

Water resources of Viotikos Kifissos basin: hydrogeological setup, evolution, threats and environmental status

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Land Reclamation Institute**



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VIOTIKOS KIFISSOS BASIN

- **Viotikos Kifissos Basin (VKB)** spans at 2720 km² and consists of three sequential interconnected parts, namely: Upper route, Median route, and Lower route (where Copais plain is located) including the sub-basin of **Yliki - Paralimni**



Water resources of Viotikos Kifissos basin:
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VIOTIKOS KIFISSOS BASIN

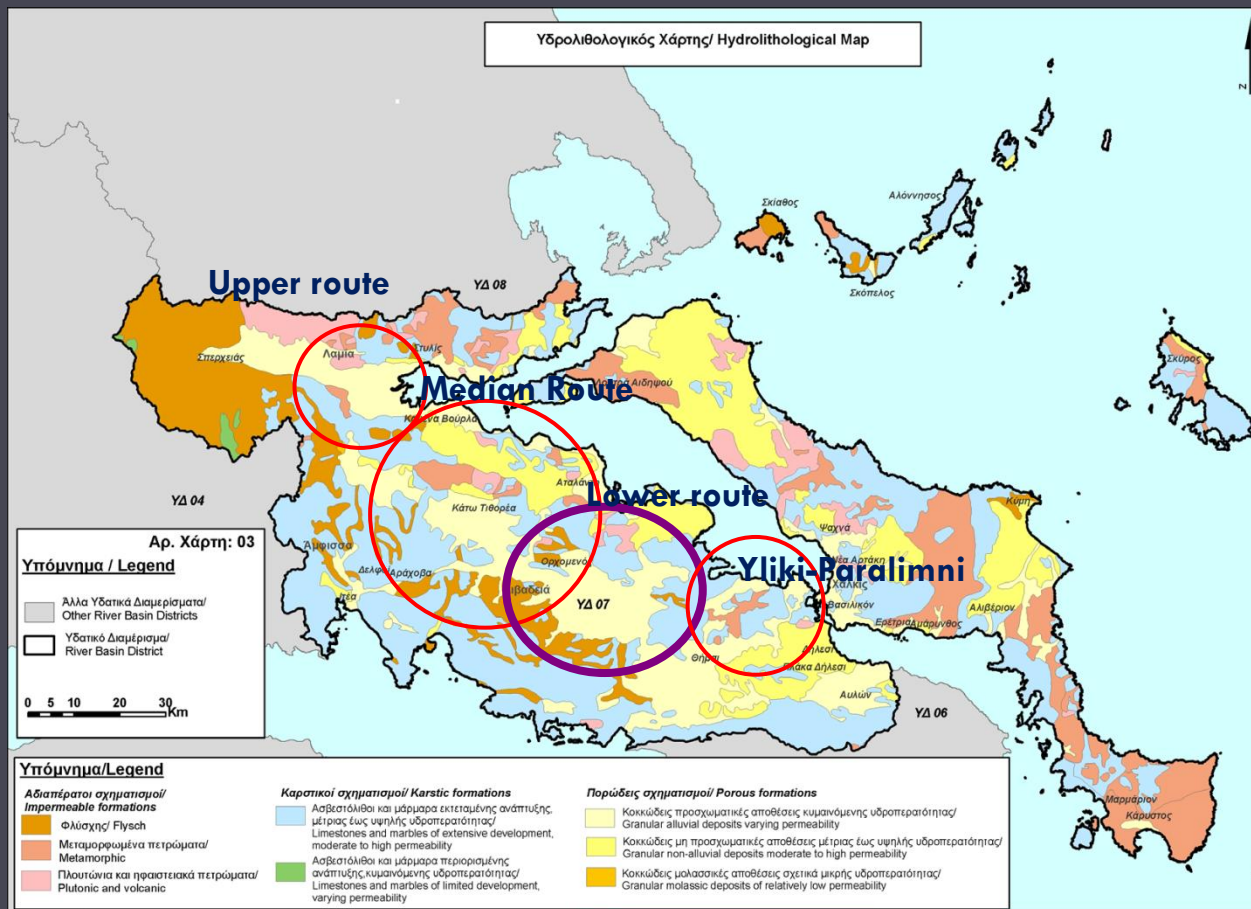
- **Viotikos Kifissos Basin** belongs to the Greek Water District GR 07 which embraces totally 7 main River basins



**Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status**

VIOTIKOS KIFISSOS BASIN / hydrolithology

Dominant hydrolithological units of VKB include: a) Flysch (impermeable), b) Metamorphic rocks (impermeable), c) Limestones frequently karstified (Permeable), and d) Granular alluvial depositions (semi-permeable)



**Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status**

VIOTIKOS KIFISSOS BASIN / hydrology

- The dominant hydrological feature is **Viotikos Kifissos River** that originates from Mt. Parnassus and ends through an artificial tunnel at Yliki Lake
- Secondary features include **Melas river** and the dense **collective irrigation-drainage network** of Copais plain



Water resources of Viotikos Kifissos basin:
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VIOTIKOS KIFISSOS BASIN / hydrogeology

- General groundwater flow along the parts of VKB is heading from NW to SE
- Copais plain is recharged by the lateral crossflows of the Median Route and the hydraulic connections with Mt. Parnassus (SW) and Mt. Helikonas (S)



Water resources of Viotikos Kifissos basin:
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VIOTIKOS KIFISSOS BASIN / hydrogeology

- Groundwater flows mainly through the **extended karstic massif** that connects the adjacent routes of VKB
- At the plain parts of the basin **shallow alluvial aquifers** exist with significantly smaller potential compared to the karst, still important as a buffer zone (hydrologically and in terms of pollution migration)



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VIOTIKOS KIFISSOS BASIN / hydrogeology

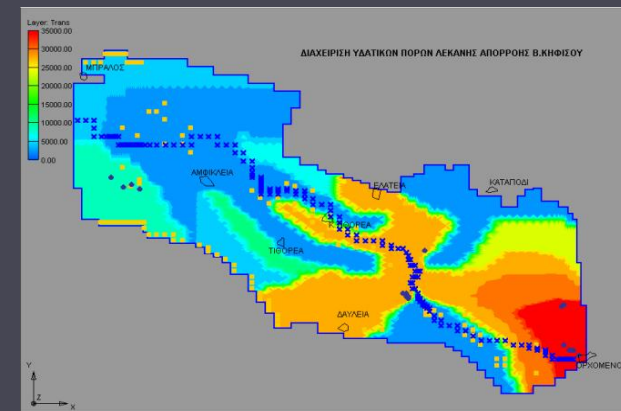
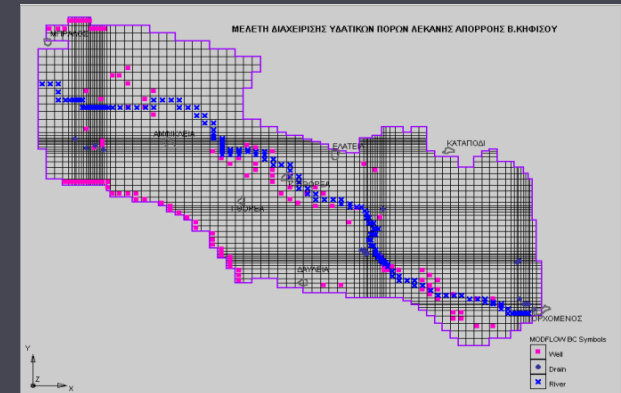
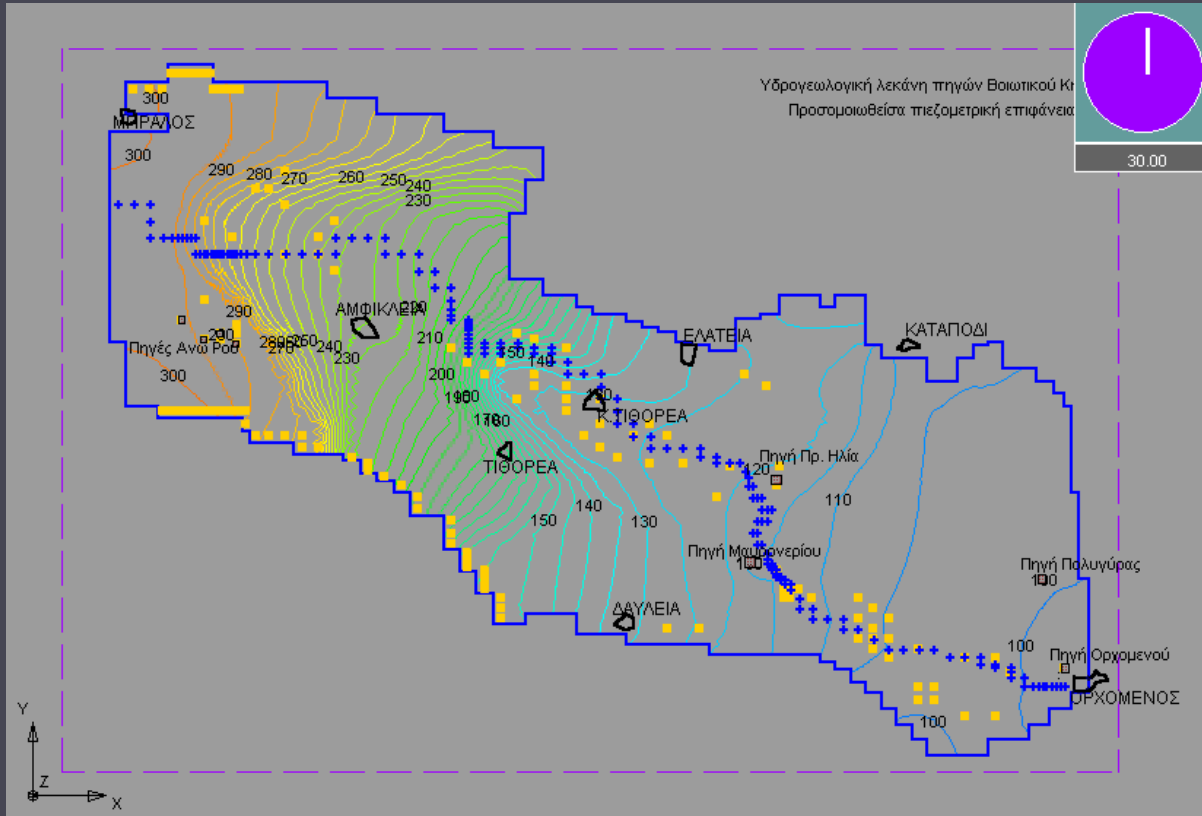
- Groundwater **outflows** Copais plain through three main routes:
 - NNE towards **Euboic Gulf** through Larymna city,
 - E towards **Euboic Gulf** through the extended karstic network of **katavothraes**,
 - SE towards **Vayia plain**



