D2.3 Full implementation of SWS pilot test site in karstic aquifer in Schinias

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Executive Summary

Marathon plain is a coastal area, thus a potentially productive and economically dominant area of the Attica region. However, the increased water demand, along with the impact of climate change, put pressure on their freshwater resources and ecosystems. Therefore, there is a seasonal water shortage of the over-exploited coastal aquifer, as well as saline intrusion, water, soil and wetland degradation, resulting in adverse effects on activities connected with agriculture and tourism as well as on the ecological processes of the ecosystems.

To address a typical Mediterranean problem, a set of innovative, practical concepts have been developed for protection, enlargement and utilization of freshwater resources in coastal areas. These subsurface water solutions (SWS) combine innovations in water well design and configuration, allowing for advanced groundwater management, and maximum control over freshwater resources. Schinias pilot aims to test these SWS configurations coupled with novel pollution remediation techniques, including Reverse Osmosis (RO) and Advanced Oxidation Methods (AOP) to make use of water from karstic coastal aquifers and address saltwater intrusion.

Regarding the field activities that have been conducted in the Marathon coastal aquifer system these include hydrological field measurements targeted to the quality of the groundwaters of both the alluvial as well as the karstic aquifer. Three different types of chemical analyses are carried out until today: (i) basic chemical composition of groundwater samples from the saturated zones of both the alluvial and karst aquifer, (ii) isotopic composition of groundwater samples from the saturated zones of both the alluvial and karst aquifer, and (iii) chloride and EC measurements from extracted porewater within the unsaturated zone of the alluvial aquifer.

The groundwater samples from the saturated zone were collected on frequent basis in the form of campaigns from both karstic and alluvial aquifer (Figure 1), during the wet and dry periods of 2015, 2016 and 2017. Physicochemical parameters such as Specific Electrical Conductivity, pH, Temperature and Dissolved Oxygen were measured in-situ, while the water samples were transferred to the laboratory, where chemical analysis was conducted for their basic ionic composition (Ca^{2+}, Mg^{2+}, Na^{+} , K^{+} , HCO_3^{-} , SO_4^{2-}, Cl^{-} , NO_3^{-}). The results from the above show that the Marathon aquifer suffers from seawater intrusion within well defined parts of its extent, while the alluvial aquifer shows also vulnerability in terms of nitrate concentrations. The upstream part of the alluvial aquifer, shows increased concentrations of HCO_3^{-} and Ca^{2+}, that reveals diffuse recharge from the surrounding marble units.

Additionally, samples were taken for stable isotopic analysis of ^{2}H and ^{18}O targeting at the identification of specific hydrologic processes within the unsaturated and saturated zone. In general terms, the isotopic compositions of the samples appear to be very close to the meteoric water lines that are relevant to the area of interest, suggesting that recharge occurs rapidly in the system. Recharge takes place through certain pathways, between ephemeral streams in the area, the karstic aquifer units and the upper unconsolidated formation.

For the investigation of unsaturated zone, a sampling campaign of multi-level undisturbed soil samples was conducted during the wet period of 2017, using portable vibro-coring technologies. The above has lead to the successful retrieval of undisturbed soil samples through the unsaturated column providing in depth analysis of the hydrogeological properties of the soil matrix as well as of the chemical and isotopic composition of the pore water. At present, pore water extraction has been applied (using azeotropic distillation technique) for the estimation of EC and chloride concentrations in the pore waters of the alluvial aquifer, on a multi-level basis down to 3m coring depth. The results until today show a distinct coincidence between chloride concentrations and grain size of the unsaturated column, while the chloride concentrations will be used further for chloride mass balance calculations.

The SWS technology that has been implemented in Schinias pilot is a hybrid application of ASR and Freshmaker and is based on the following concept: utilization of deep groundwater resources of karst aquifer, advanced treatment of contaminated groundwater and dual use of treated groundwater i.e. seawater intrusion barrier along the coast and restoration of Schinias wetland.

For this purpose, the system has been designed with increased flexibility and the configuration consists of three (3) main building blocks as follows: (a) Water supply installations that abstract water from Makaria springs and transfer it through the Olympic Rowing Canal to the treatment unit; (b) Water treatment unit, using a system of coupled RO and AOP units; and (c) Artificial Recharge configuration, consisting of a four wells system, three vertical and one horizontal.

The water supply infrastructure consists of water pipes of 63mm and 75mm as well as electric pumps. Water is transferred for 1.700m, including the approximately 200m of the rowing canal. Water pipes and power supply cables were installed through the canal by divers.

The water treatment unit comprises of an RO unit as well as an AOP unit. The RO unit is designed to process water of conductivity of about 4500μS/cm and temperatures between 15 and 30^{o}C and to produce an outflow of 200μS/cm at 60m^3/day. The AOP unit utilises heterogeneous photocatalysis using titanium dioxide (TiO^2), as a catalyst, in order to confront organic pollution stemming from e.g. agricultural, stock-farming, other activities, random or systematic pollution events.

The artificial recharge (AR) configuration consists of: (a) one Artificial Recharge well in a depth of 23m, equipped with 3 piezometer nests for recharge; (b) two side wells in a depth of 12m at a distance of 16m each from the central AR well, screened with microfissured pipes for monitoring and recovery and (c) one Horizontal Directional Drilling (HDD) well at a length of 50m and maximum depth of 4.1m passing below the AR well, screened with PVC pipe, for buffer creation and possibly recovery.

The configuration is currently operational and in the following months tests will be performed and measurements will be taken. The generated data will be collected locally and transferred through telemetric technologies to the SUBSOL Data Monitoring System in order to process the data and carry out modeling activities.

Regarding further installations, certain automation will be installed to ensure the smooth operation of the setting and prevent unexpected events. Additionally, the remaining compartments of the AOP unit will be purchased and installed in order to improve the operation of the SWS pilot configuration.

Finally, the stakeholder group, which forms part of the potential end users (farmers, municipality, tourist sector, environmental protection agencies), will be updated and involved in the implemented technology, in order to accelerate acceptance of SWS and broaden the market reach and uptake.

1. Introduction

The coastal site of Schinias in the Marathon plain (40 km^2), 45 km NE of Athens (Greece), presents a particular interest as a natural landscape of outstanding scenery and a unique cultural landscape (Hadjibiros 2005). In the wider area, there are important archeological monuments while it maintains characteristics of the classic Attica coastal landscape. However, urbanisation of adjacent hills and plains has led to a less attractive wider scenery that remains unprotected. Scattered second-home developments, road network expansion, agricultural land-use changes and other disturbances have an important impact on the everyday landscape beyond Schinias and undermine conservation perspectives; there is little chance that this urban sprawl can be adequately controlled (Hadjibiros 2010).

Schinias is a land area of 9 km^2 with a variety of natural habitats: freshwater spring, coastal wetland, coastal sand dunes covered by a Pinus pinea and Pinus halepensis forest and a rocky peninsula covered by Mediterranean maquis; the forest covers an area of about 1.20 km^2 on a sandy strip about 400 m wide; the wetland covers an area of about 7 km^2; very few coastal wetlands are still extant in the coastline of south-eastern Greece and the Aegean islands. More than 320 species of flora and an important diversity of fauna species, including threatened resident and migrating birds, freshwater fish, amphibians and reptiles, live in the land biotope. Inflow of freshwater from Makaria spring and stagnation of fresh and brackish water in the wetland during many months of the year are essential factors for ecological habitat formation and function, for coastal forest persistence and regeneration and for land and aquatic wildlife diversity (ENVECO 1997).

The area of Schinias is valuable for nature conservation education, environmental sensitization and outdoor recreation for more than four million people living in the Attica region. If managed properly it could become an attractive place for hundreds of thousands nature lovers. They will find there a tasteful and functional space for mild activities such as hiking, cycling, swimming, acquaintance with nature, bird watching and environmental education. Effective conservation of this site should be a high priority on the basis of its important natural and cultural landscape values; the application of strict protection rules in the framework of a National Park could promote conservation and environmental awareness activities. On the other hand, many social responses towards conservation have been adverse up to now, especially those from the local community.

1.1 Background and pressures

Multiple and persistent anthropogenic pressures have been exerted on Schinias for decades. In the 20s, the water of the Makaria spring was diverted to the sea; only about 10% of water inflow remained available for the wetland; therefore the dynamic balance between surface and underground salt, brackish and fresh water has been modified and the wetland has been partially drained. However, the drainage project has never been completed; only a part of the wetland has been cultivated, while the rest has remained a semi-dried marsh in which small American and Greek military bases and a small civil airport have been established. Environmental pressures, like decrease of surface water and brackishness of underground water, noise and toxic pollution, urban solid waste disposal as well as uncontrolled hunting, fishing, grazing, motocross, car parking, camping and housing have acted for decades, resulting in considerable natural landscape degradation: habitat fragmentation, decrease of nesting, wintering or resident bird populations, extinction risk for endemic and rare species, limited regeneration of Pinus pinea (ENVECO 1997).

The upgrading of the environment in Schinias seemed almost impossible in the middle of the 90s. In spite of its ecological values, the reversal of the draining that was in effect for 80 years and the return of the water to the wetland would be minimally probable.

In 1997, Schinias was designated as a National Park and therefore strict rules applied in terms of technical works or other interventions. However, the designation of Schinias as a protected area out of the Olympic Games context was not easy and it did not give an operational solution to the problem of landscape protection. The National Park was treated with insufficient interest by the government before the Games and with indifference after the Games, so that the very existence of the National Park was discredited in the minds of inhabitants and visitors; in fact, the government tried to remove Schinias from the list of Natura 2000 sites in 1999. Overcoming the obstacles for the operation of a protected area, and also securing the necessary financial and political support for dismantling disturbing infrastructures like the airfield and the old military facilities of the American Base would not have been feasible without the powerful boost of the Olympic Games.

In the context of the country's preparation for the Olympic Games 2004, socioeconomic conditions have been favorable for environmental design. The construction of an Olympic Rowing Centre had been planned to upgrade environmental functions, while the creation of Schinias National Park in 2003 aimed at ecosystem and landscape conservation. However, these favorable conditions did not last after the Games (Hadjibiros 2010).

The Rowing Centre was constructed and operates under strict environmental conditions (ENVECO 1997, Romas et al 2005a). The Rowing Centre comprises two interconnected semi-natural lakes (earthen reservoirs, mild inclines) and was expected to have a positive impact on the ecological functions of the biotope. The location and design principles adopted for this facility aimed at restoring the natural hydrological regime and suppressing other disturbing uses. The water's natural flow was restored by diverting the water of Makaria spring towards the lake and then, through spillways, to the wetland.

The construction of the Rowing Center resulted into several benefits for the natural environment (Hadjibiros 2005). In particular, a lifting of the drainage that had begun in 1923 was essentially caused; the creation of a new, almost natural lake brought an increase of the presence of surface water and amelioration of the natural landscape condition and increased the available water quantity and quality. The small airport has been removed; this returned the ground to nature and caused a significant decrease of noise pollution. An automatic forest fire suppression system feeding with water from the new lakes has been constructed; this should contribute greatly to the protection of the coastal forest against fire. The complete dismantling of the old military facilities of the American Base, the pollution abatement and environmental rehabilitation of the natural ground they occupied, restored the natural environment to the corresponding section of the wetland. As a compensation for the sports facility inside the biotope, the founding of a National Park was decided for the effective protection and organization of the space, aiming at the reduction of illegal activities (grazing, hunting, motocross, camping, debris disposal etc.) that constituted a long-lived status quo (Hadjibiros 2010).

After the Olympic Games, mainly due to the physical changes made by the technical works, significant improvement of natural landscape has been achieved (Panagiotidis and Zogaris 2009). In fact, the technical aspects of the project have proved to be reliable and, consequently, the environmental outcomes of the intervention in Schinias have proven to be very positive (ENVECO 1997, Romas et al 2005b). The channeling of water from the Makaria spring increased the available quantity of water in the wetland and provided better hydrological conditions of groundwater with the expectation of an improvement of the forest’s natural regeneration. An extension of freshwater marshes and vegetation was observed with positive effects for the condition of the fauna. The ecosystems have been upgraded in the last years. The natural fluctuation of the water’s presence in the wetland during the years constituted an essential restoration of its function. The decrease of noise pollution and of some disturbing activities, such as hunting or debris disposal, strengthens the naturalness of the existing ecosystems; at the same time, new conditions for the increase of biodiversity were created due to the presence of a new ecological habitat (freshwater lake), (Hadjibiros 2010).

Bird diversity goes up spectacularly: 117 species were recorded in Schinias before 1997, 236 species have recently been recorded (Panagiotidis and Zogaris 2009, Hadjibiros and Sifakaki 2009). The number of aquatic birds which winter there is greater than any other count before 2004. The area has been integrated in the network of the caretakers of the Hellenic Ornithological Society since 2004 and through the continuous presence of volunteer ornithologists, knowledge about the bird fauna has improved significantly. The importance of the area for the birds has increased due to the protection and expansion of the freshwater habitats; the restoration works in the wetland, the abolition of the airfield and the removal of military infrastructure have increased the attractiveness of the area for the birds (Hadjibiros 2010).

Moreover, the freshwater fish fauna seems to have increased. At least five species have been observed. Among them, the endemic Pelasgus marathonicus that was upgraded in 2007 to the level of species and whose presence in the waters of the Rowing Centre has been ascertained (Panagiotidis and Zogaris 2009). The possibility of a financial support of the National Park through sustainable activities appeared feasible by the study conducted in the context of a LIFE project. The purpose of this project was to promote sustainable tourism and accessibility in the Park, to influence the behavior and minimize the environmental impact of visitors and to enhance the quality of life of disabled people, especially those in Attica (where almost half of the Greek population lives).

However, even though the technical intervention in Schinias seems to be successful for the upgrading of the natural landscape, major difficulties arose with regard to implementing the National Park's rules, due to lack of the absence of a well-ruled state and a developed civil society. Multiple efforts to develop environmental awareness through public hearings, local educational initiatives etc. have not led to significant improvements, resulting in the following pressures in the operation of the National Park (Hadjibiros 2010):

- Some complementary environmental conditions of the Rowing Centre were not materialized, e.g., the construction of a ring-road for the de-congestion of the Park from the traffic of cars passing through or the development of organic farming cultivations.
- Illegal taverns and bars that belong to a Building Cooperative and the Marathon Municipality remained and are operating at the edge of the forest and on the beach. They are powered by gas-engines that present the risk of causing fire in the forest and, moreover, they drain waste water into the National Park's sea illegally. These facilities should have been demolished, according to a judicial decision of 2005 that still remains unexecuted.
- In the summer, many cars enter the National Park illegally and park in the forest and on the beach. The trampling of the vegetation by the car wheels prevents the regeneration of Pinus pinea. Moreover, there is an accumulation of garbage left behind by car passengers.
- Guarding of the National Park is not sufficient or continuous due to lack of funding. The prohibition of camping, overnight staying, hunting, grazing, motocross, debris disposal etc. is often violated, though the situation has improved in relation to the past.
- The costly automatic fire extinguishing system was constructed along with the Rowing Centre in 2003 but it never functioned. Later, it broke down due to lack of maintenance; thus, there is a risk of destructive fire, especially in the dry summer months.
- The wetland is crossed by two asphalt paved roads that create undeniable nuisance to birds and other fauna species. Although one of these roads does not serve vital needs, the local community opposes its pedestrianization in spite of the fact that the National Park legislation prescribes it.
- The local public authorities (Police, Fire Department, Coast Guard, Forest Inspection, Municipal Police) do not intervene effectively for the control of illegal actions that harm the environment and lead to the degradation of the landscape.

- Some officials of the Local Government or businessmen made various suggestions, for financial utilization of the space towards e.g. the luxurious tourism development.
- Attempts of sabotage the hydraulic system that regulates the water flow from Makaria spring to the Rowing Centre and the wetland; sabotage obviously aimed at the drainage of the wetland for agricultural purposes.
- Neutral apathy of the larger part of society along with the negative actions of certain local interests. Up to now, social support to the ambitious initial plan is too weak to deal with local protests for restrictions on cars or wetland flooding and with expectations to build in the Park area.

Despite the adverse results of these pressures, the environmental situation today is the best one in the last 80 years as through the Rowing Centre technical project, there have been irreversible positive interventions. These interventions offer a significant time prospect to the effort for landscape conservation, with the expectation that, gradually, Greek society will acquire environmental concern corresponding to its economic condition (Hadjibiros 2010). A promising positive sign of the wider society's mobilization is the volunteer action. For example, thanks to the yearly repeated organized efforts of citizens from all over Attica for cleaning the coast and the forest from the garbage left by summer visitors, the National Park remains clean in the winter months; such phenomena create encouraging future prospects.

1.2 Environmental problem targeted

Marathon plain is a coastal area, thus a potentially productive and economically dominant area of the Attica region. However, the increased water demand, along with the impact of climate change, put pressure on their freshwater resources and ecosystems (figure 1).

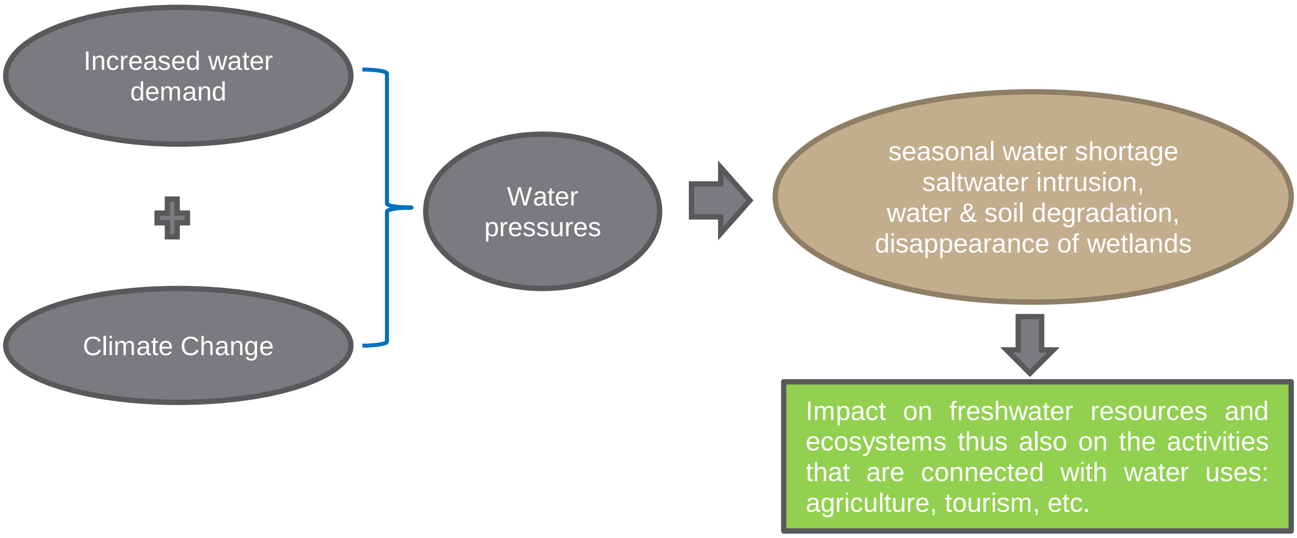


Figure 1. Water issues in coastal areas

Therefore, there is a seasonal water shortage of the over-exploited coastal aquifer, as well as saline intrusion, water, soil and wetland degradation, resulting in adverse effects on activities connected with agriculture and tourism as well as on the ecological processes of the ecosystems.

To address a typical Mediterranean problem, a set of innovative, practical concepts have been developed for protection, enlargement and utilization of freshwater resources in coastal areas. These subsurface water solutions (SWS) combine innovations in water well design and configuration, allowing for advanced groundwater management, and maximum control over freshwater resources.

2. Marathon Hydrosystem

2.1 General setting

Schinias is located in the Marathon plain in the Attica region in Greece (figure 2), which is characterized as a typical Mediterranean environment that involves a naturally occurring and today degraded coastal wetland with the characteristics of a distinct ecosystem linked to a typical coastal hydrogeological system of a semi-arid region.

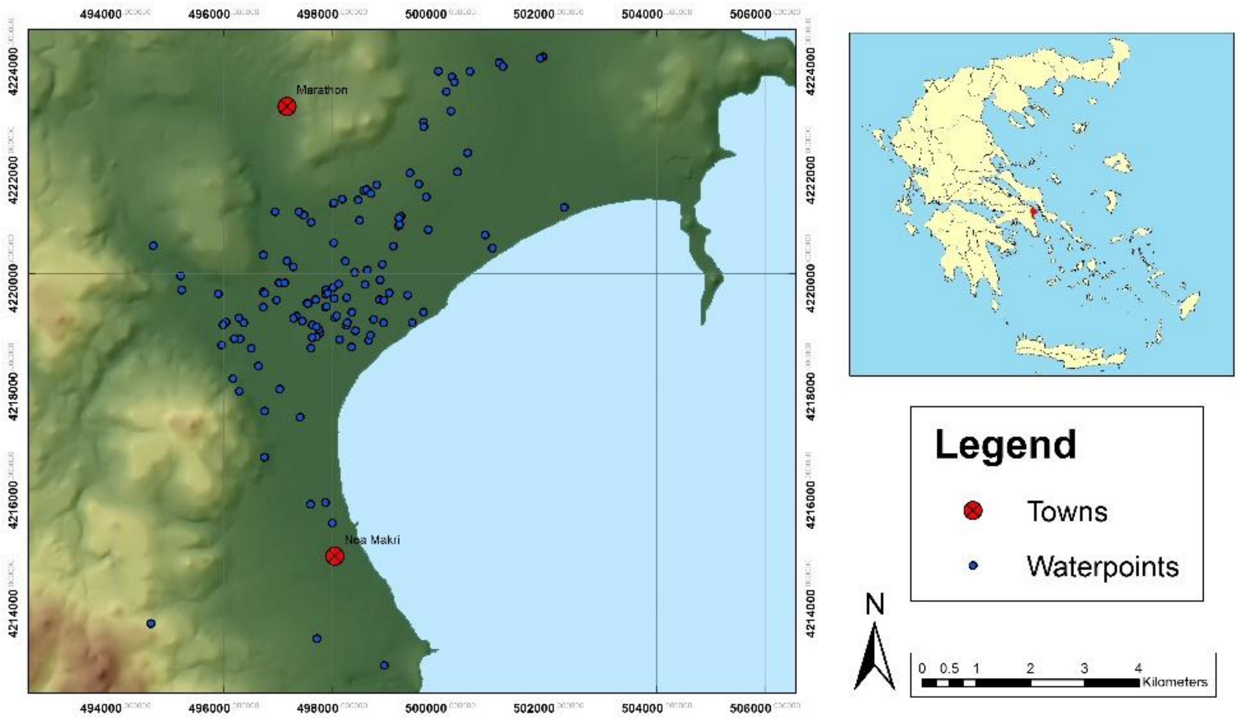


Figure 2. Sampling and measuring points of the coastal aquifer system of Marathon

The general features of Marathon plain (figure 3) include the typical land uses of the Mediterranean areas, small settlements, agricultural activities with greenhouse facilities as well as the largest coastal wetland in the region of Attica along with the Schinias Natural Park. The area also hosts the Schinias Olympic Rowing and Canoeing Centre, constructed for the Olympic Games of 2004, that has changed significantly the hydrological regime of the area.

