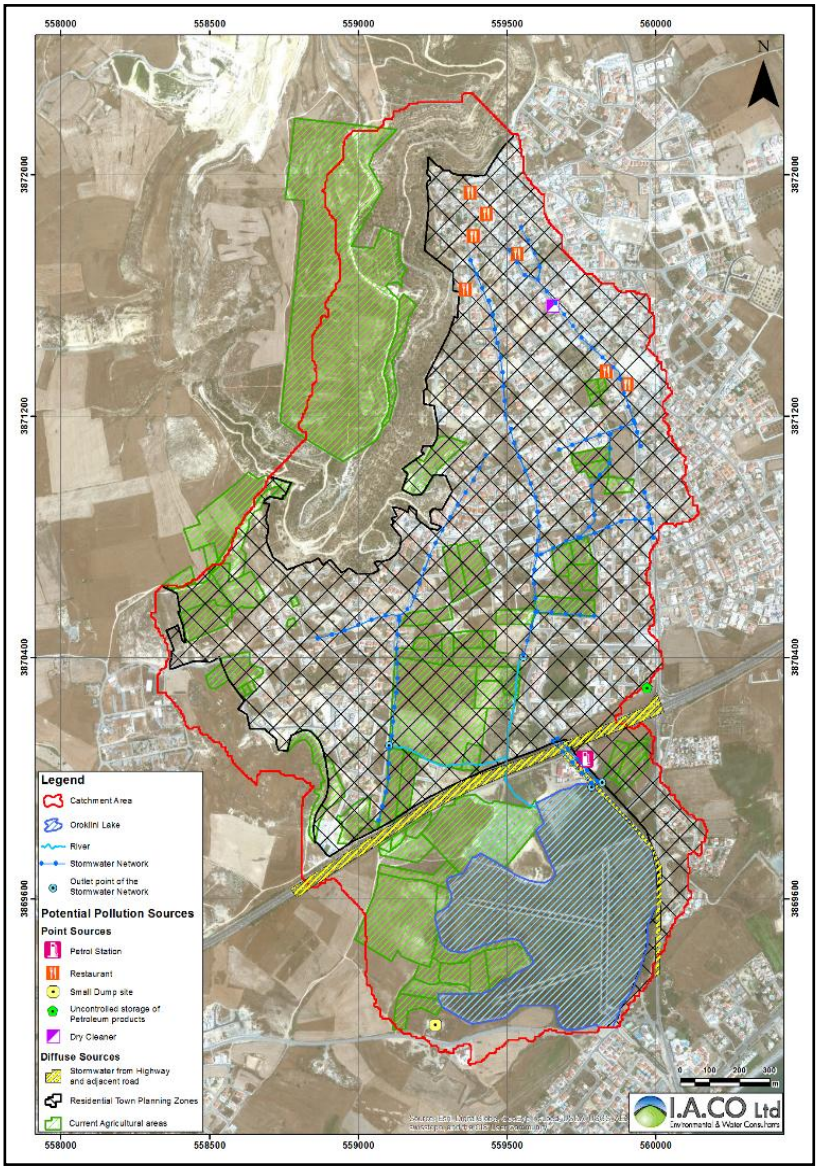

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Analysis of Pressures and Impacts on runoff water quality for the Oroklini Lake catchment

Specific task as part of the project LIFE10 NAT/CY/716 where BirdLife Cyprus is an associated beneficiary

Final Report

I.A.CO Ltd
Environmental & Water Consultants

Stavrou 3 Ave., Office 202, Strovolos 2035, Nicosia, Cyprus
Tel.: +35722429444 ● Fax: +35722519904
Email: info@iaco.com.cy ● Website: www.iaco.com.cy

CONTENTS

MAPS

TABLES

PHOTOS

FIGURES

I. EXECUTIVE SUMMARY

The study titled "Determination of important hydrological features for Oroklini Lake" carried out under the 3-year LIFE+ project titled "Restoration and Management of Oroklini Lake SPA (CY6000010) in Larnaka Cyprus" and for BirdLife Cyprus, being one of the five beneficiaries of this project, recommended that an analysis of the pressures within the catchment area that affect or could affect the quality of the surface runoff to the Lake should be performed.

I.A.CO Environmental and Water Consultants Ltd has carried out this follow up analysis of pressures. This has been done through site surveys in order to a) identify, analyse and assess potential pressures on the surface and ground water quality, and b) identify the sources of water contributing to the low and consistent runoff observed during the summer months. An impact assessment has been made through risk analysis, water sampling and analysis, and a recommended set of management measures safeguarding water quality have been provided.

The water content of the Oroklini Lake and its operation depend entirely on the surface runoff from a 2,7km^2 almost totally urbanized catchment area and on a minor contribution by rainfall falling directly on the lake and the surrounding areas, bringing the total extent of the catchment to 3,2km^2.

Runoff quantities have been estimated for a typical dry, average and a wet year, these being 0,265, 0,342, and 0,469 million cubic meters respectively. The totally dry months are normally those of May to August except for the wet year when flow is absent only in July.

Runoff to the Lake is both due to overland flow, though a heavily tampered stream, and flow from the storm-water network, the central and the western, with a 120 cm and 100 cm outlet respectively. The storm-water network was observed during flow to carry sediments and garbage most of which are held up by the reed beds in the marsh area.

Storm-water originates also from the Paralimni – Larnaca Highway as well as from the road crossing the Lake and connecting the coastal area to the Oroklini community. The polluting effect from this source and from an accidental spill of petrol and other chemicals is of some concern for the sensitive Oroklini Lake. The existing absence of sufficient runoff management conditions for the Highway and the public road have been further examined and recommendations have been made.

For the existing Petrol Station it appears that proper steps and measures have been taken to prevent pollution from within the grounds of the Station.

Local groundwater appears also to be a source of water to the Lake. Within the catchment there are no wells or boreholes bearing water indicating the very poor water bearing capacity of both the Athalassa and Nicosia Formations that make up the hydrogeological conditions in the upper half and the lower part of the catchment respectively.

The subsurface horizons in the area are being replenished with a) good quality water partly by local rainfall and from the surface runoff, b) a quantity of imported water for domestic supplies which is lost, reported to be as high as 50% of the imported quantity (or up to 0,4 million cubic meters per year), through an aging and faulty domestic supply distribution network, and c) sewage water discharged through on-site septic cesspools at each house used in lieu of an absent sewage collection system, adding an estimated 70% of the used potable water (or up to 0,271 million cubic meters per year).

Part of this groundwater is expected to rise in the area of the marsh, upstream the highway, and replenish the lake. In this area the dominating hydrogeological element is clay, marls and siltstones which form an impervious horizon to the downstream movement of groundwater.

In analysing the pressures and impacts from within the catchment area, the potential point sources were spot checked and evaluated. These amount to seven restaurants, one dry-cleaner, a petrol station, the highway itself and the road from the coast to the village, an uncontrolled dump site in the southwestern part of the lake, and an uncontrolled storage site for petroleum and other chemical products on the south-eastern fringe of the catchment upstream of the highway. Thus, for the main point potential sources of pollution the following can be highlighted:

- *Wastewater from restaurants differs from that of housing units by the Fats, Oils and Greases (FOGs) that result from kitchen waste. Sampling and analysis of runoff, always at the entrance of the culvert under the Highway, for Total Hydrocarbons and FOGs was made, which were found to be below the detection limit. Similarly the Total Petroleum Hydrocarbons (TPH) as for FOGs indicate a low concentration.*
- *The dry cleaning store was found to be equipped with modern dry cleaning machines that use a closed-loop system. This means high solvent recovery rates and reduced air pollution. The solvent used in the process is PERC (tetrachloroethylene). From the site visits performed, it seems that the dry cleaner management keeps all the precautions and terms set by the competent authorities.*
- *Of particular concern to the sensitive area of the Oroklini Lake has been the presence of the petrol station only a few meters away from the Lake. The measures taken regarding the disposal of runoff both of storm water as well as of any other chemical, oils and petrol, within the grounds of the Station, appear to safeguard the discharge of any of these to the Lake. Besides the screened gutter in the periphery of the station, and the low rim wall around the whole property, a screened gutter at the entrance to the Station prohibits any outflow of effluents from the Station to the road and the storm-water network. Additionally, a double wall of the underground storage facilities, an electrical detector of oil spills, special leakage infrastructure facilities, an oil/water separator and a vapor recovery unit, are in place.*
- *A major "point-source" of pollution due to the heavy traffic involved, is the storm runoff from the Paralimni – Larnaca highway which crosses the stream that discharges to the lake area. Additionally, another source is the road connecting the coastal area to both the highway and the Oroklini Community and which crosses the lake itself. A potential source would also be a traffic accident of a vehicle carrying petrol and /or other chemicals. The sensitive wetland ecosystem of Oroklini Lake needs to be protected by minimizing the road and bridge-related impact risks by establishing protective measures to reduce the runoff of pollutants, through the use and proper maintenance of structural controls.*
- *At the south-western part of the catchment area of the Lake, exists an uncontrolled dump site, well before 2003, of various types of wastes. Runoff from the area flows through and directly into the Lake.*
- *At the south-eastern fringe of the water-divide of the catchment just north of the Highway, a site where petroleum, other chemicals and scrap metal are laid out in the open exists. From*

this area a storm-water runoff ditch begins, enters the highway and ends up in the Lake. This site presents a threat to the Lake especially since the full type of products stored are not known.

The pressures and impacts of the potential diffuse or non-point sources were evaluated, the main ones being:

- *Agricultural practices, since these take up a substantial area (0,82 km^2) within the catchment area. Data were requested and granted from public services as to the area and type of crops and, agrochemical products used. The parameters selected for the monitoring of the impact were TN and TP to represent the possible pollution from fertilizers. For the investigation of agrochemicals there must be a further survey with the specific farmers of the area.*
- *Except for a narrow strip of land at the coast (450 m wide) which is covered by the sewerage network of "Larnaca Sewerage and Drainage Board", the rest of the area within the Oroklini's administrative boundaries is not covered by a waste-water sewer system and all housing units drain their sewage waste into on-site septic systems. Although the area has a population equivalent (p.e.) of 11000 and should be served by a sewerage system, it is reported that this is included in the National Implementation Plan which is under preparation. For monitoring the impact of the urban area with no sewerage the parameters selected were BOD_5, COD, TN, TP, TSS and E. Coli.*
- *Storm-water runoff from an urban environment washes pollutants off the roadways, parking lots, construction sites, roofs and lawns. These include gasoline, motor oil, heavy metals, polycyclic aromatic hydrocarbons (PAHs), sediments, organic contaminants, nutrients, pesticides etc., which may be harmful to receiving waters. Keeping pollutants out of storm-water runoff is less expensive than installing storm-water treatment facilities. The Oroklini Community Council needs among other to consider control regulations of construction site erosion and storm–water management in new developments, extension of present storm-water network, incentives for household hazardous waste collections, oil recycling, limit the use of fertilizers pesticides and, cleaning roadways.*

The impact analysis has also been based on three samplings of the flow just upstream of the highway culvert made on the 3rd and 16th of April, with light rain the previous day, and on the wet 6th of May 2014.

- *The high TN concentrations on the 3rd and 16th April is due to application of fertilizer in spring on the cereal crops that surround the lake and are present in all the catchment area. On these samplings the BOD5 and COD levels were considerably low.*
- *The high Electrical Conductivity and Boron levels are mainly due to natural causes arising from the geological formations possibly associated with halite commonly associated with evaporate deposits. When rainfall occurs, as on the 6/5/2014, these are diluted considerably.*
- *Total Hydrocarbons (TH) and FOG levels are below the detection limits indicating little, if any, impact from the road network and traffic and restaurants and households, respectively.*
- *High levels of E. Coli after the rainfall events can be explained by fecal material, from a variety of animals (pets, livestock, and wildlife etc.), that are washed out into storm-water*

following a rain event. The soil-aquifer treatment is expected to prevent E. Coli or BOD5 and COD reaching the stream from wastewater disposed into septic pits.

- *The TP concentrations were below the analytical detection limits. The only detected amount is on the day that rainfall occurred, which could be due to fertilizers being washed out from the fields.*

The indications are that no urban wastewater leaks into the storm-water network. Any contribution of groundwater containing wastewater appearing as rising water at the marsh area is considered to have been undergone natural soil-aquifer treatment. The agriculture areas around the lake appear though to have an impact on the water ending up in the lake.

The impacts to the lake from other point pollution sources such as the petrol station, the uncontrolled petroleum products junk-yard or the highway and adjacent road, cannot be identified by the monitoring carried out at the selected point of flow.

Changes of the water regime associated with the lake could have a serious impact on it. Such changes could be:

- *A storm-water network expansion to cover areas south of the Highway and disposing storm-water beyond the Lake and depriving the flows to it. Any change should end upstream of the main culvert, which passes under the Highway, and any network developed for the built up area around the Lake should be a separate and independent of the one serving the catchment area providing water to the Lake.*
- *The establishment in the future of a sewage collection network and transfer of the wastewater for treatment outside the catchment area of Oroklini will reduce the quantity of water flowing to the Lake but at the same time it will decisively improve the quality of the surface water. Thus, it is suggested that, in this eventuality, a substantial quantity of tertiary treated effluent be requested to be returned to the area for irrigation or other uses so that the water resources available in the area are maintained.*
- *Any improvement of the water supply system, which is bound to be carried out, will reduce the quantity of "unaccounted" water that is lost to the underground. A normal percentage of "unaccounted" water would be of the order of 20 to 25%. Thus, any efforts towards reducing the loss of fresh water could amount to a reduction of the present replenishment by about half the quantity that is being lost today. This will have an impact on the present day water regime reducing the available water resources.*

Hydro-morphological changes also within the catchment could also have an impact such as:

- *Stream reed beds dominated by the Common Reed (Phragmites Australia), cover a significant proportion of the area, and are maintained by the seasonal surface and the subsurface flows in the south part of the drainage area upstream of the Lake. These impound the stream corridor and impair the free flow of water into the lake and at peak flows might lead to the flooding of a wider area. A large quantity of reed biomass is removed using mechanical means, normally just before the rainy season. Although this facilitates the inflow into the lake their role as water purifiers in aquatic environments is diminished. Thus, the removal of reed beds should be made with extreme caution and only when deemed to be absolutely necessary.*

- *A drainage stream channelization and concrete lining should be avoided considering the water purification potential of reed beds. The loss of reed beds and their ecosystem services will downgrade water quality and will undermine the ecosystem as a whole.*

Recommendations of pollution prevention control measures have been put forward for the Dry cleaner, the Restaurants, and for the agricultural practice:

- *For the Dry cleaner, compliance to the environmental permit terms is required, no storage of large quantities of chemicals, solvent wastes and waste areas to be managed accordingly, and a hazardous waste contingency plan must be developed.*
- *For the Restaurants , among other, use of dry clean-up methods to remove FOGs, reduce water consumption, collect and send used grease to a licensed liquid industrial waste collector, ensure grease traps are in place, dumpsters used for garbage should be protected from rainwater to avoid unwanted substances from entering storm drains.*
- *For agriculture, the Code of Agricultural Practice should be adhered to as well as any restrictions on the quantity of fertilizers and their seasonal use. The same applies to any agrochemicals used.*

Managing the traffic pollution risk from the Highway and the public road crossing the lake received special attention. The protection system must cover both the regular storm-water runoff from the roadways reaching the stream that feeds the Lake and the event of an accidental spill of a pollutant after a truck or bowser accident.

A simplified system is proposed in which storm-water from the highway and the public road as well runoff in the eventuality of an accidental spill, are made to enter a pipeline that transfers them downstream the Lake at the point of exit of the water to the stream that carries it to the sea avoiding thus the discharge into the Lake.

Additionally, the systems involves a low wall at the rim and a crash barrier on or either side of the road. Traffic speed bumps will slow motor-vehicle traffic so that safety conditions are improved and traffic accidents next to the Lake are prevented.

A Systematic Monitoring Program is proposed in order to control the potential sources of pollution. Sampling at the point of entrance of the box culvert under the Highway and at the outlet of the central storm-sewer will show the importance of the reed beds.

The parameters that are proposed to be monitored and a monthly frequency at the start, and less intensive later have been indicated. An Occasional / Investigative Monitoring Program has also been proposed at a point under the bridge to be sampled during a rainfall event, at least twice a year in different seasons

An Emergency Plan is needed for protecting the quality of the water flowing to, or stored in the Lake, from sudden unexpected, accidental occurrences of a spill either of petroleum products, other chemicals or sewage, due to a traffic accident involving a truck transporting such substances or due to other circumstances. No matter how remote or rare might this possibility be of happening, the Community and other stakeholders need to have a working Emergency Plan for such an eventuality.

Such an Emergency Operating Plan should identify the potential hazards, the emergency procedures, acquirement of the basic tools, training of staff and occasional drills, public campaigns, lists of emergency contacts and establishment of a chain of actions for situations of an emergency.

The basic steps in responding to a spill, of a volume of a truck load or less, of an unwanted substance are: Stop the spill, Contain and recover the spill, Collect the contaminated sorbent and Secure the waste.

II. ΕΚΤΕΛΕΣΤΙΚΗ ΠΕΡΙΛΗΨΗ

Η μελέτη με τίτλο «Προσδιορισμός σημαντικών υδρολογικών χαρακτηριστικών για τη λίμνη της Ορόκλινης» που πραγματοποιήθηκε κάτω από το 3-ετές πρόγραμμα LIFE+ με τίτλο «Αποκατάσταση και Διαχείριση της ΖΕΠ Λίμνη της Ορόκλινης (CY6000010) στη Λάρνακα, Κύπρο» και για τον Πτηνολογικό Σύνδεσμος Κύπρου, που είναι ένας από τους πέντε δικαιούχους αυτού του έργου, συνέστησε τη διεξαγωγή μελέτης και ανάλυσης των πιέσεων εντός της περιοχής της λεκάνης απορροής που επηρεάζουν ή θα μπορούσαν να επηρεάσουν την ποιότητα της επιφανειακής απορροής προς τη λίμνη.

Η Ι.Α.CO Σύμβουλοι Περιβάλλοντος και Υδάτινων Πόρων Λτδ, εκπόνησε αυτή τη μελέτη-συνέχεια της ανάλυσης των πιέσεων. Αυτό έχει γίνει με επιτόπια έρευνα προκειμένου: α) να προσδιοριστούν, αναλυθούν και αξιολογηθούν πιθανές πιέσεις στην ποιότητα των επιφανειακών και υπογείων υδάτων, και β) να προσδιοριστούν οι πηγές νερού που συμβάλλουν στη χαμηλή αλλά σταθερή απορροή που παρατηρείται κατά τη διάρκεια των καλοκαιρινών μηνών. Η εκτίμηση των επιπτώσεων έχει γίνει μέσα από ανάλυση κινδύνου, και δειγματοληψία νερού και ανάλυση, και προτάθηκε μια δέσμη μέτρων διαχείρισης και διασφάλισης της ποιότητας του νερού.

Η συλλογή νερού της λίμνης Ορόκλινης και η λειτουργία της εξαρτώνται εξ ολοκλήρου από την επιφανειακή απορροή από μια, σχεδόν, εντελώς αστικοποιημένη, λεκάνη απορροής έκτασης 2,7 km^2, και από μια μικρή συμβολή από βροχοπτώσεις που πίπτουν άμεσα στην επιφάνεια της λίμνης και τις γύρω περιοχές, ανεβάζοντας τη συνολική έκταση της λεκάνης απορροής σε 3,2 km^2.

Οι ποσότητες επιφανειακής απορροής έχουν υπολογιστεί για μια τυπικά ξηρή, μέσου όρου και μια υγρή χρονιά, σε 0,265, 0,342 και 0,469 εκατομμύρια κυβικά μέτρα, αντίστοιχα. Οι εντελώς ξηροί μήνες είναι συνήθως εκείνοι του Μαΐου μέχρι και Αυγούστου εκτός από την περίπτωση της υγρής χρονιάς που η ροή απουσιάζει μόνο τον Ιούλιο.

Η απορροή προς τη λίμνη προκύπτει τόσο από χερσαία ροή από ένα έντονα αλλαγμένο υδατόρεμα, όσο και από ροή από το δίκτυο όμβριων υδάτων, το κεντρικό και το δυτικό, με αγωγούς διαμέτρου 120 cm, και 100 cm, αντίστοιχα. Το δίκτυο συλλογής όμβριων υδάτων παρατηρήθηκε, σε συνθήκες ροής, να μεταφέρει ιζήματα και σκουπίδια που, τα περισσότερα, κατακρατούνται από τη βλάστηση (νεροκάλαμα) στην περιοχή του έλους.

