed on a periodic basis.

These should be done under clear and well defined guidelines, and each report should be compared with the previous one and sent to all water users.

2.2.7.7 Remote meter reading

Remote readings of the main pipe network meters should be implemented, so as to allow for the real time detection of accidental pipe bursts.

2.2.7.8 Maintenance, retrofits and new construction contracts

All maintenance, retrofit and new construction contracts should be negotiated under the philosophy of sustainable practices in terms of all maintenance, deconstruction, transport of rubble for recycling, construction, supply of equipments and installation procedures.

2.2.8 Indoor water saving measures and appliances

2.2.8.1 Toilets

Toilets are normally one of the biggest components of the total water usage, both in hospitals and in normal households.

In Portugal ("Programa Nacional para o Uso Eficiente da Água" [8]), toilet discharges are considered to be responsible for 11% of the total domestic water consumption. Together with baths and showers, toilets are responsible for as much as 42% of the total consumption in hospitals, as indicated in "Water Use Case Study: Norwood Hospital" [5]. However, as indicated in "Construção Sustentável e Inovação Tecnológica" [7], water consumption in toilet discharges has experienced a continuous improvement over the years.

Similarly, "Opportunities for Local Governments and water Providers in New Mexico to adopt Ordinances and Regulations to Conserve Water" [9] indicates that the evolution of toilet discharges improved from as much as 20 ℓ before 1982, to around 12 ℓ between 1982 and 1994, and now as little as 6 ℓ after that year. Today, there are vacuum toilets that use as little as 1 ℓ of water per flush.

Toilets are also one of the most common water appliances in the EU. In the case of Portugal, as indicated in "Programa Nacional para o Uso Eficiente da Água" [8], 96% of its 5 million households have at least one toilet installed.

Additionally, the following information also applies

a) the average occupancy per dwelling in Portugal is 3.1 persons,

b) the average of each toilet discharge is conservatively estimated at 10 ℓ, and

c) each person flushes the toilet an average of 4 times per day.

With this information, it is estimated that in Portugal, toilets alone are responsible for the consumption of about 217 x 10^6 m^3 of water per year, or 38 % of the total domestic water consumption of 570 x 10^6 m^3 per year.
No reliable information is available regarding the number of households with two and more toilets.
However, it should be noted that the number of toilets in a household does not increase or decrease the number of flushes for that particular household.
Nevertheless, and still according to the "Programa Nacional para o Uso Eficiente da Água" [8], in Portugal, 62% of the households have 4 or more rooms and, since 1951, it has become mandatory to install at least 2 toilets in every household with 3 or more bedrooms.
Regarding toilet types and models, flush toilets have traditionally been considered the top of the range for hygienic reasons and because of their high flushing capacities.
These toilets have no cistern. The water is flushed directly from the supply pipes by the push of a button. The flush is interrupted as soon as the operator lifts his or her finger, by the action of an internal spring.
The main disadvantages of flush toilets are that they are noisy, require higher pressures and lager diameters in the pipe network (although this can be controlled by the installation of less strong springs), and have much higher instant flows (between 1.0 and 1.5 ℓ/s at least). It is precisely for these reasons that they require larger pipe diameters.
A greater concern is that the closing spring has tendency to break down, resulting in uninterrupted flows which can last for days. Therefore, the overall water consumption of flush toilets tends to be excessive!
The cistern toilets normally found in Portugal have deposits with capacities varying between 7 ℓ and 15 ℓ (as much as 18 ℓ in older models). Newer models normally have the smaller capacities, to the point that the most modern toilets have today capacities of not more than 6 ℓ, and their efficiency in normal households is as good as that of the older toilets with larger cisterns.

The reduction of toilet discharges (in normal households) from the estimated average of 10ℓ to 6 ℓ per flush, imply savings of about 40%, or some 50 ℓ per day and per household. This is equivalent to some 18 m^3 per household and per year.

Dual flush toilets arrived in Portugal not long ago, but are being installed at an impressive pace. They are cistern toilets with double push-buttons, one for 3 ℓ and the other for 6 ℓ discharges, the later meant to be used only when faecal matter is present. By now they have been sufficiently tested and work well. Their overall efficiency is mainly derived from the fact that only 30% of all the toilet uses involve the flush of faecal matter, as indicated in "Programa Nacional para o Uso Eficiente da Água" [8].

Vacuum toilets may also be a proposition if adequate conditions exist, because they only use about 1 ℓ of water for each discharge. However, it must be noted that they are more expensive to install and to run than other conventional models, they are noisy, they use energy and need frequent servicing. For these reasons, in principle they only are a viable proposition for normal public toilet facilities with high rates of use. They are not recommended for hospitals, at least at the present level of their technology.

It should be mentioned that the overall water consumption in toilets is not only for the body elimination processes. It also includes the additional water consumption resulting from leaks and from the incorrect use of toilets as dustbins for all kinds of tissues, wrappers, cigarette butts, etc.

Water savings in existing toilets, can be obtained by the installation of water saving devices. These can vary from the most basic displacement volumes, "dams", etc., inside oversized cisterns of antiquated design, to the most modern devices available for such purposes (dual-flush adapters, for example)..

Water savings in new installations and in major retrofits are basically implemented through the installation of dual flush toilets.

The installation of vacuum flush toilets should also be implemented whenever justified, mainly in trains, buses, ferries and aeroplanes.

An indirect but important measure to save water is to promote and advertise the general idea that toilets are not dust bins, and that tissues, wrappers, cigarette butts, etc., should not be thrown into toilets and flushed forthwith, but rather thrown into the adequate recipients.

Regarding hospitals, reduced toilet discharges have to be seriously evaluated before being recommended and implemented, as flushes of reduced volumes of water may not be able to avoid sewer blockings resulting from the generalised (and incorrect?) use of paper towels.

Accordingly, the reduction of flush volumes in new households, in new office blocks and in major retrofits (but not in hospitals!), could be achieved by installing toilets with smaller deposits, by installing vacuum toilets or even by installing dual flush toilets. However, the financial return of such investments varies from place to place, depending on local water, material and labour costs, taxes, etc.

In the case of existing cistern toilets working satisfactorily in normal dwellings, the sinking of 1, 2 or even 3 stock bricks in the cisterns (depending on their individual volumes), is a free and efficient way to save water (but, again, not in hospitals!).

2.2.8.2 Showers and bathtubs

Showers and baths are also some of the highest water consumers in a household.

In Portugal showers are responsible for about 30% of the total domestic water demand which, added to the consumption of toilets, give a total of about 40%, as indicated by "Programa Nacional para o Uso Eficiente da Água" [8].

Most Portuguese households have at least one bathtub with one shower. Therefore, they constitute an area where significant water savings can be implemented.

Regarding water consumption characteristics, the basic differences between bathtubs and showers are that the volumes of water consumed by bathtubs are determined by the actual dimensions of the bathtub and by the number of baths taken, whilst the volumes of water consumed by showers depend on the rate of the water flow, on the duration of the shower and, like for the bathtubs, on the number of showers taken daily. Typical unit figures in Portugal for conventional bathtubs and showers are totals of between 120 and 300 ℓ of cold and hot water for baths, with an average of 180 ℓ, and between 35 and 110 ℓ of cold and hot water for showers, with an average of 60 ℓ.

Showers, rather than baths, are better hygienic propositions, and are an easy way to implement considerable water savings. Notwithstanding that, it must also be noted that at least one bathtub must always be installed in

every residential unit. This is because baths are better propositions for the elderly, mainly if dependant, and for the children of early ages.
Reference also has to be made to some variations of domestic bathtubs and shower heads recently made available, which have brought about significant increases in the consumption of water with doubtful benefits to people's wellbeing (as opposed to what the manufacturers claim). They are the individual or collective "home Jacuzzi bathtubs", and the "gang shower heads", whose installation should be limited to situations under professional surveillance, namely hospitals.
Proposals for water savings in the use of bathtubs and showers include

a) to take showers instead of baths,

b) to take short showers, with a total of not more than 5 minutes of running water,

c) to turn off the shower tap while soaping,

d) to discourage the installation of "gang" shower heads (of flows of up to 0.15 ℓ/s per head),

e) to promote the installation of low flow shower heads and, at the same time,

f) to encourage the installation of push-button showers taps, to allow for the automatic shutting off water, while soaping and/or shampooing, and

g) if a bath is the alternative, mainly for young children and the elderly, only fill the bathtub up to ¼ to ⅓ of the total height.

The use of bathtubs in specific areas of hospitals is dictated by the permanent needs of special patients, and/or by the temporary needs of other patients.
No specific policy was found regarding the number and quantity of bathtubs recommended for the various sections of hospitals. This is an area where further research is recommended.

The installation and operation of normal and other specialized bathtubs and swimming pools in Physical Medicine and Rehabilitation areas is dictated by specific medical reasons and technologies, and has to be done strictly in accordance with the respective manufacturers' directives.

In particular, special care has to be paid to the on-going introduction of fresh flows into the (otherwise) water purification closed circuits. Metering of the water abstracted by these equipments should be done systematically, in order to immediately detect and correct any excessive or reduced intake of fresh flows (meaning, respectively, water wastage or reduction on the standards of the quality required for the water to be returned to service).

2.2.8.3 Washing machines

Washing machines are considerable water users, both in the normal domestic sector and in hospitals. However, their improved technology produced significant water savings over the last few years. In fact, between 1980 and 2000, the improved technology of washing machines caused water savings of some 70%.

Their expected life span is between 8 and 16 years.

As indicated in "Opportunities for Local Governments and water Providers in New Mexico to adopt Ordinances and Regulations to Conserve Water" [9], in residential units, the quantity of water used for the washing of normal full loads (of 5 kg) of soiled cotton linen decreased from more than 150 ℓ per load with the older washing machine models (from around 1970), to about 90 ℓ per load in 1990, and to not more than 35 ℓ per load with the most recent models.

As indicated by "Programa Nacional para o Uso Eficiente da Água" [8], on average it can be said that in Portugal a washing cycle of 5kg uses some 90 ℓ of water. This is equivalent to 18 ℓ of water per kilogram of washed soiled linen.

However, this value can be further reduced, to just 7 ℓ/kg, if more recent and sophisticated machines are used.

About 80% of all the Portuguese households have at least a self heating washing machine in normal service.

The same source "Programa Nacional para o Uso Eficiente da Água" [8], also concludes that, in Portugal, washings cycles are repeated, on average, every second day. Therefore, it is concluded that washing machines are, on average, responsible for about 45 ℓ/day of the total household consumption, or 14.5 ℓ/day of the overall domestic *per capita* water consumption in Portugal. As a matter of fact, washing machines alone were responsible for the last noticeable increase in the otherwise "static" *per capita* water consumption diagram in Portugal.

From the above information, it is concluded that further significant savings are still possible in laundry washing.

Proposals recommended in "Water Conservation Manual" [10] for water savings in the use of domestic washing machines are of several natures. Regarding the actual volumes of water used per washing cycle, the recommendations are basically to wash only full loads of laundry, to operate in strict accordance with the manufacturer's instructions (namely to use only the washing cycles prescribed for the particular linen), and to use only the lowest water consumption programmes. The use of adequate detergents, and in the recommended quantities (biodegradable if possible!), is also an important water saving measure, as it avoids unnecessary rinsing.

The installation of individual in house horizontal axis "tumble action" washing machines is also recommendable, so as to take advantage of their lower water usage requirements. Finally, the installation and operation of coin operated communal washing machines, is highly recommended in multifamily housing units (instead of individual washing machines at each and every individual dwelling).

Hospital laundries are heavy duty units facing totally different challenges, both in the quality and in the quantity of the linen they have to deal with. They have variable capacities of up to 50kg (depending on the user's specific requirements), and normally require the supply of exterior hot water at the various temperatures imposed by their various washing programs. This implies not only the existence of hot water generation and supply systems (which are normal in hospitals), but also temperature sensitive and remote controlled mixing valves.

Notwithstanding that, and as indicated by "Water Use Case Study: Norwood Hospital" [5], laundries can represent as little as 5% of the total water consumption in a hospital, if only some basic water saving measures are observed.

It is estimated in "Energy Consumption in Hospitals" [15] that the overall production of soiled linen in regional hospitals is 11 pieces per bed and per day, with an average mass of 0.5 kg per piece.

Basic recommendations for water savings in hospital laundries are to wash only full loads of linen, to practice washing cycles of the same type of linen (to be able to use the best adaptable programmes), to use only the best detergents (biodegradable, if at all possible!) and at the prescribed quantities, to pass the rinsed water through reclamation systems for reuse in pre-wash rinses, and to reduce the flow for the pre-wash rinses.

Due to the specialised nature of a hospital laundry, there has recently been a trend to outsource this function, by centralising the laundry units of various hospitals in one laundry, which has the required washing capacity to serve various hospitals. The soiled linen is packed and transported in specialised trucks to the central laundry, and returned afterwards to the hospital in hermetically sealed containers. Although all trucks are fully disinfected after each trip with contaminated loads, this is a highly controversial policy because of the increased danger to the community brought about by trucks circulating on a daily basis in the public roads, with full loads of potentially high risk contaminated linens.

2.2.8.4 Dishwashing machines

Dishwashing machines experienced significant water savings over the last few years. Between 1980 and 2005, the efficiency of dishwashing machines was improved by some 5 times.

It is estimated that there are some 750,000 domestic dishwashers in service in Portugal, as indicated in "Programa Nacional para o Uso Eficiente da Água" [8].

On average, it can be said that some 22 ℓ of water are used per dishwashing cycle. In Portugal, the domestic dishwasher is operated on a full cycle, on average every second day. This means that dishwashing machines are only responsible for about 3.5 ℓ/day of the overall domestic *per capita* water consumption in Portugal.

Proposals for water savings in the use of domestic dishwashing machines are to wash only full loads, to operate in accordance with the manufacturer's instructions (namely cleaning filters and removing deposits regularly), to avoid the use of unnecessary rinsing, to use only the most adequate programmes, to use only adequate detergents (biodegradable if possible!), and to use them at the prescribed rates.

Heavy duty industrial dish washers are used in hospitals, and their individual capacities are dictated by the specific hospital's requirements.

The basic water saving measures in hospital kitchens are to do dishwashing of full loads only, to use only appropriate detergents (biodegradable, if possible!) and at the prescribed quantities, and to use foot operated taps for the rinsing of pot scrubbing sinks.

In this regard, it is interesting to mention that, as indicated by "Water Use Case Study: Norwood Hospital" [5], in the fairly small 113 beds Milton Hospital, near Boston, Massachusetts, a foot pedal installed in the kitchen for the pre-rinsing of pots, did produce annual savings in excess of 1,350 m^3 of water. In this particular case, the supply and installation cost of the foot pedal was €190.00 (at the exchange rate of 1 € = 1.25 US$) and the savings in water were €2,640.00/year. The return period of the investment was inferior to one month!

2.2.8.5 Hand washing basins, bidets and kitchen sinks

As indicated in "Programa Nacional para o Uso Eficiente da Água" [8], the water consumption of these appliances in a normal household with a minimum of 3 to 5 taps installed, depends strongly on their respective tap models and service characteristics, namely their calibre, the duration of each service, and the daily number of services.

No reliable information was found about typical use of taps in Portugal.

Nevertheless, "Programa Nacional para o Uso Eficiente da Água" [8] indicates that the domestic taps installed in Portugal for hand washing basins, bidets and kitchen sinks are the most common devices for water supply in the Country. The same reference estimates that they are responsible for up to 16% of the total indoor domestic water consumption.

There exists a wide range of models, of which reference has to be made of the taps offering the best levels of comfort, namely those supplying flows of between 2.8 to 5.7 ℓ per minute (or 0,05 to 0,10 ℓ/s) for hand washing basins and bidets, and between 7.6 to 9.0 ℓ per minute (or 0,13 to 0,15 ℓ/s) for kitchen sinks.

Other models of taps worth mentioning are those with incorporated aerators (air injectors). These also offer good levels of comfort for hand washing basins and for bidets, with debit flows of just 3.4 ℓ per minute (or 0,06 ℓ/s).

"Programa Nacional para o Uso Eficiente da Água" [8], lists the following general proposals for water savings in the use of taps

a) to close properly all taps after each use,

b) to close the tap while brushing the teeth,

c) to cock the hand washing basin or the sink and fill it to an appropriate level (instead of doing it under free running taps) to rinse clothes, vegetables, dishes and cutlery, to defrost food stuffs, to shave and for hand washing,

d) to reduce the amount of water used for cooking, using pressure cookers and microwaves,

e) to make soup with water previously used to cook vegetables,

f) to use only adequate detergents (biodegradable if possible!), and to use them only in the prescribed quantities, to avoid unnecessary rinsing,

g) to use only low flow taps with aerators in new installations,

h) when needed, to substitute old taps by low flow newer ones, and if possible, with aerators,

i) to always use push button and self closing taps in public installations,

j) to avoid the installation of flush taps, which are only justified in specific hospital sections, in abattoirs and in other non-usual situations,

k) to promote the installation of hot water return loops, instead of long dead ends connecting the end user with the source of hot water. This practice saves both water and energy, because less water is needed to run until the required temperature for use is attained. Furthermore, after the conclusion of each service, less water and heating energy is wasted in the section of the hot water pipe immediately upstream of the tap, The detailed survey done to the internal water supply system of Hospital Amadora Sintra confirms the above general recommendations for the design of hospitals, old age homes and similar specialised buildings, and leads also to the conclusion that particular attention must be paid to the design of hot water distribution loops, to avoid long hot water dead ends. This is particularly important in places where the use of hot water tends to be at long intervals and of short duration, to avoid water and energy losses, and also to diminish the ever present danger of development of *Legionella*.

Still concluded from that survey, is the fact that attention must be paid to the type of taps to be installed in certain departments, particularly where the danger of contamination requires stronger water jets for improved washing and cleansing purposes (e.g. surgery block, mortuary and associated pathologic services, oncology, palliative care unit, etc).

Notwithstanding these specific situations, the recommendations for other buildings, residential or not, are equally valid to all the other sections of hospitals, where the danger of perilous contaminations does not exist directly (e.g. kitchen and cafeterias, stores, public and staff toilets, staff changing rooms, etc.). Accordingly, in these latter cases, it is highly recommended the use of low flow taps, aerators, push button and self closing taps.

It must also be noted that other conclusions and recommendations will certainly emanate from the evaluation of the internal unit water consumptions, as detailed in the following Paragraph 3.6.

2.2.8.6 Indoor stopcock and other shutting valves

The installation of stopcock valves at the entrance of all private kitchens and WC's, in well visible places, and the knowledge of their positions by all residents, is an important measure to save water and to reduce damage to property in case of accidental bursts.

In the case of hospitals, the position and the nature of all shutting valves (cold and hot water, oxygen, etc.) must be clearly marked and identified. Furthermore, all stopcock valves along the water supply systems (cold, hot and return) must be placed in visible and easily accessible places, and their positions and functions must be familiar to all medical and non medical staff working in each section, ward, etc. The prompt and correct use of these stopcock valves in the case of accidental bursts, will not only avoid damage to property, but will also prevent the interruption of the service to other hospital sections in the case of minor repairs, maintenance, etc.

2.2.8.7 Maintenance of the water pressure within acceptable limits

Excessive water pressure in the pipe network of any building, or part thereof, is cause for increased indoor spillage and water wastage in taps. It also shortens the working life and adds to the strain on the fittings and plumbing equipment.

On the other hand, insufficient water pressure in buildings disables, or at least reduces the performance of fittings and the comfort of their users.

Water retail authorities are often unable to keep the water pressure within acceptable limits in all areas of their distribution networks. This means it is up to the designers, or ultimately the owners or the building managers, to save water by keeping the water pressure within acceptable limits in their properties (or parts thereof, in the cases of high rise buildings and in major properties with severe variations of topographic levels).

"Design Standards & Policies Manual" [11], a reference in USA, recommends that municipal water supply systems should be designed for ground working pressures of between 345 kPa and 824 kPa. However, they also recommend the installation of pressure relief devices for pressures in excess of 548 kPa. Incidentally, that minimum pressure of 345 kPa is the reference pressure of the USA's Federal Energy Policy Act of 1992, for the definition of maximum flows through taps. As indicated in "Report on Water Conservation and water Use efficiency" [14], if the water pressure is kept within the above limits, domestic water savings of 3 to 5% can be achieved just in spillage.

The Portuguese Regulations "Regulamento Geral dos Sistemas Públicos e Prediais de Distribuição de Água e de Drenagem de Águas Residuais" [12] and the reference manual "Manual dos Sistemas Prediais de Distribuição e Drenagem de Águas" [13], recommend working pressures between 50 kPa and 600 kPa, with an optimum range between 150 kPa and 300 kPa.

The case of water pressures assume particular importance in some hospitals, namely in Hospital Amadora Sintra, where all the service water is first stored in three free surface reservoirs installed in parallel, each with the capacity of 270 m^3, and with invert at level 122,10 m and full supply at level 126,1 m. These reservoirs act simultaneously as buffer and contingency reservoirs, and imply the loss of the water pressure in the supply network.

The water pressure is subsequently raised to a service pressure of 800 KPa. This means that the static pressure at the 1st floor (level 115,8 m) can reach some 900 KPa which, in addition to the extra strain on pipes and fittings, increases also spillages and water and energy losses.
This matter shall be discussed later, when dealing with the case study of the Hospital Professor Doutor Fernando Fonseca ("Amadora Sintra").

2.2.8.8 Standard indoor water supply regulations

These regulations should require

a) the mandatory installation of pressure reducing valves at all building inlets, or part thereof, where the static water pressure may exceed 600 kPa, as recommended by "Regulamento Geral dos Sistemas Públicos e Prediais de Distribuição de Água e de Drenagem de Águas Residuais" [12] and the reference manual "Manual dos Sistemas Prediais de Distribuição e Drenagem de Águas" [13]. Ideally, the service pressure should be maintained between 150 kPa and 300 kPa at the inlet of all domestic appliances,

b) the mandatory installation of low flow taps and other low flow water faucets, except in exceptional cases where flush taps may be specifically recommended (hospitals, abattoirs, etc.).

c) the mandatory installation of self closing taps, infrared sensors or other reliable self closing water outlets at all public water facilities,

d) the mandatory installation of foot operated taps in large industrial kitchens and similar users (regional hospitals, major industrial dining-halls, prisons, etc.),

e) the mandatory implementation of periodic, systematic leak detection routines (of all faucets, water appliances and plumbing fixtures) and the subsequent execution of the required remedial work, both in terms of maintenance repairs and in terms of periodic mandatory retro fittings,

f) the definition, for design purposes, of the approved water heating systems and devices, and heating and storage capacities,

g) the mandatory installation of hot water pipe insulation, to prevent heat losses and, at the same time, to reduce water wastage while users wait for the required water temperature to be attained,

h) the definition, for design purposes, of the maximum capacity of the domestic, commercial and industrial hot water supplying systems, above which the installation of hot water return loops should be mandatory, and

i) the definition, for design purposes, of the maximum pipe length between the hot water source (be it the actual hot water source or a return loop), and the last hot water tap to be served.

2.2.9 Outdoor water saving measures and appliances

2.2.9.1 Common and private open spaces

Common open spaces, be they residential or not, provide focal points for recreation and interaction, significantly increasing the quality of life of those involved.

No comprehensive information concerning private residential gardens in Portugal was found. However, the "Programa Nacional para o Uso Eficiente da Água" [8] states that only some 30% of all the Portuguese dwellings have gardens (about 1,5 million dwellings), and that their average area is 40 m^2.

In Portugal, garden irrigation, including vegetable-gardening, is necessary during the 5 hottest months of the year, when temperatures and radiation are high, and precipitation is zero or very low.

The average water requirements for garden irrigation in those periods, is of about 0.2 m^3/m^2/month. That means a total of 40 m^3 per dwelling and per year, or a total of 60 x 10^6 m^3 of water per year for the whole Country.

2.2.9.2 Standard outdoor water supply regulations

Outdoor water supply regulations should be universally promoted, including

a) the installation of pressure reducing valves at all inlets of open landscaped areas, or part thereof, where the static water pressure may exceed 600 kPa, as referred in "Regulamento Geral dos Sistemas Públicos e Prediais de Distribuição de Água e de Drenagem de Águas Residuais" [12] and in the reference manual "Manual dos Sistemas Prediais de Distribuição e Drenagem de Águas" [13]. Ideally, the service pressure should be maintained between 150 kPa and 300 kPa,

b) the periodic implementation of leak detection routines (of all hosepipes, watering equipment and plumbing fixtures) and the subsequent execution of the required remedial work,

c) the installation of adequate recirculation and disinfection compact units in all private swimming pools,

d) the installation of adequate covers in all private swimming pools that are only used in summer,

e) the use of drought tolerant native plants in new open spaces and in all major retro fittings of existing ones,

f) the control of pressurised water jets for irrigation and for special washings (to wash away concentrated pesticides, for example) must be at the hand of the operator and not at the hydrant, so as to avoid water wastage while the operator walks to and from the hydrant,

g) the installation of pluviometers in open spaces, to adapt the volumes of irrigation water to the precipitation occurred in the previous days,

h) the installation of timing devices, timed meters or even, when justified, weather satellite controlled irrigation devices in all new open spaces, and

i) the collection and the storage of rain water, for garden and for landscape purposes.

2.2.9.3 Ways to improve outdoor water savings

In addition to those that may be imposed by local regulations, possible ways to improve outdoor domestic water savings, including hospital landscaped areas, are

a) adapting the irrigation schedule of gardens and lawns to the species of vegetation to be watered, i.e., to supply just the necessary amount of water required by the particular species, and to do that bearing in mind the most recent amounts of precipitation and prevailing weather conditions,

b) to promote the use of drought tolerant native plants, replacing whenever possible, turf grasses with native species, or other plants requiring lower quantities of water.
In this regard, it must be noted that, in general, building managers and homeowners have the propensity to plant and to care for large areas of grass and other water intensive landscaping, instead of choosing species which require less water to develop, but which are still highly appealing. Furthermore, drought tolerant plants are an important factor contributing to a reduction in the use of water in dry periods,

c) to promote mulching, to retain garden moisture,

d) to promote the installation of drip irrigation systems,

e) to maintain a fine tuning of all irrigation systems,

f) to promote the installation of timing devices, to adjust the watering schedules of automatic sprinkler systems to the dark hours of the day or, alternatively

g) to encourage the installation of devices using modern weather satellite technology supplying the prevailing weather conditions on a zone-to-zone basis, to automatically adjust the programmed watering schedules of automatic sprinklers to the local weather conditions,

h) to encourage the installation of "timed meters" solely dedicated to irrigation, combined with the offer of lower rates for water supplied for irrigation purposes during the dark hours of the day. This not only reduces water losses by evaporation, but also reduces water consumption during the peak hours of the day,

i) to promote, mainly in new developments, the implementation of adequately pressurised secondary irrigation systems for in-house recycled grey waters. Although this specific use of secondary water will reduce the required volumes of potable water, it should never be perceived as an opportunity for the unrestrained use of grey waters.
In the future, these systems may be integrated in real public secondary systems, and metered and charged accordingly,

j) to promote the sweeping of sidewalks, driveways and walking lanes, instead of their cleansing by water jets,

k) if, for strict hygienic reasons, pressurised water jets have to be used for pavement washing (abattoirs, for example), the control of the flow should be at the hand of the operator and not at the hydrant, so as to avoid water wastage while the operator walks to and from the hydrant,

l) to maintain all lawns well trimmed and all other landscaped areas free of weeds, to reduce the overall water needs of these areas, and

m) to encourage the collection and storage of rain water, for garden and for landscape purposes.

2.2.10 <u>Dual drainage systems</u>

2.2.10.1 <u>Fundamentals</u>

The installation of dual pipe drainage systems for in-house separation of dark and grey waters is an important step towards a more efficient way to save water and to use it wisely.

However, to separate grey and dark waters is not sufficient. A partial on-site treatment of those grey waters has to follow, so as to restore them to acceptable quality standards to be re-used in selected applications that require lower quality standards. These applications are basically toilet flushing, irrigation of landscaped areas (with recovery of some nutrients), and also car and indoor and outdoor floor washing.

The recycling of grey waters in any medium sized building with sufficient out space for the installation of a compact water treatment plant, can reduce significantly the global use of water.

Furthermore, the use of local phitobiological treatment plants for dark waters, followed by their direct return to nature, has also been considered as an acceptable way to simultaneously

a) reduce the dimension of the sewage pipe systems,

b) reduce the load onto the municipal treatment plants, and

c) implement a more widely dispersed return to nature.

However, such practice requires the installation of special fittings which, in general, do not raise the interest of home promoters because of the increased costs involved.

The same practical results apply to hospitals, as concluded from the many conversations and working sessions with several senior technical and administrative officials at "Hospital Amadora Sintra" and "Hospital de Sanra Maria" (references [21] to [25]), for whom the idea of re-using their grey waters in hospitals raise strong opposition, not because of the granted quality of the treated effluents, but because of the negative psychological effect that the use of those waters have on many persons, be they patients or not.

Furthermore, it is considerably more expensive to buy the materials and to install a dual system of drainage pipes than a single pipe system, and there is also to consider the additional first investment and associated running costs of that treatment plant to be installed.

The additional costs of biodegradable detergents should also be considered, because the efficiency of those treatment plants is largely improved with the use of those detergents.

Consequently, and because of their additional costs, such dual drainage systems are not appealing propositions, neither to individual or multifamily home owners, developers or building managers, nor to hospital managers.

2.2.10.2 Risks involved

The risks involved with the re-use of partially treated water ("Programa Nacional para o Uso Eficiente da Água" [8]), depend clearly on the dichotomy level of treatment versus the kind of water usage.

In general, it can be said that the use of recycled water may involve the following hazards

a) in agriculture, it can pollute surface waters and the aquifer, it can jeopardize the commercialisation of fresh produce irrigated by them, can accumulate salts in the soil and in plants, and it can represent a danger for the agriculture workers (because of the ever present possibility of pathogenic components),

b) in landscape irrigation they can pollute surface waters and the aquifer, can accumulate salts in the soil and in plants, and can represent a major and direct danger for the public (again, because of the ever present possibility of pathogenic components),

c) for the industry, they can cause the development of incrustations and corrosion in the pipes and fittings, can cause the development of adverse biologic colonies, and it can represent a danger for the industrial workers,

d) for aquifer recharge, they can adversely affect waters with potential for later uses, because of the possible presence of toxic chemicals, dissolved solids, nitrates, other pathogenic components, etc.,

e) for surface waters, they can produce euthrophycation due to their possible contents of nitrogen and phosphorus, can be a danger to the public and can also be a threat to aquatic life,

f) for urban usage (for laundry, floor cleaning, car washing, irrigation, etc., but not for human consumption), recycled grey waters can be a danger for the public because of their possible pathologic content, can cause the development of incrustations, corrosion, the development of adverse biologic colonies, and can even be mistakenly used for human consumption, and

g) for human consumption (if the water is treated to human consumption standards), consumers have to be psychologically prepared to accept recycled water into their lives, and there is always the danger of transmission of any pathogenic components (mainly viruses).

Notwithstanding this, it must be said that water, fully recycled to the required standards for human consumption, is part of the water supply system of several major cities in the world.

This is the case, for example, of the Gauteng region in South Africa, where the respective Water Board supplies water abstracted from the Vaal Barrage for the consumption of millions of people (Johannesburg and Pretoria included), and about 50% of the inflow to that reservoir consists of purified domestic and industrial sewage effluents.

2.2.11 Car washing

2.2.11.1 Common cars

The washing of family cars within the residential premises, both inside garages and in the surrounding open spaces, is another practice where water savings are possible and easily achieved.

Instead of using hose pipes, or even portable over-pressurised water saving devices, cars should rather be washed with buckets of soapy (biodegradable!) water, and rinsed while they are parked on or near the grass or landscaped areas.

This is a good way to put the water runoff to a beneficial use, instead of wasting it directly into the drainage system.

Assuming, realistically, that a car is washed once a week and that it takes 10 minutes to wash it with a hose pipe debiting 15 ℓ per minute (or 0,25 ℓ/s), the water consumed in washing that car is about 7.8 m^3 per car and per year.

Assuming further that half a million family cars are washed in this way (some 18% of the total of 2.8 million motorized vehicles circulating in Portugal), the total volume of water consumed in Portugal for "domestic" car washing is 3.9 x 10^6 m^3 per year.

Assuming now that the same car wash is done the same number of times with 5 x 10 ℓ buckets of water (1 to wet, 1 to soap and 3 to rinse), the total amount of water used in this way would only be 1,3 x 10^6 m^3 per year. That corresponds to savings of 2.6 x 10^6 m^3 of water per year, or some 67% of the former volume. This is equivalent to the total amount of water that the Greater Lisbon area consumes in about 5 days!

If over-pressurised washing systems are used, car washing times can realistically be reduced by half, due to the increased washing capacities. Therefore, a consumption of 75 ℓ of water is sufficient for each car wash, or 1.95 x 10^6 m^3 of water per year, for those same half million family cars. Savings of 50% are still achieved in this way.

2.2.11.2 Hospital vehicles

Regarding the washing of hospital ambulances, trucks for the transport of soiled and infected linen (in those cases when the laundry and the ironing services are outsourced), as well as other service vehicles and hearses, the volumes of water involved are considerably higher, as informed by the Technical Inspector at "Amadora Sintra" ([21].

There are two basic types of ambulances: those dedicated to the actual transport to the hospital of casualties and seriously ill persons, and those dedicated to the transport of medical home visitors and frequent out patients.

Ambulances of the first kind are washed and disinfected up to three times daily, with an average of one time per day. For the over-pressurised washing systems normally used for these purposes and described in the previous paragraph 2.2.11.1, 75 ℓ of water are consumed per washing, or 27.4 m^3 of water are required per year and per each one of these ambulances.

Ambulances for the transport of home visitors and out patients are washed twice per week on average. For the same over-pressurised washing systems consuming 75 ℓ of water per washing, 7.8 m^3 of water are required per year for each one of these ambulances.

Other light service vehicles are normally washed once every week, and 3.9 m^3 of water are required per year for each one of them.

Regarding the trucks for the transport of soiled and infected hospital linen, they only exist if the actual laundry and pressing services are contracted out and are done outside the hospital premises, or if a hospital does the laundry of other hospital(s), in which cases the linen has to be transported to and from the laundry.

In such cases, these trucks make up to two return trips daily, are washed and disinfected at the laundry on every return trip, and only circulate during working days (about 250 days per year). For the same over-pressurised washing systems, 120 ℓ of water per washing are required on average, or 60 m^3 of water per year and per truck.

Hearses are, on average, washed every second day. For the same over-pressurised washing systems consuming 75 ℓ of water per washing, 13.7 m^3 of water are required per year and per hearse.

Obviously, the volumes of water required to wash the linen trucks and to wash the hearses, may not be consumed at the hospital. However, they are mentioned here as part of the hospital's water requirements because, directly or indirectly, they contribute for the normal running of the hospital.

2.2.12 Swimming pools

2.2.12.1 Private swimming pools

No reliable information exists about private swimming pools in Portugal. Only some educated guesses can be done.

According to the "Programa Nacional para o Uso Eficiente da Água" [8], there are some 5 million households in Portugal, of which 36%, or 1.8 million, are multifamily residential units. Therefore, 3.2 million are detached houses (cottages, villas and the like). Of these, it is further estimated that 3% have private swimming pools. A total of 96,000 private swimming pools is therefore estimated for Portugal.

In addition, there are also some 195,000 hotels and similar establishments in Portugal, of which some 20% are of superior category (therefore, with private swimming pools). A total of 39,000 swimming pools are therefore installed in Portuguese hotels.

Swimming pool merchants also claim that some 5,000 units are installed in multifamily buildings and *condominia*. That corresponds to a ratio of 2.8 swimming pools per thousand households in multifamily residential blocks, which also seems to be an acceptable figure for Portugal.

The above figures lead to the conclusion that, at present, there are some 140,000 private swimming pools in Portugal.

Typical dimensions of those swimming pools are about 40 m^2 in plant and 1.5 m in average depth, therefore with average capacities of 60 m^3.

It is suggested by the "Programa Nacional para o Uso Eficiente da Água" [8] that those swimming pools are used on average 4 hours per day during the summer season of 3 months (mid June to mid September), and that they have water circulation cycles of 8 hours.

If no closed circuit exists for the re-use of the water, the consumption of each swimming pool would be of some 2,700 m^3 of water per year.

On the other hand, if a closed circuit exists to re-circulate the water (compact units doing coagulation, filtration and disinfection), the estimated consumption is only some 3,5% of that volume (or about 95 m^3 per season and per swimming pool). Some 2,600 m^3 of water per swimming pool and per year can therefore be saved if a re-circulation unit is also installed.

It must also be stressed that evaporation is a strong contributing factor to water losses in swimming pools, and that it can be significantly reduced with swimming pool covers.

The mandatory installation of re-circulation units in all swimming pools, and swimming pool covers in all swimming pools of summer use only, should therefore be considered.

2.2.12.2 Public swimming pools

The "Programa Nacional para o Uso Eficiente da Água" [8] indicates that there are about 250 public outdoor swimming pools in Portugal with individual water surface areas between 350 and 500 m^2 in plant, with maximum depth of 2.5 m, and average capacities of 1,000 m^3.

They all have sophisticated closed circuit re-circulation compact units which circulate the water in cycles of 4 to 8 hours, and treat it with coagulation, filtration and disinfection. They work an average of 12 hours per day during 6 months per year, and the estimated yearly consumption of 3,5% make up water of these swimming pools is 12,600 m^3 per unit (considering average cycles of 6 hours).

The number of indoor swimming pools is still negligible in Portugal, therefore with no significant impact on the global volume of water consumed for circulation and for make up in public swimming pools.

Unfortunately, it was not possible to obtain information about the various specialized swimming pools installed at the Physical Medicine and Rehabilitation service of the "Amadora Sintra", namely their capacities, circulation periods, percentages of water renovation at each cycle and estimated global water consumption per annum.

3. SURVEYS

3.1 Foreword

Regional hospitals in Portugal are major hospitals of between 400 and 1,100 beds, and all the related ancillary supporting services.

In essence, they are central hospitals serving a network of (smaller) base hospitals and nursing centres, which have limited medical resources and rely on their reference regional hospitals for all cases requiring services and equipment above their own capabilities.

After the preliminary contacts and investigations towards the selection of the hospital or hospitals to be investigated, it was decided to concentrate efforts in Hospital de Santa Maria, a major 1100 beds regional hospital in service in Lisbon since 1953 which, it was expected, would provide comprehensive data records, reliable operational information and easiness of access.

Unfortunately, no reliable records were found in this hospital.

That forced the change of the main investigation into Hospital Amadora Sintra, a 776 beds regional hospital in service since 1993 in the North-Western suburbs of Lisbon. Most of the required information exists in this hospital, and was kindly supplied for this Thesis.

However, the evidence and the conclusions possible to be derived from the survey of Hospital de Santa Maria, constitute valid information and is incorporated in this Thesis.

Incidentally, one of the Professional Engineers helping us at Hospital de Santa Maria, was subsequently transferred to Hospital Amadora Sintra, where he also supported our work and helped establishing comparisons. His contribution (reference [25]) is highly appreciated.

Hospital Amadora Sintra is of a fairly recent design and construction, is located in the heart of the North-Western suburbs of the greater Lisbon area, and serves directly the two major residential and industrial areas of Sintra and Amadora.

The ever present goodwill and kind support given to this work by the Administration and the technical and maintenance services of "Amadora Sintra" cannot be overemphasized. The candidate is deeply indebted for their kind support, as without it this Thesis could not be successfully completed.

The actual work at Hospital Amadora Sintra consisted of detailed surveys of the internal and external water supply systems, the daily water supply routines, the existing construction and installation documents, the historic records of the volumes of water consumed by the hospital along the years, and interviews with the team of engineers in charge of these services.

3.2 The hospital "Amadora Sintra" at a glance

3.2.1 Overall description

"Hospital Professor Doutor Fernando Fonseca", more commonly known as Hospital "Amadora Sintra", is the regional hospital for the North-Western region of the Greater Lisbon area. It serves the municipalities of Amadora and Sintra, and shall be referred below as "Amadora Sintra".

As already indicated in paragraph **3.1** above, "Amadora Sintra" is a second choice, because of the lack of information concerning the hospital initially considered.

"Amadora Sintra" is a typical 750 to 800 beds regional hospital with a fully equipped casualties department, with all kinds of specialised medical staff, and with state of the art equipment to cater for all medical requirements.

Naturally, these medical capabilities are complemented by the normal ancillary supporting services (laundry, hot water generators, incineration plant, etc.), their running and maintenance being controlled by a technical department disposing of comprehensive technical information about the buildings and equipments, and systematic records of their running.

As a regional hospital, "Amadora Sintra" is the back-bone of a network of satellite clinics, where (at least in principle!) all patients are previously observed and receive primary assistance. Only serious casualties and cases needing more sophisticated medical support are referred to "Amadora Sintra". It renders in excess of 2 million medical services per year, to a population of about 650,000 inhabitants

"Amadora Sintra" was inaugurated in 1993, serves a population of some 650,000, and is located along the border line between the two municipalities of Amadora and Sintra, on a 26.3 ha piece of land with a gentle slope towards the North. It is in the western end of Amadora and in the eastern limit of Sintra, and is served by the main road connecting the two municipal regions.

The actual hospital complex consists of the main hospital building, the industrial block and other minor buildings and structures (porters, water and fuel deposits, etc).

As indicated in the following Figure 3-1, the actual hospital consists of two general floors where all the services and sections are installed (Floors 1 and 2). These floors are topped by a technical floor (Floor 3), and by two towers protruding from the general floors. It is in these towers that the wards are installed (Floors 3 to 6).

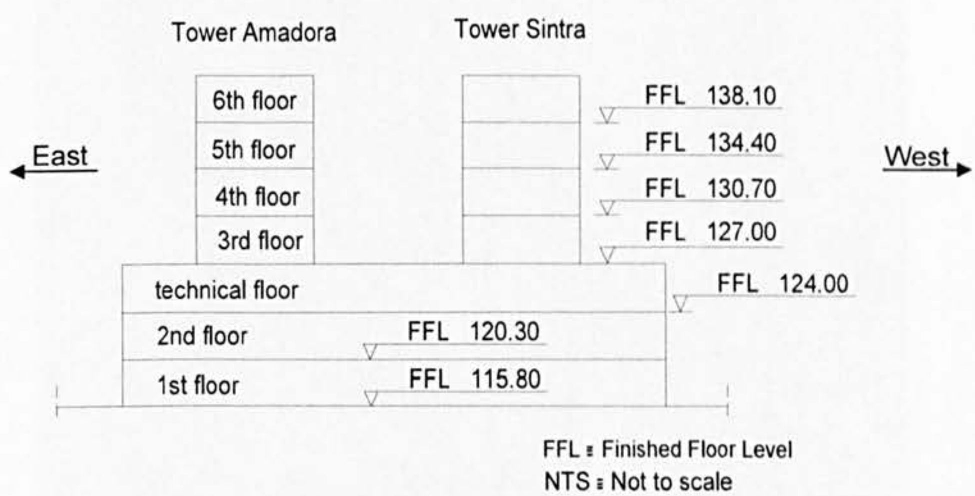

Figure 3-1 - NTS sketch (facing South) of the main building of Hospital "Amadora Sintra"

The Finished Floor Levels (FFL) of the various floors are also indicated.

The eastern tower is named "Tower Amadora", and the western tower is the "Tower Sintra".

The hospital has 776 hospital beds and a total floor area of 67,750 m^2. Several major supporting services, such as the Management and Administrative Services, Pharmaceutical Department, the kitchen, staff eating hall, several cafeterias, etc are also installed in the hospital block.

The industrial building has a floor area of 4,180 m^2. It is in it that the laundry, incineration plant, water heating systems and most of the other mechanical and electrical supporting services are located.

There is an underground service gallery between Level 1 of the hospital and the industrial building, which is used for the circulation of hermetic container trolleys conveying soiled hospital linen to the laundry, and dangerous residues for the incineration plant.

It is also along this gallery that the power cables and the fluid transportation conduits run from the industrial block to and from the hospital.

The overall area of the hospital premises (Figure 3-2) has 263,000 m^2 and consists of 26,300 m^2 of buildings accommodating 71,930 m^2 of floor area, 71,500 m^2 of parking bays and access and circulation roads, 5,200 m^2 of pedestrian walkways, and 160,000 m^2 of landscaped areas, with lawns, flower beds and decorative shrubs and trees.

Figure 3-2 - Aerial view of Hospital Dr. Fernando Fonseca (NTS)

3.2.2 Services rendered

Hospital Amadora Sintra was designed and is staffed and equipped to

a) deal with a daily population of up to 5,000 (including medical and other staff, patients and accompanying persons, visitors, etc.),

b) deal annually with up to 20,000 in-patients, 160,000 out-patients, 100,000 casualties, 6,500 major surgeries, 3,500 birth deliveries, 120,000 exams of radiology/imagiology, and 1,800,000 clinical pathology tests,

c) serve annually more than 800,000 hot meals to the staff, and to

d) disinfect, wash, press, pack and hermetically seal up to 850 tons per annum of all kinds of hospital linen.

3.2.3 The two water supply systems

3.2.3.1 Introduction

The philosophy of the initial design of the water supply system to Hospital Amadora Sintra, was to use water from the municipal system for all the hospital's internal requirements (more expensive water, but with an expected better quality), and to use the cheaper water from a borehole sunk at the hospital's premises for the laundry and for the watering of the surrounding landscaped areas.

However, regarding the borehole water, it should be noted that analyses made periodically over time show that, along the whole year, this water complies with the requirements for human consumption.

In order to guarantee an emergency reserve for any accidental malfunctions, all the water intakes are first conducted to three free surface storage tanks installed in parallel and with invert level at 122.10 m, each with a net capacity of 270 m^3. They are referred below as Deposits 1, 2 and 3.

3.2.3.2 Water from the municipal supply system

The water from the municipal water supply system enters the hospital premises on the western side of the main entrance, at level 113,0 m and with a guaranteed service pressure of 300 kP (maximum static pressure of 550 kP).

There, it is metered, is re-chlorinated and is forwarded to Deposits 2 and 3 via a Φ125 mm NB access pipe. The inlets of these two deposits are Φ75 mm NB admission pipes, individually controlled by floating valves.

The water thus stored is subsequently pumped to a pressure of 800 KPa and forwarded:

a) to the internal cold water supply network of Levels 1 and 2 (including the kitchen), via a Φ100 mm NB pipe,

b) to the two cold water supply networks of the ward towers, via a Φ75 mm NB pipe,

c) to the heating plant (ambient and domestic water heating) via a Φ100 mm NB pipe, and

d) to the internal cold water supply network of the industrial building, also via a Φ100 mm NB pipe.

For this reason, the hospital's typical daily diagram of the water abstracted from the municipal supply system is of a nearly rectangular shape. This does not allow for the definition of the daily peaks, neither in terms of their magnitudes nor in terms of their times of occurrence, as is clearly indicated in Figure 3-3 (which shows the rate of the water abstracted from the municipal system on 17 January 2009).

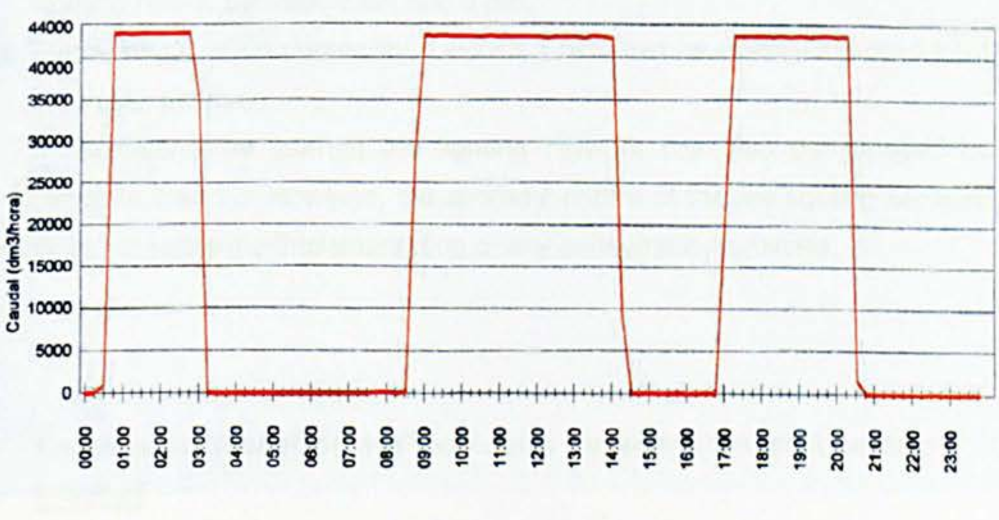

Figure 3-3 - Water abstracted from the municipal water suppl system on January 17th, 2009

3.2.3.3 <u>Water from the borehole</u>

The borehole has a yield of 8 ℓ/s, or 29 m^3/hour, and the pump system raises the water to an elevation of 117 m. As previously indicated, the water thus abstracted has quality standards acceptable for direct human consumption during the whole year.

After abstraction, the water is chlorinated and pumped into Deposit 1 via a Φ63 mm NB rising main.

Subsequently, it is pumped to a pressure of 800 KPa and forwarded:

a) to the laundry, via a Φ100 mm NB pipe,

b) to the internal and external fire fighting systems, and

c) to the irrigation network of the landscaped areas surrounding the hospital, via a Φ100 mm NB pipe.

If the borehole yield becomes insufficient for the simultaneous supply of water to the laundry and for garden purposes, than Deposits 2 and 3 can supply temporary the laundry.

This situation only happens for a few hours at most, because those two combined demands exceed the yield of the borehole, and the capacity of Deposit 1 is insufficient for that simultaneous supply during the 9 normal working hours, between 8 am and 5 pm.

Furthermore, when necessary, Deposit 1 can also be directly supplied from the municipal main.

If necessary, the internal fire fighting network can also be supplied by Deposits 2 and 3. However, the sporadic nature of the fire fighting services does not justify the implementation of any consumption analysis.

3.3 Analysis and modelling methodologies for water consumption data

3.3.1 <u>Synopsis</u>

This chapter introduces the mathematical methodologies for the construction and testing of time series, to be used in Chapter 4 in the data processing and modelling of the global water consumption patterns, and to be used later, as a continuation of this Thesis, for the same purposes in the analyses of the unit water consumptions.

However, only those demonstrations not found in the references and considered pertinent for this Thesis are presented.

This chapter **3.3**,

a) starts with the definition of the basic concepts of time series and their main components, and how they can be used to model the evolution of the water supply routines,

b) follows the multiplicative decomposition methodology and the explanation of how the main components are identified and evaluated (equations 3.1 to 3.10),

c) presents univariate models for long term components (equations 3.11 to 3.45) and for pure harmonic seasonal components (equations 3.46 to 3.54), to be applied later in the various forms of the dichotomy "water consumption" versus "time period of consumption",

d) follows the presentation of the "dummy" variable models, also univariate, advantageous for irregular but periodic events, and includes applications for the cases of periods of a year and monthly, weekly and daily seasons (equations 3.55 and 3.58),

e) long term bivariate models follow, for the case of one dependent variable (the "water consumption"), under the simultaneous influences of two independent variables, the "time period of occurrence" and the "ambient temperature" at that same time period (equations 3.59 to 3.63),

f) attempts a new approach of a intuitive static relationship between water consumption and ambient temperature, using equations already presented for long term tendencies (equations 3.11 to 3.14), and

g) ends with an analysis of the accuracies of the various regressions presented. Several parameters directly derived from the differences between registered, average and expected values of the dependent variable are introduced (equations 3.64 to 3.71), and a universal parameter is also presented for the quantification of that accuracy (equations 3.72 to 3.75).

3.3.2 Introduction and definitions

3.3.2.1 Time series

"Forecasting Time Series and Regression - An Applied Approach" [28] and "Análise de Sucessões Cronológicas" [29], consider "time series", also commonly referred to as "chronological series", as a series of observations made sequentially over time. Time series are therefore systematically recorded observations of phenomena, ordered according to their time of occurrence. It is this time order of events that distinguishes time series from other series, because the former reflect the fact that events occurred in a particular moment have influence on other facts to happen afterwards.

For the purpose of this Thesis, and in line with the above mentioned references "Forecasting Time Series and Regression - An Applied Approach" [28] and "Análise de Sucessões Cronológicas" [29],

a) time series records will consist of $\mathbf{n}$ sets of chronologically ordered data groups $(\mathbf{t}_i, \mathbf{q}_i, \mathbf{r}_i, \ldots \mathbf{z}_i)$, with each group consisting of

   i) one or two independent variables, namely the time period $\mathbf{t}_i$ (which is discrete and such that $\mathbf{t}_1 < \mathbf{t}_2 < \ldots < \mathbf{t}_n$) and, eventually, also the temperature $\mathbf{q}_i$, and

   ii) one or several dependent real variables $\mathbf{r}, \ldots, \mathbf{z} \in \Re$,

b) In all cases, $\mathbf{i} \in [\mathbf{1}, \mathbf{n}] \in \Im$,

c) the most common time recurring records can be considered univariate time series, or data pairs in which the independent variable is the "time period" $\mathbf{t}$, and the dependent variable is the recorded value $\mathbf{r}$ for the water consumption during that time period (data sets with two independent variables will only be considered in a multiple regression), and

d) changes occur in the domestic water consumption patterns with the passing of time. Therefore, those patterns are dynamic, they are not static.

3.3.2.2 Returning events

"Returning events" are phenomena which occur repeatedly, with or without any evident period of repetition. Ocean tides are examples of the former and earthquakes are examples of the latter.

Accordingly, "returning time series" are series whose values are somehow periodically repeated, i.e., their values give evidence of some historically repeated pattern.

3.3.2.3 Models and forecasts

In the case of sufficiently long and reliable records of repeated phenomena with detectable returning patterns (such as, for example, systematic water consumption records of a community over the months and the years), the analysis of those records may lead to the establishment of mathematical expressions of the form $\mathbf{p_i = f(t_i, r_i)}$, defining the "most probable value" $\mathbf{p_i}$, in function of the $\mathbf{n}$ pairs of recorded data $\mathbf{(t_i, r_i)}$.

Such mathematical expressions, if they exist, are called the "mathematical models" or the "linear regressions" of the returning time series, and are mathematical representations of phenomena in evolution. However, quite correctly in the opinion of the candidate, some experts consider that "linear regressions" are just the mathematical processes to define the best fitting equations, and "mathematical models" are only their end product.

If the regression process is established between only two variables, namely the independent and the dependent variables, it is normally called a "simple linear regression".

If the mathematical model reproduces with acceptable accuracy the values of the dependent variables for past situations, and if the conditions influencing the recorded values are expected to remain unaltered, it is then admissible to make extrapolations, in order to predict future values of those dependent variables. These predictions are expected to have the same accuracy and are called "forecasts". Therefore, forecasts are just beliefs, being no more than statements about uncertain future happenings.

Notwithstanding the above, forecasts are obviously of fundamental importance in many hydraulic engineering instances, such as for the prediction of floods and droughts, previsions of peak water demands, etc.

3.3.2.4 "Residuals"

"Residuals", or "prediction errors", are the individual differences between the recorded values of the dependent variables $\mathbf{r}_i$ and their corresponding most probable values $\mathbf{p}_i$, as produced by the mathematical model, i.e.,

$$\mathbf{Residual}_i = \mathbf{r}_i - \mathbf{p}_i$$

3.3.2.5 Components of a time series

The analysis of time recurring series to define

a) the relationship between the dependent and the independent variables and

b) the evolution of their relationship,

should be aimed at pinpointing the main components of that relationship, namely the trend, the periodic oscillations and any other irregular and unexpected oscillations (as indicated in "Análise Exploratória de Dados" [27], in "Forecasting Time Series and Regression - An Applied Approach" [28], and in "Análise de Sucessões Cronológicas" [29]).

3.3.2.6 The trend

The trend is the long term evolution of a time series. The evolution can obviously be increasing, decreasing or even static (Figure 3-4).

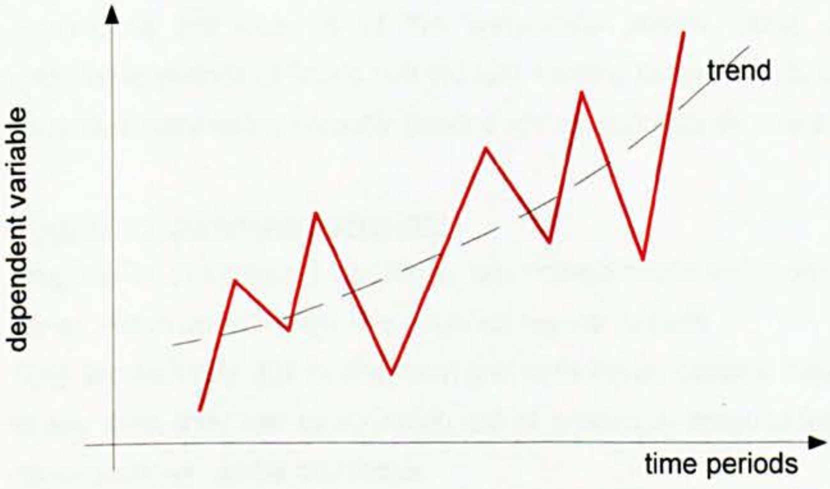

Figure 3-4 – Time series with a growing trend

3.3.2.7 Periodic oscillations

Periodic oscillations can be classified into two categories, in terms of their periods. Oscillations with periods of up to one year are called "seasonal oscillations", while oscillations with periods of more than a year are known as "cyclic oscillations".

Seasonal oscillations are normally calendar or weather related, as the case is, for example, of Christmas sales and the sales of bathing suits.

They normally have regular periods, but their peaks may vary (Figure 3-5).

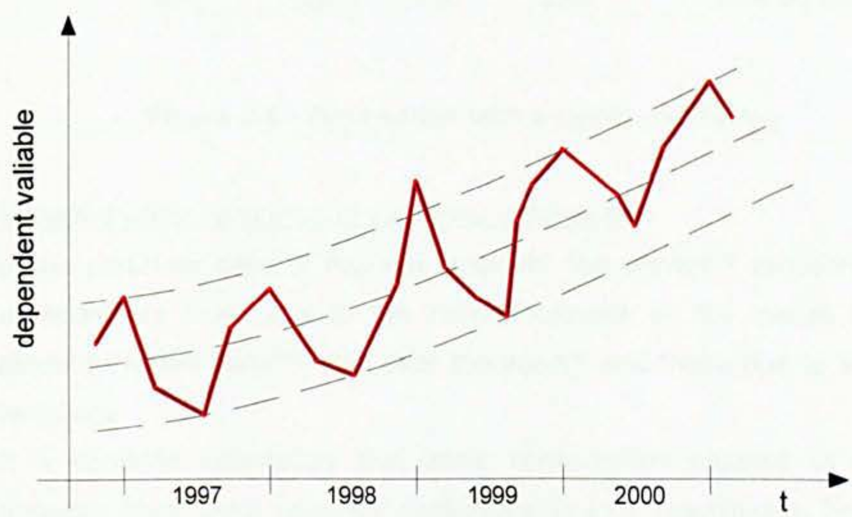

Figure 3-5 – Time series with a seasonal oscillation of a nearly constant magnitude

Cyclic oscillations depend normally on the simultaneous influence of various causes, as the case is of the agricultural annual yields caused by successive periods of floods and drought, varying temperatures, etc.

They may have rather irregular periods and magnitudes (Figure 3-6).

3.3.2.8 Irregular (or unexpected) variations

Irregular or unexpected variations are unpredictable variations of a time series, which do not follow any apparent regular pattern.

They are normally due to abnormal and unforeseen causes, they can occur at any time, they can easily reach out of proportion magnitudes, and their consequences can be disastrous.

Tsunamis are typical examples of irregular oscillations in the time series of the sea waves breaking on the shore.

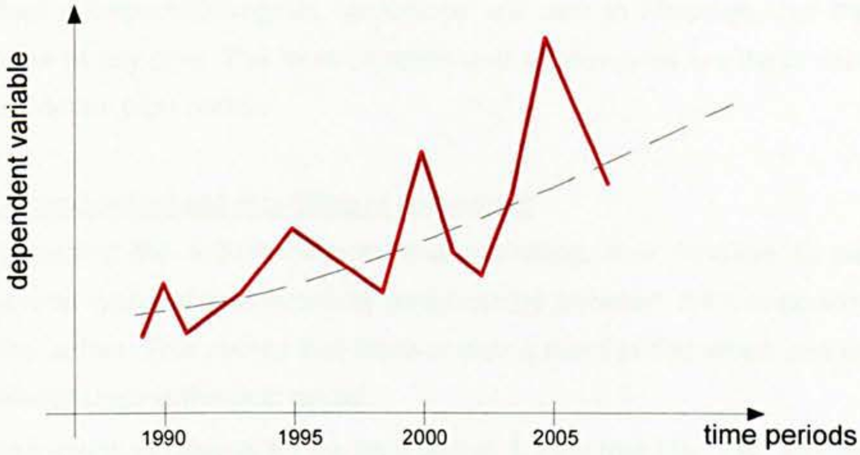

Figure 3-6 - Time series with a cyclic oscillation

3.3.2.9 Expected water consumption variations in hospitals

In the particular case of regional hospitals, the prevalent variations to be expected are those due to the trend (increases on the overall services rendered to the communities over the years), and those due to seasonal variations.

It is common knowledge that water consumption patterns in regional hospitals show clear seasonal oscillations in their magnitudes. These are the cases of down periods of non-urgent medical services in August and by Christmas, sharp increases in water consumption as from the first week of the year, higher daily water consumptions on Mondays, lowest on Sundays, etc.

In hospitals, it is therefore expected to find water consumption seasonal oscillations of different returning periods, some over the hours of the day, others over the days of the week and still others over the weeks and the months of the year.

In addition, for each of these periods, the water consumption will also be influenced by the prevalent ambient temperature, relative humidity, etc.

No cyclic water consumption variations are to be expected in regional hospitals, as the irregular epidemic outbreaks may only have very negligible influences of the cyclic type.

Accordingly, cyclic oscillation components in water consumption patterns of regional hospitals are expected to be very close to one in multiplicative decomposition methods. This matter will be discussed later.

Real unexpected/irregular oscillations are rare in hospitals, but they can occur at any time. The most common and serious ones are those caused by accidental pipe bursts.

3.3.2.10 Decomposition and modelling of time series

Regarding the actual mathematical modelling, it is possible to establish several types of mathematical relationships between the components of a time series. This means that there is also a need to find which one of these relationships is the best model.

Representing (always for the time period $\mathbf{t}_i$) the trend by $\mathbf{TR}_i$, the seasonal component by $\mathbf{SN}_i$, the cyclic component by $\mathbf{CL}_i$ and the irregular component by $\mathbf{IR}_i$, the relationship between these components can be

a) a "multiplicative composition", if the components are related by an expression of the form

$$\mathbf{p}_i = \mathbf{TR}_i \times \mathbf{SN}_i \times \mathbf{CL}_i \times \mathbf{IR}_i \tag{3.1}$$

b) an "additive composition", if the components are related by an expression of the form

$$\mathbf{p}_i = \mathbf{TR}_i + \mathbf{SN}_i + \mathbf{CL}_i + \mathbf{IR}_i \tag{3.2}$$

c) or a "mixed composition", of a more complex nature, when the relationship among the components involves multiplications and additions, such as, for example

$$\mathbf{p}_i = (\mathbf{TR}_i + \mathbf{SN}_i) \times \mathbf{CL}_i + \mathbf{IR}_i \tag{3.3}$$

Although it is normally difficult to anticipate which one of the composition models will best fit a particular series, it may be said that, in general but not as a definite rule, multiplicative models are better for series with variable seasonal oscillations (the case of the precipitations occurring in pluviometer stations over the years), and additive models are better for series with constant seasonal variations (such as the sun rise and the sun set hours along the year).

Nevertheless, it is often necessary to make several attempts until an acceptable model is found for a series.

3.3.3 Multiplicative decomposition models

3.3.3.1 Introduction

In line with the definitions introduced in paragraph 3.3.2.4 to 3.3.2.8 above, the aim now is to analyse water consumption records by numerical methods as defined in "Análise Exploratória de Dados" [27], "Forecasting, Time Series and Regression" [28], "Análise de Sucessões Cronológicas" [29], and "Estatística Aplicada à Economia e Administração" [30], in order to tentatively identify, define and evaluate the accuracy of the factors of a multiplicative model of the general form (equation 3.1)

$$\mathbf{p_i = TR_i \times SN_i \times CL_i \times IR_i}$$

in which,

$\mathbf{p_i}$ is the most probable value for the series at time period $\mathbf{t_i}$

$\mathbf{TR_i}$ is the trend component at time period $\mathbf{t_i}$,

$\mathbf{SN_i}$ is the component of the seasonal oscillation at time period $\mathbf{t_i}$,

$\mathbf{CL_i}$ is the component of the cyclic oscillation at time period $\mathbf{t_i}$, and

$\mathbf{IR_i}$ is the component of the irregular variation at time period $\mathbf{t_i}$.

3.3.3.2 "Moving average" and "centred moving average"

Still in accordance with "Análise Exploratória de Dados" [27], "Forecasting Time Series and Regression - An Applied Approach" [28], and "Análise de Sucessões Cronológicas" [29]), let $\mathbf{(t_i, r_i)}$ be a set of $\mathbf{n}$ data pairs, in which $\mathbf{r_i}$ are the values of the dependent variable, at equally spaced time periods $\mathbf{t_i}$.

If $\mathbf{k}$ is the number of seasons of the considered period, and if the average of the first $\mathbf{k}$ values of the dependent variable $\mathbf{r_i}$ is calculated, we will have the "first $\mathbf{k}$ - period" average.

Subtracting the value of $\mathbf{r_1}$ from the sum of the first $\mathbf{k}$ values, adding to that difference the value of $\mathbf{r_{k+1}}$ and dividing again by $\mathbf{k}$, we get the "second $\mathbf{k}$ - period" average.

Repeating the process successively until the last group of $\mathbf{k}$ values is averaged, a total of $\mathbf{(n-k+1)}$ "moving averages" are obtained, with each of them centred in the middle of the respective "$\mathbf{k}$ - period".

It must be noted that the term "moving average" is used here because the successive averages are calculated one after the other by eliminating the "oldest" observation contributing to the last average calculated, and including the following "newest" observation of the time series, for the calculation of the following average.

If $\mathbf{k}$ is even, each of the moving averages will be centred in-between the two central time periods/seasons of the $\mathbf{k}$ interval. Therefore, in order to obtain averages centred at seasons with even values of $\mathbf{k}$, it is necessary to calculate first the averages of every two consecutive $\mathbf{k}$ periods, and calculate afterwards their own average. The first of these new "centred" averages will be centred at the season of order $(\frac{\mathbf{k}}{\mathbf{2}}+\mathbf{1})$, and the others will follow at $\mathbf{t}$ intervals until the last one, of order $\left(\mathbf{n}-\frac{\mathbf{k}}{\mathbf{2}}\right)$.

A total of $(\mathbf{n}-\mathbf{k})$ centred moving averages will therefore be calculated, if $\mathbf{k}$ is even.

On the other hand, if $\mathbf{k}$ is odd, each of the averages will be centred at the middle season of the interval. The first of these averages will then be centred at the season of the order $(\frac{\mathbf{k}+\mathbf{1}}{\mathbf{2}})$, and the others will follow at $\mathbf{t}$ intervals until the last one of order $\left(\mathbf{n}-\frac{\mathbf{k}-\mathbf{1}}{\mathbf{2}}\right)$. A total of $(\mathbf{n}-\mathbf{k}+\mathbf{1})$ centred moving averages will therefore be calculated with odd values of $\mathbf{k}$.

Moving averages centred at successive seasons are called "centred moving averages", and are normally represented by $\mathbf{cma_i}$, with $\mathbf{i}$ indicating the order of the $\mathbf{k}$ season at which it is centred.

A numeric value calculated for $\mathbf{cma_i}$ is the point estimate of $\mathbf{CMA_i}$, the most probable value of the centred moving average at time period/season $\mathbf{t_i}$.

In view of the above, it may be concluded that the seasons at which the values of $\mathbf{cma_i}$ are centred are

a) $\mathbf{i}=\left(\frac{\mathbf{k}}{\mathbf{2}}+\mathbf{1}\right),\ldots,\left(\mathbf{n}-\frac{\mathbf{k}}{\mathbf{2}}\right)$ if $\mathbf{k}$ is even, with a total of $(\mathbf{n}-\mathbf{k})$ centred moving averages, or

b) $i = \left(\frac{k+1}{2}\right), \dots, \left(n - \frac{k-1}{2}\right)$ if k is odd, with a total of $(n-k+1)$ centred moving averages.

In practical terms, the 12 months or the 52 weeks of the year are normally the seasons considered for the analysis of water consumption data.
Therefore, for annual periods of 12 seasons of 1 month each, there will be a total of $n-12$ centred moving averages, starting at cma_7 and ending at cma_{n-6}, and for annual periods of 52 seasons of 1 week each, there will be a total of $n-26$ centred moving averages, starting at cma_{27} and ending at cma_{n-26}.
The centred moving average methodology for periods of 12 months (or 52 weeks), has the disadvantage of neglecting the values of the first 6 months (or of the first 26 weeks), and the values of the last 6 months (or of the last 26 weeks) of the available records.
While the loss of the first $k/2$ records (the oldest) should not constitute a serious disadvantage, the loss of the last $k/2$ values (the most recent) may be much more significant. The reason for this is that as time goes by, older information tends to lose importance and/or relevance for the evaluation of the very latest tendencies of the time series.
For that reason, some authors suggest that extrapolations of the last values should be used, to get at least some indication of the latent tendencies.
The candidate considers that this will not constitute a matter of major concern for the analysis of water supply patterns to regional hospitals, because their components are not expected to experience any seasonal variations outside of the ranges of the values previously recorded.
The main advantage of the centred moving averages is that they tend to produce smoother transformed series. This is so because the evolution of the averages of sets of successive k values (of the original series) will have to have a smoother variance than that of the individual terms of the series at which they are centred.
If the centred moving averages methodology is applied to sets of values with one only season of each period, the process tends to "average-out" the short term components, namely the seasonal and the irregular components.

As such, only the longer term components of the original series tend to remain, namely the trend and the cyclic components.

3.3.3.3 Multiplicative decomposition of time series into their main components

As previously mentioned, a model of the type of equation 3.1 is now envisaged.

To rephrase our objective, the aim is to determine the components $\mathbf{TR_i}$, $\mathbf{SN_i}$, $\mathbf{CL_i}$ and $\mathbf{IR_i}$ of equation 3.1, so that it becomes the best fitting multiplicative model for a particular set of numeric records.

It must be said in advance that, in view of the expected water consumption patterns in Hospitals (i.e., mainly trend and seasonal components), the values of $\mathbf{CL_i}$ and $\mathbf{IR_i}$ are expected to be close to 1. Accordingly, for regional hospitals, the actual regression equation is expected be of the form

$$\mathbf{p_i = TR_i \times SN_i} \qquad (3.4)$$

The actual numeric process will need to be implemented in several intermediate steps, with the application of successive rational criteria in each one of them. These steps are

a) Determination of the $\mathbf{cma_i}$ values

The calculation of each of the $\mathbf{n-k}$ successive centred moving averages (because $\mathbf{k}$ is even, namely 12 months or 52 weeks) tend to approach the value of $\mathbf{tr_i \times cl_i}$, which is the point estimate of $\mathbf{TR_i \times CL_i}$.

This is so because the averaging process tends to "average out" both the seasonal oscillation $\mathbf{sn_i}$ (because one only value from each season is considered for the average), and the noise components $\mathbf{ir_i}$ (because of their rather fortuitous nature).

However, it is expected that neither the long term tendency $\mathbf{tr_i}$ nor the cyclic component $\mathbf{cl_i}$ will be affected by the averaging process.

Therefore, each value of $\mathbf{cma_i}$ will tend to approach the corresponding value of $\mathbf{tr_i \times cl_i}$, i.e.,

$$\mathbf{cma_i = tr_i \times cl_i} \qquad (3.5)$$

where $i = 7,8,...,n-6$ and $n-12$ centred moving averages will be calculated if the number of seasons in the year is $L = 12$ months, or $i = 27,28,...,n-26$ and $n-52$ centred moving averages will be calculated if the number of seasons in the year is $L = 52$ weeks.

b) Evaluation of the products $sn_i \times ir_i$

From the original equation 3.1, and considering also equation 3.5, it is concluded that

$$sn_i \times ir_i = \frac{r_i}{tr_i \times cl_i} = \frac{r_i}{cma_i} \tag{3.6}$$

i.e., the value of each of the $n-k$ products $sn_i \times ir_i$ can be calculated via the corresponding values of the centred moving averages.

c) Determination of the seasonal factors sn_i

The elimination of the irregular components ir_i tends to be achieved when the values of $sn_i \times ir_i$ are sorted by like seasons and then averaged.

Provisional values $sn_j(prov)$ of the seasonal component of the order j are thus obtained ($j = 1,2,...,L$).

Since the sum of all the seasonal factors will have to be exactly the total number of seasons ($L = 12$ or $L = 52$ for the cases under consideration), the first approaches $sn_j(prov)$ must then be refined, by multiplying each of these individual L values by the refining factor

$$\chi = \frac{L}{\sum_{j=1}^{j=L} sn_j(prov)} \tag{3.7}$$

to obtain each of the refined and final seasonal values SN_j. Obviously, $j = 1,2,...,L$.

d) Deseasonalised data

It is now possible to "deseasonalise" the original data, by dividing each of the $\mathbf{n}$ initially recorded values $\mathbf{r_i}$ by the corresponding (month or week) seasonal factors $\mathbf{SN_j}$.

The improved $\mathbf{n}$ values, which we shall represent as $\mathbf{D_i}$, are therefore available for the determination of the trend regression.

e) Trend regression

Various mathematical models for the trend can be obtained by applying the deseasonalised data to equations 3.11 to 3.14 (below), and the respective coefficients of determination can also be obtained by the application of equation 3.72 (also below) to those models.

The highest value of the Coefficient of Determination will indicate the best fitting trend equation.

The corresponding $\mathbf{n}$ values of $\mathbf{TR_i}$ $(\mathbf{i = 1,2,...,n})$ can then be calculated and tabled.

f) Determination of the cyclic oscillations $\mathbf{CL_i}$

So far, all $\mathbf{TR_i}$ and $\mathbf{SN_j}$ values are known. Accordingly, and again from equation 3.1, it is concluded that

$$\mathbf{CL_i \times IR_i = \frac{r_i}{TR_i \times SN_j}} \quad (3.8)$$

with $\mathbf{i = 1,2,...,n}$ and $\mathbf{j = 1,2,...,L}$.

As indicated in "Forecasting, Time Series and Regression" [28], the values of $\mathbf{CL_i}$ can then be extracted from the values of $\mathbf{CL_i \times IR_i}$, because experience shows that the components $\mathbf{IR_i}$ can be averaged out.

In fact, experience shows that, for moving averages, three periods are sufficient to average out the $\mathbf{IR_i}$ components from the products $\mathbf{CL_i \times IR_i}$, i.e.,

$$\mathbf{CL_i = \frac{CL_{i-1}IR_{i-1} + CL_iIR_i + CL_{i+1}IR_{i+1}}{3}} \quad (3.9)$$

with $i = 2,3,...,n-1$.

g) Determination of the irregular components IR_i

Finally, the irregular components IR_i can be calculated because

$$IR_i = \frac{CL_i \times IR_i}{CL_i} \quad (i = 2,3,...,n-1) \qquad (3.10)$$

3.3.3.4 Conclusions

As detailed above, a comprehensive numerical analysis of the available data can be performed, and with this analysis a first mathematical model is obtained.

At the same time, the smoothed values of the various components obtained in the modelling process constitute themselves new improved sets of data, to be subsequently used for the determination of the equations of the trend and of the seasonal components of the hospital's water supply patterns.

Irregular components excluded, these models can then be used to prepare short to medium term forecasts.

As the water consumption patterns in stable regional hospitals should be free from noticeable irregular and cyclic oscillations, their modelling process should be based on their trend and seasonal components only.

However, when the trend components are noticeable, their removal is not only possible but recommended (for analysis purposes only!), to allow for an "uncontaminated" seasonal analysis.

Accordingly, if the trend analysis leads to the conclusion that non-negligible trend components are present in the global patterns, these TR_i components must be removed from the data, to allow for a better determination of the SN_j values. In turn, these values multiplied by the applicable trend values, will produce a forecast for p_i of the form of equation 3.4:

$$p_i = TR_i \times SN_i$$

3.3.4 Trend - Analytical analysis

3.3.4.1 Introduction

As previously defined, a trend is the long term and smooth evolution of a time series.

For the case of the global water consumption of a population, or parts thereof, the trend will always be dependent of random combinations of several possible external factors, such as changes in the behaviour of water users due to changing economic and social conditions, improved education, changes in the price of water, water scarcity or abundance, air temperature, improved technologies, commercial and/or community developments, etc.

These external causes, acting individually and/or in consonance, have a direct influence on the consumption of water by the communities, their hospitals, holiday resorts, etc.

Therefore, hospitals' water consumption records can be considered as a time series of two variables, one being the independent variable time period of consumption, and the other being the actual volume of water consumed during that time period.

Obviously, with the passing of time, the combined action of those external factors can produce growing, static or decreasing trends, as previously indicated.

3.3.4.2 Extension and worthiness of data records

The volume of data required to properly evaluate a time series and to produce acceptable forecasts in any prevailing circumstances, depends directly on the aim of the project and on the extension and accuracy of the available records.

For example, twenty or even less years of records of precipitation and flow records may be acceptable to define the hydraulic project of a much needed dam to produce staple food in a Developing Country, while two to three centuries of records may not be sufficient to define the influence of the prevalent diet on the average height of a population.

In the case of hospitals working in stable conditions for several years, with the same infrastructure and for the same stable community, some 3 to 5 years of consumption records will certainly be a solid basis for an acceptable trend analysis and modelling, and also for the analysis and modelling of their monthly and weekly seasonal variations.

Omissions of reliable data, due to missing and/or erratic records, will have to be routinely handled under the assumption that missing occurrences can be considered to be either,

a) the average between the equivalent anterior and the equivalent posterior reliable records if they both exist, or,

b) if either the equivalent anterior or the equivalent posterior occurrences have not been reliably recorded, the missing record can than be considered to be equal, respectively, to the posterior or to the anterior equivalent occurrences, or,

c) if neither the equivalent anterior nor the equivalent posterior occurrences have been reliably recorded, the missing records will then have to be considered to be equal to an expected rationale value, carefully chosen in function of the neighbouring reliable records.

3.3.4.3 Trend modelling

The trend is normally the easiest component of a time series to be mathematically modelled.

In order to establish how the trend can be analytically defined ("Estatística" [26]), let $(\mathbf{t_i},\mathbf{r_i})$ (with $\mathbf{t_i}$ discrete, $\mathbf{r_i} \in \Re$ and $\mathbf{i} \in [\mathbf{1},\mathbf{n}] \in \Im$) be a time series consisting of $\mathbf{n}$ pairs of recorded values of the variables $\mathbf{t}$ and $\mathbf{r}$, in which $\mathbf{t_i}$ is the time period of order $\mathbf{i}$ (the independent variable), and $\mathbf{r_i}$ is the value of the dependent variable at that same time period.

The aim is to define the equation of the best fitting line, i.e., the equation of the line fitting those $\mathbf{n}$ pairs of values $(\mathbf{t_i},\mathbf{r_i})$ with the highest possible accuracy.

Although other equations may at times be found, in practice the most commonly used to define trends are monomial functions, of the type of equations 3.11 to 3.14 below.

As already indicated (paragraph 3.3.2.3), the values given by any of those equations for the dependent variable at the time period $\mathbf{t_i}$, are called the "most probable values of the dependent variable", and are represented by $\mathbf{p_i}$ (being $\mathbf{p_i} \in \Re$ and $\mathbf{i} \in [\mathbf{1},\mathbf{n}] \in \Im$).

The actual forms of these most common equations are

a) logarithmic functions $$\mathbf{p_i} = \mathbf{a} + \mathbf{b} \ln \mathbf{t_i} \qquad (3.11)$$

b) straight line functions $p_i = a + bt_i$ (3.12)

c) exponential functions $p_i = ae^{bt_i}$ $(a>0)$ (3.13)

d) and power functions of the type $p_i = at_i^b$ $(a>0)$ (3.14)

All the above four equations incorporate two numeric constants $\mathbf{a}$ and $\mathbf{b}$, which are real numbers known as "regression coefficients". It is evident that they have to be numerically defined in terms of the sets of data (t_i, r_i).

A quick reference has also to be made to the Logistic Function ("Estatística", [26] and "Análise Exploratória de Dados" [27]), with an equation of the form $p_i = \frac{c}{1+ae^{-bt_i}}$, where $\mathbf{a}$, $\mathbf{b}$ and $\mathbf{c}$ are also constants numerically defined in terms of the sets of data (t_i, r_i).

However, for records of human water consumptions, the logistic function is suited for application to trends over many decades, centuries even (for example, the evolution of the *per capita* water consumption in Tokyo, from 1850 to the present day). Accordingly, this function will not be considered here, because the extension of the available records does not exceed five years.

3.3.4.4 <u>Basic statistical values associated with each data pair (t_i, r_i)</u>

Each pair of recorded data values (t_i, r_i) will be uniquely associated with their most probable value p_i, as given by the best fitting trend line (Figure 3-7).

Furthermore, there is still a forth parameter that is uniquely associated with the whole set of recorded data (t_i, r_i). It is the "mean" value of the dependent variables, defined numerically as

$$r_{mean} = \frac{\sum_{i=1}^{i=n} r_i}{n} \quad (3.15)$$

Since the mean does not take into consideration the time periods of occurrence, it can be considered as the expected value of r_i at any time

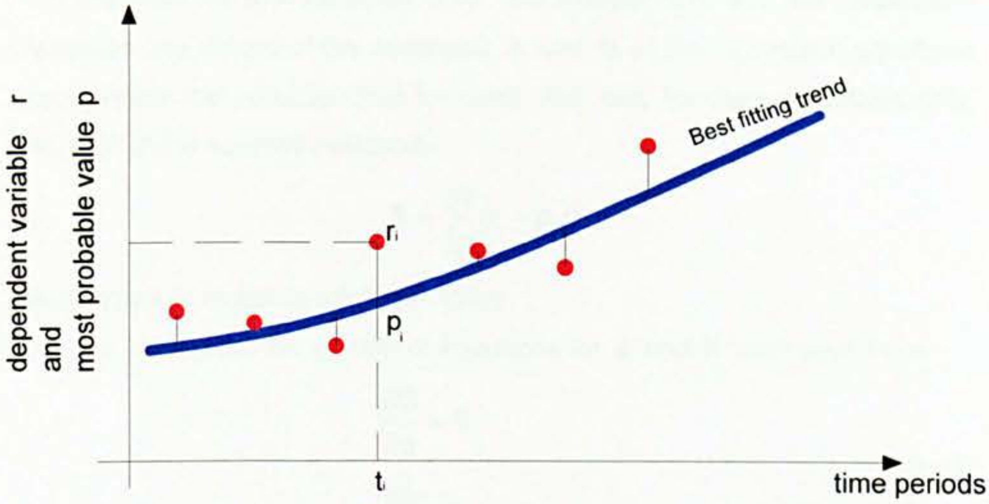

Figure 3-7 - Recorded value r_i and most probable value p_i at time period t_i

period. It can therefore be considered as the first approximation for all values of r_i.

It is clear that the mean is a rougher approximation than is the most probable value p_i, precisely because the latter considers the values of r_i at their actual time periods of occurrence.

In view of the above, it is concluded that, for analytical purposes, each recorded data pair t_i, r_i is associated with two further values, the most probable value p_i and the mean value r_{mean}.

3.3.4.5 <u>The least squared methodology</u>

Regarding the accuracy of the actual regression process ("Estatística" [26]), it must be noted that any methods of curve drawing by sentiment, to fit a trend curve to a particular set of data, are subjective and dependant on the operator's judgement.

However, it is evident that any subjective solution will not constitute a unique, let alone the best fitting solution for any particular set of data.

Scientific rigour and discipline impose that only the best fitting curves should be used, and in this respect the least squared methodology is a valuable contribution, as it applies logical mathematical calculations to determine the equation that best fits a particular set of data.

For the case of two variables only, the independent and the dependent variables, the values of the constants **a** and **b** of the regression equations must satisfy the condition that for them, and only for them simultaneously, the sum of the squared residuals

$$S = \sum_{i=1}^{i=n} (r_i - p_i)^2$$

must reach its absolute minimum value.

