MEDITERRANEAN DOCUMENT ON GROUNDWATER

1 INTRODUCTION

General Description of the Mediterranean Region – Groundwater resources in the region: their role and importance

(i) Basic facts about Malta

The Maltese archipelago consists of three inhabited islands: Malta, Gozo and Comino, and a number of uninhabited islets scattered around the shoreline of the major islands. Its location is about 96km south of Sicily (Italy) and 290km north of Tunisia. The total surface area is about 316km^2 and the perimeter of the shoreline of Malta is 136km while that of Gozo is 43km.

The Maltese islands have a population of around 398,000, increasing at a rate of about 2,400 inhabitants/year. Official statistics show that the Maltese population is expected to continue growing for the next 20-year period to a total of 425,000 inhabitants. This increase will put further pressures on the socio-economic and socio-cultural structures of the country, with significant added strains on the water resources. With a population density of 1,250 inhabitants/km^2, Malta is among the most densely populated countries of the world. Consequently, Malta is highly urbanized and more than 23% of the total surface area is built up.

Tourism plays an important part in the country's development. Through the multiplier effect, it contributes towards an employment complement of about 40,000. About 1.1 million tourists visit the islands, for an average of 10.5 million days per year. The average daily tourist population is 32,000. Tourist arrivals peak in July and August, placing additional strains on the country's water resources.

Urban development in Malta has increased dramatically in the last 50 years and development has altered the physical characteristics of the landscape drastically, increasing the sprawl of impermeable surfaces and, thereby, reducing infiltration processes. The result has been a decrease in natural groundwater recharge.

(ii) The main challenges in managing Malta's water resources

Malta is densely populated but poorly endowed with freshwater resources. Annual rainfall is about 550mm and highly variable. There are no surface waters that can be exploited economically, and groundwater resources are subject to increasing competition. Historically, the Maltese people have coped with water scarcity through a limited allocation of water per person. However, in recent decades, urban water users have not experienced prolonged periods of water shortages. One reason for the good supply reliability record is that, since the early 1980's a large proportion of the urban water demand has been sourced from desalination plants.

In contrast, agricultural water users continue to be more dependent on the vagaries of the climate and access to water resources for irrigation. Water shortages have resulted in farmers shifting towards cultivation practices and irrigation systems that make efficient use of water resources. The main source of water is groundwater pumped from private boreholes and conveyed to the fields via pipe networks and water

tankers. Although farmers are relatively more conscious of the importance of water conservation than urban water users, increased agricultural water use and excessive groundwater abstraction has in recent years affected the sustainability and viability of aquifer systems.

Other users of water include the tourism and industrial sectors. Their overall water demands however are considerably lower than either the domestic or agricultural sectors.

2 OVEREXPLOITATION OF GROUNDWATER RESOURCES

(i) Water Production

The total volume of water produced in the Maltese islands during 2003 was an estimated 59hm^3. The Water Services Corporation (national utility) was the single main producer of water, whilst the agricultural sector was the main producer of water (in this case primarily abstractor) in the private sector. The WSC produced slightly more desalinated seawater than groundwater.

Urban water supply

The two main sources of urban water supply are groundwater and desalinated sea-water. In 2003/04, desalination contributed about 55% of the water supplied to the public distribution system. Currently, the WSC operates three seawater Reverse Osmosis plants at Lapsi, Cirkewwa and Pembroke. It should be noted that Malta has one of the longest track records of RO plant operation in the Mediterranean region with high output levels and reliability. There has been a significant decrease in RO-water production in the last decade largely as a result of water-demand management actions adopted by the WSC. These actions include intensive leakage control, improved management practices and water conservation programmes.

Agricultural water supply

The development of agriculture in Malta is constrainted by the natural and geographical characteristics of the islands. The major constraints facing agricultural activity are the opportunity cost of land, scarcity of water resources and high labour costs. The total agricultural land (inclusive of dry, irrigated and garigue land) stands at around 12,000ha. The amount of irrigated land amounts to just more than 9% of all agricultural land in the Maltese islands; most of which is found in the northern and western regions of the islands; where historically, the shallow depth to groundwater and the occurrence of natural springs made water resources for agriculture more easily accessible.