Ροή όμβριων νερών προέρχεται επίσης από τον αυτοκινητόδρομο Παραλιμνίου – Λάρνακας καθώς και από το δημόσιο δρόμο που διέρχεται της λίμνης και συνδέει την παραλιακή περιοχή με την Κοινότητα της Ορόκλινης. Η ρυπογόνα επίδραση, από αυτές τις πηγές και το ενδεχόμενο μιας τυχαίας διαρροής πετρελαιοειδών και άλλων χημικών ουσιών σε περίπτωση ατυχήματος είναι ανησυχητική για την ευαίσθητη λίμνη της Ορόκλινης. Η σημερινή έλλειψη επαρκούς διαχείρισης της απορροής από τον αυτοκινητόδρομο και τον δημόσιο δρόμο εξετάστηκαν περαιτέρω και γίνονται οι σχετικές συστάσεις.

Για το υφιστάμενο Πρατήριο Πετρελαιοειδών φαίνεται ότι έχουν γίνει τα αναγκαία βήματα και ληφθεί τα κατάλληλα μέτρα για την πρόληψη ρύπανσης από τους χώρους εντός του σταθμού.

Τοπική υπόγεια υδροφορία φαίνεται επίσης να αποτελεί ακόμη μια, έστω μικρή, πηγή νερού της λίμνης. Στη λεκάνη απορροής δεν υπάρχουν πηγάδια ή γεωτρήσεις με υδροφορία, κάτι που δείχνει

την πολύ πτωχή υδροφορία των Σχηματισμών Αθαλάσσας και Λευκωσίας που συνθέτουν τις υδρογεωλογικές συνθήκες στο άνω ήμισυ και στο κάτω μέρος της λεκάνης απορροής, αντίστοιχα.

Οι υπόγειοι ορίζοντες στην περιοχή αναπληρώνονται με: α) καλής ποιότητας νερό, από την τοπική βροχόπτωση και από την επιφανειακή απορροή, β) από μια ποσότητα του εισαγόμενου για υδρευτικούς σκοπούς νερού που χάνεται από το πεπαλαιωμένο ή και ελαττωματικό δίκτυο διανομής, και που φέρεται να είναι το 50% των εισαγόμενων ποσοτήτων (ή μέχρι 0,4 εκατομμύρια κυβικά μέτρα ετήσια), και γ) από λύματα που απορρίπτονται σε σηπτικούς βόθρους σε κάθε σπίτι, λόγω της απουσίας συστήματος συλλογής λυμάτων, προσθέτοντας περίπου το 70% του πόσιμου νερού που χρησιμοποιείται, ή μέχρι 0,271 εκατομμύρια κυβικά μέτρα ετήσια.

Μέρος αυτού του υπόγειου νερού αναμένεται να αναβλύζει στην περιοχή του έλους ανάντη του αυτοκινητόδρομου, και να ενισχύει τη λίμνη. Σε αυτή την περιοχή το κυρίαρχο υδρογεωλογικό στοιχείο είναι ο άργιλος, μάργες και ιλυόλιθοι που αποτελούν ένα αδιαπέραστο ορίζοντα για την προς κατάντη κυκλοφορία των υπόγειων υδάτων.

Στην ανάλυση των πιέσεων και επιπτώσεων από σημειακές πηγές εντός της υδρολογικής λεκάνης, οι πιθανές πηγές ελέγχθηκαν μια προς μία και αξιολογήθηκαν. Αυτές πρόκειται για επτά εστιατόρια, ένα στεγνοκαθαριστήριο, ένα πρατήριο βενζίνης, τον αυτοκινητόδρομο, και τον δρόμο από την ακτή προς την κοινότητα, ένα χώρο ανεξέλεγκτης διάθεσης αποβλήτων στο νοτιοδυτικό τμήμα της λίμνης, καθώς και ένα χώρο ανεξέλεγκτης αποθήκευσης ειδών πετρελαίου και άλλων χημικών προϊόντων στο νότιο-ανατολικό περιθώριο της λεκάνης απορροής ανάντη του αυτοκινητόδρομου. Έτσι, για τις κύριες σημειακές δυνητικές πηγές ρύπανσης τα ακόλουθα μπορεί να επισημανθούν:

- *Τα λύματα από εστιατόρια διαφέρουν από εκείνα των οικιστικών μονάδων λόγω της περιεκτικότητάς τους σε λίπη, λάδια και άλλα λιπαντικά που προκύπτουν από τα απόβλητα των κουζινών. Δειγματοληψία και ανάλυση των απορροών, πάντα στην είσοδο το οχετού κάτω από τον αυτοκινητόδρομο, έδειξε τους Ολικούς Υδρογονάνθρακες και Λίπη και Έλαια (FOG) να είναι κάτω από το όριο ανίχνευσης. Ομοίως οι Ολικοί Πετρελαϊκοί Υδρογονάνθρακες (TPH) καθώς και τα FOG δείχνουν χαμηλή συγκέντρωση.*
- *Το στεγνοκαθαριστήριο είναι εξοπλισμένο με σύγχρονες μηχανές στεγνού καθαρισμού που χρησιμοποιούν ένα κλειστό σύστημα λειτουργίας (closed loop system). Αυτό σημαίνει τιμές υψηλής ανάκτησης διαλυτών (solvents) και μειωμένη ρύπανση του αέρα. Ο διαλύτης που χρησιμοποιείται στη διαδικασία είναι το PERC (Τετραχλωροαιθυλένιο).*
- *Η παρουσία του πρατήριου πετρελαιοειδών μόνο λίγα μέτρα μακριά από τη λίμνη προκαλεί ιδιαίτερη ανησυχία για την ευαίσθητη περιοχή της λίμνης της Ορόκλινης. Τα μέτρα που ελήφθησαν σχετικά με τη διάθεση της απορροής τόσο από όμβρια όσο και από οποιαδήποτε άλλα χημικά, έλαια και πετρελαιοειδή, εντός των χώρων του πρατηρίου, φαίνεται να εξασφαλίζουν την αποφυγή διαρροής οποιωνδήποτε από αυτά στη λίμνη. Επιπλέον στο πρατήριο υπάρχουν, διπλά τοιχώματα στις υπόγειες εγκαταστάσεις αποθήκευσης, ένας ηλεκτρικός ανιχνευτής πετρελαιοκηλίδας, ειδικές εγκαταστάσεις υποδομής για διαρροές, ένας διαχωριστής ελαίου/νερού και μια μονάδα ανάκτησης ατμών.*
- *Μια σημαντική «σημειακή πηγή» μόλυνσης λόγω της μεγάλης τροχαίας κίνησης είναι η απορροή όμβριων από τον αυτοκινητόδρομο Παραλιμνίου – Λάρνακας που διέρχεται υπεράνω του υδατορέματος που ρέει προς την περιοχή της λίμνης. Επιπλέον, μια άλλη πηγή*

είναι ο δρόμος που συνδέει την παράκτια περιοχή τόσο με τον αυτοκινητόδρομο όσο και με την Κοινότητα της Ορόκλινης και που διασχίζει τη Λίμνη. Μια πιθανή πηγή μπορεί επίσης να είναι ένα τροχαίο ατύχημα οχήματος μεταφοράς πετρελαιοειδών, λυμάτων και/ή άλλων χημικών ουσιών. Το ευαίσθητο υγροτοπικό οικοσύστημα της λίμνης Ορόκλινης πρέπει να προστατευτεί ελαχιστοποιώντας τους κινδύνους και επιπτώσεις που σχετίζονται με τον δρόμο και τη γέφυρα υπεράνω του υδατορέματος με τη θέσπιση μέτρων προστασίας για τη μείωση της απορροής των ρύπων, μέσα από τη χρήση και τη σωστή συντήρηση των δομικών έργων ελέγχου.

- *Στο νότιο-δυτικό ακραίο τμήμα της λεκάνης απορροής της λίμνης υπάρχει ένας χώρος μη ελεγχόμενης απόρριψης διαφόρων τύπων αποβλήτων, αρκετά νωρίτερα από το 2003. Απορροή από την περιοχή αυτή διέρχεται της περιοχής αυτής, και ρέει άμεσα προς τη λίμνη.*

- *Στη νοτιο-ανατολική παρυφή του υδροκρίτη της λεκάνης απορροής, ακριβώς βόρεια του αυτοκινητόδρομου Παραλιμνίου – Λάρνακας, υπάρχει ένας χώρος υπαίθριας αποθήκευσης ειδών πετρελαίου, άλλων χημικών ουσιών, παλιοσίδερων και μηχανημάτων. Από αυτή την περιοχή ξεκινά ένα αυλάκι απορροής όμβριων υδάτων που εισέρχεται και ακολουθεί κατά μήκος τον αυτοκινητόδρομο και καταλήγει στη λίμνη. Αυτός ο χώρος αποτελεί μια απειλή για τη λίμνη ιδιαίτερα γιατί τα αποθηκευμένα υλικά και τύποι των προϊόντων δεν είναι γνωστά.*

Οι πιέσεις και οι επιπτώσεις των δυνητικών διάχυτων ή μη σημειακών πηγών αξιολογήθηκαν, οι κυριότερες των οποίων είναι:

- *Η γεωργία, δεδομένου ότι αυτή καταλαμβάνει μια σημαντική έκταση (0,82 km^2) της λεκάνης απορροής. Έχουν ζητηθεί και παραχωρηθεί στοιχεία από Δημόσιες Υπηρεσίες, αναφορικά με την έκταση και το είδος των καλλιεργειών και, των αγροχημικών προϊόντων που χρησιμοποιούνται. Οι παράμετροι που επελέγησαν για την παρακολούθηση των επιπτώσεων ήταν οι TN και TP, για διερεύνηση της πιθανής ρύπανσης από λιπάσματα. Για τη διερεύνηση των αγροχημικών στην περιοχή, θα πρέπει να υπάρξει μια περαιτέρω έρευνα με συγκεκριμένους αγρότες της περιοχής.*
- *Εκτός από μια στενή λωρίδα γης στην ακτή (450 μ. πλάτος), που καλύπτεται από το δίκτυο αποχέτευσης του «Συμβουλίου Αποχετεύσεων Λάρνακας», η υπόλοιπη περιοχή εντός της διοικητικών ορίων Ορόκλινης δεν καλύπτεται από σύστημα αποχέτευσης λυμάτων και όλες οι Οικιακές μονάδες απορρίπτουν τα λύματα τους σε επί τόπου σηπτικά συστήματα. Αν και η περιοχή έχει ισοδύναμο πληθυσμό (ι.π.) ύψους 11.000 και θα πρέπει να εξυπηρετείται από ένα αποχετευτικό σύστημα, αυτό έχει αναφερθεί ότι περιλαμβάνεται στο Εθνικό Σχέδιο Υλοποίησης που είναι στο στάδιο της προετοιμασίας του. Για την παρακολούθηση των επιπτώσεων της αστικής περιοχής χωρίς αποχετευτικό σύστημα οι παράμετροι που επελέγησαν ήταν BOD5, COD, TN, TP, TSS και E. Coli.*
- *Οι απορροές όμβριων υδάτων από το αστικό περιβάλλον ξεπλένουν ρύπους από δρόμους, χώρους στάθμευσης, εργοτάξια, στέγες και χλοοτάπητες. Αυτοί οι ρύποι περιλαμβάνουν βενζίνη, μηχανέλαια, βαρέα μέταλλα, πολύ-αρωματικούς υδρογονάνθρακες (PAH), ιζήματα, οργανικούς ρυπαντές, θρεπτικές ουσίες, φυτοφάρμακα κ.λπ., που μπορεί να είναι επιβλαβή στα νερά που καταλήγουν. Η αποφυγή των ρύπων από την απορροή των όμβριων υδάτων είναι λιγότερο δαπανηρή από την εγκατάσταση κτιρίων/υπηρεσιών επεξεργασίας όμβριων υδάτων. Το Κοινοτικό Συμβούλιο Ορόκλινης πρέπει μεταξύ άλλων να εξετάσει κανονισμούς*

ελέγχου εργοταξίων για τη διάβρωση υλικών από αυτά, επέκταση του παρόντος δικτύου όμβριων υδάτων, κίνητρα συλλογής οικιακών επικίνδυνων αποβλήτων, ανακύκλωση ελαίων, περιορισμό στη χρήση φυτοφαρμάκων και λιπασμάτων και, καθαρισμό οδοστρωμάτων.

Η ανάλυση των επιπτώσεων (impact analysis) στηρίχθηκε επίσης σε τρεις δειγματοληψίες της ροής του υδατορέματος από σημείο στην είσοδο του οχετού που βρίσκεται αμέσως ανάντη του αυτοκινητοδρόμου, στις 3 και 16 Απριλίου, με ελαφριά βροχή την προηγούμενη ημέρα, καθώς στις 6η Μαΐου 2014 που ήταν βροχερή ημέρα.

- *Οι ψηλές συγκεντρώσεις TN στις 3 και 16 Απριλίου οφείλονται στη χρήση λιπασμάτων κατά την άνοιξη στις καλλιέργειες σιτηρών που περιβάλλουν τη λίμνη και που βρίσκονται σε ολόκληρη τη λεκάνη απορροής. Σε αυτές τις δειγματοληψίες τα επίπεδα του BOD_5 και COD ήταν πολύ χαμηλά.*
- *Οι ψηλές τιμές της Ηλεκτρικής Αγωγιμότητας και τα επίπεδα του Βόριου οφείλονται κυρίως σε φυσικά αίτια που προκύπτουν από τους γεωλογικούς σχηματισμούς που σχετίζονται ενδεχομένως με Αλίτη (Halites) και γύψους που συνδέονται με εναποθέσεις που έχουν υποστεί εξάτμιση. Με την εμφάνιση βροχής, όπως στις 6/5/2014, αυτά υπόκεινται σε διάλυση με αποτέλεσμα να παρουσιάζεται αύξηση αλάτων στη ροή του νερού.*
- *Οι Ολικοί Υδρογονάνθρακες (TH) και τα επίπεδα FOG είναι κάτω από τα όρια ανίχνευσης, υποδεικνύοντας ελάχιστες, αν υπάρχουν οποιεσδήποτε, επιπτώσεις από το οδικό δίκτυο, την κυκλοφορία οχημάτων, και εστιατόρια/ νοικοκυριά, αντίστοιχα.*
- *Τα ψηλά επίπεδα των E. Coli, μετά τη βροχή μπορούν να δικαιολογηθούν από περιττωματικό υλικό διαφόρων ζώων και πτηνών (κατοικίδια και άγρια ζώα, περιστέρια κτλ.), που έχει ξεπλυθεί από τα όμβρια νερά μιας βροχής. Η φυσική επεξεργασία καθαρισμού του συστήματος εδάφους-υδροφορέα αναμένεται να αποτρέπει τα E. Coli ή BOD_5 και COD, από τα λύματα που απορρίπτονται σε σηπτικούς λάκκους, να φθάνουν στο υδατόρεμα.*
- *Οι συγκεντρώσεις TP ήταν κάτω από τα όρια ανίχνευσης των αναλυτικών μεθόδων. Η μόνη ποσότητα που εντοπίστηκε ήταν την ημέρα που σημειώθηκε βροχόπτωση κάτι που μπορεί να οφείλεται στο ξέπλυμα λιπασμάτων από τις καλλιέργειες της περιβάλλουσας τη λίμνη περιοχής.*

Οι ενδείξεις είναι ότι δεν υπάρχουν διαρροές αστικών λυμάτων μέσα στο δίκτυο αποχέτευσης όμβριων υδάτων. Οποιαδήποτε συνεισφορά υπόγειου νερού που περιέχει λύματα και που αναβλύζει στην περιοχή του έλους θεωρείται, ότι έχει ήδη υποστεί τη φυσική επεξεργασία καθαρισμού από το σύστημα εδάφους – υδροφορέα. Οι γεωργικές περιοχές γύρω από τη λίμνη όμως φαίνεται να επιδρούν αρνητικά στην ποιότητα του νερού που καταλήγει στη λίμνη.

Οι επιπτώσεις από τις άλλες σημειακές πηγές ρύπανσης όπως το πρατήριο πετρελαιοειδών, ο υπαίθριος χώρος αποθήκευσης πετρελαϊκών και άλλων προϊόντων, παλιοσίδερων κλπ., ή ο αυτοκινητόδρομος και ο δρόμος δίπλα στη λίμνη, δε μπορούν να προσδιοριστούν από την παρακολούθηση που έγινε στο συγκεκριμένο σημείο δειγματοληψίας της ροής νερού προς την Λίμνη.

Αλλαγές του υδατικού ισοζυγίου που συνδέεται με τη λίμνη, θα μπορούσαν να έχουν σοβαρές επιπτώσεις σε αυτή. Τέτοιες αλλαγές θα μπορούσαν να είναι:

- *Μια επέκταση του δικτύου όμβριων υδάτων για να καλύψει και περιοχές νότια του αυτοκινητόδρομου και η διάθεση των όμβριων υδάτων πέρα από τη λίμνη, θα αποστερούσε τις ροές προς αυτή. Οποιαδήποτε αλλαγή πρέπει να τελειώνει ανάντη του οχετού που περνάει κάτω από τον αυτοκινητόδρομο. Οποιοδήποτε νέο δίκτυο που θα αναπτυχθεί για την περιοχή γύρω από τη λίμνη θα πρέπει να είναι ανεξάρτητο από αυτό που εξυπηρετεί την περιοχή της λεκάνης απορροής και που παρέχει νερό στη λίμνη.*
- *Η μελλοντική κατασκευή δικτύου αποχέτευσης και μεταφορά των λυμάτων για επεξεργασία εκτός της λεκάνης απορροής της Ορόκλινης θα μειώσει την ποσότητα του νερού που ρέει προς τη λίμνη, αν και ταυτόχρονα θα βελτιώσει αποφασιστικά την ποιότητα των επιφανειακών υδάτων. Έτσι, προτείνεται ότι, σε αυτή την περίπτωση, μια σημαντική ποσότητα των τριτοβάθμια επεξεργασμένων αποβλήτων θα πρέπει να ζητηθεί να επιστρέφεται στην περιοχή για άρδευση ή άλλες χρήσεις, ώστε να διατηρούνται οι διαθέσιμοι υδατικοί πόροι της περιοχής στα ίδια επίπεδα.*
- *Οποιαδήποτε βελτίωση του συστήματος ύδρευσης, που αναμένεται να πραγματοποιηθεί, θα μειώσει την ποσότητα των «απωλειών» φρέσκου νερού που χάνεται προς το υπόγειο νερό. Ένα κανονικό ποσοστό «απωλειών» νερού θα ήταν της τάξης του 20 έως 25%. Έτσι, κάθε προσπάθεια για τη μείωση της απώλειας του γλυκού νερού θα μπορούσε να πετύχει μείωση του παρόντος εμπλουτισμού στη μισή ποσότητα που χάνεται σήμερα. Αυτό θα έχει αντίκτυπο στο ισοζύγιο του νερού και τη μείωση των διαθέσιμων υδατικών πόρων.*

Επιπτώσεις μπορούν να προκύψουν και από υδρο-μορφολογικές αλλαγές μέσα στη λεκάνη απορροής όπως:

- *Καλαμιώνες στην κοίτη του ρέματος με κυρίαρχο είδος το Κοινό Καλάμι (Phragmites australis), καλύπτουν ένα μεγάλο μέρος της περιοχής στο νότιο τμήμα της λεκάνης απορροής, ανάντη της λίμνης. Αυτοί συντηρούνται από την εποχιακή επιφανειακή και υπόγεια ροή νερού. Οι καλαμιώνες αυτοί περιορίζουν την κοίτη του ρέματος και εμποδίζουν την ελεύθερη ροή του νερού προς τη λίμνη. Σε ακραίες συνθήκες ροής αυτό μπορεί να οδηγήσει σε πλημμύρα μιας ευρύτερης περιοχής. Μια μεγάλη ποσότητα βιομάζας απομακρύνεται με μηχανικό τρόπο, συνήθως λίγο πριν από την περίοδο των βροχών. Αν και αυτό διευκολύνει την εισροή στη λίμνη, μειώνει τον ρόλο των καλαμιώνων σαν σύστημα φυσικού καθαρισμού του νερού μέσα σε ένα υδατικό περιβάλλον. Έτσι, η απομάκρυνση των καλαμιώνων πρέπει να γίνεται με εξαιρετική προσοχή και μόνο όταν κρίνεται απολύτως απαραίτητη.*
- *Η πιθανή διαμόρφωση καναλιού για αποστράγγιση και επένδυση του με μπετόν θα πρέπει να αποφευχθεί, λαμβάνοντας υπόψη τη δυνατότητα καθαρισμού του νερού από τους καλαμιώνες. Η απώλεια των καλαμιώνων και του ρόλου τους στο οικοσύστημα θα υποβαθμίσει την ποιότητα των υδάτων και θα υπονομεύσει το οικοσύστημα στο σύνολο του.*