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VIOTIKOS KIFISSOS BASIN / brief literature review

Application of MODFLOW mathematical simulation in a karstic aquifer. The case of Viotikos Kifissos River Basin (Panagopoulos et al. 2004)



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VIOTIKOS KIFISSOS BASIN / brief literature review

Environmental and hydrogeochemical study of eastern Copais – Yliki plain and aquifer vulnerability assessment with the use of Geo-informatics (Tziritis, 2008)

Groundwater and soil geochemistry of Eastern Copais region, (Beotia, central Greece) (Tziritis, 2009)

Main environmental pressures of eastern Copais plain

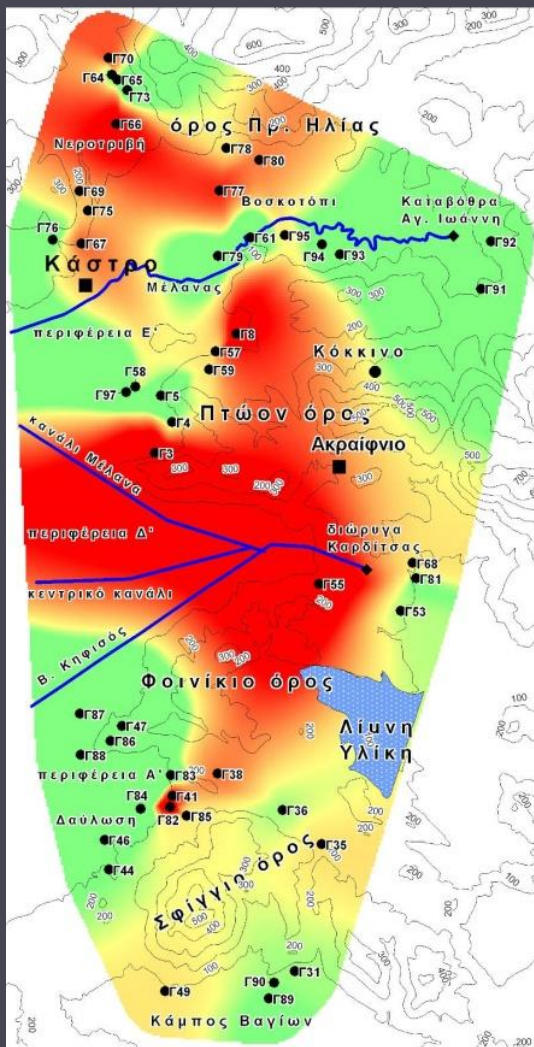
- Elevated values of Ni and Cr due to natural (geogenic) sources of the substrate
- Elevated values of NO₃ due to irrational fertilization practices
- Early signs of salinization due to overexploitation of boreholes at the SE part
- Elevated values of Fe and Mn due to redox conditions



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VIOTIKOS KIFISSOS BASIN / brief literature review

Simulation of NO₃ spatial distribution (karstic aquifer)



Based on geological data as well as from classic chemical analyses and stable isotopes, the main NO₃ load of the karstic aquifer is transferred from the Median Route of VKB (Tziritis, 2009)

NO ₃ mg/L	
<25	Green
25-50	Yellow
>50	Red

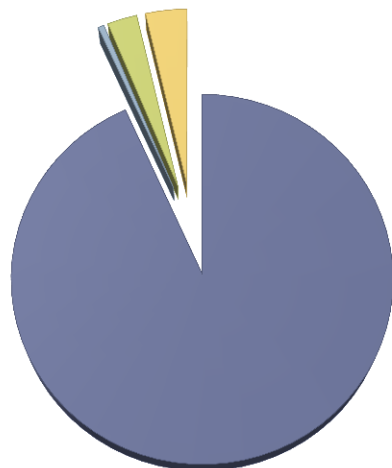


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VIOTIKOS KIFISSOS BASIN / brief literature review

Water Resources Management Plan (Special Secretariat for Water Resources)

% Water Use in VKB



385x10⁶ m³ Total

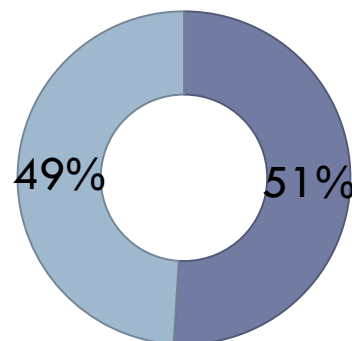
■ Irrigation (93.2%)

■ livestock (0.5%)

■ drinking (2.6)

■ Industry (3.6)