Figure 3. Aerial photo of Schinias, Marathon

Such coastal environments are considered important ecosystems that provide valuable services to human population, such as agricultural and touristic activities.

These activities usually induce surface and groundwater deterioration by means of water resources degradation and seawater intrusion in the inland (Melloul and Goldenberg, 1997; Pulido-Leboeuf, 2004; de Montety et al., 2008; Kazakis et al., 2016). As most coastal Mediterranean hydrosystems, the coastal plain of Marathon faces severe surface and groundwater degradation issues due to recent human activities (Perdikaki el al., 2017).

2.2 Hydrogeological setting

The hydrogeological setting includes the following items (figure 4):

Figure 4. Marathon hydrogeological setting

- Inflow to the karstic aquifer mainly originating from precipitation during the wet period of the hydrological year.
- Defuse recharge from the alluvial aquifer and the wadi.
- Outflows of the aquifer are the discharge to the alluvial aquifer and the karstic springs of Makaria.

The main hydrogeological units of the area involve a multi-layer aquifer system that consists of (i) an upper unconsolidated formation dominated mostly by alluvial quaternary deposits and (ii) the surrounding and underlying karstified marble units. Both aquifers are subjected to intensive pumping conditions due to agricultural activities in the largest part of the plain.

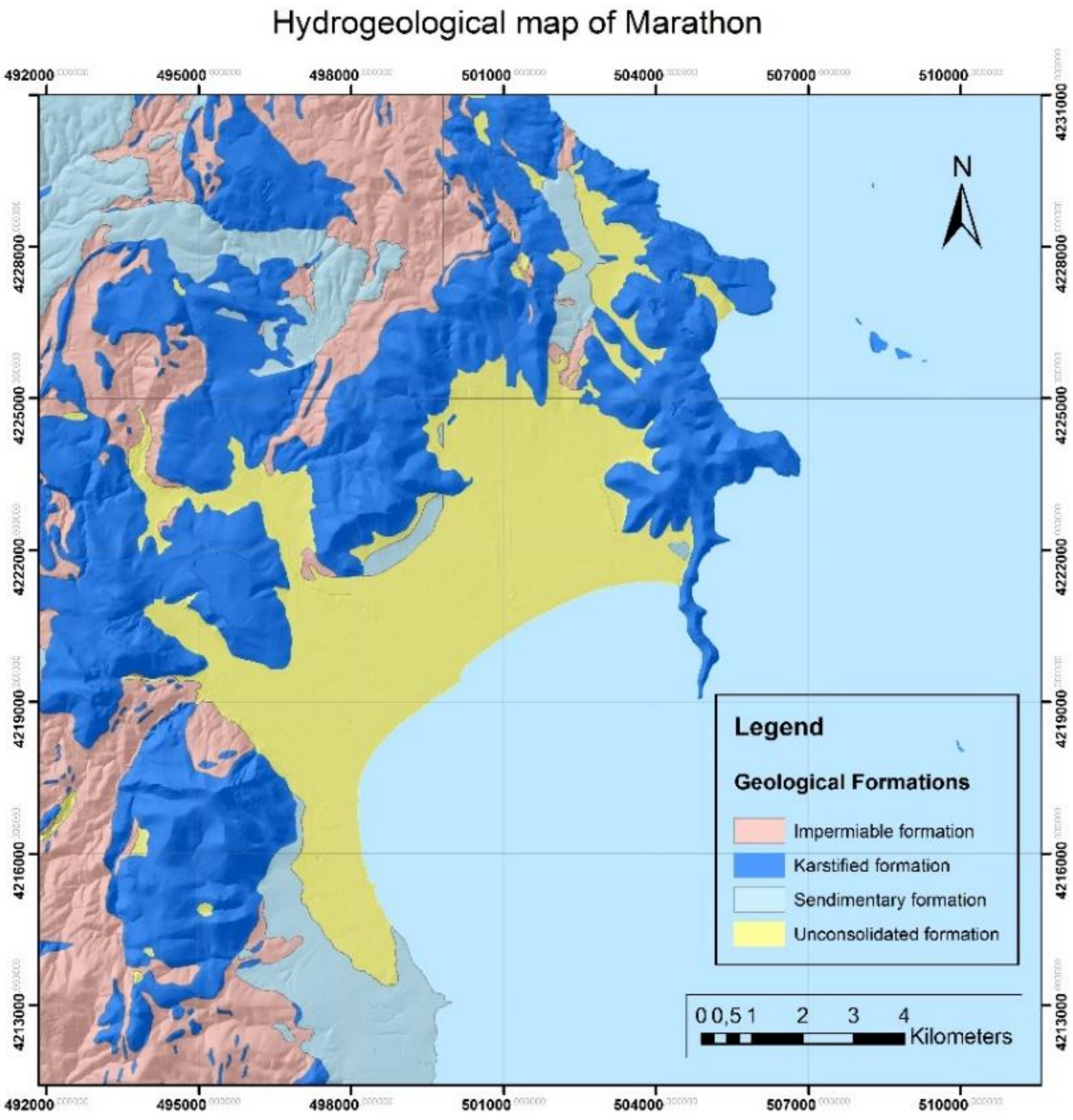


Figure 5. Hydrogeological map of Marathon

As a result, seawater intrusion has affected the groundwater within both formations; however it is more pronounced in the upper unconsolidated layer (Melissaris and Stavropoulos, 1999; Siemos, 2010), (figure 5).

2.3 Research and field activities

The remediation of the groundwater system is vital for the restoration of Marathon's coastal wetland. The rehabilitation of a polluted aquifer depends mainly upon the establishment of an adequate monitoring program in order to provide data collection and analysis, evaluation of the results and finalize a method for the recovery of the aquifer (Perdikaki el al., 2017).

Within the scope of SUBSOL project, part of the hydrological field measurements targeted to the quality of the groundwaters of both the alluvial as well as the karstic aquifer of Marathon coastal aquifer system (figure 6). This investigation focused on the hydraulic connection between the surrounding karst aquifer units of Marathon, the natural recharge conditions of the alluvial aquifer from direct precipitation and percolation from surface water bodies as well as the intrusion of seawater.

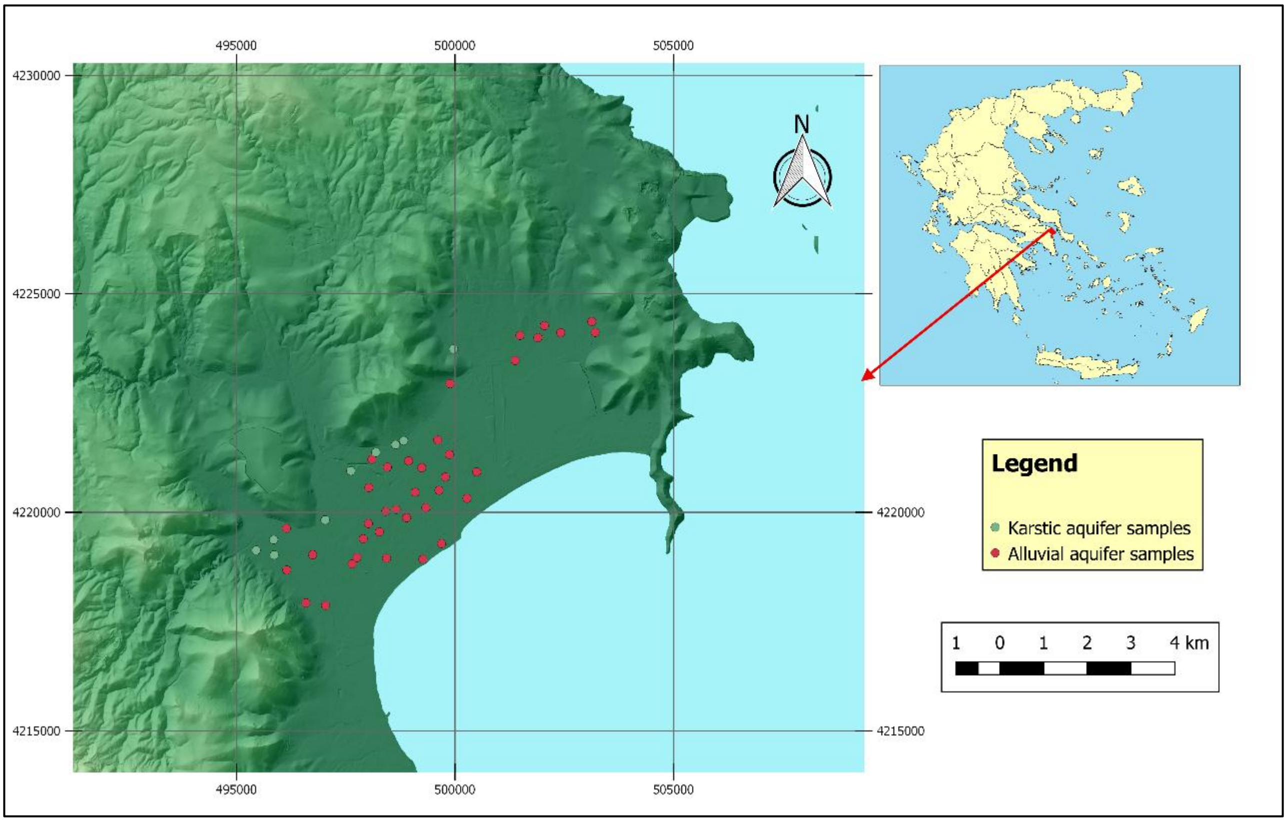


Figure 6. Groundwater monitoring positions in Marathon Plain

The tasks of the research actions include surface geophysics and remote sensing, hydrogeophysics and field analysis as well as groundwater quality monitoring. In particular, the field activities included data collection from previous studies, survey of existing groundwater wells, shallow wells within the alluvial formation, deep wells within the marble layer, geological mapping for groundwater model boundaries definition, series of infiltration tests within the alluvial aquifer, groundwater sampling campaigns in the alluvial and karst aquifers. Additionally, recently designed monitoring network were installed with regard to shallow boreholes for the investigation of the alluvial aquifer, wadi discharge measuring points and installation of pressure transducers and multiparameter probes for monitoring hydraulic heads and salinity fluctuations at selected points above. Spatial TDR within the alluvial valley was set to monitoring wadi water level and groundwater sampling campaign was performed in both layers (alluvial & marble) for isotopic signatures (stable isotopes for groundwater recharge investigations) (figure 7).

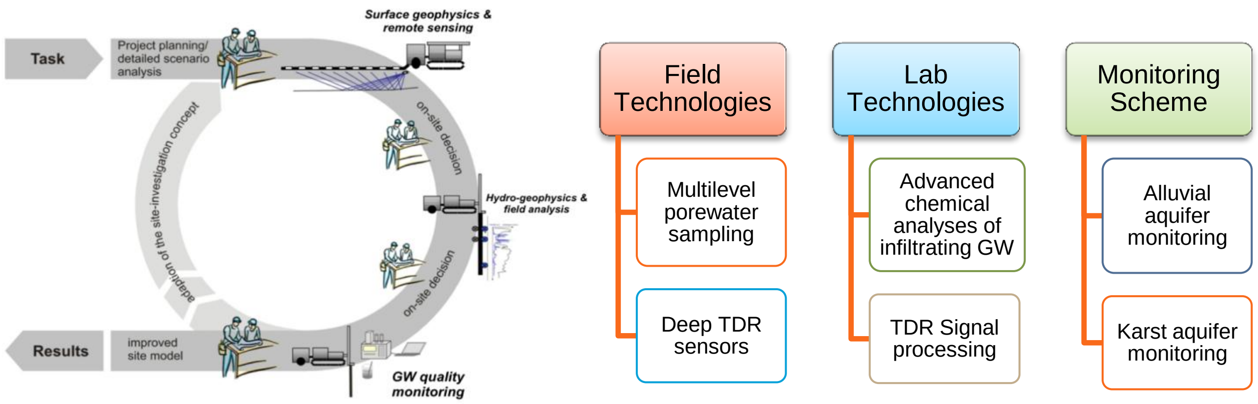


Figure 7. Research activities tasks

Field technologies were used such as multilevel porewater sampling, deep TDR sensors, etc. With regards to the laboratory technologies advanced chemical analyses of infiltrating groundwater as well as TDR signal processing were used. The monitoring scheme included alluvial aquifer monitoring as well as karst aquifer monitoring (figure 7).

The infiltration tests that have been conducted at selected locations (figure 8), include:

- Double ring infiltrometer is a method often used to estimate infiltration rate i(T) and vertical hydraulic conductivity Kz considering ideal flow conditions and homogenous soil.
- The Parameter Equation by Philip (1957) was used to calculate the infiltration rate.

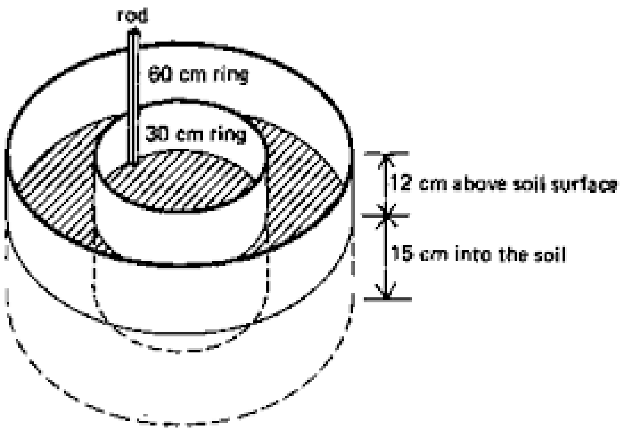


Figure 8. Infiltration tests

Three different types of chemical analyses have been carried out until today: (i) basic chemical composition of groundwater samples from the saturated zones of both the alluvial and karst aquifer (figure 6), (ii) isotopic composition of groundwater samples from the saturated zones of both the alluvial and karst aquifer (figure 9), and (iii) chloride and EC measurements from extracted porewater within the unsaturated zone of the alluvial aquifer (figure 10).

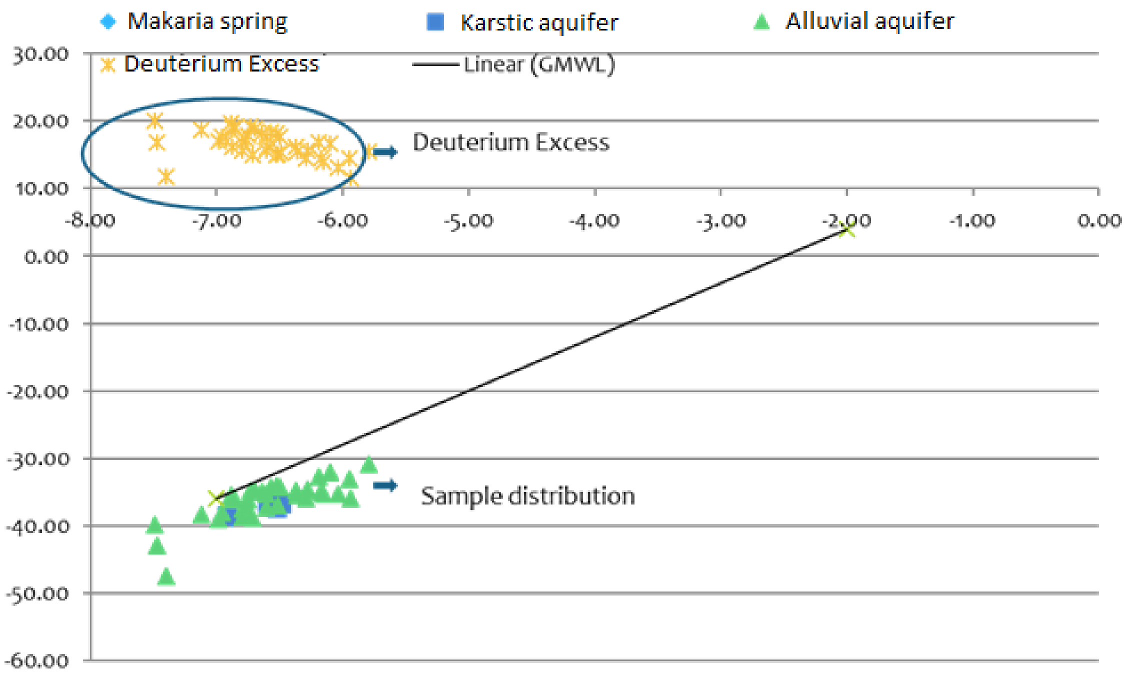


Figure 9. Isotopic signatures

The groundwater samples from the saturated zone were collected on frequent basis in the form of campaigns from both karstic and alluvial aquifer, during the wet and dry periods of 2015, 2016 and 2017 (table 1). Physicochemical parameters such as Specific Electrical Conductivity, pH, Temperature and Dissolved Oxygen were measured in-situ, while the water samples were transferred to the laboratory, where chemical analysis was conducted for their basic ionic composition (Ca^{2+}, Mg^{2+}, Na^{+} , K^{+} , HCO_3^{-} , SO_4^{2-}, Cl^{-} , NO_3^{-}). The results from the above show that the Marathon aquifer suffers from seawater intrusion within well defined parts of its extent, while the alluvial aquifer shows also vulnerability in terms of nitrate concentrations. The upstream part of the alluvial aquifer, shows increased concentrations of HCO_3^{-} and Ca^{2+}, that reveals diffuse recharge from the surrounding marble units.

Additionally, samples were taken for stable isotopic analysis of ^{2}H and ^{18}O targeting at the identification of specific hydrologic processes within the unsaturated and saturated zone. In general terms, the isotopic compositions of the samples appear to be very close to the meteoric water lines that are relevant to the area of interest, suggesting that recharge occurs rapidly in the system. Recharge takes place through certain pathways, between ephemeral streams in the area, the karstic aquifer units and the upper unconsolidated formation.

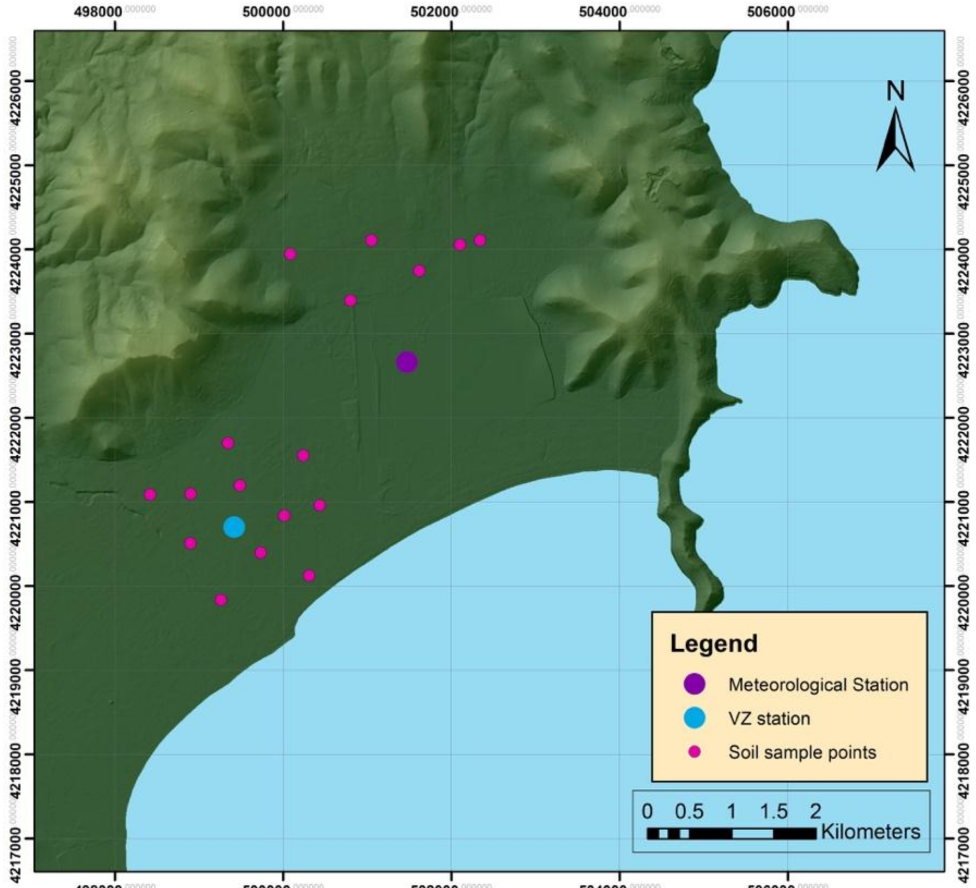


Figure 10. Unsaturated zone (upper unconsolidated aquifer formation) sampling locations

MONITORING WATER PARAMETERS				
Parameter	**Frequency**	**Measurement type**	**Area of interest**	**Measurement type**
Physico-chemical parameters (SEC, pH, T, DO)	Monthly	In situ	Schinias-Marathon	Campaign
Major ions	Monthly	In laboratory	Makaria Spring	Campaign
Trace elements	Monthly	In laboratory	Schinias-Marathon	Campaign
Cations: Na, K, Mg, Ca, Sr, Ba	Monthly	In laboratory	Schinias-Marathon	Campaign
Anions: SO4, Si, S, HCO3, Cl	Monthly	In laboratory	Schinias-Marathon	Campaign
Stable Isotopes ($\delta^{18}O$, $\delta^{2}H$)	Every 2 months	In laboratory	Schinias-Marathon	Campaign
Physico-chemical parameters (SEC,pH,T)	10mins	In situ	Schinias	Automatic
Samples of rainwater	Not available	In situ	Schinias	Automatic
Other parameters (ex. Pesticide residues, Heavy metals etc.)	Other	In laboratory	Schinias-Marathon	Campaign
Hydrological measurements (surface & groundwater)				
Parameter	**Frequency**	**Measurement type**	**Area of interest**	**Measurement type**
Groundwater level	Monthly	In situ	Schinias-Marathon	Campaign
Groundwater level	10mins	In situ	Schinias	Automatic
Groundwater level	10mins	In situ	Schinias-Marathon	Automatic
Groundwater level	10mins	In situ	Makaria Spring	Automatic
Groundwater level	10mins	In situ	Schinias	Automatic
Groundwater level	10mins	In situ	Makaria Spring	Automatic
Stream Discharge	10mins	In situ	Schinias	Automatic
Field work				
Parameter	**Frequency**	**Measurement type**	**Area of interest**	**Measurement type**
Aquifer hydraulic parameters	Not available	Pumping tests	Schinias-Marathon	Campaign
Recharge rate	Not available	Double ring infiltration test (in situ)	Schinias-Marathon	Campaign
Water content profile	Not available	In situ	Schinias-Marathon	Campaign
Measurements in water treatment plant	**Frequency**	**Measurement type**	**Area of interest**	
Physico-chemical parameters (SEC, pH, T, TOC, turbidity, COD)	Every 15 days	Water treatment plant	Schinias	
Cations: Na, K, Mg, Ca, Sr, Ba	Every 15 days	Water treatment plant	Schinias	
Anions: SO4, Si, S, HCO3, Cl	Every 15 days	Water treatment plant	Schinias	

Table 1. Monitoring water parameters

For the investigation of unsaturated zone, a sampling campaign of multi-level undisturbed soil samples was conducted during the wet period of 2017, using portable vibro-coring technologies (figure 10). The above has lead to the successful retrieval of undisturbed soil samples through the unsaturated column providing in depth analysis of the hydrogeological properties of the soil matrix as well as of the chemical and isotopic composition of the pore water (after appropriate water extraction technique is applied). At present, pore water extraction has been applied (using azeotropic distillation technique) for the estimation of EC and chloride concentrations in the pore waters of the alluvial aquifer, on a multi-level basis down to 3m coring depth. The results until today show a distinct coincidence between chloride concentrations and grain size of the unsaturated column, while the chloride concentrations will be used further for chloride mass balance calculations.