Συστάσεις για μέτρα ελέγχου και πρόληψης της ρύπανσης έχουν διατυπωθεί για το Καθαριστήριο, τα εστιατόρια, καθώς και για τη γεωργική πρακτική στην περιοχή:

- *Για το στεγνοκαθαριστήριο, απαιτείται συμμόρφωση προς τους όρους της περιβαλλοντικής άδειας, δε θα πρέπει να γίνεται καμία αποθήκευση μεγάλων ποσοτήτων χημικών ουσιών, κατάλληλη διαχείριση των απόβλητων διαλυτών και των χώρων αποβλήτων, και θα πρέπει να υπάρχει ή να αναπτυχθεί ένα σχέδιο έκτακτης ανάγκης επικίνδυνων αποβλήτων.*
- *Για τα εστιατόρια, μεταξύ άλλων, η χρήση μεθόδων ξηρού καθαρισμού για αφαίρεση των FOG, μείωση της κατανάλωσης νερού, συλλογή και αποστολή χρησιμοποιημένων τηγανελαίων σε αδειούχους συλλέκτες/διαχειριστές, ύπαρξη σχετικών λιποπαγίδων, προστασία των κάδων σκουπιδιών ώστε να αποφεύγεται η κατάληξη ανεπιθύμητων ουσιών στο δίκτυο συλλογής όμβριων.*
- *Για τη γεωργία, θα πρέπει να γίνεται τήρηση του κώδικα ορθής γεωργικής πρακτικής καθώς και περιορισμοί σχετικά με την ποσότητα των λιπασμάτων και την εποχιακή χρήση τους. Το ίδιο ισχύει και για τη χρήση οποιωνδήποτε αγρο-χημικών προϊόντων.*

Η διαχείριση του κινδύνου ρύπανσης από την κυκλοφορία στον αυτοκινητόδρομο και το δημόσιο δρόμο που διαπερνά την Λίμνη, απαίτησε ιδιαίτερη προσοχή. Το σύστημα προστασίας πρέπει να καλύπτει τόσο την απορροή συνήθων όμβριων υδάτων από τα οδοστρώματα που καταλήγουν στο υδατόρεμα που τροφοδοτεί τη λίμνη όσο και την περίπτωση μιας τυχαίας διαρροής ενός ρύπου μετά από ένα αυτοκινητιστικό ατύχημα.

Προτείνεται ένα απλοποιημένο σύστημα στο οποίο όμβρια από τον αυτοκινητόδρομο και το δημόσιο δρόμο καθώς και απορροή στην υποθετική περίπτωση μιας τυχαίας διαρροής, θα καταλήγουν σε ένα αγωγό που θα τα μεταφέρει κατάντη της λίμνης στο σημείο εξόδου του νερού και που το υδατόρεμα στη συνέχεια θα τα μεταφέρει προς τη θάλασσα, απευθείας ή μετά από επιπρόσθετα μέτρα καθαρισμού , αποφεύγοντας έτσι την απόρριψη στη λίμνη.

Επιπρόσθετα, το σύστημα περιλαμβάνει και ένα χαμηλό τοιχίο στις άκρες του δρόμου και στηθαία ασφαλείας και στις δύο πλευρές. Κυρτώματα χαμηλής ταχύτητας θα μειώσουν τις ταχύτητες των οχημάτων ώστε να βελτιωθούν οι συνθήκες ασφαλείας και να αποφεύγονται τα τροχαία ατυχήματα παραπλεύρως της Λίμνης.

Προτείνεται ένα Συστηματικό Πρόγραμμα Παρακολούθησης για τον έλεγχο των δυνητικών πηγών μόλυνσης. Δειγματοληψία στο σημείο εισόδου του οχετού κάτω από τον αυτοκινητόδρομο και στην έξοδο του κεντρικού συστήματος αποχέτευσης όμβριων θα δείξει την αξία των καλαμιώνων στον καθαρισμό των νερών.

Έχουν καθοριστεί οι παράμετροι που προτείνονται για παρακολούθηση σε μηναία συχνότητα στην αρχή και λιγότερο εντατικά αργότερα. Έγινε επίσης πρόταση για ένα Περιστασιακό /Ερευνητικό Πρόγραμμα Παρακολούθησης στο σημείο κάτω από τη γέφυρα του αυτοκινητόδρομου για δειγματοληψία κατά τη διάρκεια βροχής τουλάχιστον δύο φορές τον χρόνο σε διαφορετικές εποχές.

Απαιτείται η ύπαρξη ενός Σχεδίου Έκτακτης Ανάγκης για την προστασία της ποιότητας του νερού που ρέει, ή είναι αποθηκευμένο στη λίμνη, από ξαφνική, απροσδόκητη εμφάνιση/ διαρροή είτε προϊόντων πετρελαίου, άλλων χημικών ουσιών ή λυμάτων, λόγω τροχαίου ατυχήματος οχήματος που μεταφέρει τέτοιες ουσίες ή σε περίπτωση άλλων περιστάσεων. Δεν έχει σημασία πόσο μικρή είναι πιθανότητα ενός τέτοιος συμβάντος. Η Κοινότητα και τα άλλα ενδιαφερόμενα μέρη θα πρέπει να έχουν ένα λειτουργικό Σχέδιο Έκτακτης Ανάγκης για ένα τέτοιο ενδεχόμενο.

Ένα τέτοιο Σχέδιο Λειτουργίας Έκτακτης Ανάγκης θα πρέπει να προσδιορίσει τους πιθανούς κινδύνους, τις διαδικασίες έκτακτης ανάγκης, την εξασφάλιση των βασικών εργαλείων, την εκπαίδευση προσωπικού και τις περιστασιακές ασκήσεις ετοιμότητας, εκστρατεία ενημέρωσης του κοινού, καταλόγους επαφών σε περίπτωση έκτακτης ανάγκης και δημιουργία ιεραρχίας χειρισμού καταστάσεων έκτακτης ανάγκης.

Τα βασικά βήματα αντιμετώπισης σε μια διαρροή, του όγκου μεταφοράς ενός οχήματος ή λιγότερο, μιας ανεπιθύμητης ουσίας σε συντομία είναι: Σταμάτημα της διαρροής, περιορισμός και ανάκτηση της ουσίας, συλλογή του μολυσμένου απορροφητικού υλικού που χρησιμοποιήθηκε, και εξασφάλιση της σωστής διαχείρισης των αποβλήτων.

1 INTRODUCTION

"Action A.4" of the 3-year LIFE+ project titled "Restoration and Management of Oroklini Lake SPA (CY6000010) in Larnaka Cyprus", with grant agreement reference no. LIFE10 NAT/CY/716, and for which responsibility was within BirdLife Cyprus being one of the five beneficiaries of this project, constituted of a study titled "Determination of important hydrological features for Oroklini Lake" was performed. At the conclusion of the above study, which was performed by I.A.CO Environmental and water Consultants Ltd, it was recommended that an analysis of the pressures within the catchment area that affect or could affect the quality of the surface runoff should be initiated. The European Commission gave permission to carry out the proposed study as part of the LIFE Oroklini project.

I.A.CO Environmental and Water Consultants Ltd has been contracted to carry out the follow up recommended by the previous study as above, as per the Agreement of External Assistance no: 2014/1 signed on the 26th of February 2014.

Oroklini's Lake water quality objectives call for (a) only moderate fluctuations in salinity in each compartment through the year, particularly in spring-autumn, avoiding fresh or hypersaline conditions; and (b) reasonable water quality, particularly nutrient inputs (<1mg/l N).

The main objective of the present study is to thoroughly investigate via site surveys the Oroklini Lake catchment area in order to a) identify, analyse and assess potential pressures (sources of pollution) on catchment water and ground water quality, which would be serious enough to the Lake water quality, and b) the sources of water contributing to the low and consistent runoff observed during the summer months. An impact assessment is to be made through risk analysis, water sampling and analysis, and provision of a recommended set of management measures safeguarding water quality are other equally important objectives.

This report is the draft Final Report of the study as requested in the Agreement and which covers:

1. An inventory of all potential sources of pollution within the Oroklini Lake catchment area (Point and Diffuse Sources), including associated emissions and type of pollution (such as Nutrients, Chemical, Oxygen Depleting, Microbiological, Suspended matter), the location and other available information such as name, source, etc.
2. A report on the existing storm water network and further plans for this as well as for the sewage network.
3. An impact assessment and risk analysis of above sources on the basis of the Source → Pathway → Receptor model.
4. Analyses of collected samples of runoff water quality (three samples just upstream of highway culvert, at the beginning, in the middle and 15 days prior to study conclusion) – Parameters involved include BOD, COD, selection of heavy metals, nutrients, microbiological load, Suspended Solids, and others defined during the project execution.
5. Recommendations of pollution prevention and control measures.
6. A Design of a monitoring program for the quality of surface flow

7. A set up of an emergency plan

2 DRAINAGE CONDITIONS

2.1 SOURCES OF WATER

The water content of the Oroklini Lake and its operation depend entirely on the surface runoff of the stream originating within the Oroklini catchment. A minor contribution is made by rainfall falling directly on the lake area and the surrounding areas. By using the monthly rainfall data (1991-2005) of Meteorological Station No. 713 at Aradippou, at 45 m a.m.s.l and 6,5 km to the northwest, over the catchment area of 2,7 km^2 and an assumed runoff coefficient of 37%, which was deemed reasonable for the extent of urbanization of the catchment, the runoff was evaluated[1] for a dry, an average and a wet year (Table 2-2).

The imported water for domestic supply is another source of water that contributes, to a sizable extent, the surface runoff, as rising water, near the marsh upstream the highway. A sizable amount of the imported water for domestic purposes is reported by the Community Council to be unaccounted for, increasing from about 30% in the period of 2007 to 2009 to around 50% in the last three years. This amount of water is considered as being lost to the underground through aging and faulty pipe distribution network (Tables 2-4 and 2-5).

Furthermore, there does not, as yet, exist a sewage collection system and thus septic cesspools are being used at each house or building where water is used. On the average, 60% - 90% of the potable water is directed to an on-site septic system. Water not returned to the underground is typically used for irrigation and other applications. For the Oroklini Community having in mind the type of housing and gardening, a quantity of some 70% of this water is assumed to be returned to the groundwater (Tables 2-4 and 2-5).

The groundwater outflow from the area occurs irrespectively of the surface catchment but rather it follows the existing subsurface hydraulic gradient and the subsurface lithological horizons. Part of this water is expected to rise and replenish the runoff to the lake in the area of the marsh in the area upstream the Highway and just downstream.

2.2 SURFACE WATER

2.2.1 Catchment characteristics

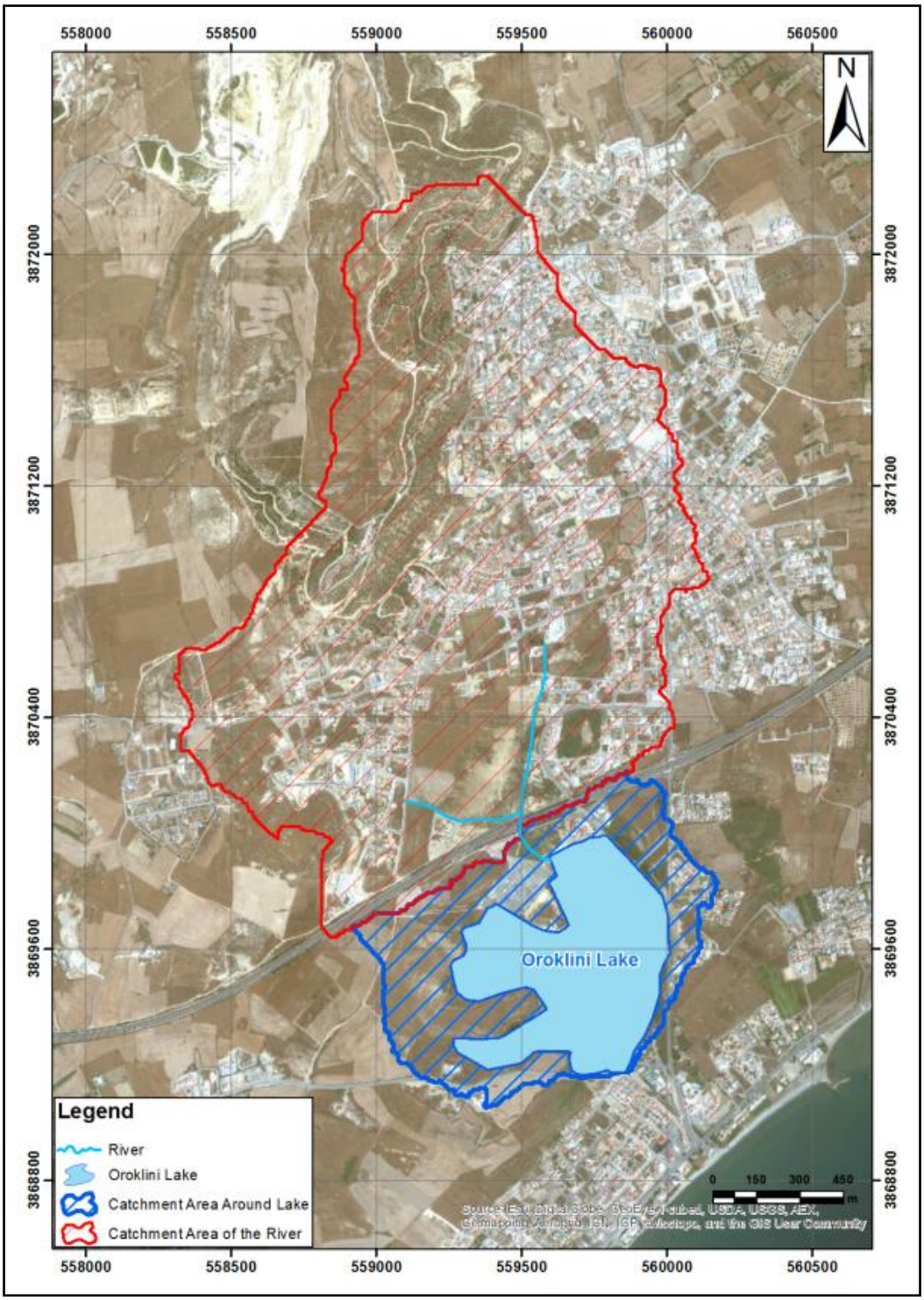
The Lake is replenished by the flow of the stream that issues from the 2,7 km^2 catchment area which has been urbanized, almost totally, by the Oroklini community. The catchment area of the streams flowing to the Lake and of the area around the Lake is shown on Map 2-1. Map 2-2 shows the morphology of the area. Table 2-1 presents the main characteristics of the catchment areas.

[1] I.A.CO Environmental and Water Consultants Ltd, (2012): **"**Determination of important hydrological features for Oroklini Lake", Foreseen as part of the project LIFE10 NAT/CY/716 where BirdLife Cyprus is an associated beneficiary

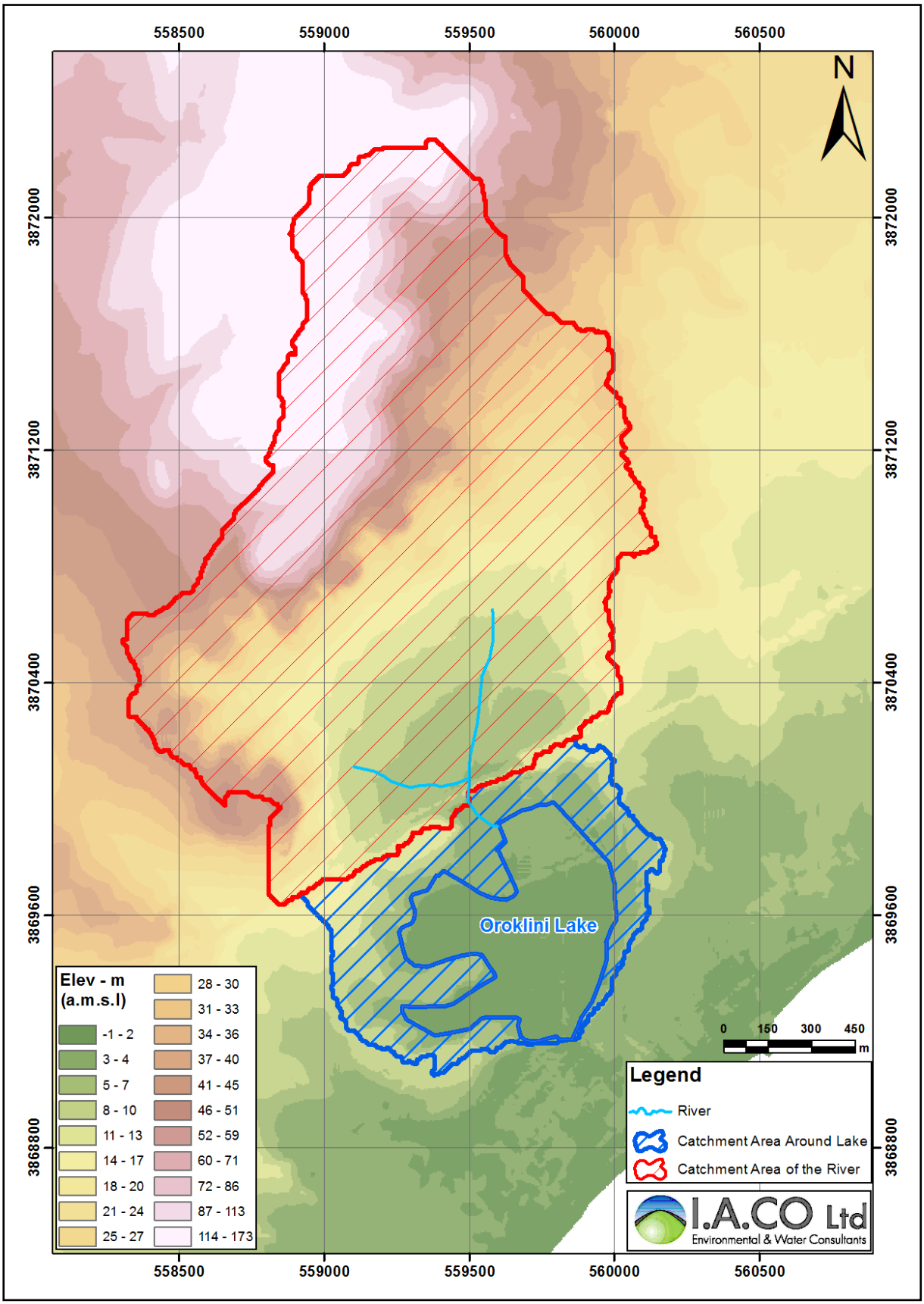
The time of concentration (T_c) for the catchment - the time needed for water to flow from the most remote point in the watershed to the lake - with these characteristics has been evaluated to be 1,5 hours.

Table 2-1. Characteristics of the catchment area of the streams flowing into Oroklini Lake and of the Lake itself

Catchment area	Basin Area (km^2)	Mean slope of Basin (m/m)	Longest Flow Path (m)	Mean Basin Elevation (m)	Min Basin Elevation (m)	Max Basin Elevation (m)
Oroklini River	2,7	0,1	2500	39	1,7	171
Around the Lake	0,5	-				



Map 2-1. Satellite photo of the catchment area of the streams and the Lake



Map 2-2: Elevation map of the subcatchments around the streams and the lake

2.2.2 Natural drainage network

The estimated surface runoff to the Lake has been evaluated using the Rational Formula on the basis of the monthly rainfall of the Meteorological Station MS 713 at Aradippou which is the closest, being only 6,5 km away, and most representative in terms of altitude (of 45 m. a.m.s.l) to the catchment area of Oroklini. This runoff has been based only on the rainfall information available and an assumed runoff coefficient. Measured runoff values are not available. It is expected that runoff is more if "unaccounted" water supply and wastewater contribution are considered.