% Sources used for irrigation water in VKB



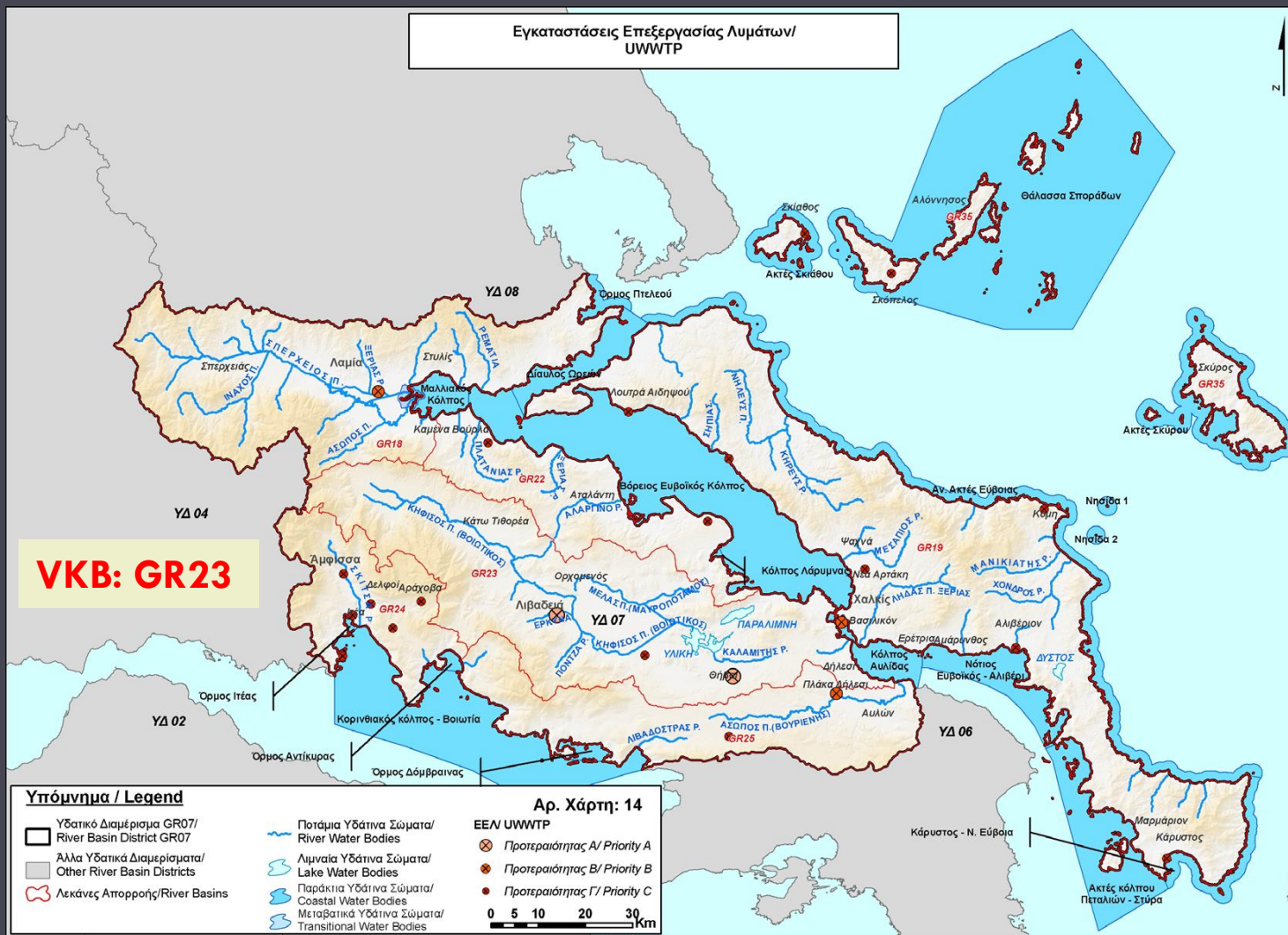
■ Surface water

■ Groundwater



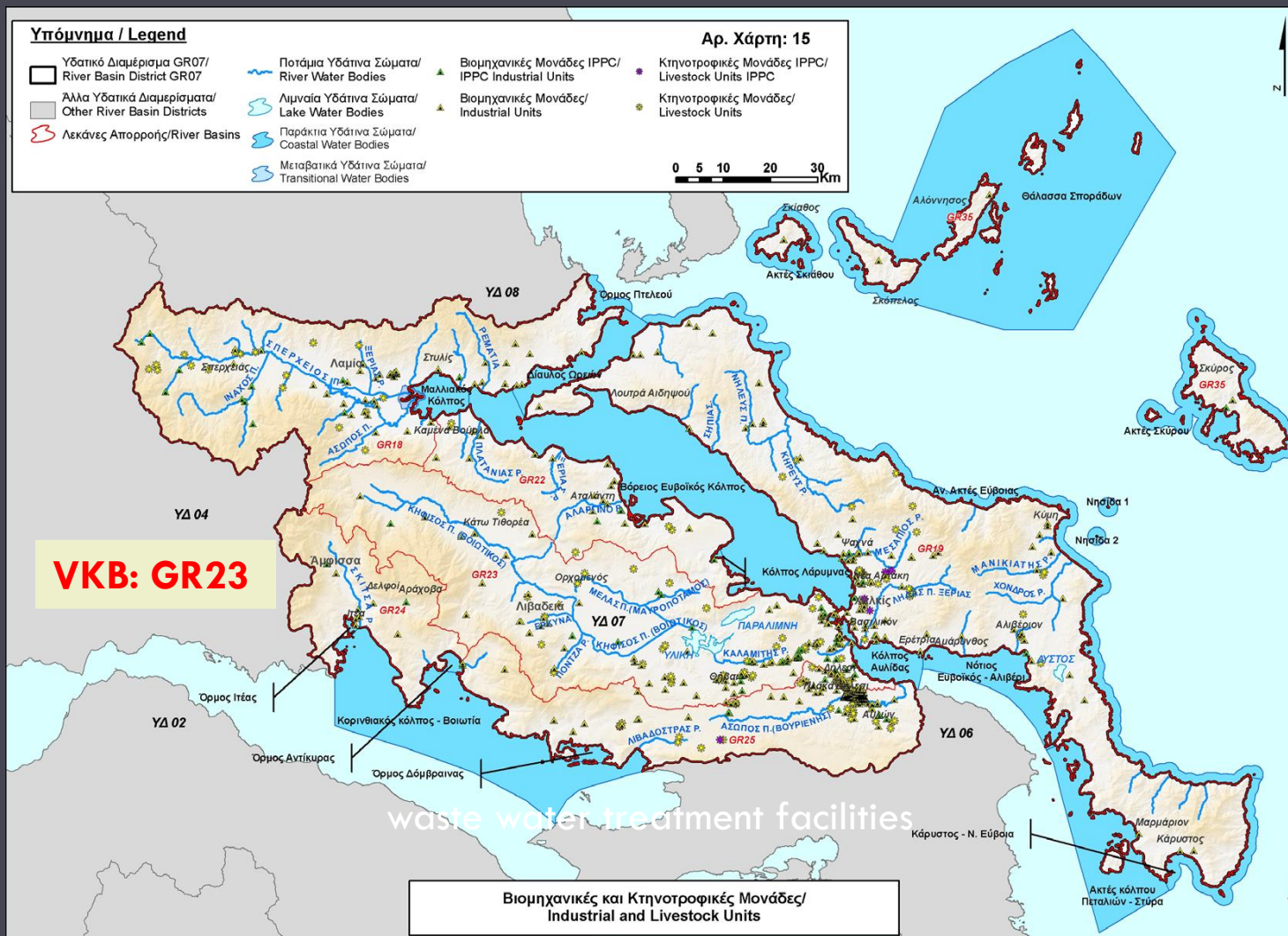
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VIOTIKOS KIFISSOS BASIN / Potential environmental pressures



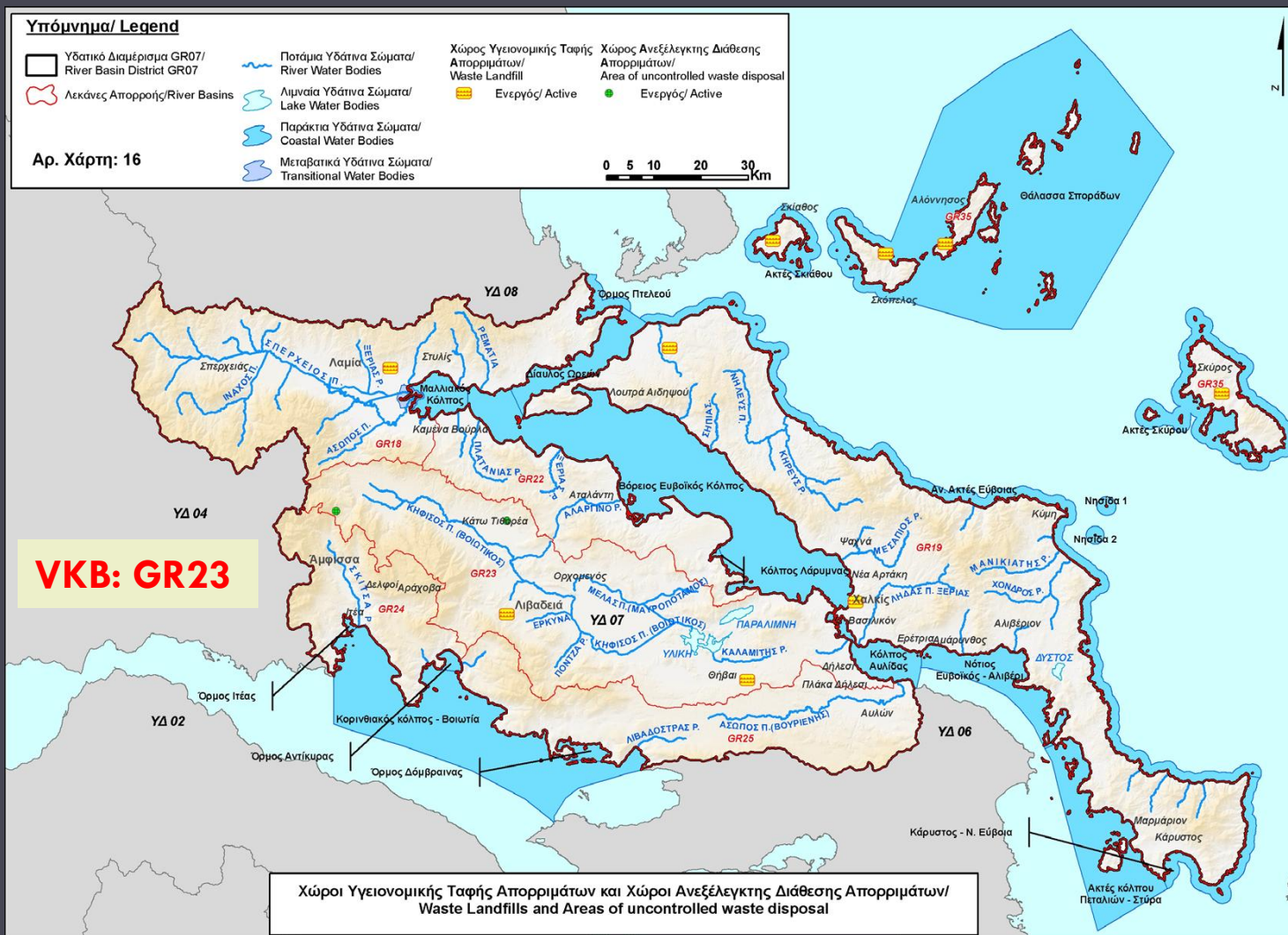
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VIOTIKOS KIFISSOS BASIN / Potential environmental pressures