At present, the following measurements are taking place, in connection to the above: (i) chemical analyses of groundwater samples from the saturated zone of the alluvial and kasrtic aquifer (wet period of 2017), (ii) isotopic composition of groundwater samples for the dry period of 2016 and wet period of 2017, (iii) different porewater extractions for further investigations of stable isotopic composition in the unsaturated zone, (iv) estimation of hydraulic conductivities from soil samples in the unsaturated zone, (v) permeability.

2.3.1 Inorganic pollution indicators

The results were introduced in a GIS database in order to specify the range of seawater intrusion and the occurrence of other pollutants in both groundwater units (unconsolidated and karstic aquifer). In particular, 48 sampling points were used (9 points of the karstic aquifer and 39 points of the alluvial aquifer), two campaigns per year (May and October) and 9 chemical elements for each sample.

To monitor the range of seawater intrusion in a polluted aquifer, chloride was used as an indicator. The chemical analysis of the collected samples during the wet and dry period of 2016 in Marathon plain, confirmed the high concentrations of ions due to the seawater intrusion in both coastal aquifers (alluvial and karstic). Figures 11 and 12 present thematic maps of chloride concentration for the two periods.

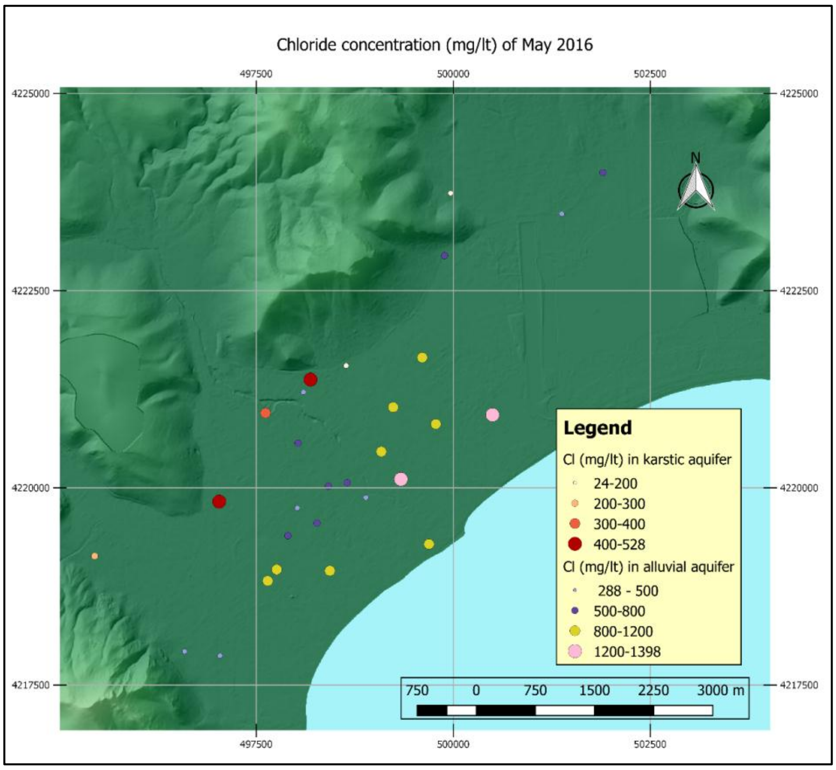


Figure 11. Cl- concentration in Marathon - May 2016

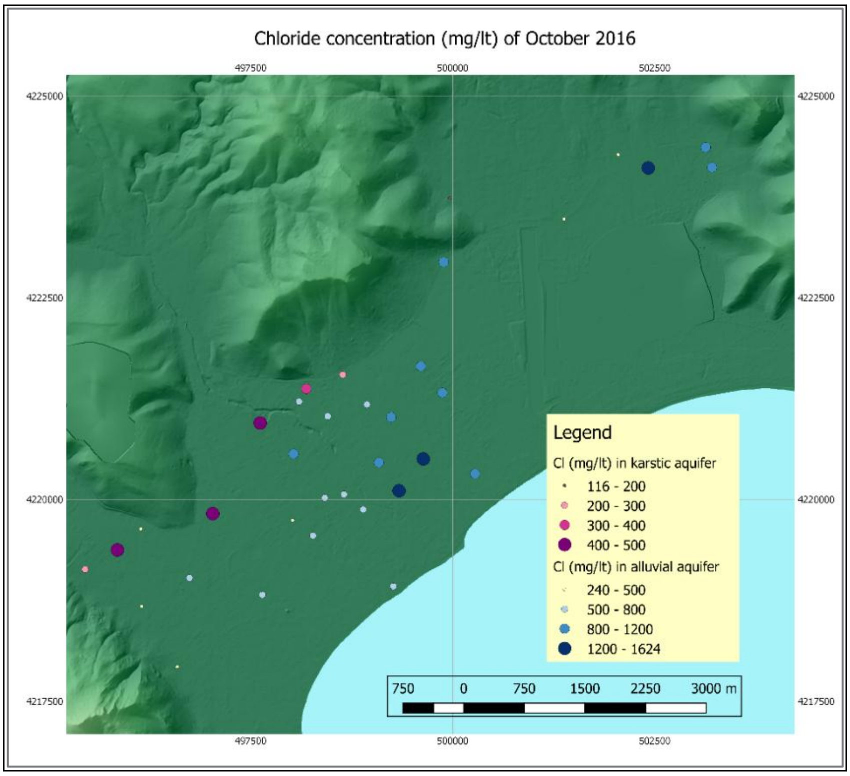


Figure 12. Cl- concentration in Marathon - October 2016

The qualitative status of coastal aquifer system is illustrated through the chlorine concentration of the alluvial aquifer (figure 13), while the Specific Electrical Conductivity (SEC) spatial distribution is depicted in figure 14.

In summary, existing monitoring wells inventory includes 66 wells in the alluvium and 13 wells from previous studies in the karstic system that has water table depth measurements, chemical analysis (major ions, heavy metals) and indication about which aquifer each well or drill exploits.

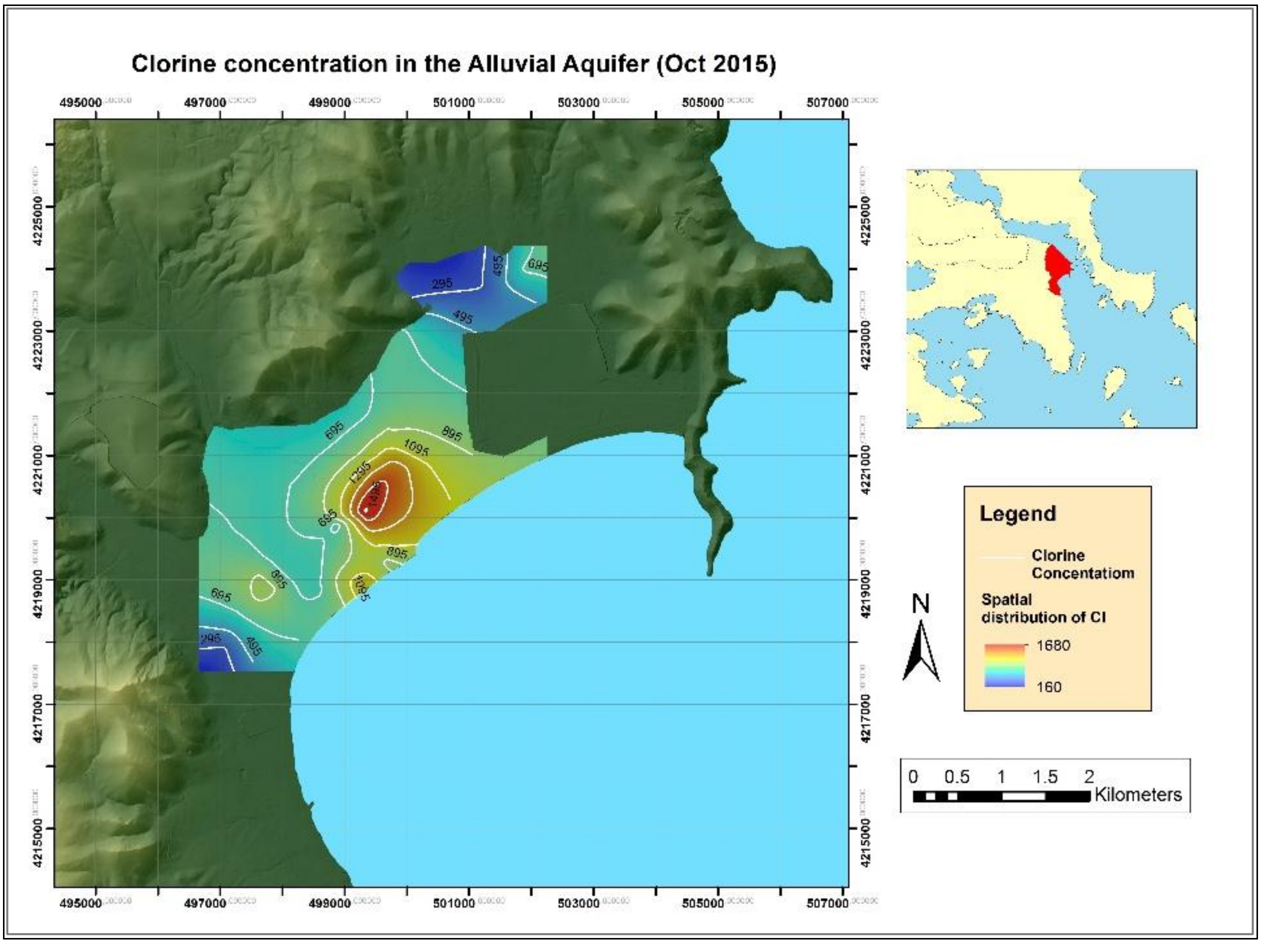


Figure 13. Chlorine concentration in the alluvial aquifer (October 2015)

The main problems include the lack of lithological records, longtime series of piezometric level and lack of a central authority that has records about the locations of all the wells in the area. The involved stakeholders in data acquisition include the following: (i) Institute of Mineralogical and Geological Exploration, (ii) Decentralized administration of Attica, (iii) National Meteorological Services, (iv) Municipality of Marathon, (v) Ministry of Agriculture and (vi) Athens Water Supply and Sewerage Company (EYDAP SA).

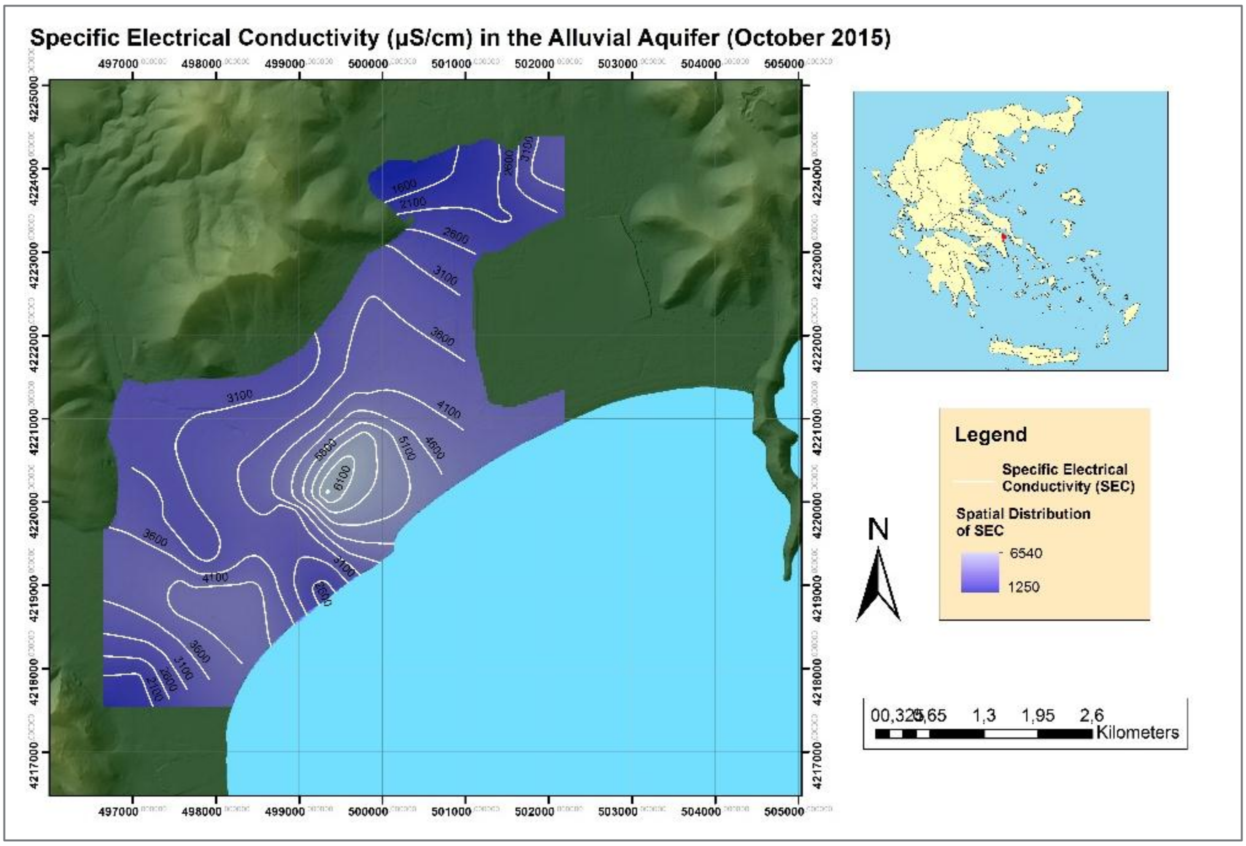


Figure 14. Specific Electrical Conductivity (SEC) in the alluvial aquifer (October 2015)

2.3.1 Organic pollution indicators

The area of Schinias comprises of a large variety of habitats, including freshwater springs, coastal wetlands, forests and rocky areas. Intrusion of seawater in the upper levels of groundwater is a constant and escalating problem. The water quality of the lower karstic aquifers, although expected to be of higher quality and lower inorganic load, has not been well documented and analysed in past studies.

Few data were available and objective difficulties in the assessment of the karstic water quality remain unsolved: unregistered urban solid waste disposal, unaccounted toxic pollution from various streams and interconnection of groundwater aquifers has not been thoroughly studied. Only a part of the wetland is cultivated, and few data are available on the use of pesticides (introducing organic pollution) and fertilisers (introducing inorganic pollution of nitrates and phosphates).

Also, in the area, for almost 40 years, a navy military base was operating, including a small power plant, warehouses, fuel containers and auxiliary buildings. In a past instance, toxic liquid containing PolyChlorinated Biphenyls and PolyAromatic Hydrocarbons has been discharged illegally in the area. Significant concentrations of heavy metals and petroleum residuals have also been detected in environmental samples originating from the area. Furthermore, various agricultural and stock-raising facilities are located near the selected source of water, with little or no data regarding their production of waste or use of chemical substances through their productive process.

Since the available data on the quality of the karstic aquifer to be used for recharging upper water levels, was extremely limited, it was crucial to assess its quality, based on the concentration of inorganic and organic content and to implement novel groundwater remediation techniques, able to remove pollutants that are currently or could be implicitly present under the appropriate physicochemical conditions.

Two types of pollutants were initially expected to be present on the studied system: a) Inorganic pollution in the form of salinity due to the possible intrusion of seawater, the increased dissolution of minerals from the underground karstic geological formations or the gradual penetration of fertilisers and b) organic in the form of PCBs, PAHs, oil and fuel additives or various pesticides.

Chemical analysis of the source water during 2016, proved the presence of organic pollution (various pesticides and volatile organic pollutants) at low concentrations. COD of the sampled water reached 65.5 mg/L while TOC values reaching 1.95 mg/L. It is noteworthy that concentrations and types of pollutants could vary among different sampling areas and time periods, based on rainfall or climatic conditions, and on random or systematic types of anthropogenic pollution.

2.3 Modelling processes

A useful tool to monitor the seawater diffusion in an aquifer is the production of thematic maps that represent ion concentrations. Chloride is the most suitable indicator to specify the range of seawater encroachment in a polluted aquifer and is also considered a key factor for the characterization of the groundwater use (Perdikaki et al 2017).

The AkvaGIS module has been proved a helpful tool in representing the concentration of chloride ions at the vicinity of Marathon. The calculated values of Cl- ions for May indicate a hydrochemical evidence of seawater intrusion that is far more notable in the shallow formation with a high spatial range between 288 and 1400 mg/lt. The highest concentration is mainly observed at the central part of the area and near the coast, where the Cl^- ions exceed 800 mg/lt, while the salinity is being depleted in the NE and SW parts of the plain where the unconsolidated formation meets the karstified one. On the contrary, the karstic aquifer has a lower range of Cl- concentration (from 24 to 528 mg/lt).

Thematic maps of chloride concentration for the two periods are presented in figures 11 and 12, using the “Chemical Parameter Map” tool of AkvaGIS and the “Print Composer” tool of QGIS (Perdikaki et al 2017).

Additional processing of the Marathon hydrosystem data is described below:

- Simulation of multi-aquifer system of Marathon for alluvial and karst units (figure 15)
- Use of free and open source GIS integrated software
- Calibration under steady state conditions
- System conceptualization based on historical data and newly acquired field data

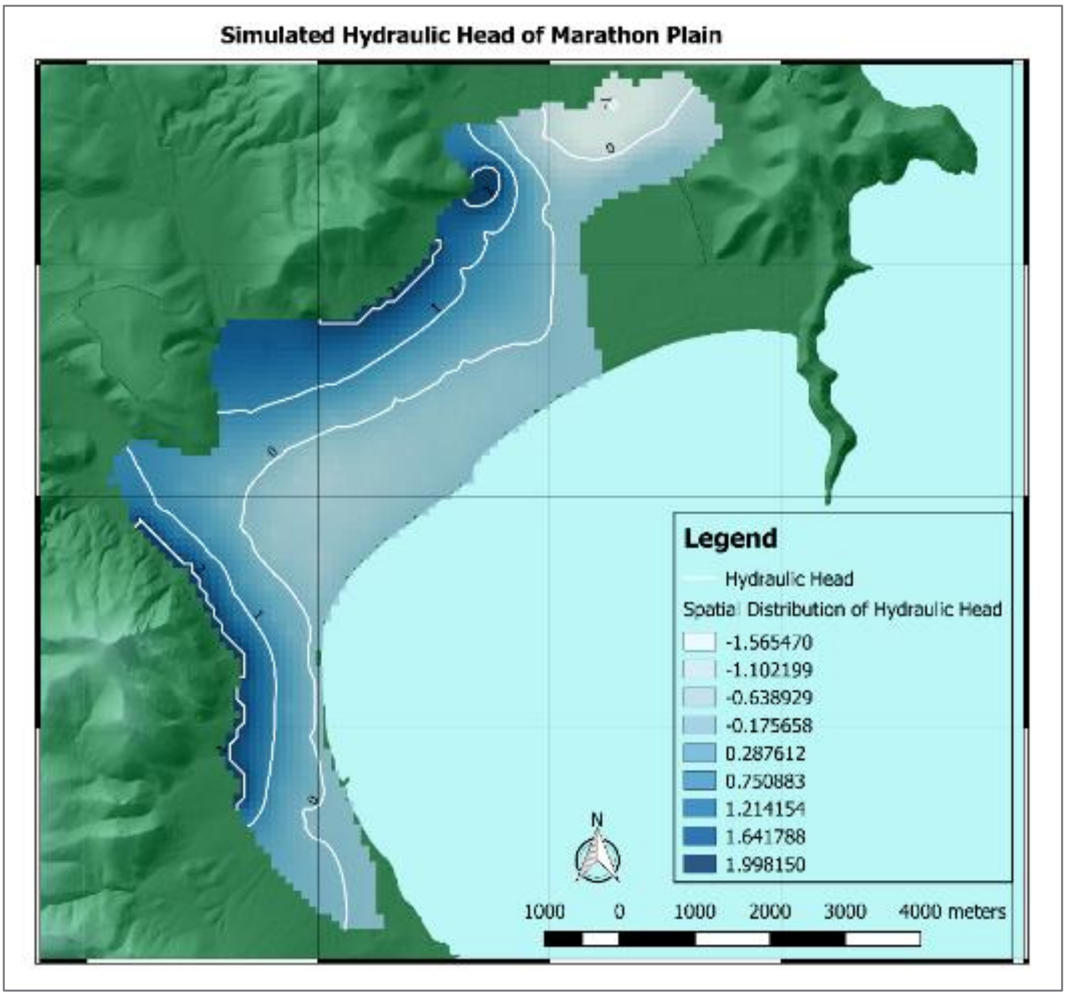


Figure 15. Simulated Hydraulic Head of Marathon Plain

Also modelling plans for next stage include the following:

- Participatory driven scenarios
- Contaminant transport
- FARM `USGS module for agricultural water optimization
- System response after SUBSOL full scale implementation

3. Strategy for SWS implementation

3.1 Schinias pilot concept

The Schinias pilot exploits a rather usual context: the alluvial aquifer in use by both the wetland and agriculture, is sitting on top of a karstic aquifer, discharging relatively good quality water straight to the sea. Within the framework of the SWS technologies, the Schinias pilot attempts to use karstic water resource, treat it with novel pollution remediation techniques (Reverse Osmosis and Advanced Oxidation Methods) and reinject in the alluvial aquifer. The aim is to demonstrate how this currently unused resource, can be turned into a source for protection, regeneration and financial sustainability for the area as well as other similar ones throughout the Mediterranean.