For this to happen, the system of equations for **a** and **b** shall have to be

$$\frac{\partial S}{\partial a} = 0 \qquad\qquad (3.16)$$

$$\frac{\partial S}{\partial b} = 0$$

In this context, it must be noted that the algebraic sum of the residuals, i.e.,

$$Sum = \sum_{i=1}^{i=n} (r_i - p_i)$$

cannot be used for the determination of the best fitting lines, because each of the individual residuals $(r_i - p_i)$ can be positive or negative, and their algebraic sum will thus be lower than that of the sum of the absolute values of those differences. Accordingly, the sum to be minimised must be that of the squared residuals, as indicated above.

3.3.4.6 Deduction of regression coefficients and statistical properties

As the deduction, by the least squared methodology, of the coefficients **a** and **b** for equations 3.11 to 3.14, can be found in several undergraduate text books, these expressions will simply be introduced without their deduction.

However, the least squared methodology is deemed to be of interest for application in the deduction of sinusoidal and trend linear regressions with one and with two independent variables, because no such deductions were found in the reference material. Accordingly, it is included in this report.

Thus, if any mathematical deduction is included in the text, it is because it was not found elsewhere.

3.3.4.7 Simple logarithmic regressions

a) Regression coefficients

It is envisaged to define the equations of the regression coefficients **a** and **b** of the logarithmic equation 3.11

$$\mathbf{p_i = a + b \ln t_i}$$

so that this equation (Figure 3-8) becomes the best fitting logarithmic trend line for the set of **n** data pairs $(\mathbf{t_i, r_i})$ (i.e. it becomes the equation for which the sum of the squared residuals will reach its minimum value).

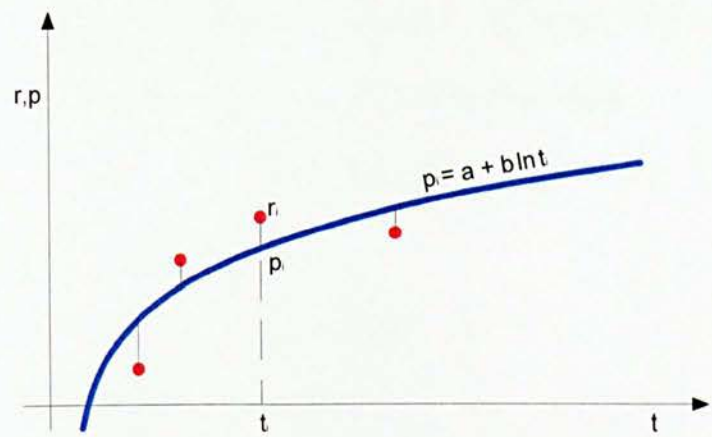

Figure 3-8 - Simple logarithmic linear regression

The application of the system of equations 3.16 to equation 3.11 leads to

$$\mathbf{a = \frac{1}{n}\left(\sum_{i=1}^{i=n} r_i - b\sum_{i=1}^{i=n} \ln t_i\right)} \tag{3.17}$$

and

$$\mathbf{b = \frac{\sum_{i=1}^{i=n} \ln t_i \sum_{i=1}^{i=n} r_i - n\sum_{i=1}^{i=n} r_i \ln t_i}{\left(\sum_{i=1}^{i=n} \ln t_i\right)^2 - n\sum_{i=1}^{i=n} (\ln t_i)^2}} \tag{3.18}$$

Therefore, for a set of **n** data pairs $(\mathbf{t_i, r_i})$, equations 3.17 and 3.18 give the coefficients **a** and **b** for the best fitting logarithmic regression equation $\mathbf{p_i = a + b \ln t_i}$.

b) Statistic properties

The application of the set of equations 3.16 to the sum of the squared residuals of equation 3.11 results in

$$S = \sum_{i=1}^{i=n}(r_i - p_i)^2 = \sum_{i=1}^{i=n}(r_i - a - b\ln t_i)^2$$

This equation will reach its minimum value if, and only if, simultaneously,

$$\frac{\partial S}{\partial a} = -2\sum_{i=1}^{i=n}(r_i - a - b\ln t_i) = -2\sum_{i=1}^{i=n}(r_i - p_i) = 0 \qquad (3.19)$$

and

$$\frac{\partial S}{\partial b} = -2\sum_{i=1}^{i=n}\ln t_i(r_i - a - b\ln t_i) = -2\sum_{i=1}^{i=n}\ln t_i(r_i - p_i) = 0 \qquad (3.20)$$

From equation 3.19 it is forthwith concluded that

$$\sum_{i=1}^{i=n}(r_i - p_i) = 0 \qquad (3.21)$$

or

$$\sum_{i=1}^{i=n} r_i = \sum_{i=1}^{i=n} p_i \qquad 3.22)$$

or, dividing both terms by n,

$$r_{mean} = p_{mean} \qquad (3.23)$$

From equation 3.20 it is also concluded that

$$\sum_{i=1}^{i=n} r_i \ln t_i = \sum_{i=1}^{i=n} p_i \ln t_i \qquad (3.24)$$

and from equation 3.11 it is further concluded that

$$\sum_{i=1}^{i=n} p_i = na + b\sum_{i=1}^{i=n}\ln t_i$$

or, dividing by n,

$$p_{mean} = a + b\frac{\sum_{i=1}^{i=n}\ln t_i}{n} \qquad (3.25)$$

c) Practical conclusions

The following conclusions are of practical value when applying the best fitting logarithmic regressions:

i) the sum of all residuals is zero (equation 3.21),

ii) the mean of all residuals is also zero (equation 3.21),

iii) the sum of all recorded values is equal to the sum of all corresponding most probable values (equation 3.22),

iv) the mean of all recorded values is equal to the mean of all corresponding most probable values (equation 3.23),

v) the sum of the products of the recorded values by the logarithms of their time periods of occurrence, is equal to the sum of the products of the same logarithms by the corresponding most probable values (equation 3.24), and

vi) the best fitting logarithmic line contains the point of coordinates (equation 3.25).

$$\mathbf{p_{mean}} \text{ and } \frac{\sum_{i=1}^{i=n} \ln t_i}{n}$$

3.3.4.8 Simple straight line regressions

a) Regression coefficients

Equation 3.12 for the straight line regression is

$$\mathbf{p_i = a + bt_i}$$

It is now envisaged to find the regression coefficients **a** and **b** of the best fitting straight line equation (Figure 3-9).

The application of the set of equations 3.16 to equation 3.12 leads to

$$\mathbf{a} = \frac{1}{n}\left(\sum_{i=1}^{i=n} r_i - b\sum_{i=1}^{i=n} t_i\right) \tag{3.26}$$

and

$$b = \frac{n\sum_{i=1}^{i=n} r_i t_i - \sum_{i=1}^{i=n} t_i \sum_{i=1}^{i=n} r_i}{n\sum_{i=1}^{i=n} t_i^2 - \left(\sum_{i=1}^{i=n} t_i\right)^2} \tag{3.27}$$

Therefore, for a set of **n** data pairs $(\mathbf{t_i, r_i})$, equations 3.26 and 3.27 give the coefficients **a** and **b** for the best fitting straight line regression $\mathbf{p_i = a + bt_i}$ (equation 3.12).

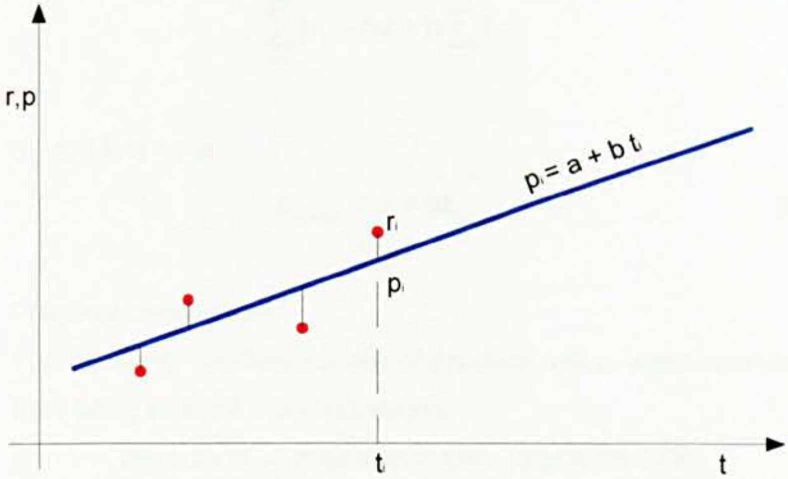

Figure 3-9 – Simple straight linear regression

b) Statistic properties

Following again the same reasoning as for the case of the logarithmic regression, namely

$$\frac{\partial \mathbf{S}}{\partial \mathbf{a}} = \frac{\partial}{\partial \mathbf{a}} \sum_{i=1}^{i=n} (\mathbf{r}_i - \mathbf{a} - \mathbf{b}\mathbf{t}_i)^2 = -2\sum_{i=1}^{i=n} (\mathbf{r}_i - \mathbf{p}_i) = \mathbf{0}$$

it is concluded that

$$\sum_{i=1}^{i=n} (\mathbf{r}_i - \mathbf{p}_i) = \mathbf{0} \tag{3.28}$$

or

$$\sum_{i=1}^{i=n} \mathbf{r}_i = \sum_{i=1}^{i=n} \mathbf{p}_i \tag{3.29}$$

or

$$\mathbf{r}_{mean} = \mathbf{p}_{mean} \tag{3.30}$$

Similarly,

$$\frac{\partial \mathbf{S}}{\partial \mathbf{b}} = \frac{\partial}{\partial \mathbf{b}} \sum_{i=1}^{i=n} (\mathbf{r}_i - \mathbf{a} - \mathbf{b}\mathbf{t}_i)^2 = -2\sum_{i=1}^{i=n} \mathbf{t}_i(\mathbf{r}_i - \mathbf{p}_i) = \mathbf{0}$$

from which it is concluded that

$$\sum_{i=1}^{i=n} \mathbf{t}_i(\mathbf{r}_i - \mathbf{p}_i) = \mathbf{0} \tag{3.31}$$

or

$$\sum_{i=1}^{i=n} \mathbf{r}_i\mathbf{t}_i = \sum_{i=1}^{i=n} \mathbf{p}_i\mathbf{t}_i \tag{3.32}$$

Furthermore,

$$\sum_{i=1}^{i=n} p_i = na + b\sum_{i=1}^{i=n} t_i$$

or, dividing by **n**

$$p_{mean} = a + bt_{mean} \qquad (3.33)$$

c) Practical conclusions

The following conclusions are of practical value when applying the best fitting straight line regressions:

i) the sum of all residuals is zero (equation 3.28),

ii) the mean of the residuals is also zero (equation 3.28),

iii) the sum of all recorded values is equal to the sum of the corresponding most probable values (equation 3.29),

iv) the mean of all recorded values is equal to the mean of all corresponding most probable values (equation 3.30),

v) the sum of the products of the recorded values by their time periods of occurrence, is equal to the sum of the products of the same time periods by the corresponding most probable values (equation 3.32).

vi) the best fitting straight line contains the point of coordinates t_{mean} and p_{mean} (equation 3.33).

3.3.4.9 <u>Simple exponential regressions</u>

a) Regression coefficients

It is now envisaged to find the regression coefficients **a** and **b** of the best fitting exponential equation 3.13

$$p_i = ae^{bt_i} \quad (a > 0)$$

as shown in Figure 3-10.

For this particular case, it is recommended to transform the original data set (t_i, r_i), into the transformed set $(t_i, \ln r_i)$. In fact, applying logarithms to equation 3.13, the result obtained is

$$\ln p_i = \ln a + bt_i$$

which is the equation of a straight line.

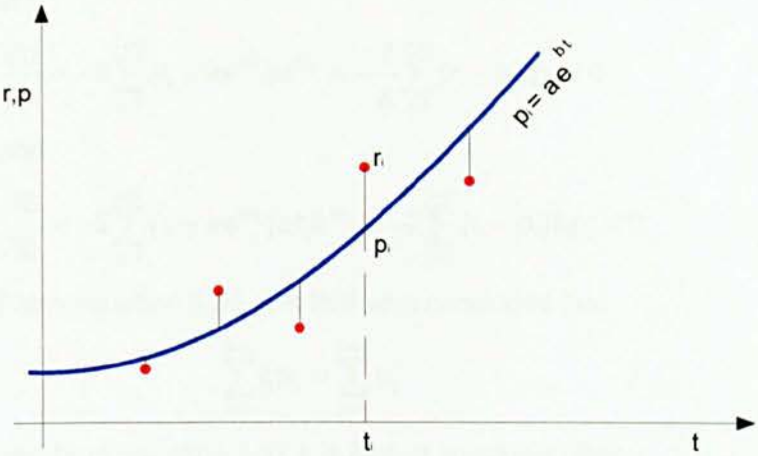

Figure 3-10 - Simple exponential linear regression

Hence, equations 3.26 and 3.27 are valid, if the data set $(\mathbf{t_i}, \mathbf{\ln r_i})$ is considered instead of the original set $(\mathbf{t_i}, \mathbf{r_i})$. Therefore, it follows that

$$\ln a = \frac{1}{n}\left(\sum_{i=1}^{i=n} \ln r_i - b\sum_{i=1}^{i=n} t_i\right)$$

or

$$a = e^{\frac{1}{n}\left(\sum_{i=1}^{i=n} \ln r_i - b\sum_{i=1}^{i=n} t_i\right)} \tag{3.34}$$

and

$$b = \frac{n\sum_{i=1}^{i=n} t_i \ln r_i - \sum_{i=1}^{i=n} t_i \sum_{i=1}^{i=n} \ln r_i}{n\sum_{i=1}^{i=n} t_i^2 - \left(\sum_{i=1}^{i=n} t_i\right)^2} \tag{3.35}$$

Consequently, for a set of **n** data pairs $(\mathbf{t_i}, \mathbf{r_i})$, equations 3.34 and 3.35 give the coefficients **a** and **b** for the best fitting exponential regression $\mathbf{p_i = ae^{bt_i}}$.

b) Statistic properties

Again, following the same reasoning as for the previous regressions, it is concluded that

$$S = \sum_{i=1}^{i=n} (r_i - p_i)^2 = \sum_{i=1}^{i=n} (r_i - ae^{bt_i})^2$$

and

$$\frac{\partial S}{\partial a} = -2\sum_{i=1}^{i=n}(r_i - ae^{bt_i})e^{bt_i} = -\frac{2}{a}\sum_{i=1}^{i=n}(r_i - p_i)p_i = 0 \qquad (3.36)$$

and

$$\frac{\partial S}{\partial b} = -2\sum_{i=1}^{i=n}(r_i - ae^{bt_i})at_ie^{bt_i} = -2\sum_{i=1}^{i=n}(r_i - p_i)t_ip_i = 0 \qquad (3.37)$$

From equation 3.36, it is forthwith concluded that

$$\sum_{i=1}^{i=n} r_ip_i = \sum_{i=1}^{i=n} p_i^2 \qquad (3.38)$$

and from equation 3.37 it is further concluded that

$$\sum_{i=1}^{i=n} r_ip_it_i = \sum_{i=1}^{i=n} p_i^2t_i \qquad (3.39)$$

c) Practical conclusions

The following conclusions are of practical value when applying exponential regressions:

i) the sum of the products of the recorded values by their corresponding most probable values, is equal to the sum of the squares of the same most probable values (equation 3.38),

ii) the sum of the products of the recorded values by their corresponding most probable values and by their time periods of occurrence, is equal to the sum of the products of the same time periods of occurrence by the squares of their most probable values (equation 3.39).

3.3.4.10 Simple power regressions

a) Regression coefficients

It is now envisaged to find the regression coefficients **a** and **b** of the best fitting power equation (equation 3.14)

$$p_i = at_i^b \quad (a>0)$$

as shown in Figure 3-11.

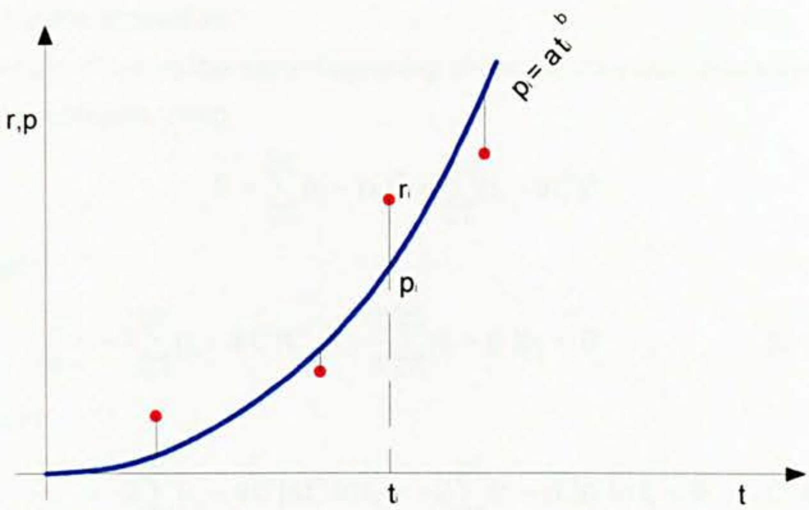

Figure 3-11 – Simple power linear regression

It is again recommended to transform the original data set (t_i, r_i), into the transformed set $(\ln t_i, \ln r_i)$. In fact, applying logarithms to equation 3.14, we obtain

$$\ln p_i = \ln a + b \ln t_i$$

which is again the equation of a straight line. Hence, equations 3.26 and 3.27 are valid if the data set $(\ln t_i, \ln r_i)$ is considered instead of the original set (t_i, r_i).

Therefore, it follows that

$$\ln a = \frac{1}{n} \left(\sum_{i=1}^{i=n} \ln r_i - b \sum_{i=1}^{i=n} \ln t_i\right)$$

or

$$a = e^{\frac{1}{n}\left(\sum_{i=1}^{i=n} \ln r_i - b \sum_{i=1}^{i=n} \ln t_i\right)} \qquad (3.40)$$

and

$$b = \frac{n\sum_{i=1}^{i=n} \ln t_i \ln r_i - \sum_{i=1}^{i=n} \ln t_i \sum_{i=1}^{i=n} \ln r_i}{n\sum_{i=1}^{i=n} \ln t_i^2 - \left(\sum_{i=1}^{i=n} \ln t_i\right)^2} \qquad (3.41)$$

Therefore, for a set of n data pairs (t_i, r_i), equations 3.40 and 3.41 give the coefficients a and b of the best fitting power regression equation $p_i = at_i^b$.

b) Statistic properties

Again following the same reasoning as for the previous regressions, it is concluded that

$$S = \sum_{i=1}^{i=n}(r_i - p_i)^2 = \sum_{i=1}^{i=n}(r_i - at_i^b)^2$$

and

$$\frac{\partial S}{\partial a} = -2\sum_{i=1}^{i=n}(r_i - at_i^b)t_i^b = -\frac{2}{a}\sum_{i=1}^{i=n}(r_i - p_i)p_i = 0 \qquad (3.42)$$

and

$$\frac{\partial S}{\partial b} = -2\sum_{i=1}^{i=n}(r_i - at_i^b)at_i^b \ln t_i = -2\sum_{i=1}^{i=n}(r_i - p_i)p_i \ln t_i = 0 \qquad (3.43)$$

From equation 3.42 it is forthwith concluded that

$$\sum_{i=1}^{i=n} r_i p_i = \sum_{i=1}^{i=n} p_i^2 \qquad (3.44)$$

and from equation 3.43 it is also concluded that

$$\sum_{i=1}^{i=n} r_i p_i \ln t_i = \sum_{i=1}^{i=n} p_i^2 \ln t_i \qquad (3.45)$$

c) Practical conclusions

The following conclusions are of practical value when applying power regressions:

i) The sum of the products of the recorded values by their most probable values, is equal to the sum of the squares of the most probable values (equation 3.44).

ii) The sum of the products of the recorded values by their most probable values and by the logarithms of their time periods of occurrence, is equal to the sum of the products of those logarithms by the squares of their most probable values (equation 3.45).

3.3.5 Analysis of seasonal oscillations

3.3.5.1 Introduction

In addition to the trend, or long term tendency of a time series, domestic water supply patterns usually show typical signs of seasonal oscillations.

The following concepts apply to the analysis of seasonal patterns, as indicated in "Análise Exploratória de Dados" [27], "Forecasting, Time Series and Regression" [28] and "Análise de Sucessões Cronológicas" [29]:

a) "Period" of a seasonal pattern

The classical definition of the "period of an oscillation" applies: "Period", or "Returning Period" of a seasonal oscillation, represented hereinafter by $\mathbf{T}$, is the equal time gap between any two consecutive peaks, or between any two consecutive troughs, or between any two consecutive homologous time periods ($\mathbf{t}_i$ and $\mathbf{t}_i + \mathbf{T}$) of the seasonal pattern.

Typical domestic water consumption returning periods are the day, the week and the year.

b) Seasons

"Seasons" are the equal time intervals, into which the returning periods of the periodic patterns are divided for analysis purposes.

Therefore, each individual returning period $\mathbf{T}_k$ (with $\mathbf{k} = 1,2,...,\mathbf{N}$) will consist of a total of $\mathbf{L}$ seasons of constant duration $\mathbf{t}$, and all the seasons of one returning period are equal to all the seasons of the other returning periods of the same analysis, i.e.,

$$\mathbf{T}_1 = \mathbf{T}_2 = ...\mathbf{T}_k = ... = \mathbf{T}_N = \mathbf{T} = \sum_{j=1}^{j=L} \mathbf{t}_j = \mathbf{Lt} \qquad (3.46)$$

with $\mathbf{t}_1 = \mathbf{t}_2 = ... = \mathbf{t}_j = ... = \mathbf{t}_L = \mathbf{t}$.

i) In the case of returning periods of one day ($\mathbf{T} = 1$ day), the season normally adopted is the hour. In such cases, the seasons shall be of $\mathbf{t}_j = 1$ hour, with $\mathbf{j} = 1,2,...,\mathbf{L}$, and $\mathbf{L} = 24$ seasons.

$\mathbf{N}$ shall then be the total number of returning periods (days) of recorded data available.

It must be noted that where more precise conclusions are envisaged, shorter seasons are, at times, used. A quarter of an hour is the smallest season normally considered by water authorities, corresponding to daily periods of 96 seasons, each of 15 minutes.

These short seasons are useful to locate the precise peaks of consumption. However, it must also be noted that the use of too short seasons, may tend to be inconsequent, due to the much higher probability of drastic variations in-between consecutive seasons.

ii) If weekly periods are considered ($\mathbf{T = 1}$ week), the season normally adopted is the day, i.e., $\mathbf{t_j = 1}$ day, $\mathbf{j = 1, 2, \ldots, L}$, and $\mathbf{L = 7}$ seasons. **N** will then be the total number of weeks of recorded data available for the analysis.

iii) In the case of annual periods ($\mathbf{T = 1}$ year), the seasons are usually either the week or the month.

If the season is the week, i.e., if $\mathbf{t_j = 1}$ week, then $\mathbf{j = 1, 2, \ldots, L}$ and $\mathbf{L = 52}$ seasons. **N** will be the total number of years of recorded data available.

Alternatively, if the season is the month, i.e., if $\mathbf{t_j = 1}$ month, then $\mathbf{j = 1, 2, \ldots, L}$ and $\mathbf{L = 12}$ seasons. In this case, **N** will again be the total number of years of recorded data available.

c) Seasonal oscillations with constant or with variable magnitudes

Seasonal oscillations of fairly constant magnitudes, have peaks and troughs of similar sizes during their successive returning periods.

A typical example of a seasonal oscillation with a constant magnitude, is the already mentioned evolution of the number of daylight hours during the days of the year ($\mathbf{T = 1}$ year and $\mathbf{L = 365}$ seasons of one day each), in latitudes between the Equator and the Arctic and the Antarctic Circles.

Seasonal oscillations with variable magnitudes, are those in which the size of the seasonal swings experience noticeable variations from one period to the next.

Typical examples of seasonal oscillations of variable magnitude are found in domestic water consumption patterns over the years in popular holiday resorts, where the volumes of water consumed, and their peaks, are directly related to the number of holidaymakers, and they in turn depend on the prevailing economic cycle, on the evolution of the "socialite" reputation of the resort, etc.

Needless to say, strong and irregular oscillations in the domestic water demand cause added design and operation difficulties for the water supply services, which should be able to accommodate those oscillations without causing the end users any unacceptable fluctuations in the quality or in the quantity of the water supplied to them.

In general, variable oscillations may also depend on the weather and other external factors. That is the case, for example, of the influenza spells in winter, which can be damped by vaccination campaigns, by other medical prevention measures, or simply by improved living conditions.

d) Regular and irregular seasonal oscillations

Regular seasonal oscillations are harmonic oscillations with near-sinusoidal patterns during the periods of analysis. The variation of the number of daylight hours during the days of the year in latitudes between the Equator and the Arctic or the Antarctic Circles, is once again a good example.

Irregular seasonal oscillations are oscillations with returning irregularities in their otherwise regular patterns. They are typically exemplified by the evolution of the total water consumption along the days of the week in Portuguese hospitals.

In fact, as indicated in Figure 3.12, the evolution of the daily global water consumption in a typical week at Hospital Amadora Sintra (the week of April 14th to 20th, 2008), is such that Mondays and Tuesdays are normally the days with the highest consumption (in part because of the linen accumulated for washing over the weekend), and Sundays are normally the days with the lowest consumption.

e) Typical seasonal water consumption patterns over the years

Figure 3-13 shows a typical seasonal water consumption pattern of a stable community along the years. Clearly, there is little or no

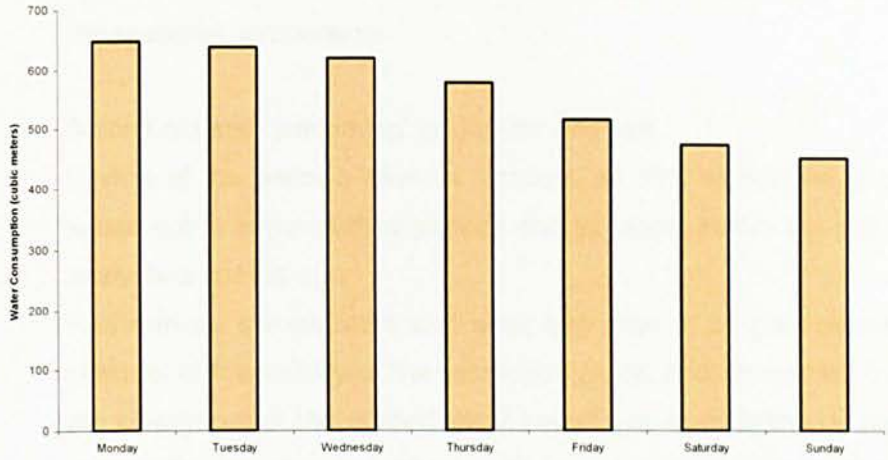

Figure 3-12 – Daily total water consumption at "Amadora Sintra", during the week of 14 April 2008

evolution on their water consumption habits with the passing of time, with peaks and troughs fairly constant in magnitude and in their time periods of occurrence.

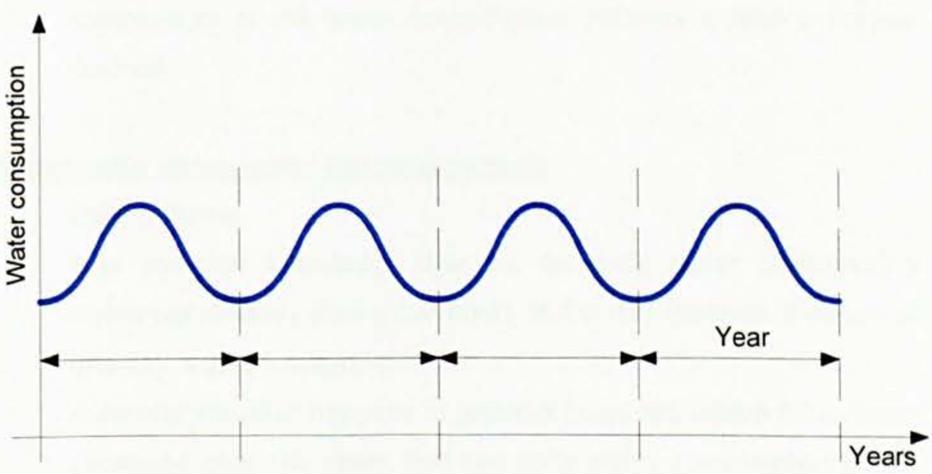

Figure 3-13 - Domestic water consumption over the years, in a stable community

f) Trend elimination

Trend elimination (after modelled, and for analysis purposes only) is often made, to produce clearer images of the other components of the time series. Needless to say, it can be expected that in fairly stable water supply patterns those "other components" shall only be the seasonal components.

g) Sorting out and "smoothing" of data for analysis

In view of the periodic analysis concept, all data shall have to be sorted out in terms of their periods and seasons, before the actual analysis is carried out.

Furthermore, the available data shall also have to be pre-analysed in terms of the validity of the recorded values, and all records that are clearly out of the context shall have to be substituted by new ones, within the range of values to be fairly expected in terms of the data evolution (for example, as indicated in paragraph 3.3.4.2 above).

These important pre-processing arrangements are normally referred to as "data smoothing".

In addition, and as mentioned in sub-paragraph f) above, the possibility of removing the trend to better enhance the periodic components of the water consumption patterns is also a normal practice.

3.3.5.2 <u>Common water consumption seasonal patterns</u>

a) Daily patterns

It is common knowledge that the domestic water consumption varies significantly during the hours of the day (periods of return of one day, with 24 seasons).

A parallel situation happens in regional hospitals, where it has been perceived over the years that two daily water consumption peaks exist, these being normally, one in the morning and the other in the afternoon. They are of different magnitudes and asymmetrically distributed, with the highest being typically centred at around 09.00 hours, and the second highest at around 17.00 hours. Furthermore, very little consumption is also normally registered between 22.00 and 06.00 hours.

However, as described in paragraph 3.2.3.2 above, the peaks of the daily water consumption pattern at "Amadora Sintra" cannot be defined, because of the particular water supply system there installed.

b) Week patterns

As previously mentioned, and as shown in Figure 3-12 above, weekly water consumption patterns in hospitals are irregularly distributed over the days of the week, a returning period of analysis with 7 seasons.

In the domestic/residential sector, weekly variations are somewhat different, being closely tied to the economic and social statuses of the populations served. In fact, middle class residential areas have water consumption habits clearly differentiated between working days and weekends, whereas upper class areas tend to show no such accentuated variations between working and non working days.

c) Annual patterns

In stable communities, annual water consumption patterns tend to show regular harmonic oscillations over the months of the year.

A similar situation occurs in hospitals, except for the distinct reductions normally recorded during the summer holidays and over the Christmas period (as later referred and indicated in Figures 4.12 and 4.13 below).

However, it must be said that such localized variations of magnitude can also appear in the domestic sector. That is the typical case of communities with additional temporary populations (winter sports resorts, most popular seaside destinations, etc.), which can show localized consumption peaks and troughs varying from negligible to ten to twenty times their normal rates of water consumption.

3.3.5.3 Introduction to the analysis of periodic oscillations

a) Methodology

The analysis of periodic oscillations in water consumption records has to take into consideration the periods of analysis and their respective seasons, the constant magnitude or variability of the oscillations, and the single, multi-harmonic or even non-harmonic nature of the oscillations.

b) Pre-processing

The pre-processing of data to convert seasonal oscillations of variable magnitude into seasonal oscillations of constant magnitude, is a usual practice because the easiest seasonal oscillations to analyse are those with constant magnitudes.

Accordingly, in the case of seasonal oscillations of variable magnitudes, it is common practice to transform them into other oscillations of a quasi-constant magnitude. Needless to say, these transformations are for analysis purposes only.

This can be achieved by transforming the original set of data $(\mathbf{t_i}, \mathbf{r_i})$, into another set of data of the type $(\mathbf{t_i}, \mathbf{r_i^{\lambda}})$, with $0 < \lambda < 1$, and then analysing the transformed set of data.

Constant or quasi-constant seasonal oscillations are also often reached by changing the original set of data into the transformed set $(\mathbf{t_i}, \ln \mathbf{r_i})$.

Constant or quasi-constant seasonal oscillations should be expected only in yearly periods of analysis.

3.3.5.4 Trigonometric analysis of pure harmonic seasonal oscillations

Magnitudes of pure harmonic seasonal oscillations (with zero trend or with the trend removed), can be adequately modelled in terms of the general season $\mathbf{t_j}$, as indicated in "Análise Exploratória de Dados" [27].

The amplitude of pure harmonic oscillations, as previously stated, is such that

$$\mathbf{SN_{j1} = SN_{j2} = \ldots = SN_{jk} = \ldots = SN_{jN}}$$

for all seasons $\mathbf{t_j}$ of all periods $\mathbf{T_k}$ $(\mathbf{j = 1,2,\ldots,L}$ and $\mathbf{k = 1,2,\ldots,N})$.

Furthermore, and as indicated in paragraph 3.3.5.1.b) and in equation 3.46 above, all seasons $\mathbf{t_j}$ have the same duration, i.e.,

$$\mathbf{t_1 = t_2 = \ldots = t_j = \ldots = t_L = t}$$

and all the returning periods $\mathbf{T_k}$ also have their own equal duration, i.e.,

$$T_1 = T_2 = \ldots = T_k = \ldots T_N = T$$

Accordingly,

$$T = Lt$$

and, for pure harmonic oscillations, the expected magnitude SN_j of the oscillation in the season t_j of any period T_k, can be expressed in terms of a trigonometric function of the type

$$SN_j = A + B\cos\omega t_j + C\sin\omega t_j \qquad (3.47)$$

where A, B and C are the regression coefficients, to be determined by the least squared methodology.

The period T is related to the natural circular frequency ω by the basic equation $T = \frac{2\pi}{\omega}$, and the natural frequency f is defined as the inverse of the period: $f = \frac{1}{T} = \frac{\omega}{2\pi}$.

Equation 3.47 can therefore be re-written for any seasonal component SN_j of any period $T_k = T$ as

$$SN_j = A + B\cos\frac{2\pi}{T}t_j + C\sin\frac{2\pi}{T}t_j \qquad (3.48)$$

with $j = 1,2,\ldots,L$.

For determining the regression coefficients A, B and C, it is necessary to apply the general system of equations 3.16, to the sum of the squared residuals derived from the trigonometric regression 3.47 (or 3.48).

Accordingly, for the N periods of records, each with L seasons, the sum of the squared residuals shall have $N \times L$ parcels, and shall have to be of the form

$$S = \sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\left[r_{jk} - A - B\cos\omega t_j - C\sin\omega t_j\right]^2$$

Bearing in mind that S will reach its minimum value when, and only when, simultaneously (equations 3.16),

$$\frac{\partial S}{\partial A} = -2\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}(r_{jk} - A - B\cos\omega t_j - C\sin\omega t_j) = 0$$

and

$$\frac{\partial S}{\partial B} = -2\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}(r_{jk} - A - B\cos\omega t_j - C\sin\omega t_j)\cos\omega t_j = 0$$

and

$$\frac{\partial S}{\partial C} = -2\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}(r_{jk} - A - B\cos\omega t_j - C\sin\omega t_j)\sin\omega t_j = 0$$

it is concluded that

$$LNA + B\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\cos\frac{2\pi}{T}t_j + C\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\sin\frac{2\pi}{T}t_j = \sum_{k=1}^{k=N}\sum_{j=1}^{j=L}r_{jk} \qquad (3.49)$$

and

$$\begin{aligned} & A\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\cos\frac{2\pi}{T}t_j + \\ & +B\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\cos^2\frac{2\pi}{T}t + C\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\sin\frac{2\pi}{T}t_j\cos\frac{2\pi}{T}t_j = \\ & = \sum_{k=1}^{k=N}\sum_{j=1}^{j=L}r_{jk}\cos\frac{2\pi}{T}t_j \end{aligned} \qquad (3.50)$$

and

$$\begin{aligned} & A\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\sin\frac{2\pi}{T}t_j + B\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\cos\frac{2\pi}{T}t_j\sin\frac{2\pi}{T}t_j + \\ & +C\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\sin^2\frac{2\pi}{T}t_j == \sum_{k=1}^{k=N}\sum_{j=1}^{j=L}r_{jk}\sin\frac{2\pi}{T}t_j \end{aligned} \qquad (3.51)$$

The constants **L** and **N** are known, being respectively the number of seasons in each of the returning periods, and the number of recorded returning periods. Furthermore, some of the numeric coefficients of the last set of equations 3.49 to 3.51 can be simplified. In fact,

$$\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\cos\frac{2\pi}{T}t_j = N\sum_{j=1}^{j=L}\cos\frac{2\pi}{T}t_j$$

$$\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\sin\frac{2\pi}{T}t_j = N\sum_{j=1}^{j=L}\sin\frac{2\pi}{T}t_j$$

$$\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\cos^2\frac{2\pi}{T}t_j = N\sum_{j=1}^{j=L}\cos^2\frac{2\pi}{T}t_j$$

$$\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\sin\frac{2\pi}{T}t_j\cos\frac{2\pi}{T}t_j = N\sum_{j=1}^{j=L}\sin\frac{2\pi}{T}t_j\cos\frac{2\pi}{T}t_j$$

$$\sum_{k=1}^{k=N}\sum_{j=1}^{j=L}\sin^2\frac{2\pi}{T}t_j = N\sum_{j=1}^{j=L}\sin^2\frac{2\pi}{T}t_j$$

Therefore, the set of equations 3.49 to 3.51 becomes

$$ALN + BN\sum_{j=1}^{j=L}\cos\frac{2\pi}{T}t_j + CN\sum_{j=1}^{j=L}\sin\frac{2\pi}{T}t_j = \sum_{k=1}^{k=N}\sum_{j=1}^{j=L}r_{jk} \qquad (3.52)$$

and

$$AN\sum_{j=1}^{j=L}\cos\frac{2\pi}{T}t_j + BN\sum_{j=1}^{j=L}\cos^2\frac{2\pi}{T}t_j + \\ +CN\sum_{j=1}^{j=L}\sin\frac{2\pi}{T}t_j\cos\frac{2\pi}{T}t_j = \sum_{k=1}^{k=N}\sum_{j=1}^{j=L}r_{jk}\cos\frac{2\pi}{T}t_j \qquad (3.53)$$

and

$$AN\sum_{j=1}^{j=L}\sin\frac{2\pi}{T}t_j + BN\sum_{j=1}^{j=L}\cos\frac{2\pi}{T}t_j\sin\frac{2\pi}{T}t_j + \\ +CN\sum_{j=1}^{j=L}\sin^2\frac{2\pi}{T}t_j = \sum_{k=1}^{k=N}\sum_{j=1}^{j=L}r_{jk}\sin\frac{2\pi}{T}t_j \qquad (3.54)$$

This system of equations 3.52 to 3.54 is solvable for the coefficients $\mathbf{A}$, $\mathbf{B}$ and $\mathbf{C}$, which means that equation 3.48 is capable of modelling any season $\mathbf{j}$ of any period $\mathbf{k}$ ($\mathbf{j = 1,2,...,L}$ and $\mathbf{k = 1,2,...,N}$) of pure harmonic oscillations.

Finally, if this model satisfactorily reproduces recent records, it will be fair to use it to produce forecasts.

However, it must be noted that this method may only be suited to produce acceptable forecasts for the volumes of domestic water consumed weekly or monthly by stable communities (therefore, under pure harmonic seasonal oscillations).

It will therefore be a valid tool to plan the operation of water supply services to stable communities, with little variations from year to year.

In such cases, the period will be the year, the seasons will be either the 12 months or the 52 weeks of the year, and the data to be processed will be the total volumes of water consumed and recorded during each one of the $\mathbf{N \times 12}$ months or during each of the $\mathbf{N \times 52}$ weeks of the existing records.

However, if there are changes in the number of the water users (periodically or not), and/or in their routines and/or in their water consumption habits, this methodology will produce unacceptable forecasts.

3.3.5.5 "Dummy" regression analysis of irregular seasonal oscillations

3.3.5.5.1 Introduction

Irregular seasonal oscillations are typically found in the water consumption patterns of regional hospitals, when the returning periods are the weeks and the seasons are the days of the week (situation as indicated in Figure 3.12 above).

An expedite way to model these irregular oscillations in a single model, is to use the classic fictitious (or "dummy") variables methodology, as indicated in "Forecasting, Time Series and Regression" [28], to ensure that only the correct seasonal components are allocated to the corresponding seasons.

In essence, these "dummy" variables are independent multiplicative factors assuming the value **1** in the corresponding season, and the value **0** in all the other seasons of the period.

A usual way to apply this type of modelling is to select one of the seasons as the "reference season", and to use it as the basis to calculate all the other $\mathbf{L-1}$ seasons, by adding or by multiplying it, respectively, by the appropriate parcel or by the appropriate factor.

The "reference season" can be anyone of the seasons in the period of analysis but, from a practical point of view, the process becomes neater to apply if the season with the lowest magnitude is selected as the "reference season". In fact, in such cases, either all the parcels to add to the reference season will be positive, or all the multiplicative factors will be greater than one.

Incidentally, for weekly periods, the last season (day) of the period is Sunday, which is also the day of the week with the smallest water consumption in regional hospitals (see again Figure 3-12).

Furthermore, for well established regional hospitals running close to their design capacities, the global water consumption pattern remains fairly constant over the years.

If the trend is negligible, or even excluded for analysis purposes, a "dummy variables" model for the daily (seasonal) components of the global volumes of water consumed weekly in a hospital (with irregular seasonal oscillations) can be accomplished by $\mathbf{L}$ sums of $\mathbf{L+1}$ parcels, of the intuitive general form

$$SN_j = \frac{\sum_{k=1}^{k=N} r_{Lk}}{N} + \sum_{m=1}^{m=L} \left[\frac{\sum_{k=1}^{k=N} (r_{jk} - r_{Lk})}{N} \right] \times \alpha_{jm} \quad (j,m = 1,2,\ldots,L) \qquad (3.55)$$

where:

SN_j is the most probable amplitude of the generic seasonal component of season j ($j = 1,2,\ldots,L$),

N is the number of returning periods covered by the available records,

k is the generic period ($k = 1,2,\ldots,N$),

r_{jk} is the numeric value recorded for season j of returning period k,

r_{Lk} is the numeric value recorded for the last season of the period k, and

α_{jm} is the "dummy" variable, which assumes the value $\alpha_{jm} = 1$ when $j = m$, and the value $\alpha_{jm} = 0$ whenever $j \neq m$).

It must be noted that

i) all but one of the $L+1$ parcels of each of the L sums are multiplied by a "dummy" factor,

ii) all but one of those L "dummy" parcels become nil for all seasons of order 1 to $L-1$, and

iii) all the L "dummy" parcels become nil for the season of order L.

Since the reference season is simultaneously the lowest season, it is concluded that each of the seasonal values can be approached by adding a nil or a positive parcel to the average of the recorded "reference seasons".

In turn, the values of each of these positive quantities can be approached as the products of the "dummy" factors, by the average of the algebraic differences between each of the recorded r_{jk} values, and the corresponding "reference seasons" r_{Lk}.

It is again stressed that equation 3.55 is particularly suited for the case of irregular yearly water consumption seasonal patterns in hospitals, because the last seasons (namely the last week or the last month of the year) are, simultaneously, the seasons with the lowest water consumptions. Furthermore, and trend excluded, these lowest consumptions are fairly constant over the years.

It must be noted that model 3.55 is a static model, i,.e., it considers that the seasonal factors SN_j are constant for like seasons in all periods. That in turn means that the values of

$$\frac{\sum_{k=1}^{k=N} r_{Lk}}{N}$$

are constant for all seasons, and the values of

$$\sum_{m=1}^{m=L}\left[\frac{\sum_{k=1}^{k=N}(r_{jk}-r_{Lk})}{N}\right] \qquad (k=1,2,\ldots,N) \quad (j,m=1,2,\ldots,L)$$

are constant for each season of order j, in all periods of order k.

3.3.5.5.2 <u>"Dummy" models for year periods and weeks seasons</u>

For yearly periods of 52 weeks, and taking the last week of the year as the "reference season", equation 3.55 can model the weekly global water consumptions over the years as

$$SN_j = \sum_{k=1}^{k=N}\frac{r_{52k}}{N} + \sum_{m=1}^{m=52}\left[\frac{\sum_{k=1}^{k=N}(r_{jk}-r_{52k})}{N}\right]\times \alpha_{jm} \qquad (3.56)$$

with $(j,m=1,2,\ldots,52)$, where the last week of the year (i.e., $L=52$) is the "reference season", and

j is the order of the season (week),

k is the order of the year ($k=1,2,\ldots,N$),

N is the total number of years of existing records, and

α_{jm} is the "dummy" variable", which assumes the value $\alpha_{jm}=1$ when $j=m$, and the value $\alpha_{jm}=0$ whenever $j \neq m$.

Equation 3.56 also shows that, in each of the 52 sums of 53 parcels, 52 of the 53 parcels are multiplied by the "dummy" factor α_{jm}.

Furthermore, 51 out of those 52 "dummy" parcels become nil for weeks 1 to 51, and all of the 52 "dummy" parcels become nil for week 52.

As indicated,

$$\frac{\sum_{k=1}^{k=N} r_{52k}}{N} = \text{constant} \quad (k = 1,2,\ldots,N)$$

and

$$\frac{\sum_{k=1}^{k=N} (r_{jk} - r_{52k})}{N} = \text{constant} \qquad (j = 1,2,\ldots,52)$$

for each of the weeks of order j.

3.3.5.5.3 "Dummy" models for yearly periods and monthly seasons

For the case of annual periods of 12 months, and if the month of December is chosen as the "reference season", the general equation 3.55 will model the constant irregular monthly global water consumption patterns over the years as

$$SN_j = \frac{\sum_{k=1}^{k=N} r_{12k}}{N} + \sum_{m=1}^{m=12} \left[\frac{\sum_{k=1}^{k=N} (r_{jk} - r_{12k})}{N} \right] \times \alpha_{jm} \qquad (3.57)$$

with $(j,m = 1,2,\ldots,12)$, and where

j is the order of the month ($1 \equiv$ January, $2 \equiv$ February, ...),

k is the order of the year ($k = 1,2,\ldots,N$),

N is the total number of years of existing records, and

α_{jm} is the "dummy" variable, and assumes the value $\alpha_{jm} = 1$ when $j = m$, and the value $\alpha_{jm} = 0$ whenever $j \neq m$.

Still similarly,

$$\frac{\sum_{k=1}^{k=N} r_{12k}}{N} = \text{constant} \quad (k = 1,2,\ldots,N)$$

and

$$\frac{\sum_{k=1}^{k=N} (r_{jk} - r_{12k})}{N} = \text{constant} \qquad (j = 1,2,\ldots,12)$$

for each of the months of order j.

Equation 3.57 also shows that, in each of the 12 sums of 13 parcels each, 12 of the 13 parcels are multiplied by the "dummy" factor α_{jm}, 11 out of those 12 parcels become nil for months 1 to 11, and all of the 12 "dummy" parcels are nil for month 12.

3.3.5.5.4 "Dummy" models for weekly periods and daily seasons

The general equation 3.55 should not be applied to the case of weekly periods of 7 days (seasons), because neither the global water consumption on Sundays is constant for all the Sundays of the year (i.e., the water consumption on a Sunday in August, is not expected to be the same as the water consumption on a Sunday in January), nor do the differences between the water consumptions during the various days of the week remain fairly unchanged throughout the year (i.e., the difference between the water consumption on a Monday and on the following Sunday in August, is different from the difference between the consumption on a Monday and the following Sunday in January).

3.3.5.5.5 "Dummy" models for yearly periods and daily seasons

Since the daily seasonal variations are fairly constant over the years, the daily consumptions over the years should be tentatively modelled by an equation considering the days as part of their weeks, of the form

$$\mathbf{SN}_{i,j} = \frac{\sum_{k=1}^{k=N} \mathbf{r}_{(i,j)k}}{\mathbf{N}} \quad (\mathbf{i} = 1,2,...,7 \text{ and } \mathbf{j} = 1,2,...,52) \qquad (3.58)$$

provided that an adequate volume of data exists, and where

$\mathbf{SN}_{i,j}$ is the most probable value for the global water consumption in the day of order $\mathbf{i}$ of week of order $\mathbf{j}$,

$\mathbf{i}$ is the day of the week ($\mathbf{i} = 1,2,...,7$), Monday being day $\mathbf{1}$,

$\mathbf{j}$ is the week of the year ($\mathbf{j} = 1,2,...,52$),

$\mathbf{k}$ is the year ($\mathbf{k} = 1,2,...,\mathbf{N}$)

$\mathbf{N}$ is the number of time periods (years) covered by the available data, and

$\mathbf{r}_{(i,j)k}$ is the global consumption recorded for the day of order $\mathbf{i}$, of the week of order $\mathbf{j}$, of the year of order $\mathbf{k}$,

Accordingly, $\mathbf{SN}_{27}$ will be, trend excluded, the most probable value for the global water consumption on the Tuesday of the 7th week of the year, and

$r_{(2,7)4}$ will be the value of the water consumption recorded for the Tuesday of the 7th week of the 4^{th} year of records.

3.3.5.6 Conclusions about the analysis of seasonal oscillations

Provided that the water supply system is fairly stable over the periods (years), the "dummy" regression method is, in general, the best methodology for the analysis of seasonal oscillations in water consumption patterns, because each seasonal component $\mathbf{SN}_{ji}$ is modelled individually.

This means that, with "dummy" variables, patterns with regular or with irregular seasonal oscillations are accommodated and modelled exactly in the same way and with the same simplicity.

However, equation 3.58 should be applied with great care (mainly in the first and in the last weeks of the year, when the variations are more drastic) as the same calendar day will have a cyclical rotation over the days of the week, with the passing of the years.

On the other hand, trigonometric regressions are much easier to handle, but should only be tried for very regular oscillations, as their complexity increases unnecessarily when irregular patterns are present.

3.3.6 Influence of the ambient temperature. Multiple linear regressions

3.3.6.1 Introduction

All the regressions analysed and proposed thus far, had in common the fact that the dependent variable $\mathbf{r}_i$ was always a univariate function of the independent variable $\mathbf{t}_i$.

However, other independent variables may simultaneously have direct impacts on the dependent variables. This is the case, for example, of the influence of the ambient temperature (another independent variable) on the volumes of domestic water consumed, i,e., in addition to the date or the hour of consumption, the ambient temperature may also influence sensibly the water consumption pattern.

In reality, many factors influence the consumption of domestic water but, for a constant population, it is fair to admit that the most important ones are exactly the time period of consumption and the ambient temperature at that time period.

Therefore, it is convenient to tie the water consumption with those two simultaneous independent variables.
The mathematical regression of univariate or multi-variable functions is basically the same.

3.3.6.2 Mathematical modelling and regression coefficients

3.3.6.2.1 Bivariate models

The generic model of the combined influences of those two independent variables will obviously be of the form

$$\mathbf{p}_i = \mathbf{f}(\mathbf{t}_i, \mathbf{q}_i) \qquad (3.59)$$

in which $\mathbf{q}_i$ is the independent variable temperature at the (also independent variable) time period $\mathbf{t}_i$

Equation 3.59 shall have to be deducted with the application of the least squared methodology. However, this must be done having in consideration that the dependence between the dependant variable "water consumption" and the two independent variables "ambient temperature" and "time period of occurrence", cannot be modelled by any of the univariate equations 3.11 to 3.14.
But the trends of those relationships can be, being also acceptable to apply afterwards the seasonal factors.

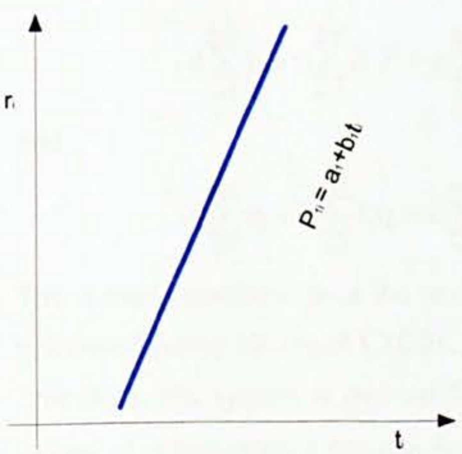

Figure 3-14 - Plot of r versus t

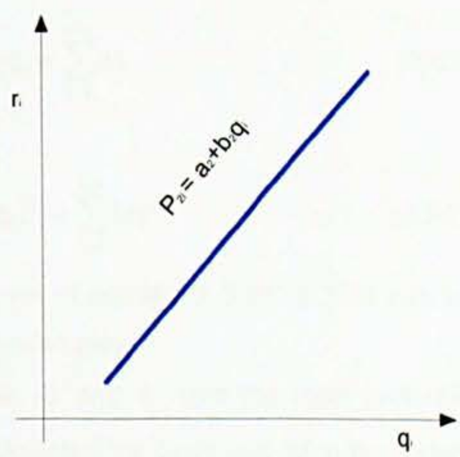

Figure 3-15 - Plot of r versus q

Accordingly, for a tentative approach, it seems to be fair to accept that straight lines will satisfactorily model those two individual relationships.
Let than be $\mathbf{p}_{1i} = \mathbf{f}_1(\mathbf{t}_i) = \mathbf{a}_1 + \mathbf{b}_1\mathbf{t}_i$ and $\mathbf{p}_{2i} = \mathbf{f}_2(\mathbf{q}_i) = \mathbf{a}_2 + \mathbf{b}_2\mathbf{q}_i$ the two relations under consideration (Figures 3.14.and 3.15).

In such case, it is still reasonable to expect that equation 3.59 will take the generic form

$$p_i = a + bt_i + cq_i \qquad (3.60)$$

Thus, the sum of the squared residuals becomes

$$S = \sum_{i=1}^{i=n}(r_i - a - bt_i - cq_i)^2$$

The three derivatives are, therefore (equations 3.16)

$$\frac{\partial S}{\partial a} = -2\sum_{i=1}^{i=n}(r_i - a - bt_i - cq_i) = 0$$

and

$$\frac{\partial S}{\partial b} = -2\sum_{i=1}^{i=n}t_i(r_i - a - bt_i - cq_i) = 0$$

and

$$\frac{\partial S}{\partial c} = -2\sum_{i=1}^{i=n}q_i(r_i - a - bt_i - cq_i) = 0$$

Hence, the system of equations for a, b and c is

$$na + b\sum_{i=1}^{i=n}t_i + c\sum_{i=1}^{i=n}q_i = \sum_{i=1}^{i=n}r_i \qquad (3.61)$$

and

$$a\sum_{i=1}^{i=n}t_i + b\sum_{i=1}^{i=n}(t_i)^2 + c\sum_{i=1}^{i=n}t_iq_i = \sum_{i=1}^{i=n}r_it_i \qquad (3.62)$$

and

$$a\sum_{i=1}^{i=n}q_i + b\sum_{i=1}^{i=n}t_iq_i + c\sum_{i=1}^{i=n}(q_i)^2 = \sum_{i=1}^{i=n}r_iq_i \qquad (3.63)$$

The numeric coefficients of the above set of equations 3.61 to 3.63 can be calculated (using Microsoft EXCEL, for example).

Therefore, the system is defined for a, b and c, and the most probable values of p_i (equation 3.60) can be calculated for each pair of independent variables (t_i, q_i).

The seasonal factors must then be applied.

3.3.6.2.2 Direct univariate models "ambient temperature - water consumption"

Since the dependence between the volumes of water consumed in a hospital and their time periods of occurrence can also be considered as a direct interdependence between water consumption and the prevailing ambient temperature, this relationship is also going to be investigated.

However, such investigation has to be done in strict accordance with the basic internal water requirements of the hospital, some of which cannot be considered as dependent on the prevailing temperature (laundry, kitchen, etc.), but rather on the weekly routines.

Accordingly, the daily consumptions were associated with the maximum temperature at the day of their occurrence, and were also grouped by the respective days of the week.

Seven sets of data (r_i, q_i) were thus considered, one for each day of the week, r_i being the volume of water consumed in day of order i, and q_i being the maximum temperature for that same day.

Regressions of the type of equations 3.11 to 3.14 can then be performed for each one of the days of the week.

3.3.7 Accuracy of regressions

3.3.7.1 Introduction

The previous chapters 3.3.4.7 to 3.3.4.10, 3.3.5.4, 3.3.5.5.1 to 3.3.5.5.5, 3.3.6.2.1 and 3.3.6.2.2 were focused on determining the best fitting regressions.

Those best fitting equations are a fundamental part of any analysis. However, they alone are not sufficient for a complete analysis, because they do not provide an idea of how well they fit their data.

In other words, they give the best global approximation of their family of curves (be they logarithmic, exponential, etc.) to the original set of data, but do not provide any indication of the precision of the actual fittings, let alone if one is better than the other.

Figure 3-16 shows two sets of data pairs and their best fitting lines $p_{1i} = f_1(a_1, b_1, t_i)$ and $p_{2i} = f_2(a_2, b_2, t_i)$.

It is clearly visible that the degree of accuracy of the regression shown at left is lower than that of the regression shown at right.

However, none of these equations provide an idea about their individual degrees of accuracy.

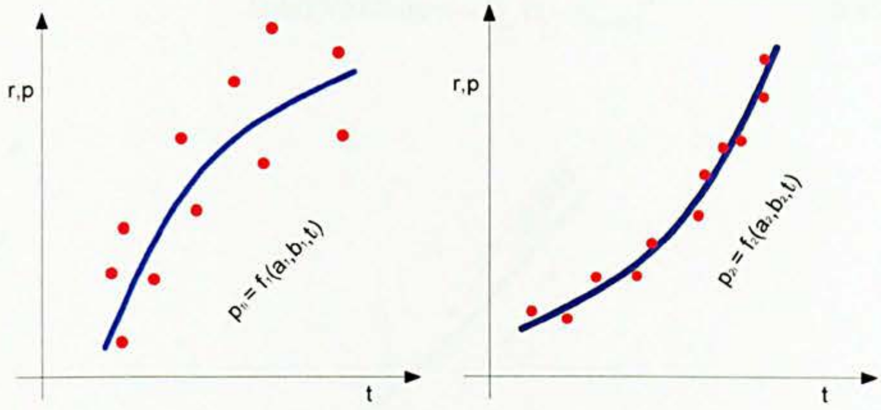

Figure 3-16 - Different degrees of trend accuracy

Needless to say, a quantification of the degree of accuracy is fundamental, not only for the analysis of past situations but also, and especially, when forecasts are envisaged.

As indicated in paragraph 3.3.3.4 above, when a set of data $(\mathbf{t_i},\mathbf{r_i})$ is analysed with the aim of defining a trend, each pair of initially recorded values $\mathbf{t_i},\mathbf{r_i}$ becomes uniquely associated with two other values, the most probable value $\mathbf{p_i}$ and the mean value $\mathbf{r_{mean}}$ (the later being unique to the whole set of values).

Accordingly, it is reasonable to expect that the values of $\mathbf{p_i}$ and $\mathbf{r_{mean}}$ will play a role in the definition of the degree of accuracy of the best fitting trend line of any set of recorded values $(\mathbf{t_i},\mathbf{r_i})$.

3.3.7.2 Definitions

The following definitions apply to both simple and multiple linear regressions (Figure 3-17), as indicated in "Estatística" [26] and "Estatística Aplicada à Economia e Administração" [30]:

a) "Residual", or "Prediction error" of an observation of order i, is the generic difference

$$\textbf{Residual of order } \mathbf{i} = \mathbf{r_i} - \mathbf{p_i} \qquad (3.64)$$

b) "Total variation" is the sum of the squared differences between each recorded value $\mathbf{r_i}$ and the mean value $\mathbf{r_{mean}}$, i.e.,

$$\textbf{total Variation} = \sum_{i=1}^{i=n} (r_i - r_{mean})^2 \tag{3.65}$$

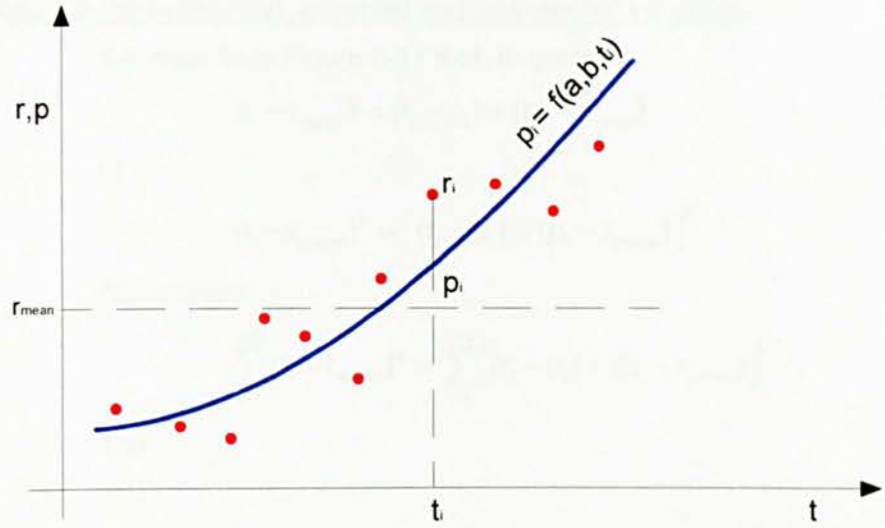

Figure 3-17 - Total, expected and unexpected variations

c) "Variance", represented normally by σ^2 is defined as

$$\textbf{Variance} = \sigma^2 = \frac{\sum_{i=1}^{i=n} (r_i - r_{mean})^2}{n} \tag{3.66}$$

d) "Expected variation" is the sum of the squared differences between each most expected value $\mathbf{p_i}$ and the mean value $\mathbf{r_{mean}}$, i.e.,

$$\textbf{Expected variation} = \sum_{i=1}^{i=n} (p_i - r_{mean})^2 \tag{3.67}$$

It represents the portion of the recorded values lying within the range of normally expected values.

e) "Unexpected variation" is the sum of all the squared prediction errors, i.e.,

$$\textbf{Unexpected variation} = \sum_{i=1}^{i=n} (r_i - p_i)^2 \tag{3.68}$$

It represents the portion of the recorded values lying outside the range of normally expected values. Needless to say, this equation

3.68 is nothing other than the basis for the application of the least squared methodology.

3.3.7.3 Relations between total, expected and unexpected variations

a) It is clear from Figure 3-17 that, in general,

$$(r_i - r_{mean}) = (r_i - p_i) + (p_i - r_{mean})$$

or

$$(r_i - r_{mean})^2 = \left[(r_i - p_i) + (p_i - r_{mean})\right]^2$$

Accordingly,

$$\sum_{i=1}^{i=n}(r_i - r_{mean})^2 = \sum_{i=1}^{i=n}\left[(r_i - p_i) + (p_i - r_{mean})\right]^2$$

and

$$\sum_{i=1}^{i=n}(r_i - r_{mean})^2 =$$

$$= \sum_{i=1}^{i=n}(r_i - p_i)^2 + \sum_{i=1}^{i=n}(p_i - r_{mean})^2 + 2\sum_{i=1}^{i=n}(r_i - p_i)(p_i - r_{mean})$$

The last parcel of this equation can still be written as

$$2\sum_{i=1}^{i=n}(r_i - p_i)(p_i - r_{mean}) =$$

$$= 2\sum_{i=1}^{i=n}p_i(r_i - p_i) - 2r_{mean}\sum_{i=1}^{i=n}(r_i - p_i) \tag{3.69}$$

b) In the case of a logarithmic regression ($p_i = a + b\ln t_i$), equation 3.69 can be rewritten as

$$2\sum_{i=1}^{i=n}p_i(r_i - p_i) - 2r_{mean}\sum_{i=1}^{i=n}(r_i - p_i) =$$

$$= 2a\sum_{i=1}^{i=n}(r_i - p_i) + 2b\sum_{i=1}^{i=n}\ln t_i(r_i - p_i) - 2r_{mean}\sum_{i=1}^{i=n}(r_i - p_i) = 0$$

due to equations 3.19 and 3.20.

c) In the case of a straight line regression ($p_i = a + bt_i$), equation 3.69 can be rewritten as

$$2\sum_{i=1}^{i=n} p_i(r_i - p_i) - 2r_{mean}\sum_{i=1}^{i=n}(r_i - p_i) =$$

$$= 2a\sum_{i=1}^{i=n}(r_i - p_i) + 2b\sum_{i=1}^{i=n} t_i(r_i - p_i) - 2r_{mean}\sum_{i=1}^{i=n}(r_i - p_i) = 0$$

due to equations 3.28 and 3.31.

d) In the case of an exponential regression ($p_i = ae^{bt_i}$, with $a > 0$), equation 3.69 can be rewritten as

$$2\sum_{i=1}^{i=n} p_i(r_i - p_i) - 2r_{mean}\sum_{i=1}^{i=n}(r_i - p_i) =$$

$$= 2a\sum_{i=1}^{i=n} e^{-bt_i}(r_i - p_i) - 2r_{mean}\sum_{i=1}^{i=n}(r_i - p_i) = -2r_{mean}\sum_{i=1}^{i=n}(r_i - p_i)$$

due to equation 3.36.

e) In the case of a power regression ($p_i = at_i^b$ $(a > 0)$, equation 3.69 can be rewritten as

$$2\sum_{i=1}^{i=n} p_i(r_i - p_i) - 2r_{mean}\sum_{i=1}^{i=n}(r_i - p_i) =$$

$$= 2a\sum_{i=1}^{i=n} t_i^b(r \; - p_i) - 2r_{mean}\sum_{i=1}^{i=n}(r_i - p_i) = -2r_{mean}\sum_{i=1}^{i=n}(r_i - p_i)$$

due to equation 3.42.

f) For logarithmic and for straight line regressions, equation 3.69 combined with equations 3.19 and 3.20, or 3.28 and 3.31, respectively, results in a relationship of the form

$$\sum_{i=1}^{i=n}(r_i - r_{mean})^2 = \sum_{i=1}^{i=n}(r_i - p_i)^2 + \sum_{i=1}^{i=n}(p_i - r_{mean})^2 \qquad (3.70)$$

which means that, for logarithmic and for straight line regressions, the total variation is equal to the sum of the expected and the unexpected variations.

Equation 3.70 establishes an unequivocal Pythagoras-like relationship between total, unexpected and expected variations, for the cases of logarithmic and straight line regressions. Therefore, in these cases, any one of the parcels can be directly calculated if the other two are known.

g) Similarly, for exponential and for power regressions, equation 3.69 combined, respectively, with equation 3.36 or 3.42, result in a relationship of the form

$$\sum_{i=1}^{i=n}(r_i - r_{mean})^2 = \sum_{i=1}^{i=n}(r_i - p_i)^2 + \sum_{i=1}^{i=n}(p_i - r_{mean})^2 - 2r_{mean}\sum_{i=1}^{i=n}(r_i - p_i) \qquad (3.71)$$

which means that, for exponential and for power regressions, the total variation is equal to the sum of the expected and the unexpected variations, minus twice the product of the mean by the sum of the residuals.

3.3.7.4 Coefficient of determination

"Coefficient of determination", or "Pearson's correlation coefficient", is the ratio between the expected and the total variations.

It represents the fraction of the total variation which can be considered expectable by the simple linear regression. In other words, it measures the degree of accuracy of the actual regression.

It is normally represented by c^2 and, defined as,

$$\textbf{coefficient of determination} = c^2 = \frac{\sum_{i=1}^{i=n}(p_i - r_{mean})^2}{\sum_{i=1}^{i=n}(r_i - r_{mean})^2} \qquad (3.72)$$

Due to the definitions of the expected and total variations, it is clear that

$$0 \le c^2 \le 1 \qquad (3.73)$$

3.3.7.5 Coefficient of correlation

Instead of c^2, it is often convenient to use the "coefficient of correlation" c, which is the square root of the former:

$$\textbf{Coefficient of correlation} = c = \pm\sqrt{c^2} \qquad (3.74)$$

because in this case it is possible to allocate a sign to c, to indicate the relative evolution of the two variables t and r.

In fact, it can be stipulated that c is positive if the two variables t and r increase or decrease simultaneously, and that c is negative when one of the variables increases and the other decreases simultaneously.

More precisely,

a) in the cases of logarithmic and straight line regressions, **c** is positive when $\mathbf{b>0}$, and is negative when $\mathbf{b<0}$, and

b) in the cases of power and exponential regressions, **c** is positive when **a** and **b** have the same sign, and are negative when **a** and **b** have different signs.

In view of equation 3.73, the value of **c** is such that

$$-1 \le c \le +1 \tag{3.75}$$

3.3.8 Cyclic oscillations and final conclusions on the analysis of water consumption patterns in regional hospitals

No cyclic oscillations can be expected in the water consumption patterns of regional hospitals because, in normal conditions, the very nature of the process only generates trend and seasonal oscillations.

This is a result of the actual services rendered in hospitals, including regional hospitals, where the work load is normally between 70% and full capacity, and where really abnormal rates of water consumption can only result from rather exceptional situations such as social unrest, abnormal epidemics, internal and/or external pipe bursts, etc.

3.4 Water consumption records

The available "as recorded" data (Annexe 1 and Figure 3-18), consists of intermittent daily records

a) of the volumes of water consumed for hospital use, as supplied by the municipality, and

b) of the volumes of water abstracted from the borehole sunk in the hospital's premises for the laundry and for the garden, as supplied by Hospital Amadora Sintra.

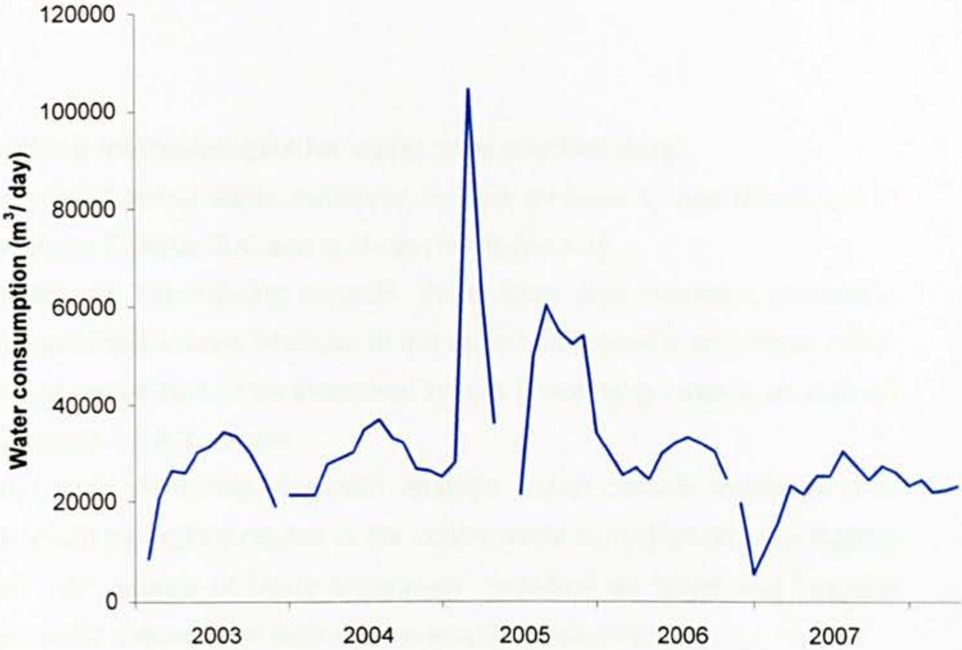

Figure 3-18 – Recorded data

Thus, the global water consumption of the hospital is the sum of the volumes of water abstracted from those two sources.

The records cover the following periods between 1 January 2003 and 3 May 2008,

i. From 1 February 2003 to 31 October 2003 (period equivalent to 273 full days, 38 full weeks and 9 full months),

ii. From 01 January 2004 to 31 January 2005 (period equivalent to 397 full days, 56 full weeks and 13 full months),

iii. From 12 December 2005 to 25 November 2006 (period equivalent to 349 full days, 49 full weeks and 10 full months), and

iv. From 02 February 2007 to 30 April 2008 (period equivalent to 454 full days, 63 full weeks and 14 full months).

In total, the available records cover 1465 full days, 206 full weeks and 46 full months.

3.5 Smoothing methodologies for water consumption data

The recorded global water consumption data (Annexe 1) was introduced in the previous Chapter **3.4**, and is shown in Figure 3-18.

In addition to the missing records, there were also recorded unrealistic and/or unreliable values because of the buried pipe bursts, and these rather abnormal values had to be smoothed before processing (criteria as defined in paragraph 3.3.4.2 above).

Without such smoothing, the data analysis would contain numerical data which would be neither related to the actual water consumption at "Amadora Sintra", nor capable of being statistically classified as "short and irregular components", because of their several months of duration.

It must be noted that those abnormal excessive flows have no influence in the working data and, as such, also have no influence on all the subsequent analyses and conclusions.

It must also be noted that those pipe bursts did not influence at all the actual water consumption inside the hospital, because they were bursts in buried pipes under a minimum guaranteed working pressure of not less that 300 kPa. The loss of water was therefore not noticeable in the hospital.

A second smoothing exercise was subsequently performed in specific situations, where it became clear that the first smoothing did produce also unrealistic values. This happened mainly with the older records, when the values resulting from the first smoothing were clearly out of context. Figure 3-19 shows one of such cases.

It contains a straight line regression of the consumption recorded in a particular month in successive years, and it shows that, while the values of $\mathbf{p}_{i2004}$ to $\mathbf{p}_{i2008}$ seem to be acceptable, the value of $\mathbf{p}_{i2003}$ is clearly out of contest.

The smoothed data will be the basis for all the subsequent analyses, and is referred to as "working data".

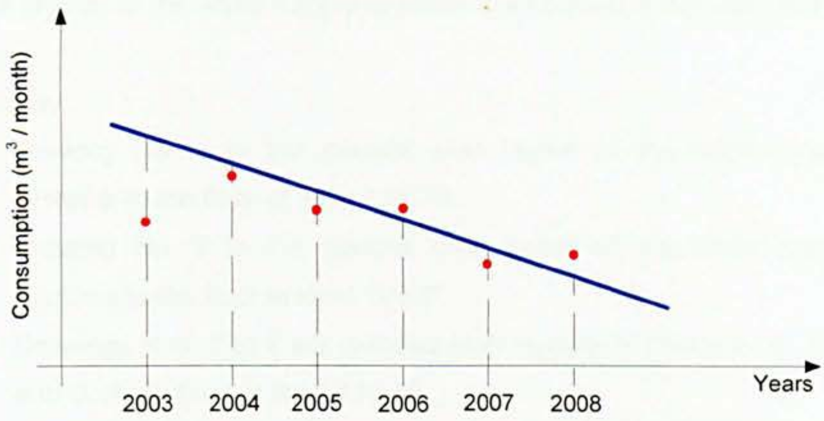

Figure 3-19 - Linear regression of the consumption records for a particular month along the years

The actual working data values will be introduced in paragraph 4.1 below.

3.6 Planning of the evaluation of the water requirements of the individual sections

3.6.1 Introduction

This chapter deals with the planning of the evaluation of the water consumption requirements of each of the hospital's forty internal sections, as this information will definitely contribute for future improved designs.

Unfortunately, it was not possible to include in this Thesis the actual unit water consumptions, because no funds were available to pay for the installation, and subsequent recovery of the water meters (to be kindly supplied free of charge by EPAL), and for the supply and installation of the required appurtenant valves.

However, recent contacts lead the author to believe that those funds may be available by early 2012.

If confirmed, the actual measuring campaign may take place during 2012.

For that, the three internal water supply networks (cold water, hot water and hot water return) were investigated to define the positions required for the water meters and isolating valves, so that their simultaneous records will allow for the determination of the individual water consumptions of each one of those sections.

The plan layouts of the water supply systems are detailed in the attached 17 drawings.

More exactly,

i. Drawing No. 1 is the general plan layout of the water supply systems to the floor at level 115,80,

ii. Drawing No. 7 is the general plan layout of the water supply systems to the floor at level 120,30,

iii. Drawings Nos. 2 to 6 are detailed plan layouts of Zones A, B, C, D and G of the floor at level 115,80,

iv. Drawings Nos. 8 to 14 are detailed plan layouts of Zones A, B, C, D, E, F and G of the floor at level 120,30,

v. Drawing Nos.15 and 16 are diagrammatic perspectives of the water supply networks to, respectively, Tower Amadora and Tower Sintra, and

vi. Drawing No.17 is a plan layout of the Technical Galery.

These drawings are attacked in A3 paper format in Annexe 10, and a CD is also included in the same Annexe for more detailed consultations.

3.6.2 Description of metering branches at level 1

3.6.2.1 Sector A (Administrative Area), Drawings Nos. 1 and 2

a) Sector A in Level 1 is the area where the central administrative core is located, namely the Administration and appurtenant bureaucratic services.

The only water consumption points in this area are the pantries and toilet facilities for the administrative staff.

b) The main Administrative Area has the following characteristics:

i.	Number of administrative workers	-	xxx workers
ii.	Area occupied (m^2)	-	xxx m^2

c) The unitary water consumptions (of cold water, hot water and total water consumption) of this section shall be evaluated in terms of the average daily consumption

i. per administrative employee,

ii. per square meter of area occupied by the service,

iii. per inhabitant served by the hospital, and

iv. per bed existing in the hospital.

d) The total cold water consumption of this sector shall be metered by CM04 (1½").

The incoming volume of hot water shall be metered by HM03 (1¼") and the outgoing volume of hot water shall be measured by RM03 (¾"). Thus, the actual volume of hot water consumed by this sector shall be the difference between the volumes recorded by meters HM03 and RM03, i.e.,

Total hot water consumption
in the Administrative Block = (3.76)
= HM03 - RM03

Accordingly, the total water consumption at the Administrative Block shall be such that

Total water consumption
in the Administrative Block = (3.77)
= CM04 + HM03 - RM03

e) Meters CM04, HM03 and RM03 shall be installed and removed with the temporary closing of existing valves CV02 (2"), HV02 (2"), and RV02 (1"), in Sector C.

3.6.2.2 Sector B (Staff Mess, Staff Coffee Shop, Linen Storage and control Services, Health at Work Head Office, Staff Training Department, Public Coffee Shop, Public Toilets, Staff toilets and Courtyard 19), Drawings Nos.1 and 3.

3.6.2.2.1 Staff Mess

This mess is actually a canteen serving hot meals to the hospital's employees, and is part and parcel of the main kitchen (described below in Sector D, paragraph 3.6.2.4.4).

3.6.2.2.2 Coffee Shop 1 (Staff)

a) This coffee shop is located next to the mess hall, and is only used by the staff. All types of sandwiches, pastries, soups, light meals, coffee and non alcoholic drinks are on offer daily, from 08.00 to 03.00 hours.

b) The Staff coffee shop has the following characteristics:

i. Area occupied - xxx m^2

c) The unitary water consumption (of cold water, hot water and total water consumption) of this section shall be evaluated in terms of the average daily consumption per square meter of area occupied.

d) The total cold water inflowing to this coffee shop shall be metered by CM45 (1¼").

The incoming volume of hot water shall be metered by HM29 (1¼"), and the outgoing volume of hot water shall be measured by RM04 (¾"). Thus, the actual volume of hot water consumed by this coffee shop shall be the difference between the volumes recorded by meters HM29 and RM33, i.e.,

Total hot water consumption
in the coffee shop for the staff = (3.78)
= HM29 – RM04

Accordingly, the total water consumption at the Coffee Shop shall be such that

Total water consumption
in the coffee shop for the staff = (3.79)
= CM45 + HM29 – RM04

e) Meters CM45, HM29 and RM04 shall be installed and removed with the temporary closing of existing valves CV17 (1½"), HV17 (1¼"), and RV17 (¾").

3.6.2.2.3 <u>Linen Services</u>

The clean linen dispensary has 1 hand wash basin and a toilet for the staff. This minor consumption shall be ignored.

3.6.2.2.4 "Health at Work" Head Office

a) There exists a Head Office of a "Health at Work" private company within the hospital premises, where only administrative work is done.

b) This private "Health at Work" Head Office has the following characteristics:

   i. Number of staff - xxx employees

   ii. Area occupied - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this administrative head office shall be evaluated in terms of the average daily consumption

   i. per square meter of area occupied by these services, and

   ii. per employee.

d) The total cold water flowing into the head office of the "Health at Work" company and into the training facilities shall be metered by CM09 (1¼"), but the net cold water consumption of that head office shall be determined by the difference between the volumes recorded by meters CM09 and CM26 (to the Training Sector), i.e.,

Total cold water consumption
in the "Health at Work Head Office" = (3.80)
= CM09 - CM26

Similarly, the total volume of hot water flowing into the "Health at Work" head office and into the Training Sector shall be metered by HM07 (1¼"), but the net hot water actually inflowing to the "Health at Work" head office, shall be the difference between the volumes recorded by meters HM07 and HM24 (Training Sector). This will be the net volume of hot water consumed by the "Health at Work" head office (because no hot water returning line exists out of the "Health at Work" head office). Thus,

Total hot water consumption
in the "Health at Work" Head Office = (3.81)
= HM07 - HM24

Accordingly, the total water consumption at the "Health at Work" head office shall be such that (equations 3.80 and 3.81)

Total water consumption
in the "Health at Work" Head Office = (3.82)
= CM09 – CM26 + HM07 – HM24

e) Meters CM09, CM26, HM07 and HM24 shall be installed and removed with the temporary closing of existing valves CV05 (1¼"), HV04 (1¼"), and RV16 (½").

3.6.2.2.5 Training Sector

a) The area dedicated to staff training comprises an amphitheatre, 3 multipurpose classrooms and ancillary supporting services and toilets.

b) The Training Sector has the following characteristics:
   i. Number of staff - xxx employees
   ii. Area occupied - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this sector shall be evaluated in terms of the average daily consumption
   i. per permanent training worker,
   ii. per square meter of area occupied by the training service,
   iii. per inhabitant served by the hospital,
   iv. per bed existing in the hospital, and
   v. per successful trainee.

d) The total cold water consumption of the Training Sector shall be metered by CM26 (1¼").
The incoming volume of hot water shall be metered by HM24 (1") and the outgoing volume of hot water shall be measured by RM20 (½"). Thus, the actual volume of hot water consumed by the

Training Sector shall be the difference between the volumes recorded by meters HM24 and RM20, i.e.,

Total hot water consumption
in the Training Sector = (3.83)
= HM24 - RM20

Accordingly, the total water consumption at the Training Sector shall be such that

Total water consumption
in the Training Sector = (3.84)
= CM26 + HM24 – RM20

e) Meters CM26, HM24 and RM20 shall be installed and removed with the temporary closing of existing valves CV05 (1¼"), HV04 (1¼"), and RV16 (½").

3.6.2.2.6 Coffee Shop 2 (Public)

a) This coffee shop, located in the main entrance, is used by visitors and staff alike. All types of sandwiches, pastries and non alcoholic drinks are served, but no hot meals.

b) The public coffee shop has the following characteristics:

i. Area occupied - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this section shall be evaluated in terms of the average daily consumption

i. per square meter of area occupied by the facility.

d) The total cold water inflowing to this coffee shop shall be metered by CM45 (1½").

The incoming volume of hot water shall be metered by HM41 (1"). This will be the net volume of hot water consumed at this coffee shop, because no hot water returning line exists out of it.

Accordingly, the total water consumption at this Coffee Shop shall be such that

Total water consumption
in the coffee shop 2 = (3.85)
= CM45 + HM41

e) Meters CM45 and HM41 shall be installed and removed with the temporary closing of existing valves CV05 (1½"), HV04 (1¼"), and RV16 (½").

3.6.2.2.7 Public Toilets

a) These toilet facilities, located in the main entrance, are used by visitors and out patients alike.

b) This Public Toilets have the following characteristic:
   i. Area occupied by the facility - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of these toilets shall be evaluated in terms of the average daily consumption
   i. per square meter of area occupied by the facility.

d) The total cold water inflowing to these public toilet facilities shall be metered by CM08 (1½").
The incoming volume of hot water shall be metered by HM06 (1"). This will be the net volume of hot water consumed at these public toilets, because no hot water returning line exists out of them.
Accordingly, the total water consumption at these toilets shall be such that

Total water consumption
in the public toilets = (3.86)
= CM08 + HM06

e) Meters CM08 and HM06 shall be installed and removed with the temporary closing of existing valves CV05 (1½"), HV04 (1¼"), and RV16 (½").

3.6.2.2.8 Staff toilets

a) These toilet facilities are at the entrance of the coffee shop and mess hall, and are primarily for staff use.

b) The Staff Toilets have the following characteristics:

   i. Area occupied - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of these toilets shall be evaluated in terms of the average daily consumption

   i. per square meter of area occupied by the facility.

d) The total cold water inflowing to these toilet facilities shall be metered by CM07 (1½").
The incoming volume of hot water shall be metered by HM08 (1"). This will be the net volume of hot water consumed at these toilets for the staff, because no hot water returning line exists out of them. Accordingly, the total water consumption at these toilets for the staff shall be such that

Total water consumption
in the toilets for the staff = (3.87)
= CM07 + HM08

e) Meters CM07 and HM08 shall be installed and removed with the temporary closing of existing valves CV17 (1½"), HV17 (1¼"), and RV17 (¾").