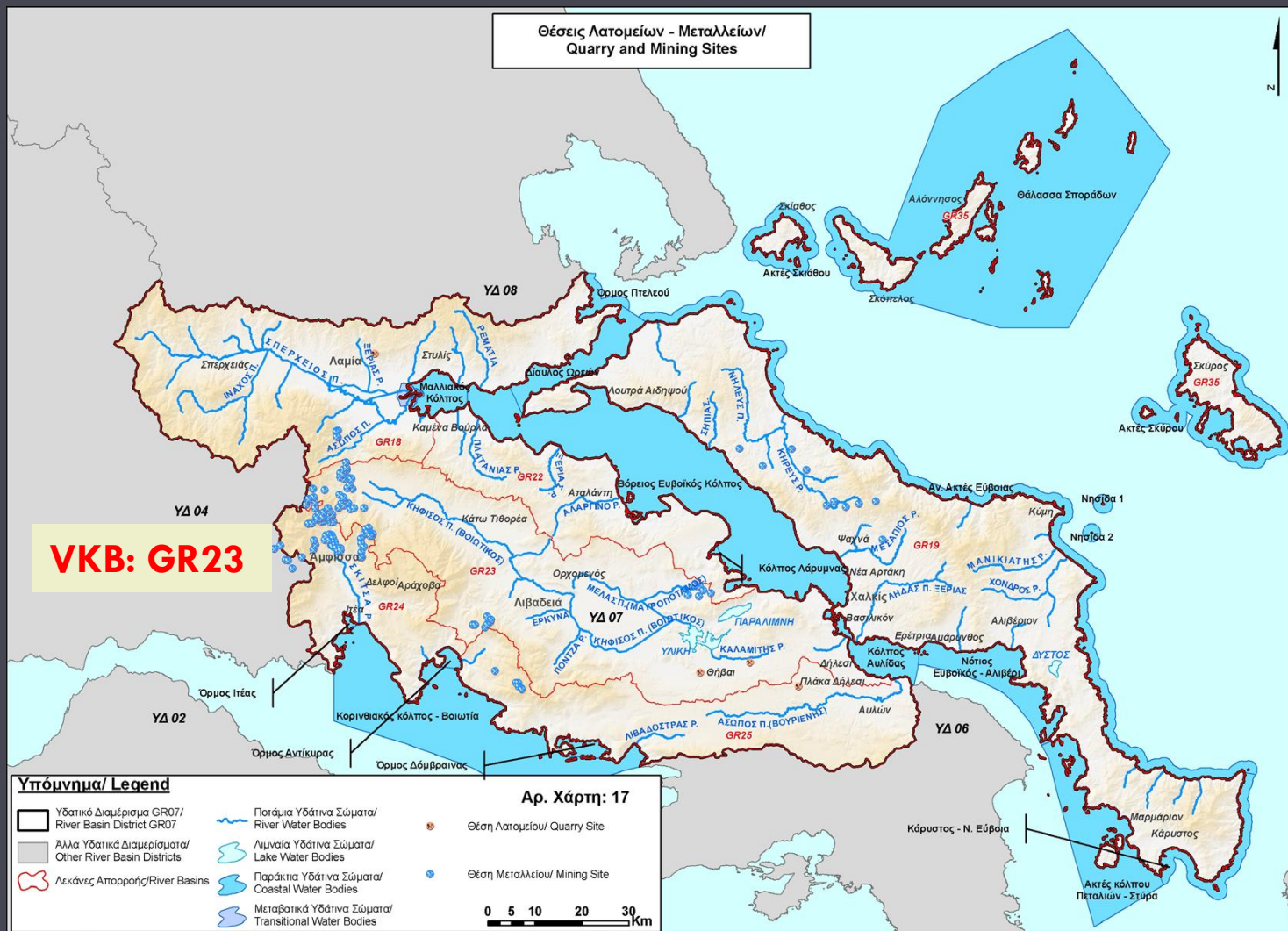
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ΒΙΟΤΙΚΟΣ ΚΙΦΙΣΣΟΣ BASIN / Potential environmental pressures



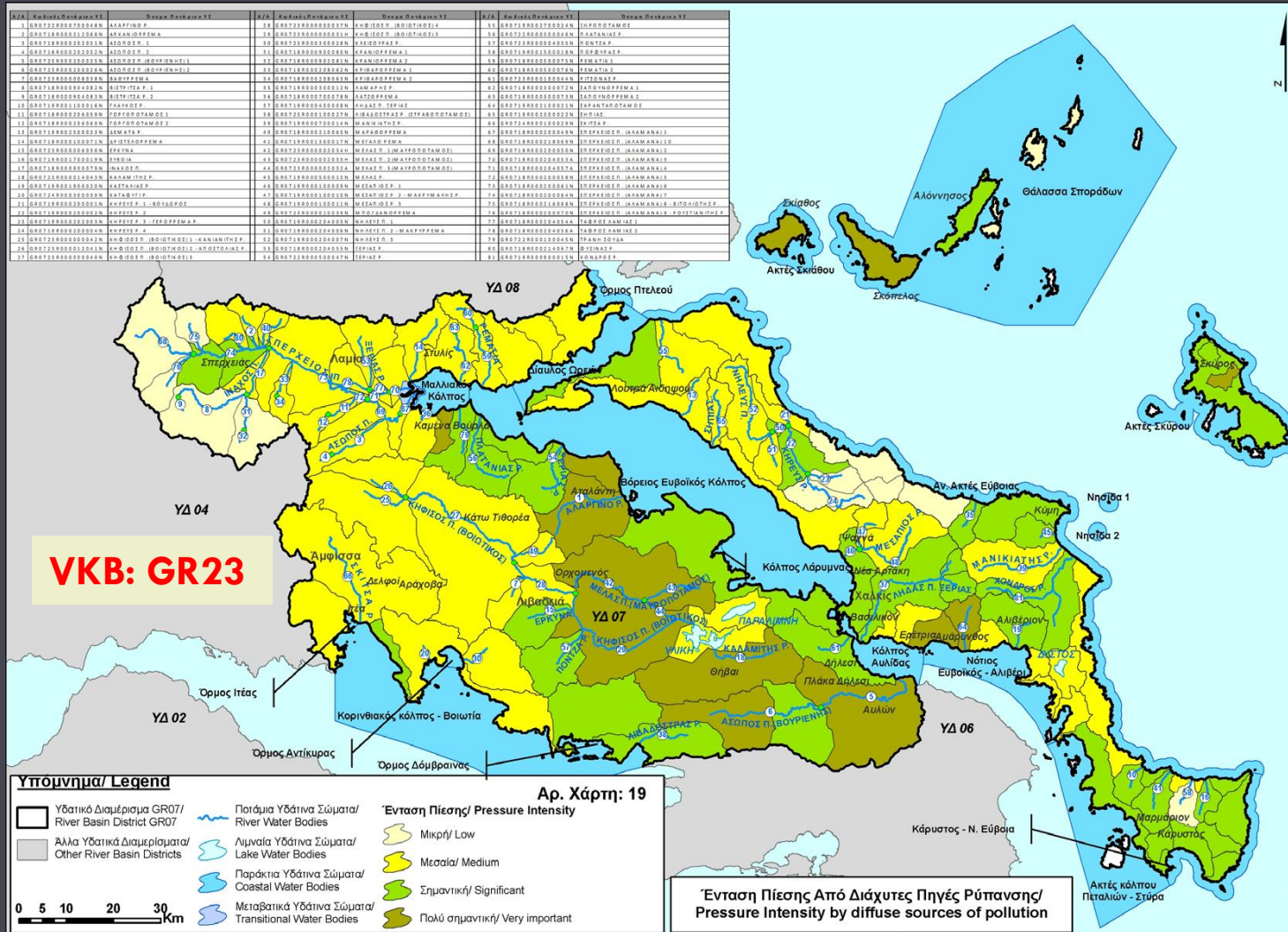
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VIOTIKOS KIFISSOS BASIN / Potential environmental pressures