The evaluation of the runoff factor has been based on a mix of land use making up the catchment and analysed into 68% residential area and 32% other type (16% cultivated and 16% forest). The hydrologic soil group on the basis of the classification by the NRCS (Natural Resources Conservation Service, USDA) has been determined as of "Group B", being silt loam or loam. For a slope >6% the runoff coefficient for Residential area (single house plots) is 0,44, for cultivated land is 0,28 and for forest is 0,18. These figures for the mix of land use as given above result to a coefficient of runoff of 37%.

Table 2-2 shows the runoff for a typical Dry (1995-96), an Average (1976-77) and a Wet year (2001-02). This varies from 0,265 to 0,469 million cubic meters per year with totally dry months being normally the months of May to August except for the wet conditions when flow is absent only in the month of July.

Table 2-2: Estimated[2] monthly runoff to the Lake (in m^3) per type of hydrological year

MONTH	Under DRY Conditions (1995-1996)	Under AVERAGE Conditions (1976-1977)	Under WET Conditions (2001-2002)
OCTOBER	4.714	21.857	30.749
NOVEMBER	41.892	61.498	26.464
DECEMBER	6.857	113.890	163.495
JANUARY	100.926	69.855	65.998
FEBRUARY	48.856	11.571	35.570
MARCH	23.035	20.357	41.677
APRIL	35.356	38.249	28.499
MAY	3.428	0	11.250
JUNE	0	0	21.857
JULY	0	0	0
AUGUST	0	0	23.142
SEPTEMBER	107	5.571	19.928
ANNUAL	**265.171**	**342.848**	**468.629**

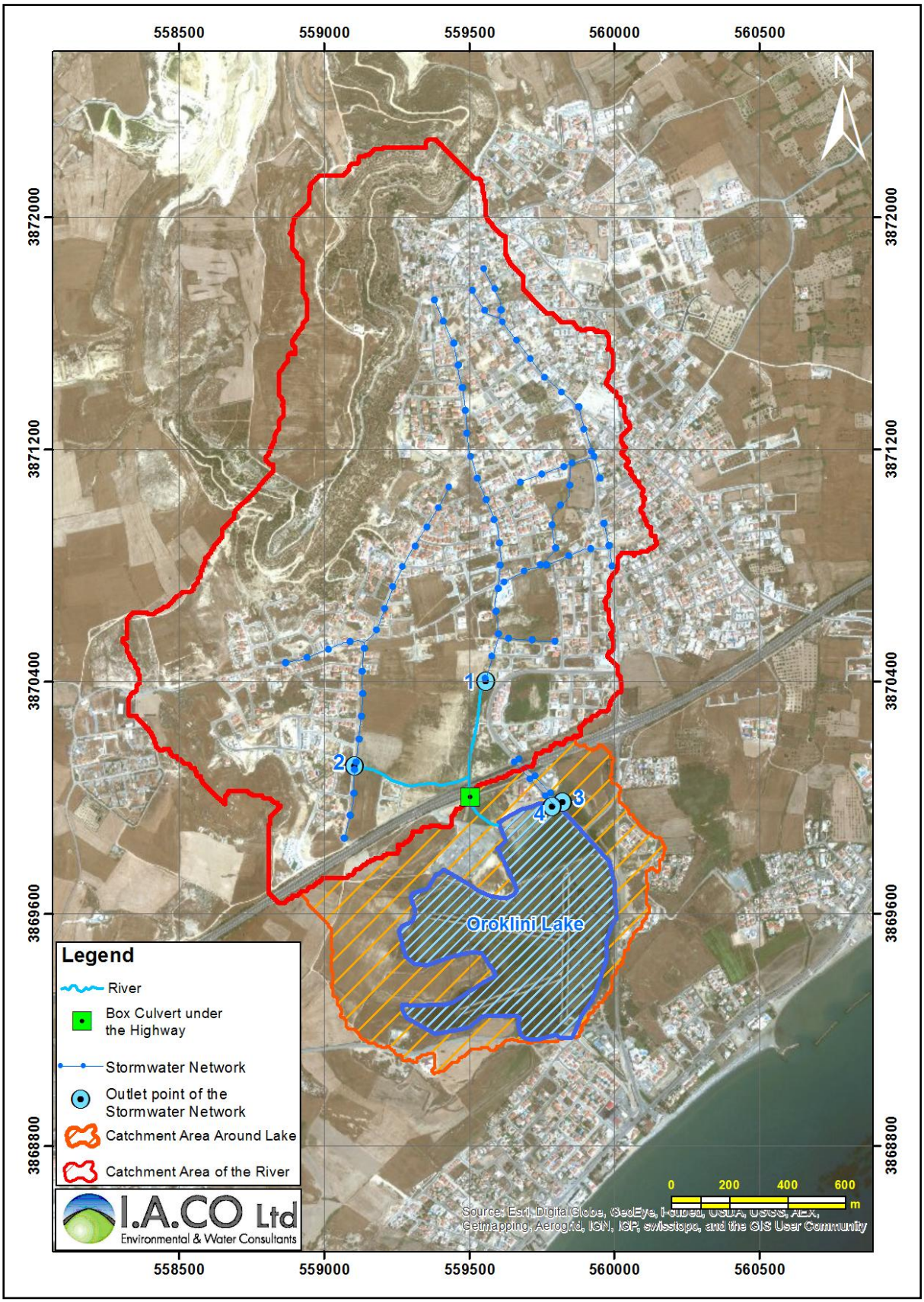
[2] I.A.CO Environmental and Water Consultants Ltd, (2012): **"**Determination of important hydrological features for Oroklini Lake", Foreseen as part of the project LIFE10 NAT/CY/716 where BirdLife Cyprus is an associated beneficiary.

2.2.3 Storm-water network

The storm-water network of Oroklini is shown on Map 2.3. This is divided into two parts: the central one with an outlet of 120 cm culvert diameter and the western part with an outlet of 100 cm culvert diameter. The whole network is within the catchment area that discharges into the Lake. It should be noted that there is no officially registered stream by the Land Registry Department and thus no stream appears on the Cadastral maps. As a result, the natural stream has been tampered with by the urbanization and most of the flow is currently carried through the stormwater network.

The Photo 2-1, taken on the 6th of May 2014 during a storm, shows the exit of the box culvert under the Highway.

Photo 2-1: Stream flow towards the Lake on the 6th of May 2014. Drainage of highway runoff may also be noted



Map 2-3. Extent of the storm-water network at Oroklini Village

Photo 2-2, taken on the same day as above, shows the 100 cm diameter storm-water outlet of the western section of the network flowing towards the culvert under the Highway (point 2 on Map 2-3).

Photo 2-2. Storm-water outlet of 100cm diameter, of the western section of the network

Photo 2-3, taken on the same date as above, shows the 120 cm diameter outlet of the central part of the storm-water network of Oroklini Village (point 1 on Map 2-3).

The Photo 2-4, taken on the same date as above, shows the inlet of the storm-water sewer collecting the water from a small area upstream the Highway underpass and receiving runoff from the eastern part of the highway itself and discharging it downstream of the Petrol Station to the small eastern part of the Lake (point 3 on Map 2-3).

The Photo 2-5 shows the outlet of the storm-water sewer collecting the water from a small area upstream the Highway underpass and discharging it to the Lake (point 4 on Map 2-3).

Of interest to note is the amount of sediment and garbage carried through the entire storm-water network which, if not held by the reed, will end up in the Lake itself. The value of the reed beds for this purpose is discussed in more detail in subchapter 3.3.1 of this report.

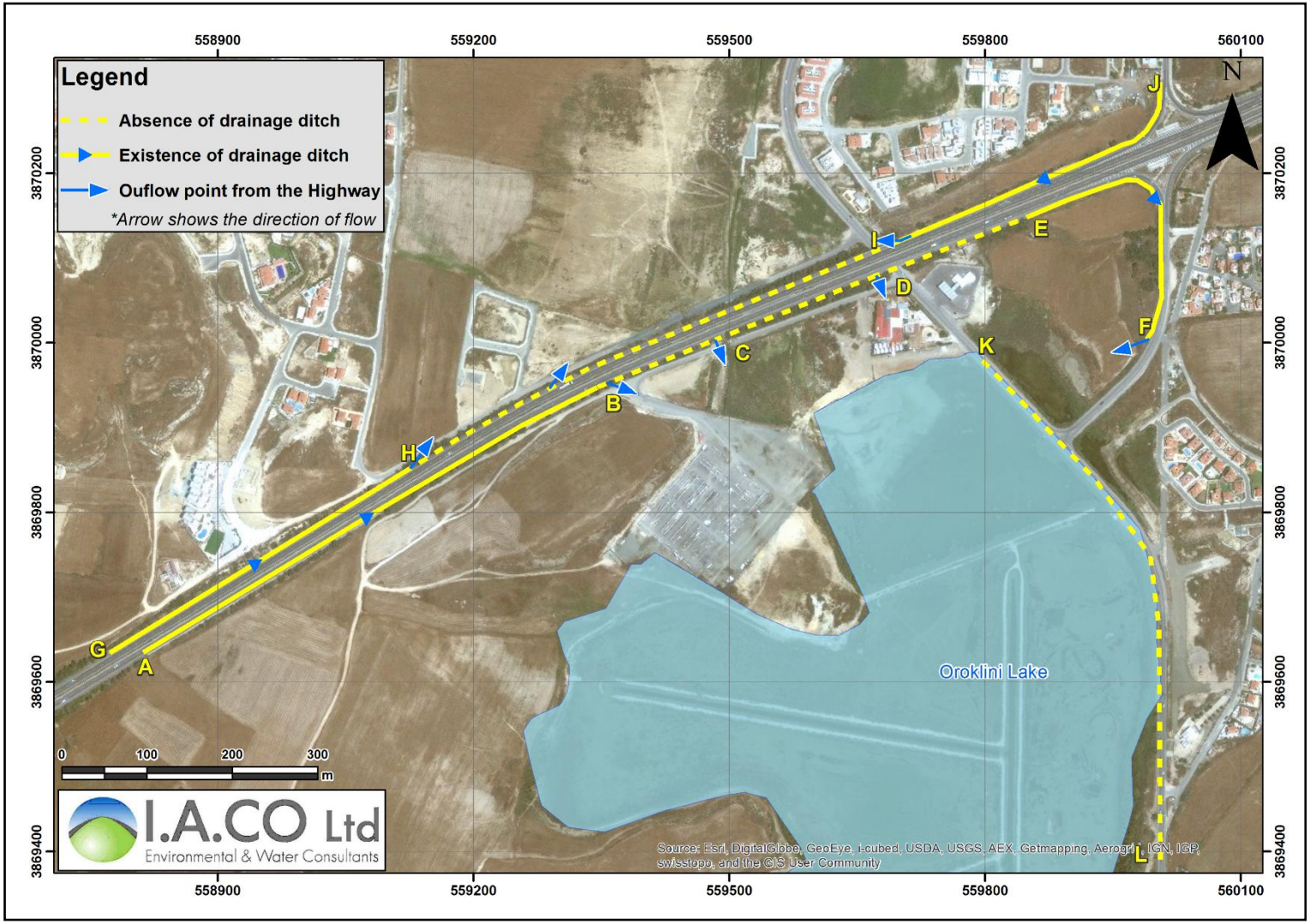
Photo 2-3. Outlet (120 cm diameter) of the central part of the storm-water network of the Oroklini Village

Photo 2-4. Entrance to the eastern part of the local drainage system in the area of the Lake which ends in the eastern part of the lake, next to the petrol station.

Photo 2-5. Outlet of western part of local storm-water drainage at the Lake area

2.2.4 Highway drainage and present conditions

The storm-water runoff and potential accidental spill of petrol and other chemicals of the Paralimni – Larnaca Highway and of the road crossing the Lake connecting the coastal area to the Oroklini community is of some concern for the sensitive Oroklini Lake. The existing runoff management conditions at the highway and the road crossing the lake are as shown on Map 2-4 and Table 2-3.



Map 2-4. Storm runoff management conditions at the Highway and the road crossing the Lake

Table 2-3. Storm water runoff management at the Highway and at the road from coast to Oroklini

Location as per Map 2-4	Type of structure
A to B	Flow through a concrete ditch (for half distance) and earth ditch (Photo 2-6)
B to C	Flow without ditch discharging to a point above the Box Culvert (Photos 2-7 and 2-8)
D to C	Flow without ditch discharging to the point above the Box Culvert (Photos 2-7 and 2-8)
E to D	Flow without ditch discharging to point D through a small v-notch (Photo 2-9)
E to F	Flow through concrete ditch up to half distance and discharge to the eastern part of the lake (Photo 2-10)
G to H	Flow through concrete ditch and discharge to the adjacent service road, which lies on a lower elevation Photos 2-11, 2-12 and 2-13)
I to H	There is no ditch (no Photo)
J to I	Runoff is collected at a concrete ditch at the side of highway and discharged to inlet at entrance of bridge. (Photos 2-14, 2-15, 2-16 and 2-17)
K to L	There is no ditch. Runoff discharges on either side of the road (Photos 2-18 and 2-19)

Photo 2-6: Points A to B: Runoff through a concrete and an earth ditch

Photo 2-7: Points B to C and from D to C: Runoff discharging to a point above Box Culvert without ditch

Photo 2-8: Runoff from Highway between points B to C and from D to C flowing over culvert and to the Lake

Photo 2-9: Points E to D: Runoff discharging to point D through a small V-notch

Photo 2-10: Points E to F: Flow through concrete ditch (for half distance) and discharge to the eastern part of the lake

Photo 2-11: Points G to H: Runoff through a concrete ditch and discharge to the adjacent service road

From the existing conditions at the highway and the road crossing the lake, it is apparent that no management plan to control the runoff away from the Lake exists. Rather, all the runoff finds its way to the lake. The same can be assumed that will happen in the event of an accident of, for example, a truck carrying petrol or any other chemical or of a bowser carrying wastewater.

This does not include the Petrol Station for which, as its described in paragraph 3.1.1.3, proper steps and measures have been taken to prevent pollution from within the grounds of the Station.

Obviously, a management plan needs to be established to correct the situation for the Highway and the road crossing the Lake. Some suggestions /recommendations towards this direction are provided later in the text.

Photo 2-12: Points G to H: Runoff through a concrete ditch and discharge to the adjacent service road

Photo 2-13: Points G to H: Runoff through a concrete ditch and discharge to the adjacent service road

Photo 2-14: Point J to I: Concrete ditch starting from side-road entering Highway at "Scrap and petrol products storage area"

Photo 2-15: Zoom –in of area shown by Photo 2-14

Photo 2-16: Point J to I: Concrete ditch off side of highway before entering cascade steps and entering the storm-water sewer

Photo 2-17: Cascade steps for runoff flow into storm-water sewer shown on Photo 2-4

Photo 2-18: Points K to L: The road connecting the coast to Oroklini and crossing the Lake (looking north). Runoff flows to the Lake on either side

Photo 2-19: Points K to L: The road connecting the coast and Oroklini and crossing the Lake shown to the right (looking south). Runoff flows to the Lake on either side

2.3 GROUNDWATER

2.3.1 Hydrogeological conditions

The upstream half of the catchment is made up of the Athalassa Formation (Upper Pliocene to Lower Pleistocene) which overlies the Nicosia Formation, exposed further downstream and covering the Lake area as well. The Athalassa Formation is made up of multiple layers of median to coarse grained, fossil bearing calcarenite with intervening layers of sandy marl.

The Nicosia Formation (Pliocene) is made up of fossil bearing grey marls and fine to coarse calcarenites. A gradual transition from fine grained rocks such as silts to more coarse grained such as calcarenites is observed from below to higher grounds.

Within the catchment there are no wells or boreholes bearing water indicating the very poor water bearing capacity of both formations in the area. An exception is the spring at the foothills in the northwest of Oroklini village which issues from calcarenitic deposits of the Athalassa Formation. This spring has been cultivated and the water is pumped uphill to irrigate forest vegetation.

The dominating hydrogeological element in the area of the marsh and the Lake is the clay, the marls and the siltstones. These form an impervious horizon to the downstream movement of groundwater.

2.3.2 Replenishment of the groundwater

The subsurface horizons in the area are being replenished with good quality water partly by local rainfall and from the surface runoff. A sizable source of fresh “unaccounted” water is lost presumably through aging and faulty pipe distribution network (Tables 2-4 and 2-5) as reported by the Community Council. The last complete estimates (2012) indicate an annual quantity of some 400.000 cubic meters. Thus, more water is purchased than sold, the difference being lost to the groundwater (Table 2-4 and 2-5).

Furthermore, and since there does not as yet exist a sewage collection system and instead septic cesspools are being used at each house or building where water is used, considerable quantities of

untreated urban wastewater finds its way into the groundwater (Tables 2-4 and 2-5). The estimated annual amount of wastewater retuned to the groundwater (2012) is of the order of 271.000 cubic meters.

Table 2-4: Losses (Unaccounted water) from domestic water network and return to the groundwater (in m^3)

YEAR	2007	2008	2009	2010	2011	2012	2013*
UNACCOUNTED	158.560	142.633	152.910	246.174	332.936	401.541	259.251
DOMESTIC (70%)**	237.671	205.069	256.547	302.140	278.631	271.062	218.567
TOTAL	**396.231**	**347.702**	**409.457**	**548.314**	**611.567**	**672.603**	**477.818**

**incomplete data*

*** Sewage water discharged through on-site septic cesspools at each house used in lieu of an absent sewage collection system, adding an estimated 70% of the used potable water to the groundwater.*

The groundwater outflow from the area occurs irrespectively of the surface catchment. It rather follows the existing subsurface hydraulic gradient and lithological horizons.

2.3.3 Rising water

The losses of fresh water from the water supply network and the return of wastewater to the groundwater contributes to the water resources of the area. Part of this water rises and adds to the runoff to the lake in the marsh in the area, mainly upstream and partly just downstream of the Highway.

Evidence of this is shown (Figure 2-1) by the rise of the groundwater level in mid-August (16/8/2012) as recorded in an investigative borehole drilled[3] just downstream the Highway.

This rise occurred although there was no rain during that period. On the same date increased runoff was observed at the culvert under the Highway.

This has also been the long-time observation of local residents, in that there is presence of water which, in effect, it is groundwater that rises gradually to the surface at the marsh area upstream of the highway. This is the main reason that flow could be observed at the stream under the Highway culvert during summer, in periods without rainfall.

[3] I.A.CO Environmental and Water Consultants Ltd, (2012): **"**Determination of important hydrological features for Oroklini Lake", Foreseen as part of the project LIFE10 NAT/CY/716 where BirdLife Cyprus is an associated beneficiary.

The increase of domestic water import to the area and the consumption which almost doubles (increase by 60-70%) in the period of July – August, as shown in Table 2-5, is the reason why groundwater exceeds the capacity of the aquiferous zones and rises to the surface.

Another reason causing the occurrence of 'rising "water at the area of the marsh is the presence of the "gleyic solonchalks" (salty soils with typical dark grey color of the gleyic type of soils) which have a very low permeability not allowing the travel of groundwater in the same amounts further downstream.