The Schinias pilot research and engineering concept includes the following steps (figure 16):

- Utilization of deep groundwater resources of karst aquifer
- Advanced treatment of brackish groundwater
- Dual use of treated groundwater to benefit (a) seawater intrusion barrier along the coast and (b) restoration of Schinias wetland, which is a win-win scenario.
- Multi-directional drilling and MAR optimization schemes

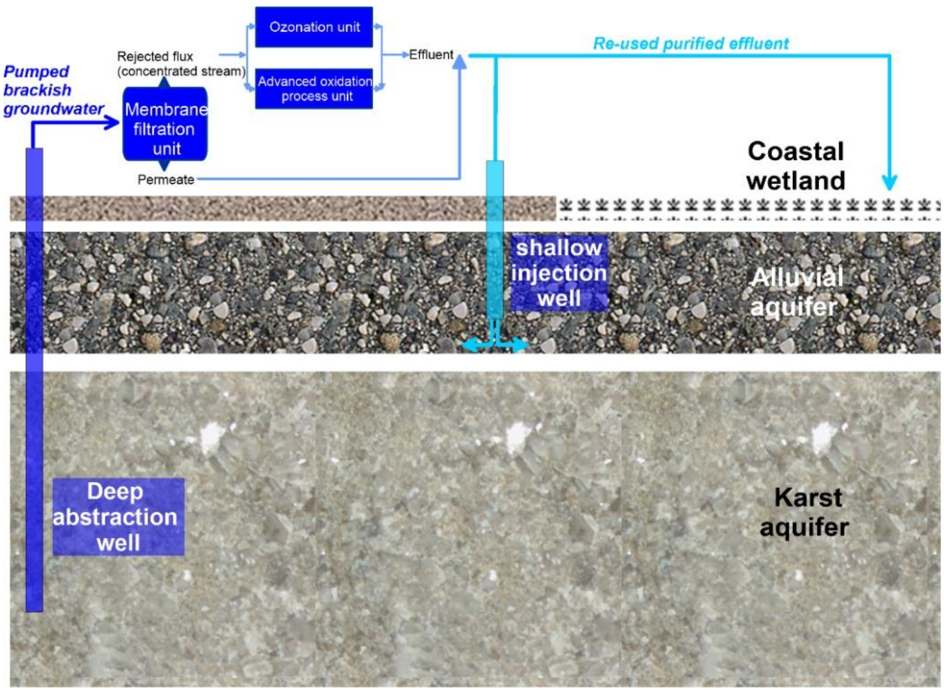


Figure 16. Schinias pilot research and engineering concept

3.2 Pilot site selection

The Schinias site (figure 17) was selected based on several criteria as are illustrated below:

- Typical hydrogeological conditions for Mediterranean coastal areas
- Karst system of high groundwater potential
- Typical groundwater environmental problems
- Typical land use and agricultural activities
- Increased touristic activities
- Alternative groundwater resources utilization
- Artificial Recharge (AR) site specific conditions (figure 18)

Figure 17. Schinias site

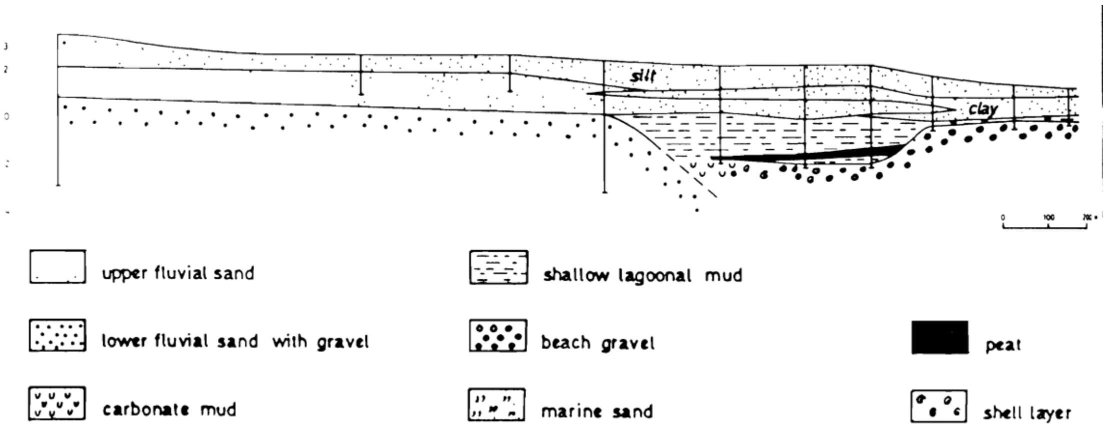


Figure 18. Artificial Recharge (AR) site specific conditions

(Adapted from Baeteman C. 1984)

3.3 Pilot permit procedures

The permit procedures have started at an early stage of the project through informing the involved stakeholders for the necessary permits. The basic outcomes of this procedure include the following:

- ✓ NTUA has signed a contract with the Public Properties Company (ETAD SA) to rent a specific space of Schinias Olympic Rowing Center to set up the water treatment unit. The rent was low due to the scientific purpose of the project.
- ✓ The Management Board of Schinias National Park provided official permit and supported the implementation of the pilot in the protected area.
- ✓ The Archaeological Service granted official permits for the necessary surveys and drilling activities.
- ✓ Forestry has provided official permit for setting the pilot installations in the specific area.
- ✓ The Region of Attica checked the official documentation for the pilot implementation and provided a positive opinion to the Decentralized Administration of Attica.
- ✓ The Decentralized Administration of Attica - Water Directorate issued the water use permit to operate the configuration. Indeterminate permits for the construction of the wells have also been issued. The permit to dispose the brine has been issued in the same documentation.
- ✓ ETAD provided permission to use the existing power supply for the operation of the unit and other needs of the configuration. The installations for the power supply are completed and power supply is set.

NTUA has also been in close cooperation with several stakeholders in the scope of the pilot project as follows: Athens Water Company - EYDAP (since January 2016), Marathon Municipality (since September 2015), Management Board of Schinias Marathon National Park (since October 2015), Power supply company - DEH / DEDDHE (since November 2015), Public Properties Company - ETAD SA (since October 2015), Hellenic Meteorological Service (since October 2015), Archaeological Service (since December 2015), Region of Attica (since December 2015), Decentralized Administration of Attica – Water Directorate (since December 2015), Marathon Municipal Community (since January 2016), Agricultural Association of Marathon (since January 2016), Regional Urban Planning Authority (since February 2016), Ministry of Environment (since February 2016), Forestry of Attica (since April 2016). The feedback from all the stakeholders for the expected project results has been so far positive.

3.4 SWS Configuration

The technology that has been implemented in the Schinias pilot is a hybrid application of ASR and Freshmaker technologies of the subsurface water solutions. The system has been designed with increased flexibility and there are three (3) main building blocks described below (figure 19).

Figure 19. Schinias SWS configuration

3.4.1 Water supply installations

In this area (Area A), karstic water is abstracted from Makaria springs and transferred through the Olympic Rowing Canal to the treatment unit (figure 20).The water supply infrastructure consists of water pipes of 63mm and 75mm as well as electric pumps; water is transferred from Makaria springs through the rowing canal to the treatment unit (about 1700m to the south). Water pipes and power supply cables were installed by divers (figures 21).

Figure 20. Water supply installations

Figure 21. Installation of water pipes and power cables through the canal by divers

3.4.2 Water treatment unit

The measured data indicate that the treatment unit installed in the area before the recharge of the upper aquifer should include a series of novel remediation techniques in the flow of the pumped groundwater, before it is reintroduced in the upper groundwater aquifer. The final aim is to reduce both the overall inorganic and organic load of the source water and to provide the aquifer with water of high quality.

These techniques include a) a reverse-osmosis system, which drastically reduces the ionic content of the water and removes residual organic species of increased molecular weight and b) an Advanced Oxidation Processes system for the degradation and mineralization of organic pollutants in the presence of inorganic ions, which are present in the rejected flux of the membrane filtration unit. The capacity of the installed devices have been selected according to the inorganic and organic load of the water originating from the karstic aquifer, the total average organic and inorganic content of the rejected concentrate and the flow of the pumped water. They are also designed to remotely monitor and operate, so as to be tested and applied in similar remote locations.

The water treatment unit (Area B) has been designed, constructed and installed in place in the south part of the installations of the Rowing Canal (figure 22), which is the place that has been rented for this purpose. It is quite a flexible setup and uses a system of coupled RO and AOP units (figure 23).

Figure 22. Water treatment unit location

3.4.2.1 Advanced Oxidation Process (AOP) unit (partly installed)

The design and installation of the specific AOP process ensures the degradation of pollutants under different environmental conditions, pollution concentrations and flow rates, producing water adequate to be processed in an RO unit. Nonetheless, the aim of the design is to produce a universal, versatile and modular water treatment unit that is suitable to be used in a variety of environments.

In particular, the AOP unit utilises heterogeneous photocatalysis using titanium dioxide (TiO_2), as a catalyst, in order to confront organic pollution stemming from e.g. agricultural, stock-farming, other activities, random or systematic pollution events (figure 23).

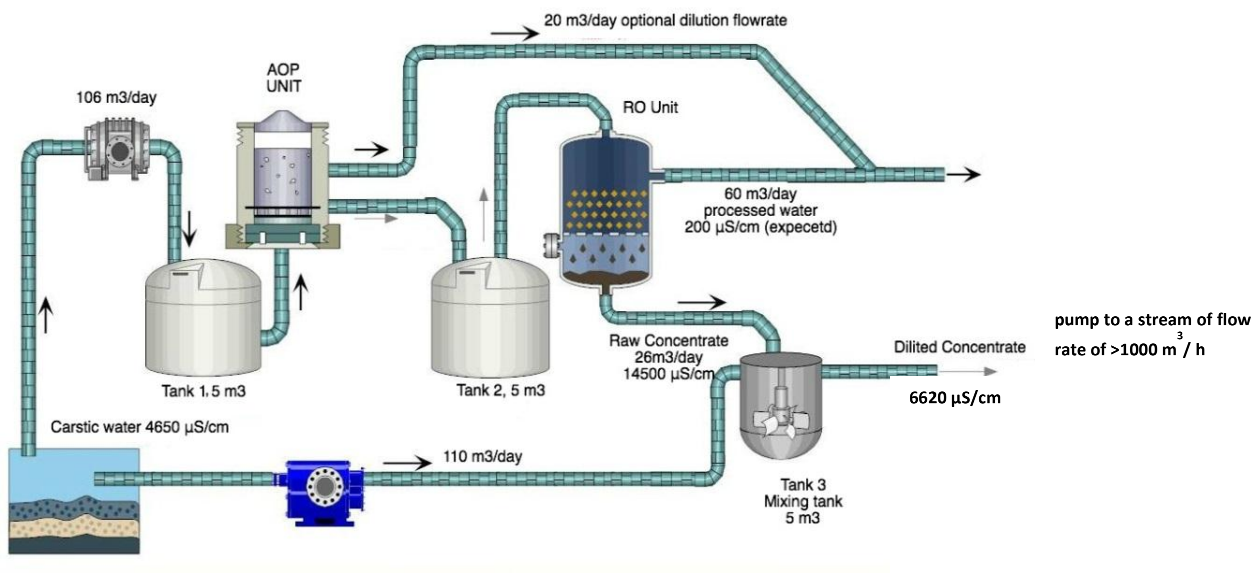


Figure 23. Water treatment unit setup

TiO_2 is considered an efficient, low cost and highly stable semiconductor photocatalyst, widely used in water treatment applications. When photocatalyst TiO_2 absorbs Ultraviolet (UV) radiation from sunlight or illuminated light source (fluorescent lamps), it produces pairs of electrons and holes. The electron of the valence band of titanium dioxide becomes excited when illuminated by light.

The excess energy of this excited electron promoted the electron to the conduction band of titanium dioxide therefore creating the negative-electron (e-) and positive-hole (h+) pair. Wavelength of the light necessary for photo-excitation is: 1240 (Planck's constant, h) / 3.2 ev (band gap energy) = 388 nm. The positive-hole of titanium dioxide breaks apart the water molecule to form hydrogen gas and hydroxyl radical. The negative-electron reacts with oxygen molecule to form super oxide anion. This cycle continues when light is available. Thus, due to the formation of strong oxidative species, the AOP can achieve degradation of toxic organic pollutants without the production of any kind of residue, thus being considered as particularly effective and environmentally friendly method.

The AOP unit was designed to use a grade 304 stainless steel tank of $1m^3$, in which the slurry of the catalyst and the treated water will be illuminated for certain contact time and a continuous flow of air will ensure the presence of conditions as well as proper mixing. The number of tanks needed and consequently the contact time was determined according to the amount of pollution of the treated water, offering modularity in the system that can be modified to meet the needs. The selected photocatalyst was a novel material; it is photocatalytically active fumed titanium dioxide granules (>99,5%) with particle size of about 20 μm. Focusing on making the whole procedure cost effective and environmentally friendly, the design of the unit ensures minimum use of reagents, optimum treatment time according to the requirements set for the final effluent quality and a combination of artificial and solar illumination.

The use of AOP is designed to be installed before the RO unit, which ensures the degradation and remediation of organic pollutants up to the point of full mineralization. The absence of a pretreatment AOP unit before the RO unit would mean that organic pollutants reaching the RO unit would eventually be separated from the purified water stream and pre-concentrated in the reject stream, exponentially increasing their concentration and finally rejected in the environment. This type of process would not remediate the source water but just transfer the pollution to other water compartments. Furthermore, the organic content of the water would eventually promote fouling and deterioration of the RO membranes, reducing their lifetime and efficiency.

Special attention has been given on designing the unit so that it can provide multiple information about the quality of the influent as well as the effluent and rejection streams and can constitute, by itself or as a part of the wider monitoring system, a valuable toolbox for decision making and an early warning platform for random or systematic pollution events.

3.4.2.2 Reverse Osmosis (RO) unit (operational)

The RO unit was designed in collaboration with and produced by Lenntech BV (Delft, Netherlands), (figure 24).

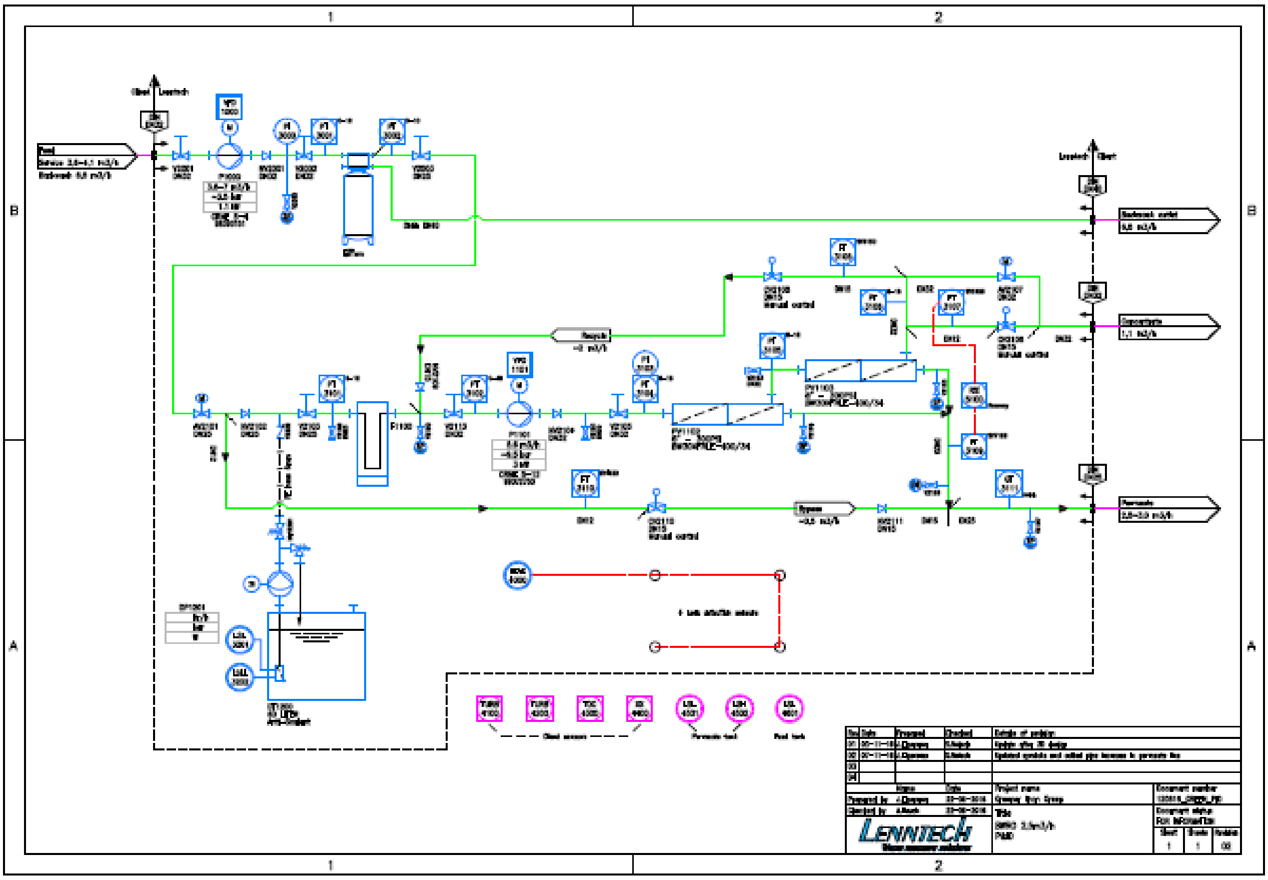


Figure 24. Schematic of the RO process

The input water is pretreated in order to protect the membranes in the cartridges. Small particles are filtered, bacteria and microorganisms are killed. The pH is adjusted and any buoyant particles are removed to avoid minerals residing in the membranes. Next, this pretreated water passes through a high pressure pump that increases the pressure to the required levels where the membranes operate.

Next is the RO stage, where separation of water from salt and other small minerals takes place. The membranes allow water molecules to pass through, whilst they prevent salt molecules from entering. As the pretreated water enters the membranes, it meets two streams; one stream of purified water and another more dense stream of salt water that is rejected.

Then the purified water has to go through a post-treatment process since it presents small hardness and low pH. The pH is increased from 5 to 7 through the addition of sodium hydroxide and its hardness is increased by passing the water through columns that contain magnesium and calcium. This final post treatment produces a high quality drinking water.

The RO unit was designed to process water of conductivity of about 4500 μS/cm and temperatures between 15 and 30^{o}C and to produce an outflow of 200 μS/cm at 60 m^3/day. A small by-pass line was also foreseen over the reverse osmosis plant, with manual regulation, in order to produce an increased outflow of up to 80 m^3/day, with slightly higher conductivity in the final product, by mixing the osmotic water produced with the feed water at a 3:1 ratio. The RO unit includes the following process: sand filtration, antiscalant dosing, 5 μm cartridge filter and reverse osmosis. It has been tested by technicians and is ready to be connected with the rest of the configuration parts (figure 25).

Figure 25. Water treatment unit

For the process of remote monitoring and control, a programmable logic controller (PLC) was employed connected to a virtual private network (VPN) by means of a laptop computer and a 4G mobile internet wireless router. An alarm and fault messaging system was set up by means of a GSM SIM card. Regarding the disposal of outflow water, the RO unit produces a concentrate of 14500 μS/cm at 26 m^3/day. After thorough investigation and targeted measurements, it was decided that the most efficient way for RO concentrate disposal, both in terms of cost and environmental impact, is to dilute it with excess of feed water (>100M 60 m^3/day) and pump it to a stream of estimated flow rate at >1000 m^3/h. The mixing of the concentrate with the excess of feed water is expected to produce an outflow of 6620 μS/cm at 5.4 m^3/day. Finally, it should be mentioned that this is the first pilot of a coupled AOP and RO system.

3.4.3 Artificial recharge configuration

The artificial recharge (AR) site (Area C) is located in the south area of the Olympic Rowing Center within the secured area. The site was carefully selected based on through survey and investigation of the area as well as targeted measurements. Additionally, hydraulics calculations and modeling activities have been performed and guidelines and methodologies of the project coordinator (KWR) have been implemented. Finally, for the AR site a four wells system was constructed, one horizontal and three vertical wells. The location of the AR site was selected based on dedicated geophysical measurements that established the various stratigraphic and hydraulic settings of the area.

The AR site conditions are presented in figure 26.

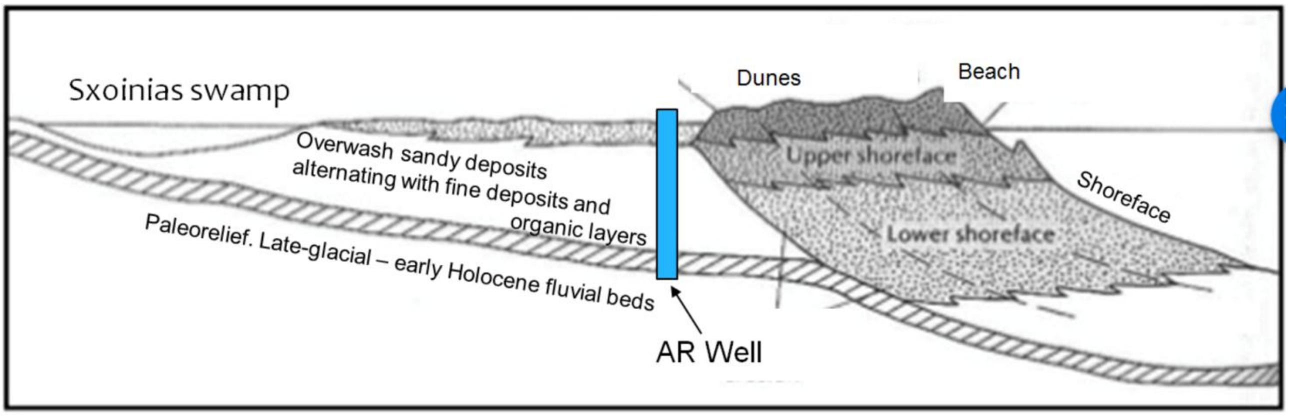


Figure 26. Artificial Recharge site specific conditions

In order to thorough study this area, several steps were implemented:

- **Initial phase**: Non Destructing (ND) assessment of the area selected for possible existing anthropogenic constructions (antiquities), prior to proceed in destructive activities such as drilling etc. This phase was very important and critical for the project as in fact the entire Marathon Bay is characterized as Archaeological Site and thus special permit is required for such investigations including ND assessment by the Greek Ministry of Culture. The permit was provided and the investigation took place.

The most appropriate ND method to investigate the shallow subsurface layers is the Ground Penetrating Radar (GPR) method. The subsurface was radiated with very low electromagnetic energy pulses and all the reflections were recorded in real time. In addition, the method was direct and the results were shown during the acquisition time (real time).

Concerning the spatial resolution, the method can achieve resolution of cm mostly depending of the sampling interval and the frequency of the electromagnetic energy used. In the specific case, two frequencies have been used, one low frequency of 250 MHZ reaching a depth of about 10m below the ground surface and one high frequency of 800 MHZ, reaching a depth of about 4m, with one resolution of 2cm. The data acquisition system was also controlled from one very accurate GPS position tool, Real Time Kinematic GPS and the positions have the accuracy of 1 cm.

The position of the GPR profiles (scans) was controlled from two separate systems:

a) One Base Station of type Trimble 4000 SSI, providing RTK correction and named "BASE STATION" (BS). The BS system was in one continuous RF link, using modems with the second system (figure 27).

Figure 27. Base Station, installed in the AR investigation area

b) One Rover Station again of type Trimble 4000 SSE, installed in the GPR data acquisition system, named "ROVER STATION" (RS). The RS system was also in one continuous RF link with the BS, performing one RTK data collection with accuracy reaching the 1cm precision (figure 28).