3.6.2.2.9 Courtyard 19

The water supply to this Courtyard shall be datailed together with Courtyard 5, in paragraph 3.6.2.5.6 below.

3.6.2.3 Sector C (Haemodialysis, Gastroenterology and Nephrology Ward and Technical Unit of Gastroenterology, Toilet Facilities for Patients, Consulting Rooms PA7, Technical Unit of Pneumology and Physical Medicine and Rehabilitation), Drawings 1 and 4

3.6.2.3.1 Haemodialysis

a) There exists a Haemodialysis unit with xxx posts in the Gastroenterology and Nephrology Ward, which shall be metered separately (cold water only).

b) The haemodialysis room has the following characteristics:
   i. Area of the haemodialysis room - xxx m^2.
   ii. Number of haemodialysis posts - xxx posts

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this haemodialysis room shall be evaluated in terms of the average daily consumption
   i. per medical employee attached to this unit,
   ii. per square meter of area occupied by the unit,
   iii. per haemodialysis post installed, and
   iv. per service rendered.

d) The total consumption of water of this unit shall be measured by CM03 (1").

e) This meter shall be installed and removed with the temporary closing of existing valve CV02 (2").

3.6.2.3.2 Gastroenterology and Nephrology Ward and Technical Unit of Gastroenterology

a) This ward has xxx beds and includes all the ancillary supporting services.

b) The Gastroenterology and Nephrology Ward and Technical Unit of Gastroenterology have the following characteristics:
   i. Number of staff - xxx employees
   ii. Area occupied - xxx m^2

c) The water supply system to the Gastroenterology and Nephrology Ward also supplies the Technical Unit of Gastroenterology, which consists of 8 hand wash basins. This is clearly a negligible volume of water if compared with the water consumption in the actual ward. Accordingly, for the purposes of this thesis, the volumes consumed by those hand wash basins and sinks shall be considered as part of the ward.

However, it must be noted that the most significant volume of water consumed in result of the existence of a technical unit of gastroenterology, is the volume of water used by the patients in the toilet facilities, after the exams are performed.

That will be treated in paragraph 3.6.2.3.3 below.

d) The unitary water consumption (of cold water, of hot water and total water consumption) of this section shall be evaluated in terms of the average daily consumption

i. per medical employee attached to this ward,
ii. per square meter of area occupied by the ward,
iii. per inhabitant served by the hospital,
iv. per bed installed in this ward, and
v. per bed installed in the hospital.

e) The total cold water flowing into the Gastroenterology and Nephrology Ward, and into the Technical Unit of Gastroenterology shall be metered by CM02 (1½"), but its net cold water consumption shall be determined by the difference between the volumes recorded by meters CM02 and CM03 (haemodialysis), i.e.,

Total cold water consumption in the Gastroenterology and Nephrology Ward, and in the Technical Unit of Gastroenterology = (3.88)
= CM02 – CM03

Similarly, the volume of hot water flowing into the Gastroenterology and Nephrology Ward and into the Technical Unit of Gastroenterology, shall be metered by HM02 (1½") and the volume of hot water flowing out shall be measured by RM02 (¾"). Thus, the actual volume of hot water consumed by the Gastroenterology and Nephrology Ward and by the Technical Unit of Gastroenterolog shall be the difference between the volumes recorded by meters HM02 and RM02, i.e.,

Total hot water consumption in the Gastroenterology and Nephrology Ward and in the Technical Unit of Gastroenterology =
= HM02 – RM02 (3.89)

Accordingly, the total water consumption at the Gastroenterology and Nephrology Ward, and at the Technical Unit of Gastroenterology shall be such that (equations 3.88 and 3.89)

Total water consumption in the Gastroenterology and Nephrology Ward and in the Technical Unit of Gastroenterology =
= CM02 - CM03 + HM02 - RM02 (3.90)

f) Meters CM02, CM03, HM02 and RM02, shall be installed and removed with the temporary closing of existing valves CV02 (2"), HV02 (2"), and RV02 (1").

3.6.2.3.3 <u>Toilet facilities for Patients at Consulting Rooms PA7</u>

a) These toilet facilities are used by the patients submitted to the medical exams made at the technical unit of gastroenterology (out patients only), and by the out patients being observed at Consulting Rooms PA7 (for consultations of gastroenterology, nephrology, pneumology and physical medicine and rehabilitation).

b) The Toilet facilities for Patients have the following characteristic:
   i. Area occupied - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of these toilets shall be evaluated in terms of the average daily consumption
   i. per square meter of area occupied by the toilet facility,

ii. per inhabitant served by the hospital, and

iii. per bed existing in this ward.

d) The total cold water flowing into these toilet facilities shall be metered by CM23 (1¼").

The incoming volume of hot water shall be metered by HM21 (1¼") and the outgoing volume of hot water shall be measured by RM17 (½"). Thus, the actual volume of hot water consumed by these toilet facilities shall be the difference between the volumes recorded by meters HM21 and RM17, i.e.,

Total hot water consumption
in the toilet facilities at PA7 = (3.91)
= HM21 - RM17

Accordingly, the total water consumption at the toilet facilities at PA7 shall be such that

Total water consumption
in the toilet facilities at PA7 = 3.92)
= CM23 + HM21 – RM17

e) Meters CM23, HM21 and RM17, shall be installed and removed with the temporary closing of existing valves CV02 (2"), HV02 (2"), and RV02 (1").

3.6.2.3.4 Consulting Rooms PA7

a) This group of consulting rooms is for consultations of gastroenterology, nephrology, pneumology and physical medicine and rehabilitation, and is only for the use of out patients.

b) The Consulting Rooms PA7 have the following characteristics:

i. Number of staff - xxx employees

ii. Area occupied - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of these consulting rooms shall be evaluated in terms of their average daily consumption

i. per medical employee attached to these consulting rooms,

ii. per square meter of area occupied by the consulting rooms, and

iii per consultation rendered.

d) The total cold water flowing into this area (consulting rooms plus the Administrative Services, downstream), shall be metered by CM24 (2"), but the net cold water consumption of Consulting Rooms PA7 shall be determined by the difference between the volumes recorded by meters CM24 and CM04 (Administrative Sector). Thus,

Total volume of cold water
consumed by Consulting Rooms PA7 = (3.93)
= CM24 - CM04

Similarly, the total volume of hot water inflowing to Consulting Rooms PA7 and the Administrative Services shall be metered by HM22 (1½"), but the net hot water actually inflowing to the consulting rooms, shall be the difference between the volumes recorded by meters HM22 and HM03 (Administrative Sector). Thus,

Total volume of hot water
flowing into Consulting Rooms PA7 = (3.94)
= HM22 - HM03

The total volume of hot water flowing out of Consulting Rooms PA7 and the administrative Services shall be metered by meter RM18 (1"), and the net volume of hot water flowing out of the consulting rooms shall be the difference between the records of meters RM18 and RM03. Thus,

Total volume of hot water
flowing out of Consulting Rooms PA7 = (3.95)
= RM18 - RM03

Accordingly, the net volume of hot water consumed by these consulting rooms shall be the difference between the net inflow and the net outflow (equations 3.94 and 3.95), v.z.,

Consumption of hot water
within Consulting Rooms PA7 = (3.96)
= (HM22 - HM03) - (RM18 - RM03)

Accordingly, the total water consumption at Consulting Rooms PA7 shall be such that (equations 3.93 and 3.96)

Total volume of water consumed
within Consulting Rooms PA7 = (3.97)
= CM24 - CM04 + [(HM22 - HM03) - (RM18 - RM03)]

e) Meters CM24, CM04, HM22, RM18 and RM03, shall be installed and removed with the temporary closing of existing valves CV02 (2"), HV02 (2"), and RV02 (1").

3.6.2.3.5 <u>Technical Unit of Pneumology</u>

a) This Technical unit is dedicated to the various exams of pneumology and is for out patients only.

b) The Technical Unit of Pneumology has the following characteristics:
   i. Number of staff - xxx employees
   ii. Area occupied - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this technical unit shall be evaluated in terms of their average daily consumption
   i. per medical employee attached to this technical unit,
   ii. per square meter of area occupied by the technical unit,
   iii. per inhabitant served by the hospital, and
   iv. per pneumologic test made.

d) The total cold water consumption of this sector shall be metered by CM25 (1¼").

The incoming volume of hot water shall be metered by HM23 (1¼") and the outgoing volume of hot water shall be measured by RM19 (½"). Thus, the actual volume of hot water consumed by this sector shall be the difference between the volumes recorded by meters HM23 and RM19, i.e.,

Total hot water consumption
in the Technical Unit of Pneumology = (3.98)
= HM23 - RM19

Accordingly, the total water consumption in the Technical Unit of Pneumology shall be such that

Total water consumption
in the Technical Unit of Pneumology = (3.99)
= CM25 + HM23 – RM19

e) Meters CM25, HM23 and RM19 shall be installed and removed with the temporary closing of existing valves CV01 (2"), HV01 (1½"), and RV01 (1").

3.6.2.3.6 <u>Physical Medicine and Rehabilitation</u>

a) This area has important water consuming equipments, such as the main swimming pool, the Hubbart and Galvanic bathing tubs, medical jet showers, several other hydrotherapy apparatus and toilets and change rooms.
The main swimming pool has a purification and recirculation facility, implying that fresh flows are only required for the compensation of the water lost in the normal use.

b) The services of Physical Medicine and Rehabilitation have the following characteristics:
   i. Number of staff - xxx employees
   ii. Area occupied - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of these physical medicine and rehabilitation services shall be evaluated in terms of their average daily consumption

i. per medical employee attached to these services,

ii. per square meter of area occupied by the services, and

ii. per service rendered.

d) The total cold water flowing into this area (Physical Medicine and Rehabilitation services plus the Technical Unit of Pneumology, downstream), shall be metered by CM01 (2"), but the net cold water consumption of the Physical Medicine and Rehabilitation services shall be determined by the difference between the volumes recorded by meters CM01 and CM25 (Technical Unit of Pneumology), i.e.,

Total volume of cold water flowing into the Physical Medicine and Rehabilitation services =
= CM01 – CM25 (3.100)

Similarly, the total volume of hot water flowing into the Physical Medicine and Rehabilitation services plus the Technical Unit of Pneumology shall be metered by HM01 (1½"), but the net hot water actually inflowing to the Physical Medicine and Rehabilitation services, shall be the difference between the volumes recorded by meters HM01 and HM23 (Technical Unit of Pneumology), i.e.

Total volume of hot water flowing into Physical Medicine and Rehabilitation services =
= HM01 – HM23 (3.101)

The total volume of hot water flowing out of the Physical Medicine and Rehabilitation services plus the Technical Unit of Pneumology shall be metered by meter RM01 (1"), and the net volume of hot water flowing out of the Physical Medicine and Rehabilitation services only, shall be the difference between the records of meters RM01 and RM19 (Technical Unit of Pneumology).

Thus, the net volume of hot water consumed by the Physical Medicine and Rehabilitation services shall be the difference between the net inflow and the net outflow, v.z.,

Consumption of hot water within the
Physical Medicine and Rehabilitation Services (3.102)
= (HM01 - HM23) - (RM01 - RM19)

Accordingly, the total water consumption at the Physical Medicine and Rehabilitation services shall be such that (equations 3.100 and 3.102)

Total water consumption within the
Physical Medicine and Rehabilitation Services = (3.103)
= CM01 - CM25 + [(HM01 - HM23) - (RM01 - RM19)]

e) Meters CM01, HM01 and RM01, shall be installed and removed with the temporary closing of existing valves CV01 (2"), HV01 (1½"), and RV01 (1").

3.6.2.4 <u>Sector D (Cleaning Services, Main Washing and Changing Rooms, Chapel and Kitchen), Drawings 1 and 5</u>

3.6.2.4.1 <u>Cleaning Services</u>

a) The area allocated to the support and control of the cleaning services of the whole hospital include two offices (one for the resident director and the other for the supervisors), male and female change rooms and toilets, storage rooms for cleaning equipment and for consumables, two separate rooms for the washing of trolleys and cleaning equipment, and two pantry/eating rooms for the workers.

Due to the existing layout of the water supply network, only the central core of the Cleaning Services (toilets, change rooms and washing rooms) is of importance to meter. The remaining consumption of water within the Cleaning Services (cleaning workers pantries) is of negligible importance and shall be negleted.

b) The Cleaning Services have the following characteristics:

i. Number of staff - xxx employees

ii. Area occupied - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of these services shall be evaluated in terms of the average daily consumption

i. per square meter of the total hospital, and

ii. per bed existing in the hospital.

d) The total cold water flowing into the Cleaning Services shall be metered by CM10 (1½").

The total volume of hot water consumed by the cleaning services shall be metered by HM09 (1½"), as no hot water returning line exists out of the cleaning services.

Accordingly, the total water consumption at the Cleaning Services shall be such that

Total water consumption
in the Cleaning Services = (3.104)
= CM10 + HM09

e) Meters CM10 and HM09 shall be installed and removed with the temporary closing of existing valves CV06 (2"), HV06 (2"), and RV04 (¾").

3.6.2.4.2 <u>Main Changing Rooms</u>

a) The main washing and change rooms offer all the normal washing and toilet facilities to the workers, plus individual lockers.

b) The main changing rooms have the following characteristics:

i. Area occupied - xxx m^2

ii. Number of workers using the facility - xxx workers

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this sector shall be evaluated in terms of the average daily consumption

i. per square meter of the total hospital,

ii. per bed existing in the hospital, and

iii. per worker using the facilities.

d) The total cold water inflowing to the main changing rooms shall be metered by CM27 (2").

The incoming volume of hot water shall be metered by HM25 (1½") and the outgoing volume of hot water shall be measured by RM21 (½"). Thus, the actual volume of hot water consumed by the main changing rooms shall be the difference between the volumes recorded by meters HM25 and RM21, i.e.,

Total volume of hot water
consumed by the Changing Rooms = (3.105)
= HM25 - RM21

Accordingly, the total water consumption at the Changing Rooms shall be such that (equation 3.105)

Total water consumption
in the Changing Rooms = (3.106)
= CM27 + HM25 - RM21

e) Meters CM27, HM25 and RM21 shall be installed and removed with the temporary closing of existing valves CV06 (2"), HV06 (2"), and RV04 (¾").

3.6.2.4.3 Chapel

In Sector D there exists a Roman Catholic Chapel, with minor water using facilities.

This church is frequented by normal church goers, but no funeral services are performed there (which might involve concentrations of mourners). Accordingly, the water consumption of the chapel shall be ignored.

3.6.2.4.4 Main Kitchen

a) The main kitchen is dimensioned and equipped to serve up to xxx hot meals per day to the staff, being about xxx at lunch time (between 12.00 and 15.00 hours), and the remaining at the end of the day (between 19.00 and 21.00 hours).

The kitchen includes all the main departments of an industrial kitchen (toilet facilities to the kitchen workers, control offices, storage and cold storage rooms, food washing, preparation and cooking), as well as the dispensing od meals in the mess hall, on a self-service basis.

The packing of hot and cold meals to be transported to the wards, loading of trolleys, etc., is also made in the kitchen, but the confectioning of the patients' meals is contracted out.

b) The kitchen has the following characteristics:

i.	area occupied	-	xxx m^2
ii.	Number of kitchen workers.	-	xxx
iii.	Number of meals prepared and cooked in the kitchen, and served daily	-	xxx meals
iv.	Number of meals received from out suppliers, packed and transported daily to the wards	-	xxx meals
v.	Number of workers at the wards pantry	-	xxx workers

c) The unitary water consumption (of cold water, of hot water and total water consumption) of the kitchen shall be evaluated in terms of the average daily consumption

i. per meal prepared in house,

ii. per hospital worker (medical and non medical),

iii. per square meter of the kitchen, and

iv. per meals served to the wards.

d) The water consumption of the kitchen is measured by existing dedicated meters.

3.6.2.5 Sector G (General Archive, General Stores, Pharmaceutical Services, Pathology, Mortuary and Courtyards), Drawings 1 and 6

3.6.2.5.1 General Archive

In the General Archive there are only minor toilet facilities for the workers of this service. Accordingly, the water consumption of the archive shall be ignored.

3.6.2.5.2 General Stores

a) The General Stores are the core of the hospital supplies, and have their own toilet and washing facilities for their workers.

b) The General Stores have the following characteristics:

   i. Area occupied - xxx m^2

   ii. Number of workers - xxx workers

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this section shall be evaluated in terms of the average daily consumption

   i. per square meter of area occupied,

   ii. per bed installed in the hospital and

   iii. per worker attached to the General Stores.

d) The total cold water inflowing to the General Stores shall be metered by CM30 (1¼").

   The incoming volume of hot water shall be metered by HM27 (1"). This will be the net volume of hot water consumed at the General Stores, because no hot water returning line exists out of them.

   Accordingly, the total water consumption at the General Stores shall be such that

Total water consumption
in the General Stores = (3.107)
= CM30 + HM27

e) Meters CM30 and HM27 shall be installed and removed with the temporary closing of existing valves CV03 (2"), HV03 (1½"), and RV03 (1").

3.6.2.5.3 Pharmaceutical Services

a) All pharmaceutical and related services are concentrated in this area, with their own toilet, washing and pantry facilities, offices, sterilisation and preparation laboratories, reception, storage and dispensing of medicines and related products, etc.

b) The Pharmacy has the following characteristics:

i. Area occupied - xxx m^2

ii. Number of workers - xxx workers

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this section shall be evaluated in terms of the average daily consumption

i. per square meter of area occupied,

ii. per bed installed in the hospital, and

iii. per worker in the Pharmacy.

d) General Archive neglected, the total volume of cold water flowing into the Pharmacy, plus Courtyard 5, plus General Stores, plus Pathology and plus the Mortuary, shall be metered by CM05 (2"). Accordingly, the net volume of cold water consumption of the Pharmacy shall be determined by the difference between the volumes recorded by meter CM05 minus meter CM31 (Courtyard 5), minus meter CM29 (General Stores, plus Pathology, plus Mortuary). Thus

Cold Water consumption in the Pharmacy =
= CM05 - CM31 - CM29 (3.108)

Similarly, General Archive neglected, the total volume of hot water flowing into the Pharmacy, plus the General Stores, plus Pathology and plus the Mortuary, shall be metered by HM04 (1½").

Accordingly, the net volume of hot water consumed by the Pharmacy shall be determined by the difference between the volumes recorded by meter HM04 minus meter HM26 (General Stores, plus Pathology, plus Mortuary). Thus

Hot water consumption
in the Pharmacy = (3.109)
= HM04 - HM26

Accordingly, the total water consumption at the Pharmacy shall be such that (equations 3.108 and 3.109)

Total water consumption in the Pharmacy = (3.110)
= CM05 - CM31 - CM29 + HM04 - HM26

e) Meters CM05, CM31, CM29, HM04 and HM26 shall be installed and removed with the temporary closing of existing valves CV03 (2"), HV03 (1½"), and RV03 (1").

3.6.2.5.4 Pathologic Services in Level 1

a) Pathologic services are installed in Levels 1 and 2, in Level 1 being the microscopic facilities, as well as the photographic services, offices and toilets.
The remaining pathologic services are in Level 2, and shall be analysed separately in paragraph 3.6.3.7.1 below.
Notwithstanding this separate analysis of the individual water consumptions in each of the two levels of the Pathology, the final conclusions will obviously be in terms of the global consumption of the Pathology as a whole.
It must also be noted that in these services, the consumption of water (cold) may tend to be higher than expected because of the cooling requirements of the electronic microscope, whose own cooling system tends to be out of order frequently.
For that reason, cold meter CM33 (½") shall be installed to control the electronic microscope water performance, so that special recommendations are made in this regard if justified.

b) The Pathologic Services in Level 1 have the following characteristics:

i. Area occupied in Level 1 - xxx m^2

ii. Number of workers (in both Levels) - xxx workers

c) The unitary water consumption (of cold water, of hot water and total water consumption) of the Pathologic Services (in Levels 1 and 2) shall be evaluated in terms of the average daily consumption

i. per square meter of area occupied,

ii. per bed existing in the hospital, and

iii. per worker in the unit.

d) The total cold water consumption of this part of the Pathologic Services shall be metered by CM06 (1").

The incoming volume of hot water shall be metered by HM05 (1") and the outgoing volume of hot water shall be measured by RM06 (½"). Thus, the actual volume of hot water consumed by this sector shall be the difference between the volumes recorded by meters HM05 and RM06, i.e.,

Total volume of hot water consumed in Level 1 of the Pathologic Services = HM05 - RM06 (3.111)

These values must be added to the values to be determined in paragraph 3.6.3.7.1, to obtain the total water consumption in the Pathologic Services.

e) Meters CM06, HM05 and RM06 shall be installed and removed with the temporary closing of existing valves CV03 (2"), HV03 (1½"), and RV03 (1").

3.6.2.5.5 Mortuary

a) The Mortuary services (deposit and preparation of corpses, autopsies, offices, mourning chambers, cleaning, disinfecting, washing and toilet facilities for workers and for mourners, are located at the SW tip of the hospital, and have direct access to the exterior.

The Chapel is located in another area of the hospital, and no funeral services are there celebrated.

b) The Mortuary have the following characteristics:

i. Area occupied - xxx m^2

ii. Number of workers - xxx workers

c) The unitary water consumption (of cold water, of hot water and total water consumption) of the Mortuary shall be evaluated in terms of the average daily consumption

i. per square meter of area occupied,

ii. per bed existing in the hospital, and

iii. per deceased patient.

d) The total cold water flowing into this area (General Stores, Pathology and Mortuary), shall be metered by CM29 (2"), but the net cold water consumption of the Mortuary shall have to be determined by the difference between the volume recorded by meter CM29 and the sum of the volumes recorded by meters CM30 (General Stores) and CM06 (Pathology).

Thus, the net volume of cold water consumed by the Mortuary shall be

Consumption of cold water in the Mortuary = CM29 - (CM30 + CM06) (3.112)

Similarly, the total volume of hot water flowing into the General Stores, plus the Pathology, plus the Mortuary, shall be metered by HM26 (1½"), but the net volume of hot water actually flowing into the mortuary, shall be determined by the difference between the volume of hot water recorded by meter HM26 and the sum of the volumes of hot water recorded by hot meters HM27 (General Stores) and HM05 (Pathology), i.e.,

Total volume of hot water flowing into the Mortuary = HM26 - (HM27 + HM05) (3.113)

The total volume of hot water flowing out of the Mortuary plus Pathology (no hot water flows out of General Stores) shall be metered by meter RM05 (1"), and the net volume of hot water flowing out of the Mortuary only, shall be the difference between the records of meters RM05 and RM06 (Pathology), i.e.,

Total volume of hot water flowing out of the Mortuary = RM05 - RM06 (3.114)

Thus, the net volume of hot water consumed by the Mortuary shall be the difference between the net inflow and the net outflow (equations 5.38 and 5.39), v.z.,

Consumption of hot water in the Mortuary =
= [HM26 - (HM27 + HM05)] - (RM05 - RM06) (3.115)

Accordingly, the total water consumption at the Mortuary shall be such that (equations 3.112, 3.113 and 3.114)

Total water consumption in the Mortuary = CM29 - (CM30 + CM06) + (3.116)
+[HM26 - (HM27 + HM05)] - (RM05 - RM06)

e) Meters CM06, CM29, CM30, HM05, HM26, HM27, HM05, RM05 and RM06 shall be installed and removed with the temporary closing of existing valves CV03 (2"), HV03 (1½"), and RV03 (1").

3.6.2.5.6 Courtyards

a) There are 20 internal courtyard gardens, all being watered from the main cold water supply system.

b) The Courtyards have a total green area of 4440 m^2. There individual areas are as follows:
Courtyard 1 - 207 m^2

Courtyard 2	-	226 m^2
Courtyard 3	-	78 m^2
Courtyard 4	-	401 m^2
Courtyard 5	-	172 m^2
Courtyard 6	-	92 m^2
Courtyard 7	-	337 m^2
Courtyard 8	-	263 m^2
Courtyard 9	-	386 m^2
Courtyard 10	-	191 m^2
Courtyard 11	-	178 m^2
Courtyard 12	-	258 m^2
Courtyard 13	-	189 m^2
Courtyard 14	-	302 m^2
Courtyard 15	-	191 m^2
Courtyard 16	-	191 m^2
Courtyard 17	-	302 m^2
Courtyard 18	-	0 m^2 (totally paved)
Courtyard 19	-	381 m^2
Courtyard 20	-	95 m^2

c) The unitary water consumption (of cold water) of Courtyards 5 and 19 shall be evaluated in terms of their average daily consumptions per square meter of green area, and that value shall be extrapolated to all the other courtyards, *pro rata* to their green areas.

d) The consumption of water by Courtyard 5 shall be measured by CM31 (½"), and the consumption of water by Courtyard 19 shall be measured by CM28 (½").

e) Meter CM31 shall be installed and removed with the temporary closing of existing valve CV03 (2"), and meter CM28 shall be installed and removed with the temporary closing of existing valve CV05 (1¼").

3.6.3 Description of metering branches at Level 2

3.6.3.1 Sector A (Out Patients Consulting Rooms), Drawings 7 and 8)

a) Sector A in Level 2 is the area where most of the out patients' consulting rooms and ancillary services are located (reception, public toilets, coffee shop, waiting rooms, etc.).

The whole of this area has the same water consumption characteristics. Accordingly, one single set of water meters (cold water, hot water and return circuit) will be sufficient to meter the whole of this sector.

b) This out patient's consulting rooms have the following global parameters:

i.	Number of consulting rooms	-	xxx consulting rooms
ii.	Area occupied	-	xxx m^2
iii.	Number of medical staff	-	xxx employees

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this area of consulting rooms shall be evaluated in terms of the average daily consumption

i. per square meter of area occupied by the consulting rooms,

ii. per consulting room existing in this area,

iii. per medical worker in these consulting rooms,

iv. per bed existing in the hospital, and

v. per inhabitant served by the hospital.

d) The total cold water consumption in this consulting rooms shall be metered by CM11 (2").

The incoming volume of hot water shall be metered by HM10 (1½") and the outgoing volume of hot water shall be measured by RM07 (¾"). Thus, the actual volume of hot water consumed by this sector shall be the difference between the volumes recorded by meters HM10 and RM07, i.e.,

Consumption of hot water
by Consulting Rooms in Sector A = (3.117)
= HM10 - RM07

Accordingly, the total water consumption at the Coffee Shop shall be such that (equation 5.42)

Total water consumption
in the Consulting Rooms in Sector A = (3.118)
= CM11 + HM10 – RM07

e) Meters CM11, HM10 and RM07 shall be installed and removed with the temporary closing of existing valves CV07 (2"), HV07 (1½"), and RV05 (¾").

3.6.3.2 Sector B (Library, Doctors' Offices and Dietetics), Drawings 7 and 9)

a) Sector B in Level 2 is the area where the Library and the Doctors' offices are, plus appurtenant services and the Department of Dietetics (with negligible water consumption).
The whole of this area has basically the same water consumption characteristics. Accordingly, one single set of water meters (cold water, hot water and return circuit) will be sufficient for the whole of this sector.

b) The Library and Doctors' offices have the following characteristics:

i.	Total number of Doctors' working stations	-	xxx staff
ii.	Area occupied by these offices	-	xxx m^2
iii.	Area occupied by the library	-	xxx m^2
iv.	Number of librarians	-	xxx staff
v.	Area occupied by the Department of Dietetics	-	xxx m^2
vi.	Number of nutritionists	-	xxx staff

c) The unitary water consumption (of cold water, of hot water and total water consumption) of these sections shall be evaluated in terms of the average daily consumption

i. per square meter of area occupied by the Doctors' offices,
ii. per square meter of area occupied by the Library,
iii. per square meter of area occupied by the dietetic services, and

iv. per doctor's working post,

d) The total cold water consumption of this sector shall be metered by CM12 (1¼").
The incoming volume of hot water shall be metered by HM11 (1¼") and the outgoing volume of hot water shall be measured by RM08 (¾"). Thus, the actual volume of hot water consumed by this sector shall be the difference between the volumes recorded by meters HM11 and RM08, i.e.,

Consumption of hot water in
Library, Doctors' Offices and Dietetics = (3.119)
= HM11 - RM08

Accordingly, the total water consumption at the Library, Doctors' offices and the Department of Dietetics shall be such that (equation 3.119)

Total water consumption in the
Library, Doctors' offices and the
Department of Dietetics = (3.120)
= CM12 + HM11 – RM08

e) Meters CM12, HM11 and RM08 shall be installed and removed with the temporary closing of existing valves CV08 (1¼"), HV08 (1¼"), and RV06 (¾").

3.6.3.3 Section C (Social Services, Paediatric Ward, Clinical Pathology Laboratory, Oncology Day Hospital and Immunohemotherapy Service), Drawings Nos. 7 and 10

3.6.3.3.1 Social services

These Social Services have only 1 hand wash basin and a toilet for the staff. This minor consumption shall be ignored and metered as part of the Paediatric Ward.

3.6.3.3.2 Paediatric Ward

a) The Paediatric Ward and appurtenant services occupy the eastern tip of block C in Level 2 and shall be metered separately.

b) The Paediatric Ward has the following characteristics:

i.	Number of beds	-	xxx beds
ii.	Area occupied by this ward	-	xxx m^2
iii.	Number of workers	-	xxx workers

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this ward shall be evaluated in terms of their average daily consumption

i. per bed installed in this ward,

ii. per square meter of area occupied by the ward,

iii. per medical worker attached to this ward, and

iv. per inhabitant served by the hospital.

d) The total cold water consumption of this ward shall be metered by CM13 (2").

The incoming volume of hot water shall be metered by HM12 (1½") and the outgoing volume of hot water shall be measured by RM09 (¾"). Thus, the actual volume of hot water consumed by this sector shall be the difference between the volumes recorded by meters HM12 and RM09, i.e.,

Consumption of hot water
in the Paediatric Ward = (3.121)
= HM12 - RM09

Accordingly, the total water consumption of this ward shall be such that (equation 3.121)

Total water consumption
in the Paediatric Ward = (3.122)
= CM13 + HM12 - RM09

e) Meters CM13, HM12 and RM09 shall be installed and removed with the temporary closing of existing valves CV09 (2"), HV09 (1½"), and RV07 (¾").

3.6.3.3.3 Oncology Day Hospital

a) The Oncology Day Hospital and appurtenant services occupy the SW tip of block C in Level 2 and shall be metered separately.

b) The Oncology Day Hospital has the following characteristics:

i.	Number of beds	-	xxx beds
ii.	Area occupied by this hospital	-	xxx m^2
iii.	Number of medical staff	-	xxx staff

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this day hospital shall be evaluated in terms of their average daily consumption

i. per square meter of area occupied by this day hospital,
ii. per inhabitant served by the hospital,
iii. per bed installed in the whole hospital,
iv. per medical worker, and
v. per patient assisted.

d) The total cold water consumption of this day hospital shall be metered by CM15 (1¼").
The incoming volume of hot water shall be metered by HM14 (1¼") and the outgoing volume of hot water shall be measured by RM11 (½"). Thus, the actual volume of hot water consumed by this sector shall be the difference between the volumes recorded by meters HM14 and RM11, i.e.,

Consumption of hot water
in the Oncology Day Hospital = (3.123)
= HM14 - RM11

Accordingly, the total water consumption at the Oncology Day Hospital shall be such that (equation 3.123)

Total water consumption
in the Oncology Day Hospital = (3.124)
= CM15 + HM14 - RM11

e) Meters CM15, HM14 and RM11 shall be installed and removed with the temporary closing of existing valves CV11 (1¼), HV11 (1¼), and RV09 (½").

3.6.3.3.4 Immunohemotherapy

a) The Immunohemotherapy and appurtenant services occupy the NW tip of block C in Level 2 and shall be metered separately.

b) The Immunohemotherapy Service has the following characteristics:
   i. Area occupied by this service - xxx m^2
   ii. Number of medical staff - xxx staff

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this Service shall be evaluated in terms of their average daily consumption
   i. per square meter of area occupied by the Service,
   ii. per bed installed in the whole hospital, and
   iii. per worker in the service.

d) The total cold water consumption of this service shall be metered by CM14 (1").
The incoming volume of hot water shall be metered by HM13 (1") and the outgoing volume of hot water shall be measured by RM10 (½"). Thus, the actual volume of hot water consumed by this sector shall be the difference between the volumes recorded by meters HM13 and RM10, i.e.,

Consumption of hot water in the
Immunohemotherapy Services = (3.125)
= HM13 - RM10

Accordingly, the total water consumption at the Immunohemotherapy Services shall be such that (equation 3.125)

Total water consumption
in the Immunohemotherapy Services = (3.126)
= CM14 + HM13 - RM10

e) Meters CM14, HM13 and RM10 shall be installed and removed with the temporary closing of existing valves CV10 (1"), HV10 (1"), and RV08 (¾").

3.6.3.3.5 Clinical Pathology Laboratory

a) The Clinical Pathology Laboratory serves the whole hospital, namely wards, services and out patients.

b) The Clinical Pathology Laboratory has the following characteristics:
   i. Number of staff - xxx staff
   ii. Area occupied by this laboratory - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of these consulting rooms shall be evaluated in terms of their average daily consumption
   i. per medical employee attached to the laboratory,
   ii. per square meter of area occupied by the laboratory,
   iii. per pathologic test made by the hospital,
   iv. per bed installed in the hospital.

d) The total cold water flowing into the Clinical Pathology Laboratory plus Oncology Day Hospital plus Immunohemotherapy Services, shall be metered by CM16 (2"), but the net cold water consumption of the Clinical Pathology Laboratory shall be determined by the difference between the volumes recorded by meter CM16 and the sum of the volumes recorded by meters CM14 (Immunohemotherapy) and CM15 (Oncology Day Hospital), i.e.,

Consumption of cold water within the
Clinical Pathology Laboratory = (3.127)
= CM16 - (CM14 + CM15)

Similarly, the total volume of hot water flowing into the Clinical Pathology Laboratory plus Oncology Day Hospital plus Immunohemotherapy Services shall be metered by HM15 (1½"), but the net hot water actually flowing into the Clinical Pathology Laboratory shall be the difference between the volumes recorded by meter HM15 and the sum of the volumes recorded by meters HM13 (Immunohemotherapy) and HM14 (Oncology Day Hospital), i.e.,

Inflow of hot water into the
Clinical Pathology Laboratory = (3.128)
= HM15 - (HM13 + HM14)

The total volume of hot water flowing out of the Clinical Pathology Laboratory plus Oncology Day Hospital plus Immunohemotherapy Services, shall be metered by meter RM12 (¾"), and the net volume of hot water flowing out of the Clinical Pathology Laboratory shall be the difference between the volume recorded by meter RM12 and the sum of the volumes recorded by meters RM10 and RM11, i.e.,

Outflow of hot water from the
Clinical Pathology Laboratory = (3.129)
= RM12 - (RM10 + RM11)

Thus, the net volume of hot water consumed by the Clinical Pathology Laboratory shall be the difference between the net inflow and the net outflow (equations 3.128 and 3.129), v.z.,

Consumption of hot water by the
Clinical Pathology Laboratory =
= HM15 - (HM13 + HM14) – (3.130)
- [RM12 - (RM10 + RM11)]

Accordingly, the total water consumption at the Clinical Pathology Laboratory shall be such that (equations 3.127 and 3.130)

Total water consumption in the
Clinical Pathology Laboratory =
= CM16 - (CM14 + CM15) + (3.131)
+ HM15 - (HM13 + HM14) -
- [RM12 - (RM10 + RM11)]

e) Meters CM16, HM15 and RM12, shall be installed and removed with the temporary closing of existing valves CV12 (2"), HV12 (1½"), and RV10 (¾").

3.6.3.4 <u>Sector D (Otorrino-Laringology and Ophthalmology Casualties, Technical Units of Cardiology, Urology, Otorrino-Laringology and Ophthalogy, and Imagiology), Drawings Nos. 7 and 11</u>

3.6.3.4.1 <u>Otorrino-Laringology and Ophthalmology Casualties, and Technical Units of Cardiology, Urology, Otorrino-Laringology and Ophthalmology</u>

a) All these services have similar water consumption patterns, and shall be metered as a unit.

b) These services have the following characteristics:

i.	Area occupied by the casualties	-	xxx m^2
ii.	Area occupied by the technical units	-	xxx m^2
iii.	Casualties - Number of workers	-	xxx staff/shift
iv.	Technical Units - Number of workers	-	xxx staff/shift

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this Service shall be evaluated in terms of their average daily consumption

i. Casualties - Per square meter of area occupied,
ii. Technical Units - Per square meter of area occupied,
iii. Casualties - Per bed installed in these services,
iv. Technical Units - Per bed installed in the whole hospital,
v. Casualties - Per medical worker, and
vi. Technical Units – Per medical worker.

d) The total cold water consumption of these services shall be metered by meters CM19 (1¼") and CM20 (2"), i.e.,

Cold water consumption in the Otorrino-Laringology and Ophthalmology Casualties, and Technical Units of Cardiology, Urology, Otorrino-Laringology and Ophthalmology = = CM19 + CM20 (3.132)

The total volume of hot water flowing into those 2 sectors shall be metered by meters HM17 (1") and HM18 (1½"), i.e.,

Hot water inflow into the Otorrino-Laringology and Ophthalmology Casualties, and Technical Units of Cardiology, Urology, Otorrino-Laringology and Ophthalmology = HM17 + HM18 (3.133)

The total volume of hot water flowing out of these 2 sectors shall be metered by meters RM14 (½") and RM15 (¾"), i.e.,

Hot water flowing out of the Otorrino-Laringology and Ophthalmology Casualties, and Technical Units of Cardiology, Urology, Otorrino-Laringology and Ophthalmology = RM14 + RM15 (3.134)

Thus, the actual volume of hot water consumed by both these sectors shall be such that (equations 3.133 and 3.134)

Total volume of hot water consumed by the Otorrino-Laringology and Ophthalmology Casualties, and Technical Units of Cardiology, Urology, Otorrino-Laringology and Ophthalmology = = HM17 + HM18 - (RM14 + RM15) (3.135)

Accordingly, the total water consumption at the Coffee Shop shall be such that (equations 3.132 and 3.135)

Total water consumption in the
Otorrino-Laringology and Ophthalmology
Casualties and Technical Units of (3.136)
Cardiology, Urology, Otorrino-Laringology
and Ophthalmology =
= CM19 + CM20 + HM17 + HM18 - (RM14 + RM15)

e) Meters CM19, HM17 and RM14 shall be installed and removed with the temporary closing of existing valves CV13 (2"), HV13 (1½") and RV11 (1"), and meters CM20, HM18 and RM15 shall be installed and removed with the temporary closing of existing valves CV15 (2"), HV15 (1½"), and RV13 (¾").

3.6.3.4.2 Magnetic Resonance

a) Magnetic Resonance is a department of the Imagiology services where consumption of water (cold) may tend to be higher than expected because of the cooling requirements of the system.

b) The Magnetic Resonance room has the following characteristics:
   i. Area occupied - xxx m^2
   ii. Number of staff - xxx staff

c) The unitary water consumption (cold water only) of the Magnetic Resonance shall be evaluated in terms of the average daily consumption
   i. per square meter of area occupied, and
   ii. per worker in the unit.

d) The total cold water consumption of the Magnetic Resonance shall be metered by CM18 (½").

e) Meter CM18 shall be installed and removed with the temporary closing of existing valve CV13 (2").

3.6.3.4.3 Imagiology Services

a) The Imagiology Services occupy the whole of the west side of sector D, and satisfy all the hospital's requirements in terms of imagiologic exams.

The Magnetic Resonance room is part of the Imagiology Services, but shall be treated separately because of the tendency for high cold water consumptions when the apparatus' chilling system is out of service.

b) The Imagiology Services have the following characteristics:

i. Number of staff - xxx staff

ii. Area occupied - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of the Imagiology Services shall be evaluated in terms of their average daily consumption

i. per medical employee attached to these services,

ii. per square meter of area occupied by these services, and

iii. per bed existing in the hospital.

d) The total cold water flowing into the Imagiology Services, including the Magnetic Resonance, shall be metered by CM17 (1½"), but the actual cold water consumption of the Imagiology Services (excluding Magnetic Resonance) shall be determined by the difference between the volumes recorded by meter CM17 and meter CM18 (Magnetic Resonance), i.e.,

Consumption of cold water
within the Imagiology Services = (3.137)
= CM17 - CM18

The incoming volume of hot water (neglecting the hot water consumption of the Magnetic Resonance) shall be metered by HM16 (1¼") and the outgoing volume of hot water shall be measured by RM13 (¾"). Thus, the actual volume of hot water consumed by the Imagiology Services shall be the difference between the volumes recorded by meters HM16 and RM13, i.e.,

Total consumption of hot water
by the Imagiology Services = (3.138)
= HM16 - RM13

Accordingly, the total water consumption at the Imagiology Services shall be such that (equations 3.137 and 3.138)

Total water consumption
in the Imagiology Services = (3.139)
= CM17 - CM18 + HM16 - RM13

e) Meters CM17, CM18, HM16 and RM13 shall be installed and removed with the temporary closing of existing valves CV13 (2"), HV13 (1½") and RV11 (1").

3.6.3.5 Sector E (Psychiatry Ward, Neurology Ward and Psychiatry and Neurology Consulting Rooms), Drawings Nos. 7 and 12

3.6.3.5.1 Psychiatry Ward

a) The Psychiatry Ward is located in the Northern and North-Eastern façades of Sector E, is supplied of water via meters CM21 (2"), HM19 (2"), and supply the neurology ward via CM22 (2") and HM20 (1½").
Meters CM21 and HM19 (2"), as well as RM16 (1"), are installed in Sector F, as indicated in paragraph 3.6.3.6.6.

b) The Psychiatry Ward has the following characteristics:

i.	Number of staff	-	xxx staff
ii.	Area occupied	-	xxx m^2
iii.	Number of beds in ward	-	xxx beds

c) The unitary water consumption (of cold water, of hot water and total water consumption) of the Psychiatry Ward shall be evaluated in terms of its average daily consumption

i. per medical employee attached to the ward,
ii. per square meter of area occupied by the ward,

iii. per bed existing in the ward.

d) The total volume of cold water flowing into the Psychiatry Ward shall be metered by CM21, and the total volume of cold water flowing out of this ward shall be measured by CM22. Thus, the actual volume of cold water consumed by this ward shall be the difference between the volumes recorded by meters CM21 and CM22, i.e.,

Total volume of cold water
consumed by the Psychiatry Ward = (3.140)
= CM21 - CM22

The total volume of hot water flowing into the Psychiatry Ward shall be metered by HM19 and the total volume of hot water flowing out shall be measured by HM20. Thus, the actual volume of hot water consumed by this ward shall be the difference between the volumes recorded by meters HM19 and HM20, i.e.,.

Total volume of hot water
consumed at the Psychiatry Ward = (3.141)
= HM19 - HM20

Accordingly, the total water consumption at the Coffee Shop shall be such that (equations 3.140 and 3.141)

Total water consumption
in the Imagiology Services = (3.142)
= CM21 - CM22 + HM19 - HM20

e) Meters CM21, CM22, HM19 and HM20 shall be installed and removed with the temporary closing of existing valves CV16 (2"), HV16 (1½") and RV14 (1"), in Sector F.

3.6.3.5.2 Neurology Ward and Psychiatry and Neurology Consulting Rooms

a) The Neurology Ward and Psychiatry and Neurology Consulting Rooms are located in the Southern and Western façades of Sector

E, and are supplied of water via meters CM22 (2"), HM20 (1½"), and RM16 (1").

Since the Consulting Rooms (PA6) only have installed 2 hand wash basis and 1 toilet (of the deposit type), they shall be neglected for water consumption purposes, and considered as part of the Neurology Ward.

b) The Neurology Ward has the following characteristics:

i.	Number of medical staff	-	xxx staff
ii.	Area occupied	-	xxx m^2
iii.	Number of beds in ward	-	xxx beds

c) The unitary water consumption (of cold water, of hot water and total water consumption) of the Psychiatry Ward shall be evaluated in terms of its average daily consumption

i. per medical employee attached to the ward,
ii. per square meter of area occupied by the ward,
iii. per bed existing in the ward, and
iv. per bed existing in the hospital.

d) The total volume of cold water flowing into the Neurology Ward shall be metered by CM22.

The total volume of hot water flowing into the Neurology Ward shall be metered by HM20 and the total volume of hot water flowing out shall be measured by RM16. Thus, the actual volume of hot water consumed by this ward shall be the difference between the volumes recorded by meters HM20 and RM16, i.e.,.

Total volume of hot water
consumed at the Neurology Ward = (3.143)
= HM20 - RM16

Accordingly, the total water consumption at the Coffee Shop shall be such that (equation 3.143)

Total water consumption
in the coffee shop for the staff = (3.144)
= CM22 + HM20 - RM16

e) Meters, CM22, HM20 and RM16 shall be installed and removed with the temporary closing of existing valves CV16 (2"), HV16 (1½") and RV14 (1").

3.6.3.6 <u>Sector F (Out Patients Surgery, Adult Casualties, Paediatric Casualties, Labour Complex, Paediatric Intensive Care Unit and Palliative Care Unit, and water supply to Sector E). Drawings Nos. 7 and 13</u>

3.6.3.6.1 <u>Out Patients Surgery</u>

a) The whole of the Out Patients Surgery Block is located in the NW tip of Sector F, and is supplied of water via meters CM34 (1¼"), HM30 (1¼") and RM23 (½").

b) The Out Patients Surgery Block has the following characteristics:
   i. Number of staff - xxx staff
   ii. Area occupied - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of the Out Patients Surgery Block shall be evaluated in terms of its average daily consumption
   i. per medical employee attached to the block,
   ii. per square meter of area occupied by the block,
   iv. per surgery made, and
   v. per bed existing in the hospital.

d) The total cold water consumption of the Out Patients Surgery Block shall be metered by CM34.
The incoming volume of hot water shall be metered by HM30 and the outgoing volume of hot water shall be measured by RM23. Thus, the actual volume of hot water consumed by this sector shall be the difference between the volumes recorded by meters HM30 and RM23, i.e.,

Total volume of hot water consumed at the Out Patients Surgery Block = HM30 - RM23 (3.145)

Accordingly, the total water consumption at the Out Patients Surgery Block shall be such that (equation 3.145)

Total water consumption in the Out Patients Surgery Block = = CM34 + HM30 - RM23 (3.146)

e) Meters CM34, HM30 and RM23 shall be installed and removed with the temporary closing of existing valves CV14 (1¼"), HV14 (1¼"), and RV12 (½").

3.6.3.6.2 Adult Casualties

a) The Adult Casualties services are located in the SW tip of Sector F, and are supplied of water via meters CM35 (2"), HM31 (1½") and RM24 (¾").

b) The Adult Casualties services have the following characteristics:

i.	Number of staff	-	xxx staff
ii.	Area occupied	-	xxx m^2
iii.	Average number of services rendered	-	xxx services

c) The unitary water consumption (of cold water, of hot water and total water consumption) of the Out Patients Surgery Block shall be evaluated in terms of its average daily consumption

i. per medical employee attached to adult casualties,

ii. per square meter of area occupied by the casualties services,

iii. per case attended, and

iv. per number of beds existing in the hospital.

d) The total cold water consumption of the Adult Casualties services shall be metered by CM35.

The incoming volume of hot water shall be metered by HM31 and the outgoing volume of hot water shall be measured by RM24. Thus, the actual volume of hot water consumed by this sector shall be the difference between the volumes recorded by meters HM31 and RM24, i.e.,

Total volume of hot water
consumed at adult Casualties = (3.147)
= HM31 - RM24

Accordingly, the total water consumption at the Adult Casualties services shall be such that (equation 3.147)

Total water consumption
in the Adult Casualties services = (3.148)
= CM35 + HM31 - RM24

e) Meters CM35, HM31 and RM24 shall be installed and removed with the temporary closing of existing valves CV18 (2"), HV18 (1½"), and RV18 (¾").

3.6.3.6.3 Paediatric Casualties

a) The Paediatric Casualties are located in the Eastern top of Sector F, and are supplied of water via meters CM36 (1½"), HM32 (1½") and RM25 (¾").

b) Paediatric Casualties have the following characteristics:

i. Number of medical staff - xxx staff

ii. Area occupied - xxx m^2

iii. Average number of services rendered per day - xxx services

c) The unitary water consumption (of cold water, of hot water and total water consumption) of the Paediatric Casualties shall be evaluated in terms of its average daily consumption

i. per medical employee attached to Paediatric Casualties,

ii. per square meter of area occupied by Paediatric Casualties,

iii. per case attended, and

iv. per bed existing in the hospital.

d) The total cold water consumption of the Out Patients Surgery Block shall be metered by CM36.

The incoming volume of hot water shall be metered by HM32 and the outgoing volume of hot water shall be measured by RM25. Thus, the actual volume of hot water consumed by this sector shall be the difference between the volumes recorded by meters HM32 and RM25, i.e.,

Total volume of hot water
consumed at the Paediatric Casualties = (3.149)
= HM32 - RM25

Accordingly, the total water consumption at the Coffee Shop shall be such that

Total water consumption
in the Paediatric Casualties = (3.150)
= CM36 + HM32 - RM25

e) Meters CM36, HM32 and RM25 shall be installed and removed with the temporary closing of existing valves CV19 (2"), HV19 (2"), and RV19 (1").

3.6.3.6.4 Labour Complex

a) The Labour Complex consists of the Labour ward, theatre and Obstetric emergency rooms, and is located in the centre of Sector F.

The existing water supply network is more elaborated than usual, and that causes a more elaborated than usual metering system. For that reason, the water supplied to the Labour complex shall have to be metered via meters CM37 (1"), CM38 (1¼"), CM39 (1¼"), HM33 (1¼"), HM34 (1"), RM26 (½"), RM27 (½") and RM28 (¾").

b) The Labour Complex has the following characteristics:

i. Number of medical staff - xxx staff

ii. Area occupied - xxx m^2

iii. Maximum capacity - xxx births per day

c) The unitary water consumption (of cold water, of hot water and total water consumption) of the Labour Complex shall be evaluated in terms of its average daily consumption

i. per medical employee attached to the Labour Complex,

ii. per square meter of area occupied by the Labour Complex,

iii. per birth recorded, and

iv. per bed existing in the Labour Complex.

d) The total cold water consumption of the Labour Complex shall be metered by meters CM37, CM38 and CM39 (it is neglected the water consumed by the tea kitchen and toilets of the sleeping quarters for the medical staff on duty). Thus,

Total cold water consumption
in Labour Complex = (3.151)
= CM37 + CM38 + CM39

The total incoming volume of hot water shall be metered by meters HM33 and and HM34, i.e.,

Total hot water flow
into the Labour Complex = (3.152)
= HM33 + HM34

The total volume of hot water flowing out of the Labour Complex shall be metered by meters RM26, RM27 and RM28, i.e.,

Total hot water flowing
out of the Labour Complex = (3.153)
= RM26 + RM27 + RM28

Thus, the actual volume of hot water consumed by the Labour Complex shall be such that (equations 3.152 and 3.153)

Total volume of hot water
consumed by the Labour Complex = (3.154)
= HM33 + HM34 - (RM26 + RM27 + RM28)

Accordingly, the total water consumption at the Labour Complex shall be such that (equations 3.151 and 3.154)

Total water consumption
in the Labour Complex =
= CM37 + CM38 + CM39 + HM33 + (3.155)
+ HM34 – (RM26 + RM27 + RM28)

e) Meters CM37, CM38, CM39, HM33, HM34, RM26, RM27 and RM28 shall be installed and removed with the temporary closing of existing valves CV19 (2"), HV19 (2"), and RV19 (1").

3.6.3.6.5 <u>Paediatric Intensive Care Unit (ICU) and Palliative Care Unit</u>

a) Both these 2 units shall be metered together, because it is negligible the volume of water consumed by the Palliative Care Unit.
Due to the complexity of the water supply network in this area, the water consumption of these 2 units shall me evaluated in terms of the water consumption recorded by meters CM40 (2"), HM35 (2") and RM29 (1") minus the water consumed by the Paediatric Casualties (meters CM36, HM32 and RM25) and minus the water consumed at the Labour Complex (meters CM37, CM38, CM39, HM33, HM34, RM26, RM27 and RM28).

b) The Paediatric Intensive Care Unit and the Palliative Care Unit have the following characteristics:
i. Number of staff at the Paediatric ICU - xxx staff
ii. Number of staff at the Palliative Care Unit - xxx staff
iii. Area occupied by the Paediatric ICU - xxx m^2
iv. Area occupied by the Palliative Care Unit - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of these units shall be evaluated in terms of their average daily consumption

i. per medical employee attached to the Paediatric ICU,
ii. per medical employee attached to the Palliative Care Unit,
iii. per square meter of area occupied by the Paediatric ICU,
iv. per square meter of area occupied by the Palliative Care Unit,
v. per bed existing in the Paediatric ICU, and
vi. per bed existing in the Palliative Care Unit.

d) The total cold water consumed by the Paediatric ICU plus the Palliative Care Unit shall be metered by meters CM40, minus CM36, CM37, CM38 and CM39. Thus,

Total cold water consumption of
Paediatric ICU and Palliative Care Unit = (3.156)
= CM40 - (CM36 + CM37 + CM38 + CM39)

The total volume of hot water coming into the Paediatric ICU plus the Palliative Care Unit shall be metered by meters HM35, minus HM32, HM33 and HM34, i.e.,

Total hot water inflowing into the
Paediatric ICU plus Palliative Care Unit = (3.157)
= HM 35 - (HM32 + HM33 + HM34)

The total volume of hot water flowing out of the Paediatric ICU plus Palliative CU shall be metered by meter RM29 minus RM25, RM26, RM27 and RM28, i.e.,

Total hot water flowing out of the
Paediatric ICU plus Palliative CU = (3.158)
= RM29 - (RM25 + RM26 + RM27 + RM28)

Thus, the actual volume of hot water consumed by the Paediatric ICU plus the Palliative CU shall be such that (equations 3.157 and 3.156)

Total hot water consumed by the
Paediatric ICU plus Palliative CU =
= HM35 - (HM32 + HM33 + HM34) - (3.159)
- [RM29 - (RM25 + RM26 + RM27 +RM28)]

Accordingly, the total water consumption at the Paediatric ICU plus Palliative CU shall be such that (equations 3.156 and 3.159)

Total water consumption
in the Paediatric ICU plus Palliative CU =
= CM40 - (CM36 + CM37 + CM38 + CM39) + (3.160)
+ HM35 - (HM32 + HM33 + HM34) -
- [RM29 - (RM25 + RM26 + RM27 +RM28)]

e) Meters CM40, HM35, and RM29 shall be installed and removed with the temporary closing of existing valves CV19 (2"), HV19 (2") and RV19 (1").

3.6.3.6.6 Water Supply to Sector E

The total water supply scheme to Sector E was described in paragraph 3.6.3.5 above, but the valves controlling the water access to that Sector, as well as the meters controlling the whole of that supply, are installed in this Sector F.

They are valves CV16 (2"), HV16 (1½") and RV14 (1"), and meters CM21 (2"), HM19 (1½") and RM16 (1").

3.6.3.7 Sector G (Pathologic Services in Level 2, Sterilization Services, Intensive Care Unit, Anaesthesiology and General Surgery Block), Drawings Nos. 7 and 14

3.6.3.7.1 Pathologic Services in Level 2

a) These services are the complement of the Pathologic Services existing in Level 1, as described in paragraph 3.6.2.5.4 above.

For water supply purposes, the Pathologic Services in Level 2 are serviced by 2 separate conduits, one controlled by CM42 (1") and HM37 (1"), the other conduit being controlled by CM43 (1"), HM38 (1") and RM30 (1").

b) The Pathologic Services in Level 2 have the following characteristics:

i. Area occupied in Level 1 - xxx m^2

ii. Number of staff (in both Levels) - xxx staff

c) The unitary water consumption (of cold water, of hot water and total water consumption) of the Pathologic Services (in Levels 1 and 2) shall be evaluated in terms of the average daily consumption

i. per square meter of area occupied,

ii. per bed existing in the hospital, and

iii. per worker in the unit.

d) The total cold water consumption of this part of the Pathologic Services (Level 2) shall be metered by CM42 (1").
The total volume of hot water flowing into the Pathologic Services in Level 2 shall be metered by HM37 (1").
The above values must be added to the values determined in paragraph 3.6.2.5.4, to obtain the total water consumption in the Pathologic Services. Thus

Total volume of cold water consumed
in the Pathologic Services (both Levels) = (3.161)
= CM06 + CM42

and (due to equation 3.111)

Total volume of hot water consumption
by the Pathologic Services (both Levels) = (3.162)
= HM05 - RM06 + HM37

Accordingly, the total water consumption at the Pathologic Services (both Levels) shall be such that (equations 3.161 and 3.162)

Total water consumption
in the Pathologic Services (both Levels = (3.163)
= CM06 + CM42 + HM05 - RM06 + HM37

e) Meters CM42 and HM37 shall be installed and removed with the temporary closing of existing valves CV21 (1½"), HV21 (1¼") and RV21 (1").

3.6.3.7.2 Sterilization Services

a) The Sterilization Services are located immediately upstream of the Pathologic Services in Level 2. The cold and hot water consumption of the Sterilization Services shall be determined by the difference between the values flowing into the Sterilization plus Pathology Services, minus the volumes flowing out to the Pathologic Services.

b) The Sterilization Services have the following characteristics:

i. Area occupied - xxx m^2

ii. Number of staff - xxx staff

c) The unitary water consumption (of cold water, of hot water and total water consumption) of the Sterilization Services shall be evaluated in terms of the average daily consumption

i. per square meter of area occupied,

ii. per bed existing in the hospital,

iii. per operation theatre existing in the General Surgery Block, and

iv. per medical worker attached to the sterilization services.

d) The total cold water consumed by the Sterilization Services shall be the volume metered by CM41 (1½"), minus the volume passed to the Pathologic Services, v.z., meter CM42 (1"), i.e.,

Total volume of cold water consumed
in the Sterilization Services = (3.164)
= CM41 - CM42

The volume of hot water flowing into the Sterilization Services and Pathologic Services shall be metered by meter HM36 (1½") and the outgoing volume of hot water (to the Pathologic Services) shall be measured by meters HM37 (1"). Thus, the actual volume of hot water consumed by the Sterilization Services shall be the difference between the volume recorded by HM36, minus the volume recorded by meter HM37, i.e.,

Total volume of hot water
consumed by the Sterilization Services = (3.165)
= HM36 - HM37

Accordingly, the total water consumption at the Sterilization Services shall be such that (equations 3.164 and 3.165)

Total water consumption
in the Sterilization Services = (3.166)
= CM41 - CM42 + HM36 - HM37

e) Meters CM41, CM42, HM36 and HM37 shall be installed and removed with the temporary closing of existing valves CV21 (1½"), HV21 (1¼") and RV21 (1").

3.6.3.7.3 Intensive Care Unit (ICU)

a) The Intensive care Unit is located in the NE corner of Sector G. The water supply to this Unit is made via CM44 (1¼"), HM39 (1¼") and RM22 (½").

b) The Intensive care Unit has the following characteristics:

i. Number of staff - xxx staff
ii. Area occupied - xxx m^2
iii. Number of beds - xxx beds

c) The unitary water consumption (of cold water, of hot water and total water consumption) of this section shall be evaluated in terms of the average daily consumption

i. per square meter of area occupied by the Unit,

ii. per bed existing in the ICU, and

iii. per medical worker in the ICU.

d) The total cold water consumption of the ICU shall be metered by CM44 (1¼").

The incoming volume of hot water shall be metered by HM39 (1¼"), and the outgoing volume of hot water shall be measured by RM31 (½"). Thus, the actual volume of hot water consumed by this Unit shall be the difference between the volumes recorded by meters HM39 and RM31, i.e.,

Total volume of hot water
consumed in the Intensive Care Unit = (3.167)
= HM39 - RM31

Accordingly, the total water consumption at the Coffee Shop shall be such that

Total water consumed
at the Intensive Care Unit = (3.168)
= CM44 + HM39 - RM31

e) Meters CM44, HM39 and RM31 shall be installed and removed with the temporary closing of existing valves CV22 (1¼"), HV22 (1¼"), and RV22 (½").

3.6.3.7.4 Anaesthesiology and General Surgery Block

a) The Anaesthesiology and the General Surgery Block shall be metered together because, for water supply purposes, not only the 2 services work as one, but the consumption of the Anaesthesiology is also negligible in comparison with the consumption of the surgery block.

The water supply to these 2 services shall be made via CM32 (2"), HM28 (1½") and RM32 (1").

b) The Anaesthesiology and the General Surgery Block have the following characteristics:

i. Number of staff at the Anaesthesiology - xxx staff

ii. Area occupied by the Anaesthesiology - xxx m^2

iii. Number of staff at the Surgery Block - xxx

iv. Area occupied by the Surgery Block - xxx m^2

c) The unitary water consumption (of cold water, of hot water and total water consumption) of each of these 2 services shall be evaluated in terms of the average daily consumption

i. per square meter of area occupied by the Surgery Block and the Anaesthesiology,

ii. per bed existing in the hospital.

iii. per medical worker in the Surgery Block and the Anaesthesiology,

iv. per operation theatre existing the General Surgery Block.

d) The total cold water consumption in these 2 services shall be metered by CM32 (2").

The total volume of hot water flowing into the Anaesthesiology and into the General Surgery Block shall be metered by HM28, and the total volume of hot water flowing out of the Anaesthesiology and out of the General Surgery Block, shall be determined by the difference between the volume recorded by RM32 (1"), and the sum of the volumes recorded by meters RM30 (1") and RM31 (½").

Thus, the actual volume of hot water consumed by Anaesthesiology and the General Surgery Block shall be

Total hot water consumed by the Anaesthesiology and General Surgery = (3.169)
= HM28 - [RM32 - (RM30 + RM31)]

Accordingly, the total water consumption at the Anaesthesiology and the General Surgery Block shall be such that

Total water consumption in the Anaesthesiology and the General Surgery Block = (3.170)
= CM32 + HM28 - [RM32 - (RM30 + RM31)]

e) Meters CM32, HM28 and RM30, RM31 and RM32 shall be installed and removed with the temporary closing of existing valves CV20 (2"), HV20 (1½"), HV21 (1¼"), HV22 (1¼"), and RV20 (1").

3.6.4 Description of metering branches for the wards at level 4 (FFL 127,00), at level 5 (FFL 130,70), at level 6 (FFL 134,40) and at level 7 (FFL 138,10)

The metering of the cold and hot water consumption at the wards will hopefully be made globally and by sanitary installation (and, indirectly, by ward), in order to identify as much as possible the actual water requirements of each specific ward.

The actual global planning of these measurements is indicated in Drawings Nos. 15 (Tower Amadora) and 16 (Tower Sintra), with the meters of each particular supply line to be installed immediately downstream of the indicated valves.

However, the actual detail planning for each ward can only be done case by case, in line with the daily random requirements of quietness of the wards.

In fact, the installation of each individual metering system will be particularly sensitive, possibly with many operational limitations. In general, hospitals only allow these works to be carried out at night between 01.00 and 05.00 hours, and the wards offer the added difficulty of the night noises, which are not expected to disturb the tranquillity of the patients.

3.6.5 Detail of the water meters and isolation valves at each section

3.6.5.1 Identification of meters and valves

CM - Meter in a cold water line

HM - Meter in a hot water line

RM - Meter in a returning water line

CV - Valve in a cold water line

HV - Valve in a hot water line

RV - Valve in a returning water line

3.6.5.2 Details of sections:

Level 1, Sector A, Administrative Services:
CM04, HM03, RM03
CV02 HV02 RV02

Level 1, Coffee Shop (Staff):
CM45, HM29, RM04
CV17, HV17, RV17

Level 1, Sector B, "Health at Work:":
CM04, CM26, HM07, HM24
CV05, HV04, RV16

Level 1, Sector B, Training Sector:
CM26, HM24, RM30
CV05, HV04, RV16

Level 1, Sector B, Coffee Shop (Public):
CM45, HM41
CV05, HV04, RV16

Level 1, Sector B, Public Toilets:
CM08, HM06
CV05, HV04, RV16

Level 1, Sector B, Staff Toilets:
CM07, HM08
CV17, HV17, RV17

Level 1, Sector C, Haemodialysis:
CM03
CV02

Level 1, Sector C, Gastro + Nefro Ward
and Technical Services:
CM02, CM03, HM02, RM02
CV02, HV02, RV02

Level 1, Sector C, Toilets, PA7:
CM23, HM21, RM17
CV02, HV02, RV02

Level 1, Sector C, PA7:
CM04, CM24, HM03, HM22, RM03, RM18
CV02, HV02, RV02

Level 1, Sector C, Tech Unit Pneumo:
CM25, HM23, RM19
CV01, HV01, RV01

Level 1, Sector C, PMR:
CM01, CM25, HM01, HM23, RM01, RM19
CV01, HV01, RV01

Level 1, Sector D, Cleaning:
CM10, HM09
CV06, HV06, RV04

Level 1, Sector D, Changing Rooms:
CM27, HM25, RM21
CV06, HV06, RV04

Level 1, Sector G, General Stores:
CM30, HM27
CV03, HV03, RV03

Level 1, Sector G, Pharmacy:
CM05, CM29, CM31, HM04, HM26, RM03
CV03, HV03, RV03

Level 1, Sector G, Pathology:
CM06, HM05, RM06
CV03, HV03, RV03

Level 1, Sector G, Mortuary:
CM06, CM29, CM30, HM05, HM26, HM27, RM05, RM06
CV03, HV03, RV03

Level 1, Sector Courtyards 5 and 19:
CM28, CM31
CV03, CV05

Level 2, Sector A, Const. Rooms:
CM11, HM10, RM07
CV07, HV07, RV05

Level 2, Sector B, Library + Doctors:
CM12, HM11, RM08
CV08, HV08, RV06

Level 2, Sector C, Paediatric Ward:
CM13, HM12, RM09
CV09, HV09, RV07

Level 2, Sector C, Onc. Day Hospital:
CM15, HM14, RM11
CV11, HV11, RV09

Level 2, Sector C, Immunihemotherapy:
CM14, HM13, RM10
CV10, HV10, RV08

Level 2, Sector C, Clinical Pathology:
CM14, CM15, CM16, HM13, HM14, HM15, RM10, RM11, RM12
CV12, HV12, RV10

Level 2, Sector D, Oto+Oft. Casul + Technical Units.:
CM19, CM20, HM17, HM18, RM14, RM15
CV15, HV15, RV13

Level 2, Sector D, Magnetic Res.:
CM18
CV13

Level 2, Sector D, Imagiology:
CM17, CM18, HM16, RM13
CV13, HV13, RV11

Level 2, Sector E, Psyq. Ward:
CM21, CM22, HM19, HM20
CV16, HV16, RV14

Level 2, Sector E, Neur ward+Cons. Rooms:
CM22, HM20, RM16
CV16, HV16, RV14

Level 2, Sector F, Out Surgery:
CM34, HM30, RM23
CV14, HV14, RV12

Level 2, Sector F, Adult Casualt.:
CM35, HM31, RM24
CV18, HV18, RV18

Level 2, Sector F, Paed. Casult.:
CM36, HM32, RM25
CV19, HV19, RV19

Level 2, Sector F, Labour Complex:
CM37, CM39, HM33, HM34, RM26, RM27, RM28
CV19, HV19, RV19

Level 2, Sector F, Paed. ICU:
CM36, CM37, CM38, CM39, CM40, HM32, HM33, HM34, HM35,
RM25, RM26, RM27, RM28, RM29
CV19, HV19, RV19

Level 2, Sector G, Pathology:
CM42, HM37, RM30
CV21, HV21, RV21

Level 2, Sector G, Sterilization:
CM41, CM42, HM37, HM36
CV21, HV21, RV21

Level 2, Sector G, ICU:
CM43, HM38, RM31
CV22, HV22, RV22

Level 2, Sector G, Anest+Surgery:
CM32, HM28, RM30, RM31, RM32
CV20, HV20, HV21, HV22, RV20

3.6.6 Water meters: Bores and positions

3.6.6.1 Cold water meters

COLD WATER METERS				
REF.	SECTION	SECTOR	LEVEL	SERVICE
CM01	2"	C	1	FMR + Pneumology Technical Unit
CM02	1 ½"	C	1	Gastro + Nephro Wards + Gastro Technical Unit + Haemodialysis
CM03	1"	C	1	Haemodialysis
CM04	1 ½"	A	1	Administrative Services
CM05	2"	G	1	Pharmacy, Pathology (Level 1) and Mortuary
CM06	1"	G	1	Pathology
CM07	1 ½"	B	1	Staff Toilets
CM08	1 ½"	B	1	Public Toilets
CM09	1¼"	B	1	"Health at Work" and Training Centre
CM10	1 ½"	D	1	Changing Rooms and Cleaning Installations
CM11	2"	A	2	Out Patients Consulting Rooms
CM12	1¼"	B	2	Doctors' Offices and Library
CM13	2"	C	2	Paediatric Ward and Social Services
CM14	1"	C	2	Immunohemotherapy
CM15	1¼"	C	2	Oncologic Day Hospital
CM16	2"	C	2	Clinical Pathology Laboratory
CM17	1 ½"	D	2	Imagiology
CM18	½"	D	2	Magnetic Resonnance
CM19	1¼"	D	2	Otorrino + Oftalmic Casualties
CM20	2"	D	2	Special Exams + Otorrino and Oftalmic Casualties
CM21	2"	E F	2	Psiquiatry and Neurology Wards and Consulting Rooms
CM22	2"	E	2	Psiquiatry and Neurology Wards and Consulting Rooms
CM23	1¼"	C	1	Gastro Tecnical Unit Toilets
CM24	2"	C	1	Administrative Services + Consulting Rooms PA7
CM25	1¼"	C	1	Pneumology Tehcnical Unit
CM26	1¼"	B	1	Training Centre
CM27	2"	D	1	General Changing Rooms
CM28	½"	B	1	Courtyard 19
CM29	2"	G	1	Mortuary + Pathology
CM30	1¼"	G	1	General Stores
CM31	½"	G	1	Courtyard 5
CM32	2"	G	2	Surgery + Anestesiology
CM33	½"	G	1	Electronic Microscope

COLD WATER METERS (continued)				
REF.	SECTION	SECTOR	LEVEL	SERVICE
CM34	1¼"	F	2	Out patients Surgery
CM35	2"	F	2	General Casualties
CM36	1 ½"	F	2	Paediatric Casualties
CM37	1"	F	2	Delivery Block
CM38	1¼"	F	2	Delivery Block
CM39	1¼"	F	2	Delivery Block
CM40	2"	F	2	Paediatric ICU
CM41	1 ½"	G	2	Pathology (Level 2) + Sterilization
CM42	1"	G	2	Pathology
CM43	1¼"	G	2	Intensive Care Unit (ICU)
CM44	1¼"	B	1	Staff Coffee Shop
CM45	1 ½"	B	1	Public Coffee Shop

3.6.6.2 Hot water meters

HOT WATER METERS				
REF.	**SECTION**	**SECTOR**	**LEVEL**	**SERVICE**
HM01	1 ½"	C	1	FMR + Pneumology Technical Unit
HM02	1 ½"	C	1	Gastro + Nephro Wards + Gastro Technical Unit + Haemodialysis
HM03	1¼"	A	1	Administrative Services
HM04	1 ½"	G	1	Pharmacy, Pathology (Level 1) and Mortuary
HM05	1"	G	1	Pathology
HM06	1"	B	1	Public Toilets
HM07	1¼"	B	1	"Health at Work" and Training Centre
HM08	1"	B	1	Staff Toilets
HM09	1 ½"	D	1	Changing Rooms and Cleaning Installations
HM10	1 ½"	A	2	Out Patients Consulting Rooms
HM11	1¼"	B	2	Doctors' Offices and Library
HM12	1 ½"	C	2	Paediatric Ward and Social Services
HM13	1"	C	2	Immunohemotherapy
HM14	1¼"	C	2	Oncologic Day Hospital
HM15	1 ½"	C	2	Clinical Pathology Laboratory
HM16	1¼"	D	2	Imagiology
HM17	1"	D	2	Otorrino + Oftalmic Casualties
HM18	1 ½"	D	2	Special Exams + Otorrino and Oftalmic Casualties
HM19	1 ½"	E F	2	Psiquiatry and Neurology Wards and Consulting Rooms
HM20	1 ½"	E	2	Psiquiatry and Neurology Wards and Consulting Rooms
HM21	1¼"	C	1	Gastro Tecnical Unit Toilets
HM22	1 ½"	C	1	Administrative Services + Consulting Rooms PA7
HM23	1¼"	C	1	Pneumology Tehcnical Unit
HM24	1"	B	1	Training Centre
HM25	1 ½"	D	1	General Changing Rooms
HM26	1 ½"	G	1	Mortuary + Pathology
HM27	1"	G	1	General Stores
HM28	1 ½"	G	2	Surgery + Anestesiology
HM29	1¼"	B	1	Staff Coffe Shop
HM30	1¼"	F	2	Out patients Surgery
HM31	1 ½"	F	2	General Casualties
HM32	1 ½"	F	2	Paediatric Casualties
HM33	1¼"	F	2	Delivery Block
HM34	1"	F	2	Delivery Block

HOT WATER METERS (continued)				
REF.	SECTION	SECTOR	LEVEL	SERVICE
HM35	2"	F	2	Paediatric ICU
HM36	1¼"	G	2	Pathology (Level 2) + Sterilization
HM37	1"	G	2	Pathology
HM38	1¼"	G	2	Intensive Care Unit (ICU)
HM39	1¼"	G	2	Surgery + Anestesiology
HM40	1 ½"	G	2	Surgery + Anestesiology
HM41	1"	B	1	Public Coffee Shop

3.6.6.3 Hot water return meters

HOT WATER RETURN METERS				
REF.	SECTION	SECTOR	LEVEL	SERVICE
RM01	1"	C	1	FMR + Pneumology Technical Unit
RM02	¾"	C	1	Gastro + Nephro Wards + Gastro Technical Unit + Haemodialysis
RM03	¾"	A	1	Administrative Services
RM04	¾"	B	1	Staff Coffe Shop
RM05	1"	G	1	Pharmacy, Pathology (Level 1) and Mortuary
RM06	½"	G	1	Pathology
RM07	¾"	A	2	Out Patients Consulting Rooms
RM08	¾"	B	2	Doctors' Offices and Library
RM09	¾"	C	2	Paediatric Ward and Social Services
RM10	½"	C	2	Immunohemotherapy
RM11	½"	C	2	Oncologic Day Hospital
RM12	¾"	C	2	Clinical Pathology Laboratory
RM13	¾"	D	2	Imagiology
RM14	½"	D	2	Otorrino + Oftalmic Casualties
RM15	¾"	D	2	Special Exams + Otorrino and Oftalmic Casualties
RM16	1"	E F	2	Psiquiatry and Neurology Wards and Consulting Rooms
RM17	½"	C	1	Gastro Tecnical Unit Toilets
RM18	1"	C	1	Administrative Services + Consulting Rooms PA7
RM19	½"	C	1	Pneumology Tehcnical Unit
RM20	½"	B	1	Training Centre
RM21	½"	D	1	General Changing Rooms
RM22	1"	E	2	Psiquiatry and Neurology Wards and Consulting Rooms
RM23	½"	F	2	Out patients Surgery
RM24	¾"	F	2	General Casualties
RM25	¾"	F	2	Paediatric Casualties
RM26	½"	F	2	Delivery Block
RM27	½"	F	2	Delivery Block
RM28	¾"	F	2	Delivery Block
RM29	1"	F	2	Paediatric ICU
RM30	1"	G	2	Pathology (Level 2) + Sterilization
RM31	½"	G	2	Intensive Care Unit (ICU)
RM32	1"	G	2	Surgery + Anestesiology

3.6.7 Bores and positions of isolating valves

3.6.7.1 Cold water valves

COLD WATER ISOLATING VALVES				
REF.	SECTION	SECTOR	LEVEL	SERVICE
CV01	2"	C	1	FMR + Pneumology Technical Unit
CV02	2"	A C	1	Gastro + Nephro Wards + Gastro Technical Unit + Haemodialysis
CV03	2"	G	1	Pharmacy, Pathology (Level 1) and Mortuary
CV05	1¼"	B	1	Public Toilets, "Health at Work" and Training Centre
CV06	2"	D	1	Changing Rooms and Cleaning Installations
CV07	2"	A C	2	Out Patients Consulting Rooms
CV08	1¼"	B	2	Doctors' Offices and Library
CV09	2"	C	2	Paediatric Ward and Social Services
CV10	1"	C	2	Immunohemotherapy
CV11	1¼"	C	2	Oncologic Day Hospital
CV12	2"	C	2	Clinical Pathology Laboratory
CV13	2"	D	2	Imagiology and Special Exams
CV14	1¼"	F	2	Out patients Surgery
CV15	2"	D	2	Special Exams + Otorrino and Oftalmic Casualties
CV16	2"	E F	2	Psiquiatry and Neurology Wards and Consulting Rooms
CV17	1 ½"	B	1	Mess hall, Staff Coffee Shop and Staff Toilets
CV18	2"	F	2	General Casualties
CV19	2"	F	2	Delivery Block and Pediatric ICU
CV20	2"	G	2	Surgery + Anestesiology
CV21	1 ½"	G	2	Pathology (Level 2) + Sterilization
CV22	1¼"	G	2	Intensive Care Unit (ICU)

3.6.7.2 Hot water valves

HOT WATER ISOLATING VALVES				
REF.	SECTION	SECTOR	LEVEL	SERVICE
HV01	2"	C	1	FMR + Pneumology Technical Unit
HV02	2"	A C	1	Gastro + Nephro Wards + Gastro Technical Unit + Haemodialysis
HV03	1½"	G	1	Pharmacy, Pathology (Level 1) and Mortuary
HV04	1¼"	B	1	Public Toilets, "Health at Work" and Training Centre
HV06	2"	D	1	Changing Rooms and Cleaning Installations
HV07	1½"	A	2	Out Patients Consulting Rooms
HV08	1¼"	B	2	Doctors' Offices and Library
HV09	1½"	C	2	Paediatric Ward and Social Services
HV10	1"	C	2	Immunohemotherapy
HV11	1¼"	C	2	Oncologic Day Hospital
HV12	1½"	C	2	Clinical Pathology Laboratory
HV13	1½"	D	2	Imagiology and Special Exams
HV14	1¼"	F	2	Out patients Surgery
HV15	1½"	D	2	Special Exams + Otorrino and Oftalmic Casualties
HV16	2"	E F	2	Psiquiatry and Neurology Wards and Consulting Rooms
HV17	1¼"	B	1	Mess hall, Staff Coffee Shop and Staff Toilets
HV18	1½"	F	2	General Casualties
HV19	2"	F	2	Delivery Block and Pediatric ICU
HV20	1½"	G	2	Surgery + Anestesiology
HV21	1½"	G	2	Pathology (Level 2) + Sterilization
HV22	1¼"	G	2	Intensive Care Unit (ICU)

3.6.7.3 Hot water return valves

WATER RETURN ISOLATING VALVES				
REF.	**SECTION**	**SECTOR**	**LEVEL**	**SERVICE**
RV01	1"	C	1	FMR + Pneumology Technical Unit
RV02	1"	A C	1	Gastro + Nephro Wards + Gastro Technical Unit + Haemodialysis
RV03	1"	G	1	Pharmacy, Pathology (Level 1) and Mortuary
RV04	¾"	D	1	General Changing Rooms
RV05	¾"	A C	2	Out Patients Consulting Rooms
RV06	¾"	B	2	Doctors' Offices and Library
RV07	¾"	C	2	Paediatric Ward and Social Services
RV08	½"	C	2	Immunohemotherapy
RV09	½"	C	2	Oncologic Day Hospital
RV10	¾"	C	2	Clinical Pathology Laboratory
RV11	1"	D	2	Imagiology and Special Exams
RV12	¾"	F	2	Out patients Surgery
RV13	¾"	D	2	Special Exams + Otorrino and Oftalmic Casualties
RV14	1"	E F	2	Psiquiatry and Neurology Wards and Consulting Rooms
RV16	½"	B	1	Public Toilets, "Health at Work" and Training Centre
RV17	¾"	B	1	Mess hall, Staff Coffee Shop and Staff Toilets
RV18	¾"	F	2	General Casualties
RV19	1"	F	2	Delivery Block and Pediatric ICU
RV20	1"	G	2	All "G" Sector
RV21	1"	G	2	Pathology (Level 2) + Sterilization
RV22	½"	G	2	Intensive Care Unit (ICU)

3.6.8 Details of required meters (bores and quantities)

Diameter	Cold Water	Hot Water	Total Number
Φ2" (50 mm)	14	1	15
Φ1½" (38 mm)	9	16	25
Φ1¼" (32 mm)	13	12	25
Φ1" (25 mm)	5	18	23
Φ¾" (19 mm)		12	12
Φ½" (12 mm)	4	12	16
Total			116

3.6.9 Detail of required isolating valves (bores and quantities)

Diameter	Cold Water	Hot Water	Total Number
Φ2" (50 mm)	13	5	18
Φ1½" (38 mm)	2	9	11
Φ1¼" (32 mm)	5	6	11
Φ1" (25 mm)	1	9	10
Φ¾" (19 mm)		9	9
Φ½" (12 mm)		4	4
Total			63

4. CASE STUDY: GLOBAL WATER CONSUMPTION PATTERNS AT HOSPITAL AMADORA SINTRA

4.1 Working data

The recorded data was processes in accordance with the methodologies indicated in paragraph 3.3.4.2 above, was ordered by the months, by the weeks and by the days of the year, and was compiled as working data in Annexes 2, 3 and 4.

As an example, Figure 4-1 shows the working data for the period from 2003 to 2008, for year periods and for month seasons.

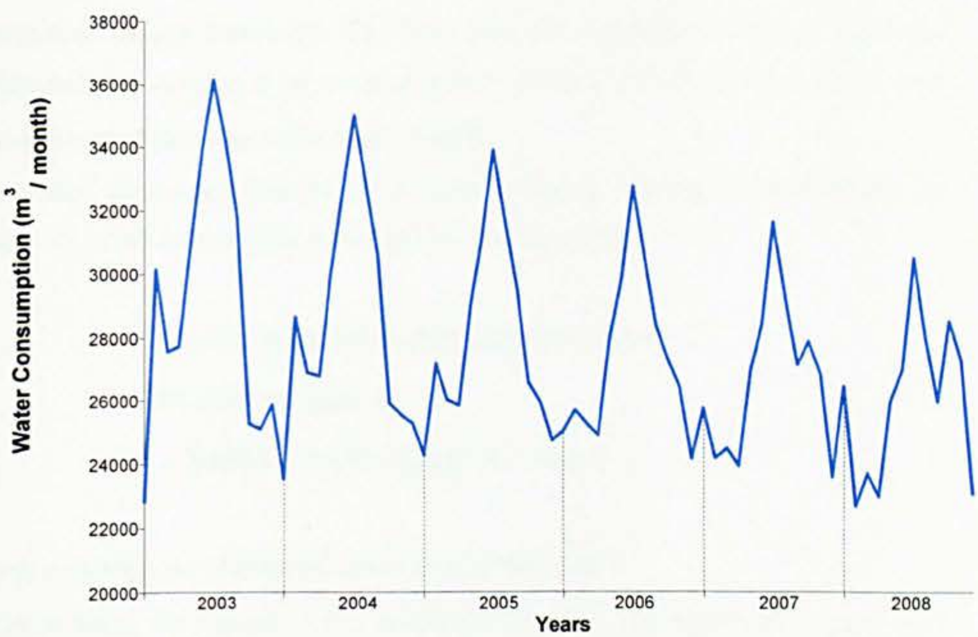

Figure 4-1 - Smoothed (working) data for total month consumptions

4.2 Data processing, models and outputs

4.2.1 <u>Working data analysis by the numeric multiplicative decomposition method</u>

4.2.1.1 <u>Introduction</u>

The working data was processed by the multiplicative decomposition method (as described in paragraph 3.3.3.3) for yearly periods and monthly seasons, and for yearly periods and weekly seasons.

The multiplicative components $\mathbf{TR_i}$, $\mathbf{SN_i}$, $\mathbf{CL_i}$ and $\mathbf{IR_i}$ (as defined by equation 3.1) are identified and tabled in Annexe 2 for year periods and month seasons and in Annexe 3 for year periods and week seasons.

An important conclusion of these analyses is that, as expected, the numeric values of $\mathbf{CL_i}$ and $\mathbf{IR_i}$ (the cyclic and the Irregular components) are close to one for both monthly and weekly seasons.