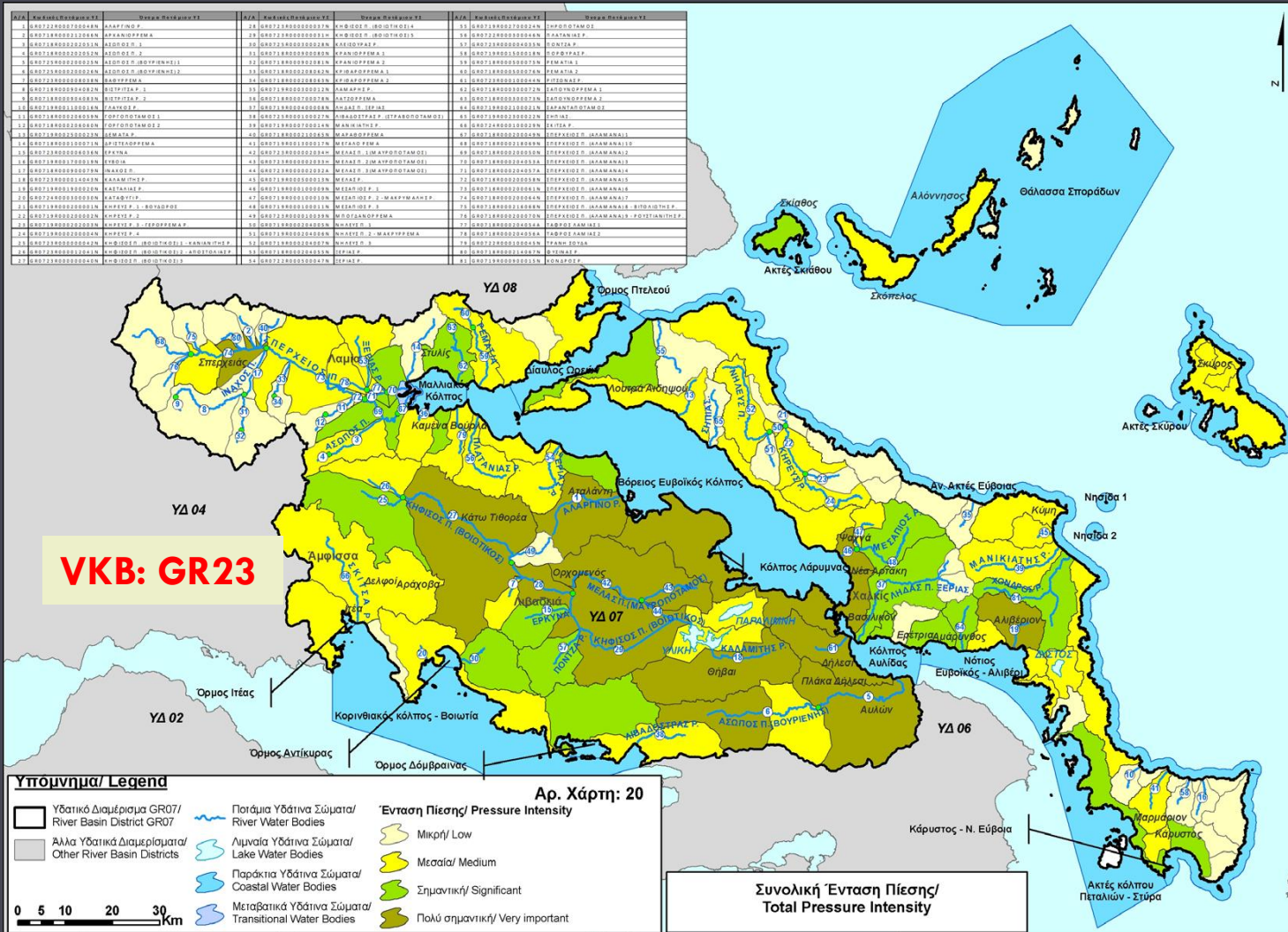
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VIOTIKOS KIFISSOS BASIN / Potential environmental pressures



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Water resources of Viotikos Kifissos basin: Hydrogeological setup, evolution, threats and environmental status

VIOTIKOS KIFISSOS BASIN / Potential environmental pressures

Κωδικός/Υπόγειο Υδατικό Συστήματα	Όνομα Υπόγειο Υδατικό Συστήματος	Κωδικός/Υπόγειο Υδατικό Συστήματα	Όνομα Υπόγειο Υδατικό Συστήματος
GR0700016	Αντιπάρκοι Τριφυλίας - Βόρειοι - Ορει.	GR0700246	Παύλιος
GR0700019	Ζήφυρος - Μεταμόρφω.	GR0700250	Ταξιάρχος (Πορτ. Αδελφού)
GR0700039	Καλαμάκι - Σουδαία	GR0700259	Σταυρού - Αγίου
GR0700040	Πλακιάς	GR0700270	Βασιλική - Νησί
GR0700045	Βασιλική	GR0700285	Μακρυδάκι
GR0700046	Μέγιστος - Καλαμάκι	GR0700290	Αρδάνης
GR0700070	Καλαμάκι	GR0700300	Παχυντή - Νησί
GR0700080	Αντιπάρκοι	GR0700310	Μακρυδάκι - Γρηγορίου
GR0700090	Ανατολική Πύλη - Βασιλική - Καλαμάκι	GR0700320	Μακρυδάκι - Σουδαία
GR0700100	Καλαμάκι - Καλαμάκι - Ορεινό - Βασιλική	GR0700330	Μέγιστος
GR0700110	Μακρυδάκι	GR0700340	Κόρινθος - Αρδάνης
GR0700120	Γαλακτώ	GR0700350	Αρδάνης - Νησί - Κόρινθος
GR0700130	Βασιλική	GR0700360	Κόρινθος
GR0700140	Γαλακτώ	GR0700370	Μέγιστος - Κόρινθος
GR0700150	Παχυντή	GR0700380	Κόρινθος - Κόρινθος
GR0700160	Αρδάνης	GR0700390	Βασιλική - Σουδαία
GR0700170	Παχυντή	GR0700400	Μέγιστος - Νησί
GR0700180	Καλαμάκι - Βασιλική - Κόρινθος	GR0700410	Κόρινθος - Κόρινθος
GR0700190	Μέγιστος - Παχυντή	GR0700420	Κόρινθος - Κόρινθος
GR0700200	Μέγιστος	GR0700430	Αρδάνης
GR0700210	Μέγιστος - Αρδάνης - Τριφυλίας	GR0700440	Μέγιστος - Σουδαία
GR0700220	Μέγιστος - Αρδάνης	GR0700450	Μέγιστος - Κόρινθος
GR0700230	Αρδάνης - Κόρινθος	GR0700460	Μέγιστος - Κόρινθος

Υπόγεια Υδατικά Συστήματα - Πιέσεις (Σημειακές & Διάχυτες)/
Groundwater Bodies - Pressures (Point & Diffuse)



VKB: GR23

Υπόμνημα / Legend

- Υδατικό Διαμέρισμα/ River Basin District
- Άλλα Υδατικά Διαμερίσματα/ Other River Basin Districts
- Θέση Λατομείου/ Quarry Site
- Θέση Μεταλλείου/ Mining Site
- Χώρος Υγειονομικής Ταφής Απορριμάτων/Waste Landfill
- Ενεργός/ Active
- Χώρος Ανεξέλεγκτης Διάθεσης Απορριμάτων/ Area of uncontrolled waste disposal
- Ενεργός/ Active