Figure 28. Rover Station, used to provide accurate coordinates to the GPR system

After this phase the artificial recharge area was selected and is indicated with the red polygon in figures 29 and 30.

Figure 29. Artificial recharge area

Figure 30. Artificial recharge area – geophysical research

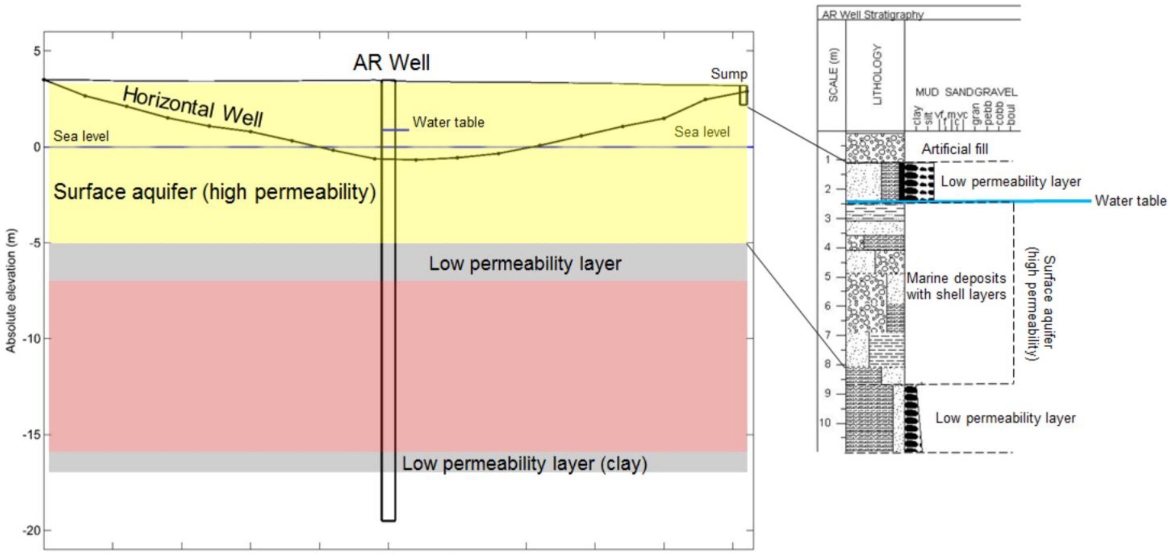
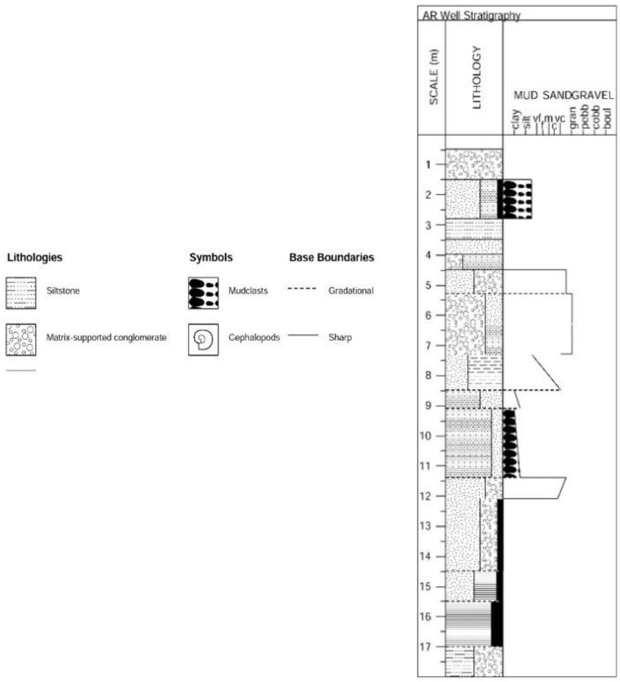


Figure 31. Stratigraphic and hydraulic setting of AR site

- Exploratory phase: In this phase, additional ND geophysical measurements were performed with complementary geophysical methods such as Electrical Resistivity Tomography (ERT), Seismic Refraction or Multichannel Analysis of Surface Waves (MASW). This phase included also three (3) exploratory wells to acquire the detailed litho-stratigraphy of the subsurface layers, including wireline methods such as Geophysical Well Logging (GWL). The stratigraphic and hydraulic settings of the three (3) vertical wells construction in the AR site are illustrated in figures 31 and 32.



AR well stratigraphy
0.0 - 1.0m: Artificial fill
1.0 - 2.3m: Peat Horizon. Salty clay with organic matter
2.3 - 3.0m: Peat with sandy material (shells)
3.0 - 3.5m: Sand (medium to coarse)
3.5 - 4.0m: Sand with increasing gravel content (hard horizon)
4.0 - 4.8m: Fine gravel with coarse sand (beach and/or coastal barrier deposits)
4.8 - 6.0m: Fine to medium gravel with quartz rich sand
6.0 - 7.0m: Fine gravel.
7.0 - 8.4m: Sandy silt with increasing clay content
8.4 - 9.0m: Clayey sand
9.0 - 11.3m: Organic clay with variable sand content
11.3 - 12.0m: Sandy gravel
12.0 - 13.5: Sandy gravel with organic matter
13.5 - 14.5m: Fine gravel with organic matter
14.5 - 15.5m: Coarse sand with increasing amounts of clay and organic matter
15.5 - 16.0m: Clay
16.0 - 16.5m: Hard horizon. Clay and/or fluvial channel deposits

Figure 32. Artificial recharge well stratigraphy

- Construction phase: In this phase, the results of the exploratory phase, including the contribution of National Technical University of Athens (NTUA) in the fields of hydraulics, modeling etc. were combined for the design of the replication site, based in the guidelines and methodologies of the project coordinator (KWR) that has the experience in these types of applications. Thus, the site consists of a four wells system, three vertical and one horizontal well (figure 33).

Figure 33. Artificial recharge configuration setting

In particular, the artificial recharge area was constructed as follows:

3.3.3.1 **One vertical artificial recharge well** at a depth of 23m, equipped with 3 piezometer nests for monitoring. The principal function of this well is recharge (figures 34).

Figure 34. Vertical wells construction

3.3.3.2 **Two vertical side wells** at a depth of 12m and a distance of 16m from the central (AR well) screened with micro-fissured pipes. The principal functions of these wells are both monitoring and recovery (figures 35).

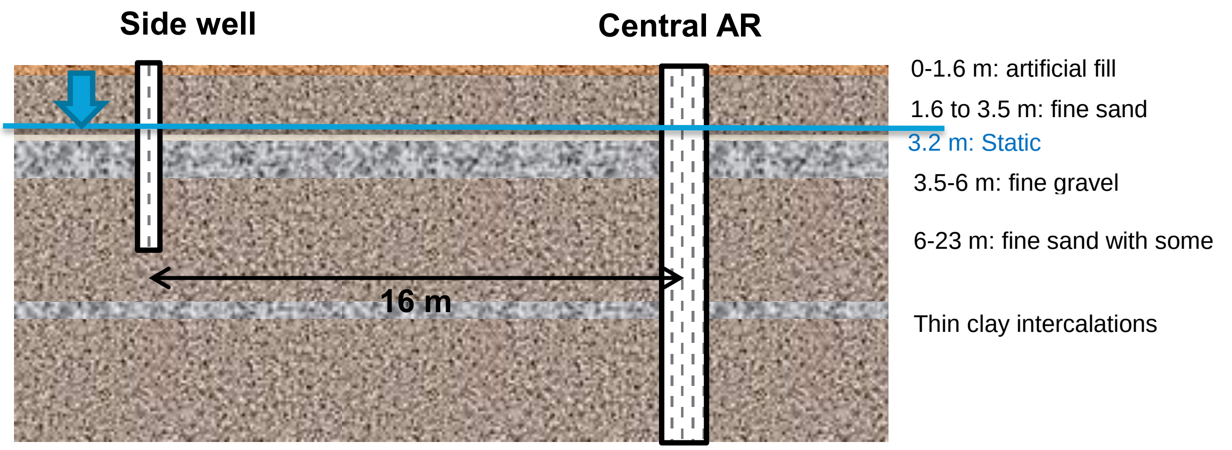


Figure 35. Cross section of the central Artificial Recharge and the side wells configuration setting

The vertical wells technical characteristics are presented below:

Artificial recharge well (central well)

Total Depth:	23 m
Screens:	4 inch microfissured pipes
Screens type:	PVC
Piezometers:	3
Static Water Level:	1.8 m
Water Electrical Conductivity:	2800 μS/cm
Coordinates	
X:	24.0170953748758
Y:	38.1388554796694
Projection:	EGSA87

Side well 1

Total Depth:	12 m
Screens:	2 inch microfissured pipes
Screens type:	PVC
Piezometers:	1
Static Water Level:	1.8 m
Water Electrical Conductivity:	2800 μS/cm
Coordinates	
X:	24.0169274268709
Y:	38.1388548010038
Projection:	EGSA87

Side well 2

Total Depth:	12 m
Screens:	2 inch microfissured pipes
Screens type:	PVC
Piezometers:	1
Static Water Level:	1.8 m
Water Electrical Conductivity:	2800 μS/cm
Coordinates	
X:	24.0171040043874
Y:	38.139003177573
Projection:	EGSA87

3.3.3.2 **One horizontal directional drilling well** of a length of 50m and maximum depth of 4.1m passing below the AR well, screened with PVC pipe. The principal function of this well is buffer creation and possibly recovery, (figure 36).

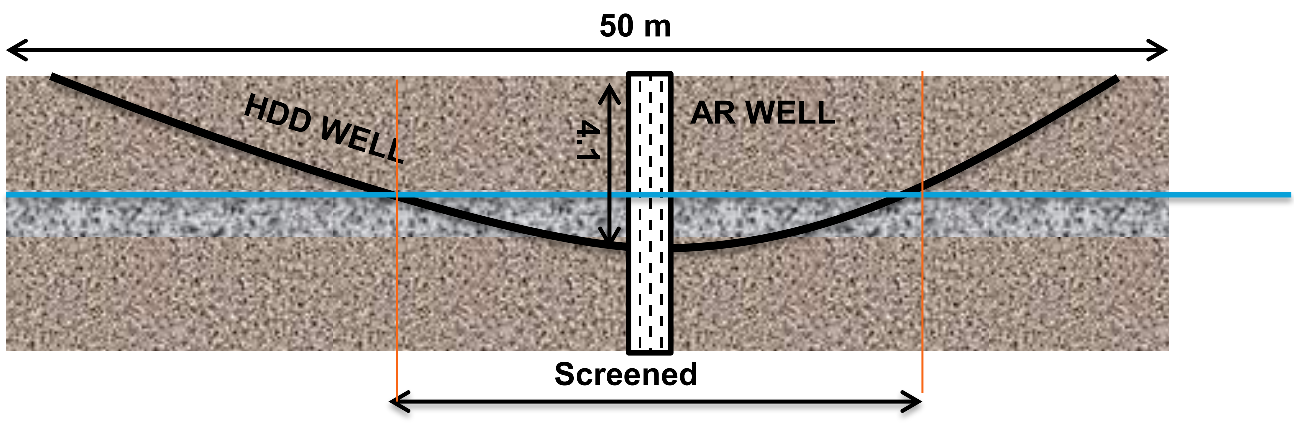


Figure 36. Cross section of the horizontal directional drilling (HDD) and the AR wells setting

The horizontal well technical characteristics are presented below:

Horizontal well entry point

Total Depth:	4.1
Screens:	3 1/4 inch microfissured pipes
Screens type:	PVC
Piezometers:	1
Static Water Level:	1.8 m
Water Electrical Conductivity:	2800 μS/cm
Coordinates:	
X:	24.016906285812
Y:	38.1387542680364
Projection:	EGSA87

Horizontal well output point

Total Depth:	4.1
Screens:	3 1/4 inch microfissured pipes
Screens type:	PVC
Piezometers:	1
Static Water Level:	1.8 m
Water Electrical Conductivity:	2800 μS/cm
Coordinates	
X:	24.0173126465335
Y:	38.1390072567742
Projection:	EGSA87

Horizontal well geometry

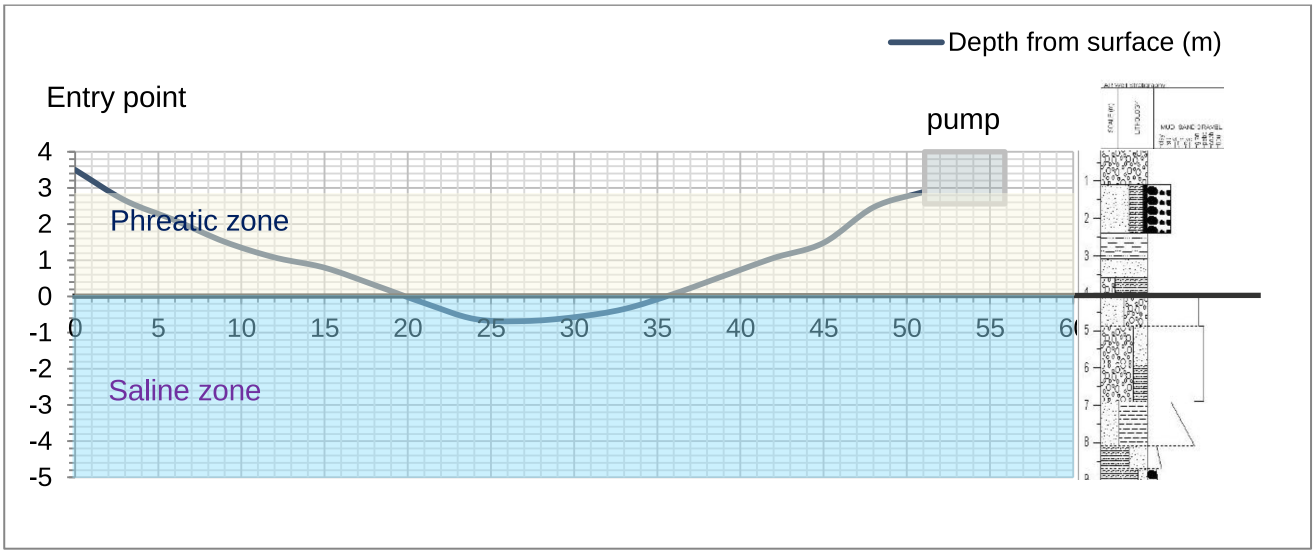


Figure 37. Horizontal Directional Drilling well geometry

The purpose of this well was to pump the water from the aquifer, at the phreatic part. The HDD well has an initial inclination in relation to the ground surface, reaches one specific depth (at this case the depth of 4.1 m) and then rises up to the surface. The purpose was to introduce one filter screen in the saturated part of the aquifer (from 2 to 4 m). This well was screened with one 75 mm plastic pipe, screened with micro-fissures (2 mm).

After the completion of the construction of the AR site, several pumping tests have been carried out to ensure the smooth operation of the site. In particular, after the construction of the 3 vertical wells, one pumping test was done in the central well with a pumping rate of 3,5 m^3/h. The dynamic water level dropped to 4m from the ground surface. Taking this into account, the Horizontal Directional Drilling well was constructed with a length of 50m, passing at a depth of 4.1m from ground surface from the central well. The groundwater dynamics in the HDD is shown in the schematic of figure 37.

The well was drilled first and after this was screened with a plastic pipe, with perforations into the saturated zone (figures 38). All appropriate cleaning processes have been performed in order to clean the bentonite mud. After cleaning, one pump was installed to pump water and perform the appropriate drawdown, in order to provide one “buffer – storage” space into the upper zone of the aquifer, to be recharged with the processed water.

Figure 38. Horizontal Directional Drilling well construction

- Monitoring phase: This phase includes long term monitoring of the different environmental, geophysical and geochemical parameters and their evolution in time during the period of pilot operation.

- Demonstration phase: This phase includes the demonstration of the site in potential end-users, including farmers in the area of Marathon but also other potential users such as municipalities, water companies, etc.

3.5 Adequacy of technology implemented – next steps

The technology that has been implemented in Schinias pilot has been designed with increased flexibility, thus the functions of the various wells will be changing during the operational period of the configuration, in order to test different scenarios and establish optimal SWS schemes.

Regarding further installations, certain automation will be installed to ensure the smooth operation of the setting and prevent unexpected events. Additionally, the remaining compartments of the AOP unit will be purchased and installed in order to improve the operation of the SWS pilot configuration.

Finally, the stakeholder group which forms part of the potential end users (farmers, municipality, tourist sector, environmental protection agencies) will be updated and involved in the implemented technology, in order to accelerate acceptance of SWS and broaden the market reach and uptake.

4. ICT component and the remote monitoring and control

The configuration will be to a significant extent remotely controlled. Regarding the remote monitoring of the configuration, a number of telemetric stations have been designed and partially installed in the Schinias pilot site, formulating a data monitoring network. These refer to constant monitoring of all hydrologic zones (surface, unsaturated and saturated zone) as well as groundwater quality monitoring (sampling and chemical analyses, isotope hydrology etc.), as well as monitoring the operation of the configuration (functionality of the treatment unit, water that enters and exits the unit, water recharged in the aquifer, etc.). Figure 39 depicts the schema of the general architecture of the ICT infrastructure responsible for data collection, management and presentation.

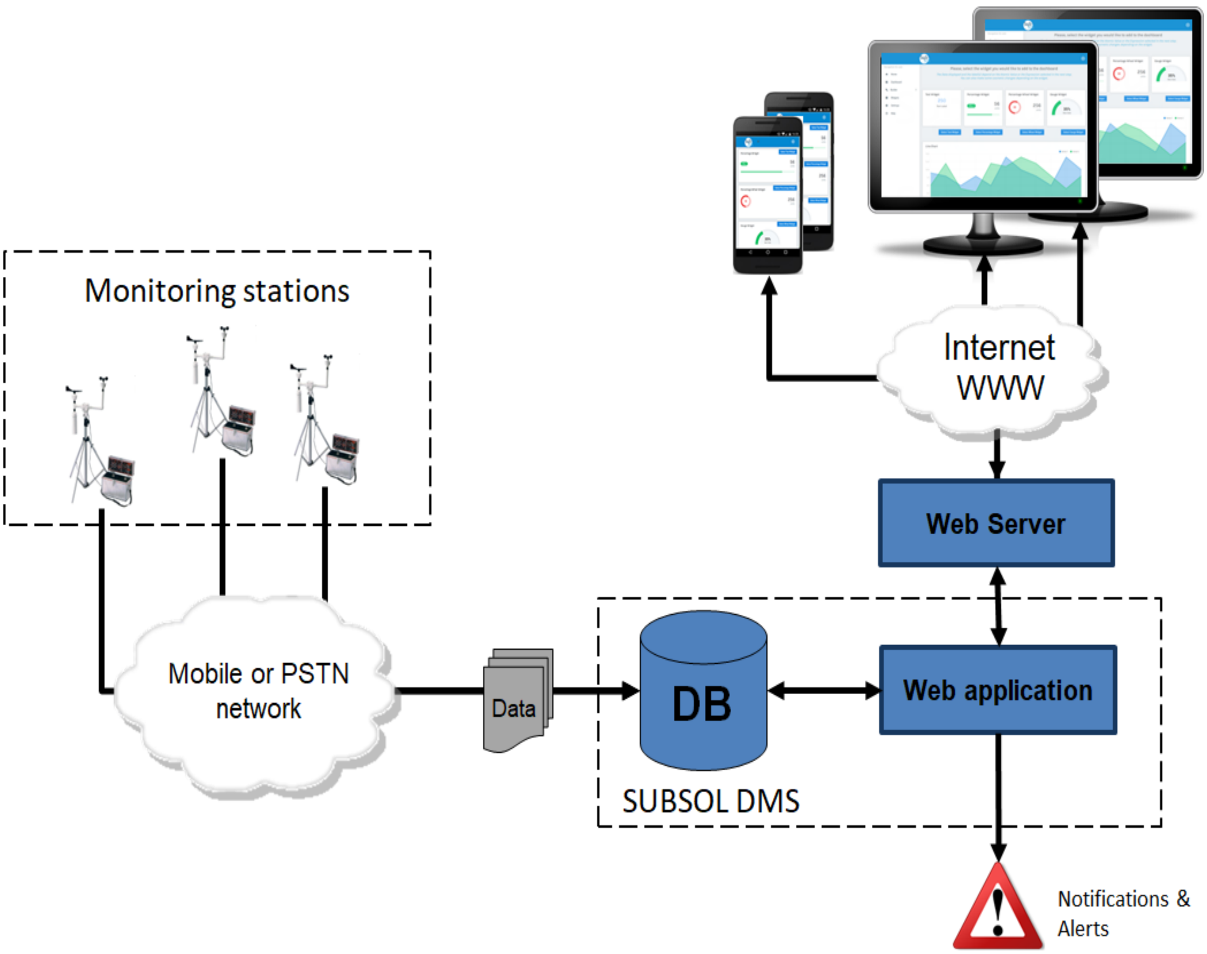


Figure 39. General architecture of the ICT infrastructure

The basic components of each telemetric monitoring station are the following:

- A number of **instruments** equipped with **sensors** measuring environmental parameters
- A **data logger** for caching the measured data. This unit acts as a short term memory of the station. Often it is replaced by an **industrial PC** providing additional management functionality to the administration of the system.
- The **data transmission** unit. Depending on the local infrastructure this unit may connect either to the mobile network (GSM/GPRS) or to the PSTN using ADSL technology.
- In case it is not possible to connect the station to the electricity network, a **power supply unit** is needed based on solar panels.

At the other end of the infrastructure, the SUBSOL Data Monitoring System (SUBSOL DMS) is responsible for the collection and management of the data from all stations of the project. The data transmission process is designed to be executed periodically with a certain frequency depending on the type of the measured environmental parameters.

The process can be initiated from both sides (server or remote system), typically using the FTP protocol. The data are usually transmitted in small CSV files. In order to minimize the volume of the transmitted data, only the last records are sent each time. The SUBSOL DMS identifies newer data and stores them permanently in a central database. Additionally, supporting datasets originating from other organisations are designed to be obtained and stored in the central database.

A web application has been developed which is responsible for user authentication, data management and presentation in a customized way using graphical elements such as charts, tables and widgets. Additionally, users are able to specify complex expressions based on the raw data and the system can issue alerts and warnings sent via email and/or SMS in case the measurements exceed user defined thresholds. The application is developed in a responsive way so that authorized users are able to access the data from their PC, tablet or mobile devices.

5. Conclusions

The site of Schinias in the Marathon plain was selected to be one of the SUBSOL pilot areas as it is a coastal wetland with the characteristics of a distinct ecosystem linked to a typical coastal hydrogeological system of a Mediterranean region. At the same time, the area of Schinias has developed plenty of productive activities (agriculture, tourism), while it is valuable for nature conservation education, environmental sensitization and outdoor recreation for more than four million people living in the Attica region.