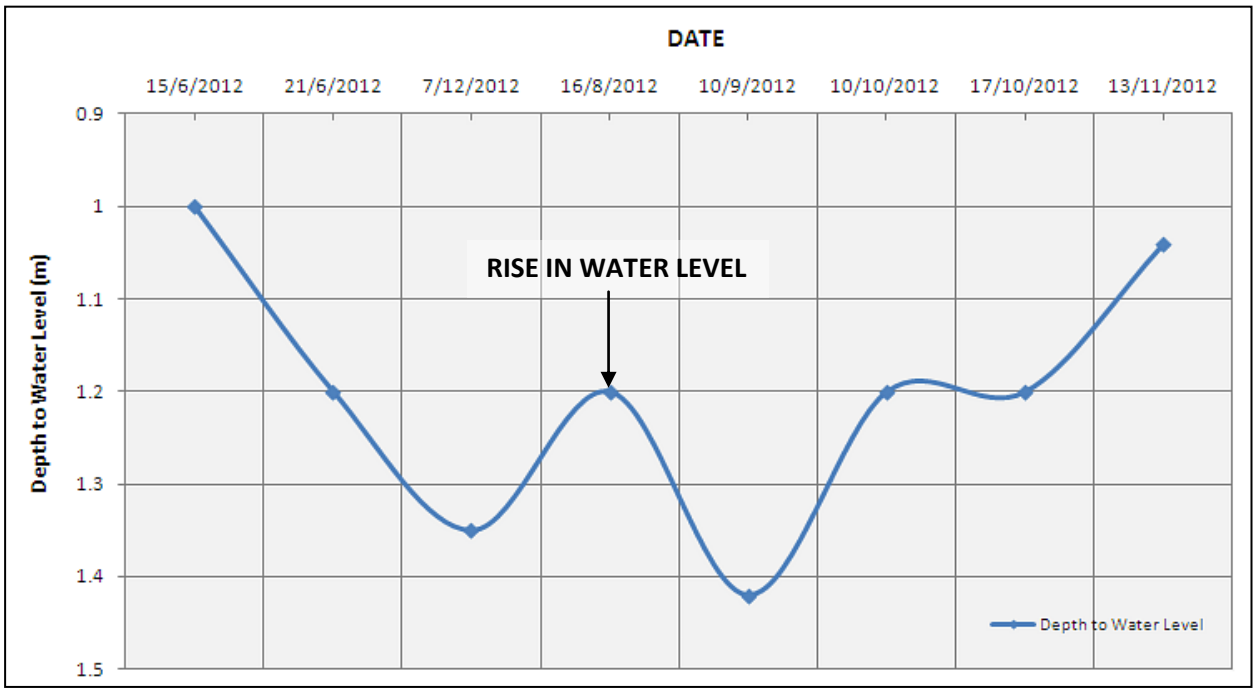


Figure 2-1: Groundwater level observations showing a rise during the touristic month of August which can only be attributed to increased return of wastewater to the underground since rainfall was nil.

2.3.4 Wastewater

The residences, institutions, the commercial and industrial establishments of the community produce urban and urban-like wastewater, that is disposed into onsite septic systems.

The passage of wastewater through the unsaturated zone and the aquifer provides a purification stage to a large extent through the well-known "soil aquifer treatment" or SAT. The major purification processes occurring in the soil aquifer system are: slow-sand filtration, chemical precipitation, adsorption, ion exchange, biological degradation, nitrification, denitrification and disinfection. The wastewater having travelled some distance is expected through SAT to have a quality suitable for a variety of non-potable uses especially for unrestricted agricultural irrigation.

Urban wastewater has higher concentrations of the following polluting parameters: Suspended Solids – TSS, Organic load defined by the parameters of COD and BOD_5, compounds of Nitrogen and Phosphorous and Coliforms. In the case that this wastewater does not receive effective and adequate treatment, the polluting load can produce serious problems to the natural receptors. The presence of organic load leads to the development of de-oxygenation of the natural water receptors (reduction of the concentration of dissolved oxygen). The ammonium nitrogen is converted to

nitrates which also lead to de-oxygenation. The nitrogen (in the form of ammonia and nitrogen) as well as phosphorus are the two categories of nutrients responsible for eutrophication.

The presence of these has been examined through analyses on samples obtained at the point where surface runoff enters the culvert, which is under the Highway, and flows to the Lake.

On the average, 60% - 90% of the used potable water is disposed to individual on-site septic systems. Water not returned to the underground is typically used for irrigation and other applications. For the Oroklini Community having in mind the type of housing and extent of gardening, a quantity of some 70% of this water is assumed to be returned to the groundwater (Tables 2-4 and 2-5).

Table 2-5. Purchase, Sale and Unaccounted water Oroklini Municipality for 2007 – 2013 (in m^3)*

YEAR	2007		2008		2009		2010		2011		2012		2013	
MONTH	PURCHASE	SALE	PURCHASE	SALE	PURCHASE	SALE	PURCHASE	SALE	PURCHASE	SALE	PURCHASE	SALE	PURCHASE	SALE
JANUARY	64.530	64.131	85.206	74.423	58.656	62.235	90.571	101.912	103.691	78.759	106.574	73.864	77.190	79.331
FEBRUARY														
MARCH	70.530		75.407		74.134		96.041		111.984		114.129		91.855	
APRIL		84.170		75.251		99.988		103.626		103.579		105.859		110.170
MAY	88.390		68.217		78.777		112.613		126.692		139.738		120.085	
JUNE														
JULY	104.780	109.018	76.680	64.328	107.661	115.199	133.659	127.235	142.743	125.883	157.161	123.095	136.705	122.738
AUGUST														
SEPTEMBER	95.580		66.730		91.225		135.048		129.449		145.477		145.655	
OCTOBER		82.211		78.953		89.073		98.855		89.823		84.414		N/A
NOVEMBER	74.280		63.348		108.952		109.870		116.421		125.694		N/A**	
DECEMBER														
TOTAL	**498.090**	**339.530**	**435.588**	**292.955**	**519.405**	**366.495**	**677.802**	**431.628**	**730.980**	**398.044**	**788.773**	**387.232**	**571.490**	**312.239**
UNACCOUNTED (m^3 & %)	**158.560**		**142.633**		**152.910**		**246.174**		**332.936**		**401541**		**259.251**	
	31,83		**32,74**		**29,44**		**36,32**		**45,55**		**50,91**		**45,36**	

*Source: Oroklini Village Board – Monthly data were not available, while the purchasing and selling periods are different, thus not allowing for a one-to-one comparison.

** Not Available

3 ANALYSIS OF PRESSURES AND IMPACTS

3.1 POTENTIAL SOURCES OF POLLUTION

3.1.1 Point Sources

The total Catchment Area to the Lake covers an area of 3,2 km^2 as mentioned in Chapter 2.2.1 and shown in Map 2-1. Within this area there is a built up area with the corresponding amenities. These amenities include the potential point pollution sources, which amount to seven restaurants, one dry-cleaner, a petrol station, an uncontrolled dump site in the southwestern part of the lake, an uncontrolled storage plot for petroleum products on the south-eastern fringe of the catchment upstream of the highway, the highway itself and the road from the coast to the village where road runoff and a possible truck or bowser accident carrying petrol or other chemicals or wastewater could result to a spill which could end up in the Lake. The potential point sources are pointed out on Map 3-1 along with a view of the residential town planning zones and the agricultural areas.

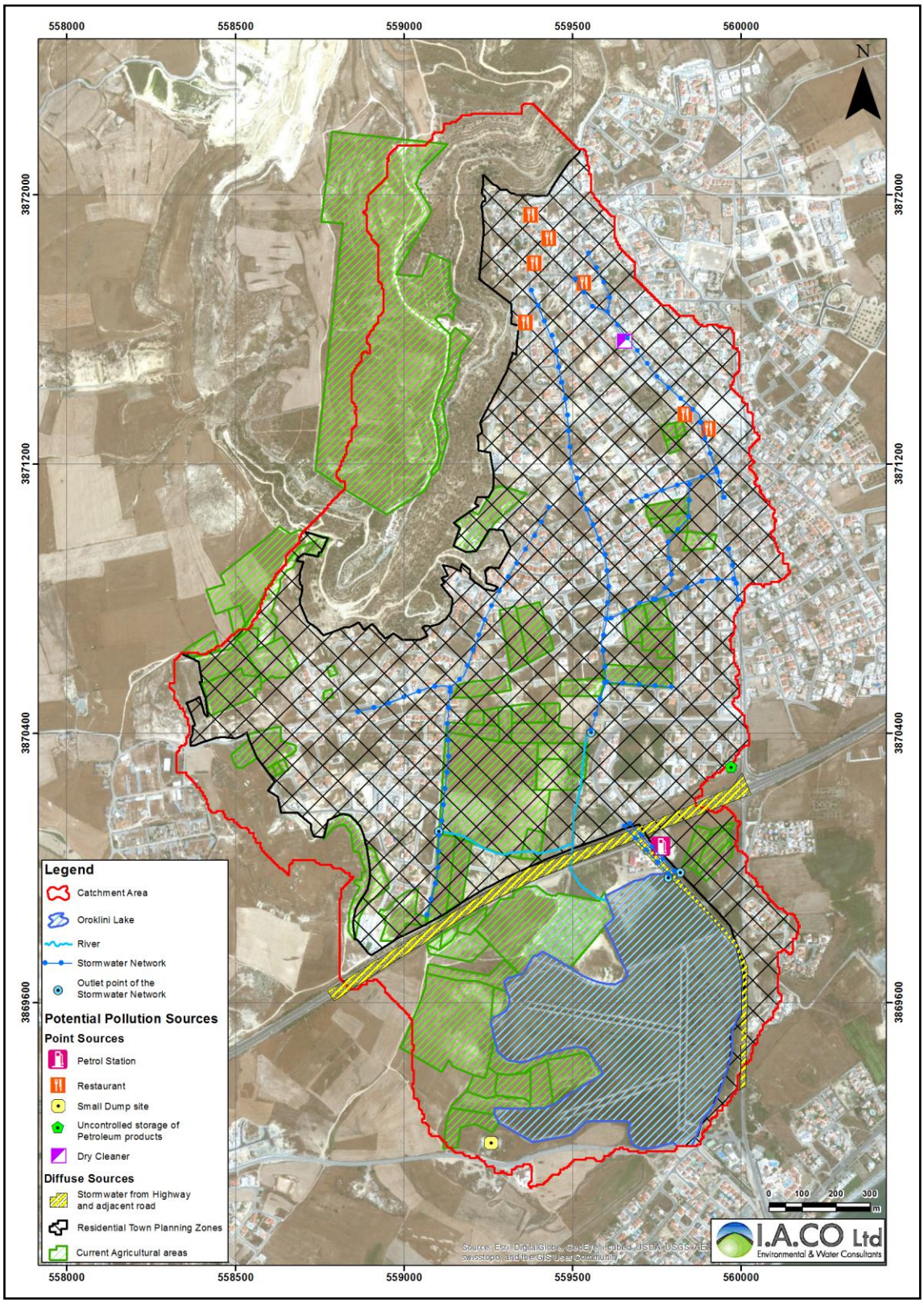
Agricultural areas are presented in more detail in paragraph 3.1.2 and Map 3-2 that follow.

Information about the actual number and exact position of the restaurants and the dry cleaning store was provided by Mr. Andreas Theodosiou, Director of the Oroklini Community Council during a meeting on the 11th of March 2014. These were spot checked and visited by I.A.CO. The Petrol Station is situated at the northeastern part of the Lake. The uncontrolled dump site at the southwestern part of the Lake and the plot with uncontrolled storage of petroleum products, considered as potential point sources were located during a visit by members of the I.A.CO team on the 6th of May.

3.1.1.1 The Restaurants

The main issues that differentiate restaurants from housing units as it concerns to wastewater, are Fats, Oils and Greases (FOGs) that result from the kitchen's waste. For this reason an initial analysis of Total Hydrocarbons was conducted in order to check the level of Hydrocarbons. According to these initial results a more detailed analysis involving Total Petroleum Hydrocarbons (TPH) and FOGs were to be made in order to finalize whether the increased levels of Hydrocarbons were due to TPH or due to FOG resulting from the restaurants. As a result as shown on Table 3-4, there was no need for TPH analysis since the Total Hydrocarbons and the FOGs were below the detection limit (Table 3-4 in paragraph 3.1.3 and Appendix 7-1). FOGs tend to accumulate on pipes, pumps, and equipment and sometimes obstruct lines. When kitchen's waste vegetable oil is left to drain outside the kitchen, ending up in the storm water network, it eventually ends up in the lake, as it is discussed in subchapter 2.2.3. Thus, as it is also further discussed in paragraph 3.1.3, the samples taken at the entry of the culvert under the Highway, indicate low concentration of TPH and the FOGs.

Photo 3-1 shows an example of poor waste vegetable oil management in a case outside one of the seven restaurants (Photo 3-1).



Map 3-1. Potential Pollution Sources within the Catchment Area

Photo 3-1. Waste vegetable oils and greases from a restaurant disposed to a street and collected by storm water network

3.1.1.2 The Dry cleaner

The dry cleaning store shown in Photo 3-2 is equipped with modern dry cleaning machines that use a closed-loop system. This means high solvent recovery rates and reduced air pollution. The solvent used in the process is PERC (tetrachloroethylene). PERC is one out of the 45 priority substances listed in Directive 2013/39/EU[4].

Possible sources of all priority substances according Directive 2008/105/EC, were investigated in detail in the project "*Preparation of an Inventory of Emissions, Discharges and Losses of Priority and Priority Hazardous Substances*"[5]. Under this project, the catchment was suggested as one of the "hotspots" that need to be considered for the establishment of a new monitoring station that would probably include PERC either on a regular basis or on an investigative basis of monitoring. From the site visits performed, it seems that the dry cleaner management keeps all the precautions and terms set to it in the Environmental Permit granted by the Department of Environment for waste disposal and by the Department of Labor Inspection for air emissions, reducing the pollution risk to a minimum.

[4] Directive 2013/39/EU amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy

[5] Department of Environment, Contract Number 14/2012 – assigned to I.A.CO Environmental & Water Consultants Ltd

Photo 3-2. Dry cleaner in Oroklini's community main road

3.1.1.3 The Petrol Station

Of particular concern to the sensitive area of the Oroklini Lake has been the presence of the petrol station only a few meters away from the Lake as shown on Map 3-1. Observing the present conditions regarding the disposal of runoff both of storm water as well as of any other chemical, oils and petrol, it appears that a number of measures have been taken to safeguard the disposal of any of these to the Lake.

The following measures have been observed:

- Peripheral screened gutter around the petrol pumps (Photo 3-3) leading effluents to a concrete watertight tank (Photo 3-4) ;
- Peripheral low cornice wall around the whole property controlling any disposal of liquids from it (Photo 3-3);
- A screened gutter at the entrance of the Petrol Station prohibiting any outflow of effluents from the station to the road and to the storm-water network (Photo 3-5).

Additionally, due to its proximity to the lake, special measures, already reported to the European Commission, have been taken so as to limit any possibility of any leakage. These include:

a) a double wall ceiling of the underground storage facilities,

b) an electrical detector of any oil leak,

c) special leakage infrastructure facilities,

d) a number of shear valves to prevent any leakage,

e) an oil water separator Class A for collecting any water / oil leakage coming from the petrol station which then is being treated towards the waste treatment pipeline in a concentration of not more than 5 ppm, and

f) a vapor recovery unit to limit and prevent any smell vapors.

Photo 3-3. The Petrol Station 10-20m away from the Oroklini Lake

Photo 3-4. Concrete watertight tank properly emptied occasionally

Photo 3-5. Screened gutter at the entrance of the Station collecting all effluents from the Station and discharging them into the watertight tank

3.1.1.4 The Uncontrolled Dump Site southwest of the Lake

During a site visit at the catchment area on the 6th of May, an uncontrolled dump site was detected on the south-western part of the catchment area of the Lake as shown on Map 3-1. Photos 3-6 to 3-9 show the extent of various types of wastes dumped at this site. Excess storm-water which becomes runoff flows directly into the lake as there is no control or management for it. On the basis of a research of satellite photographs (Google Earth) this site seems to be active since and before 2003.

Photo 3-6. Entrance to the uncontrolled dump site

Photo 3-7. Inert and electronic equipment wastes at the uncontrolled dump site

Photo 3-8. Tire wastes at the uncontrolled dump site

Photo 3-9. Inert wastes and pruning wastes at the uncontrolled dump site

3.1.1.5 The Uncontrolled storage plot for petroleum and other products

On Map 3-1 a site of uncontrolled storage of petroleum products and scrap metals is shown on the south-eastern fringe of the water-divide of the catchment just north of the Highway. Photo 3-10 shows a view of the storage site from which the storm-water runoff ditch begins, enters the highway and ends up in the Lake as discussed in detail in paragraph 2.2.4 under “Highway drainage present conditions”.

The present day conditions of the storage site are presented in the Photos 3-10 to 3-15 shown below. No storm – water runoff management arrangement has been noticed except the discharge to a ditch next to the entrance road to the highway that eventually ends up to the Lake. The same holds for any oils, greases and other petrol products that find themselves disposed within the yard.

This storage area of scrap metals and petroleum and other products presents a threat to the sensitive environment of the Lake especially since the full type of products stored in the area are not known and runoff, as explained, finds itself flowing to the Lake.

Photo 3-10: View of the uncontrolled petroleum products storage site from the highway exit (below) and view of the vehicles from within the plot

Photo 3-11: View of the uncontrolled scrap metals and petroleum products storage site from within

Photo 3-12: Lead additive products (for old engines designed to run on leaded petrol)

Photo 3-13: Engine oil products within the site

Photo 3-14: Two photos showing tanks for fuel supply

Photo 3-15: Scrap metal within the yard

3.1.1.6 The Highway and road from coast to Village

A major "point-source" of pollution due to the heavy traffic involved, is the storm runoff from the Paralimni – Larnaca highway which crosses the stream which discharges to the lake area. Additionally, another source is the road connecting the coastal area to both the highway and the Oroklini Community and which crosses the lake itself.

A serious potential pollution source is also a possible traffic accident, when especially it might involve a truck carrying petrol and or other chemicals, on both the highway bridge itself and or on the road crossing the lake. These need to be seriously considered.

The sensitive wetland ecosystem of Oroklini Lake needs to be protected by minimizing the road and bridge-related impact risks by establishing protective measures to reduce the runoff of pollutants, through the use and proper maintenance of structural controls.

The pollutants generated by motor vehicles, involving mainly petroleum hydrocarbons, through emission and deposition of automobile exhaust fumes and through discharges of both fluids and solid particles while travelling and braking, run off by themselves or are carried away by storm water runoff.

Evaluation[6] of the land uses and their respective catchment areas suggested that the degree of automotive exposure (a combination of duration of exposure to vehicles with engines running and volume of traffic) is the primary factor in the generation of petroleum hydrocarbons in runoff from automotive-intensive land uses. The intensive presence of traffic on the highway but also on the road towards Oroklini and crossing the Lake make these a serious polluting source.

The main pollutants found[7] in highway runoff, along with their likely sources, are shown in Table 3-1. Thus, runoff from the operation of the highway and the road can adversely affect vegetation, the surface waters, and the wetland with a variety of pollutants, including sediments, heavy metals, hydrocarbons, and toxic substances. The sources of highway runoff pollutants fall into two main categories: vehicle traffic and, traffic accidents (especially trucks carrying petrol or other chemicals).

Suspended solids increase turbidity, heavy metals are toxic to many aquatic organisms, and nutrients stimulate growth of algae and aquatic weeds and develop eutrophication, and BOD reduces the dissolved oxygen. Poly-aromatic Hydrocarbons (PAHs) found in petroleum products pose risks to fish and other aquatic species.

[6] Shepp, D.L. 1996. Petroleum Hydrocarbon Concentrations Observed in Runoff From Discrete, Urbanized Automotive-Intensive Land Uses. In *Proceedings of Watershed 96: Moving Ahead Together*, Baltimore, MD, June 8–12, 1996.

[7] National Cooperative Highway Research Program (NCHRP). 1999. Assessment of Impacts of Bridge Deck Runoff Contaminants on Receiving Waters. *Research Results Digest.* Number 235. National Research Council, Transportation Research Board, National Cooperative Highway Research Program, Washington, DC.