This reconfirms that, for monthly and for weekly seasons, it is expected that the hospital's global water consumption patterns will be satisfactorily modelled by simplified models of the type of $\mathbf{TR_i \times SN_i}$ (equation 3.4).

4.2.1.2 Analysis of yearly periods and monthly seasons

As shown in Figure 4-2, there exists a good overlapping between the most probable values (products $\mathbf{Tr * Sn}$) and the respective working data, as calculated in Annexe 2 for the period from January, 2003, to April, 2008. The coefficient of determination is $\mathbf{c^2 = 99\%}$.

It is also concluded that the maximum expected summer consumptions (in July, in m^3/month) can be modelled by the equation

$$\begin{aligned}&\textbf{Expected total water consumption}\\&\textbf{in July of year X=}\\&\mathbf{= 36069 - 1103 \times (year\ X - 2003)}\end{aligned} \qquad (4.1)$$

with a coefficient of determination in excess of **99%**.

Incidentally, the values of the products $\mathbf{Tr_i * Sn_i}$ (as plotted in Figure 4-2) are rather close to the values given by the SARIMA (acronym for "seasonal autoregressive integrated moving average") model made for the same working data by Professor Dulce Maria Oliveira Gomes, as a kind support to this Thesis.

Professor Dulce Gomes is in charge of the Chair of Time Series at the University of Évora, in Portugal, and hers is the SARIMA (0,1,1) $(1,1,0)_{12}$ model

$$\mathbf{Y_t = 0{,}99Y_{t-12} + \varepsilon_t - 0{,}987\varepsilon_{t-1}}$$

plotted in Figure 4-3, where $\mathbf{Y_t}$ represents logarithmic transformed data, followed by a seasonal difference and by a simple first difference.

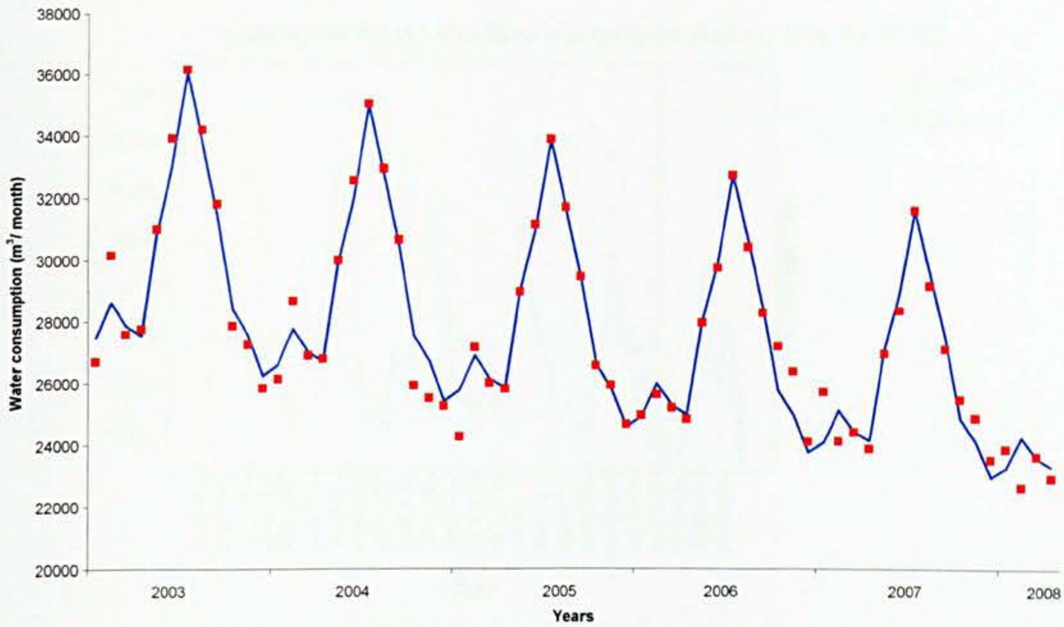

Figure 4-2 - Overlapping of most probable (-) and working data (-) values for monthly water consumptions

In particular, the expected maximum yearly summer consumptions (in the months of July, in m^3/month) derived from Professor Dulce Gomes' SARIMA model, can be expressed by the equation

$$\begin{aligned}&\textbf{Expected total water consumption}\\&\textbf{in July of year X} =\\&= \mathbf{36239 - 1172 \times (year\ X - 2003)}\end{aligned} \tag{4.2}$$

The values produced by equations 4.1 (multiplicative decomposition method) and 4.2 (SARIMA model) for the months of July of years 2006, 2007 and 2008 are shown in Table 4-1, and are within **99%** of each other.

TABLE 4-1

WATER CONSUMPTIONS IN JULY, IN m^3/MONTH

Year	2006	2007	2008
Equation 4.1	32760	31657	30554
Equation 4.2	32723	31551	30379

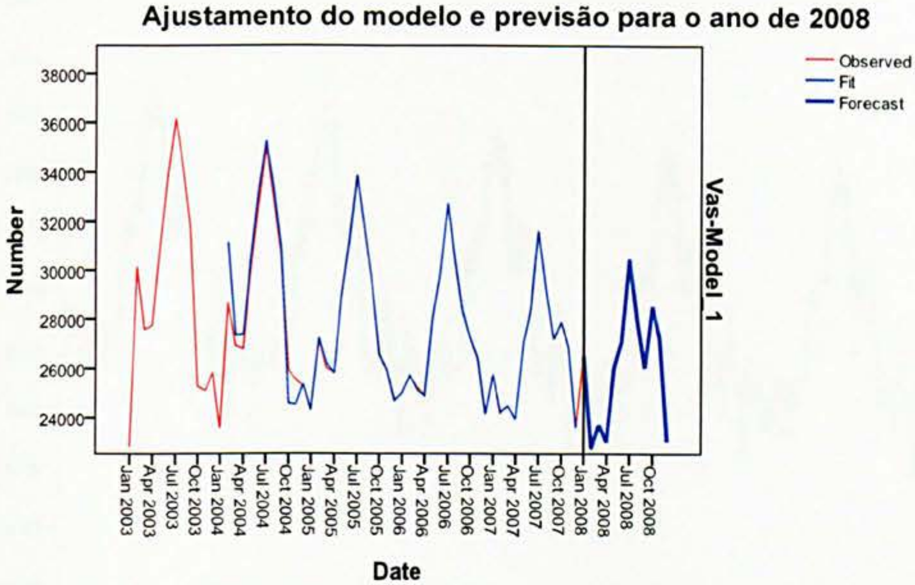

Figure 4-3 – SARIMA model produced for the same data by Professor Dulce Gomes

4.2.1.3 Analysis of yearly periods and weekly seasons

As shown in Figure 4-4, there exists a good overlapping between the most probable values (products $\mathbf{Tr * Sn}$) and the respective working data, as calculated in Annexe 3 for the period from January, 2003, to April, 2008. The coefficient of determination is $\mathbf{c^2 = 90\%}$.

4.2.1.4 Evaluation of Average and Seasonal extreme water consumption factors for yearly periods and daily seasons

The working data for the day seasons was tabled and processed in Annexe 4, to evaluate the average daily consumptions and the maxima and minima day peak coefficients.

Regarding the average daily water consumption at the hospital during the period of 5 years between 2003 and 2007, it was concluded that it was **909 m³/day**. This is equivalent to **1,172 ℓ/day/bed** for the 776 beds in service at the Amadora - Sintra.

However, it must be noted in this regard that the water consumption at Amadora - Sintra has been steadily reduced since 2006, having been of **821 m³/day** during 2007. This is equivalent to **1,058 ℓ/day/bed**.

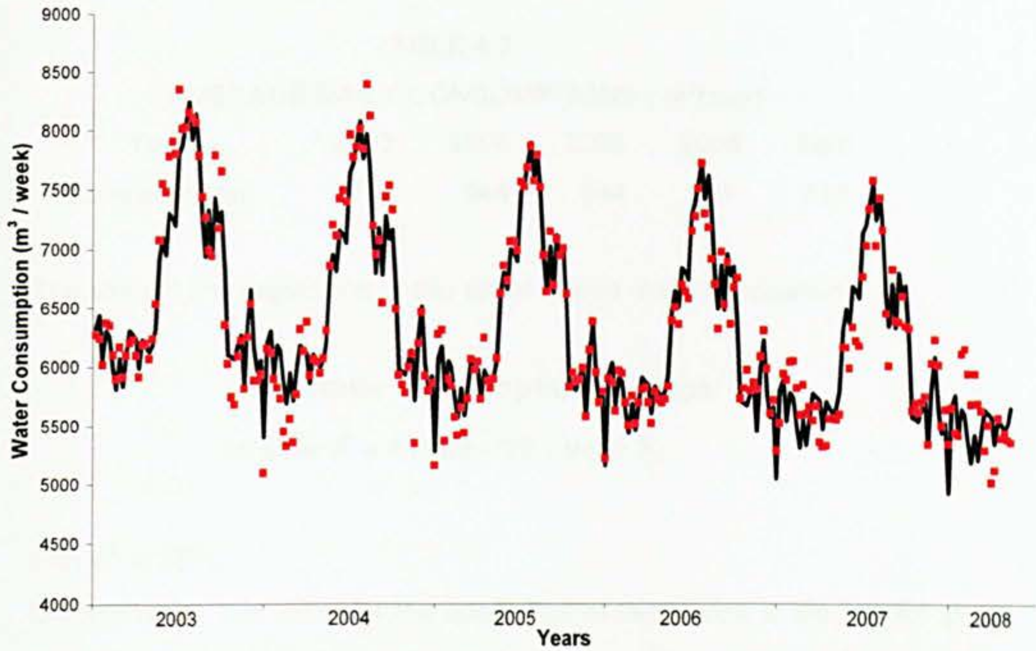

Figure 4-4 - Overlapping of most probable values (-) and working data (-) of weekly water consumption values

In view of that steady reduction of water consumption at the hospital since 2006, the year of 2007 is considered adequate in the circumstances for the evaluation of the maxima and minima factors.

Thus, it is concluded that (Annexe 4)

a) **1,377 m³/day** was the water consumed at the hospital during the day of the year 2007 with the maximum consumption. This is equivalent to **1,774 ℓ/day.bed**, and is also equivalent to a maximum consumption factor of **1.68**.

b) **436 m³/day** was the water consumed at the hospital on the day of the year 2007 with the minimum consumption. This is equivalent to **562 ℓ/day.bed**, and is also equivalent to a minimum consumption factor of **0.53**.

4.2.1.5 Prevision of average daily global water consumption

The average daily water consumptions during the years 2003 to 2007 were calculated in Annexe 4 and are as indicated in the following Table 4-2.

TABLE 4.2

AVERAGE DAILY CONSUMPTIONS (m^3/day)

Year	2003	2004	2005	2006	2007
Consumption	912	944	944	925	821

The straight line regression of this set of values leads to equation

$$\textbf{Daily water consumption average}$$
$$\textbf{in year X} = 41209 - 20 \times \textbf{year X}$$

with $c^2 = 39\%$.

Unfortunately, this value for the coefficient of regression is too low for any reliable conclusions and forecasts about average water consumption. However, this matter will be considered again, in Chapter 4.2.3.1.

4.2.2 Trend simple regression analysis

4.2.2.1 Trend regression analysis for monthly seasons

The pairs (t_i, d_i), i.e., the pairs "time period" and respective "deseasonalized" working values" as contained in Annexe 2, were processed for monthly seasons, for the determination of their four best linear regressions (introduced in paragraphs 3.3.4.7 to 3.3.4.10). The respective coefficients of determination were also calculated, and the results are

a) For the logarithmic regression:

Equation 3.17: $a = 32{,}576.367$

Equation 3.18: $b = -1{,}452.248$

Equation 3.11: $p_i = a + b \ln t_i$

Equation 3.73: $c^2 = 69\%$

b) For the straight line regression:

Equation 3.26: $\mathbf{a = 30{,}394.501}$

Equation 3.27: $\mathbf{b = -76.114}$

Equation 3.12: $\mathbf{p_i = a + bt_i}$

Equation 3.73: $\mathbf{c^2 = 81\%}$

c) For the exponential regression:

Equation 3.34: $\mathbf{a = 30{,}457.057}$ **(> 0)**

Equation 3.35: $\mathbf{b = -0.003}$

Equation 3.13: $\mathbf{p_i = ae^{bt_i}}$

Equation 3.73: $\mathbf{c^2 = 81\%}$

d) For the power regression:

Equation 3.40: $\mathbf{a = 32{,}871.124}$ **(> 0)**

Equation 3.41: $\mathbf{b = -0.051}$

Equation 3.14: $\mathbf{p_i = at_i^b}$

Equation 3.73: $\mathbf{c^2 = 68\%}$

It is therefore concluded that the trend for yearly periods and monthly seasons is equally well modelled by either a straight line or an exponential model. However, due to the easier processing, it was decided to proceed with the straight line model.

The Trend for yearly periods and monthly seasons can therefore be acceptably modelled by the equation

$$\mathbf{P_{TR_i} = 30{,}395 - 76.1t_i} \qquad (4.3)$$

with $\mathbf{c^2 = 81\%}$.

Accordingly, it can be concluded that equation 4.3 is an acceptable model for the Trend of the global water consumption at "Amadora Sintra", when yearly periods and monthly seasons are considered.

In this particular case, $\mathbf{t_1}$ corresponds to the month of January, 2003. All the subsequent months correspond to the respective time periods counted from that month onwards.

This model is plotted in Figure 4-5, together with the $\mathbf{d_i}$ components as obtained by the decomposition analysis (Annexe 2).

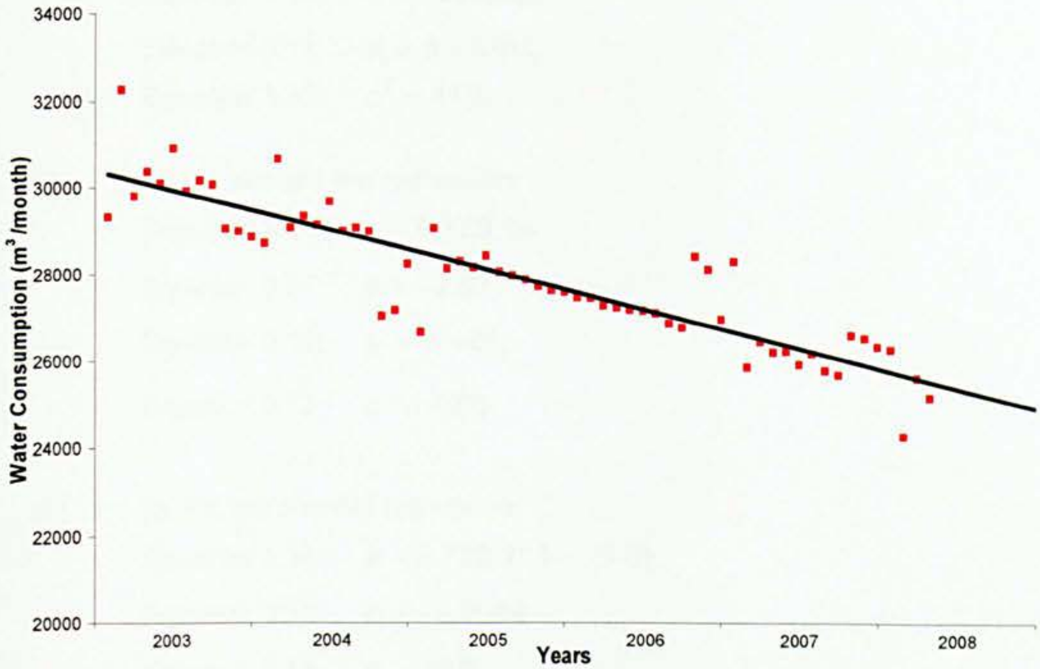

Figure 4-5- Overlapping of the trend regression of monthly consumptions, with the $\mathbf{d_i}$ components as obtained by the numeric decomposition analysis

For example, for the month of November, 2007 (month of order 59), the most probable value (model 4.3) is $\mathbf{25{,}905\ m^3}$. Multiplying this value by the seasonal factor for that month ($\mathbf{0{,}9329}$, as indicated in (Annexe 2), the expected water consumption would be $\mathbf{24{,}167 m^3}$. Since the recorded value for that month is $\mathbf{26{,}617\ m^3}$, it is concluded that the two values are within **91%** of each other.

4.2.2.2 Trend regression analysis for weekly seasons

The pairs of values $(\mathbf{t_i}, \mathbf{d_i})$ for weekly seasons were processed in Annexe 3 for the determination of the four best regressions (introduced in paragraphs 3.3.4.7 to 3.3.4.10). The respective coefficients of determination were also calculated.

The results are

a) For the logarithmic regression:

Equation 3.17: $\mathbf{a = 7{,}306.520}$

Equation 3.18: $\mathbf{b = -204.860}$

Equation 3.11: $\mathbf{p_i = a + b\ln t_i}$

Equation 3.73: $\mathbf{c^2 = 41\%}$

b) for the straight line regression:

Equation 3.26: $\mathbf{a = 6{,}729.14}$

Equation 3.27: $\mathbf{b = -2.677}$

Equation 3.12: $\mathbf{p_i = a + bt_i}$

Equation 3.73: $\mathbf{c^2 = 49\%}$

c) for the exponential regression:

Equation 3.34: $\mathbf{a = 6{,}733.111 \quad (> 0)}$

Equation 3.35: $\mathbf{b = -0.0004}$

Equation 3.13: $\mathbf{p_i = ae^{bt_i}}$

Equation 3.73: $\mathbf{c^2 = 49\%}$

d) for the power regression:

Equation 3.40: $\mathbf{a = 7{,}375.911 \quad (> 0)}$

Equation 3.41: $\mathbf{b = -0.032}$

Equation 3.14: $\mathbf{p_i = at_i^b}$

Equation 3.73: $\mathbf{c^2 = 40\%}$

It is therefore concluded that the weekly trend is equally well modelled by a straight line or by an exponential equation. Because of the ease of manipulation, however, it was decided to proceed only with the straight line equation, of the form

$$\mathbf{P_{TR_i} = 6{,}729 - 2.7t_i} \tag{4.4}$$

with $\mathbf{c^2 = 49\%}$.

Accordingly, it is concluded that equation 4.4 is not a reliable model for the Trend of the global water consumption at “Amadora Sintra”, when yearly periods and weekly seasons are considered.

In this particular case, $\mathbf{t_1}$ corresponds to the first week of 2003. All the subsequent weeks correspond to the respective time periods counted from that week onwards.

This model is plotted in Figure 4-6, together with the $\mathbf{d_i}$ components as obtained by the decomposition analysis (Annexe 3).

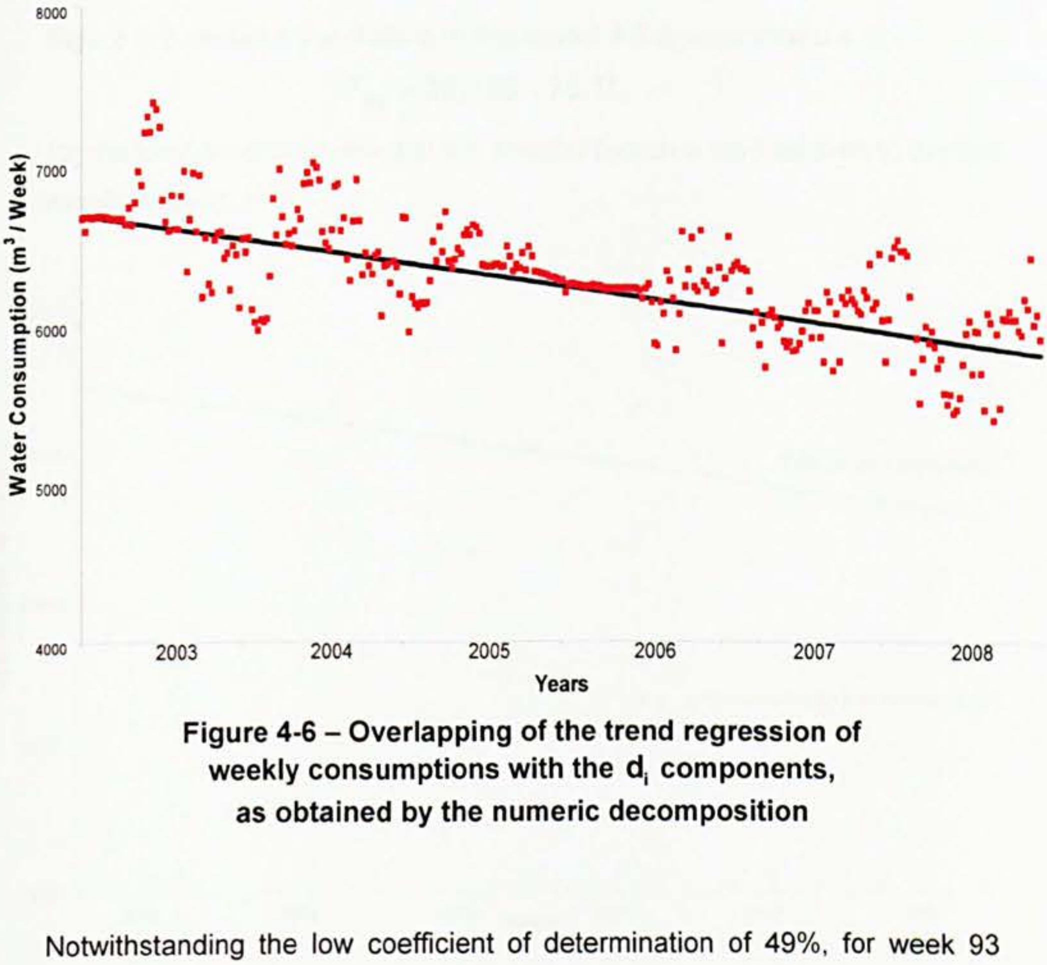

Figure 4-6 – Overlapping of the trend regression of weekly consumptions with the $\mathbf{d_i}$ components, as obtained by the numeric decomposition

Notwithstanding the low coefficient of determination of 49%, for week 93 (October, 2004), the most probable consumption (model 4.4) is $\mathbf{6,478\,m^3}$. Multiplying this value by the seasonal factor for that month (**0,9218**, as indicated in the same Annexe 3), the expected water consumption would be $\mathbf{5,971 m^3}$. Since the recorded value for that week is $\mathbf{6,457\,m^3}$, it is concluded that the two values are within **92%** of each other.

4.2.3 Long term water consumption evolution

4.2.3.1 The two combined sources of water

The model of the smoothed values of the water abstracted from the municipal water supply system was also evaluated. It is referred to the first month of 2003, and is

$$p_{iMunic} = 22,823\text{-}89.4t_i \tag{4.5}$$

with $c^2 = 83\%$.

Figure 4-7 contains the plotting of this model 4.5 against model 4.3

$$P_{TR_i} = 30,395 - 76.1t_i$$

for the total water consumed at the hospital (which is also referred to the first month of 2003).

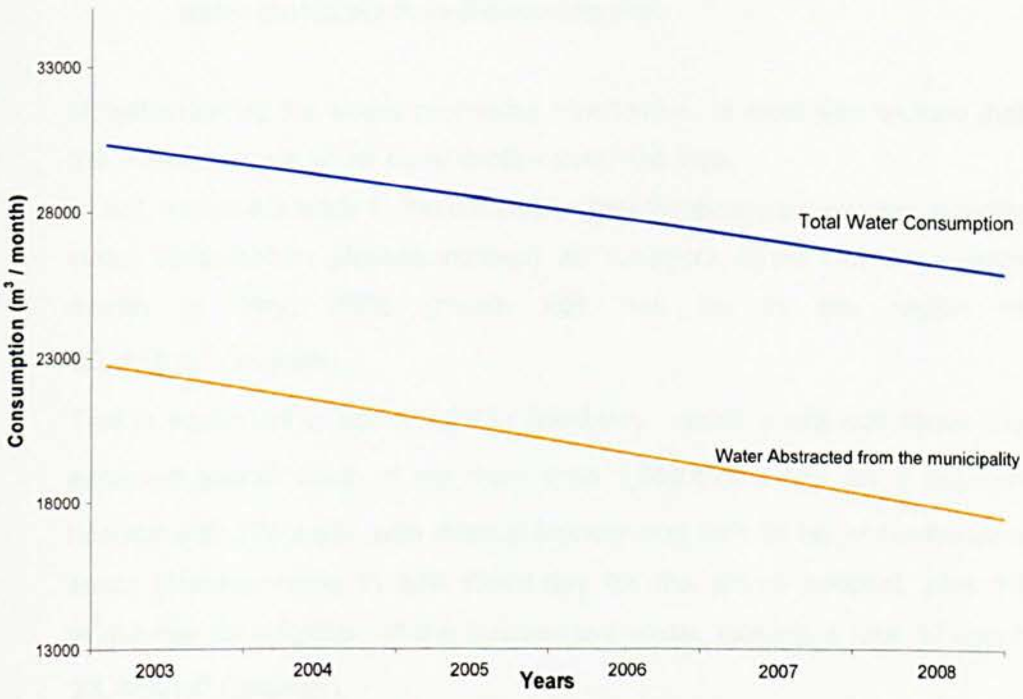

Figure 4-7 – Long term evolution of the water consumption at "Amadora Sintra" (from the municipality (-), and total (-))

The conclusion is that, unequivocally, Hospital Amadora Sintra is managing wisely its global use of water.

In fact, on average, the hospital

a) is being environmentally minded, by consuming less water (overall savings of some **900 m³ / year** over the last few years),

b) is also saving money, by abstracting less water from the municipality. The corresponding savings are about **$1{,}100\ m^3/year$** at an overall rate of **$€3.71/m^3$** of water, or some **$€4{,}100/year$** (about **$£3{,}700/year$**), and

c) the above water and money savings are attained by an increased abstraction of not more than **$160\ m^3/year$** of water from the borehole pumped to an height of **117 m** with an efficiency of **85%**, at an electricity rate of **$€0.09/kWh$**. That means a neglectful cost of **$€0.0338/m^3$** of water pumped into Deposit 1 (or about **$£0.0304/m^3$**). This cost is 110 times lower that the cost of the water abstracted from the municipality!

Notwithstanding the above promising conclusions, is must also be said that the actual average water consumption is still too high.

In fact, model 4.3 leads to the conclusion that the expected average monthly water consumption (deseasonalised) at "Amadora Sintra" for the current month of May, 2008 (month 65), will be in the region of **$25{,}450\ m^3/month$**.

That is equivalent to about **$1{,}093\ \ell/bed.day$**, which is still well above the expected overall value of not more than **1,000 ℓ/bed.day** for a regional hospital with **776** beds, with internal laundry and with **16 Ha** of landscaped areas (corresponding to **800 ℓ/bed.day** for the actual hospital, plus **10 m^3/ha.day** for irrigation of the landscaped areas, making a total of about **$23{,}450\ m^3/month$**).

At the current overall water savings rate of **$76.1\ m^3/month$** (model 4.3), it can be forecast that ideal consumption of **$23{,}450\ m^3/month$** will be reached by early during the second semester of 2010.

4.2.3.2 <u>Preliminary cost analysis of the sinking of a new borehole, associated with the installation of a water purification plant</u>

The possibility of supplying borehole water to the whole hospital should also be seriously investigated.

In fact, all indications lead to the preliminary conclusion that a second borehole would be a viable proposition, as it would bring significant water savings without jeopardizing the quality of the service. The sinking of another borehole at the South-Eastern boundary of the hospital, some **300 m** distant from the existing one, would comply with the minimum legal distances between boreholes, as prescribed by the Portuguese Law 382/99. Additionally, the ground morphology does not change from the local where the present borehole is sunk, at least visually, and the position proposed for the second one is within the same catchment and at a lower level,

In line with the recommendations of "Critérios Gerais de Concepção e de Avaliação Económica" [20] for the preliminary evaluation of the civil, mechanical and electrical costs involved with the sinking and the operation of boreholes, the estimated costs for another borehole at Amadora - Sintra are as follows:

a) Estimated cost of construction and installation of the borehole

The above recommendations propose the following formula for the civil costs, with VAT included:

$$\mathbf{Civil\ cost,\ in\ Euros} =$$

$$= \mathbf{(46500 + 50 \times depth\ in\ meters) \times 1.21} =$$

$$= \mathbf{(46500 + 50 \times 140) \times 1.21 = Euros\ 64{,}750}$$

and the following formula for the mechanical and electrical costs, where **Q** is the yield in ℓ/s and **H** is the depth in meters:

$$\mathbf{Mechanical\ and\ electrical\ costs,\ in\ Euros} =$$

$$= \left[\mathbf{240 (QH)^{0.466} + 151 Q^{0.769} H^{0.184}}\right] \times \mathbf{1.21} =$$

$$= \left[\mathbf{240 \times (8.0 \times 140)^{0.466} + 151 \times 8.0^{0.769} \times 140^{0.184}}\right] \times \mathbf{1.21} =$$

$$= \mathbf{Euros\ 9{,}900}$$

Accordingly, the expected price for the installation of the borehole is **€74,650** (or **£67,900**), VAT included.

Regarding the cost of the water purification plant to purify the water of the two boreholes, **ADP** recons that each hospital bed is equivalent to 4 persons (i.e., 1 hospital bed uses 800 ℓ/day, which is equivalent to 4 persons at **200 ℓ/day** each). Thus, the whole hospital is equivalent to 776 x 4 = 3,104 inhabitants.

For such a plant, **ADP** expects a overall price of **€50,000** (or **£45,500)**, VAT included, and a running cost of **€7,500** (or **£6,800**) per annum.

In view of the above, the overall cost of installation of the second borehole and of the purification plant (the later to serve both boreholes) is estimated in **€125,000**, VAT included.

The operation costs are basically the costs of energy and the costs of reagents.

Assuming that the two boreholes will have the same yield of $\mathbf{30\,m^3/hour}$ (or $\mathbf{8.3\,\ell/s}$), each one shall have to work **17** hours per day to supply a combined total of **1,000 m³/day**.

The energy required by the second borehole to pump half of that volume of water to a height of some **130 m** is

$$\textbf{Required Energy per year} =$$

$$= \frac{30\times 17\times 1000\times 9{,}81\times 140}{0{,}85}\times\frac{1}{3600\times 1000}\times 365 =$$

$$= \textbf{83,500 Kwh / year}$$

which corresponds to an additional annual cost of **€7,500** per year for energy, at the current rate of **€0,09/Kwh**.

Thus, the combined overall operation cost of the second borehole and of the purification plant, will be in the region of **€15,000** (or **£13,500**) per annum.

b) Preliminary evaluation of the rentability of a second borehole

Assuming that at present each bed draws **800 ℓ/day** from the municipal water supply system, the cost of that water will be

$$\textbf{Cost of water from the municipality} =$$

$$= 0{,}8\times 776\times 30\times 12\times 3{,}71 =$$

$$= \textbf{Euros 829,150 / year}$$

i.e., the combined cost of the second borehole and purification plant would be recovered in a few months!

However, the above assumptions can only be considered as part of a preliminary planning program.

A hydro geologist should be consulted to assess the quality and expected yield of this second borehole, to confirm the above assumptions.

In anyway, the existing connection to the municipal system would always be left active and should be tested daily, to act as a reserve for emergency supplies.

4.2.4 Seasonal regression analysis

4.2.4.1 Seasonal regression analysis for monthly seasons

The pairs of values (t_i, SN_i) for monthly seasons were processed (Annexe 5) in accordance with the methodology introduced in paragraph 3.3.4.4 above, for the determination of the best seasonal model (equation 3.47).

The data values to consider for j, L and N correspond to 5 periods of records, of 12 seasons each, i.e., $j = 1,2,...,12$, $L = 12$ and $N = 5$.

The coefficients of equations 3.52 to 3.54 for those values, become

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=12}\cos\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=12}\cos\frac{2\pi}{T}t_j = 0$$

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=52}\sin\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=52}\sin\frac{2\pi}{T}t_j = 0$$

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=12}\cos^2\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=12}\cos^2\frac{2\pi}{T}t_j = 30$$

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=12}\sin\frac{2\pi}{T}t_j\cos\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=12}\sin\frac{2\pi}{T}t_j\cos\frac{2\pi}{T}t_j = 0$$

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=12}\sin^2\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=12}\sin^2\frac{2\pi}{T}t_j = 30$$

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=12}r_{jk} = 5\sum_{j=1}^{j=12}r_j = 60$$

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=12}r_{jk}\cos\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=12}r_j\cos\frac{2\pi}{12}t_j = -3.1532$$

and

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=12} r_{jk} \sin\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=12} r_j \sin\frac{2\pi}{T}t_j = -2.1895$$

Therefore, the set of equations 3.52 to 3.54 becomes

$$60A = 60$$
$$30B = -3.1532$$
$$30C = -2.1895$$

which is solved for

$$A = 1.0000$$
$$B = -0.1051$$
$$C = -0.0730$$

Accordingly, the best trigonometric model (equation 3.47) for the monthly seasonal components SN_j is

$$SN_j = 1.0000 - 0.1051\cos\frac{\pi}{6}t_j - 0.0730\sin\frac{\pi}{6}t_j \qquad (4.6)$$

with $j = 1, 2, \ldots, 12$.

This equation 4.6 is plotted in Figure 4-8, together with the seasonal components SN_j as obtained by the decomposition analysis from the working data (Annexes 2 and 5). The coefficient of determination is $c^2 = 82\%$.

The maxima and minima analysis of equation 4.6 shows that, for monthly seasons, the seasonal factor SN_j in hospitals

a) Reaches periodically its minimum expected value of $SN = 0.87$ (13% below the year average) when

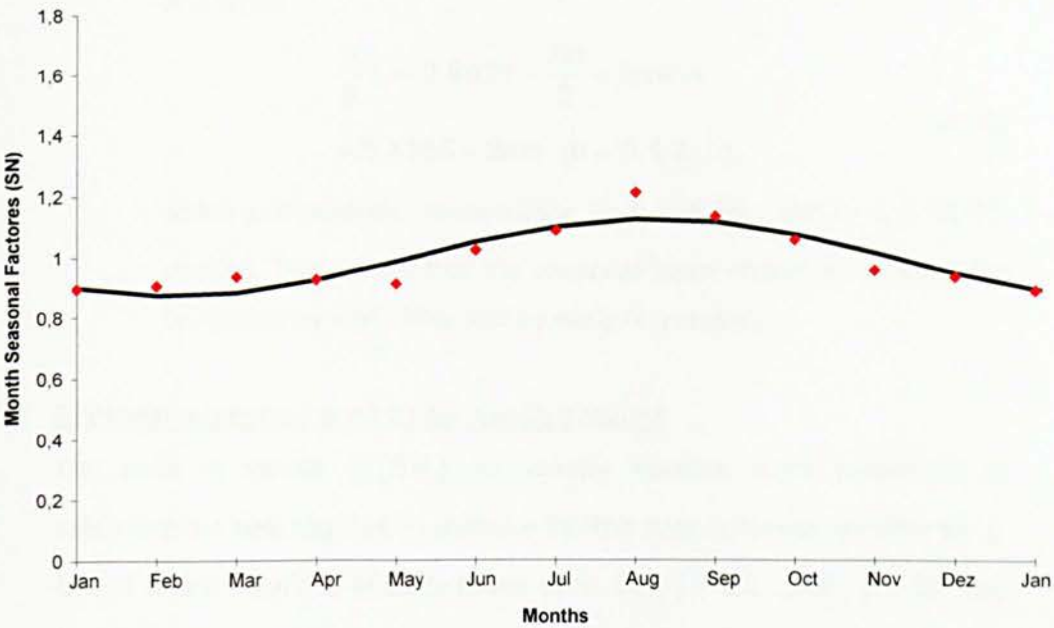

Figure 4-8 – Overlapping of the seasonal monthly components with the SN_i values as obtained by the analysis

$$\frac{\pi}{6}t_i = 0.6071 + 2n\pi \qquad (n = 0,1,2,...) \tag{4.7}$$

or, approximately, when $t_i = 1.16$ months (early February),

b) Reaches periodically its maximum expected value of $SN = 1.13$ (13% above the year average) when

$$\frac{\pi}{6}t_i = 0.6071 + \pi + 2n\pi = 3,7487 + 2n\pi \tag{4.8}$$

(with $n = 1,2,...$). This happens when $t_i = 7,16$ months.

This means that the peak of the highest consumption should be expected by early August.

c) Reaches periodically its neutral value (i,e, the expected value of $SN = 1.00$) when

$$\begin{aligned}\frac{\pi}{6}t_i &= 0.6071 + \frac{\pi}{2} + n\pi = \\ &= 2.1779 + n\pi \quad (n = 0,1,2,...)\end{aligned} \tag{4.9}$$

and when

$$\frac{\pi}{6}t_i = 0.6071 + \frac{3\pi}{2} + 2n\pi =$$
$$= 5.3195 + 2n\pi \quad (n = 0,1,2,...) \qquad (4.10)$$

which corresponds, respectively, to $t_i = 4.16$ and to $t_i = 10.16$ months. This means that the seasonal factor should be expected to be neutral by early May and by early November.

4.2.4.2 Seasonal regression analysis for weekly seasons

The pairs of values (t_i, SN_i) for weekly seasons were processed to determine the best regression (Annexe 6). The data values to consider for j, L and N are 5 periods of 52 seasons each, i.e., $j = 1,2,...,52$, $L = 52$ and $N = 5$.

Accordingly, the constants of equations 3.52 to 3.54 become

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=52}\cos\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=52}\cos\frac{2\pi}{52}t_j = 0$$

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=52}\sin\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=52}\sin\frac{2\pi}{52}t_j = 0$$

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=52}\cos^2\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=52}\cos^2\frac{2\pi}{52}t_j = 130$$

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=52}\sin\frac{2\pi}{T}t_j\cos\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=52}\sin\frac{2\pi}{52}t_j\cos\frac{2\pi}{52}t_j = 0$$

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=52}\sin^2\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=52}\sin^2\frac{2\pi}{52}t_j = 130$$

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=52}r_{jk} = 5\sum_{j=1}^{j=52}r_j = 260$$

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=52}r_{jk}\cos\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=52}r_{jk}\cos\frac{2\pi}{52}t_j = -14.9488$$

and

$$\sum_{k=1}^{k=5}\sum_{j=1}^{j=52}r_{jk}\sin\frac{2\pi}{T}t_j = 5\sum_{j=1}^{j=52}r_j\sin\frac{2\pi}{52}t_j = -8.2383$$

Therefore, the set of equations 3.52 to 3.54 become

$$260A = 260$$
$$130B = -14.9488$$
$$130C = -8.2383$$

which is satisfied for

$$A = 1.0000$$
$$B = -0,1150$$
$$C = -0,0634$$

Accordingly, the best trigonometric model for the seasonal weekly components SN_i is (equation 3.47)

$$SN_j = 1.0000 - 0.1150\cos\frac{\pi}{26}t_j - 0.0634\sin\frac{\pi}{26}t_j \qquad (4.11)$$

with $j = 1,2,...,52$.

Equation 4.11 is plotted in Figure 4-9, together with the seasonal components SN_i, as obtained by the analysis. The coefficient of determination is $c^2 = 74\%$.

The maxima and minima analysis of equation 4.11 shows that, for weekly seasons, the periodical seasonal factor SN_i

a) Reaches periodically its minimum expected value of $SN = 0.87$ (13% below the year average) when

$$\frac{\pi}{26}t_i = 0.5038 + 2n\pi \qquad (n = 0,1,2,...) \qquad (4.12)$$

or, approximately, when $t_i = 4.17$ weeks. That means that the lowest weekly consumption should be expected by the 5th week of the year, by early February.

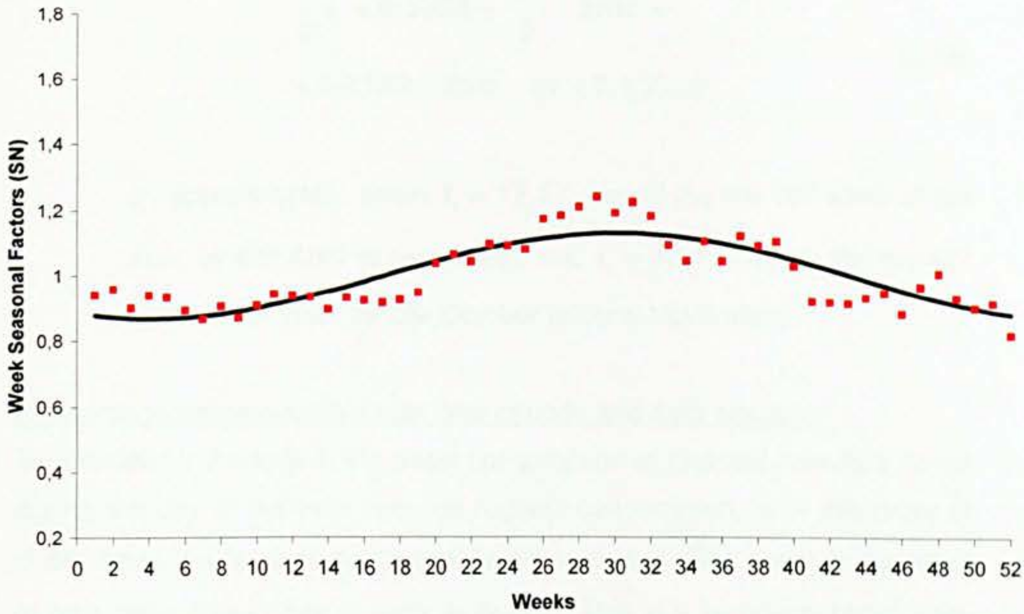

Figure 4-9 - Overlapping of the seasonal weekly components with the SN_i components, as obtained by the analysis

b) Reaches periodically its maximum expected value of $\mathbf{SN = 1.13}$ (13% above the year average) when

$$\frac{\pi}{26}t_i = 0.5038 + \pi + 2n\pi = \\ = 3.6454 + 2n\pi \quad (n = 0,1,2,...) \tag{4.13}$$

or, approximately, when $\mathbf{t_i = 30.17}$ weeks. That means that the highest weekly consumption should be expected by the 31st week of the year, either by late July or early August.

c) Is expected to be periodically neutral (i,e, $\mathbf{SN = 1.00}$) when

$$\frac{\pi}{26}t_i = 0.5038 + \frac{\pi}{2} + 2n\pi = \\ = 2.0746 + 2n\pi \quad (n = 0,1,2,...) \tag{4.14}$$

and when

$$\frac{\pi}{6}t_i = 0.5038 + \frac{3\pi}{2} + 2n\pi =$$
$$= 5.2162 + 2n\pi \quad (n = 0,1,2,...) \tag{4.15}$$

or, approximately, when $t_i = 17.17$ weeks (by the 18th week of the year, by late April or early May), and $t_i = 43.17$ weeks (by the 44th week of the year, by late October or early November).

4.2.4.3 Seasonal regression analysis for year periods and daily seasons

As indicated in Annexe 4, the water consumption at Hospital Amadora Sintra during the day of the year with the highest consumption, is of the order of **1.68** times the "annual average daily consumption. This event is expected to take place late in July or early in August. This is a surprising conclusion, because it would be expected that the hospital's water usage routines would not have such ample variations in hot summer days.

The water consumption during the day of the year with the lowest consumption, is of the order of **0.53** times the "annual average daily consumption". This event is expected to take place early in February.

4.2.5 Proposed model for yearly periods and monthly seasons

The combination of equations 4.3 and 4.6 leads to the following proposed model for monthly total water consumptions

$$p_i = (30,395 - 76.1t_i) \times$$
$$\times (1.0000 - 0.1051\cos\frac{\pi}{6}t_j - 0.0730\sin\frac{\pi}{6}t_j) \tag{4.16}$$

where, as previously indicated, t_i is the time period (month) of reference, and $j = 1,2,...,12$ is the corresponding season.

In the particular case of model 4.16, t_1 corresponds to the month of January, 2003. All the subsequent months correspond to the respective time periods counted from that month onwards.

As an example, the month of March 2007, corresponds to $t_i = 51$ (i.e., month of order 51), and the season is $j = 3$.

For that month, model 4.16 indicates that the most probable total monthly water consumption is $\mathbf{p_{51} = 24.578\, m^3}$. As the recorded value for that month is $\mathbf{r_{51} = 23{,}549\, m^3}$ and the corresponding smoothed value is $\mathbf{24{,}460 m^3}$, it is concluded that the accuracy of model 4.16 is **96%** for the recorded value, and **99%** for the smoothed value..

Equation 4.16 is plotted in Figure 4-10, together with the values of the working data for the total month water consumptions for the period January, 2004, to April, 2008. The coefficient of determination is $\mathbf{c^2 = 83\%}$.

4.2.6 <u>Proposed model for yearly periods and weekly seasons</u>

The combination of equations 4.4 and 4.11 leads to the following proposed model for weekly total water consumptions

$$\mathbf{p_i = (6{,}729 - 2.7t_i) \times} \\ \mathbf{\times(1.0000 - 0.1150\cos\frac{\pi}{26}t_j - 0.0634\sin\frac{\pi}{26}t_j)} \tag{4.17}$$

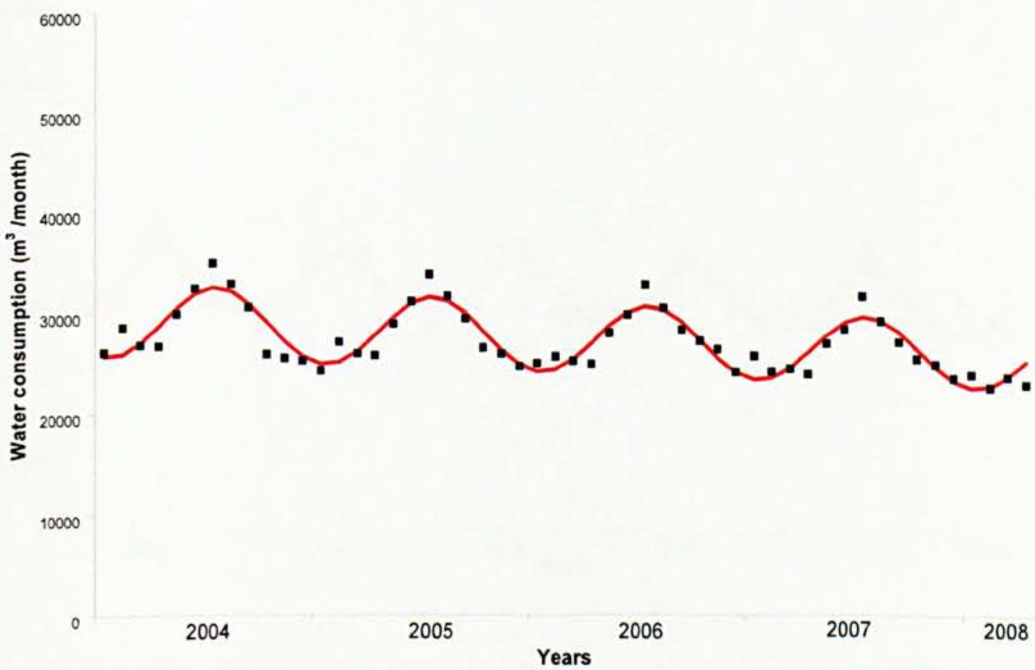

Figure 4-10 - Overlapping of the model for monthly total water consumptions, with the working data for the period January 2004 until April 2008

where, as previously indicated, $\mathbf{t_i}$ is the time period (week) of reference, and $\mathbf{j = 1, 2, ..., 52}$ is the corresponding season.

In this particular model, $\mathbf{t_1}$ corresponds to the first week of year 2003, and all the subsequent weeks corresponding to the respective time periods, counted from that first week of January 2003 onwards.

Equation 4.17 is plotted in Figure 4-11, together with the values of the total weekly water consumptions for the period January, 2003, to April, 2008. The coefficient of determination is $\mathbf{c^2 = 70\%}$.

As an example, week 16 of year 2008 corresponds to $\mathbf{t_i = 276}$ (i.e., week of order 276, in April, 2008), and the season is $\mathbf{j = 4}$. For this particular week, equation 4.17 indicates that the most probable total weekly water consumption is $\mathbf{p_{276} = 5{,}198\ m^3}$ m^3.

It is concluded that, for that week, the accuracy of model 4.17 is **94%** for the recorded value, and is **96%** for the smoothed value.

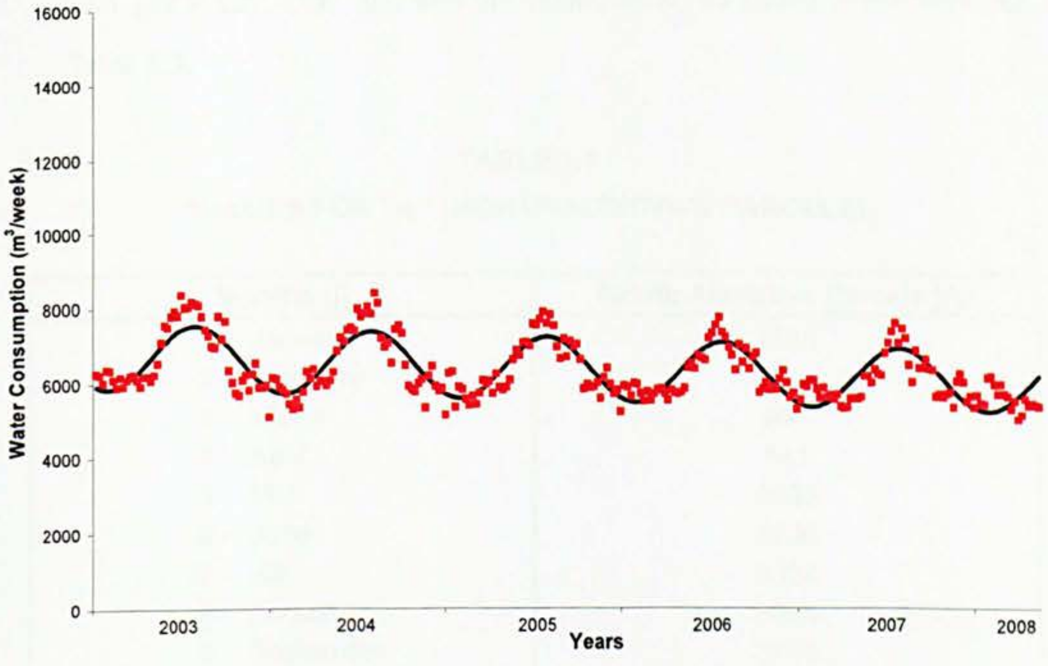

Figure 4-11- Overlapping of the model for weekly consumptions (-), with the working data for the period January, 2003, to April, 2008 (.)

It is also clearly visible that model 4.17 is less accurate for the peak summer periods, around week 30. For the year of 2007, the worst situation occurs in week 29, for which the most probable total weekly water consumption is $\mathbf{p_{237} = 6{,}881\,m^3}$, the recorded value for that week is $\mathbf{r_{237} = 7115\,m^3}$ and the corresponding smoothed value is $\mathbf{7{,}591\,m^3}$. Hence, the model's accuracy for that week 237 is **97%** for the recorded value, and **91%** for the smoothed value.

4.2.7 Dummy models for Hospital Amadora - Sintra

4.2.7.1 Dummy model for yearly periods and monthly seasons

Considering the years of 2006 and 2007, equation 3.57 becomes

$$\mathbf{SN_i = \sum_{k=1}^{k=2} \frac{r_{12k}}{2} + \sum_{m=1}^{m=12} \left[\frac{\sum_{k=1}^{k=2} (r_{jk} - r_{12k})}{2} \right] \times \alpha_{jm} =}$$

$$\mathbf{= 23{,}857 + A_j} \qquad (4.18)$$

with $\mathbf{j,m = 1,2,\ldots,12}$, and with the values of $\mathbf{A_j}$ as tabled in the following Table 4.3:

TABLE 4.3

VALUES FOR "A_j" (MONTH ADDICTIVE PARCELS)

Months (j)	Month Addictive Parcels (A_j)
1 - January	1518
2 - February	1054
3 - March	991
4 - April	541
5 - May	3633
6 - June	5236
7 - July	8324
8 - August	5976
9 - September	3880
10 - October	2506
11 - November	1806
12 - December	0

Accordingly, the most probable water consumption expected for January (month 1) will be

$$\mathbf{SN_1 = 23{,}857 + 1{,}518 = 25{,}375\,m^3}$$

The expected values for the monthly seasons, as defined by equation 4.18, are shown in Figure 4-12.

It must be mentioned that, due to the noticeable differences between the duration of the successive months (for example, a reduction of 9.7% from January to February, and an increase of 10.7% from February to March) it is often convenient to reduce the total monthly consumption to the corresponding daily averages. This is particularly evident between the months of January and February, as it may be expected that the overall consumption in February will be lower than that of January (because of the number of days of each of the months), but in fact the actual daily consumptions in February may be higher than those of February.

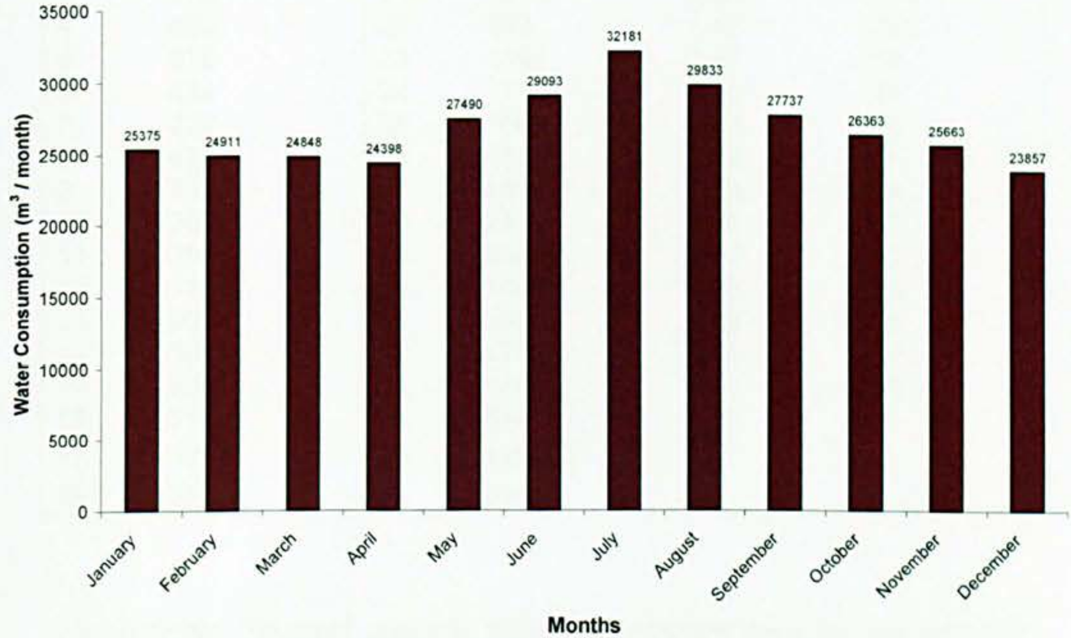

Figure 4-12 - Expected monthly water consumptions at "Amadora Sintra", as defined by the "dummy" variables methodology

4.2.7.2 Dummy model for yearly periods and weekly seasons

Considering again the most recent years of 2006 (weeks 157 to 208 in Annexe 3) and 2007 (weeks 209 to 260 of the same Annexe), equation 3.56 becomes

$$\mathbf{SN_j = \sum_{k=1}^{k=2} \frac{r_{52k}}{2} + \sum_{m=1}^{m=52} \left[\frac{\sum_{k=1}^{k=2} (r_{jk} - r_{52k})}{2} \right] \times \alpha_{jm} =}$$

$$\mathbf{= 5,334 + B_j} \tag{4.19}$$

with $j, m = 1, 2, ..., 52$.

The expected additive values B_j for each of the 52 weekly seasons, as defined by equation 4.19, are shown in the following Table 4.4:

TABLE 4.4

VALUES FOR "B_j" (WEEK ADDITIVE PARCELS)

Week (j)	Week Additive Parcel B_j	Week (j)	Week Additive Parcel B_j	Week (j)	Week Additive Parcel B_j
1	389	19	393	37	1315
2	580	20	958	38	1162
3	435	21	1013	39	1194
4	680	22	852	40	1222
5	670	23	1199	41	358
6	434	24	1110	42	431
7	226	25	1060	43	474
8	475	26	1639	44	426
9	238	27	1832	45	484
10	355	28	2101	46	257
11	354	29	2328	47	737
12	419	30	1843	48	952
13	206	31	1985	49	678
14	103	32	1720	50	237
15	238	33	1260	51	355
16	318	34	844	52	0
17	307	35	1582		
18	318	36	1141		

Accordingly, the most probable water consumption expected via equation 4.19 for week 16 will be

$$SN_{16} = 5,334 + 318 = 5,652 \text{ m}^3$$

Since this week 16 is the same week as referred to in paragraph 4.2.6 above, where it was week 276 for the application of equation 4.17, and since it was recorded the consumption of **5524 m^3** and the corresponding smoothed value is **5,416m^3** for that week, it is concluded that, for that week, the accuracy of model 4.19 is **98%** for the recorded value, and **96%** for the smoothed value.

The expected values for the weekly seasons, as defined by equation 4.19, are shown in Figure 4-13.

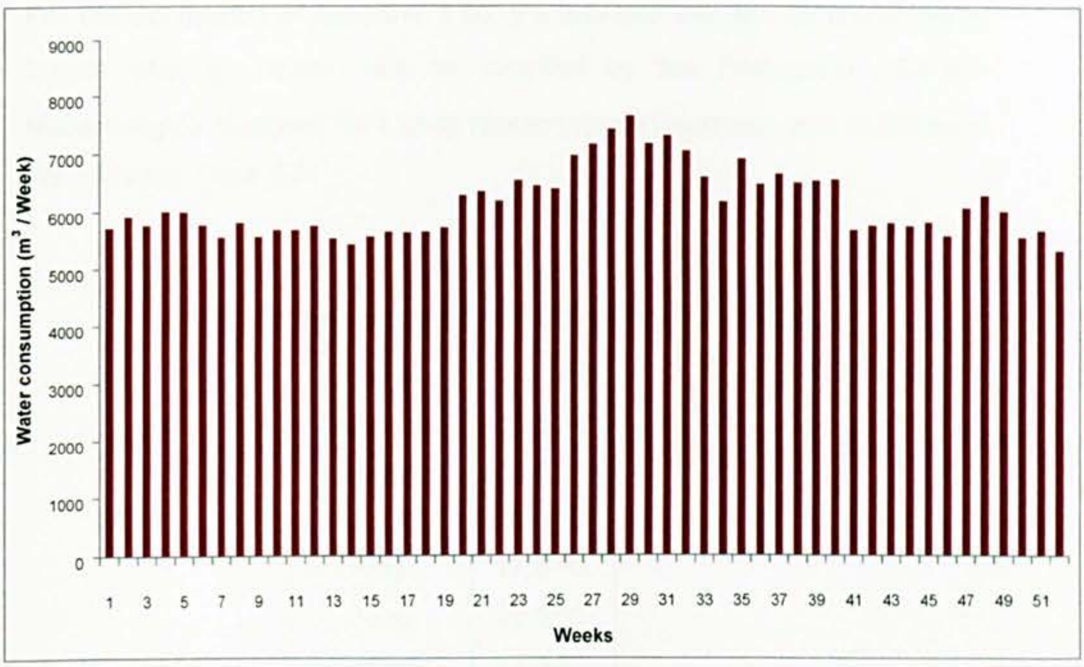

Figure 4-13 - Expected weekly water consumptions at "Amadora Sintra", as defined by the "dummy" variables method

4.2.8 Influence of ambient temperature in water consumption

4.2.8.1 Multiple regression analysis and modelling of a bi-variate model "temperature - time period - water consumption" for monthly seasons

Since equation 3.60

$$\mathbf{p_i = a + bt_i + cq_i}$$

refers to two straight line regressions with the two independent variables $\mathbf{t_i}$ and $\mathbf{q_i}$, it was decided to consider not the actual monthly water consumptions but rather their trend values, and afterwards multiply the results by their seasonal factors.

Accordingly, equation 3.60 shall be applied to the triplets $\mathbf{(t_i, TR_i, q_i)}$, with the $\mathbf{TR_i}$ values as defined by equation 4.3

$$\mathbf{P_{TR_i} = 30{,}395 - 76.1t_i}$$

and the seasonal factors as defined by equation 4.6

$$\mathbf{SN_j = 1.0000 - 0.1051\cos\frac{\pi}{6}t_j - 0.0730\sin\frac{\pi}{6}t_j}$$

for the months from January, 2006, to December, 2007 (i.e., for values of $\mathbf{i = 37, 38, ..., 60}$).

For the application of equation 3.60, the monthly average temperatures in Lisbon (the q_i values) are as supplied by the Portuguese "Serviço Meteorológico Nacional" for Lisbon (Station Gago Coutinho), and indicated in the following Table 4-5:

TABLE 4-5

AVERAGE MONTH TEMPERATURES AT LISBON

January	11. 0 °C
February	11.5 °C
March	13.5 °C
April	16.0 °C
May	17.0 °C
June	20.0 °C
July	22.0 °C
August	22.5 °C
September	21.5 °C
October	18.0 °C
November	14.0 °C
December	12.0 °C

For those values, the constants of the system of equations 3.61 to 3.63 (as introduced in paragraph 3.3.6.2.1 above) become

$$\mathbf{n=2} \qquad \sum_{i=37}^{i=60} t_i = 1{,}164 \qquad \sum_{i=37}^{i=60} q_i = 398$$

$$\sum_{i=37}^{i=60} r_i = 643{,}494 \qquad \sum_{i=37}^{i=60} (t_i)^2 = 57{,}604 \qquad \sum_{i=37}^{i=60} t_i q_i = 19{,}414$$

$$\sum_{i=37}^{i=60} r_i t_i = 31{,}163{,}744 \qquad \sum_{i=37}^{i=60} (q_i)^2 = 6{,}994 \qquad \sum_{i=37}^{i=60} r_i q_i = 10{,}872{,}488$$

Accordingly, the system of equations 3.61 to 3.63 becomes

$$2a + 1164b + 398c = 643{,}494$$

$$1{,}164a + 57{,}604b + 19{,}414c = 31{,}163{,}744$$

$$398a + 19{,}414b + 6{,}994c = 10{,}872{,}488$$

which is solved for

$$a = -421.337 \qquad b = 271.576 \qquad c = 824.677$$

Therefore, the best multiple regression for the combination "water consumption - time period of occurrence – ambient temperature" should be (equation 3.60)

$$p_i = -421.337 + 271.576t_i + 824.677q_i \tag{4.20}$$

which is calculated in Annexe 7.

The combination of equations 4.20 and 4.6 (the monthly seasonal factors) leads to the model

$$\begin{aligned} p_i &= (-421.337 + 271.576t_i + 824.677q_i)\times \\ &\times(1.0000 - 0.1051\cos\frac{\pi}{6}t_j - 0.0730\sin\frac{\pi}{6}t_j) \end{aligned} \tag{4.21}$$

which is resolved in Annexe 7 and is plotted in Figure 4-14, together with model 4.16.

Unfortunately, it has to be concluded that the above model 4.21 is not reliable for the relation between the prevailing air temperatures and the volumes of water consumed under those temperatures. This is so because it shows a tendency for increased consumptions over time, which in reality does not occur.

4.2.8.2 Direct influence of temperature on water consumption

Since the interdependence between the volumes of water consumed in a hospital and their time periods of occurrence must be ultimately influenced by the prevailing ambient temperature, it was decided to investigate this relationship.

However, such investigation has to be done in strict accordance with the basic internal water requirements of the hospital, some of which depend more on the hospital's routines than on the prevailing ambient temperature (laundry, kitchen, etc.).

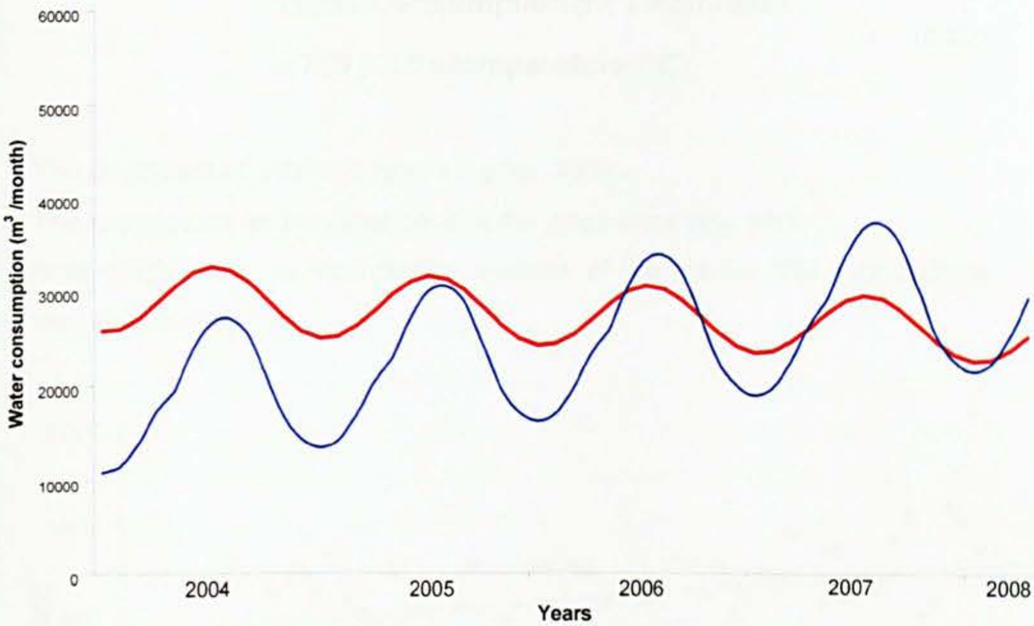

Figure 4-14 - Overlapping of models 4.6 and 4.20 for the period of January 2007 until April 2008, representing, respectively, the most probable consumption values (red) and the most probable values of the multiple regression time period - temperature –consumption (blue)

Accordingly, the daily "smoothed" consumptions for the years 2006 and 2007 (Annexe 4), and the respective maximum daily temperatures as supplied by the Portuguese "Instituto Meteorológico Nacional" for Station Gago Coutinho at Lisbon (Annexe 8), were grouped in Annexe 9 by the days of the week of their occurrence.

Seven sets of data $\mathbf{(r_i, q_i)_j}$ were thus created, with $\mathbf{i = 1, 2, ..., n}$ and $\mathbf{j = 1, 2, ..., 7}$, where $\mathbf{r_i}$ represents the "smoothed" volume of water consumed in day of order $\mathbf{i}$, and $\mathbf{q_i}$ is the maximum temperature recorded for that day.

Regressions of the type of equations 3.11 to 3.14 were then performed but, surprisingly, the results were rather poor.

The best was the straight line regression for $\mathbf{j = 1}$ (or Mondays) as shown in Figure 4-15, whose equation is

$$\begin{aligned} &\textbf{Water Consumption } (\mathbf{m^3 / Monday}) = \\ &= \mathbf{759 + 2.6 \times temperature\ (^\circ C)} \end{aligned} \tag{4.22}$$

The coefficient of determination is a poor **33%**.

The regressions for the other days of the week were also poor.

Accordingly, after an inconclusive analysis of the results, this methodology was abandoned.

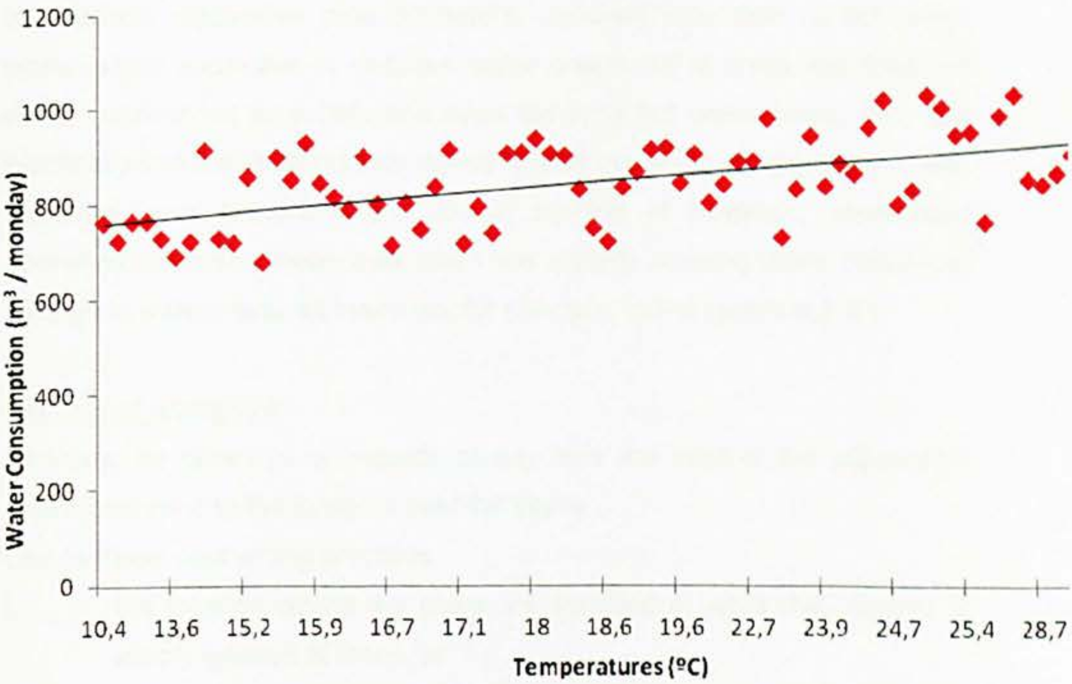

Figure 4-15 - Direct relation between temperature and water consumption on Mondays

4.3 Direct conclusions of the surveys

4.3.1 Introduction

The careful analysis of the available hospitals' documents, drawings and records, the many visits to the water supply systems of the two hospitals investigated (Hospital Amadora Sintra and Hospital de Santa Maria), and the many conversations held with their operators and responsible engineers, led the candidate to the following facts concerning the water supply systems of those two hospitals:

4.3.2 Design and operation of hospitals

The overall conclusion of the surveys is that poor designs of the water supply systems are prevalent in some of the existing Portuguese hospitals, often they have not been corrected during construction and, complementary, at times, there are also operational malpractices.

It is the combination of those factors that were responsible for increased water and energy costs and wastage in the past.

However, and notwithstanding the fact that those initial poor designs and installations (excessive pipe diameters, deficient insulation of hot water pipes, either excessive or deficient water pressures at times, too long hot water connections to outlets and even too long hot water loops, etc), are practically impossible to remedy during normal operating conditions, and are, therefore, ever present in the normal running of hospitals, some wise operative measures meanwhile taken are already causing some noticeable savings in water costs, as indicated, for example, in Paragraph 4.2.3.1.

4.3.3 Records of alterations

At times, no drawings or records of any kind are kept of the successive alterations done to the systems over the years.

Due to these past wrong practices,

i. the location where the pipes are installed or what they convey is simply ignored at times, or
ii. that knowledge is only in the memory of elderly technicians, about to be retired.

This happened in the past in both of the hospitals investigated.

4.3.4 Municipal water prices

The price paid by the Hospital Amadora Sintra for the water supplied by the municipal system is unacceptably high, several times the price of the same water sold by the same water authority to some of its other consumers.

While it is fair to practice progressive rates to curb real avoidable excessive consumptions, it is unacceptable to charge unrealistic prices to industrial and other major consumers, including big families and other living communities, to whom water is either a major component of their end product, or is a basic commodity for their personal hygiene and comfort.

For example, for the Hospital Amadora Sintra, the local water authority charges a flat rate of **€3,71/m^3** of water, and for its domestic consumers charges **€0,7833/m^3** for the first bracket (up to **5 m^3/month**), **€1,3337/m^3** for the second bracket (from **6** to **15 m^3/month**), **€2,3506/m^3** for the third bracket (from **16** to **25 m^3/month**), and **€2,4425/m^3** for the last bracket (above **25 m^3/month**).

In short, first bracket consumers pay **21%** of the rate paid by the hospital, and even a consumer of **30 m^3/month** (in the 4th bracket) pays a total amount of **€52,97** for his water, which corresponds to an overall rate of **€1,7657/m^3**. That is still **48%** of the rate paid by the Hospital Amadora Sintra for the very same water.

4.3.5 Leaking pipes and faulty devices

In both hospitals investigated, leaking pipes and faulty devices are normally reported late, and are not promptly repaired.

The situation is of particular concern when sophisticated medical devices with closed cooling systems are reported as faulty. In such cases their emergency cooling systems may be "temporary" operative for months, using free running water. The resulting water costs can be much higher than the repair costs (e.g. the case of the cooling systems of nuclear microscopes).

4.3.6 Loss of municipal water pressure

Frequently, the residual water pressure of the municipal supply networks is wasted in free surface intermediate storage tanks, at times even placed in rather low and inadequate sites. This is the case of both of the hospitals investigated.

While it is understood the need to have an emergency water reserve capable of satisfying the hospital's water requirements for a period of 24 to 36 hours, the actual implementation of such a measure at the Hospital Amadora Sintra implies the loss of some **210 KPa** of municipal water pressure (the storage tanks have their invert at level **122,10 m**, and the minimum energy level of the municipal system at the hospital's entrance is **143,0 m**).

4.3.7 Pipe diameters

Excessive pipe diameters are found at times, leading to increased water and energy costs.

This is particularly true for hot water conduits at the Hospital Amadora Sintra, where considerable quantities of water and energy can be lost if the pipes have excessive diameters, and/or if the supplied apparatuses are too distant from the hot water source (be it a loop or a hot water generator).

4.3.8 Cost of electricity

Both hospitals investigated pay electricity at **€0.09 / kWh**.

4.3.9 Internal water pressures

The water for the internal services of the Hospital Amadora Sintra is pumped from the intermediate storage deposits to **800 KPa**.

This pressure is excessive and causes increased consumptions and costs, unnecessary strain on the internal supply system and appliances, and increased water leaks.

4.3.10 Intermediate supply tanks on the roof

The water for the internal services of the Hospital de Santa Maria is pumped from the ground level storage tank into four free surface reservoirs on the roof, which in turn supply by gravity the internal systems.

This leads to low service pressures at the two top levels.

4.3.11 Hot water generation at Hospital Amadora Sintra

Hot water is centrally generated by gas heaters at the Hospital Amadora Sintra, forcing the installation of long and energy inefficient loops, and causing unacceptably low hot water service temperatures in the last sections of the loop. This is visible in Drawings Nos. 1 to 17.

4.3.12 Hot water generation at Hospital de Santa Maria

Hot water is electrically generated in dispersed heating systems at Hospital de Santa Maria. This is presently an expensive solution, but avoids the inconveniences of distribution loops. It must be noted that this solution was the cheapest in 1953, when this hospital was inaugurated.

4.3.13 Insulation of hot water conduits

The insulation of hot water pipes is poorly installed and maintained in the two hospitals investigated, causing important energy losses. In particular, bends are frequently not insulated at all, both along the loops and along the outlet connections.

4.3.14 Stopcock valves

Stopcock valves are often not found in the sanitary installations of both of the hospitals investigated, resulting in inconvenience for the users and for the services in large areas, when the water supply has to be interrupted for minor repairs.

4.3.15 Water faucets

Water devices in service in both of the hospitals investigated are often of old designs and technologies (mainly taps, toilet discharges and bathtubs), causing increased consumptions of water.

4.3.16 Tender documents

Tender and other supply documents for both of the hospitals are often unclear about the specified materials and equipments, allowing for the installation of cheaper materials and devices of inferior quality, and forcing the need to store items of different manufacturers to produce the very same service.

4.3.17 Pressure reducing valves

In both of the hospitals investigated, pressure reducing valves are rarely found in situations justifying their installation.

4.3.18 Foot operated taps

Foot operated taps are not installed in the kitchen sinks of both of the hospitals investigated.

4.3.19 Rain water drainage

All rain water is being wasted into the storm water drainage systems of the two hospitals investigated.

4.3.20 Irrigation systems

The existing irrigation system at Hospital Amadora Sintra is of low efficiency, both in terms of the equipment used (irrigation by aspersion) and in terms of the water used (mainly from a borehole, but at times also from the municipal supply system).

4.3.21 Incinerator

The incinerator at Hospital Amadora Sintra runs at comparatively low temperatures, producing dangerous emissions and not producing energy for water heating or electricity as by-products.

4.4 Conclusions of analyses

4.4.1 Introduction

The conclusions of the surveys of Hospital de Santa Maria and Hospital Amadora Sintra, the detailed conversations held with the engineers responsible for the water supply services of both Hospitals, the results of the numeric analysis of the water consumption records, and the state of the art technologies introduced above, led the candidate to the conclusions indicated in the following Paragraphs 4.4.2 to 4.4.14.

4.4.2 Daily average water consumption

The "per hospital bed" daily average water consumption at Hospital Amadora Sintra is at present about **1,093 ℓ/bed.day** (as calculated in Chapter 4.2.3.1), which can still be considered excessive. An overall daily average consumption of not more than **1,000 ℓ/bed.day** should be aimed at, even having in consideration the irrigation of the 16 ha of the landscaped areas surrounding the hospital.

4.4.3 Reduction of global water consumption

Hospital Amadora Sintra is making sensible efforts to reduce the volumes of water consumed and to simultaneously reduce the water bills, by combining

i. improved water leakage detection routines,

ii. with a reduction in the volume of water abstracted from the municipal supply system, and

iii. with increased volumes of water abstracted from the borehole.

The results achieved so far are a clear confirmation of this wise policy.

In fact, as discussed and shown in chapter 4.2.3.1 and in Figure 4-7, Hospital Amadora Sintra is achieving average overall savings of at least **900 m^3/year**, simply by reducing the abstraction from the municipal system by approximately **1,100 m^3/year**, and by increasing the abstraction from the borehole by approximately **160m^3/year**.

In addition, and as also evaluated in chapter 4.2.3.1, at the prevailing rates of **€3,71/m^3** for water and **€0,09/kwh** for electricity, savings in excess of **€4,100/year** (or about **£3,700/year**), have been progressively achieved over the last few years (and there is ample room to continue with these savings, for several years to come).

4.4.4 Maximum daily water consumption factor

The water consumption at Hospital Amadora Sintra during the day of the year with the highest consumption is of the order of **1.68** times the "annual average daily consumption" (Annexe 4 and Chapter 4.2.4.3). This event is expected to take place late in July or early in August, and is a surprising conclusion because it would be expected that the hospital's water usage routines would not have such ample variations in hot summer days.

This conclusion, as well as the conclusions presented in the following paragraphs 4.4.5 to 4.4.9, should be important parameters for the correct design and operation of the Hospital Amadora Sintra's own water supply services, if and when this hospital implements a more intensive use of borehole water.

Moreover, these and the conclusions presented in the following paragraphs 4.4.10 to 4.4.14, can be generalized to other similar hospitals, because they are ratios related to average consumptions.

4.4.5 Maximum weekly water consumption factor

Water consumption during the week of the year with the highest consumption is of the order of **1.13** times the "annual average weekly consumption" (chapter 4.2.4.2). This event is expected to take place by week 29, or 30, or 31, by late July or early August..

4.4.6 Maximum monthly water consumption factor

Water consumption during the month of the year with the highest consumption is of the order of **1.13** times the "annual average monthly consumption" (chapter 4.2.4.1). It is expected to happen late in July or early in August.

4.4.7 Minimum daily water consumption factor

Water consumption at Hospital Amadora Sintra during the day of the year with the lowest consumption, is of the order of **0.53** times the "annual average daily consumption" (Annexe 4 and Chapter 4.2.4.3). This event is expected to take place early in February.

4.4.8 Minimum weekly water consumption factor

Water consumption during the week of the year with the lowest consumption, is of the order of **0.87** times the "annual average weekly consumption" (chapter 4.2.4.2). This event is expected to take place by early February.

4.4.9 Minimum monthly water consumption factor

Water consumption during the month of the year with the lowest consumption is of the order of **0.87** times the "annual average monthly consumption" (chapter 4.2.4.1). This event is expected to happen in February.

4.4.10 Excessive internal water pressure

It is estimated that the maximum water pressure in the internal network of Hospital Amadora Sintra could be reduced by at least, **150 kPa**, i.e., from **800 KPa** to **650 KPa**.

This alone would mean additional energy savings of some **10,900 kWh** out of a total of **58,000 kWh** per annum, if only **620 m^3 / day** are pumped into the hospital water supply network on a daily basis (**620 m^3 / day** raised daily to a height of **65 m**, against the same volume of water raised to **80 m**, in both cases with efficiency of **85%**). At the current energy rates, that corresponds to savings of **€1000** per annum, equivalent to about **£900**.

With these reduction in water pressure, the maximum static pressure at the 1st floor (level **115,80 m**), would be reduced from **903 kPa** to **753 kPa**.

4.4.11 Positioning of intermediate storage reservoirs

Additionally, if the intermediate free surface storage reservoirs of Hospital Amadora Sintra were installed in the higher ground at the Southern side of the industrial building, with a possible invert level of 137,00 m instead of the actual 122,10 m, a further 150 KPa of municipal water pressure would have been saved, corresponding to additional energy savings of **10,900 kWh** per annum, if only the same **620 m^3 / day** are abstracted daily from the municipal system (**620 m^3 / day** raised daily to a height of **50 m**, against the same volume of water raised to **65 m**, in both cases with efficiency of **85%**). At the current energy rates, that corresponds to savings of **€1000** per annum, equivalent to about **£900**.

4.4.12 Possible water and energy savings at the Hospital Amadora Sintra

In short, the two measures indicated in points 4.4.10 and 4.4.11 above could save **21,800kWh** out of a total of **58,000 kWh** per annum at Hospital Amadora Sintra. That would mean energy savings of some **38%**, corresponding to about **€2,000** (or **£ 1,800**) per annum.

4.4.13 Use of available municipal pressure

Although practically impossible to implement in Hospital Amadora Sintra, or in any other existing hospital in normal service, it appears that, if it was a new hospital, further savings would still be possible to achieve with the necessary alterations in the pipe network.

In fact, if the two main floors of the hospital (at levels **115.80 m** and **120.30 m**) were to be supplied directly from the municipal main via a booster pump raising by **70 KPa** the minimum guaranteed service water pressure of **300 KPa** at the hospital inlet (at level **113,0 m**), it would be guaranteed at all times a static pressure of **297 kPa** on floor at level **120,30 m**.

Since those two main floors use some 80% of the total volume water used by the hospital (average of 620 m^3/day), that would involve an annual energy consumption of some **4,100 kWh (500 m^3 / day** raised daily to a height of **7 m**, with efficiency of **85%**). At the current energy rate, that corresponds to a cost of **€370** per annum (or **£340**).

In such case, pumping would also be necessary to supply the wards, with a total water consumption estimated at not more than **20%** of the total hospital consumption, or **125 m^3/day**. The wards are at Floors 3 to 6, and floor 6 is at level **138.10 m**.

The elevation of these **125 m^3/day** of water from level **143,0** (at the hospital inlet) to level **168,0 m** to supply floors 3 to 6, would involve an energy consumption of some **3,700 kWh** per year, against the present **58,000 kWh** per annum. Savings of about **€4,900** (or **£ 4,500**) per annum could be than achieved.

This solution, however, imply longer periods of retention for the water for the emergency supply. Accordingly, a reservoir with two levels of abstraction would have to be installed, to avoid long water retention periods.

4.4.14 Possible use of borehole water

The possibility of supplying borehole water to the whole Hospital Amadora Sintra should also be investigated.

In fact, subject to confirmation by a hydro-geologist's detailed investigation, all present indications lead to the preliminary conclusion (expressed in paragraph 4.2.3.2) that a second borehole and a purification plant would be a viable proposition, as it would bring water savings of some **€800,000** (or about **£725,000**) per year, without jeopardizing the service quality.

4.5 Recommendations for water supply services in hospitals

4.5.1 Introduction

The above surveys, state of the art technologies, detected facts, conclusions of the analyses and conversations with the engineers in charge, led the candidate to recommend the following procedures in respect of research and development, administrative requirements and design, construction, installation, operation and maintenance directives for the water supply services to hospitals.

4.5.2 Research and development

4.5.2.1 Hospitals' internal water supply networks

Research on hospitals' internal cold and hot water supply networks and consumption routines, a vital contribution for improved designs in terms of water efficiency and in terms of construction and operational savings.

4.5.2.2 Special sanitary apparatus

Research on special sanitary apparatus for the use by temporary and/or permanently disabled persons, mainly special toilets, hand wash basins, showers and bathtubs.

4.5.2.3 Numbers of sanitary apparatus to be installed

Research on the definition of the correct numbers of normal and special sanitary apparatus to be installed in hospitals and similar institutions (old age homes, specialized clinics, etc.).

4.5.2.4 Intermediate storage reservoirs

Research on the installation of free surface intermediate storage reservoirs.