Nevertheless, multiple and persistent anthropogenic pressures have been exerted on Schinias for decades. In particular, the increased water demand, along with the impact of climate change, put pressure on their freshwater resources and ecosystems. Therefore, there is a seasonal water shortage of the over-exploited coastal aquifer, as well as saline intrusion, water, soil and wetland degradation, resulting in adverse effects on activities connected with agriculture and tourism as well as on the ecological processes of the ecosystems.

The main hydrogeological units of the Marathon hydrosystem area involve a multi-layer aquifer system that consists of: (i) an upper unconsolidated formation dominated mostly by alluvial quaternary deposits and (ii) the surrounding and underlying karstified marble units. Both aquifers are subjected to intensive pumping conditions due to agricultural activities in the largest part of the plain.

Seawater intrusion has affected groundwater within both formations, however in the upper unconsolidated layer the movement of saline water into freshwater aquifer is more pronounced. The field and laboratory activities that were conducted in Marathon plain, confirmed the high concentrations of Cl- ions due to the seawater intrusion in both coastal aquifers (alluvial and karstic). However, the calculated values of Cl- ions for May 2016 indicate a hydrochemical evidence of seawater intrusion that is far more notable in the shallow formation (upper layer) with a high spatial range between 288 and 1400 mg/lt. The highest concentrations have been mainly observed at the central part of the area and near the coast, where the Cl^- ions exceed 800 mg/lt, while in the NE and SW parts of the plain the salinity is being depleted as the unconsolidated formation meets the karstified one. For the same period of measurements, the karstic aquifer demonstrated a lower range of Cl- concentration (from 24 to 528 mg/lt).

To address this typical Mediterranean problem, the Schinias pilot exploits a rather usual context: the alluvial aquifer in use by both the wetland and agriculture, is sitting on top of a karstic aquifer, discharging relatively good quality water straight to the sea. Within the framework of the developed subsurface water solutions (SWS) technologies, the Schinias pilot attempted to use karstic water resource, treat it with novel pollution remediation techniques - Reverse Osmosis (RO) and Advanced Oxidation Processes (AOP) - and recharge it in the alluvial aquifer, in order to turn this currently unused resource, into a source for protection, regeneration and financial sustainability for the area as well as other similar ones throughout the Mediterranean.

The system has been designed with increased transferability, flexibility and up scalability and there are three (3) main building blocks as follows:

(a) **Water supply installations**, where karstic water is abstracted from Makaria springs and transferred through the Olympic Rowing Canal to the treatment unit;

(b) **Water treatment unit**, which is a quite flexible setup and uses a combination system of coupled AOP and RO treatment technologies, aiming at reducing both the organic and inorganic components of the source water. The design and installation of the specific AOP ensures the degradation of pollutants under different environmental conditions, pollution concentrations and flow rates, producing water adequate to be processed in an RO unit. The RO unit is designed to process water of conductivity of about 4500μS/cm and produce an outflow of 200μS/cm, at a capacity of 60m^3/day. The impact of recharging this water to the aquifer will be studied the following period and adjustments will be performed where necessary.

(c) The **artificial recharge configuration** was carefully designed based on through survey and investigation of the area as well as targeted measurements, hydraulics calculations and modeling activities. The project coordinator (KWR) experience on implementing SWS was used.

In conclusion, the principal construction activities of the Schinias pilot have been completed and the configuration is currently operational. Nevertheless, there have been so far no adequate measurements and processing, in order to draw specific conclusions on the impact of the configuration on the protection, enlargement and utilization of freshwater resources in the specific coastal area. During the following months, tests will be performed and measurements will be taken, in order to examine different scenarios and establish optimal SWS schemes.

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Appendix

Laboratory analyses

Table 1. Chemical results from groundwaters of the alluvial and karstic aquifer of Marathon during the wet period of 2015

ID	X	Y	EC	T	pH	DO	Cl	NO3	SO4	HCO3	NO2	Ca (mg/L)	Mg (mg/L)	Na	K
MG71	497881	4219385	2810	20,4	7,12	7,81	620	46,3	140	322,08	0,027	219,463356	41,796	310,4	12
MG35	498270,43	4219553,94	2490	7,42	7,02	7,42	482	49,2	95	263,52	0,025	269,1229475	-66,096	277,6	11,2
MG24	497644,87	4218820,56	4570	19,1	6,94	5,45	254,6	999	230	414,8	0,148	387,6651982	71,928	548	9,3
MG73	498434	4218949	4340	23	7,15	3,25	568	23,2	230	240,34	0,444	198,638366	23,328	318	8,6
MG74	499691	4219287	3880	22,5	6,93	2,9	853	60,7	330	311,1	1,328	313,9767721	58,32	388	12
MG75	498891	4219878	3140	19,7	7,1	6,7	655	99	225	239,12	0,035	222,6672006	43,74	333,6	9,6
MG76	498891	4219885	2900	22	7,1	7,32	587	76,4	155	278,16	0,023	256,3075691	11,664	312	10,4
MG77	498653	4220066	4030	20,1	7,01	7,32	870	126,2	300	361,12	0,182	299,5594714	55,404	4500	15
MG13	497022,61	4219828,22	3310	22,3	7,24	4,58	718	156,2	140	312,32	0,14	256,3075691	46,656	352	6,8
MG79	497039	4217871	1905	21,9	6,9	6,7	256	146	170	234,24	0.031	237,0845014	3,888	116	3,8
MG 36	498769,26	4219152,75	1990	20,5	7,18	4,5	347	36,1	100	418,46	0,021	217,8614337	23,328	183,2	6,8
MG 34	498019,62	4219744,61	1295	18,5	7,19	8	187	57,1	95	331,84	0,05	128,1537845	23,328	110,4	6
MG 43	498029,54	4220567,01	3310	18,9	7,042	6,48	666	96	205	367,22	0,026	278,7344814	36,936	344,8	10,4
MG 41	498416,62	4220021,92	2130	20,1	7,08	7,6	51	70,9	205	385,52	0,03	294,7537044	-31,104	297,6	8,3

MG 82	499693	4221452	3880	18,9	7,092	4,47	884	60,1	300	353,8	0,038	256,3075691	69,984	426,4	11,2
MG 84	498098	4221214	2560	19,7	7,05	3	464	64	145	278,16	0,028	243,4921906	7,776	288	8,2
MG 86	499335	4220110	6650	19	6,9	5,6	1720	275,2	420	380,64	0,025	211,4537445	314,928	620	6,1
MG 88	499011	4221702	2720	20,3	7,18	6,9	582	43	150	356,24	0,021	224,2691229	15,552	318,4	1,2
MG48	499237,37	4221022,19	3840	19,9	7,24	7,5	898	105,6	220	333,06	0,019	269,1229475	66,096	404	12,8
MG57	499605,26	4221652,84	3630	21,1	6,82	4,64	756	78,6	250	459,94	0,038	358,8305967	15,552	380	8
MG100	500559	4220817	4320	18,3	6,82	4,3	1012	28,4	130	291,58	0,043	275,5306368	58,32	500	9,9
MG101	499888	4222944	3540	20,3	6,91	3,75	752	23	155	448,96	0,03	253,1037245	29,16	440	18,4
MG102	501377	4223475	2000	19,2	7,2	4,37	345	118,1	75	378,2	0,031	192,2306768	46,656	169,9	6
MG11	501897,8	4223998,36	3360	20,5	6,89	3	715	218	195	317,2	0,195	378,0536644	69,984	173,6	5,2
MG103	501487	4224049	2170	20,2	7,37	8,36	395	147	125	322,08	0,057	224,2691229	27,216	179,2	4
MG104	500681	4224035	1313	20,1	7,2	6	96	99,5	55	409,92	0,026	134,5614738	34,992	115,2	1,6
MG51	499778,05	4220809,8	5750	20,1	7,12	8,3	1405	87,5	440	385,52	1,214	379,6555867	142,884	640	8
MG72	497719	4218833					1780	6,1	530	263,52	0,366	621,545855	19,44	674	12

Table 2. Chemical results from groundwaters of the alluvial and karstic aquifer of Marathon during the wet period of 2016

ID	X	Y	EC	T	pH	DO	Cl(mg/lt)	HCO3(mg/lt)	SO4	Ca(mg/lt)	Mg(mg/lt)	Na	K
MG102	501377	4223475	1946	18,1	7,6	6	288	307,44	140	155,3864638	34,02	154,4	3,2
MG79	497039	4217871	2130	20,3	6,9	7	288	213,5	200	209,8518222	34,02	127,6	2
MG 34	498019,62	4219744,61	2290	19,8	7,5	8,3	460	350,14	150	189,0268322	4,86	264	7
MG35	498270,43	4219553,94	2440	21,6	7,2	7,45	522	352,58	180	189,0268322	30,132	281	6,4
MG 41	498416,62	4220021,92	2550	19,7	7,2	8	514	390,4	70	158,5903084	29,16	287	6
MG77	498653	4220066	2950	19,7	7,1	7,5	616	366	200	219,463356	46,656	125,2	4
MG 43	498029,54	4220567,01	3110	19,9	7	6,7	662	345,26	140	197,0364437	38,88	331	8
MG70	497901	4219394	3210	20,2	7,1	7,5	720	366	90	185,8229876	48,6	389	10
MG75	498891	4219878	3210	20	7	6,5	476	370,88	305	245,0941129	44,712	346	7,2
MG101	499888	4222944	3230	17,6	7,3	3,4	708	488	180	174,6095314	39,852	368	12
MG11	501897,8	4223998,36	3260	18,8	7	4,2	728	395,28	220	333,1998398	54,432	165,6	3,6
MG13	497022,61	4219828,22	3300	21,1	7,2	7,5	672	329,4	195	229,0748899	39,852	357	4,8
MG48	499237,37	4221022,19	3590	25	7,1	6	828	324,52	245	248,2979575	41,796	367	10
MG57	499605,26	4221652,84	3690	23	7,06	6,1	856	427	300	225,8710453	58,32	422	8

MG 81	499266	4218925	3940	18,3	7	2,7	840	414,8	410	312,3748498	50,544	410	6
MG74	499691	4219287	4000	20,4	7,3	5,02	896	417,24	375	293,1517821	49,572	402	10
MG73	498434	4218949	4020	19,9	7,2	3,5	936	378,2	230	269,1229475	82,62	449	7
MG25	497758,33	4218964,88	4110	20,1	7	6,11	956	323,3	170	310,7729275	62,208	413	9
MG123	499087	4220460	4570	20,9	6,9	5,5	1048	346,48	360	328,3940729	53,46	512	18
MG100	500497	4220926	4600	21,9	7,3	5,43	1264	292,8	150	273,9287145	76,788	497	11
MG24	497644,87	4218820,56	4630	19,8	6,9	5,5	1060	397,72	410	206,6479776	175,932	462	5
MG51	499778,05	4220809,8	4830	21,1	7,1	4,5	1160	341,6	360	326,7921506	71,928	517	12
MG 86	499335	4220110	5690	19,9	6,9	8,48	1398	339,16	420	427,7132559	90,396	512	8
MG121	496591	4217928	2070	20	7,17	8,3	364	268,4	150	232,2787345	15,552	130,8	3,2
MG 84	498098	4221214	2420	21,1	7,1	4	460	488	170	173,0076091	36,936	279	6

Table 3. Chemical results from groundwaters of the alluvial and karstic aquifer of Marathon during the dry period of 2016

ID	X	Y	EC	T	pH	DO	Cl	NO3	SO4	HCO3	Ca mg/lt	Mg mg/lt	Na	K
MG24	497644,87	4218820,56	3700	19,8	7,3	4,1	744	59	305	429,44	281,938326	26,73	411	5,2
MG81'	499266	4218925	3190	20,3	7,03	3,7	672	21,2	310	358,68	208,2498999	43,74	356	3,7
MG35	498270,43	4219553,94	2490	19,9	7	7,8	528	15,4	170	348,92	161,794153	14,58	266,5	7,5
MG34	498019,62	4219744,61	2340	19,9	7,3	7,3	492	14,8	165	348,92	155,3864638	12,636	256,5	7,1
MG43	498029,54	4220567,01	3280	20,1	7,1	6,4	812	19,4	215	341,6	218,6623949	23,328	420	9,9
MG41	498416,62	4220021,92	2510	20,4	7,27	8,1	512	16,4	200	392,84	144,1730076	25,758	271,5	6,9
MG77	498653	4220066	2840	19,7	7,1	7,54	604	23,6	205	314,76	211,4537445	32,076	292	8,6
MG75	498891	4219878	3000	19,3	7,1	5,5	660	22,4	225	368,44	220,2643172	19,926	340	8,5
MG86	499335	4220110	6320	19,3	7,05	6	1624	63,2	420	363,56	499,7997597	70,956	538	6,6
MG123	499087	4220460	4380	18,6	7,09	7,1	1048	32,6	350	341,6	321,1854225	16,524	481	7,9
MG85	498453	4221034	3000	19,4	7,2	8	664	26	200	353,8	198,638366	33,534	293	5,4
MG84	498098	4221214	2460	19,4	7,15	6,1	544	14	165	366	152,1826191	19,926	245	7,4
MG57	499605,26	4221652,84	3680	20	7,1	5,2	896	11,4	270	429,44	224,2691229	39,366	400	9,2
MG151	499871	4221325	4380	20,7	7,1	5,6	1200	8,6	300	326,96	288,3460152	69,498	430	13,6
MG152	500276	4220320	3830	19,6	7,2	5	1016	34,6	210	273,28	331,5979175	41,796	315	6,3
MG135	499635	4220505	5280	19,5	7	6,4	1340	27,6	480	366	410,8930717	93,798	450	6,6
MG48	499237,37	4221022,19	3760	20,7	7,17	6	916	27,4	225	334,28	227,4729676	61,236	392	13,6

MG153	498939	4221179	3040	20	7,2	8,5	672	28,2	200	361,12	176,2114537	42,282	364	12
MG101	499888	4222944	3900	19,6	7,4	4	948	5,2	200	492,88	181,8181818	58,32	458	20
MG102	501377	4223475	1848	19,1	7,45	5,5	312	29,8	140	331,84	141,7701241	34,506	151,2	4,3
MG155	502419	4224110	5370	19,4	7,3	8	1524	42,6	290	251,32	466,1593913	104,004	412	10
MG158	503208	4224118	3250	20,7	7,6	5,1	852	2,8	155	348,92	120,144173	86,022	383	22
MG159	503130	4224365	3400	22,4	7,7	5,3	868	19,8	235	290,36	173,0076091	69,984	385	6,8
MG136	502046	4224274	3700	22,1	7,1	7,5	872	59,2	240	261,08	382,0584702	61,722	215	15
MG103	501487	4224049	2260	19,1	7,1	8,1	440	35,6	200	324,52	203,444133	19,926	154,4	3
MG160	496141	4219634,5	1736	19,4	7,4	7,85	324	21,6	92	307,44	150,5806968	10,206	151,2	6,4
MG13	497022,61	4219828,22	3300	19,4	7,28	5,2	736	40,2	185	344,04	233,8806568	19,44	300	6,3
MG121	496591	4217928	1920	19,4	7,3	8,5	344	37,8	165	314,76	200,2402883	7,776	113,2	3,4
MG127	496151	4218680	2530	19,5	7,4	8,7	240	168,5	255	283,04	348,4181017	20,898	68,8	3,2
MG125	496742	4219031	2630	19	7,3	8,6	560	59,4	104	263,52	283,5402483	15,066	164,4	6,1
MG130	496742	4219031	2500	19,4	7,2	8,6	424	91	175	229,36	292,350821	35,478	93,6	2

Table 4. EC and chloride composition of extracted porewater from the unsaturated zone of the alluvial aquifer of Marathon (wet period of 2017)

	A1		A2		A3		A4		A5	
	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)
0-0.5	2950	512	3470	1110	2120	500	10140	2630	348	35
0.5-1	10700	2645	4650	1350	1161	230	1228	240	427	30
1-1.5	9650	2800	4860	1430	2570	430	686	110	245	10
1.5-2	6760	1800	5030	1510			482	60		
2-2.5	4200	880	5060	1420			405	50		
2.5-3	4130	960	3990	980						

	A6		A7		A8		A9		A10	
	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)
0-0.5	800	100	3590	200	494	50	1551	220	848	60
0.5-1	1433	235	810	90	511	40	3670	920	584	90
1-1.5	1234	195	714	80	1090	140	3600	870	625	80
1.5-2	663	90	578	60	1811	430	3160	810	1284	210
2-2.5	499 (2.70m)	30	1285	160	1984	475			1386	240
2.5-3			2040	300	2350	550			1298	285

	A11		A12		A13		A14		A15	
	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)
0-0.5	3230	620	508	30	360	20	702	60	335	15
0.5-1			307	40					1420	50
1-1.5	4730	1260					710	95	637	45
1.5-2	3820	1100					800	145		
2-2.5	5670	1700					624(2.7m)	100		
2.5-3	7200	2240								

	A16		A17		O	
	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)	EC(μS/cm)	CL(mg/l)
0-0.5	413	50	308	15	5450	1120
0.5-1			511	30	3980	770
1-1.5	246	15	540	80	1641	200
1.5-2			890	95	650	85
2-2.5			680	45	940	115
2.5-3						

Table 5. Isotopic signatures of groundwaters of the alluvial and karstic aquifer of Marathon during the wet period of 2015

	2H		18O	
Sample:	**Mean:**	**Stddev:**	**Mean:**	**Stddev:**
Light std	-89,33	0,83	-16,35	0,41
Heavy std	0,25	2,72	4,69	1,10
Mix std	-38,66	1,97	-4,23	0,65
2	-38,26	0,06	-7,12	0,11
4	-36,68	0,25	-6,59	0,30
8	-35,37	0,26	-6,88	0,08
9	-36,00	0,06	-5,94	0,07
11	-32,70	0,42	-6,19	0,18
13	-34,68	0,09	-6,74	0,20
24	-33,14	0,36	-5,95	0,10
34	-42,93	0,54	-7,47	0,45
35	-39,92	0,64	-7,49	0,38
36	-37,92	0,74	-6,96	0,24
41	-38,98	0,28	-6,99	0,12
43	-37,50	0,03	-6,79	0,01
44	-36,56	0,30	-6,49	0,25
48	-36,17	0,64	-6,75	0,19
51	-35,25	0,26	-6,15	0,29
53	-38,43	0,17	-6,92	0,05
57	-37,02	0,33	-6,52	0,28
71	-37,26	0,22	-6,61	0,23
72	-34,59	0,12	-6,28	0,05

73	-35,47	0,70	-6,37	0,27
74	-35,20	0,84	-6,61	0,37
75	-38,83	0,06	-6,71	0,13
76	-38,66	0,12	-6,79	0,07
77	-35,96	0,33	-6,86	0,04
78	-36,05	0,17	-6,88	0,04
79	-32,12	0,18	-6,10	0,18
80	-47,42	1,04	-7,40	0,49
82	-34,83	0,27	-6,37	0,10
84	-37,23	0,49	-6,53	0,12
86	-30,80	0,35	-5,79	0,13
88	-34,78	0,17	-6,70	0,07
100	-34,94	0,07	-6,65	0,00
101	-34,06	0,10	-6,53	0,05
102	-36,79	0,13	-6,77	0,02
103	-35,98	0,15	-6,29	0,13
104	-34,29	0,45	-6,50	0,09
118	-34,90	0,37	-6,18	0,08
119	-35,22	0,50	-6,04	0,01
120	-34,20	0,16	-6,57	0,03
EL20	-27,78	0,29	-5,13	0,08
EL25	-18,64	0,34	-3,10	0,15
EL54	-27,90	0,13	-4,99	0,18
MAKARIA	-38,81	0,02	-6,87	0,04

Table 6. Isotopic signatures of groundwaters of the alluvial and karstic aquifer of Marathon during the wet period of 2016

		δ 2H		δ 18O	
	Sample:	**‰**	**Stddev:**	**‰**	**Stddev:**
	Light	-89,33	0,66	-16,35	0,12
	Heavy	0,25	0,65	4,69	0,29
Well code	Mix	-38,59	0,52	-4,11	0,33
MG81	K1	-34,80	0,11	-6,08	0,05
MG3	K2	-33,02	0,08	-5,01	0,04
MG51	K3	-29,47	0,02	-4,06	0,02
MG13	K4	-32,07	0,14	-5,14	0,04
MG120	K5	-31,05	0,11	-4,80	0,04
MG2	K6	-34,03	0,09	-5,53	0,04
MG57	K7	-35,08	0,10	-6,01	0,00
MG11	K9	-33,56	0,35	-5,95	0,02
MG119	K10	-33,91	0,15	-6,44	0,04
W52	L1	-30,30	0,12	-5,51	0,03
W10	L2	-31,66	0,04	-6,33	0,03
D8	L3	-35,60	0,10	-6,86	0,02
W51	L5	-29,23	0,06	-5,24	0,07
MSW15	L6	-33,88	0,10	-6,40	0,09
MSW9-10	L7	-36,50	0,07	-6,44	0,03
MSW9-5	L8	-24,74	0,10	-3,60	0,02
MSW9-15	L9	-28,19	0,11	-5,41	0,06
W1	L10	-30,56	0,04	-6,00	0,05

W6	L11	-27,95	0,10	-4,76	0,08
W11	L12	-24,43	0,16	-2,43	0,01
W48	L14	-20,64	0,23	-1,20	0,04
NEW_{15}	L15	-48,28	0,09	-6,94	0,02
W39	L17	-30,91	0,09	-4,86	0,08
NEW_{10}	L18	-37,92	0,14	-4,02	0,04
D1	L19	-30,02	0,10	-5,80	0,03
MSW8	L20	-30,86	0,16	-5,88	0,02
M	L21	-29,50	0,07	-4,76	0,07
K2	L22	-30,48	0,05	-5,06	0,03
NEW_{5}	L23	-39,10	0,49	-5,73	0,07
W37	L24	-13,14	0,24	-1,06	0,05
W26	L25	-13,25	0,16	0,96	0,05
D9	L27	-30,69	0,29	-5,24	0,01
P	L28	-27,87	0,12	-4,82	0,05
K1	L29	-33,02	0,19	-5,93	0,01
MG84	M1	-38,79	0,13	-6,66	0,01
MG75	M2	-34,52	0,13	-5,81	0,02
MG103	M3	-33,16	0,06	-5,45	0,02
MG34	M4	-34,42	0,06	-5,78	0,04
THEATRO	M5	-27,45	0,12	-4,39	0,06
MG79	M6	-33,11	0,10	-5,89	0,08
XHMEIO	M7	-25,24	0,13	-4,02	0,03
MG48	M8	-33,31	0,20	-5,45	0,05
MG77	M9	-37,61	0,26	-6,99	0,15

MG121	M10	-31,85	0,06	-5,84	0,03
MG73	M11	-35,60	0,04	-6,59	0,01
MG25	M12	-35,32	0,49	-6,05	0,04
MG 41	M13	-37,71	0,11	-7,01	0,05
MG44	M14	-34,89	0,11	-5,58	0,06
MG104	M15	-37,35	0,09	-7,16	0,01
MG24	M16	-33,86	0,17	-5,99	0,01
MG102	M18	-35,02	0,90	-5,83	0,03
MG86	M19	-33,64	0,13	-5,77	0,02
MG 43	M20	-37,81	0,04	-7,07	0,07
MG123	M21	-33,97	0,04	-5,47	0,02
MG78	M22	-37,92	0,11	-7,28	0,07
MG8	M23	-33,30	0,10	-5,63	0,03
MG101	M24	-38,36	0,12	-7,20	0,03
MG 52	M25	-37,99	0,02	-6,82	0,02
MG35	M26	-38,20	0,06	-7,21	0,04
MG70	M27	-30,07	0,16	-4,37	0,09
MG74	M28	-29,52	0,11	-4,36	0,07

ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
ΤΜΗΜΑ ΧΗΜΕΙΑΣ
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Ημερομηνία: 12-09-2016
Κωδικός Έκθεσης:

ΕΚΘΕΣΗ ΑΠΟΤΕΛΕΣΜΑΤΩΝ ΑΝΑΛΥΣΕΩΝ

Α. Μέθοδος – Έκφραση Αποτελεσμάτων

Αποτελέσματα προσδιορισμού **παραμέτρων σε ένα (1)** δείγμα νερού.