(ii) Water Demand

The table below presents the breakdown of estimated water demand by sector for 2003:

Use	Demand (000 m^3)
Domestic	19,306
Tourism	2,965
Farms	2,226
Agriculture	18,000
Commercial	1,611
Industrial	2,716
Government	1,057
Others	1,123
Distribution System Demand	9,636
Total	58,641

The main striking features of demand in 2003 are:

- Domestic water use was the sector with the highest water demand
- Although representing an improvement on pervious years, system demand (losses) are still very high
- Agriculture water use for irrigation had the second largest demand

Domestic water demand

The domestic sector has registered an increase in consumption caused by higher living standards. WSC figures indicate that the consumption of water exclusively for domestic purposes was 142litres/capita/day in 2000/01. The domestic demand is expected to increase steadily in the next ten-years; however the real effect of this increase is expected to be dampened significantly through the reduction of losses in the distribution system. There is also much scope for increased harvesting of rainwater runoff at a household level, and this is expected to increase since the construction of facilities for rainwater storage are being requested at the planning stage for new developments.

Agricultural water demand

It is estimated that agriculture is meeting about 80% of its demand from groundwater while non-conventional sources such as treated effluent and rainwater harvesting are only of marginal importance. However, it is becoming more and more evident that the demands of the sector cannot be met by groundwater alone; and other sources must be brought into play. It is envisaged that in the long term, unless the demand generated by the agricultural sector is met through the involvement of unconventional sources, the current levels of agricultural activity cannot be maintained.

It should be noted that with the full implementation of the UWWD around 14hm^3 of treated effluent are expected to become available for re-use by 2008. The utilization of this resource, although presenting well known constraints, will have to be taken into account in any future national agricultural policy.

Industrial water demand
The industrial sector accounts for around 8% of total water demand in Malta. Water efficiency and water recycling are being introduced slowly, particularly in the major industrial concerns as it is recognized that these measures reduce costs in the long term. However, cost effective programmes are still a long way off for medium/small industrial concerns.
The construction and the food and beverage industries are the concerns that are most dependent on groundwater in this sector. However, no appreciable expansion is envisaged. Thus, sectoral demand for groundwater will most probably remain stable.

Tourism water demand
Tourism activities account for around 5 percent of the total water demand. Any increases in this sector are expected to be met by private RO production, with the dependence of the sector on private groundwater sources gradually decreasing. This since, for hotels – most of which are situated in near coastal areas, having a private RO-water supply represents a more reliable form of supply of better-quality water which comes at a cheaper price than other forms of supply.

Environmental water demand
Groundwater is also essential to sustain terrestrial surface-water ecosystems. These habitats depend on a year-round supply of freshwater. Thus, they are quite rare and of limited distribution. However, they support distinctive types of flora and fauna, some of which are endemic to the Maltese islands. A reduction in groundwater abstraction could be necessary in certain aquifers in order to sustain groundwater flow to these dependent ecosystems A study is underway to determine the degree of dependence of these ecosystems on groundwater in order to better ensure their future protection and sustainability.

3 DETERIORATION IN GROUNDWATER QUALITY

(i) Aquifer types

Coastal Groundwater Body
An aquifer having the sea as one of its confining boundaries, presents a situation where there is direct contact between two groundwater bodies – a fresh groundwater body and a (marine) saline groundwater body. These two bodies of groundwater have different densities, arising principally from their different saline content. In a stable system, the fresh groundwater body is found to float on the saline groundwater body, the two bodies being separated by a landward sloping ‘interface’. The saline groundwater body, thus, adopts a wedge-like shape resting on the aquifer floor.

In reality, this ‘interface’ does not represent a sharp change between the fresh and the saline groundwater bodies but takes the form of a relatively thick ‘mixing’ or ‘transition’ zone through which water changes gradually from freshwater to saltwater. The thickness of this transition zone depends on the hydrodynamic characteristics of the aquifer and the fluctuations in the hydraulic head of the groundwater body. A sharp interface between freshwater and saltwater can only be assumed when this transition zone represents a few percent of the freshwater thickness.

Island Groundwater Body
In small islands with permeable aquifer formations, the saline groundwater body can be found to underlie the whole breadth of the island and therefore the freshwater body takes the shape of a convex lens floating on saltwater. If the island is underlain by impermeable formations, the saline water body may not be continuous beneath the island.

(ii) Saline Intrusion

A simple definition of sea-water intrusion is "*the movement of saline water into regions of a groundwater body which was previously occupied by fresh (less saline) water*". The equilibrium position of the interface position separating freshwater and saltwater depends directly on the rate of discharge of groundwater at the coast. Therefore, the inward movement of the interface (or salt-water intrusion) occurs as a result of a reduction in the rate of groundwater discharge at the coast which is generally caused by increased inland groundwater withdrawals.