4.5.2.5 Direct supply from the municipal main

Research on the possible supply of water to hospitals directly from the municipal mains.

4.5.2.6 Use of rain water in hospitals

Research on the possible use of rain water in hospitals.

4.5.2.7 Use of borehole water in hospitals

Research on the possible use of borehole water in hospitals.

4.5.3 Administrative procedures

4.5.3.1 Design directives

The conclusions of the above research programs should subsequently be incorporated into official design directives for hospitals.

4.5.3.2 Government control

Government control should be applied to all local water authorities, be they private, public or quasi-public, to avoid ridiculous progressive water rates concealed under the label of "necessary and urgent water saving measures".

4.5.4 Recommended design, construction and installation procedures

4.5.4.1 Introduction

Further to the strict compliance with the relevant standard technical, legal, general and particular conditions of contract, it is recommended that the recommendations in the following Paragraphs 4.5.4.2 to 4.5.4.29 should be adhered to for the execution of detailed construction projects for water supply systems to hospitals.

4.5.4.2 Authorships

All hospitals' water supply construction projects should be performed by specialized professional consultants, and revised by independent, specialised professional review consultants.

4.5.4.3 Project guidelines

The design of water supply systems to hospitals with extensive surrounding landscaped areas, should be done for "per hospital bed" average daily consumptions of **800 ℓ/bed.day**, plus **10.0 m^3/ha.day** of landscaped surrounding areas. The peak summer day water consumption factor should be **1.7** times the average daily consumption.

4.5.4.4 Intermediate storage tanks

The installation of in-house emergency water storage tanks should be carefully evaluated, planned and installed, taking due advantage of both the hospital's ground topography, and the minimum guaranteed pressure in the public supply networks.

4.5.4.5 Specifications

The type, specifications and classes of all pipes, bends and fittings, for the internal and for the external cold and hot water supply systems, should be clearly detailed in all tender documents, including all pertinent drawings.

4.5.4.6 Identification and access to conduits

All internal and external pipes and fittings should be clearly identified on site, and should be easily accessible, for maintenance and for repairs.

4.5.4.7 Pressure reducing valves

Pressure reducing valves should be installed whenever necessary, to prevent service pressures reaching values above the recommended levels of comfort, safety and durability of the equipments.

4.5.4.8 Stopcock valves

Stopcock valves should be installed immediately upstream of all sanitary installations, including those in wards, to allow for their maintenance and repair without interfering with the normal water supply to other neighbouring installations.

4.5.4.9 Showers and bathtubs

Showers, instead of bathtubs, should be installed whenever possible. The installation of bathtubs in the wards should be limited to the elderly, to the paediatric wards and to any other medically justified situations.

4.5.4.10 Swimming pools

Hospital's swimming pools and other medical aquatic devices at the physiotherapy section, should comply strictly with all the manufacturer's instructions for installation and for operation.

The communal swimming pools for the use of the hospital's staff should have adequate recirculation and disinfection compact units and, if in the open, should be covered in winter.

4.5.4.11 Self closing taps

Reliable self closing taps should be installed in all public and staff facilities.

4.5.4.12 Dual discharge toilets

Only dual discharge toilets of the cistern type should be installed in new hospitals, except if medical reasons justify otherwise. All renovation programs should also foresee the installation of those toilets.

4.5.4.13 Flush devices

Flush devices should only be installed when strictly required for medical and/or other justified sanitary reasons.

4.5.4.14 Foot operated taps

Foot operated taps should be mandatory installed in all hospitals' kitchen sinks.

4.5.4.15 Residential quarters

In hospital's staff residential quarters, all washing and dishwashing machines, toilets, showers, hand wash basins, kitchen sinks and other taps should comply with the best technologies available in terms of water usage and water savings.

4.5.4.16 Heating fuel

The heating fuel to be used in new installations should comply with the most advanced environment requirements, and its selection should also take into consideration their market prices and the eventual ease of operation of disperse water heating units.

4.5.4.17 Hot water generators

The use of disperse hot water generators should be investigated and implemented when possible and economically viable, to improve the quality of the service and to reduce energy losses.

4.5.4.18 Hot water connections

The maximum distances between hot water taps and their respective hot water sources/loops should be limited to 4 m in all major construction projects.

4.5.4.19 Insulation of hot pipes

The nature, specifications and thicknesses of the insulation for all hot water pipes, including bends, fittings and delivery connections, should be fully detailed in the tender documents, including drawings.

4.5.4.20 Hot water temperatures

If the hot water circulates in the hot water pipes at temperatures above 45° Celsius, mixing valves should be mandatory installed at all hot water outlets, to reduce the service temperature to a maximum of 45° Celsius.

4.5.4.21 Incinerators

Incinerators should be of the plasma controlled pirolysis type whenever possible, producing no emissions and being simultaneously used for the heating of water and/or for the production of electric energy as a by-product.

4.5.4.22 Dual drainage systems

Dual drainage systems should not be installed and operated in hospitals, at least until further and reliable developments in the available technology are achieved and marketed.

4.5.4.23 Waste water from the washing of hospital vehicles

The waste water from the washing of hospital vehicles should not be used for any other purposes, and should be sent directly to the existing drainage system.

4.5.4.24 Use of storm water in hospitals

The storm water drainage reticulation should be deviated from the municipal system into sedimentation tanks followed by adequate storage tanks, and should subsequently be used for irrigation and pavement washing.

4.5.4.25 Drip irrigation

Underground drip irrigation should be installed whenever technically advisable and economically or financially viable.

4.5.4.26 Irrigation devices

Only irrigation equipments and materials of reputable manufacturers should be recommended and installed.

4.5.4.27 Use of low water demanding species

Low water demanding species should be preferentially planted in the landscaped areas.

4.5.4.28 Use of rain meters

A rain meter should be installed within the landscaped areas of all hospitals, to optimize the irrigation to the actually required quantities of water.

4.5.4.29 Weather satellite

A weather satellite receiver should also be installed at the hospital's premises, to quantify the irrigation in function of the weather forecasts.

4.5.5. Recommended operations and routine maintenance procedures

4.5.5.1 Minor alterations

All minor alterations to the water supply systems of hospitals should be dully recorded, and the respective drawings should be forthwith updated.

4.5.5.2 Faulty devices

All repairs and/or substitutions of faulty taps and other devices should be done as soon as the malfunctions are detected.

4.5.5.3 Leaks detection

Internal and external leak detection routines should be implemented at realistic intervals, and should be followed-up forthwith by the necessary remedial work.

4.5.5.4 Closed cooling circuits

Mechanical systems using closed/sealed cooling circuits (electronic microscopes, mortuary cold cameras, etc.) should be periodically inspected and any malfunctions should be repaired as soon as detected.

4.5.5.5 Staff awareness

All staff should be made well aware of the best water operational procedures, and of the need to report leaks and other malfunctions as soon as they are detected.

4.5.5.6 Excessive water pressures

Excessive water pressures should be identified and reduced whenever possible.

4.5.5.7 Routine inspections of pipe insulations

The insulation of all hot water pipes should be inspected at realistic intervals, and should be followed-up by the necessary remedial work whenever necessary.

4.5.5.8 Toilet discharges versus paper towels

If reductions in the volumes of the toilet discharges are implemented to save water, waste paper recipients should be installed at all locals where paper towels are used, to avoid the blockages resulting from those reduced discharges.

4.5.5.9 Substitution of existing toilets

When substituting existing toilets, newer cistern models of the dual discharge type should be installed at all times.

4.5.5.10 Random control of internal water consumptions

Once known the expected water consumptions of the various internal sections in a hospital, water metering of those individual sections should be periodically done at random intervals, to help the detection of unknown leaks and malfunctions.

4.5.5.11 Control of water pressure at irrigation outlets

The water pressure should be controlled at all irrigation outlets, and reduced when possible.

4.5.5.12 Water audits

Water audits should be made periodically under clear and well defined guidelines and Performance Indicators, and each report should be commented, compared with the previous ones, and divulged to the water users in general, and to the hospital managers in particular.

4.5.5.13 Water supply to residential quarters in hospitals

In hospital's staff residential quarters, all washing and dishwashing machines, toilets, showers, hand wash basins and kitchen sinks and other taps should be periodically maintained in good working condition.

4.5.5.14 Hospital's swimming pools

The hospital's swimming pools and other medical aquatic devices at the physiotherapy section, should be periodically inspected and maintained, in strict accordance with the manufacturer's instructions.

4.5.5.15. Swimming pools for the use of the hospital's staff

The communal swimming pools for the use of the hospital's staff should have adequate recirculation and disinfection compact units and, if in the open, should be covered in winter. They should also be periodically inspected and maintained.

4.5.5.16 Irrigation by aspersion versus drip irrigation

Irrigation by aspersion should be avoided as much as possible in new hospitals, where drip irrigation should be installed whenever possible.

4.5.5.17 Recommended conditions for irrigation by aspersion

In existing hospitals, irrigation by aspersion should be limited to the night hours, should not be done on windy nights, and should be controlled by pre-programmed time devices.

4.5.5.18 Aspersion apparatus

The existing aspersion apparatus should be maintained and tuned at realistic intervals.

4.5.5.19 Trimming of grassed areas

Grassed areas must be trimmed and maintained free of weeds, to reduce the required irrigation.

4.5.5.20 Advantage of indigenous species

Low water demanding indigenous species should be preferably planted in the landscaped areas, because they normally require less water.

4.5.5.21 Metering of local precipitation

The local precipitation should be metered and recorded, to allow for the optimization of the volumes of water used for irrigation.

4.5.5.22 Use of weather satellites

Weather satellites should be used for short forecast periods, to save water by anticipation.

5.0 LIST OF REFERENCES

[1] - "Our Common Future", Brundtland Report, World Commission on Environment and Development, 1987.

[2] - "Agenda 21 on Sustainable Development", CIB Report Publicaction 237, 1999.

[3] - "Water - A Key to Sustainable Development", International Conference on Freshwater, Recommendations for Action, Bonn, 2001.

[4] - "Performance Indicators for Water Supply Services", Alegre, H., Baptista, J.M. *et al*, International Water Association Publishing, 2006.

[5] - MWRA on line, "Water Use Case Study: Norwood Hospital", The Massachusetts Water Resources Authority, 1995, accessed on 4th August, 2006.

[6] - "Integrated Urban Resources Management Strategy - Water", United Nations Environment Program, Division of Technology, Industry and Economics, 2003 accessed on 24th February, 2006.

[7] - "Construção Sustentável e Inovação Tecnológica", Racionalização do Uso da Água em Edifícios", António Norberto Marques da Silva, 2002.

[8] - "Programa Nacional para o Uso Eficiente da Água", Instituto da Água, Ministério do Ambiente e do Ordenamento do Território, Lisboa, 2001

[9] - "Opportunities for Local Governments and water Providers in New Mexico to adopt Ordinances and Regulations to Conserve Water", New Mexico Drought Task Force, May, 2004, accessed on 24th June, 2005.

[10] - "Water Conservation Manual", City of Portland (Oregon), Bureau of Water Works, 2000, accessed on 14th June, 2006

[11] - Water - Design Standards & Policies Manual, City of Scottsdale, Arizona, USA, August, 2004, accessd on 8th March, 2006.

[12] - "Regulamento Geral dos Sistemas Públicos e Prediais de Distribuição de Água e de Drenagem de Águas Residuais", Decreto Regulamentar Nº 23/95, de 23 de Agosto, Editora Rei dos Livros, 2001.

[13] - "Manual dos Sistemas Prediais de Distribuição e Drenagem de Águas", V. R. Pedroso, LNEC, 2000.

[14] - "Report on Water Conservation and water Use efficiency", Department of Environment and Natural Resources, North Carolina, USA, 2004, accessed on 20th February, 2006.

[15] - "Energy Consumption in Hospitals", Department of the Environment, Transport and Regions, Best Practice Programme No. 72, 1996, accessed on 12th September, 2005.

[16] - Vickers, Amy, "Handbook of Water Use and Conservation", Waterplow Press, 2001.

[17] - "Multifamily Residential Design Guidelines and Standards", 2004, City of Overland Park, Kansas, USA, 2004, accessed on5th April, 2006.

[18]- Mayer, Peter *et al*, "Residential end uses of water", American Water Works Association, 1999, Denver, Colorado, USA.

[19] - "Water conservation plan", 2004, Bluffdale City, Otah, USA, accessed on 13th April, 2006.

[20] - "Critérios Gerais de Concepção e de Avaliação Económica", Report from Águas de Portugal, 2008.

[21] - Many conversations and working sessions with Mr. Joaquim Silva, former Technical Inspector at Hospital Amadora Sintra on behalf of Messrs. Engimais, Ltd.

[22] - Several conversations with Mr. Jacinto Basto, the new Technical Inspector at Hospital Amadora Sintra, on Behalf of Messrs. Engimais, Ltd.

[23] - Several interviews and working sessions with Dr. Tiago Rocha, Manager of Hospital Amadora Sintra (HAS).

[24] - Several meetings with Eng. Eduardo Mapril, Engineering Director of Hospital Amadora Sintra (HAS) on behalf of Messrs. Alkia, Ltd.

[25] - Several interviews and working sessions with Eng. Francisco Antunes, maintenance Engineer at Hospital de Santa Maria, and subsequently at "Amadora Sintra".

[26] - M.R.Spiegel, "Estatística", Schaum McGraw-Hill, 1994.

[27] - B.J.F.Murteira, "Análise Exploratória de Dados", McGraw-Hill, 1993.

[28] - Bowerman *et al*, "Forecasting Time Series and Regression - An Applied Approach", Brooks/Cole Cengage Learning, 2005.

[29] - B.Murteira *et al*, Análise de Sucessões Cronológicas", McGraw-hill, 1993.

[30] - L.J.Kazmier, "Estatística Aplicada à Economia e Administração, McGraw-Hill, 1982.

[31] - N. Piskounov, "Cálculo Diferencial e Integral", Lopes da Silva, 1974.

[32] - B. Demidovitch, "Análie Matemática", McGraw-Hill, 1993.

[33] - E.J.Borowski *et al*, "Dictionary of Mathematics", Collins, 1989

[34] - Peter J. Brockwell and Richard A. Davis, "Introduction to Time Series and Forecasting", Springer Texts in Statistics, Springer-Verlag, 3rd Edition, 1998.

[35] - Theodore H. Moran, "Foreign Direct Investment and Development - The New Policy Agenda for Developing Countries", Institute for International Economics, 1999.

[36] - Cid Perestrelo and V.Costa, "Trabalhos Fluviais e Marítimos", Secção de Folhas do Instituto Superior Técnico, Lisbon, 1952.

[37] - World Water Assessment Programme, Water for People, Water for Life", The United Nations Worls Water Development Report, Unesco Division of Water Sciences, 2003.

[38] - "Abastecimento de Água em Portugal - O Mercado e os Preços", Associação Portuguesa de Distribuição e Drenagem de Águas, 2004.

[39] - "Efficient Water Use for Texas: Policies, Tools and Management Strategies", Texas Water Resources Institute, .2002, accessed on 10th March, 2005.

[40] - "A Política e o Ambiente - A Dimensão do Indivíduo", João Paulo Fernandes, Perspectivas Ecológicas, 2002.

ANNEXES

WATER SUPPLY TO

PORTUGUESE REGIONAL HOSPITALS

ANNEXE 1

RECORDED DATA

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1	2003	January		53	1	3	331			NR			IR			16,5	Public Holiday
2				105	2	4	628			NR			IR			16,7	
3			1	157	3	5	578			NR			IR			17,0	
4				209	4	6	499			NR			IR			17,3	
5				261	5	7	424	IR		NR	IR		IR	IR		16,0	
6				54	6	1	IR			NR			IR			13,9	
7				106	7	2	NR			NR			IR			17,4	
8				158	8	3	NR			NR			IR			12,9	
9			2	210	9	4	NR			NR			IR			12,1	
10				262	10	5	NR			NR			IR			10,1	
11					11	6	NR			NR			IR			8,8	
12					12	7	NR	NR		NR	IR		IR	IR		9,2	
13				55	13	1	NR			NR			IR			8,9	
14				107	14	2	NR			NR			IR			10,1	
15				159	15	3	NR			NR			IR			9,8	
16			3	211	16	4	NR			NR			IR			10,2	
17				263	17	5	NR			NR			IR			13,1	
18					18	6	NR			NR			IR			14,7	
19					19	7	NR	NR		NR	IR		IR	IR		15,0	
20				56	20	1	NR			NR			IR			14,3	
21				108	21	2	NR			NR			IR			15,0	
22				160	22	3	NR			NR			IR			15,9	
23			4	212	23	4	NR			NR			IR			15,5	
24				264	24	5	NR			NR			IR			15,6	
25					25	6	NR			NR			IR			18,4	
26					26	7	NR	NR		NR	IR		IR	IR		19,5	
27				57	27	1	NR			NR			IR			22,1	
28				109	28	2	NR			NR			IR			21,7	
29				161	29	3	IR			NR			IR			14,4	
30			5	213	30	4	661			NR			IR			14,2	
31				265	31	5	645		3.765	NR		4.731	IR		8.496	11,8	Invalid record

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
32	2003	February			1	6	540			134			674			11,4	
33					2	7	439	IR		108	IR		547	IR		15,2	
34				58	3	1	683			169			851			15,3	
35				110	4	2	621			154			775			14,3	
36				162	5	3	626			155			781			15,5	
37			6	214	6	4	642			159			800			15,5	
38				266	7	5	637			158			795			14,2	
39					8	6	547			135			682			16,2	
40					9	7	477	4.233		118	1.047		595	5.280		15,4	
41				59	10	1	633			157			790			15,2	
42				111	11	2	607			150			757			15,2	
43				163	12	3	611			151			761			15,4	
44			7	215	13	4	595			147			742			14,7	
45				267	14	5	633			156			789			13,8	
46					15	6	473			117			590			14,6	
47					16	7	431	3.983		107	985		538	4.967		13,6	
48				60	17	1	619			153			772			15,0	
49				112	18	2	652			161			813			15,1	
50				164	19	3	640			158			799			11,7	
51			8	216	20	4	617			153			769			14,0	
52				268	21	5	631			156			787			13,0	
53					22	6	559			138			697			16,5	
54					23	7	541	4.260		134	1.053		675	5.313		17,0	
55				61	24	1	696			172			867			15,3	
56				113	25	2	698			173			871			12,5	
57				165	26	3	554			137			692			15,4	
58			9	217	27	4	544			135			679			15,4	
59				269	28	5	734		16.681	182		4.124	916		20.805	16,2	

IR - Invalid Result
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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
60	2003	March			1	6	502			179			681			14,5	
61					2	7	449	4.179		160	1.136		609	5.315		15,1	
62				62	3	1	571			203			774			19,2	
63				114	4	2	454			162			616			18,7	Public Holiday
64				166	5	3	642			229			871			17,6	
65			10	218	6	4	634			226			859			16,4	
66				270	7	5	661			235			896			15,1	
67					8	6	537			191			728			18,5	
68					9	7	473	3.972		168	1.413		641	5.385		19,7	
69				63	10	1	626			223			848			22,2	
70				115	11	2	670			238			909			20,9	
71				167	12	3	655			233			888			19,7	
72			11	219	13	4	624			222			846			23,7	
73				271	14	5	724			258			981			19,0	
74					15	6	707			252			959			19,5	
75					16	7	467	4.473		166	1.592		633	6.065		19,2	
76				64	17	1	638			227			865			15,0	
77				116	18	2	619			220			839			17,9	
78				168	19	3	661			235			896			18,7	
79			12	220	20	4	666			237			903			19,7	
80				272	21	5	653			232			885			20,2	
81					22	6	538			191			729			20,1	
82					23	7	496	4.270		176	1.519		672	5.789		19,5	
83				65	24	1	729			260			989			17,9	
84				117	25	2	793			282			1.075			18,1	
85				169	26	3	696			248			943			18,2	
86			13	221	27	4	825			294			1.119			17,1	
87				273	28	5	849			302			1.150			19,3	
88					29	6	649			231			880			15,9	
89					30	7	479	5.019		170	1.786		649	6.805		17,0	
90				66	31	1	804		19.489	286		6.935	1.090		26.424	19,0	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
91	2003	April		118	1	2	738			233			971			22,2	
92				170	2	3	614			194			807			17,7	
93			14	222	3	4	668			211			879			22,8	
94				274	4	5	677			214			890			18,7	
95					5	6	608			192			799			20,8	
96					6	7	491	4.599		155	1.484		645	6.082		23,2	
97				67	7	1	734			232			966			25,1	
98				119	8	2	934			295			1.229			23,3	
99				171	9	3	870			274			1.144			17,3	
100			15	223	10	4	819			259			1.078			15,5	
101				275	11	5	931			294			1.225			16,1	
102					12	6	674			213			886			18,5	
103					13	7	654	5.617		207	1.773		861	7.389		17,1	
104				68	14	1	923			291			1.214			15,3	
105				120	15	2	626			198			824			18,3	
106				172	16	3	568			179			748			20,3	
107			16	224	17	4	665			210			875			19,8	
108				276	18	5	508			160			669			16,8	Public Holiday
109					19	6	496			157			653			16,7	
110					20	7	439	4.226		138	1.334		577	5.560		18,0	Public Holiday
111				69	21	1	711			224			936			19,3	
112				121	22	2	683			215			898			19,3	
113				173	23	3	631			199			831			18,6	
114			17	225	24	4	805			254			1.060			19,3	
115				277	25	5	519			164			683			16,6	Public Holiday
116					26	6	512			162			674			20,1	
117					27	7	385	4.247		121	1.340		506	5.587		21,3	
118				70	28	1	623			197			819			19,2	
119				122	29	2	659			208			867			17,8	
120				174	30	3	670		19.836	211		6.260	881		26.096	18,8	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
121	2003	May	18	226	1	4	508			202			709			19,3	Public Holiday
122				278	2	5	686			273			960			19,9	
123					3	6	446			177			624			24,3	
124					4	7	459	4.050		182	1.451		641	5.501		20,3	
125				71	5	1	661			263			924			17,8	
126				123	6	2	624			248			872			16,5	
127				175	7	3	693			276			969			18,1	
128			19	227	8	4	794			316			1.110			23,8	
129				279	9	5	723			288			1.011			23,3	
130					10	6	525			209			734			23,3	
131					11	7	457	4.477		182	1.781		639	6.258		22,2	
132				72	12	1	647			257			904			25,3	
133				124	13	2	660			263			923			25,0	
134				176	14	3	854			340			1.194			26,6	
135			20	228	15	4	758			302			1.060			23,3	
136				280	16	5	888			353			1.241			20,9	
137					17	6	666			265			931			22,2	
138					18	7	481	4.954		191	1.971		673	6.925		23,6	
139				73	19	1	828			329			1.157			24,0	
140				125	20	2	683			272			954			27,7	
141				177	21	3	828			329			1.157			32,5	
142			21	229	22	4	900			358			1.258			34,3	
143				281	23	5	896			357			1.253			32,2	
144					24	6	625			248			873			20,0	
145					25	7	477	5.236		190	2.083		667	7.319		22,2	
146				74	26	1	991			394			1.386			27,0	
147				126	27	2	955			380			1.334			30,1	
148				178	28	3	896			356			1.253			31,0	
149			22	230	29	4	742			295			1.037			29,4	
150				282	30	5	687			273			960			22,2	
151					31	6	717		21.754	285		8.653	1.002		30.407	27,8	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
152	2003	June			1	7	498	5.485		151	2.135		649	7.620		23,2	
153				75	2	1	917			278			1.195			23,3	
154				127	3	2	754			229			983			22,5	
155				179	4	3	922			280			1.202			22,8	
156			23	231	5	4	904			274			1.178			22,6	
157				283	6	5	961			292			1.253			29,1	
158					7	6	794			241			1.036			25,0	
159					8	7	450	5.702		137	1.732		586	7.433		26,3	
160				76	9	1	969			294			1.263			27,3	
161				128	10	2	653			198			851			27,4	Public Holiday
162				180	11	3	972			295			1.268			31,9	
163			24	232	12	4	1.010			307			1.317			37,3	
164				284	13	5	1.036			315			1.351			33,4	Local Holiday (Lisbon)
165					14	6	676			205			881			24,8	
166					15	7	456	5.772		138	1.753		594	7.525		23,1	
167				77	16	1	801			243			1.045			22,3	
168				129	17	2	635			193			828			24,0	
169				181	18	3	922			280			1.202			35,3	
170			25	233	19	4	641			195			835			39,3	
171				285	20	5	943			287			1.230			32,6	
172					21	6	1.059			322			1.381			29,5	
173					22	7	466	5.468		142	1.661		608	7.128		25,4	
174				78	23	1	972			295			1.268			24,4	
175				130	24	2	1.020			310			1.329			24,4	
176				182	25	3	1.020			310			1.330			25,6	
177			26	234	26	4	998			303			1.302			23,9	
178				286	27	5	1.024			311			1.335			26,3	
179					28	6	625			190			814			24,6	
180					29	7	417	6.076		127	1.846		544	7.922		20,2	Local Holiday (Sintra)
181				79	30	1	624		24.139	190		7.332	814		31.471	23,1	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) — From Municipality: Daily	From Municipality: Weekly	From Municipality: Monthly	From Borehole: Daily	From Borehole: Weekly	From Borehole: Monthly	Total: Daily	Total: Weekly	Total: Monthly	Max. temp (°C)	Notes
182	2003	July	27	131	1	2	644			214			858			25,0	
183				183	2	3	863			287			1.151			24,1	
184				235	3	4	859			286			1.145			24,7	
185				287	4	5	1.027			342			1.369			24,2	
186					5	6	701			233			934			23,3	
187					6	7	539	5.257		179	1.732		718	6.988		26,5	
188			28	80	7	1	951			317			1.268			30,8	
189				132	8	2	874			291			1.164			28,6	
190				184	9	3	955			318			1.272			29,7	
191				236	10	4	861			287			1.148			30,2	
192				288	11	5	946			315			1.261			25,7	
193					12	6	634			211			845			22,3	
194					13	7	452	5.672		150	1.888		602	7.561		23,1	
195			29	81	14	1	830			276			1.107			24,9	
196				133	15	2	636			212			847			22,8	
197				185	16	3	888			296			1.184			24,3	
198				237	17	4	1.003			334			1.336			27,7	
199				289	18	5	915			305			1.219			28,6	
200					19	6	704			234			938			28,3	
201					20	7	509	5.485		169	1.826		678	7.310		25,7	
202			30	82	21	1	967			322			1.289			25,9	
203				134	22	2	1.045			348			1.392			27,3	
204				186	23	3	992			330			1.323			25,4	
205				238	24	4	1.021			340			1.361			28,3	
206				290	25	5	1.009			336			1.344			28,3	
207					26	6	643			214			857			28,3	
208					27	7	418	6.095		139	2.029		557	8.124		26,8	
209			31	83	28	1	1.000			333			1.333			28,9	
210				135	29	2	1.054			351			1.404			37,2	
211				187	30	3	950			316			1.266			38,5	
212				239	31	4	947		25.836	315		8.600	1.263		34.436	40,0	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day)									Max. temp (°C)	Notes
							From Municipality			From Borehole			Total				
							Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly		
213	2003	August		291	1	5	1.112			362			1.474			42,0	
214					2	6	917			298			1.215			39,3	
215					3	7	874	6.854		284	2.259		1.158	9.114		27,6	
216				84	4	1	1.077			350			1.428			33,4	
217				136	5	2	1.076			350			1.426			36,8	
218				188	6	3	1.062			346			1.408			37,7	
219			32	240	7	4	1.015			330			1.345			34,9	
220				292	8	5	1.143			372			1.514			33,0	
221					9	6	1.105			359			1.465			34,1	
222					10	7	829	7.308		270	2.377		1.099	9.684		35,3	
223				85	11	1	1.092			355			1.447			39,4	
224				137	12	2	1.054			343			1.396			36,9	
225				189	13	3	759			247			1.005			34,5	
226			33	241	14	4	718			233			951			31,2	
227				293	15	5	657			214			871			27,6	Public Holiday
228					16	6	896			291			1.187			26,0	
229					17	7	724	5.899		235	1.918		959	7.817		26,4	
230				86	18	1	803			261			1.064			29,2	
231				138	19	2	678			220			898			28,5	
232				190	20	3	917			298			1.215			27,2	
233			34	242	21	4	748			243			991			27,5	
234				294	22	5	877			285			1.162			30,9	
235					23	6	601			195			796			27,0	
236					24	7	471	5.094		153	1.657		625	6.750		24,6	
237				87	25	1	701			228			929			26,6	
238				139	26	2	661			215			875			26,4	
239				191	27	3	553			180			733			25,3	
240			35	243	28	4	649			211			860			22,8	
241				295	29	5	632			205			837			25,8	
242					30	6	468			152			620			26,5	
243					31	7	418	4.081	25.284	136	1.327	8.223	553	5.408	33.507	26,4	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
244	2003	September		88	1	1	653			199			852			26,0	
245				140	2	2	681			207			888			24,0	
246				192	3	3	739			225			965			24,7	
247			36	244	4	4	754			230			983			25,2	
248				296	5	5	730			223			953			24,6	
249					6	6	562			171			733			27,5	
250					7	7	583	4.701		178	1.433		761	6.135		24,3	
251				89	8	1	901			275			1.176			24,7	
252				141	9	2	744			227			971			26,1	
253				193	10	3	1.022			311			1.333			31,8	
254			37	245	11	4	706			215			921			35,6	Local Holiday (Amadora)
255				297	12	5	1.015			309			1.324			36,9	
256					13	6	720			220			940			35,5	
257					14	7	677	5.785		206	1.764		884	7.549		35,7	
258				90	15	1	1.025			312			1.337			29,6	
259				142	16	2	855			261			1.115			31,3	
260				194	17	3	972			296			1.268			32,2	
261			38	246	18	4	987			301			1.289			31,0	
262				298	19	5	766			234			1.000			28,5	
263					20	6	435			133			568			25,6	
264					21	7	631	5.671		192	1.729		823	7.400		25,7	
265				91	22	1	783			239			1.022			25,6	
266				143	23	2	791			241			1.032			26,5	
267				195	24	3	907			276			1.183			26,3	
268			39	247	25	4	784			239			1.023			28,8	
269				299	26	5	1.006			307			1.312			30,4	
270					27	6	723			220			943			23,7	
271					28	7	539	5.532		164	1.686		703	7.218		24,9	
272				92	29	1	671			204			875			24,6	
273				144	30	2	632		22.992	193		7.009	824		30.001	20,7	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
274	2003	October		196	1	3	675			211			886			21,3	
275			40	248	2	4	705			221			926			22,0	
276				300	3	5	622			195			817			19,8	
277					4	6	556			174			730			23,8	
278					5	7	518	4.378		162	1.360		680	5.738		24,1	Public Holiday
279				93	6	1	640			200			840			23,8	
280				145	7	2	612			192			804			26,0	
281				197	8	3	713			223			937			27,0	
282			41	249	9	4	668			209			877			28,2	
283				301	10	5	714			224			938			26,0	
284					11	6	535			168			703			19,4	
285					12	7	493	4.375		154	1.369		647	5.745		23,3	
286				94	13	1	640			200			840			22,6	
287				146	14	2	681			213			894			22,1	
288				198	15	3	594			186			780			19,9	
289			42	250	16	4	684			214			899			19,8	
290				302	17	5	638			200			838			21,9	
291					18	6	551			172			723			19,8	
292					19	7	468	4.257		146	1.332		614	5.589		20,6	
293				95	20	1	646			202			849			20,7	
294				147	21	2	642			201			844			19,9	
295				199	22	3	703			220			923			19,0	
296			43	251	23	4	698			218			916			17,1	
297				303	24	5	721			226			946			16,3	
298					25	6	487			152			639			15,9	
299					26	7	504	4.401		158	1.377		662	5.779		20,2	
300				96	27	1	624			195			820			19,2	
301				148	28	2	688			215			903			19,8	
302				200	29	3	636			199			835			17,7	
303			44	252	30	4	599			187			786			17,8	
304				304	31	5	613		19.270	192		6.031	805		25.301	16,8	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
305	2003	November			1	6	507			NR			IR			17,0	Public Holiday
306					2	7	533	4.201		NR	IR		IR	IR		17,3	
307			45	97	3	1	626			NR			IR			17,7	
308				149	4	2	666			NR			IR			15,6	
309				201	5	3	665			NR			IR			20,4	
310				253	6	4	656			NR			IR			22,0	
311				305	7	5	702			NR			IR			20,7	
312					8	6	460			NR			IR			17,7	
313					9	7	486	4.263		NR	IR		IR	IR		17,4	
314			46	98	10	1	716			NR			IR			18,1	
315				150	11	2	649			NR			IR			17,6	
316				202	12	3	663			NR			IR			18,0	
317				254	13	4	644			NR			IR			19,9	
318				306	14	5	666			NR			IR			17,3	
319					15	6	523			NR			IR			17,1	
320					16	7	553	4.415		NR	IR		IR	IR		15,1	
321			47	99	17	1	649			NR			IR			17,0	
322				151	18	2	657			NR			IR			18,5	
323				203	19	3	647			NR			IR			19,2	
324				255	20	4	646			NR			IR			18,8	
325				307	21	5	646			NR			IR			16,8	
326					22	6	627			NR			IR			15,3	
327					23	7	472	4.344		NR	IR		IR	IR		15,7	
328			48	100	24	1	610			NR			IR			14,5	
329				152	25	2	696			NR			IR			14,7	
330				204	26	3	719			NR			IR			16,1	
331				256	27	4	730			NR			IR			15,4	
332				308	28	5	741			NR			IR			15,2	
333					29	6	812			NR			IR			18,2	
334					30	7	462	4.770	18.832	NR	IR		IR	IR	18.832	16,1	

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
335	2003	December		101	1	1	665			NR			IR			11,9	Public Holiday
336				153	2	2	723			NR			IR			12,3	
337				205	3	3	717			NR			IR			13,5	
338			49	257	4	4	713			NR			IR			11,8	
339				309	5	5	295			NR			IR			11,5	
340					6	6	613			NR			IR			13,6	
341					7	7	445	4.172		NR	IR		IR	IR		16,0	
342				102	8	1	670			NR			IR			12,4	Public Holiday
343				154	9	2	665			NR			IR			14,0	
344				206	10	3	696			NR			IR			14,5	
345			50	258	11	4	800			NR			IR			15,5	
346				310	12	5	800			NR			IR			14,3	
347					13	6	635			NR			IR			15,7	
348					14	7	612	4.878		NR	IR		IR	IR		17,3	
349				103	15	1	807			NR			IR			17,0	
350				155	16	2	829			NR			IR			12,5	
351				207	17	3	770			NR			IR			15,5	
352			51	259	18	4	702			NR			IR			15,9	
353				311	19	5	771			NR			IR			14,5	
354					20	6	810			NR			IR			12,3	
355					21	7	693	5.382		NR	IR		IR	IR		15,3	
356				104	22	1	784			NR			IR			14,8	
357				156	23	2	721			NR			IR			11,6	
358				208	24	3	645			NR			IR			12,8	
359			52	260	25	4	552			NR			IR			11,3	
360				312	26	5	687			NR			IR			12,5	Public Holiday
361					27	6	643			NR			IR			13,4	
362					28	7	450	4.482		NR	IR		IR	IR		14,1	
363				1	29	1	748			NR			IR			13,8	
364				105	30	2	852			NR			IR			16,2	
365				157	31	3	703		21.218	NE		NR	IR		IR	14,9	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
366	2004	January	53	209	1	4	236			70			306			15,6	Public Holiday
367				261	2	5	279			83			362			15,0	
368					3	6	657			196			854			15,3	
369					4	7	572	4.047		171	IR		743	IR		15,7	
370			54	2	5	1	598			179			777			15,1	
371				106	6	2	789			235			1.024			14,0	
372				158	7	3	626			187			813			13,1	
373				210	8	4	654			195			849			15,6	
374				262	9	5	196			58			254			17,9	
375					10	6	583			174			757			17,8	
376					11	7	474	3.920		141	1.170		615	5.089		18,4	
377			55	3	12	1	337			101			438			16,2	
378				107	13	2	639			191			829			16,3	
379				159	14	3	580			173			753			16,7	
380				211	15	4	493			147			639			11,3	
381				263	16	5	253			75			328			14,7	
382					17	6	409			122			531			15,6	
383					18	7	510	2.883		152	961		662	3.844		13,9	
384			56	4	19	1	434			129			563			12,9	
385				108	20	2	606			181			787			15,1	
386				160	21	3	500			149			649			14,6	
387				212	22	4	641			191			833			14,1	
388				264	23	5	559			167			726			15,7	
389					24	6	536			160			696			17,9	
390					25	7	502	3.779		150	1.128		652	4.907		15,3	
391			57	5	26	1	641			191			833			16,3	
392				109	27	2	569			170			738			16,3	
393				161	28	3	575			172			747			13,7	
394				213	29	4	707			211			918			10,3	
395				265	30	5	627			187			815			15,2	
396					31	6	570		16.353	170		4.880	740		21.233	16,1	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
397	2004	February			1	7	500	4.190		87	1.188		587	5.377		15,6	
398			58	6	2	1	632			110			742			19,1	
399				110	3	2	673			117			789			19,5	
400				162	4	3	750			130			880			19,3	
401				214	5	4	635			110			745			18,3	
402				266	6	5	630			109			740			17,0	
403					7	6	587			102			689			15,1	
404					8	7	479	4.385		83	762		562	5.146		14,7	
405			59	7	9	1	635			110			745			13,5	
406				111	10	2	683			119			801			15,0	
407				163	11	3	732			127			859			16,9	
408				215	12	4	762			132			895			17,5	
409				267	13	5	610			106			715			15,9	
410					14	6	587			102			689			16,0	
411					15	7	471	4.479		82	778		553	5.257		14,5	
412			60	8	16	1	706			123			828			14,8	
413				112	17	2	803			140			943			13,6	
414				164	18	3	763			133			896			15,2	
415				216	19	4	615			107			722			15,3	
416				268	20	5	637			111			748			13,1	
417					21	6	590			102			692			13,4	
418					22	7	479	4.594		83	798		563	5.391		12,5	
419			61	9	23	1	615			107			721			11,8	
420				113	24	2	488			85			572			15,7	Public Holiday
421				165	25	3	615			107			722			14,0	
422				217	26	4	644			112			756			13,7	
423				269	27	5	661			115			776			13,0	
424					28	6	571			99			671			13,9	
425					29	7	508	4.102	18.059	88	712	3.137	596	4.814	21.196	14,4	

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
426	2004	March		10	1	1	635			239			874			11,4	
427				114	2	2	704			265			969			12,2	
428				166	3	3	616			232			848			15,7	
429			62	218	4	4	716			269			985			18,8	
430				270	5	5	623			234			857			17,1	
431					6	6	589			221			810			18,0	
432					7	7	530	4.413		199	1.659		730	6.072		16,8	
433				11	8	1	747			281			1.027			17,7	
434				115	9	2	774			291			1.065			17,6	
435				167	10	3	737			277			1.014			17,4	
436			63	219	11	4	707			266			973			16,1	
437				271	12	5	716			269			985			14,7	
438					13	6	655			246			901			15,7	
439					14	7	609	4.945		229	1.859		838	6.803		17,7	
440				12	15	1	761			286			1.047			22,0	
441				116	16	2	746			280			1.026			22,5	
442				168	17	3	737			277			1.014			20,2	
443			64	220	18	4	738			277			1.015			18,7	
444				272	19	5	681			256			937			20,1	
445					20	6	641			241			881			21,7	
446					21	7	581	4.885		219	1.836		800	6.721		19,3	
447				13	22	1	743			279			1.023			16,6	
448				117	23	2	789			296			1.085			16,4	
449				169	24	3	766			288			1.053			14,4	
450			65	221	25	4	150			56			206			17,0	
451				273	26	5	784			295			1.078			14,5	
452					27	6	578			217			795			10,5	
453					28	7	598	4.407		225	1.656		823	6.063		14,8	
454				14	29	1	702			264			966			15,0	
455				118	30	2	336			126			463			15.5	
456				170	31	3	478		20.166	180		7.580	658		27.746	16,5	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
457	2004	April	66	222	1	4	684			221			905			13,9	
458				274	2	5	807			261			1.068			15,7	
459					3	6	581			188			769			18,7	
460					4	7	611	4.199		197	1.438		808	5.637		21,7	
461				15	5	1	756			245			1.001			24,8	
462				119	6	2	818			265			1.082			24,0	
463				171	7	3	859			278			1.136			20,0	
464			67	223	8	4	678			219			897			18,5	
465				275	9	5	603			195			798			18,9	Public Holiday
466					10	6	584			189			772			17,9	
467					11	7	603	4.900		195	1.585		797	6.485		18,2	Public Holiday
468				16	12	1	703			227			930			19,8	
469				120	13	2	856			277			1.132			22,3	
470				172	14	3	867			280			1.147			21,6	
471			68	224	15	4	846			274			1.120			21,6	
472				276	16	5	764			247			1.011			15,9	
473					17	6	607			196			803			16,2	
474					18	7	581	5.223		188	1.689		769	6.912		15,7	
475				17	19	1	767			248			1.015			16,9	
476				121	20	2	738			239			977			17,7	
477				173	21	3	722			233			955			15,8	
478			69	225	22	4	740			239			979			18,3	
479				277	23	5	702			227			929			23,0	
480					24	6	672			217			889			25,8	
481					25	7	621	4.962		201	1.605		822	6.566		28,1	Public Holiday
482				18	26	1	764			247			1.010			28,6	
483				122	27	2	854			276			1.130			26,0	
484				174	28	3	1.018			329			1.347			20,6	
485			70	226	29	4	749			242			991			18,3	
486				278	30	5	837		21.989	271		7.111	1.108		29.100	15,9	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
487	2004	May			1	6	637			189			826			17,2	Public Holiday
488					2	7	571	5.429		170	1.724		741	7.153		18,0	
489				19	3	1	793			236			1.028			19,5	
490				123	4	2	787			234			1.021			17,2	
491				175	5	3	669			199			868			16,7	
492			71	227	6	4	726			216			942			17,2	
493				279	7	5	709			211			920			17,3	
494					8	6	601			179			779			18,2	
495					9	7	631	4.917		188	1.461		819	6.378		17,1	
496				20	10	1	761			226			987			16,5	
497				124	11	2	789			234			1.023			20,9	
498				176	12	3	798			237			1.035			22,2	
499			72	228	13	4	856			254			1.110			24,3	
500				280	14	5	837			249			1.086			25,4	
501					15	6	664			197			861			25,6	
502					16	7	668	5.372		199	1.597		867	6.969		27,5	
503				21	17	1	902			268			1.170			29,7	
504				125	18	2	963			286			1.250			28,5	
505				177	19	3	869			258			1.128			30,1	
506			73	229	20	4	934			277			1.211			27,9	
507				281	21	5	722			215			936			23,2	
508					22	6	661			196			857			23,1	
509					23	7	622	5.673		185	1.686		807	7.360		22,7	
510				22	24	1	769			229			998			21,8	
511				126	25	2	849			252			1.101			21,3	
512				178	26	3	715			212			927			23,2	
513			74	230	27	4	750			223			973			22,7	
514				282	28	5	849			252			1.101			23,6	
515					29	6	650			193			843			23,7	
516					30	7	592	5.174		176	1.538		768	6.712		24,9	
517				23	31	1	838		23.183	249		6.890	1.088		30.073	24,8	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
518	2004	June	75	127	1	2	824			261			1.085			28,1	
519				179	2	3	885			280			1.166			28,0	
520				231	3	4	886			281			1.167			31,8	
521				283	4	5	963			305			1.268			28,7	
522					5	6	772			245			1.017			24,8	
523					6	7	648	5.817		205	1.826		853	7.643		24,2	
524			76	24	7	1	861			273			1.134			26,1	
525				128	8	2	878			278			1.156			30,0	
526				180	9	3	894			283			1.177			30,8	
527				232	10	4	728			231			959			30,7	Public Holiday
528				284	11	5	853			270			1.123			28,8	
529					12	6	973			308			1.281			30,3	
530					13	7	800	5.987		253	1.896		1.053	7.884		33,0	Local Holiday (Lisbon)
531			77	25	14	1	1.028			326			1.353			34,4	
532				129	15	2	812			257			1.069			31,8	
533				181	16	3	1.004			318			1.322			30,2	
534				233	17	4	1.026			325			1.351			33,2	
535				285	18	5	1.070			339			1.408			27,3	
536					19	6	770			244			1.014			23,5	
537					20	7	616	6.326		195	2.004		811	8.330		25,4	
538			78	26	21	1	898			285			1.183			24,2	
539				130	22	2	890			282			1.172			24,5	
540				182	23	3	773			245			1.018			26,2	
541				234	24	4	902			286			1.188			26,1	
542				286	25	5	975			309			1.284			30,1	
543					26	6	1.084			343			1.427			30,7	
544					27	7	731	6.253		232	1.981		963	8.234		31,1	
545				27	28	1	904			286			1.190			33,4	
546				131	29	2	1.114			353			1.467			35,0	Local Holiday (Sintra)
547				183	30	3	928		26.491	294		8.391	1.222		34.882	28,6	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
548	2004	July	79	235	1	4	1.119			361			1.480			25,5	
549				287	2	5	1.054			340			1.394			27,6	
550					3	6	896			289			1.185			29,7	
551					4	7	751	6.767		242	2.165		993	8.932		28,8	
552				28	5	1	864			278			1.143			27,4	
553				132	6	2	979			315			1.294			22,5	
554				184	7	3	992			320			1.312			23,1	
555			80	236	8	4	1.040			335			1.375			23,7	
556				288	9	5	900			290			1.191			25,0	
557					10	6	841			271			1.112			25,3	
558					11	7	698	6.314		225	2.035		923	8.348		27,1	
559				29	12	1	909			293			1.203			30,3	
560				133	13	2	975			314			1.289			35,2	
561				185	14	3	999			322			1.320			35,2	
562			81	237	15	4	1.127			363			1.490			31,0	
563				289	16	5	927			299			1.225			28,7	
564					17	6	751			242			994			27,9	
565					18	7	620	7.005		200	2.033		820	9.038		27,6	
566				30	19	1	880			284			1.164			26,3	
567				134	20	2	933			301			1.234			28,2	
568				186	21	3	910			293			1.203			28,8	
569			82	238	22	4	735			237			972			29,8	
570				290	23	5	1.008			325			1.333			35,3	
571					24	6	790			255			1.045			38,1	
572					25	7	662	5.918		213	1.907		876	7.825		37,6	
573				31	26	1	907			292			1.199			35,4	
574				135	27	2	668			215			883			34,0	
575				187	28	3	902			291			1.193			26,3	
576			83	239	29	4	1.125			363			1.488			27,1	
577				291	30	5	1.239			399			1.638			28,6	
578					31	6	800		28.000	258		9.025	1.057		37.025	31,7	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
579	2004	August			1	7	595	6.235		182	2.000		777	8.235		30,5	
580				32	2	1	885			271			1.156			27,9	
581				136	3	2	477			146			624			26,1	
582				188	4	3	819			251			1.070			26,6	
583			84	240	5	4	903			276			1.179			29,9	
584				292	6	5	863			264			1.127			29,4	
585					7	6	619			190			809			30,5	
586					8	7	597	5.163		183	1.580		780	6.743		24,4	
587				33	9	1	712			218			930			23,8	
588				137	10	2	766			234			1.000			25,0	
589				189	11	3	693			212			905			25,1	
590			85	241	12	4	784			240			1.023			27,0	
591				293	13	5	756			231			987			29,3	
592					14	6	691			212			903			31,4	
593					15	7	619	5.021		190	1.537		809	6.558		29,5	Public Holiday
594				34	16	1	950			291			1.240			28,3	
595				138	17	2	826			253			1.078			25,4	
596				190	18	3	828			253			1.081			25,8	
597			86	242	19	4	880			269			1.150			26,0	
598				294	20	5	904			277			1.180			26,1	
599					21	6	854			261			1.116			30,1	
600					22	7	659	5.901		202	1.806		861	7.707		29,4	
601				35	23	1	965			295			1.260			28,8	
602				139	24	2	1.034			316			1.351			29,2	
603				191	25	3	1.090			334			1.424			31,2	
604			87	243	26	4	1.028			314			1.342			31,9	
605				295	27	5	1.156			354			1.510			29,7	
606					28	6	777			238			1.015			28,1	
607					29	7	797	6.846		244	2.095		1.041	8.941		28,9	
608				36	30	1	1.210			370			1.580			26,1	
609				140	31	2	757		25.493	232		7.802	989		33.295	26,3	

IR - Invalid Result
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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
610	2004	September		192	1	3	791			313			1.104			24,3	
611			88	244	2	4	741			293			1.034			21,6	
612				296	3	5	221			88			309			25,9	
613					4	6	596			236			832			26,9	
614					5	7	531	4.848		210	1.741		740	6.589		24,6	
615				37	6	1	813			322			1.134			25,3	
616				141	7	2	839			332			1.171			25,9	
617				193	8	3	1.009			399			1.408			25,1	
618			89	245	9	4	887			351			1.237			27,0	
619				297	10	5	665			263			928			26,4	
620					11	6	660			261			921			26,9	Local Holiday (Amadora)
621					12	7	549	5.421		217	2.144		766	7.565		24,8	
622				38	13	1	935			370			1.305			24,3	
623				142	14	2	761			301			1.062			24,5	
624				194	15	3	827			327			1.155			25,0	
625			90	246	16	4	841			333			1.174			30,9	
626				298	17	5	902			357			1.259			31,3	
627					18	6	893			353			1.246			29,5	
628					19	7	813	5.973		321	2.362		1.134	8.335		26,1	
629				39	20	1	866			343			1.209			26,4	
630				143	21	2	949			375			1.324			32,0	
631				195	22	3	606			240			845			31,7	
632			91	247	23	4	861			340			1.201			31,5	
633				299	24	5	891			352			1.243			27,2	
634					25	6	754			298			1.053			29,2	
635					26	7	577	5.504		228	2.177		805	7.680		30,7	
636				40	27	1	931			368			1.299			32,5	
637				144	28	2	840			332			1.173			28,3	
638				196	29	3	752			297			1.049			31,6	
639			92	248	30	4	809		23.110	320		9.140	1.129		32.250	27,7	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
640	2004	October		300	1	5	748			223			970			26,7	
641					2	6	730			217			947			29,5	
642					3	7	552	5.361		164	1.922		716	7.283		32,3	
643			93	41	4	1	955			284			1.239			29,5	
644				145	5	2	546			162			708			28,1	Public Holiday
645				197	6	3	754			224			978			26,0	
646				249	7	4	745			222			967			30,2	
647				301	8	5	727			216			943			23,3	
648					9	6	671			200			870			20,5	
649					10	7	580	4.976		173	1.481		753	6.457		19,4	
650			94	42	11	1	743			221			964			21,1	
651				146	12	2	740			220			960			21,4	
652				198	13	3	714			212			927			21,9	
653				250	14	4	722			215			937			19,4	
654				302	15	5	746			222			968			19,0	
655					16	6	535			159			695			20,5	
656					17	7	575	4.775		171	1.421		745	6.195		19,6	
657			95	43	18	1	740			220			960			19,7	
658				147	19	2	795			237			1.032			21,8	
659				199	20	3	352			105			457			21,6	
660				251	21	4	644			192			836			20,7	
661				303	22	5	821			244			1.066			21,2	
662					23	6	554			165			719			21,3	
663					24	7	552	4.458		164	1.326		716	5.785		19,4	
664			96	44	25	1	453			135			587			20,0	
665				148	26	2	768			228			996			18,1	
666				200	27	3	688			205			893			19,8	
667				252	28	4	710			211			921			18,5	
668				304	29	5	790			235			1.025			17,7	
669					30	6	655			195			850			17,6	
670					31	7	543	4.606	20.845	162	1.371	6.202	705	5.977	27.047	18,0	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
671	2004	November		45	1	1	649			208			857			19,9	Public Holiday
672				149	2	2	676			217			894			18,4	
673				201	3	3	714			229			943			20,3	
674			97	253	4	4	767			246			1.014			18,4	
675				305	5	5	732			235			967			19,6	
676					6	6	676			217			893			21,9	
677					7	7	517	4.731		166	1.519		683	6.250		20,4	
678				46	8	1	739			237			976			19,2	
679				150	9	2	305			98			403			20,0	
680				202	10	3	355			114			469			17,0	
681			98	254	11	4	776			249			1.025			16,2	
682				306	12	5	669			215			884			17,0	
683					13	6	611			196			808			17,0	
684					14	7	632	4.087		203	1.312		834	5.399		15,6	
685				47	15	1	672			216			887			14,6	
686				151	16	2	734			236			970			15,8	
687				203	17	3	678			218			895			15,8	
688			99	255	18	4	777			249			1.026			15,9	
689				307	19	5	672			216			888			14,8	
690					20	6	619			199			818			15,2	
691					21	7	624	4.775		200	1.533		824	6.309		14,8	
692				48	22	1	671			216			887			16,9	
693				152	23	2	813			261			1.075			17,2	
694				204	24	3	687			221			908			16,7	
695			100	256	25	4	773			248			1.021			16,8	
696				308	26	5	782			251			1.033			16,7	
697					27	6	619			199			818			14,5	
698					28	7	548	4.894		176	1.571		724	6.465		15,3	
699				49	29	1	795			255			1.050			15,4	
700				153	30	2	691		19.972	222		6.413	913		26.385	17,1	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
701	2004	December		205	1	3	623			157			780			12,5	Public Holiday
702			101	257	2	4	698			176			874			11,8	
703				309	3	5	747			188			935			14,8	
704					4	6	523			132			655			13,2	
705					5	7	574	4.650		145	1.274		718	5.924		14,6	
706				50	6	1	735			185			920			15,1	
707				154	7	2	666			168			834			14,2	
708				206	8	3	648			163			811			12,5	Public Holiday
709			102	258	9	4	782			197			979			10,9	
710				310	10	5	678			171			849			12,8	
711					11	6	634			160			794			14,1	
712					12	7	488	4.631		123	1.167		611	5.798		15,7	
713				51	13	1	784			198			982			14,0	
714				155	14	2	761			192			952			15,1	
715				207	15	3	680			171			851			16,5	
716			103	259	16	4	676			170			846			16,9	
717				311	17	5	618			156			774			15,9	
718					18	6	651			164			815			16,7	
719					19	7	517	4.687		130	1.181		647	5.868		15,9	
720				52	20	1	782			197			980			14,5	
721				156	21	2	673			169			842			13,6	
722				208	22	3	787			198			985			13,1	
723			104	260	23	4	486			122			608			14,1	
724				312	24	5	362			91			454			13,8	
725					25	6	476			120			596			12,2	Public Holiday
726					26	7	596	4.162		150	1.049		746	5.211		11,7	
727				1	27	1	672			169			842			12,3	
728				53	28	2	759			191			950			14,6	
729				157	29	3	684			172			856			14,5	
730			105	209	30	4	618			156			774			16,3	
731				261	31	5	687		20.064	173		5.056	861		25.120	17,8	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
732	2005	January			1	6	529			152			680			13,7	Public Holiday
733					2	7	613	4.562		176	1.190		789	5.751		14,4	
734				2	3	1	705			202			907			14,4	
735				54	4	2	777			223			1.001			12,8	
736				158	5	3	765			220			984			13,8	
737			106	210	6	4	775			223			998			12,9	
738				262	7	5	767			220			987			12,9	
739					8	6	605			174			779			12,0	
740					9	7	512	4.906		147	1.409		659	6.315		12,5	
741				3	10	1	801			230			1.031			13,1	
742				55	11	2	773			222			995			13,7	
743				159	12	3	773			222			994			15,4	
744			107	211	13	4	700			201			901			15,0	
745				263	14	5	775			223			997			16,2	
746					15	6	644			185			829			14,4	
747					16	7	559	5.024		161	1.443		719	6.467		15,9	
748				4	17	1	787			226			1.013			17,0	
749				56	18	2	680			195			876			15,1	
750				160	19	3	797			229			1.026			16,1	
751			108	212	20	4	797			229			1.026			17,6	
752				264	21	5	688			198			886			18,0	
753					22	6	828			238			1.066			16,7	
754					23	7	601	5.179		172	1.487		773	6.666		14,9	
755				5	24	1	759			218			977			13,1	
756				57	25	2	580			167			747			11,3	
757				161	26	3	757			217			974			11,6	
758			109	213	27	4	691			198			889			9,5	
759				265	28	5	775			223			998			10,5	
760					29	6	651			187			837			12,7	
761					30	7	569	4.782		163	1.373		733	6.155		13,1	
762				6	31	1	748		21.779	215		6.255	962		28.034	12,4	

IR - Invalid Result
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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
763	2005	February		58	1	2	830			86			916			13,7	IR
764				162	2	3	1.412			147			1.559			16,1	IR
765			110	214	3	4	1.707			177			1.884			15,9	IR
766				266	4	5	1.527			159			1.686			14,0	IR
767					5	6	1.256			131			1.387			11,8	IR
768					6	7	2.356	9.835		245	1.159		2.601	10.995		11,7	IR
769				7	7	1	3.050			317			3.367			11,6	IR
770				59	8	2	2.640			274			2.915			14,0	IR
771				163	9	3	2.702			281			2.983			16,6	IR
772			111	215	10	4	3.090			321			3.411			17,0	IR
773				267	11	5	3.944			410			4.354			17,8	IR
774					12	6	3.855			401			4.255			17,5	IR
775					13	7	2.957	22.237		307	2.312		3.265	24.548		16,3	IR
776				8	14	1	3.667			381			4.048			16,6	IR
777				60	15	2	4.036			419			4.455			16,4	IR
778				164	16	3	4.524			470			4.994			13,4	IR
779			112	216	17	4	4.431			461			4.892			13,8	IR
780				268	18	5	4.979			518			5.497			12,9	IR
781					19	6	4.425			460			4.885			15,5	IR
782					20	7	3.494	29.555		363	3.072		3.857	32.628		14,1	IR
783				9	21	1	4.286			446			4.731			12,9	IR
784				61	22	2	4.596			478			5.074			13,8	IR
785				165	23	3	4.593			477			5.070			14,8	IR
786			113	217	24	4	4.667			485			5.152			15,4	IR
787				269	25	5	3.189			332			3.521			13,6	IR
788					26	6	4.542			472			5.014			12,9	IR
789					27	7	3.663	29.536		381	3.070		4.044	32.606		10,6	IR
790				10	28	1	4.138		94.553	430		9.829	4.568		104.382	11,1	IR

IR - Invalid Result
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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
791	2005	March		62	1	2	4.562			433			4.995			10,7	IR
792				166	2	3	4.539			431			4.970			13,0	IR
793			114	218	3	4	4.287			407			4.694			13,3	IR
794				270	4	5	3.730			354			4.084			13,3	IR
795					5	6	3.434			326			3.759			15,8	IR
796					6	7	2.532	27.222		240	2.621		2.773	29.843		15,0	IR
797				11	7	1	3.135			298			3.433			15,4	IR
798				63	8	2	3.113			295			3.408			17,0	IR
799				167	9	3	2.480			235			2.715			17,4	IR
800			115	219	10	4	1.876			178			2.054			16,4	IR
801				271	11	5	2.021			192			2.213			20,0	IR
802					12	6	2.555			242			2.797			17,7	IR
803					13	7	2.019	17.198		192	1.632		2.210	18.830		18,5	IR
804				12	14	1	1.507			143			1.650			20,1	IR
805				64	15	2	1.329			126			1.455			22,3	IR
806				168	16	3	1.563			148			1.711			21,9	IR
807			116	220	17	4	1.508			143			1.652			27,1	IR
808				272	18	5	688			65			754			22,8	IR
809					19	6	1			0			1			18,5	IR
810					20	7	413	5.502		39	665		452	6.168		19,4	IR
811				13	21	1	708			67			776			16,0	IR
812				65	22	2	696			66			762			19,1	IR
813				169	23	3	774			73			848			17,8	IR
814			117	221	24	4	686			65			751			20,1	IR
815				273	25	5	1.083			103			1.186			18,5	Public Holiday
816					26	6	1.206			114			1.320			17,5	Invalid record, IR
817					27	7	1.162	6.316		110	599		1.272	6.915		16,8	Public Holiday,IR
818				14	28	1	1.953			185			2.138			17,1	Invalid record, IR
819				66	29	2	1.401			133			1.533			18,7	Invalid record, IR
820				170	30	3	1.134			108			1.242			22,0	Invalid record, IR
821			118	222	31	4	701		58.795	66		5.580	767		64.375	28,6	Invalid record, IR

IR - Invalid Result
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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
822	2005	April		274	1	5	1.540			412			1.952			20,1	Invalid record, IR
823					2	6	1.724			461			2.185			15,3	Invalid record, IR
824					3	7	1.574	10.027		421	1.787		1.996	11.813		19,5	IR
825				15	4	1	1.372			367			1.738			18,6	IR
826				67	5	2	1.169			313			1.482			22,6	IR
827				171	6	3	711			190			901			22,8	IR
828			119	223	7	4	1.427			382			1.808			22,2	IR
829				275	8	5	1.167			312			1.480			18,4	IR
830					9	6	1.011			270			1.281			19,0	IR
831					10	7	1.797	8.654		481	2.315		2.278	10.968		19,9	IR
832				16	11	1	1.555			416			1.971			22,0	IR
833				68	12	2	1.240			332			1.571			22,0	IR
834				172	13	3	697			186			883			18,1	IR
835			120	224	14	4	816			218			1.034			16,8	IR
836				276	15	5	548			147			695			15,8	IR
837					16	6	877			235			1.112			16,4	IR
838					17	7	1.072	6.806		287	1.820		1.359	8.626		16,2	IR
839				17	18	1	893			239			1.132			17,4	IR
840				69	19	2	792			212			1.004			18,3	IR
841				173	20	3	690			184			874			19,3	IR
842			121	225	21	4	800			214			1.014			20,8	IR
843				277	22	5	610			163			773			19,9	IR
844					23	6	NR			NR			IR			16,6	
845					24	7	621	4.405		166	IR		787	IR		19,0	IR
846				18	25	1	1.272			340			1.612			20,3	Public Holiday, IR
847				70	26	2	973			260			1.233			23,4	IR
848				174	27	3	718			192			910			25,2	IR
849			122	226	28	4	517			138			655			25,9	IR
850				278	29	5	NR			IR			IR			26,4	IR
851					30	6	338		28.521	90		7.628	429		36.149	20,0	IR

IR - Invalid Result
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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
852	2005	May			1	7	643	4.460		IR	IR		IR	IR		20,8	IR
853				19	2	1	703			IR			IR			20,3	
854				71	3	2	1.210			IR			IR			21,3	
855				175	4	3	754			IR			IR			21,9	
856			123	227	5	4	638			IR			IR			27,0	
857				279	6	5	575			IR			IR			29,8	
858					7	6	345			IR			IR			23,1	
859					8	7	470	4.696		IR	IR		IR	IR		20,8	
860				20	9	1	875			IR			IR			21,1	
861				72	10	2	537			IR			IR			21,5	IR
862				176	11	3	NR			IR			IR			20,3	
863			124	228	12	4	NR			IR			IR			20,9	
864				280	13	5	NR			IR			IR			19,4	
865					14	6	NR			IR			IR			19,9	
866					15	7	NR	1.411		IR	IR		IR	IR		19,6	IR
867				21	16	1	NR			IR			IR			17,7	
868				73	17	2	NR			IR			IR			20,8	
869				177	18	3	NR			IR			IR			24,9	
870			125	229	19	4	NR			IR			IR			28,4	
871				281	20	5	NR			IR			IR			24,1	
872					21	6	NR			IR			IR			21,3	
873					22	7	NR	NR		IR	IR		IR	IR		20,1	
874				22	23	1	NR			IR			IR			23,5	
875				74	24	2	NR			IR			IR			31,2	
876				178	25	3	NR			IR			IR			29,3	
877			126	230	26	4	NR			IR			IR			28,3	
878				282	27	5	NR			IR			IR			21,8	
879					28	6	NR			IR			IR			21,9	
880					29	7	NR	NR		IR	IR		IR	IR		21,8	
881				23	30	1	NR			IR			IR			24,1	
882				75	31	2	NR		6.750	IR		8.060	IR		14.810	29,6	IR

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
883	2005	June		179	1	3	NR			IR			IR			31,7	
884			127	231	2	4	NR			IR			IR			29,2	
885				283	3	5	NR			IR			IR			24,3	
886					4	6	NR			IR			IR			26,9	
887					5	7	NR	NR		IR	IR		IR	IR		34,2	
888				24	6	1	NR			IR			IR			34,4	
889				76	7	2	NR			IR			IR			35,3	
890				180	8	3	NR			IR			IR			34,4	
891			128	232	9	4	NR			IR			IR			29,3	
892				284	10	5	NR			IR			IR			28,8	
893					11	6	NR			IR			IR			24,2	
894					12	7	NR	NR		IR	IR		IR	IR		21,3	
895				25	13	1	150			IR			IR			22,9	Local Holiday (Lisbon), IR
896				77	14	2	694			IR			IR			24,5	
897				181	15	3	1.015			IR			IR			27,5	
898			129	233	16	4	852			IR			IR			33,4	
899				285	17	5	830			IR			IR			36,0	
900					18	6	459			IR			IR			32,3	
901					19	7	461	4.461		IR	IR		IR	IR		32,3	IR
902				26	20	1	837			IR			IR			31,5	
903				78	21	2	1.830			IR			IR			36,0	IR
904				182	22	3	1.471			IR			IR			30,9	IR
905			130	234	23	4	647			IR			IR			25,7	
906				286	24	5	932			IR			IR			21,4	
907					25	6	165			IR			IR			24,8	IR
908					26	7	NR	5.881		IR	IR		IR	IR		23,7	IR
909				27	27	1	660			IR			IR			23,1	
910				79	28	2	861			IR			IR			23,7	
911				183	29	3	160			IR			IR			24,5	Local Holiday (Sintra)
912			131	235	30	4	754		12.776	IR		8.718	IR		21.494	26,2	IR

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
913	2005	July		287	1	5	1.041			IR			IR			28,6	
914					2	6	425			IR			IR			32,7	
915					3	7	572	4.472		IR	IR		IR	IR		27,2	
916			132	28	4	1	1.394			IR			IR			23,7	
917				80	5	2	888			IR			IR			27,6	
918				184	6	3	1.447			IR			IR			29,5	
919				236	7	4	872			IR			IR			27,6	
920				288	8	5	1.062			IR			IR			31,9	
921					9	6	399			IR			IR			32,6	IR
922					10	7	1.127	7.191		IR	IR		IR	IR		29,6	IR
923			133	29	11	1	NR			IR			IR			32,1	
924				81	12	2	NR			IR			IR			31,3	
925				185	13	3	75			IR			IR			29,8	IR
926				237	14	4	528			IR			IR			28,2	IR
927				289	15	5	561			IR			IR			29,1	IR
928					16	6	1.455			IR			IR			27,1	IR
929					17	7	1.105	3.725		IR	IR		IR	IR		25,3	IR
930			134	30	18	1	2.103			IR			IR			27,6	IR
931				82	19	2	2.181			IR			IR			35,2	IR
932				186	20	3	2.045			IR			IR			35,5	IR
933				238	21	4	2.697			IR			IR			28,0	IR
934				290	22	5	2.270			IR			IR			27,8	IR
935					23	6	1.947			IR			IR			25,6	IR
936					24	7	1.431	14.673		IR	IR		IR	IR		27,0	IR
937			135	31	25	1	1.589			IR			IR			25,9	IR
938				83	26	2	1.503			IR			IR			25,9	IR
939				187	27	3	1.891			IR			IR			24,4	IR
940				239	28	4	1.889			IR			IR			25,2	IR
941				291	29	5	2.005			IR			IR			25,5	IR
942					30	6	1.186			IR			IR			25,8	IR
943					31	7	1.157	11.219	38.846	IR	IR	11.183	IR	IR	50.029	25,2	IR

IR - Invalid Result
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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
944	2005	August		32	1	1	2.068			IR			IR			24,9	IR
945				84	2	2	2.273			IR			IR			32,6	IR
946				188	3	3	1.947			IR			IR			37,0	IR
947			136	240	4	4	876			IR			IR			39,7	IR
948				292	5	5	408			IR			IR			38,5	IR
949					6	6	1.051			IR			IR			37,2	IR
950					7	7	1.365	9.987		IR	IR		IR	IR		31,7	IR
951				33	8	1	2.782			IR			IR			27,6	IR
952				85	9	2	1.894			IR			IR			23,4	IR
953				189	10	3	1.560			IR			IR			26,7	IR
954			137	241	11	4	1.589			IR			IR			28,4	IR
955				293	12	5	1.827			IR			IR			34,9	IR
956					13	6	1.512			IR			IR			35,0	IR
957					14	7	1.417	12.581		IR	IR		IR	IR		35,6	IR
958				34	15	1	1.918			IR			IR			31,8	IR
959				86	16	2	1.883			IR			IR			28,2	IR
960				190	17	3	2.060			IR			IR			29,0	IR
961			138	242	18	4	2.131			IR			IR			27,5	IR
962				294	19	5	1.913			IR			IR			28,8	IR
963					20	6	1.108			IR			IR			32,6	IR
964					21	7	1.212	12.226		IR	IR		IR	IR		31,7	IR
965				35	22	1	1.500			IR			IR			32,3	IR
966				87	23	2	2.116			IR			IR			34,1	IR
967				191	24	3	2.234			IR			IR			28,9	IR
968			139	243	25	4	2.195			IR			IR			27,3	IR
969				295	26	5	1.545			IR			IR			28,4	IR
970					27	6	1.144			IR			IR			28,0	IR
971					28	7	986	11.720		IR	IR		IR	IR		29,2	IR
972				36	29	1	1.724			IR			IR			31,1	IR
973				88	30	2	762			IR			IR			29,9	IR
974				192	31	3	1.461		50.461	IR		10.072	IR		60.533	26,5	IR

IR - Invalid Result
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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
975	2005	September	140	244	1	4	1.589			IR			IR			28,6	IR
976				296	2	5	1.558			IR			IR			31,8	IR
977					3	6	1.130			IR			IR			33,8	IR
978					4	7	2.109	10.333		IR	IR		IR	IR		31,8	IR
979				37	5	1	2.468			IR			IR			25,1	IR
980				89	6	2	1.803			IR			IR			24,1	IR
981				193	7	3	1.792			IR			IR			24,5	IR
982			141	245	8	4	1.252			IR			IR			25,9	IR
983				297	9	5	762			IR			IR			24,0	IR
984					10	6	540			IR			IR			23,9	IR
985					11	7	1.386	10.002		IR	IR		IR	IR		23,2	Local holiday (Amadora), IR
986				38	12	1	2.171			IR			IR			27,2	IR
987				90	13	2	2.040			IR			IR			31,4	IR
988				194	14	3	1.456			IR			IR			32,4	IR
989			142	246	15	4	2.091			IR			IR			32,7	IR
990				298	16	5	1.749			IR			IR			27,1	IR
991					17	6	1.521			IR			IR			25,8	IR
992					18	7	1.418	12.445		IR	IR		IR	IR		25,8	IR
993				39	19	1	1.608			IR			IR			27,3	IR
994				91	20	2	1.088			IR			IR			29,8	IR
995				195	21	3	1.592			IR			IR			28,5	IR
996			143	247	22	4	2.357			IR			IR			28,9	IR
997				299	23	5	2.040			IR			IR			25,6	IR
998					24	6	1.121			IR			IR			23,8	IR
999					25	7	1.665	11.470		IR	IR		IR	IR		25,3	IR
1000				40	26	1	1.986			IR			IR			29,0	IR
1001				92	27	2	2.185			IR			IR			30,2	IR
1002				196	28	3	1.375			IR			IR			27,7	IR
1003			144	248	29	4	1.942			IR			IR			30,3	IR
1004				300	30	5	2.272		50.063	IR		4.974	IR		55.037	33,3	IR

IR - Invalid Result
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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
1005	2005	October			1	6	1.490			IR			IR			29,2	IR
1006					2	7	1.516	12.765		IR	IR		IR	IR		29,6	IR
1007			145	41	3	1	1.799			IR			IR			27,0	IR
1008				93	4	2	1.622			IR			IR			29,5	IR
1009				197	5	3	1.578			IR			IR			29,7	Public holiday, IR
1010				249	6	4	2.122			IR			IR			30,3	IR
1011				301	7	5	2.562			IR			IR			28,2	IR
1012					8	6	1.446			IR			IR			26,3	IR
1013					9	7	1.649	12.778		IR	IR		IR	IR		20,5	IR
1014			146	42	10	1	1.519			IR			IR			23,4	IR
1015				94	11	2	705			IR			IR			23,2	IR
1016				198	12	3	1.319			IR			IR			20,3	IR
1017				250	13	4	1.850			IR			IR			19,0	IR
1018				302	14	5	618			IR			IR			18,8	IR
1019					15	6	1.422			IR			IR			19,5	IR
1020					16	7	494	7.926		IR	IR		IR	IR		20,9	IR
1021			147	43	17	1	702			IR			IR			21,0	IR
1022				95	18	2	700			IR			IR			20,6	IR
1023				199	19	3	763			IR			IR			21,7	IR
1024				251	20	4	1.310			IR			IR			19,8	IR
1025				303	21	5	1.910			IR			IR			19,0	IR
1026					22	6	1.184			IR			IR			21,3	IR
1027					23	7	534	7.104		IR	IR		IR	IR		20,6	IR
1028			148	44	24	1	858			IR			IR			21,5	IR
1029				96	25	2	1.726			IR			IR			21,4	IR
1030				200	26	3	2.498			IR			IR			23,3	IR
1031				252	27	4	1.437			IR			IR			19,9	IR
1032				304	28	5	2.214			IR			IR			20,4	IR
1033					29	6	1.048			IR			IR			20,5	IR
1034					30	7	1.404	11.187		IR	IR		IR	IR		19,6	IR
1035				45	31	1	1.643		43.644	IR		8.881	IR		52.525	19,8	IR

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1036	2005	November		97	1	2	1.647			IR			IR			20,4	Public Holiday, IR
1037				201	2	3	1.870			IR			IR			21,0	IR
1038			149	253	3	4	2.008			IR			IR			17,9	IR
1039				305	4	5	1.445			IR			IR			18,3	IR
1040					5	6	669			IR			IR			17,7	IR
1041					6	7	1.239	10.521		IR	IR		IR	IR		18,1	IR
1042				46	7	1	2.271			IR			IR			18,1	IR
1043				98	8	2	1.917			IR			IR			19,1	IR
1044				202	9	3	2.431			IR			IR			16,8	IR
1045			150	254	10	4	1.984			IR			IR			18,1	IR
1046				306	11	5	2.077			IR			IR			17,4	IR
1047					12	6	1.097			IR			IR			15,9	IR
1048					13	7	658	12.434		IR	IR		IR	IR		14,1	IR
1049				47	14	1	1.304			IR			IR			15,1	IR
1050				99	15	2	1.489			IR			IR			18,3	IR
1051				203	16	3	2.218			IR			IR			16,5	IR
1052			151	255	17	4	2.062			IR			IR			15,1	IR
1053				307	18	5	2.959			IR			IR			16,4	IR
1054					19	6	639			IR			IR			16,3	IR
1055					20	7	1.335	12.006		IR	IR		IR	IR		15,2	IR
1056				48	21	1	783			IR			IR			17,5	IR
1057				100	22	2	1.635			IR			IR			16,7	IR
1058				204	23	3	2.319			IR			IR			17,4	IR
1059			152	256	24	4	2.673			IR			IR			14,8	IR
1060				308	25	5	1.895			IR			IR			15,6	IR
1061					26	6	979			IR			IR			11,7	IR
1062					27	7	760	11.043		IR	IR		IR	IR		13,3	IR
1063				49	28	1	1.186			IR			IR			14,1	IR
1064				101	29	2	1.527			IR			IR			14,5	IR
1065				205	30	3	2.258		49.332	IR		4.854	IR		54.186	13,9	IR

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day)									Max. temp (°C)	Notes
							From Municipality			From Borehole			Total				
							Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly		
1066	2005	December	153	257	1	4	0			IR			IR			15,1	Public Holiday, IR
1067				309	2	5	2.247			IR			IR			16,4	IR
1068					3	6	1.043			IR			IR			17,1	IR
1069					4	7	1.580	9.841		IR	IR		IR	IR		16,4	IR
1070				50	5	1	1.226			IR			IR			15,7	IR
1071				102	6	2	1.442			IR			IR			14,4	IR
1072				206	7	3	1.262			IR			IR			15,2	IR
1073			154	258	8	4	1.634			IR			IR			15,5	Public Holiday, IR
1074				310	9	5	1.996			IR			IR			17,3	IR
1075					10	6	1.779			IR			IR			14,6	IR
1076					11	7	1.291	10.629		IR	IR		IR	IR		13,9	IR
1077				51	12	1	674			195			869			15,6	
1078				103	13	2	665			192			857			13,9	
1079				207	14	3	715			207			922			12,9	
1080			155	259	15	4	740			214			954			11,7	
1081				311	16	5	656			190			846			11,1	
1082					17	6	537			156			693			15,1	
1083					18	7	504	4.491		146	1.300		650	5.791		12,7	
1084				52	19	1	661			191			853			13,1	
1085				104	20	2	615			178			793			14,4	
1086				208	21	3	622			180			803			14,1	
1087			156	260	22	4	642			186			828			13,8	
1088				312	23	5	560			162			722			11,8	
1089					24	6	412			119			531			14,5	
1090					25	7	494	4.006		143	1.160		637	5.165		13,0	Public Holiday
1091				1	26	1	508			147			655			15,5	
1092				53	27	2	689			200			889			15,1	
1093				105	28	3	1.743			505			2.247			14,3	3.785
1094			157	209	29	4	566			164			730			14,9	
1095				261	30	5	568			165			733			15,4	13.072
1096					31	6	501		28.570	145		5.866	646		34.436	15,7	

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1097	2006	January			1	7	577	5.153		217	1.542		794	6.695		14,6	Public Holiday
1098				2	2	1	697			262			959			15,2	
1099				54	3	2	675			254			929			15,3	
1100				106	4	3	772			291			1.063			13,2	
1101			158	210	5	4	777			293			1.070			15,5	
1102				262	6	5	707			266			973			12,2	
1103					7	6	561			211			773			12,5	
1104					8	7	496	4.685		187	1.764		683	6.450		12,6	
1105				3	9	1	802			302			1.104			13,2	
1106				55	10	2	731			275			1.006			12,0	
1107				107	11	3	719			271			990			13,0	
1108			159	211	12	4	696			262			958			12,5	
1109				263	13	5	673			254			927			14,2	
1110					14	6	560			211			771			13,3	
1111					15	7	551	4.733		208	1.782		759	6.515		12,4	
1112				4	16	1	775			292			1.067			12,6	
1113				56	17	2	634			239			873			11,5	
1114				108	18	3	831			313			1.144			13,8	
1115			160	212	19	4	670			252			923			15,5	
1116				264	20	5	775			292			1.067			15,4	
1117					21	6	538			203			741			14,3	
1118					22	7	620	4.845		234	1.824		854	6.669		11,8	
1119				5	23	1	666			251			917			12,4	
1120				57	24	2	797			300			1.097			12,6	
1121				109	25	3	865			326			1.190			13,0	
1122			161	213	26	4	822			310			1.132			14,1	
1123				265	27	5	665			250			915			9,7	
1124					28	6	594			223			817			10,6	
1125					29	7	491	4.898		185	1.845		675	6.743		7,0	
1126				6	30	1	730			275			1.004			10,0	
1127				58	31	2	747		21.215	281		7.989	1.028		29.204	14,1	

IR - Invalid Result
NR - Water Consumption not recorded
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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
1128	2006	February		110	1	3	652			202			854			14,1	
1129			162	214	2	4	807			251			1.057			13,6	
1130				266	3	5	708			220			928			14,1	
1131					4	6	652			203			855			13,6	
1132					5	7	542	4.839		168	1.600		711	6.439		13,5	
1133				7	6	1	642			199			841			13,9	
1134				59	7	2	831			258			1.089			16,3	
1135				111	8	3	680			211			892			15,6	
1136			163	215	9	4	759			236			994			12,9	
1137				267	10	5	643			200			843			17,4	
1138					11	6	667			207			874			19,8	
1139					12	7	613	4.834		190	1.501		803	6.336		17,8	
1140				8	13	1	767			238			1.005			17,3	
1141				60	14	2	720			224			943			17,6	
1142				112	15	3	755			234			989			15,5	
1143			164	216	16	4	632			196			828			16,3	
1144				268	17	5	822			255			1.077			15,3	
1145					18	6	635			197			832			15,6	
1146					19	7	632	4.961		196	1.541		828	6.502		13,1	
1147				9	20	1	806			250			1.056			12,7	
1148				61	21	2	709			220			929			13,1	
1149				113	22	3	788			245			1.033			12,1	
1150			165	217	23	4	699			217			916			10,7	
1151				269	24	5	795			247			1.043			12,0	
1152					25	6	678			210			888			10,0	
1153					26	7	540	5.015		168	1.557		708	6.572		12,2	
1154				10	27	1	751			233			984			14,2	
1155				62	28	2	650		19.572	202		6.079	851		25.651	15,8	Public Holiday

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1156	2006	March		114	1	3	818			209			1.027			15,6	
1157			166	218	2	4	665			170			834			13,8	
1158				270	3	5	810			207			1.017			14,5	
1159					4	6	642			164			805			16,1	
1160					5	7	560	4.895		143	1.327		703	6.222		12,6	
1161				11	6	1	768			196			964			13,9	
1162				63	7	2	718			183			901			15,9	
1163				115	8	3	701			179			880			15,2	
1164			167	219	9	4	803			205			1.007			16,5	
1165				271	10	5	824			210			1.034			15,5	
1166					11	6	597			152			749			16,3	
1167					12	7	577	4.986		147	1.272		724	6.259		22,1	
1168				12	13	1	689			176			865			22,7	
1169				64	14	2	805			205			1.010			23,4	
1170				116	15	3	712			182			894			17,3	
1171			168	220	16	4	807			206			1.012			16,8	
1172				272	17	5	698			178			876			16,6	
1173					18	6	550			140			690			16,6	
1174					19	7	549	4.808		140	1.227		689	6.035		15,6	
1175				13	20	1	818			209			1.027			16,7	
1176				65	21	2	701			179			879			16,3	
1177				117	22	3	784			200			984			14,5	
1178			169	221	23	4	630			161			790			15,6	
1179				273	24	5	805			205			1.010			18,2	
1180					25	6	573			146			719			18,2	
1181					26	7	553	4.862		141	1.241		694	6.103		19,7	
1182				14	27	1	762			194			956			19,2	
1183				66	28	2	658			168			826			17,8	
1184				118	29	3	704			180			884			16,1	
1185			170	222	30	4	805			205			1.011			19,5	
1186				274	31	5	693		21.774	177		5.556	870		27.330	19,4	

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1187	2006	April			1	6	640			154			794			19,8	
1188					2	7	566	4.828		136	1.215		702	6.043		21,6	
1189				15	3	1	707			170			877			24,8	
1190				67	4	2	751			181			932			18,8	
1191				119	5	3	609			147			756			16,9	
1192			171	223	6	4	769			185			954			16,8	
1193				275	7	5	732			176			908			17,6	
1194					8	6	599			144			744			21,1	
1195					9	7	527	4.694		127	1.131		654	5.825		19,5	
1196				16	10	1	753			181			934			21,0	
1197				68	11	2	721			174			895			22,1	
1198				120	12	3	676			163			839			19,4	
1199			172	224	13	4	727			175			902			24,0	
1200				276	14	5	585			141			725			18,2	
1201					15	6	618			149			767			19,0	Public Holiday
1202					16	7	572	4.651		138	1.121		710	5.772		17,6	
1203				17	17	1	671			162			833			17,2	Public Holiday
1204				69	18	2	707			170			877			20,3	
1205				121	19	3	791			191			982			17,7	
1206			173	225	20	4	716			173			888			17,8	
1207				277	21	5	633			153			786			16,6	
1208					22	6	625			151			776			16,7	
1209					23	7	619	4.762		149	1.147		768	5.909		23,0	
1210				18	24	1	679			163			842			23,7	
1211				70	25	2	542			131			672			25,6	Public Holiday
1212				122	26	3	707			170			877			27,4	
1213			174	226	27	4	782			188			970			22,4	
1214				278	28	5	677			163			840			26,3	
1215					29	6	632			152			785			25,5	
1216					30	7	532	4.550	19.863	128	1.096	4.786	660	5.646	24.649	25,2	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1217	2006	May		19	1	1	596			247			843			25,0	Public Holiday
1218				71	2	2	721			299			1.019			23,6	
1219				123	3	3	729			302			1.031			19,4	
1220			175	227	4	4	722			299			1.021			19,8	
1221				279	5	5	803			333			1.136			22,5	
1222					6	6	611			253			864			21,1	
1223					7	7	577	4.758		239	1.972		816	6.731		19,9	
1224				20	8	1	640			265			906			20,6	
1225				72	9	2	687			285			972			25,0	
1226				124	10	3	790			328			1.118			28,1	
1227			176	228	11	4	744			308			1.053			23,0	
1228				280	12	5	783			324			1.107			23,4	
1229					13	6	577			239			816			26,1	
1230					14	7	506	4.727		210	1.959		715	6.686		26,3	
1231				21	15	1	730			302			1.032			25,7	
1232				73	16	2	754			312			1.066			29,8	
1233				125	17	3	763			316			1.079			26,7	
1234			177	229	18	4	726			301			1.026			22,8	
1235				281	19	5	791			328			1.118			22,1	
1236					20	6	572			237			809			24,9	
1237					21	7	619	4.954		256	2.053		875	7.007		23,0	
1238				22	22	1	713			295			1.008			20,4	
1239				74	23	2	667			276			943			20,4	
1240				126	24	3	393			163			556			24,7	
1241			178	230	25	4	1.011			419			1.429			28,7	
1242				282	26	5	799			331			1.131			32,1	
1243					27	6	585			243			828			33,6	
1244					28	7	808	4.976		335	2.062		1.143	7.039		34,6	
1245			179	23	29	1	727			301			1.028			32,8	
1246				75	30	2	743			308			1.050			25,5	
1247				127	31	3	380		21.264	157		8.813	537		30.077	23,3	