***Δειγματοληψία*:** Η δειγματοληψία έγινε από τον ενδιαφερόμενο σε πλαστική φιάλη και παραδόθηκε στο εργαστήριο στις 28/06/2016.

Το δείγμα συντηρήθηκε στους 4° C.

Ημ. Ανάλυσης: από 01-07-2016 έως 09-09-2016

Β. Αποτελέσματα:

α/α	Περιγραφή μεθόδου	Παράμετροι	Δείγμα 1 Πηγή Κωπηλατοδρομίου Σχοινιάς
1	Εσωτερική μέθοδος Ιοντικής χρωματογραφίας (in house Ion Chromatography method)	**Φθοριούχα Fluoride**	0,28mg/L
2	Εσωτερική μέθοδος Ιοντικής χρωματογραφίας (in house Ion Chromatography method)	**Χλωριούχα Chloride**	171 mg/L
3	Εσωτερική μέθοδος Ιοντικής χρωματογραφίας (in house Ion Chromatography method)	**Θειικά Sulphates**	44,3 mg/L
4	Εσωτερική μέθοδος Ιοντικής χρωματογραφίας (in house Ion Chromatography method)	**Νιτρικά Nitrate**	19,3 mg/L
5	Εσωτερική μέθοδος Ιοντικής χρωματογραφίας (in house Ion Chromatography method)	**Βρωμιούχα Bromide**	0,68 mg/L
6	Εσωτερική μέθοδος Φασματομετρίας μαζών επαγωγικά συζευγμένου πλάσματος αργού (in house ICP-MS method)	**Ασβέστιο Calcium**	116 mg/L
7	APHA 5210-D	**BOD**	<6 mg/L

8	Vyrides et al. Bioresource Technology 100 (2009) 979–982	**COD**	65,5 mg/L
9	APHA 5540	**Επιφανειδραστικές ουσίες, ανιοντικά (SAS)**	<0,1 mg/L
10	EPA 1664	**Oil & Grease**	7,6 mg/L
11	TOC analyzer	**Ολικό οργανικό φορτίο Total Organic Carbon**	1,95 mg/L
12	In house GC-MS/MS method	**PCBs**	<0,025 μg/L
13	In house LC-QTOF/MS screening method	**Φυτοφάρμακα Pesticides**	1.2.3.6-Tetrahydrophthalimide (cis-) Azaconazole Bentazone Clothiandin Flonicamid Propazine-2-hydroxy (=Prometon-Hydroxy) Thiamethoxam **ΠΑΡΑΡΤΗΜΑ Ι**
14	In house GC-MS method	**Πτητικά Volatile organics**	Chloroform: 0,14 ng/mL Ethyl Acetate: 3,67 ng/mL Toluene: 2,24 ng/mL **ΠΑΡΑΡΤΗΜΑ ΙΙ**

Ο Τεχνικός Υπεύθυνος Τμ. Β

Ν. ΘΩΜΑΪΔΗΣ

Παράρτημα Ι
Προσδιοριζόμενα φυτοφάρμακα

Acephate, 1,3,5(10)-Estratriene-3,16α,17β-triol, 1.2.3.6-Tetrahydrophthalimide (cis-), 1-Naphthylaceticacid, 2.3.4.6-Tetrachlorophenol, 2.4.5-T, 2.4.6-Trichlorophenol, 2.4-D, 2.4-DB, 2.4-DB-methylester, 2.4-D-butylester, 2.4-Dimethylaniline (Metabolite Amitraz), 2.4-D-methylester, 2-Aminobenzimidazole, 2-Benzyltetronic acid, 2-Methyl-4-amino-6-methoxy-s-triazine, 2-Phenethylamine, 2-Phenylphenol, 3 4-(dichlorophenyl)-3-methyl urea, 4-(dichlorophenyl)-urea, 3 4-dichloroaniline, 3 5 6-Trichloro-2-pyridinol, 3-Phenoxybenzoic acid, 5-Chloro-2-methyl-4-isothiazolin-3-on (CMI), Acephate, Acetamiprid, Acetiamine, Acetochlor, Acetochlor-ESA, Acetochlor-OXA, Acibenzolar-S-Methyl, Acifluorfen, Aclonifen, Acrinathrin, Alachlor, Alachlor-ESA, Alachlor-OXA, Alanycarb, Albendazole, Albendazole sulfone, Aldicarb, Aldicarb-sulfone (Aldoxycarb), Aldicarb-sulfoxide, Allethrin (I,II), Allethrin II, Allidochlor, Ametryn, Amidosulfuron, Aminocarb (Metacil), Amitraz, Amitrole, Amorolfine, Ancymidol, Anilazine. Dyrene, Anilofos, Aramite, Asana (Esfenvalerate), Aspon, Asulam, Atraton, Atrazin-desethyl-2-hydroxy (=Prometon-Hydroxy-Desisopropyl), Atrazine, AvermectinB1a (Abamectin), AvermectinB1b (Abamectin), Atrazine 2-Hydroxy, Atrazine-desethyl, Atrazine-desisopropyl, Azaconazole, Azimsulfuron, Azinphos-ethyl, Azinphos-methyl (Guthion), Aziprotryne, Azoxystrobin, Azoxystrobin acid, Barban (endo) (isomerA), Beflubutamid, Benalaxyl, Benazolin, Bendiocarb, Benfuracarb, Benodanil, Benoxacor, Bensulfuron-methyl ,Bensulide, Bensultap ,Bentazone, Benthiavalicarb-isopropyl ,Benzethonium, Benzoic acid 3 5-dibromo-4-hydroxy-, Benzoximate, Benzoylprop-ethyl, Benzthiazuron, Bifenazate, Bifenox, Bifenox acid, Bioallethrin, Bioresmethrin, Bispyribac, Bitertanol, Boscalid, Bromacil, Bromadiolone Peak 1, Bromophos (Bromophos-methyl), Bromophos-ethyl, Bromopropylate, Bromoxynil, Bromuconazole, Bupirimate, Buprofezin (Z-isomer. Buprofexin), Butachlor, Butafenacil, Butamifos, Butocarboxim, Butocarboxim-sulfoxid, Butoxycarboxim, Butralin, Buturon, Butylate, Cadusafos, Cambendazol, Captafol, Captan, Carbaryl, Carbendazim, Carbetamide, Carbofuran, Carbofuran-3-hydroxy, Carbophenothion, Carbosulfan, Carboxin Carfentrazone-ethyl, CGA 321113 (Trifloxystrobin Metabolite), Chloramben, Chlorantraniliprole, Chlorbromuron, Chlorbufam, Chlorcyclizine, Chlordimeform, Chlorfenprop-methyl, Chlorfenson, Chlorfenvinphos (E/Z), Chlorfluazuron, Chloridazone, Chloridazon-methyl-desphenyl, Chlorimuronethyl, Chlormequat, Chlorobenzilate, Chlorophacinone, Chloropropylate, Chlorothalonil-4-hydroxy, Chlorothiamid, Chlorotoluron, Chloroxuron (Chloroxifenidim), Chlorpropham, Chlorpyriphos, Chlorpyriphos-methyl, Chlorsulfuron, Chlorthal-dimethyl (DCPA. Dacthal), Chlorthion, Chromafenozide, Cinidon-ethyl, Cinosulfuron, Clethodim Peak 1, Clodinafop-propargyl, Clofentezine, Clomazone (Command), Clopyralid, Clothiandin, Coumachlor, Coumaphos, Crimidine, Crotoxyphos, Crufomate, Cyanazine, Cyanofenphos, Cyanophos, Cyazofamid, Cycloate, Cycloheximide , Cycloxydim I, Cycloxydim II, Cycluron, Cyfluthrin (Baythroid), Cyhalothrin (lambda-), Cymoxanil, Cypermethrin (I,II,III), Cyprazin, Cyproconazole, Cyprodinil, Cyromazine, Cythioate, Daimuron (Dymron), Dalapon, Dazomet, DDA (2.2-bis(4-chlorophenyl)-acetic acid), DEET (Diethyltoluamide), Deltamethrin, Demeton (total.mixed isomers), Demeton-S, Demeton-S-methylsulfone, Demeton-S-methylsulfoxid (Oxydemeton-methyl), Desmedipham, Desmetryn, DET, Diafenthiuron, Dialifos, Diallate, Diazinon, Diazinon-O-analog, Dibutylchlorendate Dicamba, Dicamba-methyl, Dicapthon, Dichlofenthion, Dichlofluanid, Dichlormid, Dichlorobenzamide, Dichlorophen, Dichlorprop, Dichlorprop-methyl, Dichlorvos, Diclobutrazol, Diclofop, Diclofop-methyl, Dicloran, Dicrotophos, Diethofencarb, Difenoconazole , Difenoxuron, Difenzoquat, Diflubenzuron, Diflufenican Diflufenzopyr, Dikegulac, Dimefuron Dimethachlor, Dimethachlor-ESA, Dimethachlor-OXA, Dimethenamid, Dimethenamid-ESA, Dimethenamid-OXA, Dimethipin, Dimethipin, Dimethirimol, Dimethoate, Dimethomorph, Dimethylanilin (N.N-), Dimethylphthalate, Dimethylvinphos, Dimetridazole, Dimoxystrobin, Dinex (2-Cyclohexyl-4.6-dinitrophenol), Diniconazole, Dinocap, Dinoseb, Dinotefuran, Dinoterb, Dioxacarb, Dioxathion, Diphacinone, Diphenamid, Diphenylamine, Diquat, Disulfoton, Disulfoton-sulfone, Disulfoton-sulfoxid, Ditalimfos, Dithiopyr, Diuron, DMSA (=N N-Dimethylaminosulfanilid), DNOC (4.6-dinitro-o-cresol), Dodemorph (I,II), Dodine , Dyrene (Anilazine), Edifenphos, Emamectin B1a, Emamectin B1b, Endosulfan I / II, Endosulfan-sulfate, Endothal , EPN, Epoxiconazole, EPTC, Esprocarb, Etaconazole , Ethiofencarb, Ethiofencarb-sulfone, Ethiofencarb-sulfoxide, Ethion, Ethiprole, Ethirimol, Ethofumesate, Ethoprop, Ethoprophos, Ethoxyquin, Ethoxysulfuron, Etoxazole, Etrimfos, Famoxadone, Fenamidone, Fenamiphos, Fenamiphos - sulfone, Fenarimol, Fenazaquin, Fenbuconazole, Fenclofos.Ronnel, Fenfluoramine, Fenfuram, Fenhexamid, Fenitrothion, Fenobucarb, Fenoprop (Silvex.2.4.5-TP), Fenoprop-methylester (Silvex-methyester), Fenothiocarb, Fenoxaprop-P, Fenoxycarb, Fenpiclonil, Fenpropathrin, Fenpropidin, Fenpropimorph, Fenpyroximate, Fenson, Fensulfothion, Fensulfothion-sulfon, Fenthion, Fenthion-oxon, Fenthion-sulfon, Fenthion-sulfoxide, Fentin (triphenylstannylium) , Fenuron, Fenvalerate, Fipronil, Fipronil-desulfinyl, Fipronil-sulfide, Fipronilsulfone, Flamprop, Flamprop-isopropyl, Flazasulfuron, Flonicamid, Florasulam, Fluacrypyrim, Fluazifop-p-butyl, Fluazinam, Fluazuron, Fluchloralin, Fluconazol, Flucycloxuron, Flucythrinate, Fludioxonil, Flufenacet, Flufenacet-ESA, Flufenacet-OXA, Flufenoxuron, Flufenzine (Diflovidazin), Flumequine, Flumethrin, Flumetsulam, Flumioxazin, Fluometuron, Fluoroglycofen-ethyl, Fluoxastrobin, Fluquinconazole, Fluridone, Flurochloridone, Fluroxypyr, Flurprimidol, Flurtamone, Flusilazole, Flutolanil, Flutriafol, Fluvalinate , Fomesafen, Fonofos, Foramsulfuron, Forchlorfenuron, Formetanate, Fosthiazate, Fuberidazole, Furalaxyl, Furathiocarb, Furilazole, Gibberellic acid, Glufosinate, Griseofulvin, Halfenprox, Halofenozide, Haloxyfop ethoxyethyl ester, Heliotrine, Heliotrine-N-oxide, Heptenophos, Hexaconazole, Hexaflumuron, Hexazinone, Hexythiazox, Imazalil, Imazamethabenz-methyl, Imazamox, Imazapyr, Imazaquin, Imazethapyr, Imazosulfuron, Imibenconazole, Imidacloprid, Imidacloprid-guanidine, Imidacloprid-urea, Imidocarb, Inabenfide, Indoxacarb, Iodofenphos (Jodfenphos), Ioxynil, Iprobenfos, Iprodione , Iprovalicarb , Irgarol, Irgarol-descyclopropyl, Isazophos, Isocarbamid (Azolamide), Isocarbophos, Isoconazole, Isofenphos, Isofenphos-methyl, Isoprocarb, Isopropalin, Isoproturon, Isoproturon-didemethyl = 1-(4-Isoprophenyl)urea, Isoxaben, Isoxadifen-ethyl, Isoxaflutole (I,II), Isoxathion, Ivermectin, Kresoxim-methyl, Lactofen, Lenacil, Leptophos, Linuron, Lufenuron, Lycopsamine, Lycopsamine-N-oxide, M1

(Irgarol-descyclopropyl), Malaoxon, Malathion, MCPA, MCPB, Mecarbam, Mecoprop, Mecoprop-methylester, Mefenacet, Mefenpyr-diethyl, Mefluidide, Mepanipyrim, Mepronil, Mercaptobenzothiazole, Mesotrion-MNBA, Metalaxyl, Metamitron, Metaxalone, Metazachlor, Metazachlor-ESA, Metazachlor-OXA, Metconazole, Methabenzthiazuron, Methacrifos , Methamidophos, Methfuroxam, Methidathion, Methiocarb (Mercaptodimethur), Methiocarb-sulfone, Methiocarb-sulfoxide, Methomyl, Methoprene , Methoprotryne, Methoxyfenozide, Methyl 2-dimethoxyphosphinothioylsulfanylacetate (formothion methanolyse), Metobromuron, Metolachlor, Metolachlor-ESA, Metolachlor-Morpholinon, Metolachlor-OXA, Metolcarb, Metominostrobin (E&Z-Isomer), Metosulam, Metoxuron, Metrafenone, Metribuzin, Metribuzin-Desamino (DA), Metribuzin-Diketo (DK), Metsulfuron-methyl, Mevinphos , Mexacarbate, MGK-264, Molinate, Monocrotaline, Monocrotaline-N-oxide, Monocrotophos, Monolinuron, Monuron, Myclobutanil, N'-(2 4-Dimethylphenyl)-N-methylformamidine, N.N-Diethyl-m-toluamide. DEET, N.N-Dimethyl-N'-p-tolylsulphamide (DMST), N-2-4-Dimethylphenylformamide (DMF. Metabolite Amitraz), Naled, Naphthoxyaceticacid (beta-), Napropamide, Naptalam (N-1-Naphthylphthalamicacid), Neburon, Nicosulfuron, Nitenpyram, Nitrothal-isopropyl, Norflurazon, Novaluron, Noviflumuron, Nuarimol, O.O.O-Triethylphosphorothioate, Ofurace, Omethoate, Orbencarb, Oryzalin, Oxadiargyl, Oxadiazon, Oxadixyl, Oxamyl, Oxasulfuron, Oxfendazole, Oxybutynin, Oxycarboxin, Oxydemeton-methyl, Oxyfluorfen, p.p-Dichlorobenzophenone, Paclobutrazole, Paraoxon, Paraoxon-methyl, Parathion, Parathion-methyl, PCP, Pebulate, Penconazole, Pencycuron, Pendimethalin, Penfluron, Pentanochlor, Permethrin (cis-), Pethoxamid, Phenazone, Phenmedipham, Phenothrin, Phenthoate, Phorate, Phorate-oxon, Phosalone, Phosmet, Phosphamidon (Dimecron) , Phoxim, P-Hydroxymesocarb, Picloram, Picolinafen, Piperonylbutoxide, Pirimicarb, Pirimicarb-desmethyl, Pirimiphos-ethyl, Pirimiphos-methyl, Pretilachlor, Prochloraz, Procymidone, Profenophos, Profoxydim , Proguanil, Prohexadione, Promecarb, Prometon, Prometryn, Propachlor, Propachlor-ESA, Propachlor-OXA, Propamocarb, Propanil, Propaphos, Propaquizafop, Propargite, Propazine, Propazine-2-hydroxy (=Prometon-Hydroxy), Propetamphos, Propham, Propoxur, Propyzamide (Pronamide), Proquinazid, Prosulfocarb, Prosulfuron, Prothioconazole, Prothioconazole-desethio, Pymetrozine, Pyraclostrobin, Pyraflufen-ethyl, Pyrazophos, Pyrazoxyfen, Pyrethrin (I,II), Pyrethrins: Cinerin (I,II), Pyrethrins: Jasmolin (I,II), Pyributicarb, Pyridaben, Pyridaphenthion, Pyridate, Pyrifenox , Pyrimethanil, Pyrimidifen, Pyrimidinol, Pyriproxyfen, Quinalphos, Quinclorac, Quinmerac, Quinoxyphen, Quizalofop, Quizalofop-ethyl, Rabenzazole, Resmethrin, Resmethrin, Retrorsine, Retrorsine-N-oxide, Rimsulfuron, Rotenone, Schradan, Sebuthylazine, Secbumeton, Senecionine, Senecionine-N-oxide, Seneciphylline, Seneciphylline-N-oxide, Senkirkine, Sethoxydim , Siduron , Simazine, Simazine 2-Hydroxy, Simetryn, Spinosad A (Spinosyn A), Spinosad D, Spinosyn B , Spirodiclofen, Spiromesifen, Spiroxamine , Sulcotrione, Sulfometuron-methyl, Sulfotepp, Sulprofos (Bolstar), SWEP (MCC), TCMTB, Tebuconazole, Tebufenozide, Tebufenpyrad, Tebupirimphos, Tebutame, Tebuthiuron, Teflubenzuron, Tefluthrin , Temephos, TEPP, Tepraloxydim , Terbacil, Terbufos, Terbufossulfone, Terbufos-sulfoxide, Terbumeton, Terbuthylazine, Terbutryn, Terbutylazin-2-hydroxy, Terbutylazin-desethyl, Terbutylazin-desethyl-2-hydroxy, Tetrachlorvinphos (Stirofos), Tetraconazole, Tetramethrin (I,II), Thenylchlor, Thiabendazole, Thiacloprid, Thiacloprid-amide, Thiamethoxam, Thiazopyr, Thidiazuron, Thifensulfuron-methyl, Thiobencarb, Thiocyclam, Thiodicarb, Thiofanox, Thiometon, Thionazin (Zinophos), Thiophanate-methyl, Thiophanat-ethyl, Thiram (Tetramethylthiuramdisulfide.TMTD), Tinidazole, Tiocarbazil, Tokuthion (Prothiophos), Tolclofos-methyl, Tolfenpyrad, Tolnaftate, Tolyfluanid, Tralkoxydim , Tralomethrin, Tranexamic acid, Triadimefon, Triadimenol (I,II), Triallate, Triasulfuron, Triazamate, Triazophos, Triazoxide, Tribenuron-methyl, Tribufos (Merphos oxide. DEF), Trichlorfon (Dylox), Trichloronate, Triclabendazole, Triclocarban, Triclopyr, Triclopyr-methylester, Tricyclazole, Trietazine, Trifloxystrobin, Trifloxysulfuron, Triflumizole, Triflumuron, Triflusulfuron-methyl, Triforine(I,II), Trimethacarb (2.3.5-), Trimethacarb (3.4.5-), Trinexapac-ethyl, Trinexapac acid, Triphenylphosphate, Triticonazole, Uniconazole, Vamidothion, Vegadex (Sulfallate), Vernolate, Warfarin, XMC, Zoxamide

Παράρτημα ΙΙ
Προσδιοριζόμενα πτητικά

1,1,1- trichloroethane, 1,1,2- trichloroethane, 1,1-Dichloroethane, 1,1 Dichloroethylene, 1,2-Dichlorobenzene, 1,2-Dichloroethane, 1,2-dicloropropane, 1,3-Dichlrorobenzene, 1,4-Dichlorobenzene, Bromodichloromethane, Bromoform, Bromomethane, Carbon Tetrachloride, Chlorobenzene, Chloroethane, Chloroform, Chloromethane, Dibromochloromethane, Epichlorhydrine, Ethyl Acetate, Ethylbenzene, Tetrachloroethene, Toluene, Trichloroethene, Trichlorofluoromethane, Vinyl-Chloride
Benzene, cis_1,3_dichloropropene, m,p-xylenes, o-xylene, trans 1,2-dichloroethene, trans 1,3-dichloropropene

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ΕΚΘΕΣΗ ΔΟΚΙΜΩΝ

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	
Εταιρεία :	**ΚΛ. ΔΗΜΗΤΡΙΑΔΗΣ & ΣΙΑ ΕΕ**
Αρμόδιος /οι :	Κος Δημητριάδης
Διεύθυνση :	Μάρκου Δράκου 52,Αθήνα, 11476

ΣΤΟΙΧΕΙΑ ΔΟΚΙΜΙΟΥ /ΩΝ	
Περιγραφή δοκιμίου /ων :	Νερό πηγής
Κωδικός /οί δοκιμίου /ων :	091116-07
Ημερομηνία παραλαβής :	09-11-2016
Κατάσταση δοκιμίου /ων κατά την παραλαβή :	Κανονική
Ημερομηνία περάτωσης αναλύσεων :	21-11-2016
Αντικείμενο που υποβλήθηκε σε δοκιμή :	Το δοκίμιο ως έχει
Δειγματοληψία :	Από τον πελάτη

ΕΠΙΣΗΜΑΝΣΗ ΔΟΚΙΜΙΟΥ /ΩΝ	
Κωδικός Δοκιμίου	Στοιχεία / Επισήμανση πελάτη
091116-07	Νερό πηγής