Table 3-1: Primary sources of highway runoff pollutants

Pollutants	Primary source
Particulates	Pavement wear and vehicle maintenance
Lead, cadmium, copper	Tire wear, lubricating oil and grease, bearing wear
Chromium, copper, nickel, cadmium	Metal plating, moving engine parts, brake lining wear
PCBs	PCB catalyst in synthetic tires
Petroleum, ethylene glycol	Spills and leaks of motor lubricants, antifreeze hydraulic fluids

3.1.2 Diffuse Sources

3.1.2.1 Agriculture

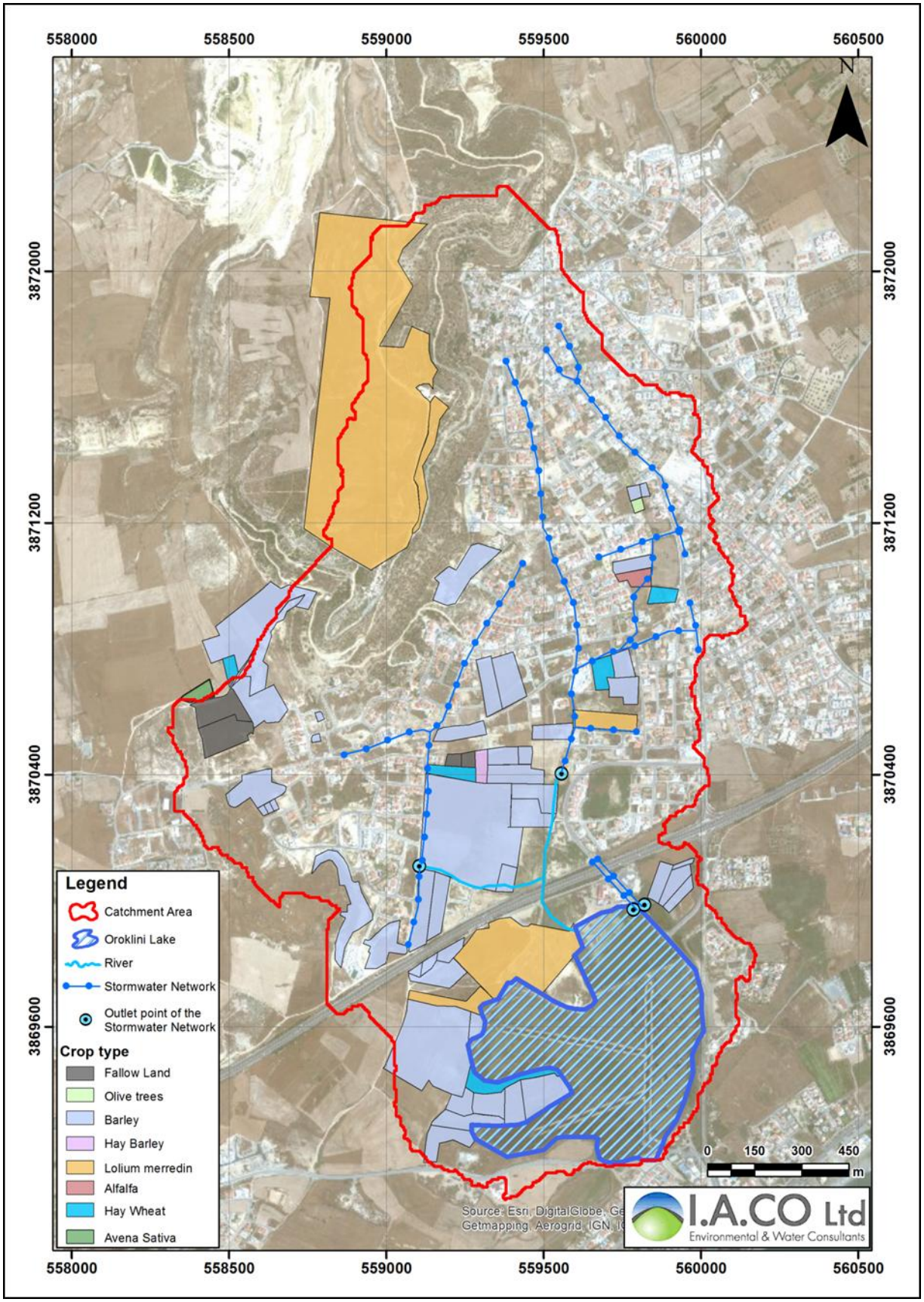
With respect to agriculture, the diffuse sources include the agricultural practices that result in pollutant loads. Due to the fact that a substantial area within the catchment area is occupied by agricultural activities, data were requested and granted from the following relevant public services:

- Up-to-date data about the area per type of crop, for each parcel that is cultivated within the catchment area. (GIS Section, Technical Services, Cyprus Agricultural Payments Organization - CAPO)
- Up-to-date data about the agrochemical products used for the above referred crops. (Agrochemicals Control Section, Department of Agriculture, Ministry of Agriculture, Natural Resources and Environment)

The parcels covered by crops that fall within the catchment area under study, sum up to an area of 0,82 km^2, from which an area of 0,055km^2 is fallow land. The proportion of each crop cultivated in the catchment area is shown in Table 3-2 and Figure 3-1 that follow.

The spatial distribution of the above mentioned crops per parcel is presented in detail on Map 3-2.

In the following photograph a sample of the crops' area is presented, particularly on the west side of the lake. On the back of the landscape shown in Photo 3-16, the barley bales can be distinguished.



Map 3-2. Crop type per agricultural parcel within the catchment area

Photo 3-16. Barley crops on the western part of the lake

Table 3-2. Variability of crop cultivation for the cultivated land in the catchment area

Crop	Area per crop (m^2)
Olive Trees	1.600
Alfalfa	3.200
Avena Sativa	4.200
Hay Barley	10.100
Hay Wheat	12.700
Lolium merredin	313.700
Barley	417.300
Total	**762.800**
Fallow Land	*54.900*

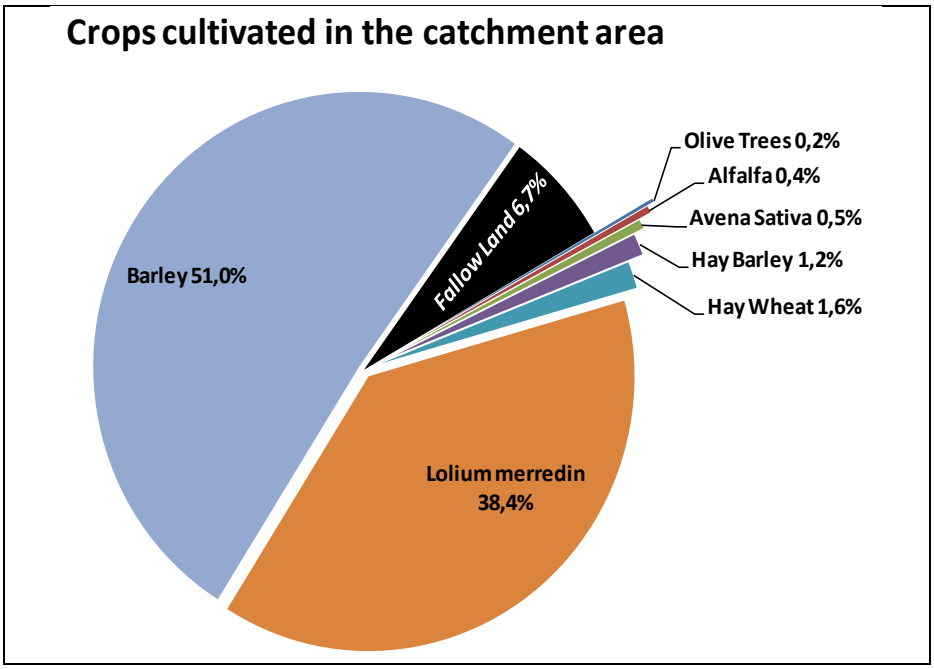


Figure 3-1. Variability of crop cultivation for the cultivated land in the catchment area

The data requested concerning agrochemicals used on these crops are as follows per main ingredients:

2,4-D	fenoxaprop-p-ethyl	pendimethalin	tribenuron methyl
dicamba	iodosulfuron methyl-sodium	pinoxaden	chlorpyriphos
tritosulfuron	glyphosate	florasulam	dimethoate
mecoprop-p	mesosulfuron	prosulfocarb	triadimenol

The above mentioned substances are included in agrochemicals used on cereals. Most of them are contained in herbicides, while chlorpyriphos and dimethoate are contained in insecticides and triadimenol in fungicides. Farmers usually are familiar with the product names rather than their ingredients. Once these product names are known, their ingredients can very easily be determined.

According to the Final Report of the project "Preparation of an Inventory of Emissions, Discharges and Losses of Priority and Priority Hazardous Substances"[8], in regard to ammonium fertilizers, these are used mainly in cereals. The enrichment of soil nitrogen through the application of ammonium fertilizers, their ammonium form predominates their nitrate form due to the fact that it can be restrained better from soils colloids, thus reducing losses caused by washout. The application of ammonium fertilizers must be followed by watering until the fertilizers are dissolved, or if this is not possible fertilizers must be incorporated into the soils in order to minimize the losses of nitrogen to the atmosphere.

Pollution from agrochemicals and fertilizers is considered to be diffused due to the fact that it is considered that it can contribute to the introduction of all the relevant substances, only in a general level of application. The crop fields that are likely to affect the lake water quality are the ones at the nearest distance, from which agrochemicals' and fertilizers' substances may end up in the lake by surface water runoff.

The parameters selected for the monitoring of the impact of the agriculture areas were TN and TP to represent the possible pollution from fertilizers. For the investigation of agrochemicals there must be a further survey with the specific farmers of the area that cultivate on the previously mentioned fields. Further analysis on this issue is presented in Chapter 5, in which a program is proposed for the water quality monitoring of the lake.

3.1.2.2 Non-sewered urban area

The urban waste-water sewerage network of "Larnaca Sewerage and Drainage Board" covers an area that reaches the Oroklini administrative boundaries, but only for a narrow land area, some 450m wide, within the administrative boundaries which is adjacent to the coast-line, comprising mainly the touristic Town Planning Zones as per the "City of Larnaca and Suburbs New Local Development Plan".

[8] Contract Number 14/2012, Department of Environment, Ministry of Agriculture, Natural Resources and Environment, Final Report – December 2012

The rest of the area within the Oroklini's administrative boundaries is not covered by a waste-water sewer system, and all housing units drain their sewage waste into site septic systems. Map 3-1 shows the urban areas within the catchment area, with no sewerage system. This is based on all the designated residential town planning zones according the "Statement of Policy for the Countryside of Cyprus – Larnaca District – Spatial Region I – Voroklini – December 2013" with the map being available on the Town Planning and Housing Department's website[9].

According to Article 16 of the Urban Waste Water Directive (UWWD) 91/271/EEC, Member States shall ensure that every two years the relevant authorities or bodies publish situation reports on the disposal of urban waste water and sludge in their areas. The latest Report[10] of the Department of Environment under Article 16 of the UWWD was submitted in October 2012 and covers the time period between 2009 and 2010. This Report states that the National Implementation Plan of 2008 sets Oroklini's centre as one of the 50 rural areas with population equivalent (p.e.) above 2.000. Specifically it has a p.e. of 11.000. A revised National Implementation Plan is under preparation. The Water Development Department (WDD) in December 2012 participated in a "Workshop on Compliance Promotion and Development of Structured Implementation and Information Frameworks (SIIFs): "Towards a Modern Information System for the Urban Waste Water Treatment Directive (91/271/EEC)" that took place in Brussels. In a presentation[11] of the WDD representative during this workshop, presenting the current status of the Monitoring of the Implementation Plan in Cyprus, as it concerns Oroklini's centre, the plan indicates that the construction of the network would start in 2014 and last for 24 months. As of today the Oroklini Community Council has not referred to such planning.

As it is shown in Maps 3-1, a percentage of 68% of the catchment's area town planning zones is residential which refers to other built-up areas or areas where residential construction is permitted under the Town Planning and House Department Regulations.

The parameters selected for the monitoring of the impact of the urban area with no sewage are BOD_5, COD, TN, TP, TSS and Fecal coli forms.

3.1.2.3 Storm-water runoff

When rain falls, the runoff in an urban environment washes pollutants off the roadways, parking lots, construction sites, other impervious surfaces, roofs and lawns. Thus, urban runoff carries a mixture of pollutants, such as gasoline, motor oil, heavy metals, trash and other pollutants from the streets and parking lots, suspended solids from construction sites, oxygen demanding substances, toxic metals and trace elements, organic contaminants as well as nutrients from fertilizers and pesticides from lawns, and pathogenic bacteria, which may be harmful to receiving waters.

Roads and parking lots are major sources of polycyclic aromatic hydrocarbons (PAHs), as well as of the heavy metals nickel, copper, zinc, cadmium, and lead. PAHs are common by-products of incomplete combustion from vehicles, wood and oil burning central heating systems. These may

[9] http://www.moi.gov.cy/moi/tph/tph.nsf/All/2F78D950889B63E6C2257C47004106A6/$file/02_voroklini.pdf
[10] http://www.moa.gov.cy/moa/environment/environment.nsf/D3C3E85AE3A886DFC2257C610046B65F/$file/ReportArticle16UWWTDSituation2009and2010.pdf
[11] http://www.moa.gov.cy/moa/wdd/wdd.nsf/All/A924DFDF2523B0ADC2257AD30041196A/$file/Presendation.pdf

accumulate in bottom sediments in urban streams and marshes and are taken up by aquatic organisms.

The main source of many metals in urban runoff is vehicle traffic. Concentrations of zinc, which could be toxic to aquatic life, cadmium, chromium and lead, appear[12] to be directly related to the volume of traffic on streets that drain into a storm sewer system. Some 70% of the zinc and lead in urban runoff has the streets as a source. Outdoor storage of scrap metal could also be a source.

Urban runoff could be loaded with sediment (see Photos 2-2 and 2-3) especially if construction sites are poorly maintained. Furthermore, it could contain flakes of metal from rusting vehicles, particles from vehicle exhaust, bits of tires and brake linings.

Organic material such as pet waste, dead animals, leaves, grass clippings and litter use up oxygen, as these materials decay, needed by aquatic life in the Oroklini Lake (Photo 3-17 and 3-18).

Generally, high faecal coliform bacteria counts for urban runoff (see analytical results of 14 to 25 thousand /100ml during rain) are typical for small urbanized areas. The sources of bacteria in urban runoff include sanitary sewer overflows, pets, urban wildlife such as pigeons, etc., (Photo 3-17).

Keeping pollutants out of storm-water runoff is less expensive than installing storm-water treatment facilities. The Oroklini Community Council needs to consider:

- Construction site erosion control regulations;
- Enactment of regulations regarding storm-water management in new developments;
- Development and implementation of a comprehensive storm-water management plan by extending the present storm-water network;
- Consideration of sponsoring or providing incentives for household hazardous waste collections, and disposal of toxic wastes properly;
- Consider oil recycling enforcement;
- Maintain clean roadways and pavements to keep waste out of storm-sewers;
- Campaign for citizens to maintain and tune cars and repair leaks;
- Limit the use of fertilizer and pesticide use;
- Campaign for cleaning up pet waste

[12] GWQ020 Polluted Urban Runoff – A Source of Concern I-02-97-5M-20-S DNR: WT-483-97 http://clean-water.uwex.edu/pubs/pdf/urban.pdf

Photo 3-17: A carcass in the culvert under the highway which discharges to the lake

Photo 3-18: Discharge with debris at the outlet of the central storm - water network. The role of the reeds in controlling pollutants is clear

3.1.3 Impact Analysis based on Monitoring Results

During the study "Determination of important hydrological features for Oroklini Lake" in November 2012, surface water standing in the lake was sampled on the 21st of June and 10th of October 2012 and the results were compared to average river water values, the EU Drinking standards and the Cyprus Threshold Values. The samples were taken from a point within the lake in its northern part. The sample analyses results and above mentioned comparison values are presented Table 3-3.

Table 3-3. Results of lake's surface water sample analyses during Action A.4 of LIFE+ project "Restoration and Management of Oroklini Lake SPA (CY6000010) in Larnaca Cyprus"

Parameter	Units	Surface water results		Mean composition of world river water [13]	EU Drinking Water Standards [14]	Cyprus Threshold Values[15]
		21/06/2012	10/10/2012			
Total Nitrogen	**mg/L-N**	7,8	10,1			
Nitrites NO_2^+	**mg/L-N**	0,1	0,03		0,50	
Total Ammonia Nitrogen	**mg/L-N**	<0,6	4,2			
Ammonium NH_4^+	**mg/L-N**	<0,58	4,0		0,50	0,50
Total Phosphorus	**mg/L-P**	0,20	0,09			
Soluble reactive Phosphates (SRP)	**mg/L-P**	<2,6	<2,6			
HCO_3^-	**mg/L**	308	355	58		
CO_3^{2+}	**mg/L**	<1	<1	7		
SO_4^{2-}	**mg/L**	4.092	4.498	11	250	250 – 3.000
Cl^-	**mg/L**	2.942	3.120	7,8	250	250 – 3.000
NO_3^- - N	**mg/L-N**	3,25	1,68	1	50	50
F	**mg/L**	<1,2*	<1,2*		1,5	
Ca^{2+}	**mg/L**	441	511	15		
Mg^{2+}	**mg/L**	657	759	4,1		
K^+	**mg/L**	23	36			
Na^+	**mg/L**	2.240	2.587	6,3	200	
B	**mg/L**	5,29	5,56		1,0	
El. Conductivity	**µS/cm**	13.700	16.250		2.500	2.500-7.000
pH	**-**	8,3	8,0		≥ 6,5 and ≤ 9,5	
Total Hardness	**mg/L $CaCO_3$**	3.780	4.375	54		
Total Alkalinity	**mg/L $CaCO_3$**	308	355			
Colour	**Hazen**	30	68		**	

[13] Source: J. HEM Study and Interpretation of the Chemical Characteristics of Natural Water USGS WS Paper 2254 with further reference to I. Oltman 1968 USGS Water Supply Paper 1964

[14] Council Directive 98/83/EC on the quality of water indented for human consumption.

[15] ANNEX 3 to the Commission Staff Working Document accompanying the Report from the Commission in accordance with Article 3.7 of the Groundwater Directive 2006/118/EC on the establishment of groundwater threshold values

Parameter	Units	Surface water results		Mean composition of world river water [13]	EU Drinking Water Standards [14]	Cyprus Threshold Values[15]
		21/06/2012	10/10/2012			
Pb	**µg/L**	<2,9	No analysis		10	10
Hg	**µg/L**	<1	No analysis		1	1
Dissolved oxygen	**mg/LO_2**	6,6	9,5			
BOD_5	**mg/L**	12	118			
COD	**mg/L**	25	188			

As already mentioned in the introduction chapter, three samplings were planned and conducted just upstream of the highway culvert, at the beginning, in the middle and 15 days prior to the study conclusion. The sampling point is shown in Map 2-3 with a green square point. Eventually the samples were collected on the 3rd of April 2014, the 16th of April 2014 and the 6th of May 2014. The analyses results of the collected samples of runoff water are presented in Table 3-4. It is worth to notice that on the 15th of April 2014, the previous day of the sampling of the 16th, there was a light rainfall, while on the 6th of May 2014 rainfall begun early in the morning and lasted until late in the afternoon.

Further to the three samplings conducted during this study, the Oroklini Community Council conducted a sampling from the same point on the 11th of July 2013. The analytical results of this sample are also presented in Table 3-4.

Table 3-4. Results of recent analysis on water samples taken from the inflow point of the lake

Parameter	Units	Date of sampling				
		By Oroklini Community council	***By IACO Environmental & Water Consultants Ltd***			
		11/07/2013	**03/04/2014** ***No rainfall***	**16/04/2014** ***Rainfall on the previous day***	**06/05/2014** ***Rainfall on the same day***	***Average Value for the sampling for the scope of this report***
pH	**-**	7,6	**7,8**	**7,6**	**7,6**	***7,7***
Electric Conductivity	**mS/cm**	9,11	**8,03**	**7,69**	**1,277**	***5,67***
BOD_5	**mg/l**	5	**<3**	**6**	**18**	***9***
COD	**mg/l**	12	**7**	**13**	**58**	***26***
Total Suspended Solids	**mg/l**	13	**10**	**12**	**61**	***27,7***
Total Hydrocarbons	**mg/l**	No analysis	**<1,6**	**<1,6**	**<1,6**	***<1,6***
FOG	**mg/l**	No analysis	**<1,6**	**<1,6**	**<1,6**	***<1,6***
TP	**mg/l**	<0,01	**<0,02**	**<0,02**	**0,19**	***0,07***
TN	**mg/l**	<0,4	**8,3**	**7,1**	**14,3**	***9,9***
Boron	**mg/l**	No analysis	**2,86**	**2,26**	**0,39**	***1,84***
E. coli	**/100ml**	No analysis	**200**	**14.000**	**25.000**	***13.067***

According to the "Report on the Classification of Water Status (rivers, natural lakes, water reservoirs)" [16], the classification systems for the various Chemical – Physicochemical parameters that were utilised for classification of the Chemical – Physicochemical status of Cyprus river monitoring stations, and relevant parameters that were analysed in the water samples above, are presented in the following Table 3-5.