IR - Invalid Result
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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1248	2006	June	179	231	1	4	1.068			500			1.567			23,1	
1249				283	2	5	913			427			1.340			29,9	
1250					3	6	792			371			1.163			32,6	
1251					4	7	532	5.154		249	2.313		781	7.466		31,5	
1252			180	24	5	1	755			353			1.108			32,9	
1253				76	6	2	750			351			1.101			28,0	
1254				128	7	3	739			346			1.084			27,3	
1255				232	8	4	686			321			1.006			26,3	
1256				284	9	5	761			356			1.117			23,8	
1257					10	6	600			281			881			25,5	Public Holiday
1258					11	7	491	4.782		230	2.237		721	7.019		29,9	
1259			181	25	12	1	816			382			1.198			28,5	
1260				77	13	2	790			370			1.160			25,0	Local Holiday (Lisbon)
1261				129	14	3	666			312			978			23,2	
1262				233	15	4	527			247			774			23,0	Public Holiday
1263				285	16	5	582			272			854			25,7	
1264					17	6	570			267			837			22,7	
1265					18	7	483	4.436		226	2.075		710	6.511		27,0	
1266			182	26	19	1	692			324			1.016			25,3	
1267				78	20	2	842			394			1.236			23,6	
1268				130	21	3	689			322			1.011			27,4	
1269				234	22	4	984			460			1.445			30,5	
1270				286	23	5	868			406			1.275			26,3	
1271					24	6	837			392			1.229			22,8	
1272					25	7	597	5.510		279	2.578		876	8.088		21,5	
1273			183	27	26	1	736			345			1.081			21,9	
1274				79	27	2	857			401			1.258			22,7	
1275				131	28	3	853			399			1.253			22,9	
1276				235	29	4	850			398			1.248			25,1	Local Holiday (Sintra)
1277				287	30	5	808		22.137	378		10.358	1.186		32.495	27,4	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1278	2006	July			1	6	689			322			1.011			24,0	
1279					2	7	610	5.404		285	2.527		895	7.932		24,1	
1280				28	3	1	720			336			1.057			24,1	
1281				80	4	2	766			358			1.124			25,0	
1282				132	5	3	718			335			1.053			24,7	
1283			184	236	6	4	840			392			1.232			26,3	
1284				288	7	5	922			431			1.353			30,9	
1285					8	6	846			395			1.241			27,7	
1286					9	7	595	5.408		278	2.525		873	7.933		31,7	
1287				29	10	1	878			410			1.288			33,3	
1288				81	11	2	722			337			1.060			34,0	
1289				133	12	3	778			363			1.141			36,0	
1290			185	237	13	4	833			389			1.223			35,2	
1291				289	14	5	926			432			1.358			36,0	
1292					15	6	691			323			1.014			36,8	
1293					16	7	642	5.470		300	2.554		941	8.024		34,8	
1294				30	17	1	877			409			1.286			32,0	
1295				82	18	2	706			330			1.036			32,3	
1296				134	19	3	829			387			1.216			27,4	
1297			186	238	20	4	600			280			880			29,9	
1298				290	21	5	808			377			1.185			28,2	
1299					22	6	666			311			977			27,8	
1300					23	7	502	4.988		234	2.329		736	7.317		29,0	
1301				31	24	1	701			327			1.028			27,5	
1302				83	25	2	824			385			1.209			28,8	
1303				135	26	3	681			318			998			27,4	
1304			187	239	27	4	974			455			1.429			26,1	
1305				291	28	5	686			320			1.007			27,2	
1306					29	6	593			277			869			29,4	
1307					30	7	450	4.909		210	2.292		660	7.201		28.9	
1308				32	31	1	826		22.900	385		10.691	1.211		33.591	28,4	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1309	2006	August	188	84	1	2	680			310			991			27,4	
1310				136	2	3	688			314			1.002			29,9	
1311				240	3	4	670			306			976			25,6	
1312				292	4	5	993			453			1.446			34,7	
1313					5	6	628			286			914			33,0	
1314					6	7	444	4.928		203	2.258		647	7.186		38,0	
1315			189	33	7	1	763			348			1.111			33,7	
1316				85	8	2	648			296			944			32,6	
1317				137	9	3	903			412			1.315			36,8	
1318				241	10	4	814			371			1.185			35,9	
1319				293	11	5	695			317			1.012			36,1	
1320					12	6	671			306			977			34,3	
1321					13	7	418	4.912		191	2.242		609	7.154		28,3	
1322			190	34	14	1	615			280			895			28,0	
1323				86	15	2	539			246			785			23,9	Public Holiday
1324				138	16	3	637			291			927			22,7	
1325				242	17	4	635			290			925			23,5	
1326				294	18	5	625			285			910			23,5	
1327					19	6	709			323			1.032			25,1	
1328					20	7	499	4.257		228	1.943		726	6.200		30,8	
1329			191	35	21	1	973			444			1.418			35,7	
1330				87	22	2	787			359			1.147			34,3	
1331				139	23	3	793			362			1.155			26,7	
1332				243	24	4	862			393			1.255			27,0	
1333				295	25	5	993			453			1.446			30,1	
1334					26	6	526			240			766			27,7	
1335					27	7	560	5.494		255	2.508		815	8.002		31,6	
1336			192	36	28	1	813			371			1.185			32,0	
1337				88	29	2	1.003			458			1.461			34,5	
1338				140	30	3	803			367			1.170			36,4	
1339				244	31	4	688		22.075	314		10.075	1.003		32.150	33,8	

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1340	2006	September		296	1	5	834			460			1.294			31,5	
1341					2	6	581			321			902			30,7	
1342					3	7	473	5.197		261	2.551		734	7.748		36,4	
1343				37	4	1	853			470			1.323			39,0	
1344				89	5	2	774			427			1.201			32,9	
1345				141	6	3	698			385			1.083			34,1	
1346			193	245	7	4	730			403			1.133			32,6	
1347				297	8	5	617			340			957			34,3	
1348					9	6	535			295			830			33,2	
1349					10	7	525	4.732		290	2.610		814	7.342		28,9	
1350				38	11	1	548			303			851			26,6	Local Holiday (Amadora)
1351				90	12	2	779			430			1.209			26,2	
1352				142	13	3	706			389			1.095			22,4	
1353			194	246	14	4	627			346			972			23,1	
1354				298	15	5	629			347			977			23,3	
1355					16	6	651			359			1.010			24,5	
1356					17	7	489	4.429		270	2.443		759	6.873		26,5	
1357				39	18	1	781			431			1.212			27,5	
1358				91	19	2	780			430			1.210			28,4	
1359				143	20	3	697			385			1.082			27,0	
1360			195	247	21	4	662			365			1.028			22,8	
1361				299	22	5	769			424			1.194			22,5	
1362					23	6	535			295			830			23,5	
1363					24	7	560	4.784		309	2.639		869	7.424		22,4	
1364				40	25	1	793			437			1.230			25,2	
1365				92	26	2	677			374			1.051			27,8	
1366				144	27	3	616			340			956			25,9	
1367			196	248	28	4	684			377			1.061			24,6	
1368				300	29	5	665			367			1.032			24,1	
1369					30	6	546		19.815	301		10.930	848		30.745	23,3	

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1370	2006	October			1	7	527	4.508		171	2.367		698	6.875		25,4	
1371				41	2	1	548			178			727			23,6	
1372				93	3	2	677			220			898			22,2	
1373				145	4	3	668			217			886			22,5	
1374			197	249	5	4	506			165			671			23,1	Public Holiday
1375				301	6	5	543			177			719			24,6	
1376					7	6	463			151			613			26,2	
1377					8	7	581	3.987		189	1.297		770	5.284		27,5	
1378				42	9	1	586			191			776			26,5	
1379				94	10	2	716			233			949			22,1	
1380				146	11	3	662			215			877			22,3	
1381			198	250	12	4	691			225			916			23,7	
1382				302	13	5	629			205			834			24,7	
1383					14	6	538			175			713			24,5	
1384					15	7	450	4.272		146	1.390		596	5.662		22,9	
1385				43	16	1	626			204			830			19,9	
1386				95	17	2	657			214			870			22,5	
1387				147	18	3	731			238			969			21,8	
1388			199	251	19	4	582			189			772			19,3	
1389				303	20	5	691			225			916			20,9	
1390					21	6	479			156			634			21,5	
1391					22	7	451	4.217		147	1.372		598	5.589		20,4	
1392				44	23	1	708			230			938			22,4	
1393				96	24	2	656			214			870			22,0	
1394				148	25	3	651			212			863			21,1	
1395			200	252	26	4	602			196			798			19,8	
1396				304	27	5	608			198			805			22,8	
1397					28	6	723			235			958			26,3	
1398					29	7	475	4.422		154	1.439		629	5.861		24,9	
1399				45	30	1	713			232			945			25,0	
1400				97	31	2	674		18.811	219		6.121	893		24.932	20,0	

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
1401	2006	November		149	1	3	543			152			695			20,5	Public Holiday
1402			201	253	2	4	609			170			780			19,5	
1403				305	3	5	685			192			877			21,7	
1404					4	6	519			145			664			21,5	
1405					5	7	466	4.210		130	1.241		597	5.451		22,7	
1406				46	6	1	724			202			926			19,6	
1407				98	7	2	695			194			889			20,9	
1408				150	8	3	640			179			819			21,2	
1409			202	254	9	4	666			186			853			22,1	
1410				306	10	5	724			202			926			21,4	
1411					11	6	503			141			643			21,0	
1412					12	7	492	4.443		138	1.243		630	5.686		20,1	
1413				47	13	1	737			206			943			19,0	
1414				99	14	2	612			171			783			14,6	
1415				151	15	3	762			213			976			18,4	
1416			203	255	16	4	605			169			774			17,4	
1417				307	17	5	770			215			985			18,2	
1418					18	6	553			155			708			19,8	
1419					19	7	469	4.507		131	1.261		600	5.768		19,1	
1420				48	20	1	748			209			957			19,1	
1421				100	21	2	665			186			851			19,4	
1422				152	22	3	838			234			1.072			18,1	
1423			204	256	23	4	688			192			880			18,3	
1424				308	24	5	743			208			951			19,3	
1425					25	6	162			45			207			17,0	IR
1426					26	7	NR	3.843		IR	IR		IR	IR		17,2	
1427				49	27	1	NR			IR			IR			18,2	
1428				101	28	2	NR			IR			IR			17,3	
1429				153	29	3	NR			IR			IR			15,3	
1430			205	257	30	4	NR		15.617	IR		4.368	IR		19.985	16,5	

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1431	2006	December		309	1	5	NR			IR			IR			17,4	Public Holiday
1432					2	6	NR			IR			IR			15,7	
1433					3	7	NR	NR		IR	IR		IR	IR		18,1	
1434			206	50	4	1	NR			IR			IR			19,4	
1435				102	5	2	NR			IR			IR			17,6	
1436				154	6	3	NR			IR			IR			15,7	
1437				258	7	4	NR			IR			IR			16,8	
1438				310	8	5	NR			IR			IR			16,6	Public Holiday
1439					9	6	NR			IR			IR			11,7	
1440					10	7	NR	NR		IR	IR		IR	IR		12,5	
1441			207	51	11	1	NR			IR			IR			13,0	
1442				103	12	2	NR			IR			IR			14,4	
1443				155	13	3	NR			IR			IR			14,4	
1444				259	14	4	NR			IR			IR			14,4	
1445				311	15	5	NR			IR			IR			13,3	
1446					16	6	NR			IR			IR			13,2	
1447					17	7	NR	NR		IR	IR		IR	IR		13,6	
1448			208	52	18	1	NR			IR			IR			15,0	
1449				104	19	2	NR			IR			IR			13,1	
1450				156	20	3	NR			IR			IR			10,9	
1451				260	21	4	NR			IR			IR			12,1	
1452				312	22	5	NR			IR			IR			11,1	
1453					23	6	NR			IR			IR			10,9	
1454					24	7	NR	NR		IR	IR		IR	IR		12,1	
1455			209	1	25	1	NR			IR			IR			10,8	Public Holiday
1456				53	26	2	NR			IR			IR			12,2	
1457				105	27	3	NR			IR			IR			14,2	
1458				157	28	4	NR			IR			IR			16,5	
1459				261	29	5	NR			IR			IR			16,1	
1460					30	6	NR			IR			IR			17,5	
1461					31	7	NR	NR	0	IR	IR	5.352	IR	IR	5.352	17,0	

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1462	2007	January		2	1	1	NR			IR			IR			16,7	Public Holiday
1463				54	2	2	NR			IR			IR			15,2	
1464				106	3	3	NR			IR			IR			14,0	
1465			210	158	4	4	NR			IR			IR			16,5	
1466				262	5	5	NR			IR			IR			16,9	
1467					6	6	NR			IR			IR			14,9	
1468					7	7	NR	NR		IR	IR		IR	IR		17,2	
1469				3	8	1	NR			IR			IR			15,2	
1470				55	9	2	NR			IR			IR			13,1	
1471				107	10	3	NR			IR			IR			11,4	
1472			211	159	11	4	NR			IR			IR			15,4	
1473				263	12	5	NR			IR			IR			13,9	
1474					13	6	NR			IR			IR			13,9	
1475					14	7	NR	NR		IR	IR		IR	IR		11,9	
1476				4	15	1	NR			IR			IR			13,6	
1477				56	16	2	NR			IR			IR			15,3	
1478				108	17	3	NR			IR			IR			16,0	
1479			212	160	18	4	NR			IR			IR			14,9	
1480				264	19	5	NR			IR			IR			16,0	
1481					20	6	NR			IR			IR			17,6	
1482					21	7	NR	NR		IR	IR		IR	IR		16,2	
1483				5	22	1	NR			IR			IR			12,8	
1484				57	23	2	NR			IR			IR			11,6	
1485				109	24	3	NR			IR			IR			11,2	
1486			213	161	25	4	NR			IR			IR			12,0	
1487				265	26	5	NR			IR			IR			10,2	
1488					27	6	NR			IR			IR			11,2	
1489					28	7	NR	NR		IR	IR		IR	IR		7,4	
1490				6	29	1	NR			IR			IR			11,9	
1491				58	30	2	NR			IR			IR			11,5	
1492				110	31	3	NR			IR			IR			13,7	

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1493	2007	February	214	162	1	4	NR		0	IR		4.920	IR		4.920	13,7	IR
1494				266	2	NR	NR			IR			IR			14,0	
1495					3	6	NR			IR			IR			14,1	
1496					4	7	NR	NR		IR	IR		IR	IR		14,0	
1497				7	5	1	NR			IR			IR			13,3	
1498				59	6	2	NR			IR			IR			14,2	
1499				111	7	3	NR			IR			IR			15,0	
1500			215	163	8	4	NR			IR			IR			16,9	
1501				267	9	5	462			237			699			16,5	IR
1502					10	6	425			218			642			17,4	
1503					11	7	409	1.296		210	IR		618	IR		16,2	IR
1504				8	12	1	583			299			882			17,2	
1505				60	13	2	553			283			836			16,9	
1506				112	14	3	652			334			986			17,8	
1507			216	164	15	4	619			317			936			16,0	
1508				268	16	5	549			281			830			15,7	
1509					17	6	452			232			684			15,2	
1510					18	7	412	3.819		211	1.958		624	5.777		15,0	
1511				9	19	1	527			270			797			15,0	
1512				61	20	2	519			266			785			13,5	Public Holiday
1513				113	21	3	547			280			827			15,4	
1514			217	165	22	4	603			309			913			17,6	
1515				269	23	5	568			291			859			17,0	
1516					24	6	439			225			663			17,5	
1517					25	7	436	3.639		224	1.866		660	5.504		17,9	
1518				10	26	1	586			301			887			16,5	
1519				62	27	2	607			311			918			18,5	
1520				114	28	3	539		10.485	276		5.376	815		15.861	15,9	IR

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1521	2007	March	218	166	1	4	549			234			783			17,5	
1522				270	2	5	616			263			879			17,4	
1523					3	6	438			187			625			17,8	
1524					4	7	388	3.724		166	1.738		554	5.461		16,0	
1525				11	5	1	553			236			789			16,2	
1526				63	6	2	581			248			829			16,5	
1527				115	7	3	547			233			780			17,6	
1528			219	167	8	4	621			265			885			18,1	
1529				271	9	5	552			236			788			21,1	
1530					10	6	450			192			642			21,9	
1531					11	7	369	3.672		157	1.567		526	5.239		22,0	
1532				12	12	1	586			250			836			19,0	
1533				64	13	2	609			260			869			20,4	
1534				116	14	3	565			241			805			20,9	
1535			220	168	15	4	588			251			838			21,1	
1536				272	16	5	552			235			787			22,6	
1537					17	6	466			199			665			21,2	
1538					18	7	393	3.758		168	1.603		561	5.362		21,7	
1539				13	19	1	506			216			722			14,2	
1540				65	20	2	602			257			859			14,2	
1541				117	21	3	617			263			880			13,6	
1542			221	169	22	4	609			260			869			16,2	
1543				273	23	5	542			231			773			16,9	
1544					24	6	502			214			717			16,6	
1545					25	7	401	3.778		171	1.612		571	5.390		16,0	
1546				14	26	1	518			221			739			17,5	
1547				66	27	2	565			241			806			15,8	
1548				118	28	3	542			231			774			16,1	
1549			222	170	29	4	618			264			882			17,4	
1550				274	30	5	598			255			853			15,6	
1551					31	6	465		16.507	198		7.042	663		23.549	14,7	

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1552	2007	April			1	7	414	3.721		160	1.570		574	5.291		15,4	
1553				15	2	1	526			203			728			14,7	
1554				67	3	2	541			208			749			15,6	
1555				119	4	3	638			246			885			16,6	
1556			223	171	5	4	563			217			780			17,2	
1557				275	6	5	471			182			653			19,7	Public Holiday
1558					7	6	456			176			633			19,1	
1559					8	7	398	3.592		153	1.385		551	4.977		17,1	Public Holiday
1560				16	9	1	541			209			750			18,6	
1561				68	10	2	523			202			724			20,9	
1562				120	11	3	595			230			825			20,1	
1563			224	172	12	4	631			243			874			17,8	
1564				276	13	5	533			206			739			19,1	
1565					14	6	484			187			671			20,9	
1566					15	7	437	3.744		168	1.444		605	5.188		24,6	
1567				17	16	1	551			213			764			25,9	
1568				69	17	2	549			212			761			26,4	
1569				121	18	3	560			216			776			24,6	
1570			225	173	19	4	592			228			820			23,1	
1571				277	20	5	575			222			796			18,2	
1572					21	6	455			176			631			25,7	
1573					22	7	406	3.688		157	1.422		563	5.110		27,6	
1574				18	23	1	617			238			855			27,8	
1575				70	24	2	593			229			822			22,7	
1576				122	25	3	448			173			620			18,9	Public Holiday
1577			226	174	26	4	542			209			751			17,6	
1578				278	27	5	622			240			862			18,9	
1579					28	6	434			167			601			18,8	
1580					29	7	413	3.668		159	1.415		573	5.083		20,1	
1581				19	30	1	539		15.646	208		6.034	747		21.680	17,0	

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Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) - From Municipality - Daily	Weekly	Monthly	From Borehole - Daily	Weekly	Monthly	Total - Daily	Weekly	Monthly	Max. temp (°C)	Notes
1582	2007	May		71	1	2	464			261			724			16,9	Public Holiday
1583				123	2	3	567			319			886			16,5	
1584			227	175	3	4	534			300			834			19,2	
1585				279	4	5	538			303			841			18,5	
1586					5	6	477			268			746			21,4	
1587					6	7	440	3.020		247	1.906		687	4.925		24,1	
1588				20	7	1	513			289			802			24,7	
1589				72	8	2	645			363			1.008			30,2	
1590				124	9	3	575			323			899			30,2	
1591			228	176	10	4	560			315			874			24,7	
1592				280	11	5	554			311			865			21,8	
1593					12	6	505			284			789			20,7	
1594					13	7	449	3.801		252	2.137		701	5.938		19,8	
1595				21	14	1	541			304			845			19,6	
1596				73	15	2	561			315			877			22,2	
1597				125	16	3	569			320			889			26,7	
1598			229	177	17	4	513			289			802			32,1	
1599				281	18	5	653			367			1.020			32,6	
1600					19	6	460			259			718			21,2	
1601					20	7	397	3.695		223	2.077		620	5.771		16,9	
1602				22	21	1	580			326			906			17,6	
1603				74	22	2	526			295			821			16,8	
1604				126	23	3	590			332			922			24,1	
1605			230	178	24	4	562			316			878			20,7	
1606				282	25	5	492			276			768			18,3	
1607					26	6	456			256			712			21,4	
1608					27	7	378	3.584		213	2.015		591	5.599		19,3	
1609				23	28	1	514			289			803			20,1	
1610				75	29	2	544			305			849			22,7	
1611				127	30	3	538			303			841			21,4	
1612			231	179	31	4	567		16.263	319		9.141	885		25.404	21,3	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
1613	2007	June		283	1	5	557			408			964			24,0	
1614					2	6	414			303			718			30,4	
1615					3	7	388	3.521		284	2.211		671	5.732		26,1	
1616			232	24	4	1	524			384			908			31,5	
1617				76	5	2	576			422			999			31,1	
1618				128	6	3	593			434			1.027			25,4	
1619				180	7	4	436			319			755			24,3	Public Holiday
1620				284	8	5	494			362			857			24,2	
1621					9	6	446			327			773			23,4	
1622					10	7	313	3.382		229	2.478		542	5.860		22,0	Public Holiday
1623			233	25	11	1	514			377			891			22,7	
1624				77	12	2	523			383			907			23,3	
1625				129	13	3	557			408			966			22,3	Local Holiday (Lisbon)
1626				181	14	4	514			376			890			21,6	
1627				285	15	5	520			381			901			22,9	
1628					16	6	442			323			765			20,2	
1629					17	7	406	3.476		297	2.547		703	6.023		21,7	
1630			234	26	18	1	515			377			892			22,7	
1631				78	19	2	519			380			899			21,6	
1632				130	20	3	575			421			996			22,3	
1633				182	21	4	546			400			946			22,6	
1634				286	22	5	510			374			884			23,5	
1635					23	6	434			318			752			26,5	
1636					24	7	380	3.478		278	2.549		658	6.027		23,1	
1637			235	27	25	1	481			352			834			23,2	
1638				79	26	2	546			400			945			23,4	
1639				131	27	3	577			423			999			25,0	
1640				183	28	4	546			400			946			23,9	
1641				287	29	5	609			446			1.055			25,7	Local Holiday (Sintra)
1642					30	6	426		14.880	312		10.902	739		25.782	25,2	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1643	2007	July			1	7	394	3.578		358	2.691		751	6.270		24,5	
1644				28	2	1	527			479			1.007			25,0	
1645				80	3	2	573			520			1.093			22,9	
1646				132	4	3	513			466			979			26,8	
1647			236	184	5	4	582			529			1.110			33,6	
1648				288	6	5	586			533			1.119			33,9	
1649					7	6	418			380			798			27,2	
1650					8	7	424	3.623		386	3.293		810	6.917		26,8	
1651				29	9	1	541			492			1.033			24,8	
1652				81	10	2	500			455			955			30,0	
1653				133	11	3	655			595			1.250			31,6	
1654			237	185	12	4	568			517			1.085			33,4	
1655				289	13	5	500			454			954			31,0	
1656					14	6	513			466			979			30,3	
1657					15	7	450	3.727		409	3.388		860	7.115		23,5	
1658				30	16	1	536			487			1.023			24,6	
1659				82	17	2	721			656			1.377			25,6	
1660				134	18	3	547			497			1.044			24,9	
1661			238	186	19	4	485			441			927			24,0	
1662				290	20	5	592			539			1.131			24,4	
1663					21	6	381			346			727			23,7	
1664					22	7	426	3.689		387	3.353		813	7.042		25,5	
1665				31	23	1	497			452			949			25,0	
1666				83	24	2	510			464			974			26,9	
1667				135	25	3	602			547			1.148			28,3	
1668			239	187	26	4	487			443			930			29,2	
1669				291	27	5	577			524			1.101			30,5	
1670					28	6	408			371			780			36,5	
1671					29	7	392	3.473		356	3.157		748	6.629		40,3	
1672				32	30	1	535			486			1.022			40,6	
1673				84	31	2	525		15.966	478		14.513	1.003		30.479	29,3	

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NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1674	2007	August		136	1	3	515			427			942			27,4	
1675			240	188	2	4	529			439			968			30,8	
1676				292	3	5	567			471			1.038			36,1	
1677					4	6	430			356			786			34,6	
1678					5	7	395	3.496		328	2.985		723	6.482		25,9	
1679				33	6	1	517			429			946			23,5	
1680				85	7	2	517			429			946			26,3	
1681				137	8	3	528			439			967			33,1	
1682			241	189	9	4	463			384			847			34,1	
1683				293	10	5	513			426			938			29,2	
1684					11	6	437			363			801			26,6	
1685					12	7	470	3.445		390	2.859		860	6.303		24,9	
1686				34	13	1	522			433			955			25,4	
1687				86	14	2	470			390			860			27,9	
1688				138	15	3	429			356			785			26,5	Public Holiday
1689			242	190	16	4	516			428			944			24,4	
1690				294	17	5	494			410			904			29,2	
1691					18	6	421			349			770			25,7	
1692					19	7	392	3.243		325	2.692		717	5.935		24,3	
1693				35	20	1	541			449			990			27,5	
1694				87	21	2	494			410			903			24,6	
1695				139	22	3	487			404			890			28,8	
1696			243	191	23	4	513			426			938			31,6	
1697				295	24	5	542			449			991			32,6	
1698					25	6	441			366			807			25,8	
1699					26	7	416	3.433		345	2.849		762	6.282		30,0	
1700				36	27	1	475			394			868			29,7	
1701				88	28	2	541			449			990			26,0	
1702				140	29	3	654			543			1.196			26,0	
1703			244	192	30	4	511			424			936			29,0	
1704				296	31	5	484		15.221	401		12.632	885		27.853	32,1	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1705	2007	September			1	6	445			280			725			28,9	
1706					2	7	449	3.559		283	2.774		733	6.333		32,7	
1707			245	37	3	1	536			338			874			31,9	
1708				89	4	2	673			424			1.097			30,0	
1709				141	5	3	569			358			927			34,1	
1710				193	6	4	492			310			802			30,9	
1711				297	7	5	519			327			845			29,7	
1712					8	6	456			287			743			25,6	
1713					9	7	385	3.629		242	2.286		627	5.914		24,7	
1714			246	38	10	1	518			327			845			28,7	
1715				90	11	2	404			255			659			27,7	Local Holiday (Amadora)
1716				142	12	3	457			288			745			26,7	
1717				194	13	4	499			314			813			27,5	
1718				298	14	5	537			338			876			27,3	
1719					15	6	455			286			741			30,4	
1720					16	7	330	3.200		208	2.016		538	5.216		28,2	
1721			247	39	17	1	516			325			840			23,9	
1722				91	18	2	292			184			476			24,8	
1723				143	19	3	610			384			994			27,0	
1724				195	20	4	823			518			1.341			28,3	
1725				299	21	5	545			343			888			25,8	
1726					22	6	361			227			588			24,5	
1727					23	7	368	3.514		232	2.214		600	5.728		27,5	
1728			248	40	24	1	634			400			1.034			27,7	
1729				92	25	2	500			315			814			23,6	
1730				144	26	3	621			391			1.013			27,3	
1731				196	27	4	823			518			1.341			28,0	
1732				300	28	5	613			386			999			24,7	
1733					29	6	464			292			756			21,5	
1734					30	7	411	4.065	15.303	259	2.561	9.639	669	6.626	24.942	21,1	

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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1735	2007	October		41	1	1	484			247			731			23,1	
1736				93	2	2	634			325			959			20,8	
1737				145	3	3	634			325			959			22,1	
1738			249	197	4	4	600			307			907			22,5	
1739				301	5	5	576			294			870			23,4	Public Holiday
1740					6	6	525			269			794			24,9	
1741					7	7	419	3.872		214	1.980		633	5.852		25,8	
1742				42	8	1	639			327			965			24,4	
1743				94	9	2	609			312			921			28,1	
1744				146	10	3	618			316			934			28,1	
1745			250	198	11	4	703			359			1.062			24,9	
1746				302	12	5	591			302			894			24,2	
1747					13	6	561			287			848			25,5	
1748					14	7	498	4.218		255	2.158		752	6.376		25,8	
1749				43	15	1	574			293			867			24,3	
1750				95	16	2	670			343			1.013			25,9	
1751				147	17	3	734			376			1.110			26,2	
1752			251	199	18	4	646			331			977			26,9	
1753				303	19	5	566			290			856			26,5	
1754					20	6	551			282			833			26,7	
1755					21	7	477	4.218		244	2.158		721	6.376		25,1	
1756				44	22	1	587			300			888			24,0	
1757				96	23	2	670			343			1.012			21,7	
1758				148	24	3	607			310			917			19,4	
1759			252	200	25	4	599			306			906			21,1	
1760				304	26	5	645			330			974			20,6	
1761					27	6	490			251			741			21,5	
1762					28	7	546	3.557		279	2.120		826	5.676		22,1	
1763				45	29	1	557			285			843			21,9	
1764				97	30	2	660			338			998			22,2	
1765				149	31	3	594		18.263	304		9.342	897		27.605	20,4	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Weekly	Monthly	From Borehole Daily	Weekly	Monthly	Total Daily	Weekly	Monthly	Max. temp (°C)	Notes
1766	2007	November	253	201	1	4	618			307			925			20,8	Public Holiday
1767				305	2	5	567			282			849			23,0	
1768					3	6	524			260			784			23,1	
1769					4	7	499	4.018		248	2.024		747	6.042		22,8	
1770				46	5	1	556			276			832			24,7	
1771				98	6	2	667			331			998			23,9	
1772				150	7	3	602			299			901			24,2	
1773			254	202	8	4	638			317			956			22,7	
1774				306	9	5	657			327			984			23,2	
1775					10	6	498			247			745			21,2	
1776					11	7	487	4.104		242	2.040		729	6.144		20,7	
1777				47	12	1	657			327			983			22,8	
1778				99	13	2	604			300			904			21,4	
1779				151	14	3	664			330			995			19,7	
1780			255	203	15	4	620			308			929			19,0	
1781				307	16	5	638			317			955			18,5	
1782					17	6	528			262			790			13,4	
1783					18	7	471	4.183		234	2.080		705	6.262		16,7	
1784				48	19	1	627			312			938			18,0	
1785				100	20	2	564			280			845			16,7	
1786				152	21	3	677			337			1.014			18,7	
1787			256	204	22	4	643			320			963			16,7	
1788				308	23	5	621			309			930			14,7	
1789					24	6	540			268			808			15,2	
1790					25	7	502	4.174		250	2.075		751	6.249		14,8	
1791				49	26	1	559			278			837			17,0	
1792				101	27	2	699			348			1.047			15,6	
1793				153	28	3	610			303			913			15,0	
1794			257	205	29	4	685			341			1.026			15,9	
1795				309	30	5	557		17.778	277		8.839	834		26.617	13,8	

IR - Invalid Result
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1 - Monday **2 - Tuesday** **3 - Wednesday** **4 - Thursday** **5 - Friday** **6 - Saturday** **7 - Sunday**

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
1796	2007	December			1	6	522			181			703			15,7	Public Holiday
1797					2	7	497	4.129		172	1.900		669	6.029		15,5	
1798				50	3	1	596			207			802			16,9	
1799				102	4	2	632			219			851			12,8	
1800				154	5	3	627			217			844			11,3	
1801			258	206	6	4	628			218			846			17,6	
1802				310	7	5	672			233			905			17,9	
1803					8	6	496			172			668			16,9	Public Holiday
1804					9	7	452	4.102		157	1.423		608	5.525		17,8	
1805				51	10	1	632			219			851			15,9	
1806				103	11	2	574			199			774			14,9	
1807				155	12	3	691			240			930			13,4	
1808			259	207	13	4	630			219			848			12,9	
1809				311	14	5	621			215			837			13,5	
1810					15	6	535			186			721			13,3	
1811					16	7	514	4.197		178	1.456		693	5.654		11,2	
1812				52	17	1	566			196			762			10,4	
1813				104	18	2	671			233			904			13,8	
1814				156	19	3	589			204			794			13,2	
1815			260	208	20	4	565			196			761			13,0	
1816				312	21	5	675			234			909			15,8	
1817					22	6	500			173			673			15,5	
1818					23	7	436	4.002		151	1.388		587	5.390		15,4	
1819				1	24	1	503			174			677			15,3	
1820				53	25	2	437			151			588			14,6	Public Holiday
1821				105	26	3	581			202			783			15,1	
1822			261	157	27	4	570			198			768			14,4	
1823				209	28	5	626			217			844			13,7	
1824					29	6	472			164			635			12,3	
1825					30	7	452	3.641		157	1.263		609	4.904		14,7	
1826				2	31	1	568		17.528	197		6.082	765		23.610	12,7	

IR - Invalid Result
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1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
1827	2008	January		54	1	2	460			213			673			14,4	Public Holiday
1828				106	2	3	697			323			1.021			15,5	
1829			262	158	3	4	644			299			943			14,5	
1830				210	4	5	589			273			862			15,6	
1831					5	6	474			220			694			16,4	
1832					6	7	338	3.771		157	1.682		495	5.453		16,9	
1833				3	7	1	616			286			902			18,3	
1834				55	8	2	532			247			778			16,4	
1835				107	9	3	563			261			824			16,3	
1836			263	159	10	4	583			270			853			17,5	
1837				211	11	5	642			298			940			15,5	
1838					12	6	413			191			604			14,2	
1839					13	7	377	3.725		175	1.727		551	5.453		15,6	
1840				4	14	1	634			294			928			15,9	
1841				56	15	2	573			266			838			15,2	
1842				108	16	3	624			289			913			15,6	
1843			264	160	17	4	609			282			891			16,1	
1844				212	18	5	588			272			860			14,7	
1845					19	6	438			203			641			16,9	
1846					20	7	353	3.818		164	1.770		517	5.588		17,8	
1847				5	21	1	619			287			906			18,2	
1848				57	22	2	598			277			875			21,0	
1849				109	23	3	589			273			861			18,0	
1850			265	161	24	4	572			265			838			16,2	
1851				213	25	5	574			266			840			15,7	
1852					26	6	487			226			712			16,2	
1853					27	7	361	3.798		167	1.761		528	5.560		16,3	
1854				6	28	1	624			290			914			17,1	
1855				58	29	2	596			276			872			18,3	
1856				110	30	3	593			275			868			16,2	
1857			266	162	31	4	576		16.934	267		7.852	843		24.786	16,6	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	Water Supply (m3/day) From Municipality Weekly	Water Supply (m3/day) From Municipality Monthly	Water Supply (m3/day) From Borehole Daily	Water Supply (m3/day) From Borehole Weekly	Water Supply (m3/day) From Borehole Monthly	Water Supply (m3/day) Total Daily	Water Supply (m3/day) Total Weekly	Water Supply (m3/day) Total Monthly	Max. temp (°C)	Notes
1858	2008	February		214	1	5	582			221			802			14,4	
1859					2	6	473			179			653			15,3	
1860					3	7	453	3.897		172	1.679		625	5.577		15,9	
1861				7	4	1	612			232			844			15,9	
1862				59	5	2	484			184			668			15,5	Public Holiday
1863				111	6	3	623			236			859			17,5	
1864			267	163	7	4	547			207			755			19,3	
1865				215	8	5	562			213			775			18,6	
1866					9	6	525			199			724			18,7	
1867					10	7	429	3.783		163	1.434		592	5.217		18,0	
1868				8	11	1	652			247			899			16,4	
1869				60	12	2	660			250			910			17,1	
1870				112	13	3	639			242			882			15,5	
1871			268	164	14	4	607			230			837			17,0	
1872				216	15	5	638			242			880			18,2	
1873					16	6	491			186			677			17,9	
1874					17	7	381	4.068		144	1.542		526	5.610		13,6	
1875				9	18	1	662			251			913			14,5	
1876				61	19	2	516			196			712			16,2	
1877				113	20	3	663			251			915			17,3	
1878			269	165	21	4	600			227			827			18,1	
1879				217	22	5	519			197			716			19,0	
1880					23	6	476			180			656			15,9	
1881					24	7	385	3.822		146	1.449		532	5.271		17,8	
1882				10	25	1	658			249			907			19,6	
1883				62	26	2	613			232			845			20,4	
1884				114	27	3	572			217			789			18,6	
1885			270	166	28	4	641			243			884			18,2	
1886				218	29	5	577		16.242	219		6.156	796		22.398	19,0	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
1887	2008	March			1	6	466			161			627			20,0	
1888					2	7	441	3.968		152	1.472		593	5.440		19,6	
1889				11	3	1	536			185			721			18,6	
1890				63	4	2	648			223			870			19,3	
1891				115	5	3	611			211			822			15,7	
1892			271	167	6	4	621			214			835			15,8	
1893				219	7	5	533			184			717			18,6	
1894					8	6	457			157			615			16,8	
1895					9	7	462	3.869		159	1.332		621	5.201		16,0	
1896				12	10	1	668			230			897			15,4	
1897				64	11	2	638			220			858			18,4	
1898				116	12	3	612			211			822			19,1	
1899			272	168	13	4	654			225			880			21,9	
1900				220	14	5	593			204			797			21,5	
1901					15	6	485			167			652			17,9	
1902					16	7	468	4.118		161	1.418		629	5.536		17,2	
1903				13	17	1	533			184			717			17,1	
1904				65	18	2	637			219			857			16,9	
1905				117	19	3	563			194			756			12,2	
1906			273	169	20	4	561			193			754			17,5	
1907				221	21	5	420			145			565			18,6	Public Holiday
1908					22	6	457			157			615			15,4	
1909					23	7	434	3.605		149	1.241		583	4.846		14,1	Public Holiday
1910				14	24	1	605			208			814			16,0	
1911				66	25	2	532			183			715			15,9	
1912				118	26	3	609			210			819			17,0	
1913			274	170	27	4	581			200			780			18,0	
1914				222	28	5	491			169			660			18,8	
1915					29	6	464			160			624			21,3	
1916					30	7	371	3.653		128	1.258		498	4.911		17,0	
1917				15	31	1	618		16.770	213		5.774	831		22.544	18,5	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday   2 - Tuesday   3 - Wednesday   4 - Thursday   5 - Friday   6 - Saturday   7 - Sunday

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day) From Municipality Daily	From Municipality Weekly	From Municipality Monthly	From Borehole Daily	From Borehole Weekly	From Borehole Monthly	Total Daily	Total Weekly	Total Monthly	Max. temp (°C)	Notes
1918	2008	April		67	1	2	606			254			860			23,8	
1919				119	2	3	493			207			700			25,2	
1920			275	171	3	4	603			253			856			28,7	
1921				223	4	5	554			232			786			30,2	
1922					5	6	420			176			595			22,4	
1923					6	7	413	3.707		173	1.507		586	5.214		22,6	
1924				16	7	1	645			271			916			19,3	
1925				68	8	2	617			259			875			17,7	
1926				120	9	3	613			257			870			19,6	
1927			276	172	10	4	500			210			710			16,4	
1928				224	11	5	645			270			915			15,5	
1929					12	6	499			209			708			17,5	
1930					13	7	374	3.892		157	1.632		530	5.524		18,1	
1931				17	14	1	648			272			920			19,4	
1932				69	15	2	639			268			906			21,9	
1933				121	16	3	621			260			881			19,5	
1934			277	173	17	4	580			243			823			17,0	
1935				225	18	5	517			217			734			16,3	
1936					19	6	475			199			675			15,8	
1937					20	7	453	3.933		190	1.649		643	5.582		16,5	
1938				18	21	1	641			269			909			17,6	
1939				70	22	2	656			275			931			18,6	
1940				122	23	3	569			239			808			20,0	
1941			278	174	24	4	664			278			942			26,0	
1942				226	25	5	476			199			675			30,2	Public Holiday
1943					26	6	473			198			671			27,4	
1944					27	7	486	3.964		204	1.661		689	5.625		26,2	
1945				19	28	1	611			256			868			19,0	
1946				71	29	2	630			264			894			18,0	
1947			279	123	30	3	546		16.664	229		6.985	774		23.649	18,7	

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday **2 - Tuesday** **3 - Wednesday** **4 - Thursday** **5 - Friday** **6 - Saturday** **7 - Sunday**

Water Supply to Hospital Amadora Sintra

Recorded Data

Annexe 1

Day Ref. Nr.	Year	Month	Week Ref. Nr.	Equiv. Weeks	Day of Month	Day of Week	Water Supply (m3/day)									Max. temp (°C)	Notes
							From Municipality			From Borehole			Total				
							Daily	Weekly	Monthly	Daily	Weekly	Monthly	Daily	Weekly	Monthly		
1948	2008	May	[illegible]	175	1	4	521						IR				Public Holiday
1949				227	2	5	569						IR				
1950					3	6	459						IR				

IR - Invalid Result
NR - Water Consumption not recorded
1 - Monday 2 - Tuesday 3 - Wednesday 4 - Thursday 5 - Friday 6 - Saturday 7 - Sunday

WATER SUPPLY TO

PORTUGUESE REGIONAL HOSPITALS

ANNEXE 2

NUMERIC DECOMPOSITION OF MONTH SEASONS

Water Supply to Hospital Amadora Sintra

Data Processing - Month Seasons - Numeric Data Decomposition

Annexe 2

Years	Months	t_i (months)	Working Data (m^3/month)	Ma (m^3/month)	Cma (m^3/month)	Sn*Ir	Sn_{PR}	Sn	Sn	d (m^3/month)	Trend (m^3/month)	Tr*Sn (m^3/month)	CI*Ir	CI	Ir
2003	January	1	26697						0,9045	29517	30318	27423	0,9736		
	February	2	30155						0,9461	31874	30242	28612	1,0539	1,0058	1,0479
	March	3	27565						0,9231	29863	30166	27845	0,9899	1,0172	0,9732
	April	4	27732						0,9145	30325	30090	27517	1,0078	1,0002	1,0076
	May	5	30990						1,0295	30101	30014	30900	1,0029	1,0127	0,9904
	June	6	33910	30011					1,1026	30754	29938	33010	1,0273	1,0108	1,0162
	July	7	36153	29965	29988	1,2056	1,2070	1,2079	1,2079	29931	29862	36069	1,0023	1,0142	0,9883
	August	8	34192	29840	29902	1,1435	1,1322	1,1331	1,1331	30176	29786	33749	1,0131	1,0093	1,0038
	September	9	31810	29783	29812	1,0670	1,0566	1,0574	1,0574	30082	29709	31416	1,0125	1,0021	1,0104
	October	10	27857	29704	29744	0,9366	0,9579	0,9586	0,9586	29060	29633	28407	0,9806	0,9936	0,9870
	November	11	27232	29621	29662	0,9181	0,9322	0,9329	0,9329	29191	29557	27574	0,9876	0,9844	1,0033
	December	12	25838	29506	29563	0,8740	0,8892	0,8898	0,8898	29036	29481	26234	0,9849	0,9851	0,9998
2004	January	13	26140	29411	29459	0,8874	0,9038	0,9045	0,9045	28901	29405	26596	0,9829	1,0002	0,9827
	February	14	28657	29307	29359	0,9761	0,9454	0,9461	0,9461	30290	29329	27748	1,0328	1,0038	1,0289
	March	15	26889	29210	29258	0,9190	0,9224	0,9231	0,9231	29130	29253	27002	0,9958	1,0107	0,9852
	April	16	26779	29049	29129	0,9193	0,9138	0,9145	0,9145	29283	29177	26682	1,0036	1,0002	1,0035
	May	17	29990	28906	28978	1,0349	1,0288	1,0295	1,0295	29130	29101	29960	1,0010	1,0071	0,9940
	June	18	32534	28859	28883	1,1264	1,1018	1,1026	1,1026	29506	29024	32003	1,0166	1,0064	1,0102
	July	19	35018	28703	28781	1,2167			1,2079	28992	28948	34966	1,0015	1,0083	0,9933
	August	20	32937	28578	28641	1,1500			1,1331	29069	28872	32714	1,0068	1,0049	1,0019
	September	21	30648	28505	28542	1,0738			1,0574	28983	28796	30450	1,0065	0,9850	1,0219
	October	22	25923	28426	28466	0,9107			0,9586	27042	28720	27531	0,9416	0,9677	0,9730
	November	23	25521	28342	28384	0,8991			0,9329	27357	28644	26722	0,9551	0,9636	0,9911
	December	24	25272	28227	28284	0,8935			0,8898	28400	28568	25421	0,9941	0,9636	1,0317
2005	January	25	24268	28133	28180	0,8612			0,9045	26831	28492	25770	0,9417	0,9820	0,9589
	February	26	27159	28030	28081	0,9672			0,9461	28707	28416	26883	1,0103	0,9821	1,0286
	March	27	26013	27933	27981	0,9297			0,9231	28181	28339	26159	0,9944	1,0013	0,9931
	April	28	25828	27987	27960	0,9238			0,9145	28243	28263	25847	0,9993	0,9974	1,0018
	May	29	28980	28024	28005	1,0348			1,0295	28149	28187	29020	0,9986	1,0010	0,9976
	June	30	31158	27977	28000	1,1128			1,1026	28258	28111	30996	1,0052	1,0015	1,0037
	July	31	33883	28038	28007	1,2098			1,2079	28052	28035	33862	1,0006	1,0022	0,9984
	August	32	31701	27913	27975	1,1332			1,1331	27978	27959	31679	1,0007	1,0004	1,0002

Ma - Moving Average
Cma - Centered moving Average
SnPR - Row Seasonal Factor
Sn - Corrected Seasonal Factor d - Deseasonalized Data
Tr*Sn - Trend multiplied by Seasonal Factorb CI - Ciclic Component Ir - Irregular Component

Water Supply to Hospital Amadora Sintra

Data Processing - Month Seasons - Numeric Data Decomposition

Annexe 2

Years	Months	t_i (months)	Working Data (m^3/month)	Ma (m^3/month)	Cma (m^3/month)	Sn*Ir	Sn_{PR}	Sn	Sn	d (m^3/month)	Trend (m^3/month)	Tr*Sn (m^3/month)	Cl*Ir	Cl	Ir
2005	September	33	29485	27848	27881	1,0575			1,0574	27884	27883	29484	1,0000	0,9993	1,0008
	October	34	26578	27769	27808	0,9558			0,9586	27726	27807	26656	0,9971	1,0002	0,9969
	November	35	25959	27686	27727	0,9362			0,9329	27826	27731	25870	1,0034	1,0015	1,0019
	December	36	24707	27571	27629	0,8942			0,8898	27765	27654	24608	1,0040	1,0033	1,0007
2006	January	37	25003	27477	27524	0,9084			0,9045	27643	27578	24944	1,0024	0,9975	1,0048
	February	38	25660	27373	27425	0,9356			0,9461	27122	27502	26019	0,9862	0,9951	0,9910
	March	39	25236	27276	27325	0,9236			0,9231	27340	27426	25316	0,9968	0,9925	1,0044
	April	40	24874	27331	27303	0,9110			0,9145	27200	27350	25011	0,9945	0,9961	0,9984
	May	41	27990	27368	27349	1,0234			1,0295	27187	27274	28079	0,9968	0,9948	1,0020
	June	42	29781	27321	27344	1,0891			1,1026	27009	27198	29989	0,9931	0,9965	0,9965
	July	43	32748	27383	27352	1,1973			1,2079	27112	27122	32759	0,9997	0,9955	1,0042
	August	44	30456	27258	27320	1,1148			1,1331	26879	27045	30644	0,9939	0,9956	0,9983
	September	45	28323	27193	27225	1,0403			1,0574	26785	26969	28518	0,9932	1,0144	0,9790
	October	46	27231	27114	27153	1,0029			0,9586	28407	26893	25780	1,0563	1,0350	1,0206
	November	47	26405	27030	27072	0,9754			0,9329	28304	26817	25018	1,0554	1,0421	1,0128
	December	48	24140	26916	26973	0,8950			0,8898	27128	26741	23795	1,0145	1,0458	0,9700
2007	January	49	25747	26821	26868	0,9583			0,9045	28466	26665	24118	1,0675	1,0142	1,0526
	February	50	24161	26717	26769	0,9026			0,9461	25538	26589	25155	0,9605	1,0092	0,9518
	March	51	24460	26620	26668	0,9172			0,9231	26499	26513	24473	0,9995	0,9832	1,0166
	April	52	23922	26475	26547	0,9011			0,9145	26159	26437	24176	0,9895	0,9945	0,9950
	May	53	26990	26351	26413	1,0218			1,0295	26216	26360	27139	0,9945	0,9880	1,0066
	June	54	28404	26304	26328	1,0789			1.1026	25760	26284	28982	0,9801	0,9911	0,9889
	July	55	31614	26151	26227	1,2054			1,2079	26173	26208	31656	0,9987	0,9884	1,0104
	August	56	29210	26026	26089	1,1196			1.1331	25780	26132	29610	0,9865	0,9902	0.9963
	September	57	27150	25961	25994	1,0445			1.0574	25675	26056	27553	0,9854	0,9985	0.9868
	October	58	25495	25882	25922	0,9836			0,9586	26596	25980	24905	1,0237	1,0134	1,0102
	November	59	24920						0,9329	26712	25904	24166	1,0312	1,0269	1,0042
	December	60	23574						0,8898	26492	25828	22983	1,0257	1,0279	0,9979
2008	January	61	23913						0,9045	26438	25752	23292	1,0266	0,9951	1,0317
	February	62	22663						0,9461	23955	25675	24291	0,9330	0,9873	0,9450
	March	63	23683						0,9231	25657	25599	23630	1,0023	0,9731	1,0299
	April	64	22970						0,9145	25118	25523	23341	0,9841		

Ma - Moving Average
Cma - Centered moving Average
SnPR - Row Seasonal Factor
Sn - Corrected Seasonal Factor d - Deseasonalized Data
Tr*Sn - Trend multiplied by Seasonal Factorb Cl - Ciclic Component Ir - Irregular Component

WATER SUPPLY TO

PORTUGUESE REGIONAL HOSPITALS

ANNEXE 3

NUMERIC DECOMPOSITION OF WEEK SEASONS

Water Supply to Hospital Amadora Sintra

Data Processing - Week Seasons - Numeric Data Decomposition

Annexe 3

t_i (weeks)	Working Data (m^3/week)	Ma (m^3/week)	Cma (m^3/week)	Sn*Ir	Sn_{PR}	Sn	Sn	d (m^3/week)	Trend (m^3/week)	Tr*Sn	Cl*Ir	Cl	Ir
1	6273						0,9408	6668	6729	6330	0,9909		
2	6237						0,9572	6516	6726	6438	0,9688	0,9844	0,9842
3	6018						0,9011	6679	6723	6058	0,9934	0,9906	1,0028
4	6373						0,9392	6786	6721	6312	1,0097	1,0055	1,0041
5	6351						0,9328	6809	6718	6266	1,0135	1,0133	1,0002
6	6101						0,8934	6828	6715	6000	1,0169	1,0150	1,0018
7	5900						0,8662	6811	6712	5814	1,0147	1,0156	0,9992
8	6166						0,9052	6811	6710	6074	1,0151	1,0146	1,0005
9	5919						0,8704	6801	6707	5838	1,0139	1,0105	1,0034
10	6096						0,9070	6721	6704	6081	1,0025	0,9997	1,0028
11	6201						0,9415	6586	6702	6310	0,9827	0,9925	0,9902
12	6229						0,9372	6647	6699	6278	0,9922	0,9838	1,0086
13	6096						0,9324	6538	6696	6244	0,9764	0,9855	0,9908
14	5918						0,8949	6612	6694	5990	0,9879	0,9855	1,0024
15	6184						0,9316	6638	6691	6233	0,9921	0,9946	0,9975
16	6197						0,9232	6713	6688	6174	1,0037	0,9956	1,0082
17	6071						0,9164	6625	6685	6127	0,9909	1,0011	0,9898
18	6236						0,9251	6741	6683	6182	1,0086	1,0108	0,9979
19	6536						0,9473	6900	6680	6328	1,0329	1,0215	1,0111
20	7081						1,0367	6830	6677	6922	1,0229	1,0397	0,9838
21	7554						1,0643	7098	6675	7104	1,0634	1,0541	1,0089
22	7486						1,0428	7178	6672	6958	1,0759	1,0681	1,0073
23	7784						1,0960	7102	6669	7310	1,0649	1,0760	0,9897
24	7911						1,0915	7248	6667	7276	1,0872	1,0784	1,0082
25	7804						1,0813	7217	6664	7206	1,0831	1,0800	1,0028
26	8355	6694					1,1725	7126	6661	7810	1,0698	1,0566	1,0124
27	8018	6692	6693	1,1979	1,1813	1,1839	1,1839	6772	6658	7883	1,0171	1,0280	0,9894
28	8030	6690	6691	1,2002	1,2074	1,2101	1,2101	6636	6656	8054	0,9971	1,0009	0,9962
29	8153	6687	6688	1,2189	1,2367	1,2395	1,2395	6577	6653	8246	0,9886	1,0029	0,9858
30	8111	6677	6682	1,2139	1,1897	1,1923	1,1923	6803	6650	7929	1,0229	1,0011	1,0218
31	8074	6665	6671	1,2104	1,2219	1,2247	1,2247	6593	6648	8141	0,9918	1,0021	0,9897
32	7788	6652	6659	1,1696	1,1792	1,1819	1,1819	6589	6645	7854	0,9916	1,0022	0,9894
33	7444	6641	6647	1,1200	1,0928	1,0953	1,0953	6797	6642	7275	1,0233	1,0208	1,0024

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Tr*Sn - Trend multiplied by Seasonal Factor Cl - Ciclic Component Ir - Irregular Component

Water Supply to Hospital Amadora Sintra

Data Processing - Week Seasons - Numeric Data Decomposition

Annexe 3

t_i (weeks)	Working Data (m^3/week)	Ma (m^3/week)	Cma (m^3/week)	Sn*Ir	Sn_{PR}	Sn	Sn	d (m^3/week)	Trend (m^3/week)	Tr*Sn	Cl*Ir	Cl	Ir
34	7275	6630	6636	1,0964	1,0437	1,0460	1,0460	6955	6640	6945	1,0476	1,0081	1,0391
35	6996	6619	6624	1,0562	1,1031	1,1056	1,1056	6328	6637	7337	0,9535	1,0013	0,9523
36	6951	6613	6616	1,0507	1,0426	1,0449	1,0449	6653	6634	6932	1,0028	1,0012	1,0016
37	7791	6615	6614	1,1780	1,1193	1,1218	1,1218	6945	6631	7439	1,0473	1,0138	1,0331
38	7182	6613	6614	1,0859	1,0905	1,0930	1,0930	6571	6629	7245	0,9913	1,0282	0,9642
39	7660	6618	6616	1,1578	1,1029	1,1054	1,1054	6930	6626	7324	1,0458	0,9895	1,0569
40	6357	6619	6618	0,9605	1,0280	1,0304	1,0304	6170	6623	6824	0,9315	0,9882	0,9426
41	6026	6616	6617	0,9107	0,9198	0,9218	0,9218	6537	6621	6103	0,9874	0,9543	1,0347
42	5747	6613	6615	0,8689	0,9179	0,9200	0,9200	6247	6618	6088	0,9440	0,9562	0,9873
43	5683	6611	6612	0,8594	0,9146	0,9167	0,9167	6199	6615	6064	0,9371	0,9558	0,9804
44	6089	6608	6609	0,9213	0,9314	0,9335	0,9335	6523	6613	6173	0,9865	0,9722	1,0147
45	6225	6603	6605	0,9424	0,9462	0,9484	0,9484	6564	6610	6269	0,9930	0,9913	1,0018
46	5818	6599	6601	0,8813	0,8835	0,8855	0,8855	6570	6607	5851	0,9944	0,9886	1,0058
47	6252	6592	6596	0,9479	0,9653	0,9675	0,9675	6462	6604	6390	0,9784	0,9849	0,9934
48	6537	6585	6589	0,9922	1,0062	1,0085	1,0085	6482	6602	6658	0,9818	0,9721	1,0100
49	5889	6578	6582	0,8948	0,9314	0,9335	0,9335	6308	6599	6160	0,9560	0,9750	0,9805
50	5889	6570	6574	0,8958	0,9023	0,9043	0,9043	6512	6596	5965	0,9872	0,9747	1,0128
51	5937	6562	6566	0,9041	0,9157	0,9178	0,9178	6468	6594	6051	0,9810	0,9705	1,0108
52	5099	6555	6559	0,7774	0,8182	0,8200	0,8200	6218	6591	5405	0,9433	0,9723	0,9702
53	6151	6550	6552	0,9388	0,9386	0,9408	0,9408	6539	6588	6198	0,9925	0,9687	1,0245
54	6116	6547	6548	0,9340	0,9550	0,9572	0,9572	6390	6586	6303	0,9703	0,9859	0,9842
55	5902	6544	6546	0,9016	0,8991	0,9011	0,9011	6549	6583	5932	0,9949	0,9694	1,0264
56	5827	6539	6542	0,8907	0,9371	0,9392	0,9392	6204	6580	6180	0,9429	0,9572	0,9850
57	5730	6545	6542	0,8759	0,9307	0,9328	0,9328	6143	6577	6135	0,9339	0,9350	0,9988
58	5453	6552	6548	0,8328	0,8914	0,8934	0,8934	6104	6575	5874	0,9284	0,9328	0,9952
59	5330	6547	6549	0,8138	0,8642	0,8662	0,8662	6153	6572	5692	0,9363	0,9332	1,0033
60	5559	6541	6544	0,8495	0,9032	0,9052	0,9052	6141	6569	5947	0,9349	0,9362	0,9985
61	5359	6542	6542	0,8192	0,8685	0,8704	0,8704	6157	6567	5716	0,9376	0,9469	0,9901
62	5765	6535	6539	0,8817	0,9050	0,9070	0,9070	6356	6564	5954	0,9683	0,9761	0,9920
63	6316	6528	6531	0,9671	0,9394	0,9415	0,9415	6709	6561	6178	1,0225	0,9961	1,0265
64	6130	6535	6531	0,9386	0,9350	0,9372	0,9372	6541	6559	6146	0,9974	1,0211	0,9767
65	6379	6529	6532	0,9766	0,9303	0,9324	0,9324	6841	6556	6113	1,0435	1,0172	1,0259
66	5927	6531	6530	0,9077	0,8929	0,8949	0,8949	6623	6553	5865	1,0107	1,0160	0,9948
67	6063	6529	6530	0,9285	0,9295	0,9316	0,9316	6509	6550	6102	0.9937	1.0013	0,9924
68	6041	6531	6530	0,9251	0,9211	0,9232	0,9232	6544	6548	6045	0,9994	0.9949	1,0045

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Water Supply to Hospital Amadora Sintra
Data Processing - Week Seasons - Numeric Data Decomposition

Annexe 3

t_i (weeks)	Working Data (m^3/week)	Ma (m^3/week)	Cma (m^3/week)	Sn*Ir	Sn_{PR}	Sn	Sn	d (m^3/week)	Trend (m^3/week)	Tr*Sn	Cl*Ir	Cl	Ir
69	5948	6533	6532	0,9105	0,9143	0,9164	0,9164	6490	6545	5998	0,9916	0,9979	0,9937
70	6069	6531	6532	0,9290	0,9231	0,9251	0,9251	6560	6542	6052	1,0027	1,0040	0,9987
71	6304	6529	6530	0,9654	0,9451	0,9473	0,9473	6655	6540	6195	1,0177	1,0107	1,0070
72	6855	6520	6525	1,0506	1,0344	1,0367	1,0367	6613	6537	6777	1,0116	1,0220	0,9898
73	7209	6519	6520	1,1057	1,0619	1,0643	1,0643	6774	6534	6954	1,0367	1,0309	1,0056
74	7114	6518	6519	1,0913	1,0405	1,0428	1,0428	6822	6532	6811	1,0444	1,0396	1,0046
75	7426	6519	6518	1,1393	1,0935	1,0960	1,0960	6776	6529	7156	1,0378	1,0447	0,9934
76	7492	6517	6518	1,1495	1,0890	1,0915	1,0915	6864	6526	7123	1,0518	1,0463	1,0053
77	7401	6515	6516	1,1358	1,0789	1,0813	1,0813	6845	6523	7054	1,0492	1,0474	1,0017
78	7961	6517	6516	1,2217	1,1699	1,1725	1,1725	6790	6521	7646	1,0413	1,0326	1,0083
79	7774	6519	6518	1,1927			1,1839	6566	6518	7717	1,0074	1,0152	0,9923
80	7860	6523	6521	1,2053			1,2101	6496	6515	7884	0,9970	0,9990	0,9980
81	8012	6513	6518	1,2293			1,2395	6464	6513	8072	0,9925	1,0000	0,9925
82	7844	6514	6513	1,2043			1,1923	6579	6510	7762	1,0106	1,0189	0,9919
83	8395	6516	6515	1,2885			1,2247	6855	6507	7969	1,0534	1,0401	1,0128
84	8120	6519	6518	1,2459			1,1819	6871	6505	7688	1,0563	1,0403	1,0154
85	7201	6520	6520	1,1045			1,0953	6575	6502	7121	1,0112	1,0305	0,9813
86	6962	6522	6521	1,0675			1,0460	6655	6499	6798	1,0241	1,0069	1,0170
87	7077	6524	6523	1,0849			1,1056	6402	6496	7182	0,9854	0,9914	0,9940
88	6546	6523	6524	1,0034			1,0449	6264	6494	6785	0,9647	0,9907	0,9737
89	7442	6519	6521	1,1412			1,1218	6634	6491	7282	1,0220	1,0166	1,0053
90	7539	6516	6517	1,1568			1,0930	6898	6488	7091	1,0631	1,0361	1,0260
91	7336	6509	6512	1,1265			1,1054	6637	6486	7169	1,0233	1,0195	1,0037
92	6494	6505	6507	0,9979			1,0304	6302	6483	6680	0,9721	0,9961	0,9760
93	5930	6509	6507	0,9114			0,9218	6433	6480	5974	0,9928	0,9823	1,0107
94	5851	6506	6508	0,8992			0,9200	6361	6478	5959	0,9819	0,9830	0,9990
95	5782	6504	6505	0,8889			0,9167	6308	6475	5935	0,9742	0,9828	0,9913
96	5995	6500	6502	0,9220			0,9335	6422	6472	6042	0,9923	0,9874	1,0050
97	6109	6496	6498	0,9400			0,9484	6441	6469	6135	0,9956	0,9743	1,0219
98	5354	6492	6494	0,8245			0,8855	6046	6467	5726	0,9350	0,9740	0,9600
99	6200	6485	6488	0,9555			0,9675	6408	6464	6254	0,9913	0,9728	1,0190
100	6465	6478	6481	0,9975			1,0085	6410	6461	6516	0,9921	0,9887	1,0035
101	5924	6471	6474	0,9150			0,9335	6346	6459	6029	0,9826	0,9893	0,9932
102	5798	6463	6467	0,8966			0,9043	6411	6456	5838	0,9931	0,9887	1,0045

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Water Supply to Hospital Amadora Sintra

Data Processing - Week Seasons - Numeric Data Decomposition

Annexe 3

t_i (weeks)	Working Data (m^3/week)	Ma (m^3/week)	Cma (m^3/week)	Sn*Ir	Sn_{PR}	Sn	Sn	d (m^3/week)	Trend (m^3/week)	Tr*Sn	Cl*Ir	Cl	Ir
103	5866	6455	6459	0,9081			0,9178	6391	6453	5922	0,9904	0,9867	1,0037
104	5166	6448	6451	0,8007			0,8200	6299	6451	5290	0,9766	1,0006	0,9760
105	6277	6443	6445	0,9738			0,9408	6672	6448	6066	1,0347	1,0117	1,0228
106	6315	6440	6441	0,9804			0,9572	6598	6445	6169	1,0237	0,9945	1,0293
107	5371	6437	6438	0,8342			0,9011	5960	6442	5805	0,9252	0,9749	0,9490
108	5902	6432	6434	0,9172			0,9392	6284	6440	6048	0,9758	0,9578	1,0188
109	5839	6420	6426	0,9087			0,9328	6260	6437	6004	0,9725	0,9729	0,9995
110	5579	6409	6415	0,8698			0,8934	6244	6434	5749	0,9705	0,9720	0,9984
111	5421	6404	6407	0,8462			0,8662	6259	6432	5571	0,9732	0,9720	1,0012
112	5659	6398	6401	0,8840			0,9052	6251	6429	5819	0,9724	0,9729	0,9994
113	5444	6400	6399	0,8508			0,8704	6254	6426	5594	0,9733	0,9766	0,9966
114	5734	6403	6401	0,8958			0,9070	6322	6424	5826	0,9842	0,9869	0,9973
115	6065	6396	6399	0,9477			0,9415	6441	6421	6045	1,0032	0,9938	1,0094
116	5979	6385	6390	0,9357			0,9372	6380	6418	6015	0,9941	1,0025	0,9916
117	6043	6379	6382	0,9469			0,9324	6481	6415	5982	1,0102	1,0010	1,0092
118	5731	6381	6380	0,8983			0,8949	6404	6413	5739	0,9986	1,0184	0,9805
119	6249	6379	6380	0,9795			0,9316	6708	6410	5971	1,0465	1,0133	1,0328
120	5885	6381	6380	0,9223			0,9232	6375	6407	5915	0,9949	1,0113	0,9838
121	5825	6383	6382	0,9126			0,9164	6356	6405	5869	0,9924	0,9946	0,9978
122	5902	6381	6382	0,9247			0,9251	6379	6402	5923	0,9965	0,9969	0,9996
123	6073	6379	6380	0,9518			0,9473	6411	6399	6062	1,0019	0,9994	1,0025
124	6630	6384	6381	1,0389			1,0367	6395	6397	6631	0,9998	1,0035	0,9963
125	6864	6383	6383	1,0754			1,0643	6450	6394	6805	1,0087	1,0067	1,0020
126	6743	6381	6382	1,0565			1,0428	6466	6391	6665	1,0117	1,0100	1,0016
127	7069	6382	6382	1,1077			1,0960	6450	6388	7002	1,0096	1,0120	0,9977
128	7072	6380	6381	1,1083			1,0915	6479	6386	6970	1,0147	1,0127	1,0019
129	6998	6379	6380	1,0969			1,0813	6472	6383	6902	1,0139	1,0134	1,0005
130	7568	6380	6379	1,1863			1,1725	6455	6380	7481	1,0116	1,0076	1,0040
131	7531	6373	6377	1,1810			1,1839	6361	6378	7551	0,9973	1,0019	0,9954
132	7690	6365	6369	1,2074			1,2101	6355	6375	7714	0,9968	0,9969	0,9999
133	7872	6370	6367	1,2363			1,2395	6351	6372	7898	0,9966	0,9971	0,9996
134	7577	6371	6370	1,1894			1,1923	6355	6370	7595	0.9977	0.9980	0,9997
135	7795	6373	6372	1,2233			1,2247	6365	6367	7797	0,9997	0.9992	1,0004
136	7525	6376	6374	1,1804			1,1819	6367	6364	7522	1.0004	0.9996	1,0008
137	6958	6377	6376	1,0912			1,0953	6353	6361	6968	0,9986	0.9995	0,9991
138	6648	6379	6378	1.0423			1.0460	6356	6359	6651	0.9995	1.0056	0.9939

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Water Supply to Hospital Amadora Sintra

Data Processing - Week Seasons - Numeric Data Decomposition

Annexe 3

t_i (weeks)	Working Data (m^3/week)	Ma (m^3/week)	Cma (m^3/week)	Sn*Ir	Sn_{PR}	Sn	Sn	d (m^3/week)	Trend (m^3/week)	Tr*Sn	Cl*Ir	Cl	Ir
139	7158	6381	6380	1,1220			1,1056	6475	6356	7027	1,0187	1,0092	1,0094
140	6701	6380	6381	1,0502			1,0449	6413	6353	6639	1,0094	1,0079	1,0015
141	7093	6375	6378	1,1120			1,1218	6322	6351	7124	0,9956	1,0025	0,9931
142	6956	6373	6374	1,0913			1,0930	6364	6348	6938	1,0026	0,9993	1,0033
143	7013	6366	6369	1,1010			1,1054	6344	6345	7014	0,9998	1,0057	0,9942
144	6631	6362	6364	1,0418			1,0304	6435	6343	6535	1,0146	1,0043	1,0103
145	5835	6354	6358	0,9177			0,9218	6329	6340	5844	0,9983	1,0115	0,9870
146	5956	6351	6352	0,9376			0,9200	6474	6337	5830	1,0216	1,0110	1,0105
147	5882	6348	6349	0,9264			0,9167	6417	6334	5807	1,0130	1,0110	1,0020
148	5901	6345	6347	0,9298			0,9335	6321	6332	5911	0,9983	1,0032	0,9951
149	5992	6341	6343	0,9447			0,9484	6318	6329	6002	0,9983	0,9980	1,0003
150	5587	6336	6338	0,8815			0,8855	6310	6326	5602	0,9974	1,0002	0,9972
151	6148	6330	6333	0,9707			0,9675	6354	6324	6118	1,0048	1,0017	1,0031
152	6393	6323	6326	1,0106			1,0085	6339	6321	6375	1,0029	1,0060	0,9969
153	5959	6316	6319	0,9430			0,9335	6383	6318	5898	1,0103	1,0041	1,0062
154	5707	6308	6312	0,9042			0,9043	6311	6316	5711	0,9993	1,0033	0,9960
155	5795	6300	6304	0,9192			0,9178	6314	6313	5794	1,0002	1,0036	0,9966
156	5233	6292	6296	0,8312			0,8200	6381	6310	5174	1,0113	1,0023	1,0090
157	5907	6287	6290	0,9391			0,9408	6279	6307	5934	0,9954	0,9934	1,0020
158	5875	6284	6286	0,9346			0,9572	6138	6305	6035	0,9735	0,9871	0,9862
159	5636	6281	6283	0,8971			0,9011	6255	6302	5679	0,9925	0,9920	1,0004
160	5976	6276	6279	0,9518			0,9392	6363	6299	5916	1,0102	1,0051	1,0050
161	5948	6265	6270	0,9487			0,9328	6377	6297	5874	1,0128	1,0125	1,0003
162	5705	6253	6259	0,9114			0,8934	6385	6294	5623	1,0145	1,0130	1,0015
163	5513	6249	6251	0,8819			0,8662	6365	6291	5449	1,0117	1,0126	0,9991
164	5758	6243	6246	0,9220			0,9052	6361	6289	5692	1,0116	1,0113	1,0003
165	5529	6239	6241	0,8860			0,8704	6352	6286	5471	1,0106	1,0077	1,0029
166	5704	6236	6238	0,9144			0,9070	6289	6283	5699	1,0009	0,9981	1,0027
167	5813	6233	6234	0,9324			0,9415	6174	6280	5913	0,9830	0,9915	0,9914
168	5828	6221	6227	0,9360			0,9372	6219	6278	5883	0,9907	0,9830	1,0078
169	5707	6215	6218	0,9178			0,9324	6121	6275	5851	0,9754	0,9840	0,9913
170	5534	6218	6216	0,8903			0,8949	6184	6272	5613	0,9859	0,9846	1,0013
171	5797	6216	6217	0,9325			0,9316	6223	6270	5841	0,9926	0,9896	1,0030
172	5729	6213	6215	0,9218			0,9232	6206	6267	5785	0,9902	0,9920	0,9982
173	5702	6215	6214	0,9175			0,9164	6222	6264	5741	0,9932	0,9911	1,0021
174	5735	6213	6214	0,9228			0,9251	6199	6261	5793	0,9900	0,9895	1,0005

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Sn - Corrected Seasonal Factor d - Deseasonalized Data
Tr*Sn - Trend multiplied by Seasonal Factor Cl - Ciclic Component Ir - Irregular Component

Water Supply to Hospital Amadora Sintra
Data Processing - Week Seasons - Numeric Data Decomposition

Annexe 3

t_i (weeks)	Working Data (m^3/week)	Ma (m^3/week)	Cma (m^3/week)	Sn*Ir	Sn_{PR}	Sn	Sn	d (m^3/week)	Trend (m^3/week)	Tr*Sn	Cl*Ir	Cl	Ir
175	5842	6211	6212	0,9403			0,9473	6167	6259	5929	0,9853	0,9876	0,9977
176	6404	6216	6213	1,0306			1,0367	6177	6256	6486	0,9874	0,9841	1,0033
177	6519	6215	6215	1,0489			1,0643	6126	6253	6655	0,9796	0,9815	0,9981
178	6371	6213	6214	1,0253			1,0428	6109	6251	6518	0,9774	0,9790	0,9984
179	6711	6214	6214	1,0800			1,0960	6123	6248	6848	0,9800	0,9778	1,0023
180	6653	6212	6213	1,0708			1,0915	6096	6245	6816	0,9760	0,9777	0,9983
181	6595	6211	6212	1,0617			1,0813	6099	6243	6750	0,9770	0,9774	0,9996
182	7164	6212	6212	1,1533			1,1725	6110	6240	7316	0,9792	0,9810	0,9981
183	7287	6205	6209	1,1737			1,1839	6155	6237	7384	0,9868	0,9876	0,9992
184	7519	6207	6206	1,2117			1,2101	6214	6234	7544	0,9967	0,9948	1,0019
185	7731	6212	6209	1,2452			1,2395	6238	6232	7724	1,0009	0,9939	1,0070
186	7310	6213	6212	1,1767			1,1923	6131	6229	7427	0,9842	0,9762	1,0082
187	7194	6215	6214	1,1577			1,2247	5874	6226	7625	0,9435	0,9565	0,9863
188	6929	6218	6216	1,1146			1,1819	5862	6224	7356	0,9419	0,9570	0,9843
189	6715	6219	6218	1,0798			1,0953	6131	6221	6814	0,9855	0,9671	1,0190
190	6334	6221	6220	1,0183			1,0460	6056	6218	6504	0,9738	0,9921	0,9816
191	6988	6223	6222	1,1231			1,1056	6321	6216	6872	1,0170	0,9995	1,0174
192	6543	6222	6223	1,0514			1,0449	6261	6213	6492	1,0078	1,0051	1,0026
193	6902	6217	6220	1,1096			1,1218	6152	6210	6967	0,9907	0,9793	1,0117
194	6373	6215	6216	1,0253			1,0930	5831	6207	6785	0,9393	0,9684	0,9700
195	6689	6208	6211	1,0769			1,1054	6051	6205	6859	0,9753	0,9912	0,9839
196	6767	6204	6206	1,0904			1,0304	6568	6202	6390	1,0590	1,0128	1,0456
197	5739	6196	6200	0,9256			0,9218	6225	6199	5715	1,0042	1,0283	0,9765
198	5825	6193	6194	0,9404			0,9200	6332	6197	5701	1,0218	1,0265	0,9954
199	5982	6190	6191	0,9662			0,9167	6526	6194	5678	1,0535	1,0267	1,0262
200	5807	6187	6189	0,9383			0,9335	6220	6191	5780	1,0046	1,0198	0,9852
201	5876	6183	6185	0,9500			0,9484	6195	6189	5869	1,0011	1,0228	0,9788
202	5821	6178	6180	0,9418			0,8855	6573	6186	5478	1,0626	1,0276	1,0341
203	6096	6172	6175	0,9872			0,9675	6300	6183	5982	1,0190	1,0319	0,9875
204	6321	6165	6168	1,0248			1,0085	6268	6180	6233	1,0141	1,0241	0,9902
205	5994	6158	6161	0,9729			0,9335	6421	6178	5767	1,0394	1,0197	1,0193
206	5616	6150	6154	0,9126			0,9043	6210	6175	5584	1,0057	1,0185	0,9874
207	5724	6142	6146	0,9313			0,9178	6237	6172	5665	1,0104	1,0212	0,9894
208	5300	6134	6138	0,8635			0,8200	6463	6170	5059	1,0476	1,0041	1,0433
209	5537	6130	6132	0,9029			0,9408	5885	6167	5802	0,9543	1,0035	0,9510
210	5951	6126	6128	0,9711			0,9572	6217	6164	5900	1,0086	1,0086	1,0000

Ma - Moving Average
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SnPR - Row Seasonal Factor
Sn - Corrected Seasonal Factor d - Deseasonalized Data
Tr*Sn - Trend multiplied by Seasonal Factor Cl - Ciclic Component Ir - Irregular Component

Water Supply to Hospital Amadora Sintra
Data Processing - Week Seasons - Numeric Data Decomposition

Annexe 3

t_i (weeks)	Working Data (m^3/week)	Ma (m^3/week)	Cma (m^3/week)	Sn*Ir	Sn_{PR}	Sn	Sn	d (m^3/week)	Trend (m^3/week)	Tr*Sn	Cl*Ir	Cl	Ir
211	5901	6124	6125	0,9635			0,9011	6549	6162	5552	1,0629	1,0392	1,0228
212	6051	6119	6121	0,9885			0,9392	6443	6159	5784	1,0461	1,0546	0,9919
213	6058	6123	6121	0,9897			0,9328	6494	6156	5743	1,0549	1,0538	1,0010
214	5830	6128	6126	0,9518			0,8934	6526	6153	5498	1,0605	1,0558	1,0044
215	5605	6124	6126	0,9149			0,8662	6471	6151	5328	1,0520	1,0550	0,9971
216	5858	6117	6121	0,9571			0,9052	6472	6148	5565	1,0526	1,0514	1,0012
217	5614	6115	6116	0,9180			0,8704	6450	6145	5349	1,0496	1,0401	1,0091
218	5673	6112	6113	0,9280			0,9070	6255	6143	5571	1,0183	1,0099	1,0083
219	5561	6102	6107	0,9105			0,9415	5906	6140	5781	0,9619	0,9891	0,9725
220	5677	6107	6105	0,9300			0,9372	6058	6137	5752	0,9871	0,9627	1,0253
221	5371	6101	6104	0,8800			0,9324	5761	6135	5720	0,9390	0,9662	0,9718
222	5338	6093	6097	0,8755			0,8949	5964	6132	5488	0,9727	0,9493	1,0246
223	5345	6091	6092	0,8774			0,9316	5738	6129	5710	0,9361	0,9647	0,9704
224	5573	6088	6090	0,9151			0,9232	6036	6126	5656	0,9853	0,9718	1,0139
225	5578	6082	6085	0,9167			0,9164	6087	6124	5612	0,9941	0,9875	1,0066
226	5568	6080	6081	0,9156			0,9251	6018	6121	5663	0,9832	0,9818	1,0015
227	5610	6078	6079	0,9229			0,9473	5923	6118	5796	0,9680	0,9752	0,9926
228	6178	6069	6073	1,0173			1,0367	5960	6116	6340	0,9745	0,9639	1,0110
229	6174	6068	6068	1,0175			1,0643	5802	6113	6506	0,9491	0,9550	0,9938
230	6000	6066	6067	0,9888			1,0428	5753	6110	6372	0,9415	0,9466	0,9947
231	6353	6067	6067	1,0472			1,0960	5796	6108	6694	0,9491	0,9420	1,0075
232	6233	6065	6066	1,0275			1,0915	5711	6105	6663	0,9354	0,9410	0,9941
233	6192	6064	6065	1,0210			1,0813	5726	6102	6598	0,9384	0,9407	0,9976
234	6781	6065	6065	1,1181			1,1725	5783	6099	7152	0,9482	0,9541	0,9938
235	7043	6068	6067	1,1610			1,1839	5949	6097	7218	0,9758	0,9735	1,0023
236	7349	6058	6063	1,2121			1,2101	6073	6094	7374	0,9966	0,9926	1,0040
237	7591	6049	6054	1,2539			1,2395	6124	6091	7550	1,0054	0,9907	1,0148
238	7043	6051	6050	1,1640			1,1923	5907	6089	7260	0,9701	0,9913	0,9786
239	7442	6053	6052	1,2297			1,2247	6077	6086	7453	0,9985	0,9890	1,0096
240	7178	6055	6054	1,1856			1,1819	6073	6083	7190	0,9984	0,9895	1,0089
241	6472	6057	6056	1,0686			1,0953	5909	6081	6660	0,9717	0,9724	0,9993
242	6021	6059	6058	0,9938			1,0460	5756	6078	6358	0.9470	0.9792	0,9671
243	6843	6061	6060	1,1292			1,1056	6189	6075	6716	1,0188	0,9918	1,0272
244	6406	6060	6060	1.0571			1.0449	6131	6072	6345	1.0096	0.9892	1.0207
245	6394	6055	6058	1,0555			1,1218	5700	6070	6809	0,9390	0,9823	0,9560
246	6618	6052	6054	1,0933			1,0930	6056	6067	6631	0.9981	0.9622	1,0373

Ma - Moving Average
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SnPR - Row Seasonal Factor
Sn - Corrected Seasonal Factor d - Deseasonalized Data
Tr*Sn - Trend multiplied by Seasonal Factor Cl - Ciclic Component Ir - Irregular Component

Water Supply to Hospital Amadora Sintra
Data Processing - Week Seasons - Numeric Data Decomposition

Annexe 3

t_i (weeks)	Working Data (m^3/week)	Ma (m^3/week)	Cma (m^3/week)	Sn*Ir	Sn_{PR}	Sn	Sn	d (m^3/week)	Trend (m^3/week)	Tr*Sn	CI*Ir	CI	Ir
247	6365	6046	6049	1,0523			1,1054	5759	6064	6703	0,9496	0,9878	0,9613
248	6344	6042	6044	1,0496			1,0304	6157	6062	6246	1,0157	0,9919	1,0241
249	5643	6047	6044	0,9335			0,9218	6121	6059	5585	1,0103	1,0165	0,9938
250	5703	6044	6045	0,9435			0,9200	6200	6056	5572	1,0237	1,0163	1,0072
251	5633	6041	6043	0,9323			0,9167	6145	6054	5549	1,0151	1,0167	0,9985
252	5712	6038	6040	0,9458			0,9335	6119	6051	5649	1,0113	1,0101	1,0011
253	5759	6034	6036	0,9541			0,9484	6072	6048	5736	1,0040	1,0055	0,9985
254	5360	6031	6032	0,8885			0,8855	6053	6045	5353	1,0012	1,0130	0,9884
255	6044						0,9675	6247	6043	5846	1,0337	1,0203	1,0132
256	6249						1,0085	6196	6040	6091	1,0259	1,0431	0,9835
257	6029						0,9335	6458	6037	5636	1,0697	1,0360	1,0326
258	5525						0,9043	6110	6035	5457	1,0124	1,0344	0,9787
259	5653						0,9178	6159	6032	5536	1,0211	1,0397	0,9821
260	5367						0,8200	6545	6029	4944	1,0856	1,0353	1,0485
261	5666						0,9408	6023	6027	5670	0,9993	1,0108	0,9886
262	5463						0,9572	5708	6024	5766	0,9475	0,9829	0,9640
263	5436						0,9011	6032	6021	5426	1,0018	1,0110	0,9909
264	6126						0,9392	6522	6018	5652	1,0837	1,0615	1,0209
265	6167						0,9328	6611	6016	5612	1,0990	1,0971	1,0017
266	5956						0,8934	6666	6013	5372	1,1086	1,1006	1,0073
267	5696						0,8662	6576	6010	5206	1,0942	1,0995	0,9952
268	5958						0,9052	6582	6008	5438	1,0955	1,0934	1,0020
269	5699						0,8704	6548	6005	5227	1,0904	1,0741	1,0151
270	5643						0,9070	6221	6002	5444	1,0365	1,0222	1,0139
271	5309						0,9415	5638	6000	5649	0,9398	0,9865	0,9526
272	5526						0,9372	5897	5997	5620	0,9833	0,9414	1,0446
273	5035						0,9324	5400	5994	5589	0,9009	0,9477	0,9507
274	5141						0,8949	5745	5991	5362	0,9588	0,9534	1,0056
275	5582						0,9316	5992	5989	5579	1,0006	0,9799	1,0212
276	5416						0,9232	5867	5986	5526	0,9802	0,9919	0,9882
277	5455						0,9164	5953	5983	5483	0,9949	0,9837	1,0114
278	5401						0,9251	5838	5981	5533	0,9761	0,9737	1,0025
279	5379						0,9473	5679	5978	5663	0,9499		