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ΑΠΟΤΕΛΕΣΜΑΤΑ ΑΝΑΛΥΣΕΩΝ

Κωδικός δείγματος : 091116-07

Παράμετρος	Αναλυτική Μέθοδος	Αποτέλεσμα	LoQ	Όρια (*) Ποσίμου	Μονάδες
pH	AWWA – 4500/H^+	**7,39**	---	6,5 – 9,5	---
Αγωγιμότητα (@ 20°C)	AWWA – 2510	**4650**	10	2.500	μS/cm
Ολικά Διαλελυμένα Στερεά	AWWA – 2540/C	**3220**	70	1.500	mg/l
Σκληρότητα Ολική* (Γαλλικοί βαθμοί) (Γερμανικοί βαθμοί)	AWWA – 2340/B AWWA – 2340/B AWWA – 2340/B	**708** **70,8** **39,6**	3,0 0,3 0,2	(*) (*) (*)	mg $CaCO_3$/l F° D°
Ανθρακικά* (CO_3^{-2})	AOAC Off. M. 920.194	**16,2**	0	(*)	mg/l
Όξινα Ανθρακικά* (HCO_3^{-1})	AOAC Off. M. 920.194	**345**	10	(*)	mg/l
Αλκαλικότητα* (Φ)	AWWA – 2320/B	**13,5**	0	(*)	mg $CaCO_3$/l
Αλκαλικότητα* (Η)	AWWA – 2320/B	**296**	10	(*)	mg $CaCO_3$/l
Χλωριούχα (Cl^-)	AWWA – 4500 – Cl^-/B	**1260**	5	250	mg/l
Νιτρικά (NO_3^-)	MERCK 1.09713	**14,5**	5	50	mg/l
Νιτρώδη (NO_2^-)	MERCK 1.14776	**ΜΑ**	0,05	0,5	mg/l
Αμμωνιακά (NH_4^+)	MERCK 1.14752	**ΜΑ**	0,05	0,5	mg/l
Φώσφορος (P_2O_5)	MERCK 1.14848	**ΜΑ**	0,15	5	mg/l
Φθόριο* (F^-)	AWWA – 4500 – F^-/E	**0,29**	0,1	1,5	mg/l
Θειικά* (SO_4^{-2})	AWWA – 4500 – SO_4^{-2}/E	**178**	10	250	mg/l
Πυριτικά (SiO_2)	MERCK 1.14794	**10,7**	0,5	(*)	mg/l
Ασβέστιο (Ca^{+2})	In house based on ASTM D 511-14	**183**	0,2	(*)	mg/l
Μαγνήσιο (Mg^{+2})	In house based on ASTM D 511-14	**60,9**	1,0	(*)	mg/l
Κάλιο (K^+)	In house based on ISO 9964-3:1993 (E)	**22,1**	0,2	12	mg/l
Νάτριο (Na^+)	In house based on ASTM D 4191-15 & ASTM D 3561-11	**724**	2	200	mg/l
Χαλκός (Cu^{tot})	In house based on ASTM D 1688-12	**ΜΑ**	0,1	2	mg/l
Ψευδάργυρος (Zn^{+2})	In house based on ASTM D 1691-12	**ΜΑ**	0,05	5	mg/l
Μαγγάνιο (Mn^{+2})	In house based on ISO 15586:2003	**ΜΑ**	2	50	μg/l
Σίδηρος* (Fe)	In house based on ISO 15586:2003	**26**	10	200	μg/l
Υπολειμματικό Χλώριο* (Cl_2)	AWWA – 4500 – Cl_2/G	**ΜΑ**	0,05	(*)	mg/l

Συντμήσεις: Μ. Α.: Μη Ανιχνεύσιμο — LoQ : Όριο Ποσοτικοποίησης
< LoQ : μικρότερο του Ορίου Ποσοτικοποίησης

Σημειώσεις: 1. **(*)**: Όρια ποσίμου (παραμετρική τιμή) βάσει της Κ.Υ.Α. Υ2/2600/2001
2. Για τις παραμέτρους που επισημαίνονται με αστερίσκο (*) δεν προβλέπεται ανώτατο όριο.

Ο Προϊστάμενος Εργαστηρίου

ΣΤΕΦ. Κ. ΑΝΔΡΕΟΥ
ΧΗΜΙΚΟΣ MSc

* Εκτός Πεδίου Διαπίστευσης

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Κωδικός Έκθεσης	091116-07
Ημ/νία : 21-11-16	Σελίδα 1 από 1
ΓΝΩΜΑΤΕΥΣΗ	

ΓΝΩΜΑΤΕΥΣΗ

- **Ακατάλληλο ως πόσιμο λόγω της αυξημένης περιεκτικότητας σε θαλασσινό νερό. Τα εμπεριεχόμενα χλωριούχα ισοδυναμούν με περίπου 6 % θαλασσινό νερό. Ως μοναδική λύση για την βελτίωση της ποιότητας του προτείνεται η εγκατάσταση μονάδας αντίστροφης όσμωσης.**

- **Δεν πρόεκυψαν ενδείξεις επιμόλυνσης του νερού με λύματα και ως εκ τούτου κρίνεται κατάλληλο για την προσωπική καθαριότητα. Για την στοματική υγιεινή συνιστάται προληπτικά η μικροβιολογική εξέταση του νερού.**

- **Ακατάλληλο για την μαγειρική χρήση (ισχύει ότι και για το πόσιμο), κατάλληλο για τις λοιπές οικιακές χρήσεις. Το αυξημένο ασβέστιο αναμένεται να δημιουργήσει προβλήματα επικαθήσεων αλάτων στις συσκευές θέρμανσης του νερού (πχ πλυντήριο , θερμοσίφωνας). Αν τα προβλήματα είναι έντονα συνιστάται η εγκατάσταση αποσκληρυντή τύπου ανταλλαγής ιόντων.**

- **Κατάλληλο για το πότισμα μόνον των ιδιαιτέρως ανθεκτικών στο αλάτι καλλιεργειών. Πριν την εγκατάσταση νέων καλλιεργειών συμβουλευτείτε συμπληρωματικά τοπικό γεωπόνο.**

Χλωριούχα : 1260 mg/L
Βαθμός Αλκαλίωσης (SAR) : 11,9

Ο Προϊστάμενος Εργαστηρίου

ΣΤΕΦ. Κ. ΑΝΔΡΕΟΥ
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Κωδικός Έκθεσης	**200117-04**
Ημ/νία : 25-01-17	**Σελίδα 1 από 2**

ΕΚΘΕΣΗ ΔΟΚΙΜΩΝ

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	
Εταιρεία :	**ΚΛ. ΔΗΜΗΤΡΙΑΔΗΣ & ΣΙΑ ΕΕ**
Αρμόδιος /οι :	Κος Δημητριάδης
Διεύθυνση :	Μάρκου Δράκου 52,Αθήνα, 11476

ΣΤΟΙΧΕΙΑ ΔΟΚΙΜΙΟΥ /ΩΝ	
Περιγραφή δοκιμίου /ων :	Νερό
Κωδικός /οί δοκιμίου /ων :	200117-04
Ημερομηνία παραλαβής :	20-01-2017
Κατάσταση δοκιμίου /ων κατά την παραλαβή :	Κανονική
Ημερομηνία περάτωσης αναλύσεων :	24-01-2017
Αντικείμενο που υποβλήθηκε σε δοκιμή :	Το δοκίμιο ως έχει
Δειγματοληψία :	Από τον πελάτη

ΕΠΙΣΗΜΑΝΣΗ ΔΟΚΙΜΙΟΥ /ΩΝ	
Κωδικός Δοκιμίου	Στοιχεία / Επισήμανση πελάτη
200117-04	Νερό, Μαραθώνας Κοπηλατοδρόμιο

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ΑΠΟΤΕΛΕΣΜΑΤΑ ΑΝΑΛΥΣΕΩΝ

Κωδικός δείγματος : 200117-04

Παράμετρος		Αναλυτική Μέθοδος	Αποτέλεσμα	LoQ	Όρια (*) Ποσίμου	Μονάδες
Χλωριούχα	(Cl^-)	AWWA – 4500 – Cl^-/B	**1310**	5	250	mg/l
Ασβέστιο	(Ca^{+2})	In house based on ASTM D 511-14	**160**	0,2	(*)	mg/l

Συντμήσεις: Μ. Α.: Μη Ανιχνεύσιμο — LoQ : Όριο Ποσοτικοποίησης
< LoQ : μικρότερο του Ορίου Ποσοτικοποίησης

Σημειώσεις:
1. **(*)**: Όρια ποσίμου (παραμετρική τιμή) βάσει της Κ.Υ.Α. Υ2/2600/2001
2. Για τις παραμέτρους που επισημαίνονται με αστερίσκο (*) δεν προβλέπεται ανώτατο όριο.

Ο Προϊστάμενος Εργαστηρίου

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ΕΚΘΕΣΗ ΔΟΚΙΜΩΝ

ΣΤΟΙΧΕΙΑ ΠΕΛΑΤΗ	
Εταιρεία :	**MALVA**
Αρμόδιος /οι :	Κος Ιωσσιφίδης
Διεύθυνση :	

ΣΤΟΙΧΕΙΑ ΔΟΚΙΜΙΟΥ /ΩΝ	
Περιγραφή δοκιμίου /ων :	Νερό
Κωδικός /οί δοκιμίου /ων :	150217-31, 150217-32 και 150217-33
Ημερομηνία παραλαβής :	15-02-2017
Κατάσταση δοκιμίου /ων κατά την παραλαβή :	Κανονική
Ημερομηνία περάτωσης αναλύσεων :	28-02-2017
Αντικείμενο που υποβλήθηκε σε δοκιμή :	Το δοκίμιο ως έχει
Δειγματοληψία :	Από τον πελάτη

ΕΠΙΣΗΜΑΝΣΗ ΔΟΚΙΜΙΟΥ /ΩΝ	
Κωδικός Δοκιμίου	Στοιχεία / Επισήμανση πελάτη
150217-31	Νερό , Μονάδα R.O.
150217-32	Νερό, Κανάλι
150217-33	Νερό, Εξέδρα Πύργος

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Κωδικός Έκθεσης	150217-31=33
Ημ/νία : 01-03-17	Σελίδα 2 από 4

ΑΠΟΤΕΛΕΣΜΑΤΑ ΑΝΑΛΥΣΕΩΝ

Κωδικός δείγματος : 150217-31 (Μονάδα R.O.)

Παράμετρος	Αναλυτική Μέθοδος	Αποτέλεσμα	LoQ	Όρια (*) Ποσίμου	Μονάδες
pH	SMEWW – 4500/H^+	**8,3**	---	6,5 – 9,5	---
Αγωγιμότητα (@ 20°C)	SMEWW – 2510	**4710**	10	2.500	μS/cm
Ολικά Διαλελυμένα Στερεά	SMEWW – 2540/C	**2750**	70	1.500	mg/l
Ολικά Αιωρούμενα Στερεά	SMEWW – 2540/D	**<LoQ(3,0)**	10	(*)	mg/l
Σκληρότητα Ολική* (Γαλλικοί βαθμοί) (Γερμανικοί βαθμοί)	SMEWW – 2340/B SMEWW – 2340/B SMEWW – 2340/B	**637** **63,7** **35,6**	3,0 0,3 0,2	(*) (*) (*)	mg $CaCO_3$/l F° D°
Ανθρακικά* (CO_3^{-2})	AOAC Off. M. 920.194	**24,0**	0	(*)	mg/l
Όξινα Ανθρακικά* (HCO_3^{-1})	AOAC Off. M. 920.194	**239**	10	(*)	mg/l
Αλκαλικότητα* (Φ)	SMEWW – 2320/B	**20,0**	0	(*)	mg $CaCO_3$/l
Αλκαλικότητα* (Η)	SMEWW – 2320/B	**216**	10	(*)	mg $CaCO_3$/l
Χλωριούχα (Cl^-)	SMEWW – 4500 – Cl^-/B	**1270**	5	250	mg/l
Νιτρικά (NO_3^-)	MERCK 1.09713	**10,2**	5	50	mg/l
Νιτρώδη (NO_2^-)	MERCK 1.14776	**0,10**	0,05	0,5	mg/l
Αμμωνιακά (NH_4^+)	MERCK 1.14752	**0,51**	0,05	0,5	mg/l
Ορθοφωσφορικά (P_2O_5)	MERCK 1.14848	**MA**	0,20	5	mg/l
Ολικός Φώσφορος * (P_2O_5)	MERCK 1.14848- SMEWW 4500 P/B	**MA**	0,20	5	mg/l
Φθόριο* (F^-)	SMEWW – 4500 – F^-/E	**0,25**	0,1	1,5	mg/l
Θειικά* (SO_4^{-2})	SMEWW – 4500 – SO_4^{-2}/E	**104**	10	250	mg/l
Πυριτικά (SiO_2)	MERCK 1.14794	**10,7**	0,2	(*)	mg/l
Ασβέστιο (Ca^{+2})	In house based on ASTM D 511-14	**150**	0,2	(*)	mg/l
Μαγνήσιο (Mg^{+2})	In house based on ASTM D 511-14	**63,8**	1,0	(*)	mg/l
Κάλιο (K^+)	In house based on ISO 9964-3:1993 (E)	**23,6**	0,2	12	mg/l
Νάτριο (Na^+)	In house based on ASTM D 4191-15 & ASTM D 3561-11	**758**	2	200	mg/l
Χαλκός (Cu^{tot})	In house based on ASTM D 1688-12	**MA**	0,1	2	mg/l
Ψευδάργυρος (Zn^{+2})	In house based on ASTM D 1691-12	**MA**	0,05	5	mg/l
Μαγγάνιο (Mn^{+2})	In house based on ISO 15586:2003	**MA**	2	50	μg/l
Σίδηρος* (Fe)	In house based on ISO 15586:2003	**31**	10	200	μg/l
Υπολειμματικό Χλώριο* (Cl_2)	SMEWW – 4500 – Cl_2/G	**MA**	0,05	(*)	mg/l

Συντμήσεις: Μ. Α.: Μη Ανιχνεύσιμο LoQ : Όριο Ποσοτικοποίησης
< LoQ : μικρότερο του Ορίου Ποσοτικοποίησης
SMEWW: Standard Methods For the Examination of Water and Wastewater

Σημειώσεις: 1. **(*)**: Όρια ποσίμου (παραμετρική τιμή) βάσει της Κ.Υ.Α. Υ2/2600/2001
2. Για τις παραμέτρους που επισημαίνονται με αστερίσκο (*) δεν προβλέπεται ανώτατο όριο.

Ο Προϊστάμενος Εργαστηρίου

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Κωδικός Έκθεσης	150217-31=33
Ημ/νία : 01-03-17	Σελίδα 3 από 4

ΑΠΟΤΕΛΕΣΜΑΤΑ ΑΝΑΛΥΣΕΩΝ

Κωδικός δείγματος : 150217-32 (Κανάλι)

Παράμετρος	Αναλυτική Μέθοδος	Αποτέλεσμα	LoQ	Όρια (*) Ποσίμου	Μονάδες
pH	SMEWW – 4500/H^+	**7,8**	---	6,5 – 9,5	---
Αγωγιμότητα (@ 20°C)	SMEWW – 2510	**4440**	10	2.500	μS/cm
Ολικά Διαλελυμένα Στερεά	SMEWW – 2540/C	**2610**	70	1.500	mg/l
Ολικά Αιωρούμενα Στερεά	SMEWW – 2540/D	**<LoQ(2,4)**	10	(*)	mg/l
Σκληρότητα Ολική* (Γαλλικοί βαθμοί) (Γερμανικοί βαθμοί)	SMEWW – 2340/B SMEWW – 2340/B SMEWW – 2340/B	**690** **69,0** **38,6**	3,0 0,3 0,2	(*) (*) (*)	mg $CaCO_3$/l F° D°
Ανθρακικά* (CO_3^{-2})	AOAC Off. M. 920.194	**5,7**	0	(*)	mg/l
Όξινα Ανθρακικά* (HCO_3^{-1})	AOAC Off. M. 920.194	**358**	10	(*)	mg/l
Αλκαλικότητα* (Φ)	SMEWW – 2320/B	**4,8**	0	(*)	mg $CaCO_3$/l
Αλκαλικότητα* (Η)	SMEWW – 2320/B	**298**	10	(*)	mg $CaCO_3$/l
Χλωριούχα (Cl^-)	SMEWW – 4500 – Cl^-/B	**1130**	5	250	mg/l
Νιτρικά (NO_3^-)	MERCK 1.09713	**17,4**	5	50	mg/l
Νιτρώδη (NO_2^-)	MERCK 1.14776	**MA**	0,05	0,5	mg/l
Αμμωνιακά (NH_4^+)	MERCK 1.14752	**MA**	0,05	0,5	mg/l
Ορθοφωσφορικά (P_2O_5)	MERCK 1.14848	**MA**	0,20	5	mg/l
Ολικός Φώσφορος * (P_2O_5)	MERCK 1.14848- SMEWW 4500 P/B	**MA**	0,20	5	mg/l
Φθόριο* (F^-)	SMEWW – 4500 – F^-/E	**0,25**	0,1	1,5	mg/l
Θειικά* (SO_4^{-2})	SMEWW – 4500 – SO_4^{-2}/E	**182**	10	250	mg/l
Πυριτικά (SiO_2)	MERCK 1.14794	**10,7**	0,2	(*)	mg/l
Ασβέστιο (Ca^{+2})	In house based on ASTM D 511-14	**179**	0,2	(*)	mg/l
Μαγνήσιο (Mg^{+2})	In house based on ASTM D 511-14	**59,1**	1,0	(*)	mg/l
Κάλιο (K^+)	In house based on ISO 9964-3:1993 (E)	**20,7**	0,2	12	mg/l
Νάτριο (Na^+)	In house based on ASTM D 4191-15 & ASTM D 3561-11	**653**	2	200	mg/l
Χαλκός (Cu^{tot})	In house based on ASTM D 1688-12	**MA**	0,1	2	mg/l
Ψευδάργυρος (Zn^{+2})	In house based on ASTM D 1691-12	**MA**	0,05	5	mg/l
Μαγγάνιο (Mn^{+2})	In house based on ISO 15586:2003	**<LoQ(0,8)**	2	50	μg/l
Σίδηρος* (Fe)	In house based on ISO 15586:2003	**26**	10	200	μg/l
Υπολειμματικό Χλώριο* (Cl_2)	SMEWW – 4500 – Cl_2/G	**MA**	0,05	(*)	mg/l

Συντμήσεις: Μ. Α.: Μη Ανιχνεύσιμο LoQ : Όριο Ποσοτικοποίησης
< LoQ : μικρότερο του Ορίου Ποσοτικοποίησης
SMEWW: Standard Methods For the Examination of Water and Wastewater

Σημειώσεις: 1. **(*)**: Όρια ποσίμου (παραμετρική τιμή) βάσει της Κ.Υ.Α. Υ2/2600/2001
2. Για τις παραμέτρους που επισημαίνονται με αστερίσκο (*) δεν προβλέπεται ανώτατο όριο.

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Κωδικός Έκθεσης	150217-31=33
Ημ/νία : 01-03-17	Σελίδα 4 από 4

ΑΠΟΤΕΛΕΣΜΑΤΑ ΑΝΑΛΥΣΕΩΝ

Κωδικός δείγματος : 150217-33(Εξέδρα- Πύργος)

Παράμετρος	Αναλυτική Μέθοδος	Αποτέλεσμα	LoQ	Όρια (*) Ποσίμου	Μονάδες
pH	SMEWW – 4500/H^+	**8,2**	---	6,5 – 9,5	---
Αγωγιμότητα (@ 20°C)	SMEWW – 2510	**4690**	10	2.500	μS/cm
Ολικά Διαλελυμένα Στερεά	SMEWW – 2540/C	**2720**	70	1.500	mg/l
Ολικά Αιωρούμενα Στερεά	SMEWW – 2540/D	**<LoQ(2,5)**	10	(*)	mg/l
Σκληρότητα Ολική* (Γαλλικοί βαθμοί) (Γερμανικοί βαθμοί)	SMEWW – 2340/B SMEWW – 2340/B SMEWW – 2340/B	**646** **64,6** **36,1**	3,0 0,3 0,2	(*) (*) (*)	mg $CaCO_3$/l F° D°
Ανθρακικά* (CO_3^{-2})	AOAC Off. M. 920.194	**20,1**	0	(*)	mg/l
Όξινα Ανθρακικά* (HCO_3^{-1})	AOAC Off. M. 920.194	**258**	10	(*)	mg/l
Αλκαλικότητα* (Φ)	SMEWW – 2320/B	**16,8**	0	(*)	mg $CaCO_3$/l
Αλκαλικότητα* (Η)	SMEWW – 2320/B	**228**	10	(*)	mg $CaCO_3$/l
Χλωριούχα (Cl^-)	SMEWW – 4500 – Cl^-/B	**1260**	5	250	mg/l
Νιτρικά (NO_3^-)	MERCK 1.09713	**10,0**	5	50	mg/l
Νιτρώδη (NO_2^-)	MERCK 1.14776	**0,09**	0,05	0,5	mg/l
Αμμωνιακά (NH_4^+)	MERCK 1.14752	**0,44**	0,05	0,5	mg/l
Ορθοφωσφορικά (P_2O_5)	MERCK 1.14848	**MA**	0,20	5	mg/l
Ολικός Φώσφορος * (P_2O_5)	MERCK 1.14848- SMEWW 4500 P/B	**MA**	0,20	5	mg/l
Φθόριο* (F^-)	SMEWW – 4500 – F^-/E	**0,25**	0,1	1,5	mg/l
Θειικά* (SO_4^{-2})	SMEWW – 4500 – SO_4^{-2}/E	**159**	10	250	mg/l
Πυριτικά (SiO_2)	MERCK 1.14794	**11,8**	0,2	(*)	mg/l
Ασβέστιο (Ca^{+2})	In house based on ASTM D 511-14	**152**	0,2	(*)	mg/l
Μαγνήσιο (Mg^{+2})	In house based on ASTM D 511-14	**64,7**	1,0	(*)	mg/l
Κάλιο (K^+)	In house based on ISO 9964-3:1993 (E)	**23,2**	0,2	12	mg/l
Νάτριο (Na^+)	In house based on ASTM D 4191-15 & ASTM D 3561-11	**720**	2	200	mg/l
Χαλκός (Cu^{tot})	In house based on ASTM D 1688-12	**MA**	0,1	2	mg/l
Ψευδάργυρος (Zn^{+2})	In house based on ASTM D 1691-12	**MA**	0,05	5	mg/l
Μαγγάνιο (Mn^{+2})	In house based on ISO 15586:2003	**MA**	2	50	μg/l
Σίδηρος* (Fe)	In house based on ISO 15586:2003	**25**	10	200	μg/l
Υπολειμματικό Χλώριο* (Cl_2)	SMEWW – 4500 – Cl_2/G	**MA**	0,05	(*)	mg/l

Συντμήσεις: Μ. Α.: Μη Ανιχνεύσιμο LoQ : Όριο Ποσοτικοποίησης
< LoQ : μικρότερο του Ορίου Ποσοτικοποίησης
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