Αρ. Χάρτη: 22

0 5 10 20 30 Km

- Κινητοτροφικές Μονάδες IPPC/ Livestock Units IPPC
- Κινητοτροφικές Μονάδες/ Livestock Units
- Βιομηχανικές Μονάδες IPPC/ IPPC Industrial Units
- Βιομηχανικές Μονάδες/ Industrial Units
- Καλλιέργειες/ Irrigated land



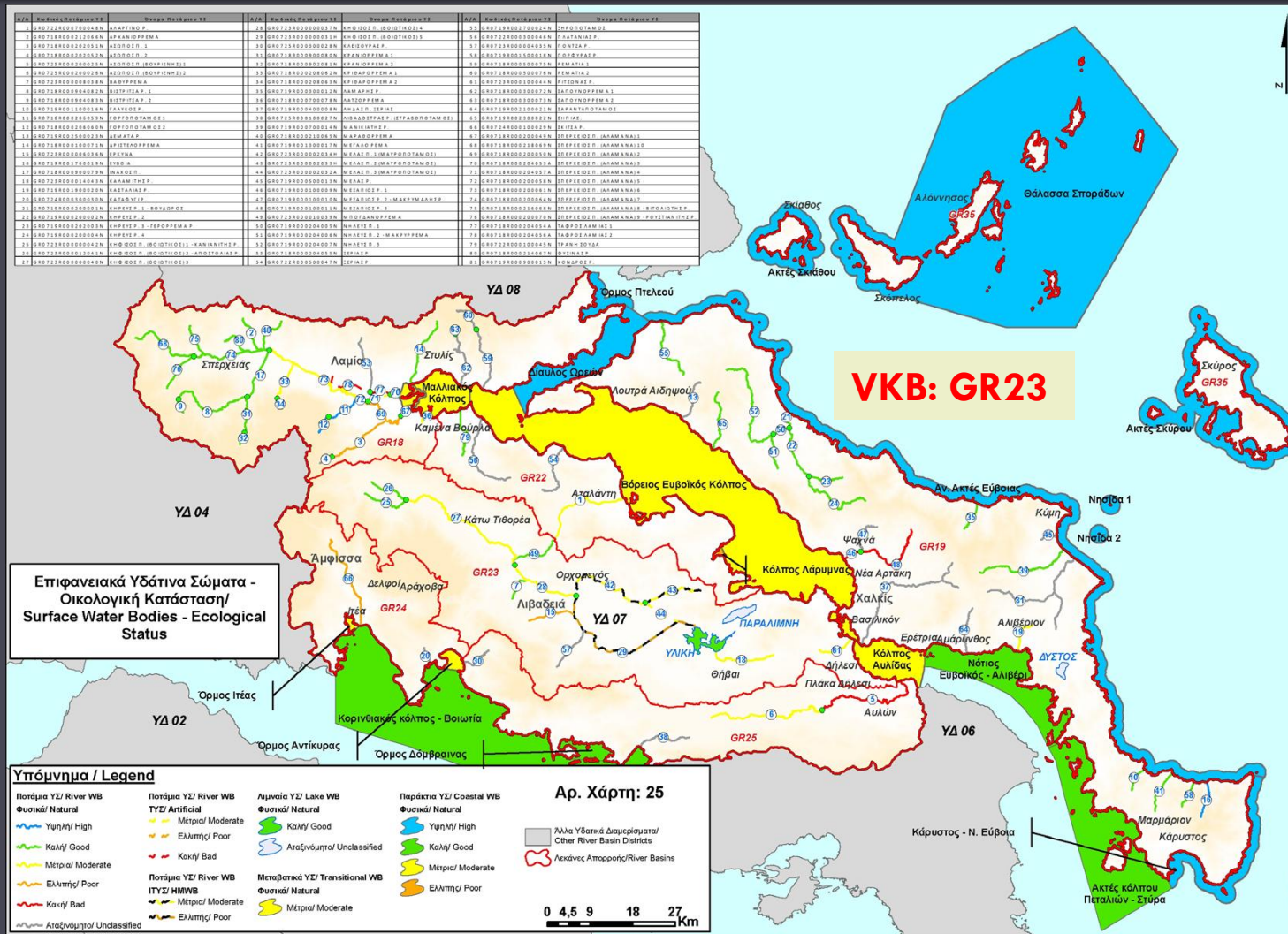
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Outline:

- Runoff from cultivation areas and livestock contributes significantly to environmental pollution
- Significant contribution of organic load, N and P
- Mainly diffuse (non-point) sources of pollution
- Overexploitation of groundwater resources leading to water deficiency and deterioration of water quality