Ma - Moving Average
Cma - Centered moving Average
SnPR - Row Seasonal Factor
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Tr*Sn - Trend multiplied by Seasonal Factor CI - Ciclic Component Ir - Irregular Component

WATER SUPPLY TO

PORTUGUESE REGIONAL HOSPITALS

ANNEXE 4

NUMERIC ANALYSIS FOR YEAR PERIODS AND DAY SEASONS

Annexe 4

Water Supply to Hospital Amadora Sintra

Numeric Analisys for year periods and day seasons

2003

Year Period Daily Average = 912
Minimum ratio =0,4053
Maximum ratio =1,6608

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1	535	0,5865
2	703	0,7709
3	830	0,9105
4	812	0,8908
5	777	0,8523
6	771	0,8452
7	758	0,8312
8	707	0,7749
9	655	0,7188
10	797	0,8741
11	771	0,8459
12	608	0,6663
13	710	0,7783
14	745	0,8173
15	679	0,7447
16	694	0,7611
17	694	0,7611
18	810	0,8889
19	648	0,7106
20	729	0,7994
21	696	0,7637
22	781	0,8566
23	762	0,8359
24	801	0,8780
25	815	0,8942
26	819	0.8987
27	670	0,7344
28	753	0.8263
29	753	0,8264
30	819	0,8987
31	795	0.8721
32	674	0.7393
33	547	0,5998
34	851	0,9337
35	775	0,8500

2004

Year Period Daily Average = 944
Minimum ratio =0,2181
Maximum ratio =1,7358

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
366	306	0,3245
367	362	0,3841
368	854	0,9047
369	743	0,7870
370	777	0,8235
371	1024	1,0854
372	813	0,8617
373	849	0,8993
374	254	0,2691
375	757	0,8024
376	615	0,6522
377	438	0,4639
378	829	0,8790
379	753	0,7976
380	639	0,6777
381	328	0,3481
382	531	0,5626
383	662	0,7021
384	563	0,5967
385	787	0,8339
386	649	0,6879
387	833	0.8827
388	726	0,7699
389	696	0,7381
390	652	0,6913
391	833	0,8824
392	738	0.7825
393	747	0,7917
394	918	0.9728
395	815	0.8634
396	740	0,7843
397	587	0,6218
398	742	0,7859
399	789	0.8365
400	880	0.9329

2005

Year Period Daily Average = 944
Minimum ratio =0,2349
Maximum ratio =2,3802

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
732	685	0,7252
733	794	0,8406
734	913	0,9672
735	1007	1,0666
736	990	1,0491
737	1004	1,0639
738	994	1,0525
739	784	0,8306
740	663	0,7021
741	1038	1,0993
742	1001	1,0608
743	1001	1,0601
744	907	0,9604
745	1004	1,0631
746	834	0,8833
747	724	0,7668
748	1020	1,0801
749	881	0,9336
750	1033	1,0939
751	1033	1,0937
752	891	0,9441
753	1073	1,1365
754	778	0,8240
755	983	1,0413
756	752	0,7964
757	980	1,0384
758	895	0,9478
759	1004	1,0635
760	843	0.8927
761	737	0.7809
762	969	1,0259
763	719	0.7614
764	898	0.9510
765	862	0,9128
766	875	0,9271

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

2003

Year Period Daily Average = 912
Minimum ratio =0,4053
Maximum ratio =1,6608

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
36	781	0,8565
37	800	0,8777
38	795	0,8716
39	682	0,7481
40	595	0,6531
41	790	0,8662
42	757	0,8298
43	761	0,8351
44	742	0,8139
45	789	0,8656
46	590	0,6473
47	538	0,5897
48	772	0,8463
49	813	0,8919
50	799	0,8760
51	769	0,8439
52	787	0,8637
53	697	0,7649
54	675	0,7403
55	867	0,9514
56	871	0,9550
57	692	0,7584
58	679	0,7448
59	916	1,0046
60	681	0,7467
61	609	0,6683
62	774	0,8490
63	616	0,6753
64	871	0,9550
65	859	0,9424
66	896	0,9831
67	728	0,7985
68	641	0,7028
69	848	0,9305
70	909	0,9965
71	888	0,9744
72	846	0,9282
73	981	1,0763
74	959	1,0517

2004

Year Period Daily Average = 944
Minimum ratio =0,2181
Maximum ratio =1,7358

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
401	745	0,7896
402	740	0,7841
403	689	0,7297
404	562	0,5953
405	745	0,7894
406	801	0,8494
407	859	0,9101
408	895	0,9481
409	715	0,7581
410	689	0,7304
411	553	0,5863
412	828	0,8777
413	943	0,9991
414	896	0,9490
415	722	0,7652
416	748	0,7928
417	692	0,7336
418	563	0,5964
419	721	0,7644
420	572	0,6066
421	722	0,7648
422	756	0,8016
423	776	0,8225
424	671	0,7107
425	596	0.6314
426	874	0.9257
427	969	1.0271
428	848	0.8987
429	985	1.0437
430	857	0.9079
431	810	0.8587
432	730	0.7732
433	1027	1.0889
434	1065	1.1285
435	1014	1.0747
436	973	1.0311
437	985	1.0440
438	901	0.9545
439	838	0.8883

2005

Year Period Daily Average = 944
Minimum ratio =0,2349
Maximum ratio =2,3802

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
767	735	0,7783
768	794	0,8411
769	885	0,9369
770	723	0,7661
771	870	0,9211
772	828	0,8767
773	873	0,9243
774	858	0,9089
775	859	0,9100
776	816	0,8639
777	765	0,8104
778	835	0,8840
779	1014	1,0742
780	873	0,9242
781	778	0,8242
782	901	0,9540
783	810	0,8583
784	791	0,8380
785	820	0,8682
786	801	0,8482
787	807	0,8544
788	739	0,7831
789	882	0,9337
790	762	0,8071
791	840	0,8894
792	823	0,8716
793	959	1.0159
794	797	0.8438
795	808	0.8556
796	881	0.9327
797	827	0.8764
798	780	0.8258
799	981	1.0392
800	1012	1.0717
801	845	0.8947
802	813	0.8613
803	890	0.9423
804	924	0.9789
805	837	0.8863

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

2003

Year Period Daily Average = 912
Minimum ratio =0,4053
Maximum ratio =1,6608

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
75	633	0,6943
76	865	0,9485
77	839	0,9205
78	896	0,9830
79	903	0,9902
80	885	0,9703
81	729	0,8001
82	672	0,7368
83	989	1,0847
84	1075	1,1786
85	943	1,0344
86	1119	1,2275
87	1150	1,2617
88	880	0,9646
89	649	0,7118
90	1090	1,1955
91	971	1,0647
92	807	0,8853
93	879	0,9637
94	890	0,9767
95	799	0,8768
96	645	0,7079
97	966	1,0594
98	1229	1,3478
99	1144	1,2549
100	1078	1,1821
101	1225	1,3439
102	886	0,9718
103	861	0,9442
104	1214	1,3314
105	824	0,9039
106	748	0,8200
107	875	0,9597
108	669	0,7335
109	653	0,7163
110	577	0,6330
111	936	1,0261
112	898	0,9851
113	831	0,9109

2004

Year Period Daily Average = 944
Minimum ratio =0,2181
Maximum ratio =1,7358

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
440	1047	1,1091
441	1026	1,0876
442	1014	1,0745
443	1015	1,0760
444	937	0,9935
445	881	0,9342
446	800	0,8476
447	1023	1,0839
448	1085	1,1500
449	1053	1,1162
450	206	0,2181
451	1078	1,1428
452	795	0,8425
453	823	0,8722
454	966	1,0234
455	463	0,4903
456	658	0,6974
457	905	0,9593
458	1068	1,1318
459	769	0,8149
460	808	0,8564
461	1001	1,0606
462	1082	1,1471
463	1136	1,2044
464	897	0,9510
465	798	0,8458
466	772	0,8187
467	797	0,8450
468	930	0,9855
469	1132	1,2000
470	1147	1,2160
471	1120	1.1868
472	1011	1.0711
473	803	0.8511
474	769	0.8152
475	1015	1.0757
476	977	1.0349
477	955	1.0121
478	979	1.0379

2005

Year Period Daily Average = 944
Minimum ratio =0,2349
Maximum ratio =2,3802

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
806	993	1,0513
807	914	0,9683
808	815	0,8629
809	815	0,8631
810	949	1,0056
811	849	0,8997
812	864	0,9156
813	870	0,9210
814	1009	1,0687
815	848	0,8979
816	445	0,4711
817	979	1,0367
818	795	0,8425
819	890	0,9432
820	723	0,7657
821	742	0,7857
822	904	0,9574
823	937	0,9930
824	879	0,9314
825	930	0,9849
826	932	0,9872
827	1084	1,1477
828	1086	1,1501
829	872	0,9238
830	772	0,8174
831	912	0,9663
832	904	0,9571
833	941	0.9970
834	1081	1.1446
835	991	1.0498
836	1000	1.0588
837	912	0.9661
838	873	0.9243
839	880	0.9316
840	1064	1.1267
841	993	1.0514
842	925	0.9798
843	932	0.9873
844	902	0.9550

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

2003

Year Period Daily Average = 912
Minimum ratio =0,4053
Maximum ratio =1,6608

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
114	1060	1,1621
115	683	0,7493
116	674	0,7394
117	506	0,5549
118	819	0,8986
119	867	0,9504
120	881	0,9668
121	709	0,7781
122	960	1,0524
123	624	0,6839
124	641	0,7030
125	924	1,0132
126	872	0,9560
127	969	1,0630
128	1110	1,2177
129	1011	1,1083
130	734	0,8049
131	639	0,7005
132	904	0,9912
133	923	1,0122
134	1194	1,3091
135	1060	1,1625
136	1241	1,3610
137	931	1,0208
138	673	0,7376
139	1157	1,2692
140	954	1,0465
141	1157	1,2687
142	1258	1,3797
143	1253	1,3740
144	873	0,9576
145	667	0,7319
146	1386	1,5198
147	1334	1,4635
148	1253	1,3740
149	1037	1,1368
150	960	1,0532
151	1002	1,0984
152	649	0,7120

2004

Year Period Daily Average = 944
Minimum ratio =0,2181
Maximum ratio =1,7358

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
479	929	0,9847
480	889	0,9425
481	822	0,8708
482	1010	1,0709
483	1130	1,1973
484	1347	1,4279
485	991	1,0501
486	1108	1,1739
487	826	0,8752
488	741	0,7850
489	1028	1,0898
490	1021	1,0822
491	868	0,9197
492	942	0,9987
493	920	0,9751
494	779	0,8260
495	819	0,8680
496	987	1,0457
497	1023	1,0844
498	1035	1,0964
499	1110	1,1762
500	1086	1,1513
501	861	0,9129
502	867	0,9189
503	1170	1,2402
504	1250	1,3243
505	1128	1,1953
506	1211	1,2835
507	936	0,9923
508	857	0,9086
509	807	0,8554
510	998	1,0577
511	1101	1,1673
512	927	0,9828
513	973	1,0310
514	1101	1,1668
515	843	0,8936
516	768	0,8139
517	1088	1,1527

2005

Year Period Daily Average = 944
Minimum ratio =0,2349
Maximum ratio =2,3802

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
845	922	0,9767
846	794	0,8408
847	1004	1,0634
848	1117	1,1829
849	1157	1,2258
850	794	0,8408
851	1004	1,0634
852	1111	1,1770
853	1151	1,2197
854	938	0,9938
855	930	0,9848
856	837	0,8870
857	877	0,9294
858	1034	1,0950
859	1025	1,0857
860	1000	1,0594
861	908	0,9623
862	874	0,9257
863	843	0,8931
864	896	0,9486
865	1054	1,1159
866	1042	1,1032
867	1073	1,1369
868	973	1,0306
869	913	0,9666
870	947	1,0030
871	966	1,0233
872	1131	1,1982
873	1147	1,2153
874	1128	1,1946
875	1023	1,0834
876	911	0,9645
877	933	0,9884
878	876	0,9276
879	790	0,8364
880	1263	1,3381
881	1029	1,0897
882	907	0,9607
883	1150	1,2181

Water Supply to Hospital Amadora Sintra

Numeric Analisys for year periods and day seasons

2003

Year Period Daily Average = 912
Minimum ratio =0,4053
Maximum ratio =1,6608

t (days)	Daily consumptions (m³/day)	Ratio Consumption / Average
153	1195	1,3110
154	983	1,0778
155	1202	1,3181
156	1178	1,2921
157	1253	1,3745
158	1036	1,1360
159	586	0,6431
160	1263	1,3848
161	851	0,9336
162	1268	1,3905
163	1317	1,4440
164	1351	1,4820
165	881	0,9660
166	594	0,6520
167	1045	1,1458
168	828	0,9077
169	1202	1,3179
170	835	0,9163
171	1230	1,3488
172	1381	1,5149
173	608	0,6667
174	1268	1,3903
175	1329	1,4578
176	1330	1,4591
177	1302	1,4276
178	1335	1,4646
179	814	0,8930
180	544	0,5961
181	814	0,8922
182	858	0,9413
183	1151	1,2622
184	1145	1,2555
185	1369	1,5012
186	934	1,0243
187	718	0,7880
188	1268	1,3902
189	1164	1,2771
190	1272	1,3955
191	1148	1,2592

2004

Year Period Daily Average = 944
Minimum ratio =0,2181
Maximum ratio =1,7358

t (days)	Daily consumptions (m³/day)	Ratio Consumption / Average
518	1085	1,1497
519	1166	1,2354
520	1167	1,2369
521	1268	1,3442
522	1017	1,0774
523	853	0,9037
524	1134	1,2021
525	1156	1,2254
526	1177	1,2476
527	959	1,0163
528	1123	1,1898
529	1281	1,3577
530	1053	1,1161
531	1353	1,4341
532	1069	1,1334
533	1322	1,4015
534	1351	1,4322
535	1408	1,4926
536	1014	1,0747
537	811	0,8596
538	1183	1,2536
539	1172	1,2416
540	1018	1,0784
541	1188	1,2593
542	1284	1,3607
543	1427	1,5125
544	963	1,0203
545	1190	1,2612
546	1467	1,5552
547	1222	1,2946
548	1480	1,5683
549	1394	1,4777
550	1185	1,2561
551	993	1,0529
552	1143	1,2108
553	1294	1,3712
554	1312	1,3903
555	1375	1,4572
556	1191	1,2618

2005

Year Period Daily Average = 944
Minimum ratio =0,2349
Maximum ratio =2,3802

t (days)	Daily consumptions (m³/day)	Ratio Consumption / Average
884	955	1,0118
885	926	0,9810
886	846	0,8956
887	1313	1,3904
888	1248	1,3217
889	1165	1,2339
890	1037	1,0989
891	1060	1,1225
892	970	1,0273
893	1110	1,1761
894	1085	1,1494
895	1156	1,2240
896	964	1,0209
897	1409	1,4922
898	1182	1,2519
899	1152	1,2203
900	636	0,6741
901	895	0,9475
902	1162	1,2305
903	807	0,8544
904	1291	1,3669
905	897	0,9505
906	1293	1,3695
907	1150	1,2181
908	955	1,0118
909	916	0,9700
910	1195	1,2655
911	222	0,2349
912	1046	1,1082
913	1481	1,5691
914	604	0,6400
915	814	0,8620
916	1984	2,1013
917	1264	1,3390
918	2060	2,1815
919	1241	1,3140
920	1511	1,6007
921	1177	1,2470
922	945	1,0013

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

2003

Year Period Daily Average = 912
Minimum ratio =0,4053
Maximum ratio =1,6608

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
192	1261	1,3832
193	845	0,9269
194	602	0,6600
195	1107	1,2139
196	847	0,9294
197	1184	1,2982
198	1336	1,4658
199	1219	1,3375
200	938	1,0292
201	678	0,7436
202	1289	1,4137
203	1392	1,5272
204	1323	1,4508
205	1361	1,4928
206	1344	1,4743
207	857	0,9403
208	557	0,6113
209	1333	1,4623
210	1404	1,5403
211	1266	1,3884
212	1263	1,3850
213	1474	1,6167
214	1215	1,3328
215	1158	1,2698
216	1428	1,5657
217	1426	1,5643
218	1408	1,5441
219	1345	1,4750
220	1514	1,6608
221	1465	1,6064
222	1099	1,2049
223	1447	1,5869
224	1396	1,5312
225	1005	1,1028
226	951	1,0430
227	871	0,9552
228	1187	1,3022
229	959	1,0520
230	1064	1,1674

2004

Year Period Daily Average = 944
Minimum ratio =0,2181
Maximum ratio =1,7358

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
557	1112	1,1783
558	923	0,9779
559	1203	1,2745
560	1289	1,3659
561	1320	1,3993
562	1490	1,5791
563	1225	1,2985
564	994	1,0530
565	820	0,8688
566	1164	1,2332
567	1234	1,3074
568	1203	1,2746
569	972	1,0296
570	1333	1,4126
571	1045	1,1076
572	876	0,9279
573	1199	1,2706
574	883	0,9362
575	1193	1,2640
576	1488	1,5770
577	1638	1,7358
578	1057	1,1206
579	777	0,8234
580	1156	1,2251
581	624	0,6608
582	1070	1,1337
583	1179	1,2492
584	1127	1,1939
585	809	0,8574
586	780	0,8263
587	930	0,9857
588	1000	1,0600
589	905	0,9590
590	1023	1,0846
591	987	1,0465
592	903	0,9568
593	809	0,8573
594	1240	1,3144
595	1078	1,1429

2005

Year Period Daily Average = 944
Minimum ratio =0,2349
Maximum ratio =2,3802

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
923	956	1,0129
924	1273	1,3482
925	1131	1,1982
926	1205	1,2766
927	953	1,0094
928	1129	1,1953
929	1136	1,2030
930	1105	1,1702
931	1040	1,1019
932	1037	1,0988
933	1129	1,1958
934	1333	1,4121
935	1168	1,2368
936	1238	1,3109
937	1119	1,1848
938	1295	1,3717
939	1130	1,1969
940	1250	1,3241
941	1398	1,4803
942	1235	1,3080
943	1287	1,3627
944	1165	1,2342
945	1132	1,1986
946	1062	1,1252
947	1107	1,1729
948	1273	1,3482
949	1340	1,4194
950	1320	1,3981
951	1047	1,1089
952	1203	1,2743
953	994	1,0529
954	1181	1,2510
955	1266	1,3406
956	1347	1,4269
957	1272	1,3478
958	1098	1,1628
959	1140	1,2072
960	928	0,9834
961	1196	1,2669

Water Supply to Hospital Amadora Sintra

Numeric Analisys for year periods and day seasons

2003

Year Period Daily Average = 912
Minimum ratio =0,4053
Maximum ratio =1,6608

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
231	898	0,9850
232	1215	1,3322
233	991	1,0866
234	1162	1,2744
235	796	0,8728
236	625	0,6850
237	929	1,0192
238	875	0,9600
239	733	0,8040
240	860	0,9428
241	837	0,9182
242	620	0,6802
243	553	0,6069
244	852	0,9341
245	888	0,9740
246	965	1,0582
247	983	1,0785
248	953	1,0452
249	733	0,8036
250	761	0,8344
251	1176	1,2900
252	971	1,0645
253	1333	1,4621
254	921	1,0097
255	1324	1,4524
256	940	1,0308
257	884	0,9694
258	1337	1,4667
259	1115	1,2232
260	1268	1,3907
261	1289	1,4132
262	1000	1,0966
263	568	0,6230
264	823	0,9025
265	1022	1,1211
266	1032	1,1314
267	1183	1,2974
268	1023	1,1223
269	1312	1,4392

2004

Year Period Daily Average = 944
Minimum ratio =0,2181
Maximum ratio =1,7358

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
596	1081	1,1456
597	1150	1,2185
598	1180	1,2507
599	1116	1,1824
600	861	0,9128
601	1260	1,3351
602	1351	1,4313
603	1424	1,5088
604	1342	1,4223
605	1510	1,5998
606	1015	1,0760
607	1041	1,1028
608	1580	1,6746
609	989	1,0482
610	1104	1,1697
611	1034	1,0960
612	309	0,3275
613	832	0,8820
614	740	0,7846
615	1134	1,2023
616	1171	1,2407
617	1408	1,4923
618	1237	1,3111
619	928	0,9836
620	921	0,9756
621	766	0,8120
622	1305	1,3829
623	1062	1,1258
624	1155	1,2238
625	1174	1,2440
626	1259	1,3345
627	1246	1,3206
628	1134	1,2019
629	1209	1,2812
630	1324	1,4033
631	845	0,8959
632	1201	1,2731
633	1243	1,3176
634	1053	1,1157

2005

Year Period Daily Average = 944
Minimum ratio =0,2349
Maximum ratio =2,3802

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
962	1073	1,1365
963	1202	1,2735
964	980	1,0385
965	1057	1,1194
966	1044	1,1058
967	1040	1,1020
968	1111	1,1769
969	1150	1,2176
970	1112	1,1775
971	1203	1,2738
972	1182	1,2517
973	1138	1,2049
974	893	0,9454
975	956	1,0122
976	697	0,7384
977	1101	1,1657
978	929	0,9845
979	794	0,8407
980	840	0,8894
981	756	0,8012
982	981	1,0393
983	959	1,0162
984	843	0,8930
985	884	0,9358
986	713	0,7557
987	793	0,8402
988	704	0,7452
989	964	1,0206
990	887	0,9398
991	882	0,9344
992	965	1,0224
993	852	0,9023
994	1110	1,1760
995	879	0,9309
996	1067	1,1307
997	1152	1,2199
998	1265	1,3401
999	944	0,9997
1000	1042	1,1038

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

2003

Year Period Daily Average = 912
Minimum ratio =0,4053
Maximum ratio =1,6608

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
270	943	1,0341
271	703	0,7713
272	875	0,9598
273	824	0,9040
274	886	0,9717
275	926	1,0155
276	817	0,8957
277	730	0,8009
278	680	0,7456
279	840	0,9212
280	804	0,8816
281	937	1,0273
282	877	0,9618
283	938	1,0284
284	703	0,7708
285	647	0,7095
286	840	0,9213
287	894	0,9809
288	780	0,8555
289	899	0,9856
290	838	0,9194
291	723	0,7934
292	614	0,6739
293	849	0,9307
294	844	0,9251
295	923	1,0122
296	916	1,0048
297	946	1,0379
298	639	0,7008
299	662	0,7262
300	820	0,8989
301	903	0,9909
302	835	0,9161
303	786	0,8626
304	805	0,8834
305	670	0,7346
306	705	0,7729
307	827	0,9075
308	880	0,9654

2004

Year Period Daily Average = 944
Minimum ratio =0,2181
Maximum ratio =1,7358

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
635	805	0,8526
636	1299	1,3765
637	1173	1,2429
638	1049	1,1119
639	1129	1,1968
640	970	1,0284
641	947	1,0031
642	716	0,7584
643	1239	1,3129
644	708	0,7502
645	978	1,0367
646	967	1,0246
647	943	0,9991
648	870	0,9223
649	753	0,7975
650	964	1,0213
651	960	1,0174
652	927	0,9820
653	937	0,9930
654	968	1,0256
655	695	0,7362
656	745	0,7900
657	960	1,0169
658	1032	1,0935
659	457	0,4843
660	836	0,8859
661	1066	1,1295
662	719	0,7615
663	716	0,7588
664	587	0,6225
665	996	1,0557
666	893	0,9465
667	921	0,9763
668	1025	1,0858
669	850	0,9006
670	705	0,7469
671	857	0,9084
672	894	0,9471
673	943	0,9991

2005

Year Period Daily Average = 944
Minimum ratio =0,2349
Maximum ratio =2,3802

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1001	966	1,0236
1002	1093	1,1581
1003	1223	1,2953
1004	878	0,9302
1005	1039	1,1005
1006	846	0,8956
1007	444	0,4703
1008	927	0,9814
1009	834	0,8837
1010	966	1,0232
1011	1003	1,0627
1012	1040	1,1013
1013	909	0,9626
1014	761	0,8059
1015	772	0,8182
1016	849	0,8994
1017	1049	1,1112
1018	887	0,9398
1019	932	0,9867
1020	954	1,0106
1021	890	0,9424
1022	1070	1,1338
1023	1018	1,0784
1024	1000	1,0590
1025	1030	1,0912
1026	879	0,9313
1027	892	0,9453
1028	928	0,9825
1029	989	1,0477
1030	802	0,8492
1031	989	1,0475
1032	975	1,0322
1033	906	0,9595
1034	867	0,9181
1035	815	0,8631
1036	801	0,8480
1037	770	0,8154
1038	1017	1,0770
1039	659	0,6979

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

2003

Year Period Daily Average = 912
Minimum ratio =0,4053
Maximum ratio =1,6608

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
309	879	0,9640
310	867	0,9506
311	928	1,0176
312	608	0,6672
313	643	0,7048
314	946	1,0374
315	858	0,9407
316	875	0,9601
317	851	0,9336
318	880	0,9654
319	691	0,7579
320	731	0,8018
321	858	0,9410
322	868	0,9521
323	855	0,9372
324	853	0,9359
325	853	0,9355
326	828	0,9085
327	623	0,6837
328	806	0,8842
329	919	1,0077
330	949	1,0413
331	964	1,0576
332	979	1,0736
333	1073	1,1771
334	620	0,6796
335	832	0,9125
336	906	0,9934
337	898	0,9852
338	892	0,9784
339	370	0,4053
340	768	0,8422
341	557	0,6114
342	839	0,9198
343	833	0,9136
344	872	0,9561
345	1002	1,0990
346	1001	1,0981
347	795	0,8718

2004

Year Period Daily Average = 944
Minimum ratio =0,2181
Maximum ratio =1,7358

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
674	1014	1,0743
675	967	1,0245
676	893	0,9469
677	683	0,7234
678	976	1,0343
679	403	0,4273
680	469	0,4973
681	1025	1,0865
682	884	0,9367
683	808	0,8560
684	834	0,8842
685	887	0,9402
686	970	1,0280
687	895	0,9486
688	1026	1,0874
689	888	0,9410
690	818	0,8669
691	824	0,8736
692	887	0,9397
693	1075	1,1388
694	908	0,9619
695	1021	1,0824
696	1033	1,0943
697	818	0,8670
698	724	0,7673
699	1050	1,1127
700	913	0,9673
701	780	0,8263
702	874	0,9260
703	935	0,9906
704	655	0,6941
705	718	0,7610
706	920	0,9755
707	834	0,8836
708	811	0,8594
709	979	1,0375
710	849	0,8997
711	794	0,8414
712	611	0,6479

2005

Year Period Daily Average = 944
Minimum ratio =0,2349
Maximum ratio =2,3802

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1040	812	0,8603
1041	757	0,8013
1042	819	0,8679
1043	787	0,8337
1044	812	0,8600
1045	880	0,9318
1046	896	0,9494
1047	842	0,8916
1048	790	0,8363
1049	749	0,7935
1050	728	0,7707
1051	771	0,8169
1052	921	0,9760
1053	863	0,9140
1054	653	0,6922
1055	703	0,7451
1056	797	0,8444
1057	790	0,8372
1058	757	0,8017
1059	691	0,7324
1060	858	0,9089
1061	812	0,8600
1062	897	0,9506
1063	792	0,8389
1064	857	0,9078
1065	762	0,8075
1066	769	0,8142
1067	829	0,8780
1068	902	0,9554
1069	830	0,8786
1070	772	0,8181
1071	903	0,9560
1072	781	0,8275
1073	889	0,9414
1074	626	0,6634
1075	696	0,7369
1076	639	0,6772
1077	674	0,7141
1078	665	0,7039

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

Year Period Daily Average = 912
Minimum ratio =0,4053
Maximum ratio =1,6608

Year	t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
2003	348	766	0,8404
	349	1011	1,1084
	350	1038	1,1382
	351	964	1,0572
	352	879	0,9636
	353	965	1,0586
	354	1015	1,1128
	355	867	0,9511
	356	981	1,0759
	357	903	0,9899
	358	808	0,8857
	359	692	0,7584
	360	860	0,9433
	361	806	0,8835
	362	564	0,6181
	363	937	1,0274
	364	1066	1,1696
	365	880	0,9655

Year Period Daily Average = 944
Minimum ratio =0,2181
Maximum ratio =1,7358

Year	t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
2004	713	982	1,0407
	714	952	1,0093
	715	851	0,9018
	716	846	0,8967
	717	774	0,8202
	718	815	0,8641
	719	647	0,6858
	720	980	1,0381
	721	842	0,8924
	722	985	1,0439
	723	608	0,6446
	724	454	0,4809
	725	596	0,6321
	726	746	0,7902
	727	842	0,8920
	728	950	1,0073
	729	856	0,9071
	730	774	0,8200
	731	861	0,9122

Year Period Daily Average = 944
Minimum ratio =0,2349
Maximum ratio =2,3802

Year	t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
2005	1079	715	0,7572
	1080	740	0,7833
	1081	656	0,6949
	1082	537	0,5691
	1083	504	0,5338
	1084	661	0,7003
	1085	615	0,6511
	1086	622	0,6592
	1087	642	0,6801
	1088	560	0,5930
	1089	412	0,4360
	1090	637	0,6747
	1091	655	0,6937
	1092	889	0,9414
	1093	2247	2,3802
	1094	730	0,7733
	1095	733	0,7763
	1096	646	0,6845

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

Year Period Daily Average = 925

Minimum ratio = 0,5811

Maximum ratio = 1,6949

2006

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1097	794	0,8591
1098	959	1,0368
1099	929	1,0041
1100	1063	1,1495
1101	1070	1,1567
1102	973	1,0526
1103	773	0,8357
1104	683	0,7389
1105	1104	1,1933
1106	1006	1,0884
1107	990	1,0709
1108	958	1,0359
1109	927	1,0025
1110	771	0,8338
1111	759	0,8203
1112	1067	1,1539
1113	873	0,9440
1114	1144	1,2372
1115	923	0,9980
1116	1067	1,1543
1117	741	0,8015
1118	854	0,9230
1119	917	0,9913
1120	1097	1,1861
1121	1190	1,2869
1122	1132	1,2243
1123	915	0,9891
1124	817	0,8835
1125	675	0,7301
1126	1004	1,0860
1127	1028	1,1121
1128	854	0,9239
1129	1057	1,1434
1130	928	1,0037
1131	855	0,9246
1132	711	0,7688
1133	841	0,9097
1134	1089	1,1772
1135	892	0,9641
1136	994	1,0753
1137	843	0,9118

Year Period Daily Average = 821

Minimum ratio = 0,5318

Maximum ratio = 1,6780

2007

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1462	750	0,9138
1463	736	0,8966
1464	808	0,9846
1465	608	0,7413
1466	583	0,7104
1467	732	0,8921
1468	593	0,7228
1469	900	1,0962
1470	831	1,0123
1471	760	0,9259
1472	612	0,7455
1473	436	0,5318
1474	795	0,9687
1475	686	0,8357
1476	726	0,8844
1477	752	0,9157
1478	829	1,0097
1479	533	0,6491
1480	486	0,5922
1481	818	0,9963
1482	739	0,9001
1483	804	0,9802
1484	785	0,9565
1485	758	0,9237
1486	565	0,6884
1487	456	0,5554
1488	798	0,9729
1489	771	0,9392
1490	759	0,9251
1491	738	0,8996
1492	740	0,9017
1493	664	0,8088
1494	492	0,5992
1495	852	1,0376
1496	813	0,9902
1497	809	0,9858
1498	785	0,9565
1499	794	0,9669
1500	645	0.7865
1501	631	0.7683
1502	579	0.7055

Water Supply to Hospital Amadora Sintra

Numeric Analisys for year periods and day seasons

Year Period Daily Average = 925
Minimum ratio = 0,5811
Maximum ratio = 1,6949

2006

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1138	874	0,9446
1139	803	0,8682
1140	1005	1,0871
1141	943	1,0198
1142	989	1,0693
1143	828	0,8951
1144	1077	1,1646
1145	832	0,9001
1146	828	0,8950
1147	1056	1,1420
1148	929	1,0042
1149	1033	1,1169
1150	916	0,9904
1151	1043	1,1273
1152	888	0,9603
1153	708	0,7655
1154	984	1,0645
1155	851	0,9205
1156	1027	1,1107
1157	834	0,9020
1158	1017	1,0997
1159	805	0,8710
1160	703	0,7598
1161	964	1,0422
1162	901	0,9740
1163	880	0,9513
1164	1007	1,0892
1165	1034	1,1181
1166	749	0,8100
1167	724	0,7829
1168	865	0,9349
1169	1010	1,0923
1170	894	0,9666
1171	1012	1,0948
1172	876	0,9469
1173	690	0,7459
1174	689	0,7448
1175	1027	1,1100
1176	879	0,9510
1177	984	1,0637
1178	790	0,8547

Year Period Daily Average = 821
Minimum ratio = 0,5318
Maximum ratio = 1,6780

2007

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1503	557	0,6792
1504	795	0,9688
1505	754	0,9186
1506	889	1,0831
1507	844	1,0280
1508	748	0,9115
1509	617	0,7512
1510	562	0,6849
1511	719	0,8758
1512	707	0,8619
1513	746	0,9085
1514	823	1,0026
1515	775	0,9440
1516	598	0,7287
1517	595	0,7252
1518	800	0,9745
1519	828	1,0088
1520	734	0,8949
1521	783	0,9541
1522	879	1,0710
1523	625	0,7618
1524	554	0,6752
1525	789	0,9608
1526	829	1,0099
1527	780	0,9505
1528	885	1,0788
1529	788	0,9601
1530	642	0,7819
1531	526	0,6414
1532	836	1,0183
1533	869	1,0585
1534	805	0,9813
1535	838	1,0214
1536	787	0,9590
1537	665	0,8106
1538	561	0,6836
1539	722	0,8792
1540	859	1,0464
1541	880	1,0722
1542	869	1,0589
1543	773	0,9415

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

2006

Year Period Daily Average = 925
Minimum ratio = 0,5811
Maximum ratio = 1,6949

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1179	1010	1,0920
1180	719	0,7778
1181	694	0,7502
1182	956	1,0339
1183	826	0,8930
1184	884	0,9558
1185	1011	1,0930
1186	870	0,9407
1187	794	0,8587
1188	702	0,7596
1189	877	0,9485
1190	932	1,0082
1191	756	0,8170
1192	954	1,0321
1193	908	0,9816
1194	744	0,8043
1195	654	0,7074
1196	934	1,0098
1197	895	0,9674
1198	839	0,9070
1199	902	0,9756
1200	725	0,7844
1201	767	0,8292
1202	710	0,7679
1203	833	0,9007
1204	877	0,9486
1205	982	1,0614
1206	888	0,9608
1207	786	0,8496
1208	776	0,8389
1209	768	0,8300
1210	842	0,9106
1211	672	0,7270
1212	877	0,9486
1213	970	1,0493
1214	840	0,9083
1215	785	0,8487
1216	660	0,7133
1217	843	0,9116
1218	1019	1,1022
1219	1031	1,1150

2007

Year Period Daily Average = 821
Minimum ratio = 0,5318
Maximum ratio = 1,6780

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1544	717	0,8731
1545	571	0,6962
1546	739	0,9001
1547	806	0,9823
1548	774	0,9427
1549	882	1,0741
1550	853	1,0397
1551	663	0,8084
1552	574	0,6993
1553	728	0,8876
1554	749	0,9126
1555	885	1,0778
1556	780	0,9499
1557	653	0,7951
1558	633	0,7707
1559	551	0,6712
1560	750	0,9132
1561	724	0,8827
1562	825	1,0053
1563	874	1,0650
1564	739	0,9005
1565	671	0,8176
1566	605	0,7372
1567	764	0,9303
1568	761	0,9268
1569	776	0,9454
1570	820	0,9990
1571	796	0,9703
1572	631	0,7687
1573	563	0,6855
1574	855	1,0413
1575	822	1,0012
1576	620	0,7556
1577	751	0,9150
1578	862	1,0505
1579	601	0,7321
1580	573	0,6979
1581	747	0,9107
1582	724	0,8823
1583	886	1,0797
1584	834	1,0166

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

Year Period Daily Average = 925
Minimum ratio = 0,5811
Maximum ratio = 1,6949

	t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
2006	1220	1021	1,1037
	1221	1136	1,2286
	1222	864	0,9343
	1223	816	0,8828
	1224	906	0,9795
	1225	972	1,0506
	1226	1118	1,2087
	1227	1053	1,1384
	1228	1107	1,1969
	1229	816	0,8821
	1230	715	0,7737
	1231	1032	1,1163
	1232	1066	1,1529
	1233	1079	1,1672
	1234	1026	1,1098
	1235	1118	1,2093
	1236	809	0,8749
	1237	875	0,9462
	1238	1008	1,0902
	1239	943	1,0200
	1240	556	0,6011
	1241	1429	1,5457
	1242	1131	1,2227
	1243	828	0,8950
	1244	1143	1,2365
	1245	1028	1,1113
	1246	1050	1,1358
	1247	537	0,5811
	1248	1567	1,6949
	1249	1340	1,4489
	1250	1163	1,2576
	1251	781	0,8440
	1252	1108	1,1984
	1253	1101	1,1905
	1254	1084	1,1724
	1255	1006	1,0882
	1256	1117	1,2076
	1257	881	0,9531
	1258	721	0,7801
	1259	1198	1,2956
	1260	1160	1,2544

Year Period Daily Average = 821
Minimum ratio = 0,5318
Maximum ratio = 1,6780

	t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
2007	1585	841	1,0244
	1586	746	0,9085
	1587	687	0,8367
	1588	802	0,9769
	1589	1008	1,2282
	1590	899	1,0950
	1591	874	1,0651
	1592	865	1,0544
	1593	789	0,9608
	1594	701	0,8546
	1595	845	1,0290
	1596	877	1,0681
	1597	889	1,0834
	1598	802	0,9772
	1599	1020	1,2434
	1600	718	0,8753
	1601	620	0,7556
	1602	906	1,1035
	1603	821	1,0004
	1604	922	1,1236
	1605	878	1,0702
	1606	768	0,9358
	1607	712	0,8680
	1608	591	0,7203
	1609	803	0,9785
	1610	849	1,0345
	1611	841	1,0247
	1612	885	1,0787
	1613	964	1,1751
	1614	718	0,8743
	1615	671	0,8181
	1616	908	1.1063
	1617	999	1.2168
	1618	1027	1.2511
	1619	755	0,9194
	1620	857	1,0438
	1621	773	0,9417
	1622	542	0.6610
	1623	891	1.0856
	1624	907	1.1049
	1625	966	1.1766

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

2006

Year Period Daily Average = 925
Minimum ratio = 0,5811
Maximum ratio = 1,6949

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1261	978	1,0578
1262	774	0,8370
1263	854	0,9237
1264	837	0,9050
1265	710	0,7673
1266	1016	1,0987
1267	1236	1,3368
1268	1011	1,0929
1269	1445	1,5622
1270	1275	1,3785
1271	1229	1,3289
1272	876	0,9478
1273	1081	1,1689
1274	1258	1,3607
1275	1253	1,3545
1276	1248	1,3492
1277	1186	1,2826
1278	1011	1,0932
1279	895	0,9678
1280	1057	1,1425
1281	1124	1,2156
1282	1053	1,1388
1283	1232	1,3322
1284	1353	1,4629
1285	1241	1,3417
1286	873	0,9441
1287	1288	1,3924
1288	1060	1,1458
1289	1141	1,2338
1290	1223	1,3220
1291	1358	1,4688
1292	1014	1,0961
1293	941	1,0179
1294	1286	1,3908
1295	1036	1,1206
1296	1216	1,3145
1297	880	0,9516
1298	1185	1,2819
1299	977	1,0564
1300	736	0,7959
1301	1028	1,1121

2007

Year Period Daily Average = 821
Minimum ratio = 0,5318
Maximum ratio = 1,6780

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1626	890	1,0846
1627	901	1,0982
1628	765	0,9321
1629	703	0,8571
1630	892	1,0871
1631	899	1,0949
1632	996	1,2134
1633	946	1,1529
1634	884	1,0775
1635	752	0,9163
1636	658	0,8015
1637	834	1,0156
1638	945	1,1520
1639	999	1,2176
1640	946	1,1529
1641	1055	1,2855
1642	739	0,9002
1643	751	0,9154
1644	1007	1,2265
1645	1093	1,3318
1646	979	1,1930
1647	1110	1,3528
1648	1119	1,3638
1649	798	0,9729
1650	810	0,9867
1651	1033	1,2583
1652	955	1,1637
1653	1250	1,5233
1654	1085	1,3217
1655	954	1,1620
1656	979	1,1923
1657	860	1,0475
1658	1023	1,2470
1659	1377	1,6780
1660	1044	1,2715
1661	927	1,1290
1662	1131	1,3780
1663	727	0,8859
1664	813	0,9909
1665	949	1,1561
1666	974	1,1863

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

2006

Year Period Daily Average = 925
Minimum ratio = 0,5811
Maximum ratio = 1,6949

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1302	1209	1,3074
1303	998	1,0796
1304	1429	1,5453
1305	1007	1,0885
1306	869	0,9402
1307	660	0,7133
1308	1211	1,3095
1309	991	1,0713
1310	1002	1,0838
1311	976	1,0555
1312	1446	1,5633
1313	914	0,9883
1314	647	0,6993
1315	1111	1,2015
1316	944	1,0210
1317	1315	1,4222
1318	1185	1,2812
1319	1012	1,0948
1320	977	1,0565
1321	609	0,6590
1322	895	0,9679
1323	785	0,8487
1324	927	1,0026
1325	925	0,9999
1326	910	0,9836
1327	1032	1,1162
1328	726	0,7855
1329	1418	1,5331
1330	1147	1,2401
1331	1155	1,2486
1332	1255	1,3574
1333	1446	1,5633
1334	766	0,8287
1335	815	0,8815
1336	1185	1,2811
1337	1461	1,5800
1338	1170	1,2651
1339	1003	1,0841
1340	1294	1,3993
1341	902	0,9753
1342	734	0,7934

2007

Year Period Daily Average = 821
Minimum ratio = 0,5318
Maximum ratio = 1,6780

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1667	1148	1,3994
1668	930	1,1327
1669	1101	1,3414
1670	780	0,9500
1671	748	0,9117
1672	1022	1,2447
1673	1003	1,2223
1674	942	1,1474
1675	968	1,1799
1676	1038	1,2643
1677	786	0,9577
1678	723	0,8815
1679	946	1,1522
1680	946	1,1522
1681	967	1,1781
1682	847	1,0317
1683	938	1,1434
1684	801	0,9754
1685	860	1,0474
1686	955	1,1635
1687	860	1,0483
1688	785	0,9568
1689	944	1,1500
1690	904	1,1012
1691	770	0,9382
1692	717	0,8736
1693	990	1,2062
1694	903	1,1005
1695	890	1,0848
1696	938	1,1434
1697	991	1,2075
1698	807	0,9832
1699	762	0,9282
1700	868	1,0581
1701	990	1,2063
1702	1196	1,4576
1703	936	1,1403
1704	885	1,0786
1705	725	0,8830
1706	733	0,8926
1707	874	1,0644

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

2006

Year Period Daily Average = 925
Minimum ratio = 0,5811
Maximum ratio = 1,6949

t (days)	Daily consumptions (m³/day)	Ratio Consumption / Average
1343	1323	1,4306
1344	1201	1,2992
1345	1083	1,1710
1346	1133	1,2252
1347	957	1,0353
1348	830	0,8972
1349	814	0,8807
1350	851	0,9202
1351	1209	1,3070
1352	1095	1,1840
1353	972	1,0512
1354	977	1,0562
1355	1010	1,0924
1356	759	0,8208
1357	1212	1,3107
1358	1210	1,3080
1359	1082	1,1700
1360	1028	1,1112
1361	1194	1,2907
1362	830	0,8975
1363	869	0,9393
1364	1230	1,3297
1365	1051	1,1364
1366	956	1,0335
1367	1061	1,1472
1368	1032	1,1156
1369	848	0,9168
1370	698	0,7547
1371	727	0,7860
1372	898	0,9708
1373	886	0,9578
1374	671	0,7254
1375	719	0,7776
1376	613	0,6630
1377	770	0,8332
1378	776	0,8394
1379	949	1,0263
1380	877	0,9481
1381	916	0,9903
1382	834	0,9022
1383	713	0,7714

2007

Year Period Daily Average = 821
Minimum ratio = 0,5318
Maximum ratio = 1,6780

t (days)	Daily consumptions (m³/day)	Ratio Consumption / Average
1708	1097	1,3364
1709	927	1,1292
1710	802	0,9766
1711	845	1,0299
1712	743	0,9056
1713	627	0,7642
1714	845	1,0295
1715	659	0,8024
1716	745	0,9074
1717	813	0,9908
1718	876	1,0670
1719	741	0,9027
1720	538	0,6561
1721	840	1,0240
1722	476	0,5800
1723	994	1,2114
1724	1341	1,6340
1725	888	1,0818
1726	588	0,7164
1727	600	0,7316
1728	1034	1,2598
1729	814	0,9923
1730	1013	1,2340
1731	1341	1,6339
1732	999	1,2170
1733	756	0,9210
1734	669	0,8157
1735	731	0,8908
1736	959	1,1684
1737	959	1,1684
1738	907	1,1046
1739	870	1,0600
1740	794	0,9675
1741	633	0,7710
1742	965	1,1764
1743	921	1,1223
1744	934	1,1378
1745	1062	1,2940
1746	894	1,0891
1747	848	1,0330
1748	752	0,9165

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

2006

Year Period Daily Average = 925
Minimum ratio = 0,5811
Maximum ratio = 1,6949

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1384	596	0,6449
1385	830	0,8973
1386	870	0,9409
1387	969	1,0482
1388	772	0,8345
1389	916	0,9902
1390	634	0,6859
1391	598	0,6466
1392	938	1,0145
1393	870	0,9407
1394	863	0,9331
1395	798	0,8627
1396	805	0,8709
1397	958	1,0357
1398	629	0,6802
1399	945	1,0221
1400	893	0,9656
1401	667	0,7217
1402	748	0,8092
1403	842	0,9103
1404	638	0,6897
1405	573	0,6192
1406	889	0,9611
1407	854	0,9232
1408	786	0,8498
1409	818	0,8849
1410	889	0,9614
1411	617	0,6677
1412	605	0,6538
1413	905	0,9791
1414	751	0,8123
1415	937	1,0127
1416	743	0,8032
1417	946	1,0225
1418	679	0,7344
1419	576	0,6227
1420	919	0,9934
1421	817	0,8831
1422	1029	1,1125
1423	845	0,9135
1424	913	0,9873

2007

Year Period Daily Average = 821
Minimum ratio = 0,5318
Maximum ratio = 1,6780

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1749	867	1,0565
1750	1013	1,2340
1751	1110	1,3521
1752	977	1,1906
1753	856	1,0424
1754	833	1,0144
1755	721	0,8786
1756	888	1,0815
1757	1012	1,2336
1758	917	1,1173
1759	906	1,1034
1760	974	1,1874
1761	741	0,9029
1762	826	1,0059
1763	843	1,0266
1764	998	1,2155
1765	897	1,0933
1766	925	1,1268
1767	849	1,0342
1768	784	0,9555
1769	747	0,9096
1770	832	1,0137
1771	998	1,2161
1772	901	1,0973
1773	956	1,1647
1774	984	1,1986
1775	745	0,9077
1776	729	0,8883
1777	983	1,1981
1778	904	1,1019
1779	995	1,2119
1780	929	1,1317
1781	955	1,1642
1782	790	0,9628
1783	705	0,8595
1784	938	1,1433
1785	845	1,0291
1786	1014	1,2357
1787	963	1,1729
1788	930	1,1336
1789	808	0,9845

Water Supply to Hospital Amadora Sintra

Annexe 4

Numeric Analisys for year periods and day seasons

2006

Year Period Daily Average = 925
Minimum ratio = 0,5811
Maximum ratio = 1,6949

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1425	770	0,8325
1426	693	0,7493
1427	832	0,8997
1428	790	0,8540
1429	763	0,8254
1430	663	0,7168
1431	652	0,7053
1432	726	0,7854
1433	908	0,9823
1434	793	0,8573
1435	890	0,9626
1436	724	0,7831
1437	678	0,7331
1438	645	0,6979
1439	774	0,8368
1440	821	0,8879
1441	814	0,8807
1442	816	0,8829
1443	873	0,9444
1444	644	0,6968
1445	587	0,6347
1446	821	0,8880
1447	747	0,8072
1448	898	0,9706
1449	818	0,8849
1450	807	0,8727
1451	696	0,7522
1452	668	0,7224
1453	735	0,7949
1454	872	0,9427
1455	766	0,8280
1456	734	0,7940
1457	877	0,9484
1458	649	0,7022
1459	567	0,6126
1460	653	0,7063
1461	567	0,6134

2007

Year Period Daily Average = 821
Minimum ratio = 0,5318
Maximum ratio = 1,6780

t (days)	Daily consumptions (m^3/day)	Ratio Consumption / Average
1790	751	0,9156
1791	837	1,0196
1792	1047	1,2753
1793	913	1,1130
1794	1026	1,2496
1795	834	1,0167
1796	703	0,8562
1797	669	0,8152
1798	802	0,9774
1799	851	1,0371
1800	844	1,0287
1801	846	1,0312
1802	905	1,1030
1803	668	0,8139
1804	608	0,7413
1805	851	1,0371
1806	774	0,9429
1807	930	1,1337
1808	848	1,0336
1809	837	1,0193
1810	721	0,8786
1811	693	0,8438
1812	762	0,9285
1813	904	1,1011
1814	794	0,9671
1815	761	0,9273
1816	909	1,1078
1817	673	0,8202
1818	587	0,7155
1819	677	0,8249
1820	588	0,7164
1821	783	0,9542
1822	768	0,9363
1823	844	1,0281
1824	635	0,7741
1825	609	0,7418
1826	765	0,9315

WATER SUPPLY TO

PORTUGUESE REGIONAL HOSPITALS

ANNEXE 5

NUMERIC DECOMPOSITION OF MONTH SEASONS

Water Supply to Hospital Amadora Sintra

Data Processing - Month Seasons - Numeric Data Decomposition - Seasonal Factors

Annexe 5

T_j	$\cos\frac{2\pi}{T}t_j$	$\sin\frac{2\pi}{T}t_j$	$\cos^2\frac{2\pi}{T}t_j$	$\sin^2\frac{2\pi}{T}t_j$	$\sin\frac{2\pi}{T}t_j\cos\frac{2\pi}{T}t_j$	Sn	$Sn\cos\frac{2\pi}{T}t_j$	$Sn\sin\frac{2\pi}{T}t_j$	SN_j
1	0,8660	0,5000	0,7500	0,2500	0,4330	0,9045	0,7833	0,4522	0,8753
2	0,5000	0,8660	0,2500	0,7500	0,4330	0,9461	0,4730	0,8193	0,8846
3	0,0000	1,0000	0,0000	1,0000	0,0000	0,9231	0,0000	0,9231	0,9252
4	-0,5000	0,8660	0,2500	0,7500	-0,4330	0,9145	-0,4572	0,7920	0,9861
5	-0,8660	0,5000	0,7500	0,2500	-0,4330	1,0295	-0,8916	0,5148	1,0512
6	-1,0000	0,0000	1,0000	0,0000	0,0000	1,1026	-1,1026	0,0000	1,1028
7	-0,8660	-0,5000	0,7500	0,2500	0,4330	1,2079	-1,0460	-0,6039	1,1273
8	-0,5000	-0,8660	0,2500	0,7500	0,4330	1,1331	-0,5665	-0,9813	1,1180
9	0,0000	-1,0000	0,0000	1,0000	0,0000	1,0574	0,0000	-1,0574	1,0774
10	0,5000	-0,8660	0,2500	0,7500	-0,4330	0,9586	0,4793	-0,8302	1,0165
11	0,8660	-0,5000	0,7500	0,2500	-0,4330	0,9329	0,8079	-0,4665	0,9514
12	1,0000	0,0000	1,0000	0,0000	0,0000	0,8898	0,8898	0,0000	0,8998
	5*∑= 0	5*∑= 0	5*∑= 30	5*∑= 30	5*∑= 0	∑= 12	5*∑= -3,1532	5*∑= -2,1895	∑= 12

Model 4.6 $$SN_j = 1.0000 - 0.1051\cos\frac{\pi}{6}t_j - 0.0730\sin\frac{\pi}{6}t_j$$

WATER SUPPLY TO

PORTUGUESE REGIONAL HOSPITALS

ANNEXE 6

RESOLUTION OF EQUATION 4.11

Water Supply to Hospital Amadora Sintra

Data Processing - Week Seasons - Numeric Data Decomposition - Seasonal Factors

Model 4.11 $SN_j = 1.0000 - 0.1150\cos\frac{\pi}{26}t_j - 0.0634\sin\frac{\pi}{26}t_j$

Annexe 6

T_j	$\cos\frac{2\pi}{T}t_j$	$\sin\frac{2\pi}{T}t_j$	$\cos^2\frac{2\pi}{T}t_j$	$\sin^2\frac{2\pi}{T}t_j$	$\sin\frac{2\pi}{T}t_j\cos\frac{2\pi}{T}t_j$	Sn	$Sn\cos\frac{2\pi}{T}t_j$	$Sn\sin\frac{2\pi}{T}t_j$	SN_j
1	4,9635	0,6027	4,9274	0,0726	0,5983	0,9408	4,6696	0,5670	0,8782
2	4,8547	1,1966	4,7136	0,2864	1,1618	0,9572	4,6468	1,1453	0,8732
3	4,6751	1,7730	4,3713	0,6287	1,6578	0,9011	4,2129	1,5977	0,8700
4	4,4273	2,3236	3,9202	1,0798	2,0575	0,9392	4,1580	2,1823	0,8687
5	4,1149	2,8403	3,3865	1,6135	2,3375	0,9328	3,8385	2,6495	0,8693
6	3,7426	3,3156	2,8013	2,1987	2,4818	0,8934	3,3439	2,9624	0,8719
7	3,3156	3,7426	2,1987	2,8013	2,4818	0,8662	2,8719	3,2417	0,8763
8	2,8403	4,1149	1,6135	3,3865	2,3375	0,9052	2,5711	3,7249	0,8825
9	2,3236	4,4273	1,0798	3,9202	2,0575	0,8704	2,0226	3,8538	0,8904
10	1,7730	4,6751	0,6287	4,3713	1,6578	0,9070	1,6082	4,2405	0,8999
11	1,1966	4,8547	0,2864	4,7136	1,1618	0,9415	1,1266	4,5710	0,9109
12	0,6027	4,9635	0,0726	4,9274	0,5983	0,9372	0,5648	4,6517	0,9232
13	0,0000	5,0000	0,0000	5,0000	0,0000	0,9324	0,0000	4,6622	0,9366
14	-0,6027	4,9635	0,0726	4,9274	-0,5983	0,8949	-0,5394	4,4422	0,9509
15	-1,1966	4,8547	0,2864	4,7136	-1,1618	0,9316	-1,1147	4,5226	0,9660
16	-1,7730	4,6751	0,6287	4,3713	-1,6578	0,9232	-1,6368	4,3159	0,9815
17	-2,3236	4,4273	1,0798	3,9202	-2,0575	0,9164	-2,1294	4,0573	0,9973
18	-2,8403	4,1149	1,6135	3,3865	-2,3375	0,9251	-2,6277	3,8069	1,0132
19	-3,3156	3,7426	2,1987	2,8013	-2,4818	0,9473	-3,1408	3,5452	1,0288
20	-3,7426	3,3156	2,8013	2,1987	-2,4818	1,0367	-3,8799	3,4373	1,0440
21	-4,1149	2,8403	3,3865	1,6135	-2,3375	1,0643	-4,3795	3,0229	1,0586
22	-4,4273	2,3236	3,9202	1.0798	-2,0575	1.0428	-4,6170	2,4232	1,0724
23	-4,6751	1,7730	4,3713	0,6287	-1,6578	1.0960	-5,1240	1.9433	1.0850
24	-4,8547	1,1966	4,7136	0.2864	-1,1618	1,0915	-5,2989	1.3060	1.0965
25	-4,9635	0,6027	4,9274	0.0726	-0.5983	1.0813	-5,3672	0,6517	1,1065
26	-5,0000	0,0000	5,0000	0.0000	0.0000	1,1725	-5,8627	0,0000	1,1150

Water Supply to Hospital Amadora Sintra

Data Processing - Week Seasons - Numeric Data Decomposition - Seasonal Factors

Model 4.11 $SN_j = 1.0000 - 0.1150\cos\frac{\pi}{26}t_j - 0.0634\sin\frac{\pi}{26}t_j$

Annexe 6

T_j	$\cos\frac{2\pi}{T}t_j$	$\sin\frac{2\pi}{T}t_j$	$\cos^2\frac{2\pi}{T}t_j$	$\sin^2\frac{2\pi}{T}t_j$	$\sin\frac{2\pi}{T}t_j\cos\frac{2\pi}{T}t_j$	Sn	$Sn\cos\frac{2\pi}{T}t_j$	$Sn\sin\frac{2\pi}{T}t_j$	SN_j
27	-4,9635	-0,6027	4,9274	0,0726	0,5983	1,1839	-5,8766	-0,7135	1,1218
28	-4,8547	-1,1966	4,7136	0,2864	1,1618	1,2101	-5,8747	-1,4480	1,1268
29	-4,6751	-1,7730	4,3713	0,6287	1,6578	1,2395	-5,7949	-2,1977	1,1300
30	-4,4273	-2,3236	3,9202	1,0798	2,0575	1,1923	-5,2789	-2,7706	1,1313
31	-4,1149	-2,8403	3,3865	1,6135	2,3375	1,2247	-5,0396	-3,4786	1,1307
32	-3,7426	-3,3156	2,8013	2,1987	2,4818	1,1819	-4,4234	-3,9188	1,1281
33	-3,3156	-3,7426	2,1987	2,8013	2,4818	1,0953	-3,6316	-4.0992	1,1237
34	-2,8403	-4,1149	1,6135	3,3865	2,3375	1,0460	-2,9711	-4,3044	1,1175
35	-2,3236	-4,4273	1,0798	3,9202	2,0575	1,1056	-2,5690	-4.8947	1,1096
36	-1,7730	-4,6751	0,6287	4,3713	1,6578	1,0449	-1,8527	-4,8851	1,1001
37	-1,1966	-4,8547	0,2864	4,7136	1,1618	1,1218	-1,3423	-5.4461	1,0891
38	-0,6027	-4,9635	0,0726	4,9274	0,5983	1,0930	-0,6587	-5,4251	1,0768
39	0,0000	-5,0000	0,0000	5,0000	0,0000	1,1054	0,0000	-5,5269	1,0634
40	0,6027	-4,9635	0,0726	4,9274	-0,5983	1,0304	0,6210	-5.1143	1,0491
41	1,1966	-4,8547	0,2864	4,7136	-1,1618	0,9218	1,1031	-4.4753	1.0340
42	1,7730	-4,6751	0,6287	4,3713	-1,6578	0,9200	1,6311	-4,3010	1,0185
43	2,3236	-4,4273	1,0798	3,9202	-2,0575	0,9167	2,1301	-4,0586	1,0027
44	2,8403	-4,1149	1,6135	3,3865	-2,3375	0,9335	2,6516	-3,8415	0,9868
45	3,3156	-3,7426	2,1987	2,8013	-2,4818	0,9484	3,1445	-3,5494	0,9712
46	3,7426	-3,3156	2,8013	2,1987	-2,4818	0,8855	3,3095	-2,9320	0,9560
47	4,1149	-2,8403	3,3865	1,6135	-2,3375	0,9675	3,9813	-2,7481	0,9414
48	4,4273	-2,3236	3,9202	1,0798	-2,0575	1,0085	4,4651	-2,3434	0,9276
49	4,6751	-1,7730	4,3713	0,6287	-1,6578	0,9335	4,3643	-1,6552	0,9150
50	4,8547	-1,1966	4,7136	0,2864	-1,1618	0,9043	4,3903	-1,0821	0,9035
51	4,9635	-0,6027	4,9274	0,0726	-0,5983	0,9178	4,5554	-0,5531	0,8935
52	5,0000	0,0000	5,0000	0,0000	0,0000	0,8200	4,1002	0,0000	0,8850
5*∑	0,0000	0,0000	130,0000	130,0000	0,0000	52,0000	-14,9488	-8,2383	52,0000

WATER SUPPLY TO

PORTUGUESE REGIONAL HOSPITALS

ANNEXE 7

MULTIPLE REGRESSION VALUES

Water Supply to Hospital Amadora Sintra

Determination of multiple regression most probable values

$$P_i = -421.337 + 271.576 t_i + 824.677 q_i$$

$$SN_j = 1.000 - 0.1051 \cos\frac{\pi}{6} t_j - 0.0730 \sin\frac{\pi}{6} t_j$$

Annexe 7

q_i (°C)	T_i (month)	T_j (month of the year)	p_i	SN_j	$p_i SN_j$
11	1	1	8922	0,8725	7784
11,5	2	2	9606	0,8842	8494
13,5	3	3	11527	0,9270	10685
16	4	4	13860	0,9893	13712
17	5	5	14956	1,0545	15771
20	6	6	17702	1,1051	19562
22	7	7	19623	1,1275	22125
22,5	8	8	20307	1,1158	22657
21,5	9	9	19753	1,0730	21195
18	10	10	17139	1,0107	17321
14	11	11	14111	0,9455	13342
12	12	12	12734	0,8949	11395
11	13	1	12181	0,8725	10627
11,5	14	2	12865	0,8842	11375
13,5	15	3	14785	0,9270	13706
16	16	4	17119	0.9893	16936
17	17	5	18215	1,0545	19208
20	18	6	20961	1,1051	23164
22	19	7	22882	1,1275	25799
22,5	20	8	23565	1,1158	26294
21,5	21	9	23012	1,0730	24692
18	22	10	20398	1,0107	20615
14	23	11	17370	0,9455	16423
12	24	12	15993	0,8949	14312
11	25	1	15440	0,8725	13471
11,5	26	2	16123	0,8842	14257
13,5	27	3	18044	0,9270	16727
16	28	4	20378	0,9893	20160
17	29	5	21474	1,0545	22645
20	30	6	24219	1,1051	26765
22	31	7	26140	1,1275	29474
22,5	32	8	26824	1,1158	29930
21,5	33	9	26271	1,0730	28189
18	34	10	23656	1,0107	23909
14	35	11	20629	0,9455	19505
12	36	12	19252	0,8949	17228
11	37	1	18698	0,8725	16314
11,5	38	2	19382	0,8842	17138
13,5	39	3	21303	0,9270	19748

Water Supply to Hospital Amadora Sintra

Determination of multiple regression most probable values

$$P_i = -421.337 + 271.576t_i + 824.677q_i$$

$$SN_j = 1.000 - 0.1051\cos\frac{\pi}{6}t_j - 0.0730\sin\frac{\pi}{6}t_j$$

Annexe 7

q_i (°C)	T_i (month)	T_j (month of the year)	p_i	SN_j	p_iSN_j
16	40	4	23637	0,9893	23384
17	41	5	24733	1,0545	26081
20	42	6	27478	1,1051	30366
22	43	7	29399	1,1275	33148
22,5	44	8	30083	1,1158	33566
21,5	45	9	29530	1,0730	31686
18	46	10	26915	1,0107	27202
14	47	11	23888	0,9455	22586
12	48	12	22510	0,8949	20145
11	49	1	21957	0,8725	19157
11,5	50	2	22641	0,8842	20020
13,5	51	3	24562	0,9270	22769
16	52	4	26895	0,9893	26608
17	53	5	27992	1,0545	29518
20	54	6	30737	1,1051	33968
22	55	7	32658	1,1275	36823
22,5	56	8	33342	1,1158	37202
21,5	57	9	32789	1,0730	35183
18	58	10	30174	1,0107	30496
14	59	11	27147	0,9455	25667
12	60	12	25769	0,8949	23061
11	61	1	25216	0,8725	22001
11,5	62	2	25900	0,8842	22902
13,5	63	3	27821	0,9270	25790
16	64	4	30154	0,9893	29833

WATER SUPPLY TO

PORTUGUESE REGIONAL HOSPITALS

ANNEXE 8

TEMPERATURE RECORDS

Maximum Recorded Temperatures as supplied by the Instituto de Meteorologia, I.P.

Period: January 2003 to December 2008

Lisboa / Gago Coutinho

Maximum air temperature (ºC)

Annexe 8

2003

Day	January	February	March	April	May	June	July	August	September	October	November	December
1	16,5	11,4	14,5	22,2	19,3	23,2	25	42	26	21,3	17	11,9
2	16,7	15,2	15,1	17,7	19,9	23,3	24,1	39,3	24	22	17,3	12,3
3	17	15,3	19,2	22,8	24,3	22,5	24,7	27,6	24,7	19,8	17,7	13,5
4	17,3	14,3	18,7	18,7	20,3	22,8	24,2	33,4	25,2	23,8	15,6	11,8
5	16	15,5	17,6	20,8	17,8	22,6	23,3	36,8	24,6	24,1	20,4	11,5
6	13,9	15,5	16,4	23,2	16,5	29,1	26,5	37,7	27,5	23,8	22	13,6
7	17,4	14,2	15,1	25,1	18,1	25	30,8	34,9	24,3	26	20,7	16
8	12,9	16,2	18,5	23,3	23,8	26,3	28,6	33	24,7	27	17,7	12,4
9	12,1	15,4	19,7	17,3	23,3	27,3	29,7	34,1	26,1	28,2	17,4	14
10	10,1	15,2	22,2	15,5	23,3	27,4	30,2	35,3	31,8	26	18,1	14,5
11	8,8	15,2	20,9	16,1	22,2	31,9	25,7	39,4	35,6	19,4	17,6	15,5
12	9,2	15,4	19,7	18,5	25,3	37,3	22,3	36,9	36,9	23,3	18	14,3
13	8,9	14,7	23,7	17,1	25	33,4	23,1	34,5	35,5	22,6	19,9	15,7
14	10,1	13,8	19	15,3	26,6	24,8	24,9	31,2	35,7	22,1	17,3	17,3
15	9,8	14,6	19,5	18,3	23,3	23,1	22,8	27,6	29,6	19,9	17,1	17
16	10,2	13,6	19,2	20,3	20,9	22,3	24,3	26	31,3	19,8	15,1	12,5
17	13,1	15	15	19,8	22,2	24	27,7	26,4	32,2	21,9	17	15,5
18	14,7	15,1	17,9	16,8	23,6	35,3	28,6	29,2	31	19,8	18,5	15,9
19	15	11,7	18,7	16,7	24	39,3	28,3	28,5	28,5	20,6	19,2	14,5
20	14,3	14	19,7	18	27,7	32,6	25,7	27,2	25,6	20,7	18,8	12,3
21	15	13	20,2	19,3	32,5	29,5	25,9	27,5	25,7	19,9	16,8	15,3
22	15,9	16,5	20,1	19,3	34,3	25,4	27,3	30,9	25,6	19	15,3	14,8
23	15,5	17	19,5	18,6	32,2	24,4	25,4	27	26,5	17,1	15,7	11,6
24	15,6	15,3	17,9	19,3	20	24,4	28,3	24,6	26,3	16,3	14,5	12,8
25	18,4	12,5	18,1	16,6	22,2	25,6	28,3	26,6	28,8	15,9	14,7	11,3
26	19,5	15,4	18,2	20,1	27	23,9	28,3	26,4	30,4	20,2	16,1	12,5
27	22,1	15,4	17,1	21,3	30,1	26,3	26,8	25,3	23,7	19,2	15,4	13,4
28	21,7	16,2	19,3	19,2	31	24,6	28,9	22,8	24,9	19,8	15,2	14,1
29	14,4		15,9	17,8	29,4	20,2	37,2	25,8	24,6	17,7	18,2	13,8
30	14,2		17	18,8	22,2	23,1	38,5	26,5	20,7	17,8	16,1	16,2
31	11,8		19		27,8		40	26,4		16,8		14,9

Water Supply to Hospital Amadora Sintra

Maximum Recorded Temperatures as supplied by the Instituto de Meteorologia, I.P.

Period: January 2003 to December 2008

Lisboa / Gago Coutinho

Maximum air temperature (°C)

Annexe 8

2004

Day	January	February	March	April	May	June	July	August	September	October	November	December
1	15,6	15,6	11,4	13,9	17,2	28,1	25,5	30,5	24,3	26,7	19,9	12,5
2	15	19,1	12,2	15,7	18	28	27,6	27,9	21,6	29,5	18,4	11,8
3	15,3	19,5	15,7	18,7	19,5	31,8	29,7	26,1	25,9	32,3	20,3	14,8
4	15,7	19,3	18,8	21,7	17,2	28,7	28,8	26,6	26,9	29,5	18,4	13,2
5	15,1	18,3	17,1	24,8	16,7	24,8	27,4	29,9	24,6	28,1	19,6	14,6
6	14	17	18	24	17,2	24,2	22,5	29,4	25,3	26	21,9	15,1
7	13,1	15,1	16,8	20	17,3	26,1	23,1	30,5	25,9	30,2	20,4	14,2
8	15,6	14,7	17,7	18,5	18,2	30	23,7	24,4	25,1	23,3	19,2	12,5
9	17,9	13,5	17,6	18,9	17,1	30,8	25	23,8	27	20,5	20	10,9
10	17,8	15	17,4	17,9	16,5	30,7	25,3	25	26,4	19,4	17	12,8
11	18,4	16,9	16,1	18,2	20,9	28,8	27,1	25,1	26,9	21,1	16,2	14,1
12	16,2	17,5	14,7	19,8	22,2	30,3	30,3	27	24,8	21,4	17	15,7
13	16,3	15,9	15,7	22,3	24,3	33	35,2	29,3	24,3	21,9	17	14
14	16,7	16	17,7	21,6	25,4	34,4	35,2	31,4	24,5	19,4	15,6	15,1
15	11,3	14,5	22	21,6	25,6	31,8	31	29,5	25	19	14,6	16,5
16	14,7	14,8	22,5	15,9	27,5	30,2	28,7	28,3	30,9	20,5	15,8	16,9
17	15,6	13,6	20,2	16,2	29,7	33,2	27,9	25,4	31,3	19,6	15,8	15,9
18	13,9	15,2	18,7	15,7	28,5	27,3	27,6	25,8	29,5	19,7	15,9	16,7
19	12,9	15,3	20,1	16,9	30,1	23,5	26,3	26	26,1	21,8	14,8	15,9
20	15,1	13,1	21,7	17,7	27,9	25,4	28,2	26,1	26,4	21,6	15,2	14,5
21	14,6	13,4	19,3	15,8	23,2	24,2	28,8	30,1	32	20,7	14,8	13,6
22	14,1	12,5	16,6	18,3	23,1	24,5	29,8	29,4	31,7	21,2	16,9	13,1
23	15,7	11,8	16,4	23	22,7	26,2	35,3	28,8	31,5	21,3	17,2	14,1
24	17,9	15,7	14,4	25,8	21,8	26,1	38,1	29,2	27,2	19,4	16,7	13,8
25	15,3	14	17	28,1	21,3	30,1	37,6	31,2	29,2	20	16,8	12,2
26	16,3	13,7	14,5	28,6	23,2	30,7	35,4	31,9	30,7	18,1	16,7	11,7
27	16,3	13	10,5	26	22,7	31,1	34	29,7	32,5	19,8	14,5	12,3
28	13,7	13,9	14,8	20,6	23,6	33,4	26,3	28,1	28,3	18,5	15,3	14,6
29	10,3	14,4	15	18,3	23,7	35	27,1	28,9	31,6	17,7	15,4	14,5
30	15,2		15,5	15,9	24,9	28,6	28,6	26,1	27,7	17,6	17,1	16,3
31	16,1		16,5		24,8		31,7	26,3		18		17,8

Water Supply to Hospital Amadora Sintra

Maximum Recorded Temperatures as supplied by the Instituto de Meteorologia, I.P.

Period: January 2003 to December 2008

Lisboa / Gago Coutinho

Maximum air temperature (°C)

Annexe 8

2005

Day	January	February	March	April	May	June	July	August	September	October	November	December
1	13,7	13,7	10,7	20,1	20,8	31,7	28,6	24,9	28,6	29,2	20,4	15,1
2	14,4	16,1	13	15,3	20,3	29,2	32,7	32,6	31,8	29,6	21	16,4
3	14,4	15,9	13,3	19,5	21,3	24,3	27,2	37	33,8	27	17,9	17,1
4	12,8	14	13,3	18,6	21,9	26,9	23,7	39,7	31,8	29,5	18,3	16,4
5	13,8	11,8	15,8	22,6	27	34,2	27,6	38,5	25,1	29,7	17,7	15,7
6	12,9	11,7	15	22,8	29,8	34,4	29,5	37,2	24,1	30,3	18,1	14,4
7	12,9	11,6	15,4	22,2	23,1	35,3	27,6	31,7	24,5	28,2	18,1	15,2
8	12	14	17	18,4	20,8	34,4	31,9	27,6	25,9	26,3	19,1	15,5
9	12,5	16,6	17,4	19	21,1	29,3	32,6	23,4	24	20,5	16,8	17,3
10	13,1	17	16,4	19,9	21,5	28,8	29,6	26,7	23,9	23,4	18,1	14,6
11	13,7	17,8	20	22	20,3	24,2	32,1	28,4	23,2	23,2	17,4	13,9
12	15,4	17,5	17,7	22	20,9	21,3	31,3	34,9	27,2	20,3	15,9	15,6
13	15	16,3	18,5	18,1	19,4	22,9	29,8	35	31,4	19	14,1	13,9
14	16,2	16,6	20,1	16,8	19,9	24,5	28,2	35,6	32,4	18,8	15,1	12,9
15	14,4	16,4	22,3	15,8	19,6	27,5	29,1	31,8	32,7	19,5	18,3	11,7
16	15,9	13,4	21,9	16,4	17,7	33,4	27,1	28,2	27,1	20,9	16,5	11,1
17	17	13,8	27,1	16,2	20,8	36	25,3	29	25,8	21	15,1	15,1
18	15,1	12,9	22,8	17,4	24,9	32,3	27,6	27,5	25,8	20,6	16,4	12,7
19	16,1	15,5	18,5	18,3	28,4	32,3	35,2	28,8	27,3	21,7	16,3	13,1
20	17,6	14,1	19,4	19,3	24,1	31,5	35,5	32,6	29,8	19,8	15,2	14,4
21	18	12,9	16	20,8	21,3	36	28	31,7	28,5	19	17,5	14,1
22	16,7	13,8	19,1	19,9	20,1	30,9	27,8	32,3	28,9	21,3	16,7	13,8
23	14,9	14,8	17,8	16,6	23,5	25,7	25,6	34,1	25,6	20,6	17,4	11,8
24	13,1	15,4	20,1	19	31,2	21,4	27	28,9	23,8	21,5	14,8	14,5
25	11,3	13,6	18,5	20,3	29,3	24,8	25,9	27,3	25,3	21,4	15,6	13
26	11,6	12,9	17,5	23,4	28,3	23,7	25,9	28,4	29	23,3	11,7	15,5
27	9,5	10,6	16,8	25,2	21,8	23,1	24,4	28	30,2	19,9	13,3	15,1
28	10,5	11,1	17,1	25,9	21,9	23,7	25,2	29,2	27,7	20,4	14,1	14,3
29	12,7		18,7	26,4	21,8	24,5	25,5	31,1	30,3	20,5	14,5	14,9
30	13,1		22	20	24,1	26,2	25,8	29,9	33,3	19,6	13,9	15,4
31	12,4		28,6		29,6		25,2	26,5		19,8		15,7

Water Supply to Hospital Amadora Sintra

Maximum Recorded Temperatures as supplied by the Instituto de Meteorologia, I.P.

Period: January 2003 to December 2008

Lisboa / Gago Coutinho

Maximum air temperature (°C)

Annexe 8

2006

Day	January	February	March	April	May	June	July	August	September	October	November	December
1	14,6	14,1	15,6	19,8	25	23,1	24	27,4	31,5	25,4	20,5	17,4
2	15,2	13,6	13,8	21,6	23,6	29,9	24,1	29,9	30,7	23,6	19,5	15,7
3	15,3	14,1	14,5	24,8	19,4	32,6	24,1	25,6	36,4	22,2	21,7	18,1
4	13,2	13,6	16,1	18,8	19,8	31,5	25	34,7	39	22,5	21,5	19,4
5	15,5	13,5	12,6	16,9	22,5	32,9	24,7	33	32,9	23,1	22,7	17,6
6	12,2	13,9	13,9	16,8	21,1	28	26,3	38	34,1	24,6	19,6	15,7
7	12,5	16,3	15,9	17,6	19,9	27,3	30,9	33,7	32,6	26,2	20,9	16,8
8	12,6	15,6	15,2	21,1	20,6	26,3	27,7	32,6	34,3	27,5	21,2	16,6
9	13,2	12,9	16,5	19,5	25	23,8	31,7	36,8	33,2	26,5	22,1	11,7
10	12	17,4	15,5	21	28,1	25,5	33,3	35,9	28,9	22,1	21,4	12,5
11	13	19,8	16,3	22,1	23	29,9	34	36,1	26,6	22,3	21	13
12	12,5	17,8	22,1	19,4	23,4	28,5	36	34,3	26,2	23,7	20,1	14,4
13	14,2	17,3	22,7	24	26,1	25	35,2	28,3	22,4	24,7	19	14,4
14	13,3	17,6	23,4	18,2	26,3	23,2	36	28	23,1	24,5	14,6	14,4
15	12,4	15,5	17,3	19	25,7	23	36,8	23,9	23,3	22,9	18,4	13,3
16	12,6	16,3	16,8	17,6	29,8	25,7	34,8	22,7	24,5	19,9	17,4	13,2
17	11,5	15,3	16,6	17,2	26,7	22,7	32	23,5	26,5	22,5	18,2	13,6
18	13,8	15,6	16,6	20,3	22,8	27	32,3	23,5	27,5	21,8	19,8	15
19	15,5	13,1	15,6	17,7	22,1	25,3	27,4	25,1	28,4	19,3	19,1	13,1
20	15,4	12,7	16,7	17,8	24,9	23,6	29,9	30,8	27	20,9	19,1	10,9
21	14,3	13,1	16,3	16,6	23	27,4	28,2	35,7	22,8	21,5	19,4	12,1
22	11,8	12,1	14,5	16,7	20,4	30,5	27,8	34,3	22,5	20,4	18,1	11,1
23	12,4	10,7	15,6	23	20,4	26,3	29	26,7	23,5	22,4	18,3	10,9
24	12,6	12	18,2	23,7	24,7	22,8	27,5	27	22,4	22	19,3	12,1
25	13	10	18,2	25,6	28,7	21,5	28,8	30,1	25,2	21,1	17	10,8
26	14,1	12,2	19,7	27,4	32,1	21,9	27,4	27,7	27,8	19,8	17,2	12,2
27	9,7	14,2	19,2	22,4	33,6	22,7	26,1	31,6	25,9	22,8	18,2	14,2
28	10,6	15,8	17,8	26,3	34,6	22,9	27,2	32	24,6	26,3	17,3	16,5
29	7		16,1	25,5	32,8	25,1	29,4	34,5	24,1	24,9	15,3	16,1
30	10		19,5	25,2	25,5	27,4	28,9	36,4	23,3	25	16,5	17,5
31	14,1		19,4		23,3		28,4	33,8		20		17

Maximum Recorded Temperatures as supplied by the Instituto de Meteorologia, I.P.

Period: January 2003 to December 2008

Lisboa / Gago Coutinho

Maximum air temperature (℃)

Annexe 8

2007

Day	January	February	March	April	May	June	July	August	September	October	November	December
1	16,7	13,7	17,5	15,4	16,9	24	24,5	27,4	28,9	23,1	20,8	15,7
2	15,2	14	17,4	14,7	16,5	30,4	25	30,8	32,7	20,8	23	15,5
3	14	14,1	17,8	15,6	19,2	26,1	22,9	36,1	31,9	22,1	23,1	16,9
4	16,5	14	16	16,6	18,5	31,5	26,8	34,6	30	22,5	22,8	12,8
5	16,9	13,3	16,2	17,2	21,4	31,1	33,6	25,9	34,1	23,4	24,7	11,3
6	14,9	14,2	16,5	19,7	24,1	25,4	33,9	23,5	30,9	24,9	23,9	17,6
7	17,2	15	17,6	19,1	24,7	24,3	27,2	26,3	29,7	25,8	24,2	17,9
8	15,2	16,9	18,1	17,1	30,2	24,2	26,8	33,1	25,6	24,4	22,7	16,9
9	13,1	16,5	21,1	18,6	30,2	23,4	24,8	34,1	24,7	28,1	23,2	17,8
10	11,4	17,4	21,9	20,9	24,7	22	30	29,2	28,7	28,1	21,2	15,9
11	15,4	16,2	22	20,1	21,8	22,7	31,6	26,6	27,7	24,9	20,7	14,9
12	13,9	17,2	19	17,8	20,7	23,3	33,4	24,9	26,7	24,2	22,8	13,4
13	13,9	16,9	20,4	19,1	19,8	22,3	31	25,4	27,5	25,5	21,4	12,9
14	11,9	17,8	20,9	20,9	19,6	21,6	30,3	27,9	27,3	25,8	19,7	13,5
15	13,6	16	21,1	24,6	22,2	22,9	23,5	26,5	30,4	24,3	19	13,3
16	15,3	15,7	22,6	25,9	26,7	20,2	24,6	24,4	28,2	25,9	18,5	11,2
17	16	15,2	21,2	26,4	32,1	21,7	25,6	29,2	23,9	26,2	13,4	10,4
18	14,9	15	21,7	24,6	32,6	22,7	24,9	25,7	24,8	26,9	16,7	13,8
19	16	15	14,2	23,1	21,2	21,6	24	24,3	27	26,5	18	13,2
20	17,6	13,5	14,2	18,2	16,9	22,3	24,4	27,5	28,3	26,7	16,7	13
21	16,2	15,4	13,6	25,7	17,6	22,6	23,7	24,6	25,8	25,1	18,7	15,8
22	12,8	17,6	16,2	27,6	16,8	23,5	25,5	28,8	24,5	24	16,7	15,5
23	11,6	17	16,9	27,8	24,1	26,5	25	31,6	27,5	21,7	14,7	15,4
24	11,2	17,5	16,6	22,7	20,7	23,1	26,9	32,6	27,7	19,4	15,2	15,3
25	12	17,9	16	18,9	18,3	23,2	28,3	25,8	23,6	21,1	14,8	14,6
26	10,2	16,5	17,5	17,6	21,4	23,4	29,2	30	27,3	20,6	17	15,1
27	11,2	18,5	15,8	18,9	19,3	25	30,5	29,7	28	21,5	15,6	14,4
28	7,4	15,9	16,1	18,8	20,1	23,9	36,5	26	24,7	22,1	15	13,7
29	11,9		17,4	20,1	22,7	25,7	40,3	26	21,5	21,9	15,9	12,3
30	11,5		15,6	17	21,4	25,2	40,6	29	21,1	22,2	13,8	14,7
31	13,7		14,7		21,3		29,3	32,1		20,4		12,7

Water Supply to Hospital Amadora Sintra

Maximum Recorded Temperatures as supplied by the Instituto de Meteorologia, I.P.