In the framework of the WFD it is convenient to distinguish between regional and localized sea-water intrusion. This, since the Directive does not regard temporary or continuous changes in flow direction and their associated effects on chemical composition as intrusions as long as they are limited and do not compromise any of the Directive's other environmental objectives for the body of groundwater.

Regional salt-water intrusion occurs when there is an inward movement of the saline-freshwater interface in response to reduced coastal groundwater discharge resulting from area-wide declines in the piezometric head of the groundwater body. In island aquifers, this type of intrusion manifests itself as an upward movement of the interface (reduction in size of the freshwater lens). Regional intrusion is generally a very slow process since large volumes of saltwater have to replace freshwater. The freshwater in the zone between the initial and final position of the interface is lost to the sea during the transitory phase, which in some cases may last several years or decades.

Localized sea-water intrusion generally occurs at a single abstraction well or a few closely located wells which are overlying the fresh/salt water interface due to the abstraction at that/those specific wells. This phenomenon is often referred to as 'upconing' because the interface is pulled up towards the bottom of the well and consequently takes the shape of a cone. Upconing of saltwater beneath abstraction wells is a much faster phenomenon than the regional movement of the interface and consequently the main effects disappear shortly after the abstraction ceases.

It should be noted that the occurrence of regional intrusion, that is the landward movement of the interface in coastal areas and the upward movement of the interface in islands makes it more likely that a production well will produce 'upconing' at the interface.

(iii) Groundwater Quality

The quality of groundwater in Malta is highly variable with contamination of groundwater by nitrates and chlorides being the main quality issues of concern.

Nitrates occur naturally in the environment and are produced from the decay of vegetable material in the soil. The natural nitrate level in the main groundwater bodies in Malta is generally expected to be low. Soil cover in Malta is relatively thin and poor in organic content. Furthermore, there are no naturally occurring formations that contribute towards nitrate content in groundwater. Thus, nitrate contamination in groundwater is largely attributed to anthropogenic activities, such as agricultural practices through the application of nitrogenous fertilizers on arable land; and contamination from human and animal wastes and refuse dump runoff. The movement of these pollutants below the surface is affected by the properties of the underlying strata. Nitrate concentration varies seasonally and by location, with maximum concentrations corresponding to the rainy season (October-March) as a result of the leaching of nitrates in the unsaturated zone; this situation being particularly evident in the shallow groundwater bodies.

Groundwater abstracted from the sea-level groundwater bodies has generally high levels of chloride concentrations, mainly as a result of localized sea-water intrusion (upconing) beneath the abstraction wells. This situation is further influenced by the karstic/fractured nature of the aquifers.

4 MONITORING AND DATA MANAGEMENT

(i) Monitoring for quantitative status

Groundwater levels are normally measured in wells and boreholes and can be easily converted into heads by taking account of the elevation of the measurement reference point above sea-level. Level measurements should be performed in non-pumped wells or boreholes to avoid the effect of pumping drawdowns. Measurement in pumping wells or boreholes are only valid after a rest period long enough to allow water to recover to its natural level; the rest period depending on the permeability of the respective aquifer formations.

Where water level measurements are undertaken, it should be recommended that automatic recording systems be used to allow correlation with fluctuations in sea-level. Probably, the most suitable automatic recording system in these situations is a standard float and pulley system connected to either a chart recorder or an electronic data logger.

Owing to the fact that coastal and island groundwater bodies do not have a fixed base, the location and thickness of the interface (transition zone) limits the amount of freshwater available. The thickness of this zone should therefore ideally be monitored. This requires taking vertical salinity/conductivity profiles in deep wells; which can be achieved either by obtaining in-site salinity logs or sampling the groundwater at different depths. It should be noted, however, that both these monitoring solutions are costly; particularly in high lying areas where the depth to the interface is considerable.

(ii) Monitoring for qualitative status

Wells with high abstraction rates cannot be utilized since the abstraction generally locally alters the water layering (density stratification) by inducing the upconing of saline water. High value of chloride concentrations and of other ions/parameters related to saltwater intrusion therefore result.

One possible solution would involve the utilization of low-yielding abstraction wells which are not influenced by salt-water upconing. Another option would be to utilize static observation (monitoring) wells.