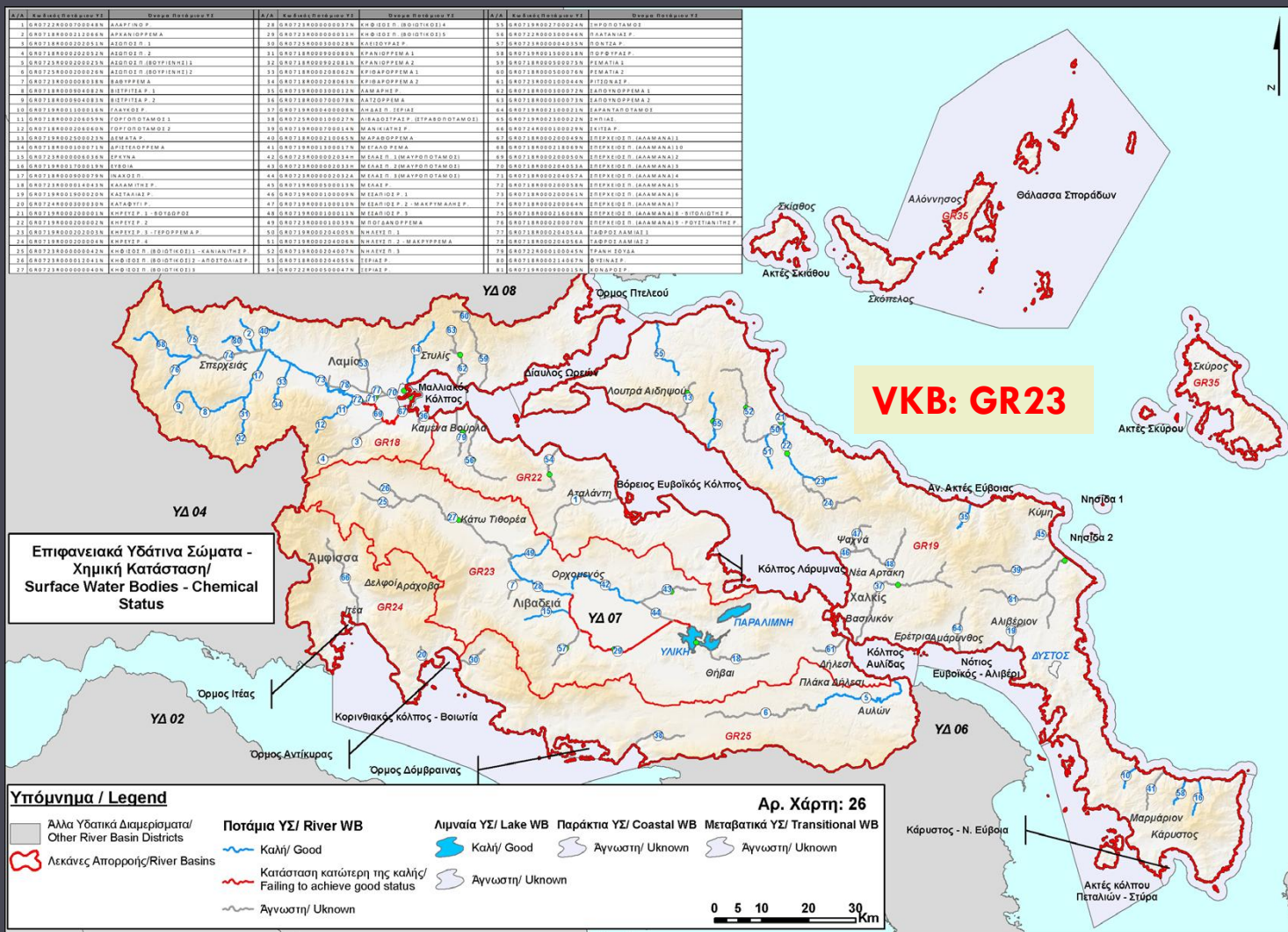


VIOTIKOS KIFISSOS BASIN / Assessment of water system's status



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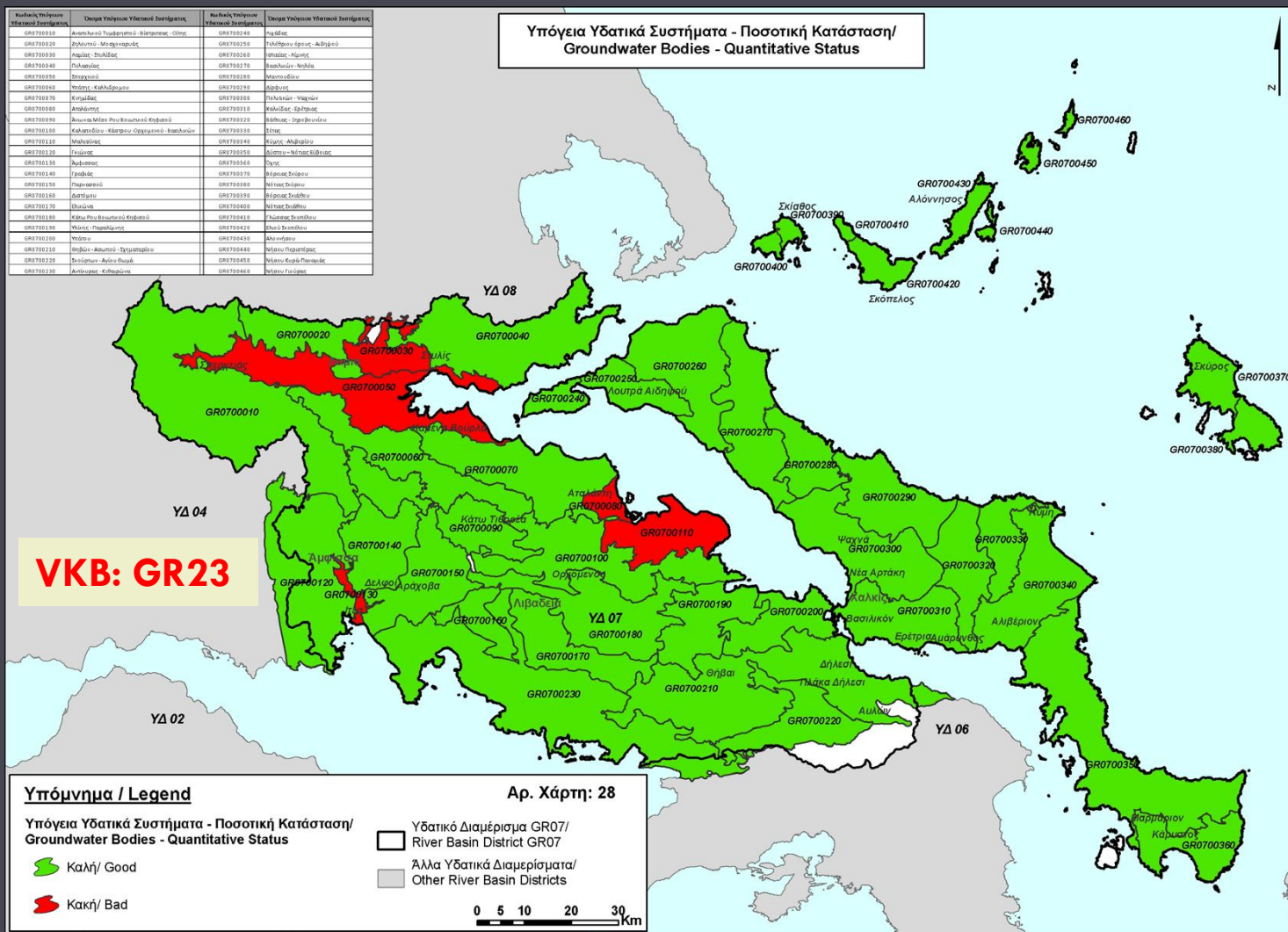
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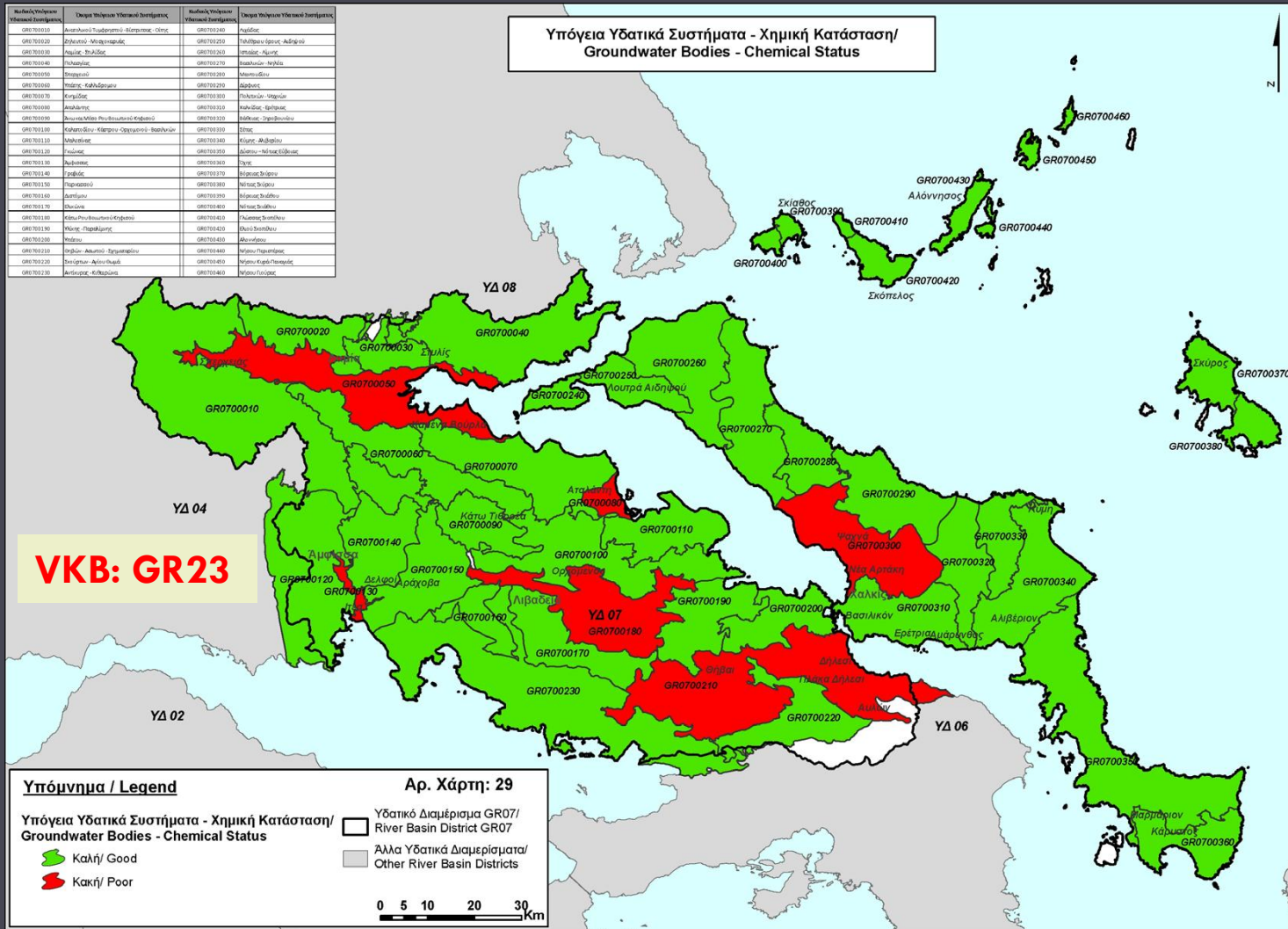
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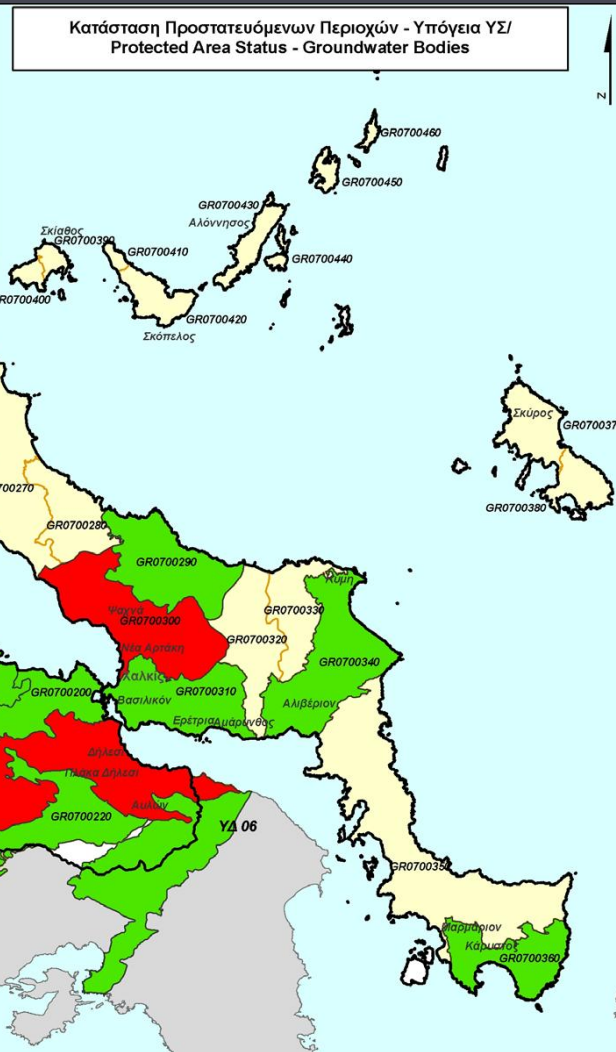
Κωδικός Υπόγειου Υδατικού Συστήματος	Όνομα Υπόγειου Υδατικού Συστήματος	Κωδικός Υπόγειου Υδατικού Συστήματος	Όνομα Υπόγειου Υδατικού Συστήματος
GR0700000	Ανατολικό Σαλαμίνα - Αδριατική - Ορεινή	GR0700000	Παλιός
GR0700020	Στάγειο - Μεσοπεδία	GR0700200	Πάπινα - Γόρτσι - Αδριατική
GR0700030	Καλαμάρι - Στάγειο	GR0700300	Στάγειο - Αλιανή
GR0700040	Πυλαία	GR0700400	Βασιλική - Αλιανή
GR0700050	Σταγιάδα	GR0700500	Ανατολική
GR0700060	Καλαμάρι - ΚΑΔΑΡΕΙΟΝ	GR0700600	Στάγειο
GR0700070	Καλαμάρι	GR0700700	Παλιός - Αλιανή
GR0700080	Ανατολική	GR0700800	Καλαμάρι - Αλιανή
GR0700090	Καλαμάρι - Πυλαία - Αδριατική - ΚΑΔΑΡΕΙΟΝ	GR0700900	Καλαμάρι - Αλιανή
GR0700100	Καλαμάρι - Αδριατική - Στάγειο - Αλιανή	GR0700100	Στάγειο
GR0700110	Καλαμάρι	GR0700110	Καλαμάρι - Αλιανή
GR0700120	Καλαμάρι	GR0700120	Καλαμάρι - Αλιανή
GR0700130	Καλαμάρι	GR0700130	Καλαμάρι - Αλιανή
GR0700140	Καλαμάρι	GR0700140	Καλαμάρι - Αλιανή
GR0700150	Καλαμάρι	GR0700150	Καλαμάρι - Αλιανή
GR0700160	Καλαμάρι	GR0700160	Καλαμάρι - Αλιανή
GR0700170	Καλαμάρι	GR0700170	Καλαμάρι - Αλιανή
GR0700180	Καλαμάρι	GR0700180	Καλαμάρι - Αλιανή
GR0700190	Καλαμάρι	GR0700190	Καλαμάρι - Αλιανή
GR0700200	Καλαμάρι	GR0700200	Καλαμάρι - Αλιανή
GR0700210	Καλαμάρι	GR0700210	Καλαμάρι - Αλιανή
GR0700220	Καλαμάρι	GR0700220	Καλαμάρι - Αλιανή
GR0700230	Καλαμάρι	GR0700230	Καλαμάρι - Αλιανή
GR0700240	Καλαμάρι	GR0700240	Καλαμάρι - Αλιανή
GR0700250	Καλαμάρι	GR0700250	Καλαμάρι - Αλιανή
GR0700260	Καλαμάρι	GR0700260	Καλαμάρι - Αλιανή
GR0700270	Καλαμάρι	GR0700270	Καλαμάρι - Αλιανή
GR0700280	Καλαμάρι	GR0700280	Καλαμάρι - Αλιανή
GR0700290	Καλαμάρι	GR0700290	Καλαμάρι - Αλιανή
GR0700300	Καλαμάρι	GR0700300	Καλαμάρι - Αλιανή
GR0700310	Καλαμάρι	GR0700310	Καλαμάρι - Αλιανή
GR0700320	Καλαμάρι	GR0700320	Καλαμάρι - Αλιανή
GR0700330	Καλαμάρι	GR0700330	Καλαμάρι - Αλιανή
GR0700340	Καλαμάρι	GR0700340	Καλαμάρι - Αλιανή
GR0700350	Καλαμάρι	GR0700350	Καλαμάρι - Αλιανή
GR0700360	Καλαμάρι	GR0700360	Καλαμάρι - Αλιανή
GR0700370	Καλαμάρι	GR0700370	Καλαμάρι - Αλιανή
GR0700380	Καλαμάρι	GR0700380	Καλαμάρι - Αλιανή
GR0700390	Καλαμάρι	GR0700390	Καλαμάρι - Αλιανή
GR0700400	Καλαμάρι	GR0700400	Καλαμάρι - Αλιανή
GR0700410	Καλαμάρι	GR0700410	Καλαμάρι - Αλιανή
GR0700420	Καλαμάρι	GR0700420	Καλαμάρι - Αλιανή
GR0700430	Καλαμάρι	GR0700430	Καλαμάρι - Αλιανή
GR0700440	Καλαμάρι	GR0700440	Καλαμάρι - Αλιανή
GR0700450	Καλαμάρι	GR0700450	Καλαμάρι - Αλιανή
GR0700460	Καλαμάρι	GR0700460	Καλαμάρι - Αλιανή