Period: January 2003 to December 2008

Lisboa / Gago Coutinho

Maximum air temperature (℃)

Annexe 8

2008

Day	January	February	March	April	May	June	July	August	September	October	November	December
1	14,4	14,4	20	23,8	19,3	20,8	28,4	26	27,4	23,1	15,4	10,5
2	15,5	15,3	19,6	25,2	23	22,3	24,1	29,9	25	22,1	15,8	12,8
3	14,5	15,9	18,6	28,7	24,8	23,2	24,6	32,7	23,2	20,6	16,1	14,2
4	15,6	15,9	19,3	30,2	23	21,7	27,7	33,4	25,2	25,5	17	15,5
5	16,4	15,5	15,7	22,4	23,7	22,3	28,1	31,8	23,6	25,2	18,2	16,1
6	16,9	17,5	15,8	22,6	26,4	26,7	22,9	29,3	23,9	24,2	18,2	15,8
7	18,3	19,3	18,6	19,3	24,2	28,5	24,4	25,8	25	20,7	18,9	15,8
8	16,4	18,6	16,8	17,7	20	27,8	27,1	26,6	26,1	21.6	16,9	16
9	16,3	18,7	16	19,6	18,5	26,4	28,2	30,7	28.7	23,1	18,3	13
10	17,5	18	15,4	16,4	18,5	27,3	27,1	28,3	28,2	27.1	19,6	13,1
11	15,5	16,4	18,4	15,5	17,1	29,7	24,4	25,7	23	23.2	18,7	13,2
12	14,2	17,1	19,1	17,5	20,3	31	24	25,1	24.3	20.4	16,8	13,7
13	15,6	15,5	21,9	18,1	19,3	31,6	25,9	25,4	27,4	22.7	17,2	14,8
14	15,9	17	21,5	19,4	19,2	30,6	32,4	23,8	30,1	24,7	17,6	12,6
15	15,2	18,2	17,9	21,9	17,8	22,6	33	28,8	27,5	26.1	17,8	11,9
16	15,6	17,9	17,2	19,5	20,1	23	33,1	25,3	23,4	23.1	19,2	13,3
17	16,1	13,6	17,1	17	19,9	25,1	32,9	26,9	23,9	22.7	20	14,9
18	14,7	14,5	16.9	16,3	19.1	26,5	37,3	26,3	25	22	17,2	10,9
19	16,9	16,2	12.2	15,8	19,3	29,5	30,8	25,7	28,8	24.7	18,7	13,2
20	17,8	17,3	17,5	16,5	19,6	29,4	26,2	25,9	28,8	25.8	18	15,3
21	18,2	18,1	18,6	17,6	21,6	30,6	32,6	27,4	25,9	23.6	18,8	15,9
22	21	19	15,4	18,6	20,3	27,9	30,8	24,8	26,4	17.8	20	14,6
23	18	15,9	14,1	20	19,7	24,4	26,3	27,3	24,8	21.6	19,2	14,2
24	16,2	17,8	16	26	18,9	24,8	25,4	27,2	24,4	22,9	16	13,4
25	15,7	19,6	15,9	30,2	18,9	30,4	25,3	25,7	27,9	25,1	14,3	13
26	16,2	20,4	17	27,4	19,1	28,8	26,6	26,3	28,3	26,1	13	14,3
27	16,3	18,6	18	26,2	19,5	32,3	27,1	28.1	26,8	20.3	14,9	10,5
28	17,1	18,2	18,8	19	19,1	34,9	26,6	31	23,8	15.5	14,9	11,8
29	18,3	19	21,3	18	20,4	30,7	25,8	27,2	26,9	16.5	11,2	14,4
30	16,2		17	18,7	20,1	29,9	27,8	25,7	28,7	18.1	11,3	15,6
31	16,6		18,5		20,5		28,3	26,6		15		16,7

WATER SUPPLY TO

PORTUGUESE REGIONAL HOSPITALS

ANNEXE 9

DAILY WATER CONSUMPTIONS AND AMBIENT TEMPERATURES

Water Supply to Hospital Amadora Sintra

Maximum recorded Day Temperatures (ºC) and Corresponding Day Water Consumptions (m^3/day)

Annexe 9

Mondays		Tuesdays		Wednesdays		Thursdays		Fridays		Saturdays		Sundays	
Temp (ºC)	(m^3/day)	Temp (ºC)	(m^3/day)	Temp (ºC)	(m^3/day)	Temp (ºC)	(m^3/day)	Temp (ºC)	(m^3/day)	Temp (ºC)	(m^3/day)	Temp (ºC)	(m^3/day)
10,4	762	15,2	701	11,2	722	16,5	579	16,9	555	14,9	697	7,4	734
11,9	723	13,1	791	11,3	844	15,4	583	13,9	416	13,9	757	11,2	693
12,7	765	15,3	716	11,4	724	14,9	507	16	463	17,6	779	11,9	653
12,8	766	11,6	748	12,2	756	12	538	10,2	434	11,2	760	13,6	526
13,3	729	11,5	703	13,2	794	13,7	598	14	443	14,1	767	14	732
13,6	691	14,2	707	13,4	930	16,9	581	16,5	631	17,4	579	14,1	583
14,2	722	16,9	754	13,6	880	16	844	15,7	748	15,2	617	14,7	609
14,5	913	13,5	707	13,7	705	17,6	823	17	775	17,5	598	14,8	751
14,7	728	18,5	828	14	769	17,5	783	17,4	879	17,8	625	15	562
15	719	16,5	829	15	715	18,1	885	21,1	788	21,9	642	15,4	574
15,2	857	20,4	869	15	913	21,1	838	22,6	787	21,2	665	15,4	587
15,3	677	14,2	859	15,1	783	16,2	869	16,9	773	16,6	717	15,5	669
15,4	897	15,8	806	15,4	746	17,4	882	15,6	853	14,7	663	15,6	551
15,9	851	15,6	749	15,5	1021	17,2	780	19,7	653	19,1	633	15,9	625
15,9	928	20,9	724	15,5	882	17,8	874	19,1	739	20,9	671	16	554
15,9	844	26,4	761	15,6	913	23,1	820	18,2	796	25,7	631	16	571
16	814	22,7	822	15,7	822	17,6	751	18,9	862	18,8	601	16	621
16,2	789	16,9	724	15,9	734	19,2	834	18,5	841	21,4	746	16,2	703
16,4	899	30,2	1008	16	789	24,7	874	21,8	865	20,7	789	16,2	557
16,5	800	22,2	877	16,1	774	32,1	802	32,6	1020	21,2	718	16,3	528
16,7	714	16,8	821	16,2	868	20,7	878	18,3	768	21,4	712	16,5	643
16,9	802	22,7	849	16,3	824	21,3	885	24	964	30,4	718	16,7	705
17	747	31,1	999	16,5	886	24,3	755	24,2	857	23,4	773	16,9	620
17	837	23,3	907	16,6	885	21,6	890	22,9	901	20,2	765	16,9	495
17,1	914	21,6	899	17	819	22,6	946	23,5	884	26,5	752	17	498
17,1	717	23,4	945	17,3	915	23,9	946	25,7	1055	25,2	739	17,1	551

Water Supply to Hospital Amadora Sintra

Maximum recorded Day Temperatures (°C) and Corresponding Day Water Consumptions (m^3/day)

Annexe 9

Mondays		Tuesdays		Wednesdays		Thursdays		Fridays		Saturdays		Sundays	
Temp (°C)	(m^3/day)	Temp (°C)	(m^3/day)	Temp (°C)	(m^3/day)	Temp (°C)	(m^3/day)	Temp (°C)	(m^3/day)	Temp (°C)	(m^3/day)	Temp (°C)	(m^3/day)
17,2	795	22,9	1093	17,5	859	33,6	1110	33,9	1119	27,2	798	17,2	565
17,5	739	30	955	17,6	780	33,4	1085	31	954	30,3	979	17,2	629
17,6	906	25,6	1377	17,8	889	24	927	24,4	1131	23,7	727	17,8	608
17,6	909	26,9	974	18	861	29,2	930	30,5	1101	36,5	780	17,8	517
18	938	29,3	1003	18,6	789	30,8	968	36,1	1038	34,6	786	17,8	532
18,2	906	26,3	946	18,7	1014	34,1	847	29,2	938	26,6	801	17,9	595
18,3	902	27,9	860	18,7	774	24,4	944	29,2	904	25,7	770	18	592
18,5	831	24,6	903	18,9	620	31,6	938	32,6	991	25,8	807	18,1	530
18,6	750	26	990	19,1	822	29	936	32,1	885	28,9	725	19,3	591
18,6	721	30	1097	19,4	917	30,9	802	29,7	845	25,6	743	19,6	593
19	836	27,7	659	19,5	881	27,5	813	27,3	876	30,4	741	19,8	701
19	868	24,8	476	19,6	870	28,3	1341	25,8	888	24,5	588	20,1	573
19,3	916	23,6	814	19,7	995	28	1341	24,7	999	21,5	756	20,7	729
19,4	920	20,8	959	20	808	22,5	907	23,4	870	24,9	794	21,1	669
19,6	845	28,1	921	20,1	825	24,9	1062	24,2	894	25,5	848	21,7	561
19,6	907	25,9	1013	20,4	897	26,9	977	26,5	856	26,7	833	21,7	703
20,1	803	21,7	1012	20,9	805	21,1	906	20,6	974	21,5	741	22	526
21,9	843	22,2	998	21,4	841	20,8	925	23	849	23,1	784	22	542
22,7	891	23,9	998	22,1	959	22,7	956	23,2	984	21,2	745	22,1	826
22,7	892	21,4	904	22,3	966	19	929	18,5	955	13,4	790	22,6	586
22,8	983	16,7	845	22,3	996	1637	963	14,7	930	15,2	808	22,8	747
23,1	731	15,6	1047	24,1	922	15,9	1026	13,8	834	15,7	703	23,1	658
23,2	834	12,8	851	24,2	901	17,6	846	17,9	905	16,9	668	23,5	860
23,5	946	14,9	774	24,6	776	12,9	848	13,5	837	13,3	721	24,1	687
23,9	840	13,8	904	24,9	1044	13	761	15,8	909	15,5	673	24,3	717
24	888	14,6	588	25	999	14,4	768	13,7	844	12,3	635	24,5	751

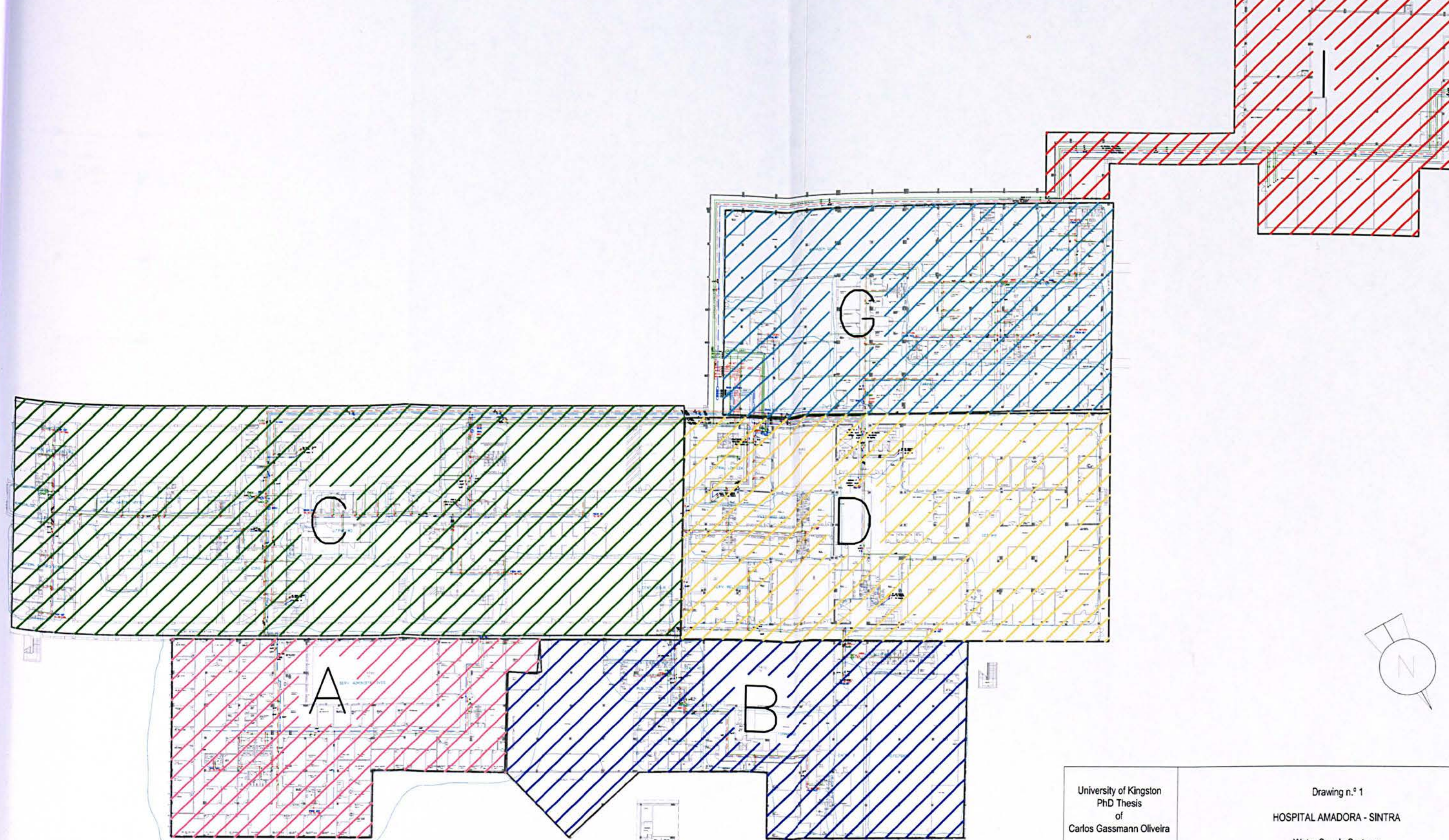
Water Supply to Hospital Amadora Sintra

Maximum recorded Day Temperatures (°C) and Corresponding Day Water Consumptions (m^3/day)

Annexe 9

Mondays		Tuesdays		Wednesdays		Thursdays		Fridays		Saturdays		Sundays	
Temp (°C)	(m^3/day)	Temp (°C)	(m^3/day)	Temp (°C)	(m^3/day)	Temp (°C)	(m^3/day)	Temp (°C)	(m^3/day)	Temp (°C)	(m^3/day)	Temp (°C)	(m^3/day)
24,3	867	14,4	673	25,2	700	14,5	943	15,6	862	16,4	694	24,6	605
24,4	965	16,4	778	25,4	1027	17,5	853	15,5	940	14,2	604	24,7	627
24,6	1023	15,2	838	26	1196	16,1	891	14,7	860	16,9	641	24,9	860
24,7	802	21	875	26,2	1110	16,2	838	15,7	840	16,2	712	25,1	721
24,7	832	18,3	872	26,5	785	16,6	843	14,4	802	15,3	653	25,5	813
24,8	1033	15,5	668	26,7	889	19,3	755	18,6	775	18,7	724	25,8	633
25	1007	17,1	910	26,7	745	17	837	18,2	880	17,9	677	25,8	752
25	949	16,2	712	26,8	979	18,1	827	19	716	15,9	656	25,9	723
25,4	955	20,4	845	27	994	18,2	884	19	796	20	627	26,1	671
25,9	764	19,3	870	27,3	1013	15,8	835	18,6	717	16,8	615	26,2	689
27,5	990	18,4	858	27,4	942	21,9	880	21,5	797	17,9	652	26,8	810
27,7	1034	16,9	857	28,1	934	17,5	754	18,6	565	15,4	615	27,5	600
27,8	855	15,9	715	28,3	1148	18	780	18,8	660	21,3	624	27,6	563
28,7	845	23,8	860	28,8	890	28,7	856	30,2	786	22,4	595	28,2	538
29,7	868	17,7	875	30,2	899	16,4	710	15,5	915	17,5	708	30	762
31,5	908	21,9	906	31,6	1250	17	823	16,3	734	15,8	675	32,7	733
31,9	874	18,6	931	33,1	967	26	942	30,2	675	27,4	671	40,3	748
40,6	1022	18	894	34,1	927								

DRAWINGS



Architectoral plans and perspectives as kindly supplied by Hospital Doutor Fernando Fonseca (Amadora Sintra)

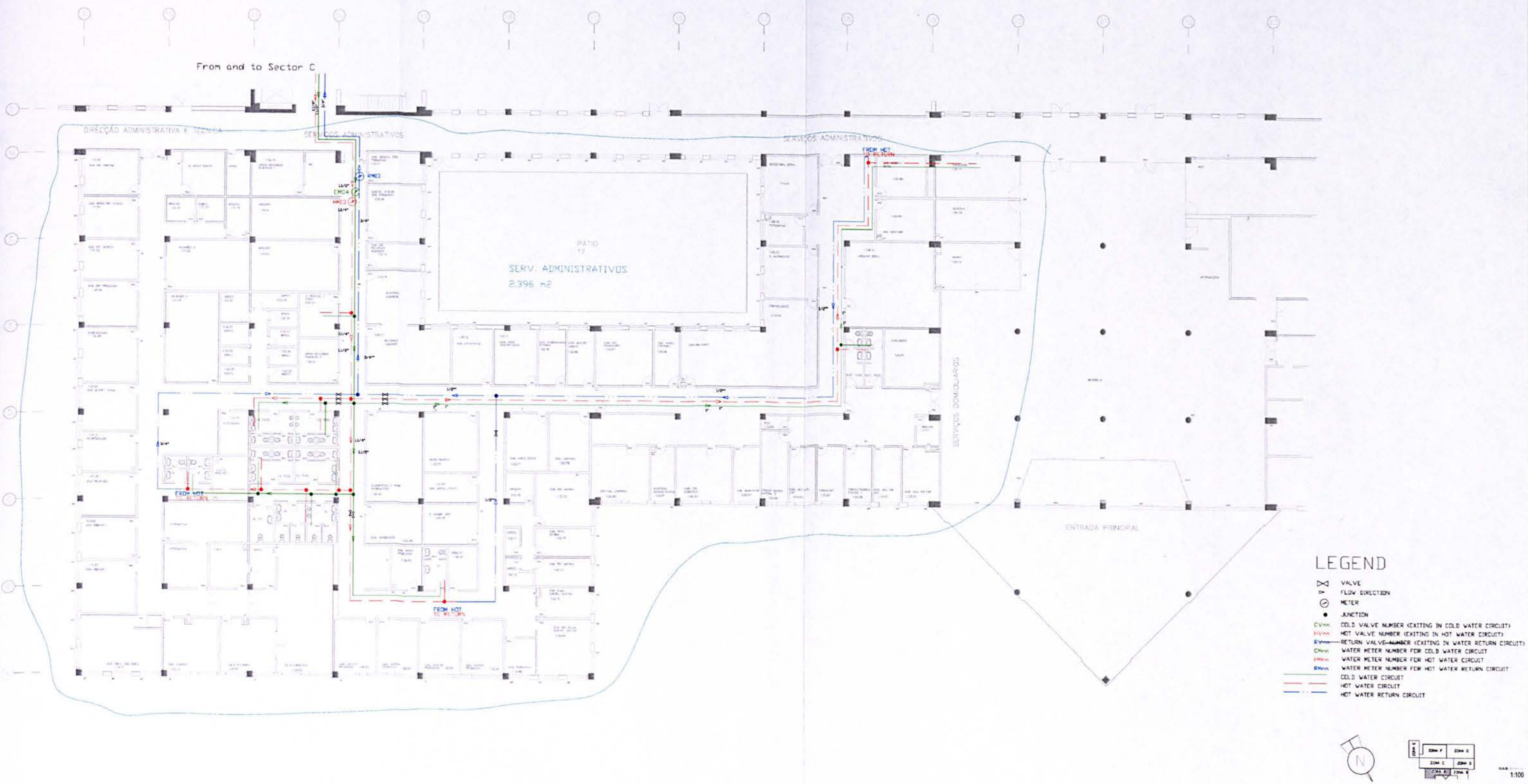
University of Kingston
PhD Thesis
of
Carlos Gassmann Oliveira

Drawing n.º 1

HOSPITAL AMADORA - SINTRA

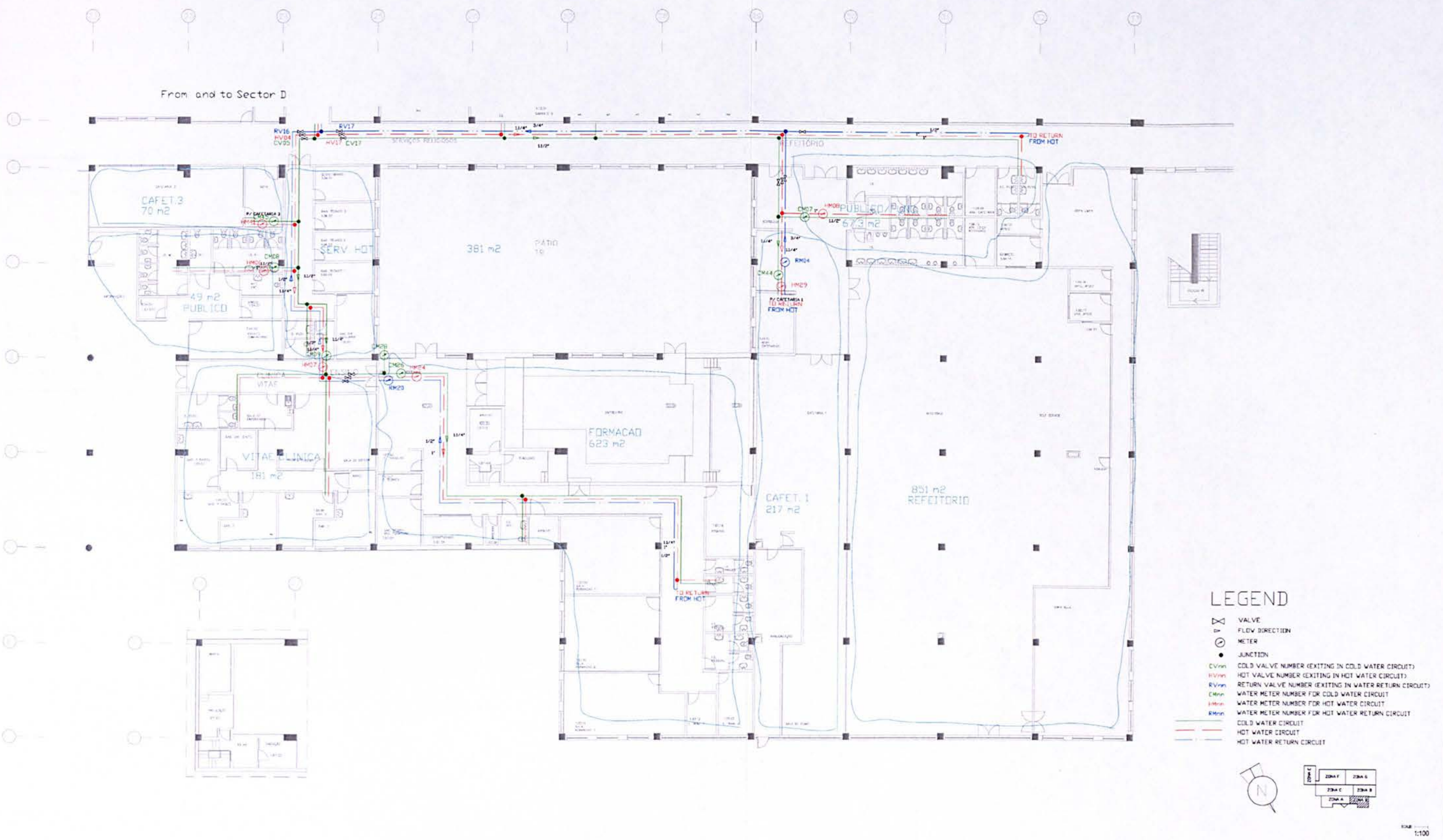
Water Supply Systems

General Plan Layout of Level 1 (FFL 115,80)



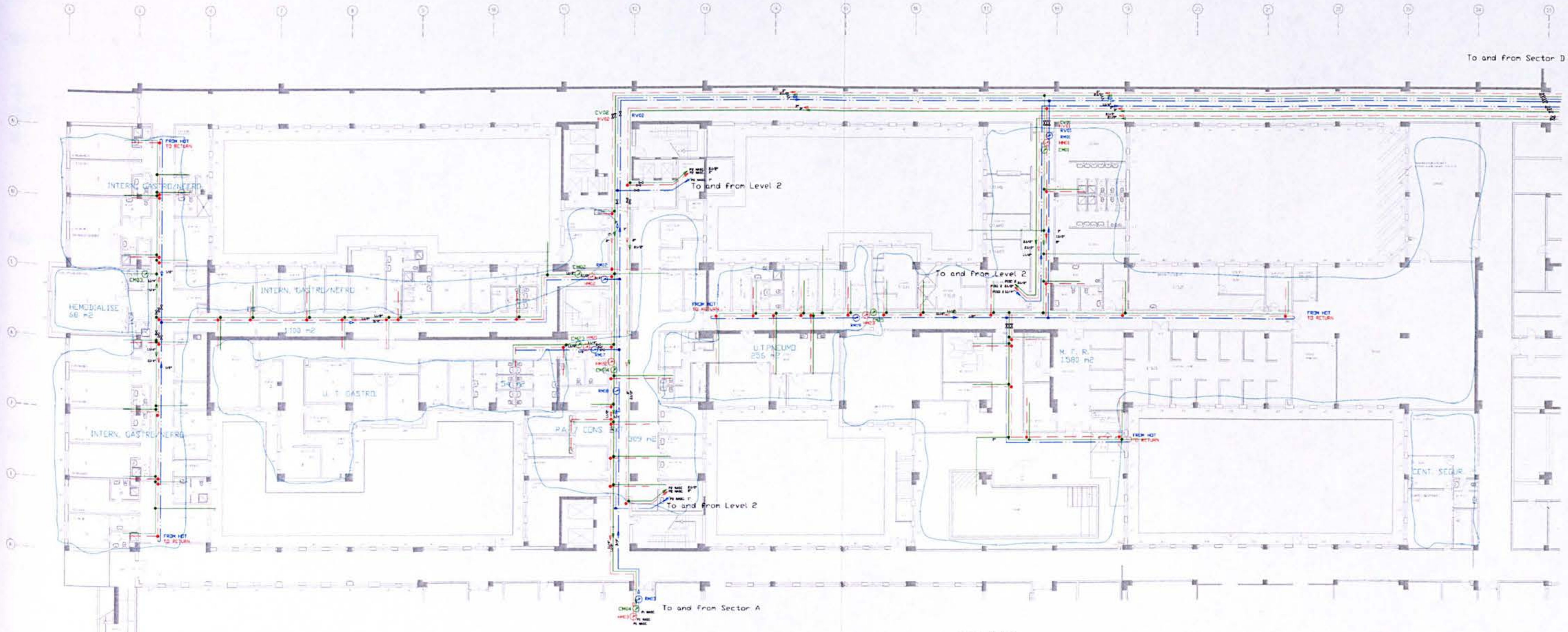
University of Kingston PhD Thesis of Carlos Gassmann Oliveira	Drawing n.º 2 HOSPITAL AMADORA - SINTRA Water Supply Systems Plan Layout of Section A, Level 1

Architectoral plans and perspectives as kindly supplied by Hospital Doutor Fernando Fonseca (Amadora Sintra)



University of Kingston PhD Thesis of Carlos Gassmann Oliveira	Drawing n.º 3 HOSPITAL AMADORA - SINTRA Water Supply Systems Plan Layout of Section B, Level 1

Architectoral plans and perspectives as kindly supplied by Hospital Doutor Fernando Fonseca (Amadora Sintra)



LEGEND

- VALVE
- FLOW DIRECTION
- METER
- JUNCTION
- CVnn — COLD VALVE NUMBER (EXITING IN COLD WATER CIRCUIT)
- HVnn — HOT VALVE NUMBER (EXITING IN HOT WATER CIRCUIT)
- RVnn — RETURN VALVE NUMBER (EXITING IN WATER RETURN CIRCUIT)
- CMnn — WATER METER NUMBER FOR COLD WATER CIRCUIT
- HMnn — WATER METER NUMBER FOR HOT WATER CIRCUIT
- RMnn — WATER METER NUMBER FOR HOT WATER RETURN CIRCUIT
- COLD WATER CIRCUIT
- HOT WATER CIRCUIT
- HOT WATER RETURN CIRCUIT

Architectoral plans and perspectives as kindly supplied by Hospital Doutor Fernando Fonseca (Amadora Sintra)

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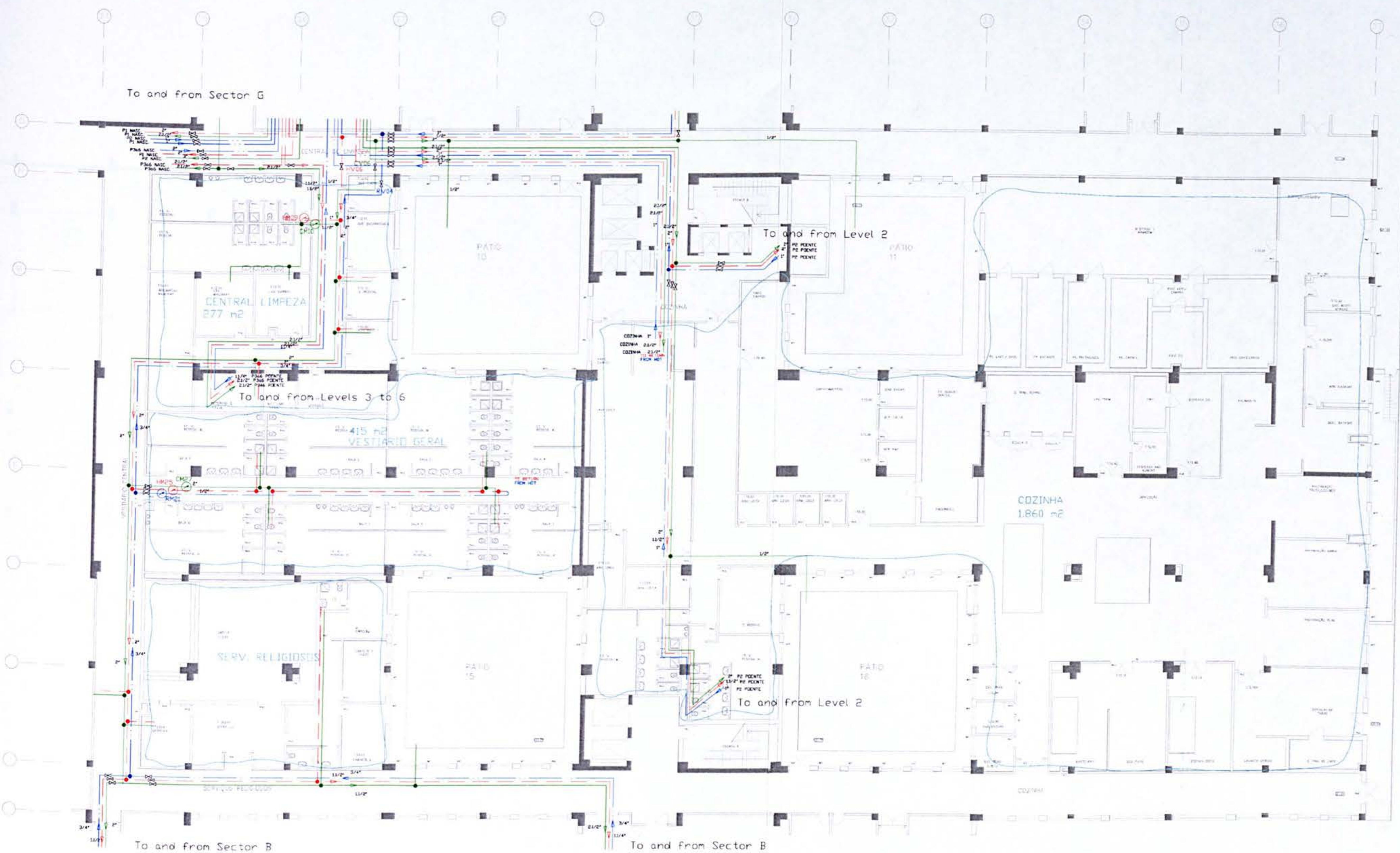
University of Kingston PhD Thesis of Carlos Gassmann Oliveira	Drawing n.º 4 HOSPITAL AMADORA - SINTRA Water Supply Systems Plan Layout of Section C, Level 1



LEGEND

	VALVE
	FLOW DIRECTION
	METER
	JUNCTION
CVnn	COLD VALVE NUMBER (EXITING IN COLD WATER CIRCUIT)
HVnn	HOT VALVE NUMBER (EXITING IN HOT WATER CIRCUIT)
RVnn	RETURN VALVE NUMBER (EXITING IN WATER RETURN CIRCUIT)
CMnn	WATER METER NUMBER FOR COLD WATER CIRCUIT
HMnn	WATER METER NUMBER FOR HOT WATER CIRCUIT
RMnn	WATER METER NUMBER FOR HOT WATER RETURN CIRCUIT
	COLD WATER CIRCUIT
	HOT WATER CIRCUIT
	HOT WATER RETURN CIRCUIT

Architectoral plans and perspectives as kindly supplied by Hospital Doutor Fernando Fonseca (Amadora Sintra)

University of Kingston PhD Thesis of Carlos Gassmann Oliveira	Drawing n.º 5 HOSPITAL AMADORA - SINTRA Water Supply Systems Plan Layout of Section D, Level 1

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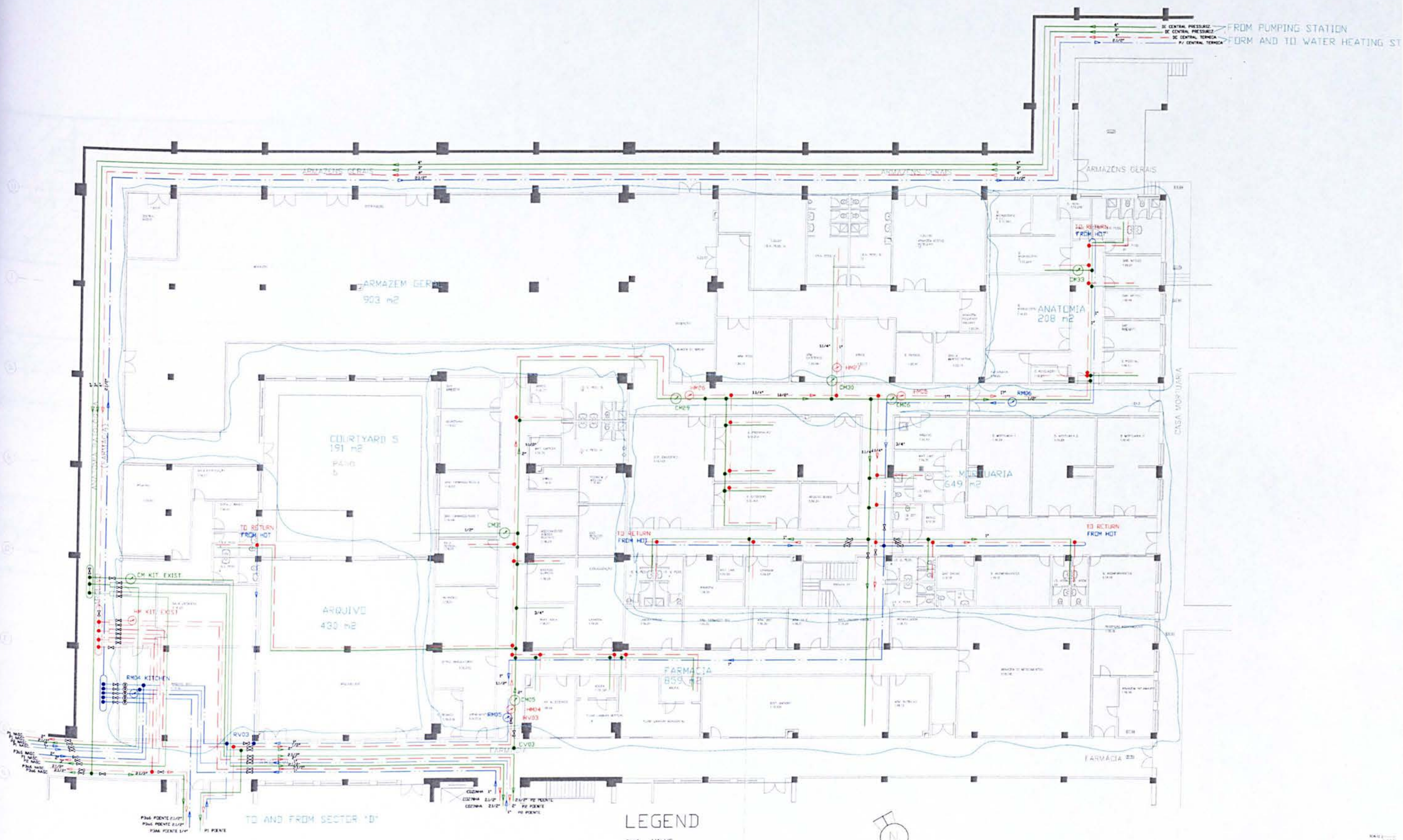
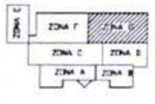


LEGEND

- VALVE
- FLOW DIRECTION
- METER
- JUNCTION
- CVnn — COLD VALVE NUMBER (EXITING IN COLD WATER CIRCUIT)
- HVnn — HOT VALVE NUMBER (EXITING IN HOT WATER CIRCUIT)
- RVnn — RETURN VALVE NUMBER (EXITING IN WATER RETURN CIRCUIT)
- CMnn — WATER METER NUMBER FOR COLD WATER CIRCUIT
- HMnn — WATER METER NUMBER FOR HOT WATER CIRCUIT
- RMnn — WATER METER NUMBER FOR HOT WATER RETURN CIRCUIT
- COLD WATER CIRCUIT
- HOT WATER CIRCUIT
- HOT WATER RETURN CIRCUIT



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of
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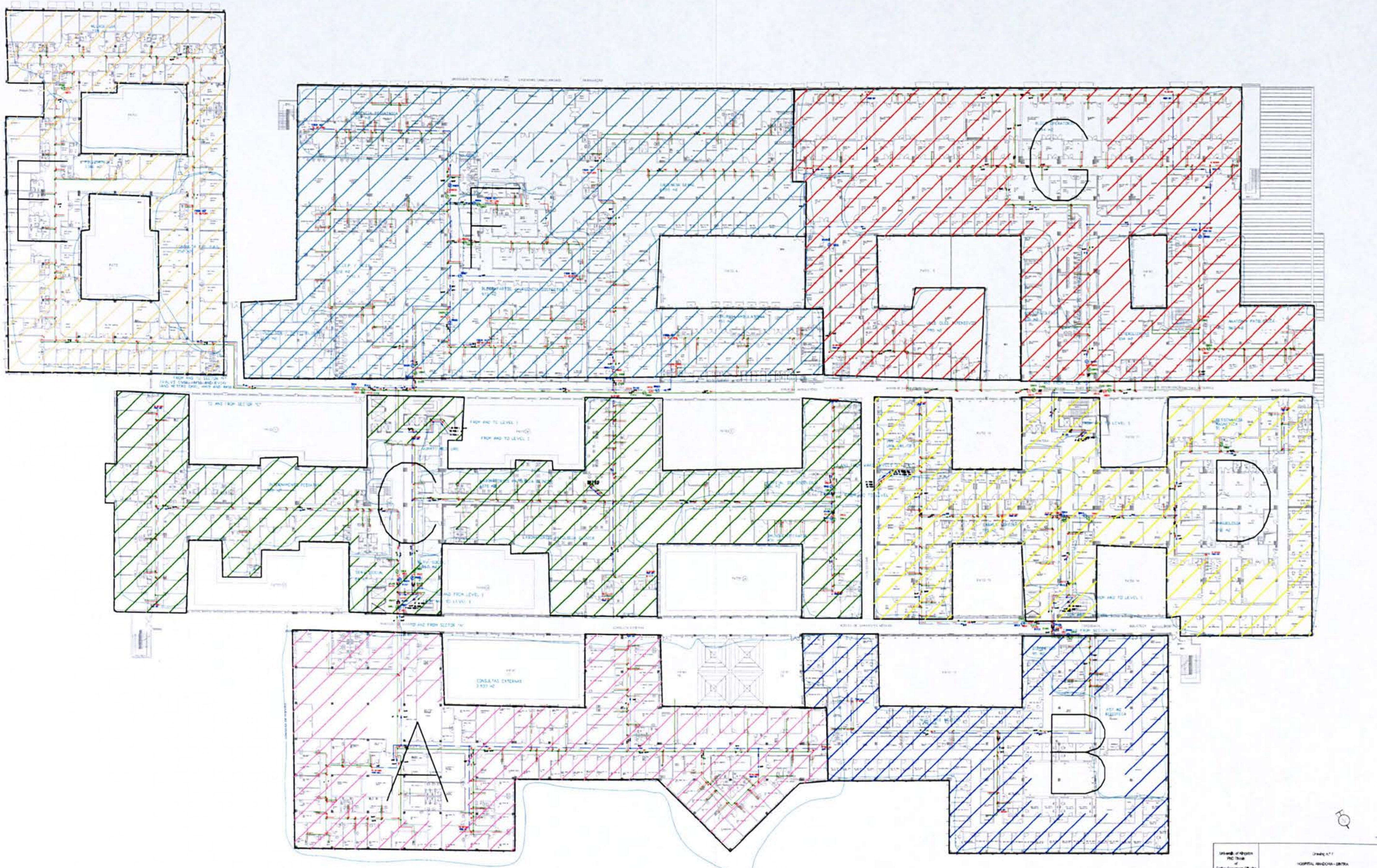
1:100

Drawing n.º 6

HOSPITAL AMADORA - SINTRA

Water Supply Systems

Plan Layout of Section G, Level 1



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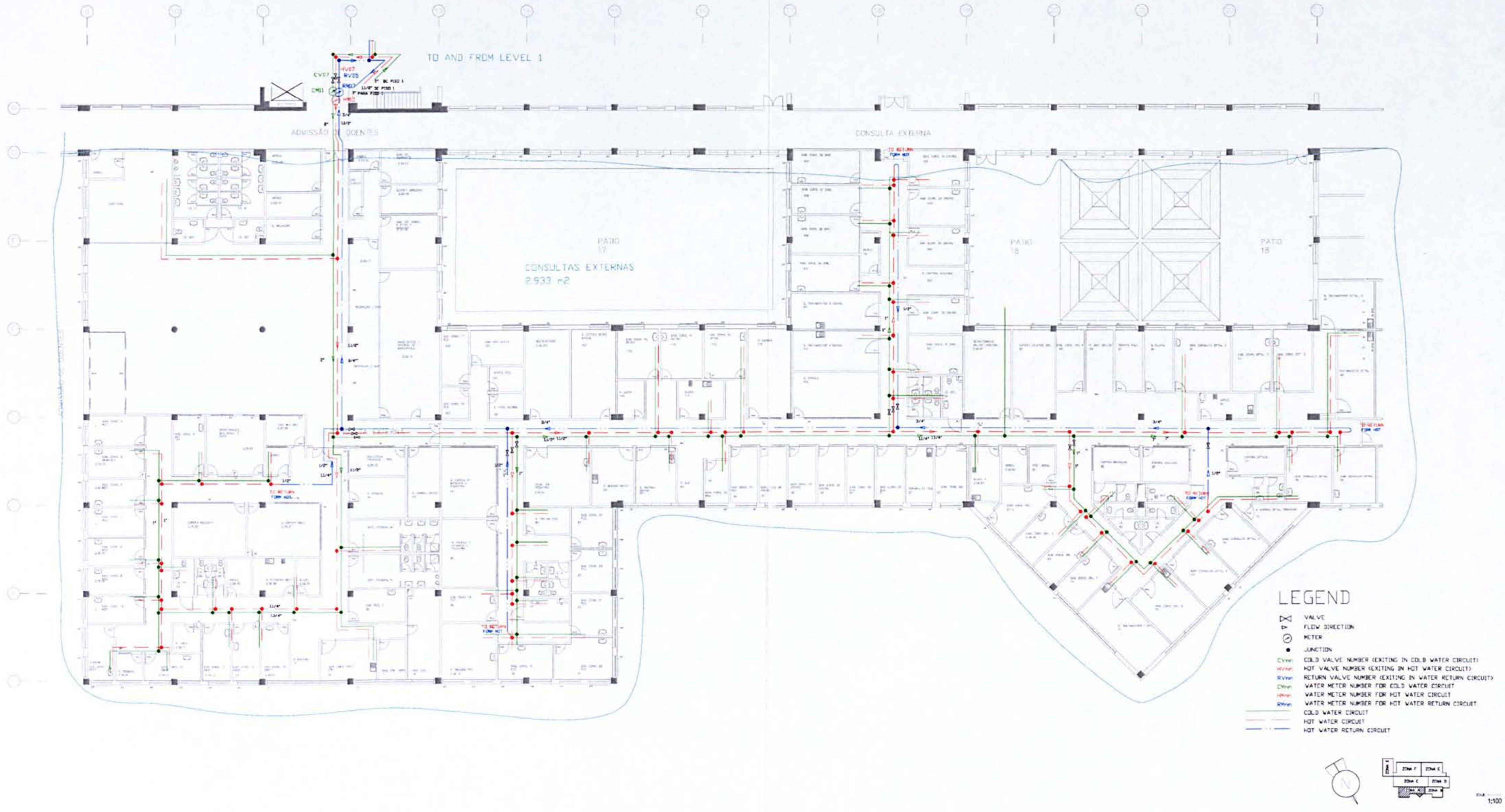
University of Kingston PhD Thesis of Carlos Guerreiro Oliveira	Drawing N.º 7 HOSPITAL AMADORA - SINTRA Water Supply Systems General Plan Layout Level 2 (PPL 120.30)



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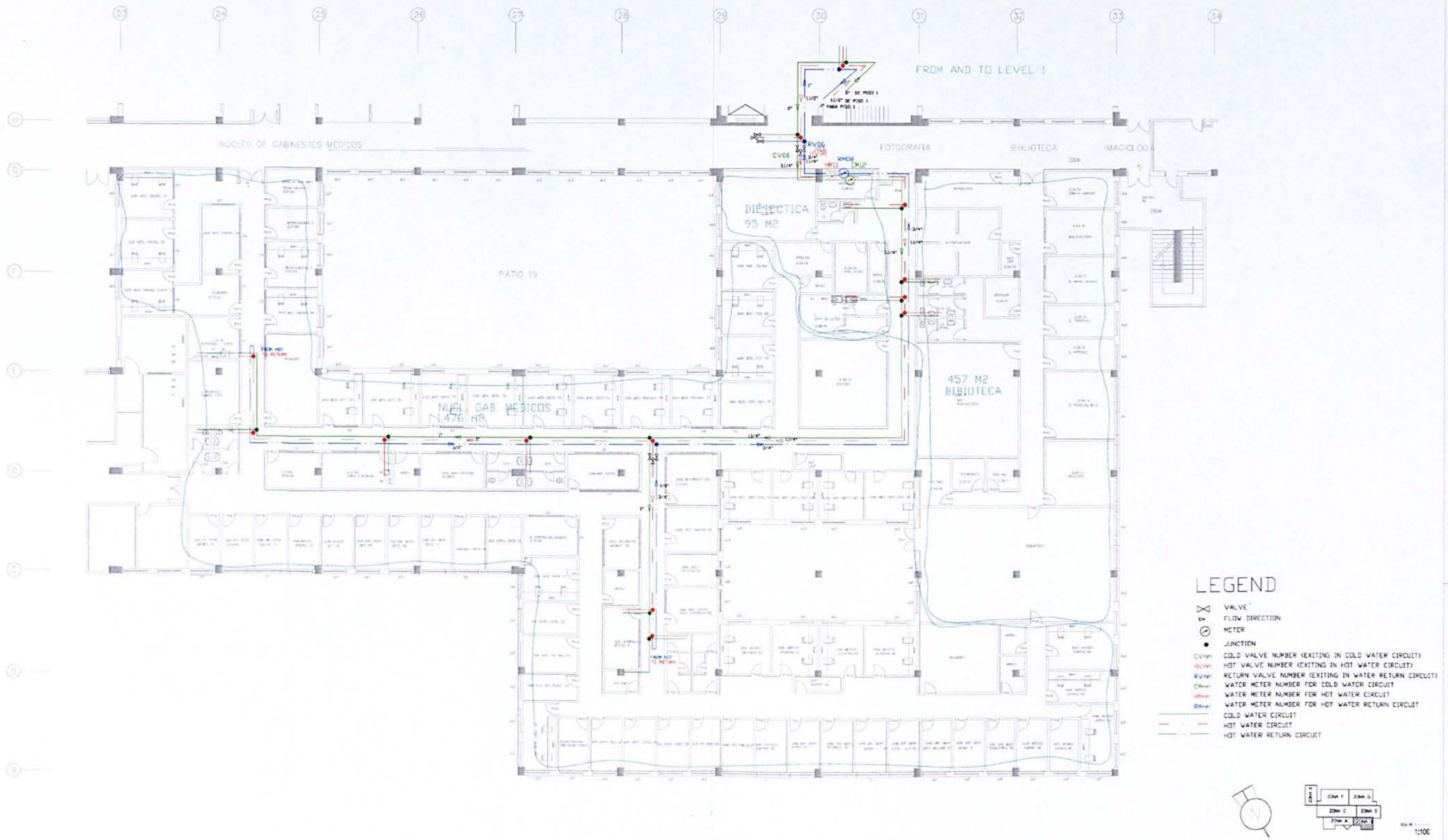
University of Kingston PhD Thesis of Carlos Gassmann Oliveira	Drawing n.º 8 HOSPITAL AMADORA - SINTRA Water Supply Systems Plan Layout of Section A, Level 2



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Drawing n.º 9

HOSPITAL AMADORA - SINTRA

Water Supply Systems

Plan Layout of Section B, Level 2

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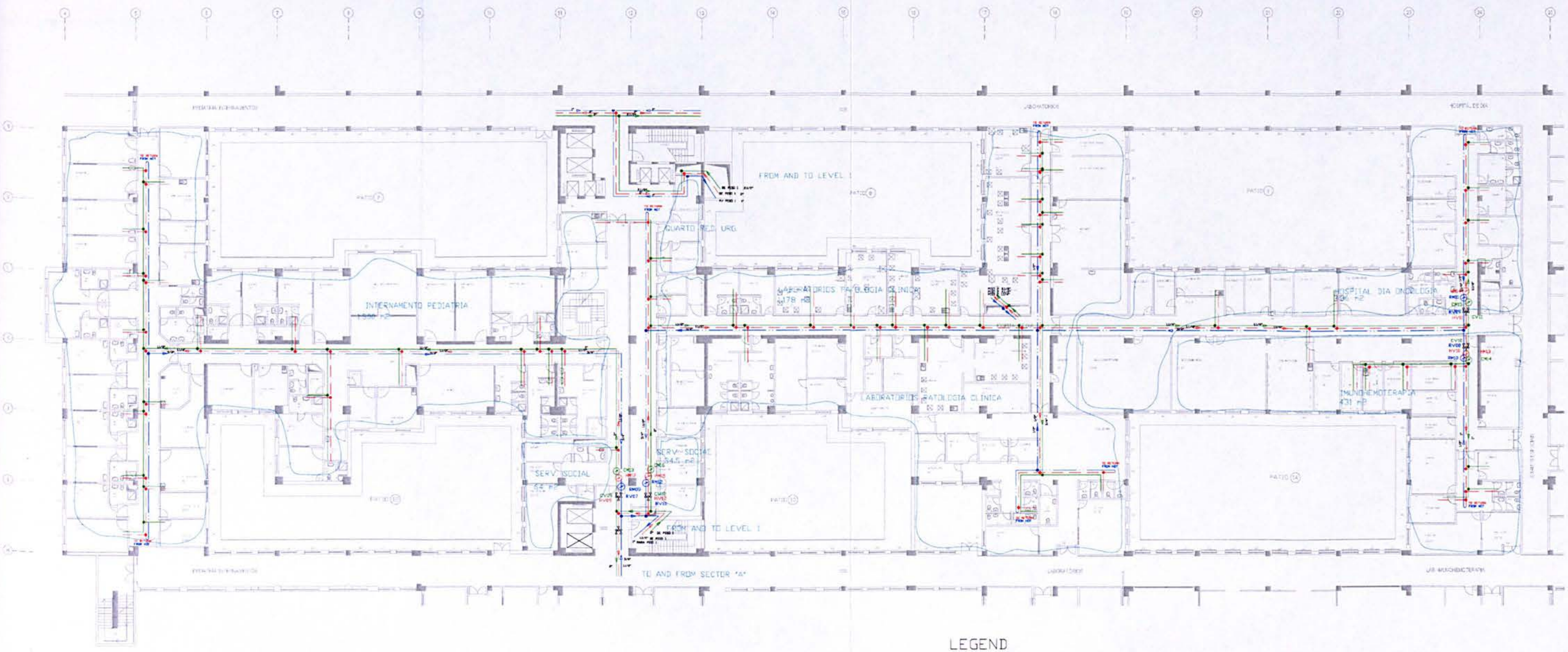

LEGEND

- VALVE
- FLOW DIRECTION
- METER
- JUNCTION
- CVnn COLD VALVE NUMBER (EXITING IN COLD WATER CIRCUIT)
- HVnn HOT VALVE NUMBER (EXITING IN HOT WATER CIRCUIT)
- RVnn RETURN VALVE NUMBER (EXITING IN WATER RETURN CIRCUIT)
- CMnn WATER METER NUMBER FOR COLD WATER CIRCUIT
- HMnn WATER METER NUMBER FOR HOT WATER CIRCUIT
- RMnn WATER METER NUMBER FOR HOT WATER RETURN CIRCUIT
- COLD WATER CIRCUIT
- HOT WATER CIRCUIT
- HOT WATER RETURN CIRCUIT

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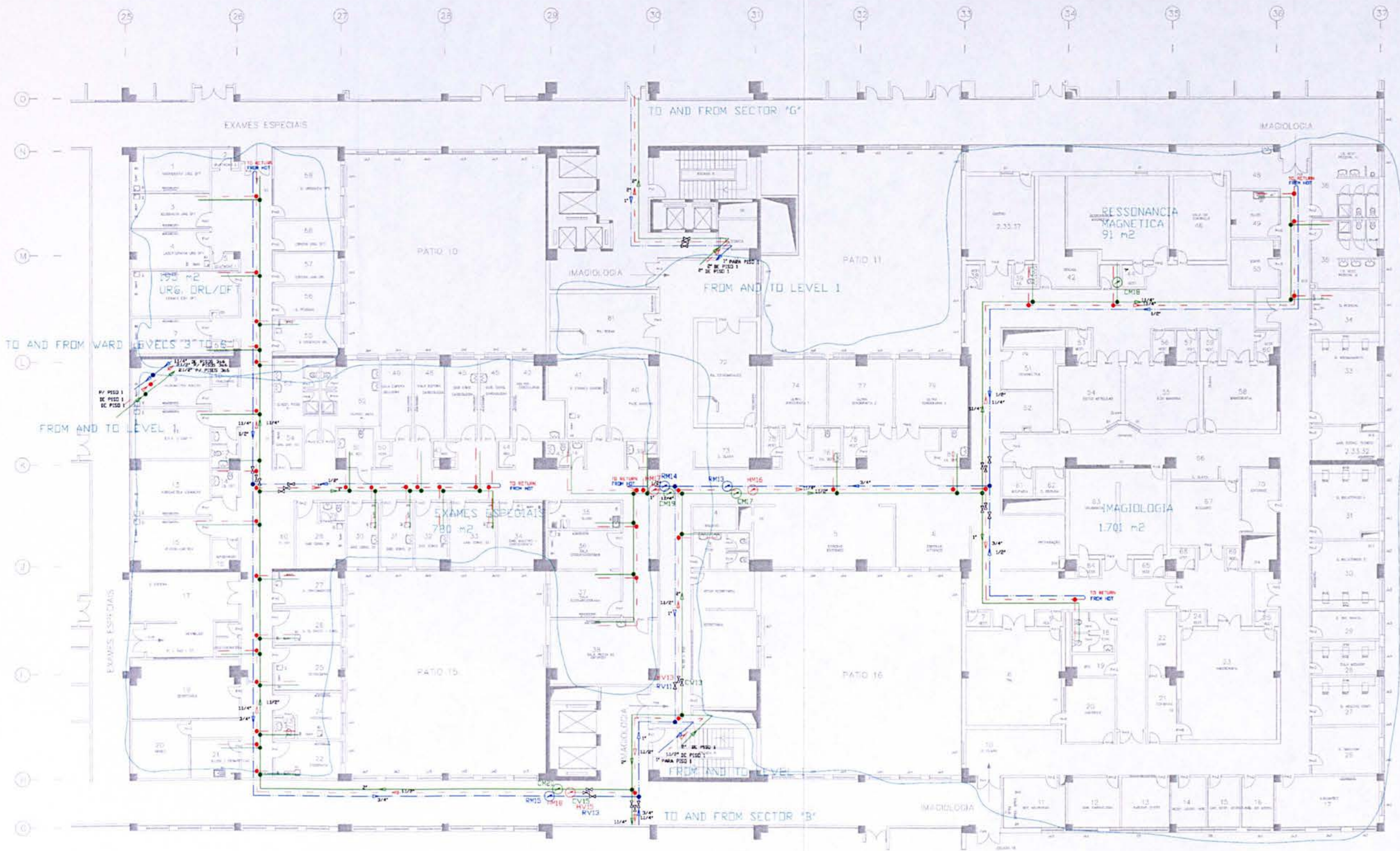
Drawing n.º 10

HOSPITAL AMADORA - SINTRA

Water Supply Systems

Plan Layout of Section C, Level 2



LEGEND

⋈	VALVE
▷	FLOW DIRECTION
⊘	METER
•	JUNCTION
CVnn	COLD VALVE NUMBER (EXITING IN COLD WATER CIRCUIT)
HVnn	HOT VALVE NUMBER (EXITING IN HOT WATER CIRCUIT)
RVnn	RETURN VALVE NUMBER (EXITING IN WATER RETURN CIRCUIT)
CMnn	WATER METER NUMBER FOR COLD WATER CIRCUIT
HMnn	WATER METER NUMBER FOR HOT WATER CIRCUIT
RMnn	WATER METER NUMBER FOR HOT WATER RETURN CIRCUIT
———	COLD WATER CIRCUIT
— — —	HOT WATER CIRCUIT
— - —	HOT WATER RETURN CIRCUIT

1:100

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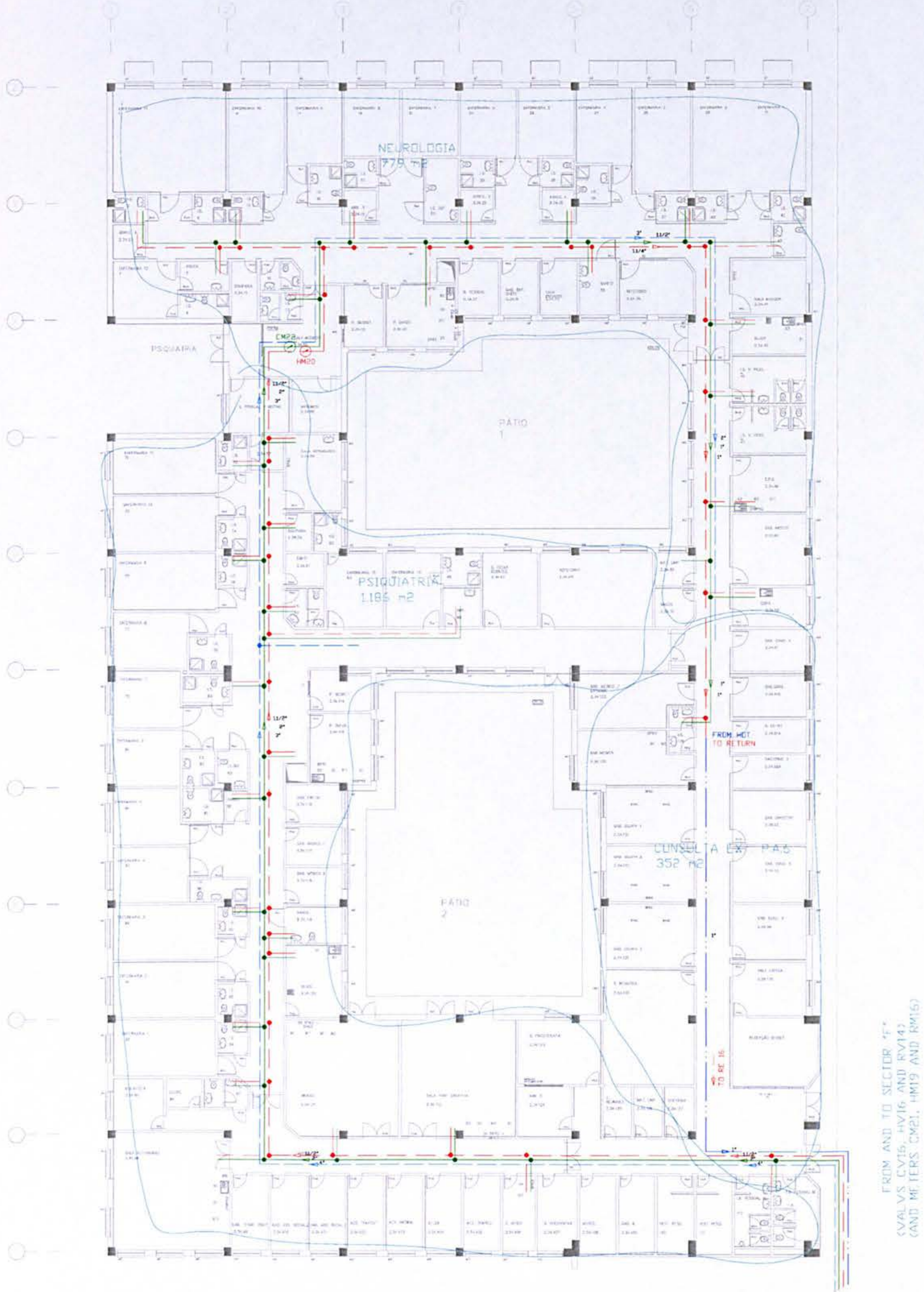
Drawing n.º 11

HOSPITAL AMADORA - SINTRA

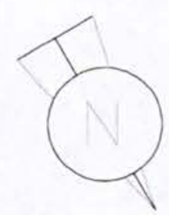
Water Supply Systems

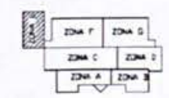
Plan Layout of Section D, Level 2



LEGEND

- VALVE
- FLOW DIRECTION
- METER
- JUNCTION
- CVnn — COLD VALVE NUMBER (EXITING IN COLD WATER CIRCUIT)
- HVnn — HOT VALVE NUMBER (EXITING IN HOT WATER CIRCUIT)
- RVnn — RETURN VALVE NUMBER (EXITING IN WATER RETURN CIRCUIT)
- CMnn — WATER METER NUMBER FOR COLD WATER CIRCUIT
- HMnn — WATER METER NUMBER FOR HOT WATER CIRCUIT
- RMnn — WATER METER NUMBER FOR HOT WATER RETURN CIRCUIT
- COLD WATER CIRCUIT
- HOT WATER CIRCUIT
- HOT WATER RETURN CIRCUIT





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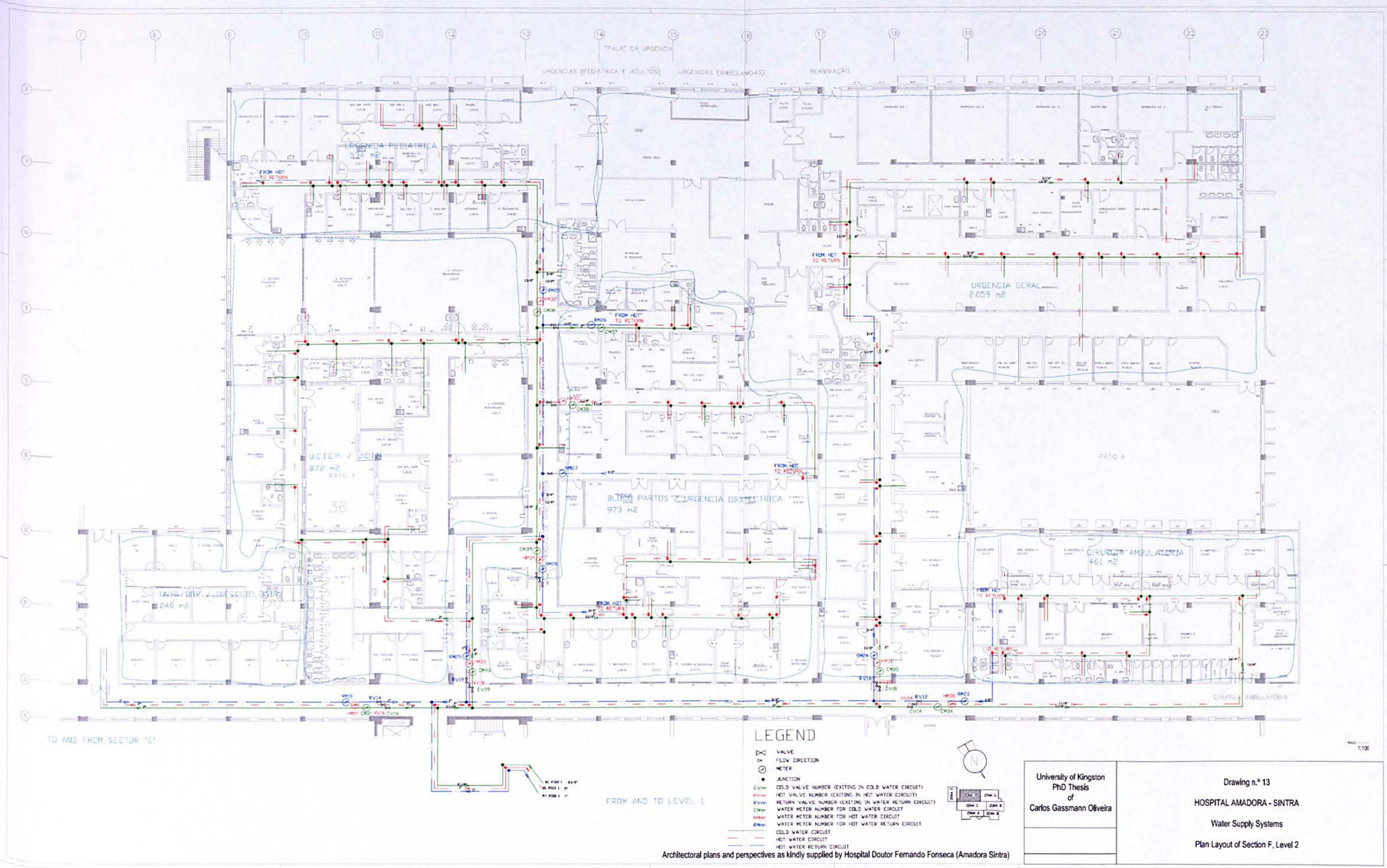

"PALA" DA URGENCIA
URGENCIAS (PEDIATRICA E ADULTOS)
URGENCIAS (AMBULANCIAS)
REANIMAÇÃO
URGENCIA PEDIATRICA
URGENCIA GERAL
2.059 m2
UCIEP / UCIN
972 m2
PATIO 3
BLOCO PARTOS / URGENCIA OBSTETRICA
973 m2
PATIO A
CIRURGIA AMBULATORIA
461 m2
CIRURGIA AMBULATORIA
FROM HOT
TO RETURN
TO AND FROM SECTOR "E"
FROM AND TO LEVEL 1
1:100
LEGEND
VALVE
FLOW DIRECTION
METER
JUNCTION
CVnn COLD VALVE NUMBER (EXITING IN COLD WATER CIRCUIT)
HVnn HOT VALVE NUMBER (EXITING IN HOT WATER CIRCUIT)
RVnn RETURN VALVE NUMBER (EXITING IN WATER RETURN CIRCUIT)
CMnn WATER METER NUMBER FOR COLD WATER CIRCUIT
HMnn WATER METER NUMBER FOR HOT WATER CIRCUIT
RMnn WATER METER NUMBER FOR HOT WATER RETURN CIRCUIT
COLD WATER CIRCUIT
HOT WATER CIRCUIT
HOT WATER RETURN CIRCUIT
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PhD Thesis
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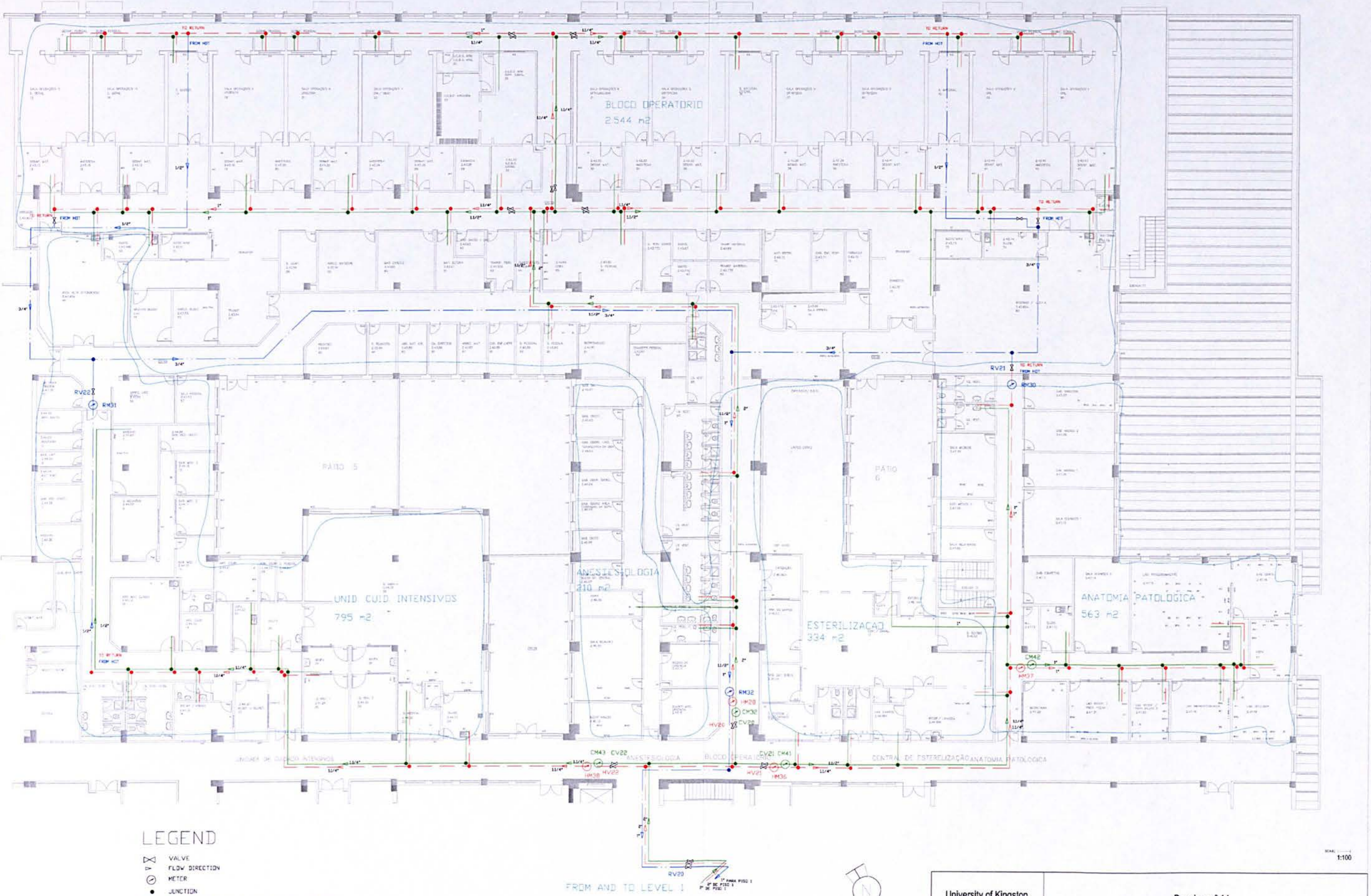
Carlos Gassmann Oliveira
Drawing n.º 13
HOSPITAL AMADORA - SINTRA
Water Supply Systems
Plan Layout of Section F, Level 2



LEGEND

- VALVE
- FLOW DIRECTION
- METER
- JUNCTION
- CVnn COLD VALVE NUMBER (EXITING IN COLD WATER CIRCUIT)
- HVnn HOT VALVE NUMBER (EXITING IN HOT WATER CIRCUIT)
- RVnn RETURN VALVE NUMBER (EXITING IN WATER RETURN CIRCUIT)
- CMnn WATER METER NUMBER FOR COLD WATER CIRCUIT
- HMnn WATER METER NUMBER FOR HOT WATER CIRCUIT
- RMnn WATER METER NUMBER FOR HOT WATER RETURN CIRCUIT
- COLD WATER CIRCUIT
- HOT WATER CIRCUIT
- HOT WATER RETURN CIRCUIT

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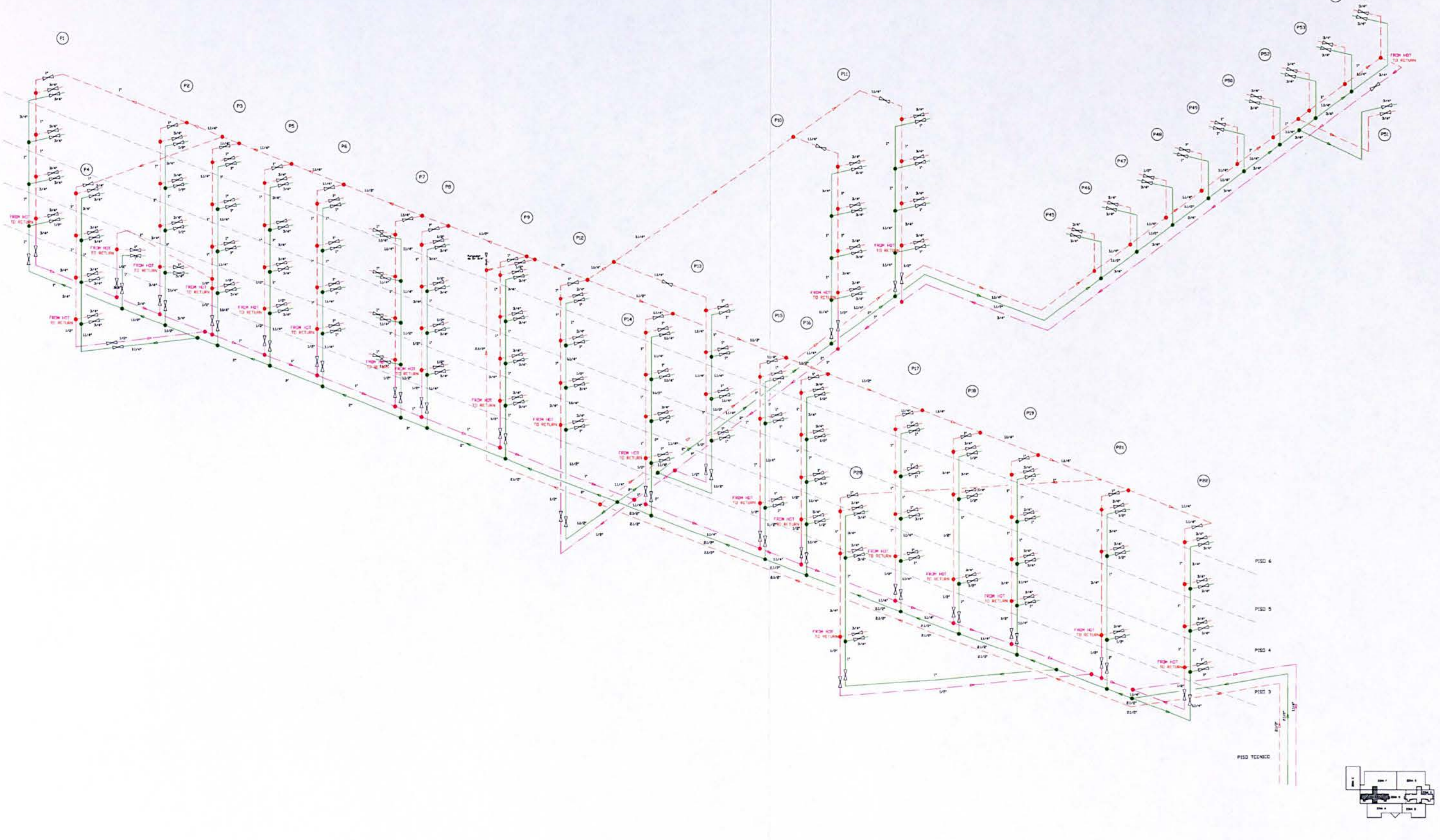

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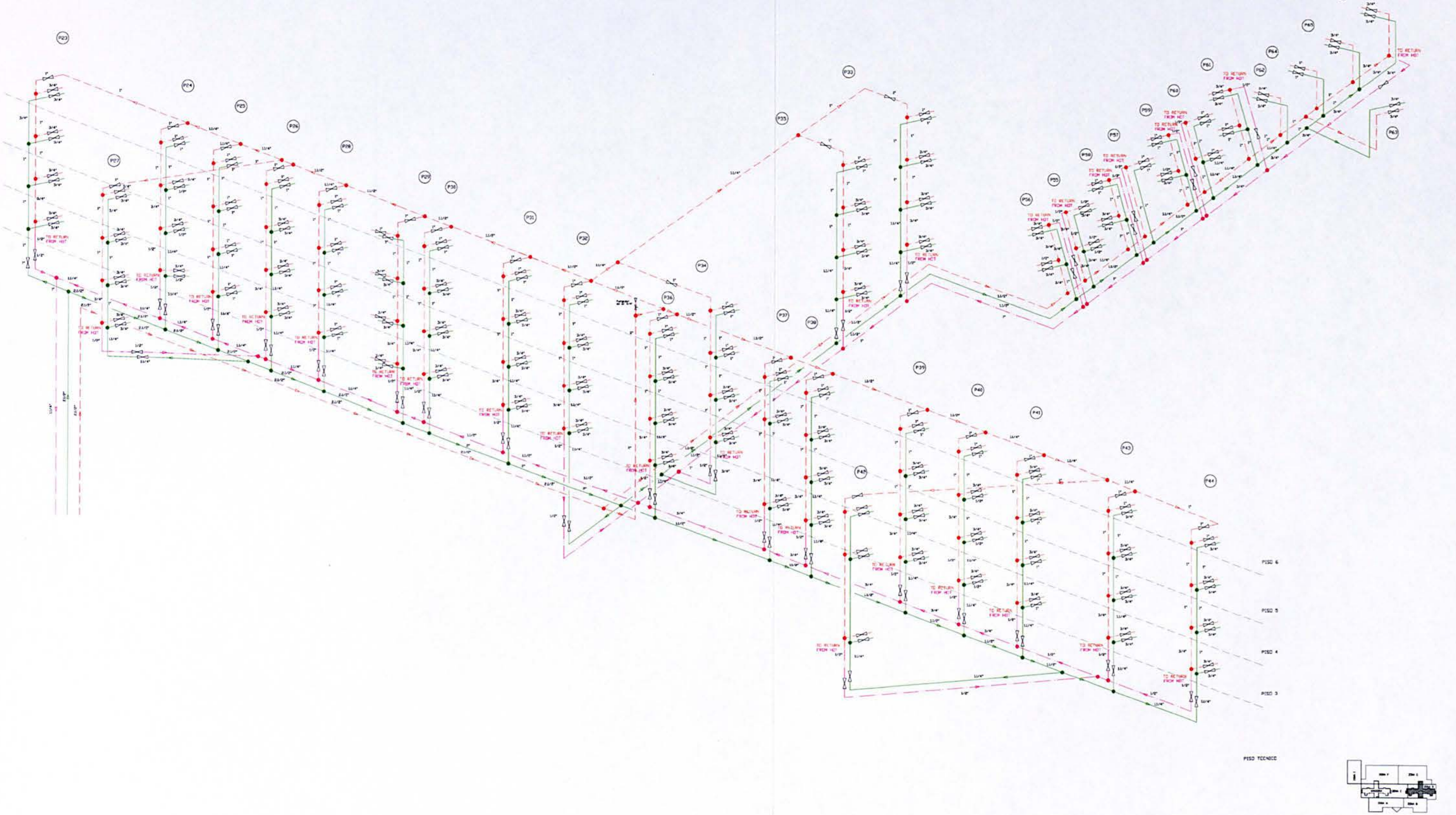
SCALE:

Drawing n.º 15

HOSPITAL AMADORA - SINTRA
TOWER AMADORA

DIAGRAMMATIC PERSPECTIVE OF WATER SUPPLY NETWORK

Architectoral plans and perspectives as kindly supplied by Hospital Doutor Fernando Fonseca (Amadora Sintra)



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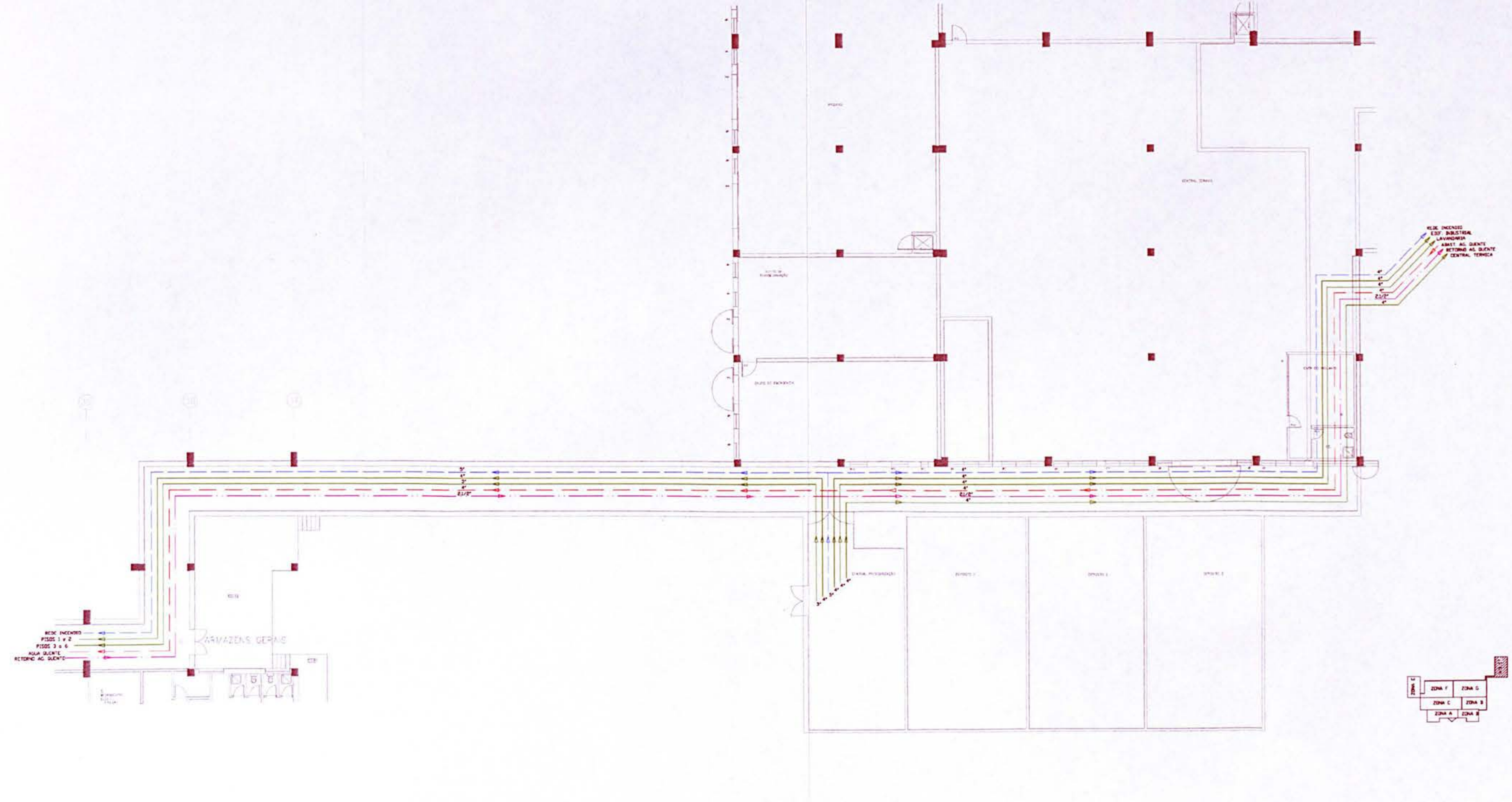
University of Kingston PhD Thesis of Carlos Gassmann Oliveira	Drawing n.º 16 HOSPITAL AMADORA - SINTRA TOWER SINTRA
SCALE:	DIAGRAMMATIC PERSPECTIVE OF WATER SUPPLY NETWORK



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SCALE:

Drawing n.º 17

HOSPITAL AMADORA - SINTRA

PLAN LAYOUT OF TECHNICAL GALERY

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