5 INTERNATIONAL COOPERATION

6 INSTITUTIONAL ASPECTS

Existing legal frameworks in Malta

(i) National Legislation

Under Maltese legislation, groundwater has only recently been recognized as a resource and regulated as such. In fact, in 1886, when the Civil Code was being drafted, water was considered "*a natural resource which falls from heaven*"; but it is now being recognized as an economic good.

The Civil Code and the Code of Police Laws are the earliest legal instruments regulating water resources. The Civil Code regulated the collection of natural water resources and identifies who has the right to collect water flowing naturally on the land. The Code of Police Laws tries to protect "*public waters*". Furthermore, it was under the Code of Police Laws that the regulation of pollution was first introduced.

Although the legal status of the codes is hierarchically superior to primary and subsidiary legislation , this hierarchic superiority is waved when more recent and more specific primary and subsidiary legislation comes into force. In 1991, the Water Services Corporation (WSC) Act was promulgated, which regulated the management of water resources. This law repealed two ordinances that regulated the abstraction of groundwater as well s the use of groundwater for irrigation, namely the 1939 Irrigation Ordinance and the Groundwater Ordinance.

Under this Act, the roles of regulator and operator were attributed to the Water Services Corporation. The Act empowers the WSC to "*acquire, transform, manufacture, distribute and sell potable and non-potable water.*" The WSC is also entrusted with the treatment, disposal and reuse of sewage water and wastewater and the reuse of storm water runoff. Although this Act does not define underground water, there is an operative part that lists the duties of the WSC "*to survey, inspect or cause the sinking of bores ….. for the purpose of ascertaining…… the presence, quality or quantity of underground water….*". This section is the first legal provision that provides for the quality of groundwater.

In 2000, the Malta Resources Authority (MRA) Act was enacted. This Act defines the functions of the WSC and the MRA as the operator and the regulator, respectively.

This new Act deleted all the provisions under the WSC Act that empowered the WSC to issue licenses for the supply, sale or any other functions concerning water, water pumps and other apparatus related to the supply of water.

The functions of the MRA, which has a directorate for the regulation of water resources, have been fashioned upon the functions laid down in the WSC Act. The only difference is that the MRA safeguards and manages water resources through the adoption of regulations and granting of licenses, whereas the WSC performs its duties and implements these functions as a water-supply utility.

Another pertinent Act is the Environment Protection Act of 2001. Under this Act, the wide definition of the term "*environment*" includes "*water*". The competent authority under this Act is the Malta Environment and Planning Authority (MEPA); which is entrusted with the implementation of the Government's duties under this Act.

Finally, the Constitution of Malta states that "*nothing* (in this article) *shall be construed as affecting the making or operation of any law so far as it provides for vesting the Government of Malta the ownership of any underground minerals, water or antiquities*". Thus, constitution can be considered to formally vest in the Government of Malta the sole ownership of all groundwater resources in the islands.

(ii) European Water Directives

The acceptance of the application submitted by Malta to become a member state of the EU triggered the process of harmonization. This has led to a major re-evaluation of Malta's legislative system, particularly in the field of environmental management. The regulation of groundwater management in Malta, has therefore also needed to be harmonized with the relative sources of the *acquis communautaire*, which are comprehensive and holistic in their approach.

The Malta Resources Authority Act and the Environment Protection Act paved the way for the adoption of subsidiary legislation that has transposed into Maltese Legislation two EU Directives regulating groundwater, namely the Water Framework Directive and the Groundwater Directive. These two Directives provide for specific measures for the protection of groundwater.

The legal instrument that adopted the EU Groundwater Directive into Maltese Legislation is "*The Regulations for the Protection of Groundwater against Pollution caused by Dangerous Substances, 2002*". This is the first regulation completely adopted for the protection and management of groundwater. The Water Framework Directive has been adopted into Maltese Legislation by "*The Water Policy Framework Regulations, 2004*". These regulations designate the MRA as the competent authority for "*inland water*". Hence, it is the task of the MRA to take all necessary measures to ensure that the environmental objectives established under these regulations are met and to co-ordinate "*all programs of measures for the whole of the water catchment district*". These regulations provide new obligations and new implementation measures that the competent authority has to follow in order to protect both the quality and the quantity of groundwater in line with European legislation.

Other Directives that also have an impact on the regulation of groundwater such as the Nitrates Directive, the Habitats Directive, the Land filling of Waste Directive, the Plant Protection Products Directive, and the Environmental Impact Assessment Directive have also been transposed into national legislation. This process has resulted in a comprehensive legal framework addressing groundwater management for the very first time in Malta's legal history.