Table 3-5: Classification systems/ limits for the Chemical – Physicochemical elements at river monitoring stations according to the Report on the Classification of Water Status (WDD Contract– YY02/2013)

Classification system per parameter	Unit	High	Good	Moderate	Poor	Bad	**Sampling results average**
Odense Pilot RB criteria for **BOD_5**	mg/l	<0,5	0,5-2,0	2,1-3,5	3,5-5,0	>5,0	**9**
NCS* for **$N\text{-}NH_4^+$**	mg/l	<0,024	0,024-0,060	0,061-0,200	0,210-0,500	>0,500	
NCS* revised for **$N\text{-}NO_2^-$**	µg/l	<3,0	3,0-8,0	8,1-30,0	30,1-70,0	>70,0	
NCS* for **$N\text{-}NO_3^-$**	mg/l	<0,22	0,22-0,60	0,61-1,30	1,30-1,80	>1,80	
SUM of NCS limits for N due to **($-NH_4^+$, $-NO_2^-$,$-NO_3^-$)****	mg/l	0,247	0,247-0,668	0,668-1,53	1,53-2,37	>2,37	**9,9**
NCS* revised for **TP**	µg/l	<85	86-165	166-220	221-405	>405	**70**
Xerothermic area criteria (Messara. Crete) for **EC**	µS/cm	<250	250-750	750-2000	2001-3000	>3000	**5666**

Classification system per parameter	Unit	Good	Moderate	**Sampling results average**
Drinking water quality Directive 98/83/EC criteria for **Boron**	mg/l	<1,0	≥1,0	**1,84**

**Nutrient Classification System (NCS) for small to medium size river catchment areas (10-1000 km^2), reference: Skoulikidis N. & Y. Amaxidis (2009). Origin and dynamics of dissolved and particulate nutrients in a minimally disturbed Mediterranean river with intermittent flow. Journal of Hydrology, 37: 218–229*

[16] Water Development Department, Contract Number YY02/2013, "Review and Update of Article 5 of Directive 2000/60/EC (water reservoirs) & Classification of water status (rivers, natural lakes and water reservoirs), that will establish baseline information and data for the 2nd Cyprus River Basin Management Plan" – assigned to the Consortium ENVECO S.A. - I.A.CO Environmental & Water Consultants Ltd

***The sampling results average is shown on Table 3-4. The SUM for NCS has been made in the present case because only Total Nitrogen was analyzed. The TN was compared to the SUM to enable indicative classification of the water at the sampling station.*

Surface water in areas not influenced by pollution according to EU Drinking Water Standards has a pH in the range of 6,5 to 8,5. For the last period of the almost eleven months, the pH is steadily within these limits.

BOD_5, COD, TSS and partly TN are affected by rainfall conditions. Airborne dust, urban debris, and eroded soils are carried by runoff, a procedure that is more intense during rainfall. TSS concentration also tends to increase during a rainfall event because of the re-suspension of the deposited sediments.

TN concentrations are mainly due to fertilizer usage on the cereal crops that surround the lake and are present in all the catchment area. This may be verified by noticing that for the 3rd and 16th of April 2014 there were significant amounts of TN in water inflow while the BOD_5 and COD levels were considerably low. The high TN is justified by the application of ammonium fertilizers mainly during spring and autumn season. Application of fertilizers during spring and summer is assumed by the practices suggested by the Good Agricultural Practice Code[17] as spring and summer are the seasons with no intense rainfall events, when no surface water runoff occurs.

Electrical Conductivity and Boron levels exceed the limits as shown in Table 3-5, and the sampling point is classified as being in “Bad status” and “Moderate status”, respectively. Nevertheless the high values of Electrical Conductivity and Boron on the first (3/4/2014) and second (16/4/2014) sampling are mainly due to natural causes arising from the geological formations possibly associated with halite commonly associated with evaporate deposits. Evaporate deposits in closed basins may contain considerable amounts of boron. The natural source of these parameters becomes clearly obvious, when observing the results for the Electrical Conductivity and Boron analyses. When rainfall occurs, as is the case of the third sampling (6/5/2014), due to the fact that these parameters do not come from any other source (point or diffuse), they are diluted by rain water and their concentration in the water sample drops dramatically.

Total Hydrocarbons and FOG levels are below the detection limits of the analytical method. That explains why none of the two parameters were detected in the water sample.

As it concerns FOG the results indicate that, for the period sampled, no actual impact from the restaurants or houses regarding waste vegetable oils leaking or finding their way into the storm-water network, is noted.

As it concerns Total Hydrocarbons, similarly for the period sampled, this is translated that no actual impact from the road network and traffic within the community built up area occurred.

Higher levels of E. Coli after the rainfall events can be explained by faecal material, from a variety of animals (pets, livestock, and wildlife etc.), that are washed out into storm-water following the rain resulting, to microbial contamination. It is unlikely that the source could also be the septic tanks since the increase is noted after rain. Besides, the soil-aquifer treatment is expected to prevent E.

[17] Regulatory Administrative Act 263/2007, Article 5, Paragraph (c)

Coli reaching the stream. This also applies for the BOD_5 and COD noted on the 6th of May, when considerable rainfall occurred.

As it concerns to TP concentrations, most of the results were below the analytical detection limits. The only detected amount is on the day that rainfall occurred, which classifies the water flow at the sampling point as in "*moderate status*". When considering the average value for the results, as it is practised for the classification after WFD (Water Framework Directive 2000/60/EC), the status of the sampling point is finally classified as in "high status" (as per Table 3-5). The unique relatively high value of 0,19 mg/l could be due to fertilizers being washed out from the fields.

All previously mentioned for BOD_5, COD, TN, TP and E. Coli, amplify the conclusion that no urban wastewater leaks into the storm-water network. Any contribution of groundwater containing wastewater appearing as rising water at the marsh area is considered to have been undergone natural soil-aquifer treatment. The agriculture areas around the lake appear though to have an impact on the water ending up in the lake.

The other point pollution sources such as the petrol station, the uncontrolled petroleum products junk-yard or the highway and adjacent road impact to the lake, cannot be identified by the monitoring conducted for this sampling point. Further analysis and recommendations for the monitoring program that could also involve these points, is described in Chapter 5.

3.2 CHANGE OF WATER REGIME

3.2.1 Storm-water Network Expansion

As discussed in subchapter 2.2.3 on the present conditions of the storm-water network, the whole system operates within the catchment area and contributes water to the marsh area upstream the highway from where a small stream develops and flows through a culvert to the Lake.

The storm-water network is already well developed and sufficiently dense to cover the major roads and most of the built up area. Thus, no serious expansion can be expected. Nonetheless, whatever expansion is made this would only increase the runoff to the Lake since runoff coefficients will increase and losses to the underground will be reduced.

All the water that flows into the Lake is provided by the storm-water network since no definite stream is clearly identified, having been covered by the built environment since no "registered" stream was ever indicated on the Cadastral plans that could have been protected by the town planning schemes of the past.

A serious risk for the Lake would develop if the storm-water network expands, as a unique system, to cover areas south of the Highway disposing storm-water beyond the Lake and depriving the flows to it. Such a scheme should definitely be avoided. Whatever expansion of the network is planned and implemented, this should end upstream of the main culvert which passes under the Highway. Any network developed for the built up area around the Lake should be a separate one and independent of the one serving the catchment area providing water to the Lake.

3.2.2 Sewage Network

The future establishment of a sewage collection network and transfer of the wastewater for treatment outside the catchment area of Oroklini will reduce the quantity of water flowing to the Lake but at the same time it will decisively improve the quality of the surface water.

The estimated runoff to the Lake under a dry, an average and a wet year are 265.171, 342.848 and 468.629 m^3, respectively.

If one considers the estimated return to groundwater of waste water being of the order of 271.000 m^3, the effect of the export of this water on the available water resources can be clearly identified.

Thus, it is suggested that, in the case of Oroklini Village area being connected to the Larnaca Sewage Board, a substantial quantity of tertiary treated effluent be requested to be returned to the area for irrigation or other uses so that the water resources available in the area are maintained.

With the development of a sewage network, the quality of the water resources is bound to improve and will remain improved even with the import of tertiary treated effluent.

3.2.3 Reduction of losses of domestic water

In the same way, an improvement of the water supply system which is bound to be carried out will reduce the quantity of "unaccounted" water that is lost to the underground. The reported present day annual quantity is of the order of 400.000 m^3 which for 2012 this was 50% of the purchased water.

A normal percentage of "unaccounted" water would be of the order of 20 to 25%. Thus, any efforts towards reducing the loss of fresh water could amount to a reduction of the present replenishment by about half the quantity that is being lost today. This will have an impact on the present day water regime reducing the available water resources.

3.3 HYDRO-MORPHOLOGICAL CHANGES

3.3.1 Stream reed beds management

As already stated, the water content of the Oroklini Lake and its operation, depends entirely on surface runoff from the stream originating within the Oroklini catchment. The stream is fed by the natural drainage network of the catchment area, but also by underground water, originating both from significant loses of the water supply network and the septic cesspools leakages of the community. The underground water rises on surface northwest of the lake and close to the marsh, following the subsurface hydraulic gradient, and accumulates in the stream flowing to the Lake.

The seasonal surface flows and the subsurface flows present throughout the year in the south part of the drainage area, maintain reed beds dominated by the Common Reed (*Phragmites australis*), a strong colonizer, that covers significant proportion of the area. The presence of dense communities of *Phragmites australis*, impounds the stream corridor and impairs the free flow of water into the lake. This, at peak flows might lead to the flooding of a wider area. Because of the fact that the common reed is a tolerant and highly aggressive disperser, presenting high growth rates at such suitable environments, the Oroklini municipality removes large quantities of reed biomass from the

stream and the adjacent canals, using mechanical means, normally just before the rainy season (Photo 3-19).

Such practices facilitate the inflow of water into the lake basin, but they also present severe drawbacks. Due to the hydrological network and the adjacent built-up areas, but also the need for supplying the lake with sufficient water quantities especially during the dry season and dry years, the water from the drainage area must flow unobstructed through the stream and the adjacent canals, into the lake. In the opposite case, the water will remain trapped in the reed beds and the lake will face the danger of shorter retention times and longer dry periods, due to reduced inflows.

On the other hand, reed beds are very well known to act as water purifiers in aquatic ecosystems, and thus enhance water quality. Their high growth rates of the common reed and the complex creeping rhizome network that it creates, enables its individuals to extract high proportions of nutrients from the sediment and water column and therefore filtering the water and reducing the risk of eutrophication phenomena. In addition, reed beds present high capacity in absorbing heavy metals such as Ni, Cd, Hg, Pb, etc, and thus minimizing the risk of toxic effects on the biota of the lake. Moreover, the extended rhizome network of reed beds improves the quality of substrate, by releasing oxygen from their tissues and create oxygenated microsites. This on the one hand creates aerobic conditions in the sediment and on the other hand enhances nitrification by converting ammonium molecules to nitrates. The ability of phytoextraction is considered crucial for the processes of Oroklini Lake, considering the fact a high proportion of inflows originates from the storm-water drainage system of built up areas and their septic system, and therefore it is expected to supply the lake with significant nutrient and heavy metal load.

Considering all of the above, the removal of reed beds from the stream and the adjacent canals should be made with extreme caution and only when deemed to be absolutely necessary. The management of reed stands should be restricted only in the stream corridor and instead of dredging, alternative methods should be explored, such as low mowing, in order to maintain the functionality of roots. This has the benefit of facilitating the water flow into the lake and at the same time keeping the root system and its functionalities in place and minimally affected.

Finally, the use of chemical methods as control agents should be ruled out, since aquatic habitats and their biota are highly sensitive and the possibility of causing negative effects on the ecosystem is high.

3.3.2 Drainage stream channelization

A possible solution that might be proposed to enhance water flow speed into the lake, but would also facilitate the works in case of residential development in the adjacent area, could be the channelization and concrete lining of the stream, as this method has been previously applied in the upper parts of the drainage basin. Such a method has been widely used in Cyprus, especially in rivers and streams of urban areas. Still, considering the water purification potential of reed beds, the option of eliminating them and concrete lining the streambed, must be avoided. The loss of reed beds and their ecosystem services will downgrade water quality and will undermine the ecosystem as a whole.

This will affect the current nutrient balance of the system and will result to eutrophication phenomena, which in turn can lead to further deterioration of water quality. In addition, concrete lining will replace aquatic habitats in the stream channel, decrease biodiversity and affect sediment dynamics and energy transportation through the river basin to the lake, by minimizing sediment and organic material transportation.

Photo 3-19: Overview of the stream feeding the Oroklini Lake, after clearing works and the removal of large quantities of *Phragmites australis* biomass, upstream the highway. The regeneration of reed shoots is already taking place

4 RECOMMENDATIONS OF POLLUTION PREVENTION AND CONTROL MEASURES

4.1 PREVENTION AND CONTROL MEASURES FOR POLLUTION SOURCES

4.1.1 The Dry cleaner

The following recommendations apply:

- Compliance with all Environmental Permit terms should be strictly kept, especially those regarding waste management.
- There should be no storage of great quantities of tetrachloroethylene on site in order to avoid accidental spills and similar risks.
- Solvent wastes or solvent containing wastes should be managed in the proper manner as they consist hazardous material according to the European Waste Catalogue and Hazardous Waste List (Codes: 14 06 03 - other solvents and solvent mixtures, 14 06 05- sludge or solid wastes containing other solvents).
- A hazardous waste contingency plan must be developed if it is required, and emergency control equipment should be inspected on a systematic basis by the competent authorities.
- Waste areas should be systematically inspected and a log of outgoing wastes to the proper collectors should be kept. Proper handling procedures should be kept for transport[18].

4.1.2 The Restaurants

The following measures should be pursued:

- Use of dry clean-up methods to remove FOGs and reduce water consumption and sewer use. Avoid disposal of kitchen greases down the drain. Collect and send used grease to a licensed liquid industrial waste collector for rendering or conversion to biofuels. Find a licensed hauler that will provide storage barrels and free pick-up service.
- Ensure that grease traps (in case there are any) and interceptors are properly maintained. Caution should be taken never to hot flush through a grease trap.
- Never wash water down a storm drain, spill materials or wastes in the parking lot or yard without cleaning them up or allow materials or waste stored outside to leak.
- Clean equipment in a designated indoor area with a drain connected to the sanitary sewer. Never pour wash water down a storm drain or gutter.
- Dumpsters used for garbage should be protected from rainwater to avoid unwanted substances from entering storm drains. Some helpful hints for dumpster maintenance include keeping the dumpster lid closed to keep out rain water, replacing damaged or missing lids as soon as possible, never placing liquid waste or leaky garbage bags into a

[18] "Plain English Guide for Perc Dry Cleaners", Program "Design for the Environment", United States Environmental Protection Agency

dumpster, keeping dumpsters or the dumpster enclosure locked to prevent illegal dumping, not hosing out the dumpster interior, applying absorbent over any fluids spilled in the dumpster, sweeping up litter, and replacing leaking dumpsters.[19]

4.1.3 Agriculture

- Regulatory Administrative Act 263/2007 sets the Code for Good Agricultural Practice. Farmers should keep their agriculture activities within this legislative framework.
- Practices should always care in mind terms about quantitative restrictions on fertilizers per crop, per seasonal application restrictions etc.
- Agrochemicals used must be certified to be legal for use as per Agrochemicals Control Section, Department of Agriculture, Ministry of Agriculture, Natural Resources and Environment Legislation.

4.2 MANAGING THE TRAFFIC POLLUTION RISK

4.2.1 Control of Highway and public road pollution risk

Both the Paralimni – Larnaca Highway passing over the stream that enters the Oroklini Lake, and the public road connecting the coastal area to Oroklini Village that runs parallel to the Lake, and crossing it at a certain location, do not have any protection measures to prevent storm-water carrying polluting substances from traffic activity and or spills of petroleum, wastewater or other chemical substances, in the case of an accident, to end up in the Lake.

The existing drainage conditions both of the Highway and the public road have been presented in detail in subchapter 2.2.4.

Two pollution conditions can occur:

- Regular storm-water runoff from the roadway reaching the stream that feeds the Lake or flowing directly to the Lake carrying pollutants such as hydrocarbons, lead, oil, etc;, and
- Accidental Spill of a pollutant after a truck or bowser accident which can reach the stream that flows into the Lake or by the truck falling off the road and directly to the Lake.

The protection system must cover both of these two pollution conditions. Such a system has been presented in detail and recommended by the Water Development Department for the case of roads crossing streams over bridges that flow to reservoirs used for drinking water[20].

In the case of the Oroklini Lake this system is simplified to the extent that storm-water from the highway and the public road as well as in the eventuality of an accidental spill, are made to enter a

[19] "Restaurant Pollution Prevention and Waste Reduction", Michigan Department of Environmental Quality, Environmental Science and Services Division, April 2008

[20] ROC-MANR&E, WDD (2013): Drinking water reservoir protection, Action plan and recommendations, Common annexes

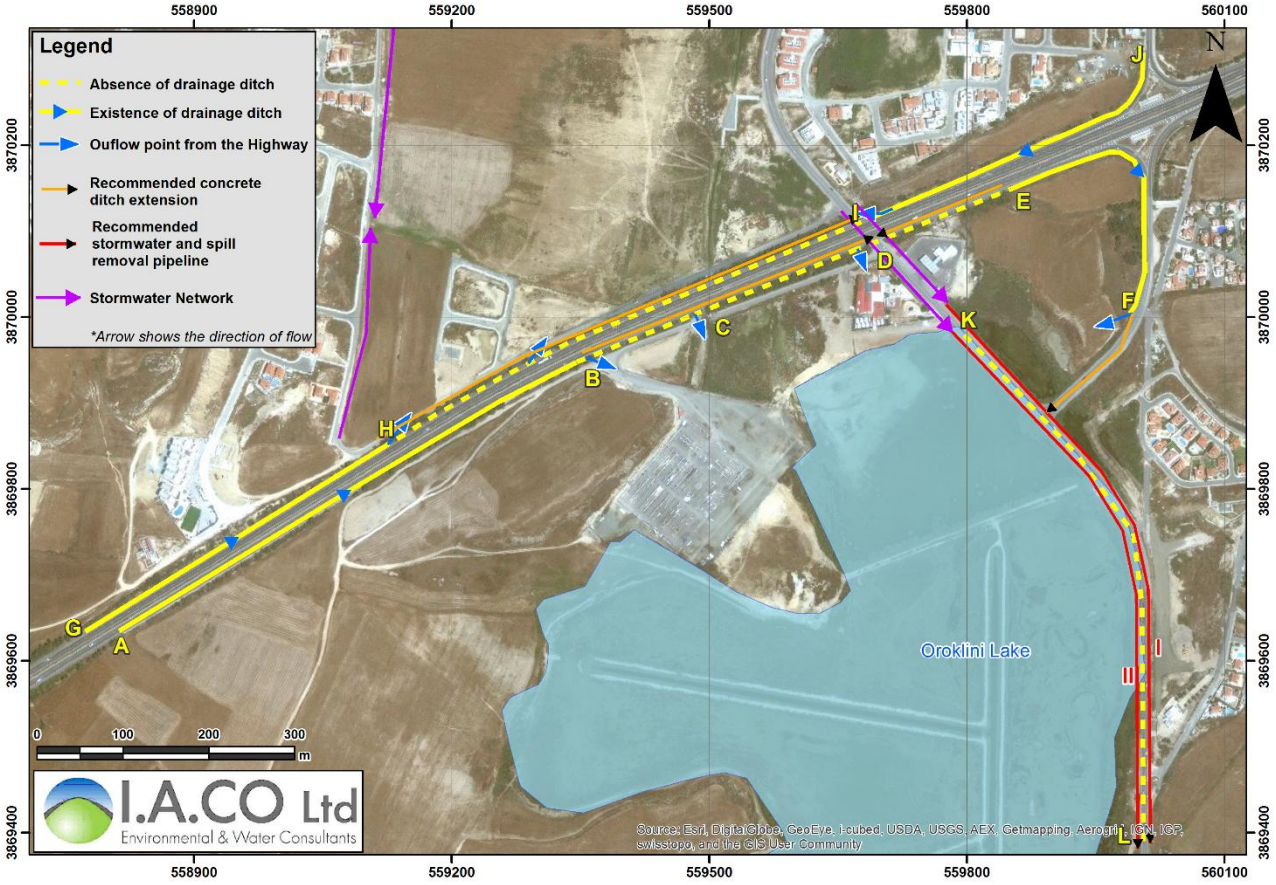
pipeline that transfers them downstream the Lake at the point of exit of the water to the stream that carries it to the sea avoiding thus the discharge into the Lake.

The following suggestions are conceptual and have to be properly designed and cost-estimated by a competent engineer on the basis of the existing topography of the area along the roadways.

The system would involve the following:

- Both, the highway and the road, should have a low wall constructed at the rim on either side to prevent runoff over either side.
- A crash barrier wall for at least some 50 to 100m needs to be constructed on either side of the highway at the point over the stream to prevent a truck or bowser to fall over in the case of an accident.
- The ditches shown on the Map 4-1 should be extended as shown to transport storm-water and or spill to the existing storm-water sewers running towards the South on either side of the road passing under the highway.
- The ditch on the service road (Point E to F) should be extended to reach and be connected to the pipeline I at the eastern side of the public road.
- The public road should be equipped with a pipe on either side of the road, such as shown on Photo 4-1, which will collect storm-water and spills from the roadside at various points and transport them away from the protected area.
- These pipelines (I at the eastern and II at the western side) will be connected to the existing storm-water sewers at either side of the public road at the point under the Highway and discharge the storm-water at a point at the southern-most outlet of the Lake.

It would be useful if the spill on the occasion of an accident is led into a concrete basin for retaining oils (accidental spills etc.). This should have a capacity equal to that of a tanker truck and be quickly emptied after a pollution incident. During a storm, the concrete basin would overflow into the point of the stream at the exit of the Lake.



Map 4-1: Map showing recommended works for managing storm-runoff and accidental spills from entering the Lake

Photo 4-1: Views of a pipeline collecting storm-water and spills from the Limassol – Paphos highway at a point over Symvoulos Reservoir and suggested for the public road crossing the Lake

4.2.2 Traffic speed bumps

It would be useful if traffic calming devices such as speed bumps are installed on the public road connecting the coastal area to the Oroklini Village from the point that this road runs parallel to the Lake area and up to the point where it passes under the Highway. This measure will slow motor-vehicle traffic so that safety conditions are improved and traffic accidents next to the Lake are prevented.

4.3 CONCRETE LINING OF THE NATURAL STREAM

As it is stated in subchapter 3.3.2 the channelization and concrete lining of the natural stream, which starts at the storm-water sewer outlet as shown on point 1 of Map 2-3 and ends up to the box culvert at the Highway, will reduce water quality and will undermine the ecosystem as a whole. Having this in mind and the key role of reed beds, it is strongly recommended that in case of any future residential development in the vicinity area of the stream and the stream itself, the riparian vegetation the streambed and stream banks should be maintained in their natural condition.

As it is mentioned above, this stream is not registered in Cadastral Maps, therefore, registration of this stream to the Cadastral maps is recommended in order to secure the natural conditions of the stream.

5 DESIGN OF A MONITORING PROGRAM FOR THE QUALITY OF SURFACE FLOW

5.1 MONITORING FOR THE QUALITY OF SURFACE WATER

5.1.1 A Systematic Monitoring Program

A Systematic Monitoring Program must be established in order to control the potential sources of pollution. The sampling point selected for the monitoring during this project (at the entrance of the box culvert under the Highway) is representative for the main quantity of water flowing into the lake. A systematic program monitoring specific pollutants must also be applied on point 1 (the central storm-sewer outlet) according to Map 2-3. The simultaneous sampling on both points will identify the importance of the presence of the reed beds to act as water purifiers in aquatic ecosystems, and thus enhance water quality. The parameters that are proposed to be monitored as part of the Systematic Monitoring are presented in Table 5-1.

Table 5-1: Systematic Monitoring Program's Parameters

Parameter	as indicated in Map 2-3	
	Point 1	Box culvert under the highway
pH	☑	☑
Electric Conductivity	☑	☑
BOD_5		☑
TSS		☑
FOG		☑
E. coli		☑
TP	☑	☑
$N\text{-}NO_3^-$	☑	☑
$N\text{-}NH_4^+$	☑	☑
Lead	☑	☑
Agrochemicals (as further explained)		☑

Frequency of the sampling is described as follows:

- Commencing as from the next hydrologic year, samples for Systematic Monitoring, from points stated in Table 5-1 ideally should be collected monthly, given that there is water flow. Once, the regime of the water quality is assessed, a less intensive monitoring program could be acceptable with a sample being collected every two months, given that there is water flow.

Concerning the agrochemicals used by the specific farmers in the area, a survey should be made, probably through a questionnaire through which the exact products of the ones mentioned in paragraph 3.1.2 are used, the quantities used and their application frequency. This will allow a selection to be made of the substances with the most frequent and quantitative use so that these can be monitored.

5.1.2 An Occasional/Investigative Monitoring Program

Occasional / Investigative Monitoring Program also must be established for point 3 shown in Map 2-3 and for the point "I" under the bridge, shown in Map 2-4 and Photo 2-16. Samples for Occasional / Investigative Monitoring should be collected during a rainfall event, at least twice a year in different seasons. The parameters that are proposed to be monitored as part of the Occasional / Investigative Monitoring Program are presented in Table 5-2.

Table 5-2: Occasional / Investigative Monitoring Program's Parameters

Parameter	Point 3	Point "I"
	as indicated in Map 2-3	as indicated in Map 2-4
TPH (Total Petroleum Hydrocarbons)	☑	☑
(PAHs) Polyaromatic Hydrocarbons	☑	☑
FOG		☑
Lead		☑

In the event there is a need to investigate the tightness of the underground fuel tanks of the petrol station, a shallow (~5m deep) observation borehole of about 3 inch diameter, will need to be drilled for collecting samples for TPH and PAHs. The borehole should be drilled down-gradient the groundwater flow that is on a point exactly outside of the petrol station on its south-eastern border.

6 EMERGENCY PLAN

6.1 NEED FOR AN EMERGENCY PLAN

The sensitive wetland ecosystem of Oroklini Lake exists within a heavily built environment and its water is being replenished from runoff originating from within a catchment that is almost totally urbanized. A dense road network exists within the Oroklini Community. The area includes houses with central heating and swimming pools, a small hotel, restaurants, small enterprises such as dry-cleaning, a shopping mall, supermarkets, schools, gyms etc.

It is normal that these activities at various times call for transport with trucks of petrol and possibly other chemicals. Furthermore, the absence of a sewage network requires occasionally the emptying of septic tanks and cesspits with a truck and transfer the sewage to a Treatment Plant or an approved disposal area outside the catchment area.

In addition to the above, the Paralimni -Larnaca Highway crosses over the upper part of the Lake. Also, a major public road connecting the coastal area with the highway and the Oroklini Village crosses the Lake. This road services also the only petrol station that exists in the area, less than 50m from the Lake itself.

From the existing conditions regarding the drainage facilities either from the built up area through the storm-water network or from the Highway and the public road crossing the Lake, all the runoff eventually finds its way to the Lake. The same can be assumed that will happen in the event of an accident with a truck carrying petrol or any other chemical or wastewater.

The Emergency Plan that is required is for protecting the quality of the water flowing, or existing, in the Lake, from sudden unexpected, accidental occurrences of a spill either of petroleum products, other chemicals or wastewater due to a traffic accident involving a truck transporting such substances. No matter how remote or rare might this possibility be of happening, the Community and other stakeholders need to have a working Emergency Plan for such an eventuality.

6.1.1 The Emergency Operating Plan

An Emergency Operating Plan (EOP) needs to be drafted involving:

- Identification of potential hazards;
- Description of the emergency procedures;
- Acquirement and storing of basic tools (sorbents, safety uniforms, mobile tanks, pumps etc.);
- Training of staff and possibly carry out of occasional drills;
- Public campaign and reporting procedures for events;
- Preparation of lists of emergency contacts; and
- Establishment of a chain of command in the event of an emergency.

In developing an EOP the Fire Department should be consulted and be involved since it is within their capacity to protect the public's safety and have the equipment, the know-how and the training to respond immediately to situations of this kind.

6.1.2 Responding to a spill

The basic steps in responding to a spill, of a volume of a truck load or less, of an unwanted substance are:

- **Stop the spill.** Preferably by properly qualified and equipped personnel.
- **Contain and recover the spill.** Spread sorbent material, sand, straw, sawdust or even dirt from the roadside to stop the flow and soak the spill. Solidifiers in the market react with petroleum and turn it to a rubbery substance.
- **Collect the contaminated sorbent.** Buckets, garbage cans or barrels can be used if a truck with a tank is not available.
- **Secure the waste.** Dispose the waste in an approved manner.

The time required for any spill on the Highway and or the public road to reach the Lake is so short (15 – 30 minutes) that proactive measures to prevent or contain a spill must be in place in advance. A spill on the road network within the urban area of Oroklini may take longer to reach the Lake (30 to 90 minutes depending on the runoff conditions at the time.

In the case that a petroleum spill has reached water in a ditch or a pond, this can be recovered by using a sorbent such as dry straw, grass, or other natural material that will float. This contaminated sorbent can then be removed with a rake and thin-spread so that biodegradation can take place.

7 APPENDICES

APPENDIX 1 : CHEMICAL ANALYTICAL RESULTS

APPENDIX 1: CHEMICAL ANALYSES RESULTS

Sampling on 3rd of April 2014:

cp. FOODLAB ltd
Χημείο Νερού – Ποτών - Τροφίμων
Λυμάτων - Περιβάλλοντος

25 Πολυφόντη, 2040 Στρόβολος
Τ.Κ. 28729, 2082 Λευκωσία - Κύπρος
Τηλ. : +(357) 22 45 68 60, 1, 2, 3
Κιν. : +(357) 99 42 68 78
Fax. : +(357) 22 32 15 17

ΕΚΘΕΣΗ ΑΠΟΤΕΛΕΣΜΑΤΩΝ

Όνομα : IACO
: (Λεωφ. Σταυρού 3, Γραφείο 202, 2035 Στρόβολος, τηλ. 22-429444)
Αρ. Δείγματος : 189185
Δειγματολήπτης : IACO
Χαρακτηριστικά Δείγματος : Νερό από ποταμό στην Οροκλίνη, σε πλαστικό , γυάλινο και αποστειρωμένο
: μπουκάλι, θερμοκρασία (5°C).
: (Ικανοποιητική κατάσταση δείγματος)
Ημερ. Παραλαβής : 03/04/14
Ημερ. Ανάλυσης : 03-14/04/14
Ημερ. Έκδοσης Αποτελεσμάτων : 14/04/14

Αποτελέσματα

Παράμετρος	Μέθοδος εξέτασης	Μονάδα	189185
pH (19°C)	APHA 4500A:2005		7.8
Αγωγιμότητα	APHA 2510A:2005	μS/cm	8030
BOD_5 Σημ. 3	APHA 2005 (5210D)	mg/l	<3
COD	APHA 2005 (5520D)	mg/l	7
TSS	APHA 2005 (2540D)	mg/l	10
Υδρογονάνθρακες (ΤΗ)	*ΜΕΘ-wt-hyd	mg/l	<1.6
FOG	APHA 5520:2005	mg/l	<1.6
TP	APHA 3120B:2005	mg/l	<0.02
TN	*APHA 4500-N C	mg/l	8.3
Βόριο (Β)	APHA 3120B:2005	mg/l	2.86
Εντερικά κολοβακτηρίδια	APHA 9222G:2005	/100ml	200

***Σημ.:**

1. Τα αποτελέσματα αφορούν μόνο το δείγμα που έχει εξεταστεί.
2. Για την ανάλυση του BOD_5 έγινε χρήση αναστολέα νιτροποίησης.
3. Η τιμή του BOD_5 είναι μεταξύ του ορίου ανίχνευσης και του ορίου ποσοτικού προσδιορισμού.

Για το cp FoodLab Ltd

Χαρά Παπαστεφάνου,
Διευθύντρια

(AB, AB)

*= Ότι φέρει (*) δεν εμπίπτει στο πεδίο εφαρμογής της διαπίστευσης

Τέλος Έκθεσης

Sampling on 16th of April 2014:

cp. FOODLAB ltd
Χημείο Νερού – Ποτών - Τροφίμων
Λυμάτων - Περιβάλλοντος

25 Πολυφόντη, 2047 Στρόβολος
Τ.Κ. 28729, 2082 Λευκωσία - Κύπρος
Τηλ. : +(357) 22 45 68 60, 1, 2, 3
Κιν. : +(357) 99 42 68 78
Fax. : +(357) 22 32 15 17

ΕΚΘΕΣΗ ΑΠΟΤΕΛΕΣΜΑΤΩΝ

Όνομα	**: I.A.CO ENVIRONMENTAL & WATER CONS.LTD**
	: Σταυρού 3, Γραφείο 202
	: Στρόβολος
	: 2035
Τηλέφωνο	: 22-429444
Αρ. Δείγματος	: 189880 / 001
Δειγματοληψία από	: IACO
Χαρακτηριστικά δείγματος	: νερό / από ποταμό στη Ορόκλινη / σε αποστειρωμένο περιέκτη
	: Θερμοκρασία παραλαβής στο εργαστήριο (7 °C)
	: Ικανοποιητική κατάσταση δείγματος.
Ημ. Παραλαβής	: 16/04/2014
Ημ. Ανάλυσης	: 16/04/2014-17/04/2014
Ημ. Έκδοσης Αποτελεσμάτων	: 23/04/2014

Αποτελέσματα

Παράμετρος	Μέθοδος εξέτασης	Μονάδα	189880 001
Εντερικά κολοβακτηρίδια	APHA 9222G:2005	/100ml	14000

*Σημ.:

1. Τα αποτελέσματα αφορούν μόνο το δείγμα που έχει εξεταστεί.

Για το cp FoodLab Ltd

Χυρά Παπαστεφάνου,
Διευθύντρια

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cp. FOODLAB ltd
Χημείο Νερού – Ποτών - Τροφίμων
Λυμάτων - Περιβάλλοντος

25 Πολυφόντη, 2047 Στρόβολος
Τ.Κ. 28729, 2082 Λευκωσία - Κύπρος
Τηλ. : +(357) 22 45 68 60, 1, 2, 3
Κιν. : +(357) 99 42 68 78
Fax. : +(357) 22 32 15 17

ΕΚΘΕΣΗ ΑΠΟΤΕΛΕΣΜΑΤΩΝ

Όνομα : **I.A.CO ENVIRONMENTAL & WATER CONS.LTD**
: Σταυρού 3, Γραφείο 202
: Στρόβολος
: 2035
Τηλέφωνο : 22-429444
Αρ. Δείγματος : 189879 / 001
Δειγματοληψία από : IACO
Χαρακτηριστικά δείγματος : Νερό / από ποταμό στην Ορόκλινη / σε πλαστικό και γύαλινο περιέκτη
: Θερμοκρασία παραλαβής στο εργαστήριο (7 °C)
: Ικανοποιητική κατάσταση δείγματος.
Ημ. Παραλαβής : 16/04/2014
Ημ. Ανάλυσης : 16/04/2014- 30/04/14
Ημ. Έκδοσης Αποτελεσμάτων : 02/05/14

Αποτελέσματα

Παράμετρος	Μέθοδος εξέτασης	Μονάδα	189879 001
pH (20°C)	APHA 4500A:2005		7.6
Αγωγιμότητα	APHA 2510A:2005	mS/cm	7.69
BOD_5	APHA 2005 (5210D)	mg/l	6
COD	APHA 2005 (5520D)	mg/l	13
TSS	APHA 2005 (2540D)	mg/l	12
Υδρογονάνθρακες (TH)	*ΜΕΘ-wt-hyd	mg/l	<1.6
FOG	APHA 5520:2005	mg/l	<1.6
TP	APHA 3120B:2005	mg/l	<0.02
TN	*APHA 4500-N C	mg/l	7.1
Βόριο (B)	APHA 3120B:2005	mg/l	2.26

*Σημ.:
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3. Η τιμή του BOD_5 είναι μεταξύ του ορίου ανίχνευσης και του ορίου ποσοτικού προσδιορισμού.

Για το cp FoodLab ltd
Χαρά Παπαστεφάνου,
Διευθύντρια

*= Ότι φέρει (*) δεν εμπίπτει στο πεδίο εφαρμογής της διαπίστευσης Τέλος Έκθεσης

Sampling on 6th of May 2014:

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Λυμάτων - Περιβάλλοντος

25 Πολυφόντη, 2047 Στρόβολος
Τ.Κ. 28729, 2082 Λευκωσία - Κύπρος
Τηλ. : +(357) 22 45 68 60, 1, 2, 3
Κιν. : +(357) 99 42 68 78
Fax. : +(357) 22 32 15 17

ΕΚΘΕΣΗ ΑΠΟΤΕΛΕΣΜΑΤΩΝ

Όνομα	**: I.A.CO ENVIRONMENTAL & WATER CONS.LTD**
	: Σταυρού 3, Γραφείο 202
	: Στρόβολος
	: 2035
Τηλέφωνο	: 22-429444
Αρ. Δείγματος	: 190696 / 001
Δειγματοληψία από	: I.A.CO ENVIRONMENTAL & WATER CONS.LTD
Χαρακτηριστικά δείγματος	: Νερό / από ποταμό στην Ορόκλινη / σε αποστειρωμένο περιέκτη
	: Θερμοκρασία παραλαβής στο εργαστήριο (5 °C)
	: Ικανοποιητική κατάσταση δείγματος.
Ημ. Παραλαβής	: 07/05/2014
Ημ. Ανάλυσης	: 07/05/2014-09/05/2014
Ημ. Έκδοσης Αποτελεσμάτων	: 09/05/2014

Αποτελέσματα

Παράμετρος	Μέθοδος εξέτασης	Μονάδα	190696 001
Εντερικά κολοβακτηρίδια	APHA 9222G:2005	/100ml	25000

***Σημ.:**

1. Τα αποτελέσματα αφορούν μόνο το δείγμα που έχει εξεταστεί.

Για το cp FoodLab Ltd

Χαρά Παπαστεφάνου,
Διευθύντρια

*= Ότι φέρει (*) δεν εμπίπτει στο πεδίο εφαρμογής της διαπίστευσης Τέλος Έκθεσης

Η παρούσα έκθεση έχει επιστημονικό χαρακτήρα και δεν μπορεί να χρησιμοποιηθεί για διαφημιστικούς ή άλλους παρόμοιους σκοπούς χωρίς την γραπτή άδεια του Εργαστηρίου

cp. FOODLAB ltd
Χημείο Νερού – Ποτών - Τροφίμων
Λυμάτων - Περιβάλλοντος

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: Θερμοκρασία παραλαβής στο εργαστήριο (5 °C)
: Ικανοποιητική κατάσταση δείγματος.
Ημ. Παραλαβής : 07/05/2014
Ημ. Ανάλυσης : 07/05/2014-13/05/14
Ημ. Έκδοσης Αποτελεσμάτων : 13/05/2014

Αποτελέσματα

Παράμετρος	Μέθοδος εξέτασης	Μονάδα	190695 001
pH (22°C)	APHA 4500A:2005		7.6
Αγωγιμότητα	APHA 2510A:2005	mS/cm	1277
BOD_5	APHA 2005 (5210D)	mg/l	18
COD	APHA 2005 (5520D)	mg/l	58
TSS	APHA 2005 (2540D)	mg/l	61
Υδρογονάνθρακες (TH)	*ΜΕΘ-wt-hyd	mg/l	<1.6
FOG	APHA 5520:2005	mg/l	<1.6
TP	APHA 3120B:2005	mg/l	0.19
TN	*APHA 4500-N C	mg/l	14.3
Βόριο (B)	APHA 3120B:2005	mg/l	0.39

***Σημ.:**

1. Τα αποτελέσματα αφορούν μόνο το δείγμα που έχει εξεταστεί.
2. Για την ανάλυση του BOD_5 έγινε χρήση αναστολέα νιτροποίησης.
3. Η τιμή του BOD_5 είναι μεταξύ του ορίου ανίχνευσης και του ορίου ποσοτικού προσδιορισμού.

Για το cp FoodLab Ltd

Χαρά Παπαστεφάνου,
Διευθύντρια

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Τέλος Έκθεσης

Το cp FoodLab είναι ανεξάρτητο διαπιστευμένο ιδιωτικό εργαστήριο
E-mail: foodlab@cytanet.com.cy, web: www.foodlab.com.cy

Σελ. 1/1

ΕΣΥΔ
Δοκιμές
Αρ. Πιστ. 114