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VIOTIKOS KIFISSOS BASIN / Assessment of water system's status

Κωδικός ΥΣ	Όνομα ΥΣ	Κωδικός ΥΣ	Όνομα ΥΣ
GR0600080	Βαλκής Πάρνηθας	GR0700200	Υπάτου
GR0700010	Ανατολικού Τυμφρηστού - Βιοτρίτσας - Οίτης	GR0700210	Θηβών - Ασωπού - Σχηματρίου
GR0700020	Σύστημα Ζηλευτού - Μοσχοκαρυάς	GR0700160	Διστόμου
GR0700030	Λαμίας - Στυλιδας	GR0700220	Σκοούρων - Αγίου Θωμά
GR0700040	Σύστημα Πελασγίας	GR0700170	Ελικώνα
GR0700050	Σύστημα Σπερχειού	GR0700180	Κάτω Ρου Βοιωτικού Κηφισού
GR0700060	Υπάτης - Καλλιόδρου	GR0700230	Αντικυρας - Κίθαιρανα
GR0700070	Κνημιάς	GR0700250	Τελέθριου όρους - Αιδηψού
GR0700080	Σύστημα Αταλάντης	GR0700190	Υλίκης - Παραλιμνής
GR0700090	Άνω και Μέσο Ρου Βοιωτικού Κηφισού	GR0700260	Ιστιαίας - Λιμνής
GR0700100	Καλαποδίου - Καστρού - Ορχομενού - Βασιλικών	GR0700290	Δίρφους
GR0700110	Μαλεσίνας	GR0700300	Πολιτικών - Ψαχνών
GR0700120	Γκιώνας	GR0700310	Χαλκίδας - Ερέτριας
GR0700130	Αμφισσας	GR0700340	Κύμης - Αλιβερίου
GR0700140	Γραβιάς	GR0700360	Όχης
GR0700150	Παρνασσού		



Υπόμνημα/ Legend

Κατάσταση Υπόγειων ΥΣ που σχετίζονται με Προστατευόμενες Περιοχές / Groundwater Bodies Status associated with Protected Areas

- Καλή/ Good
- Κακή/ Poor

Υπόγεια ΥΣ που δεν σχετίζονται με Προστατευόμενες Περιοχές / Groundwater Bodies not associated with Protected Areas

- Υπόγεια ΥΣ/ Groundwater Bodies

Υδατικό Διαμέρισμα GR07/ River Basin District GR07

Άλλα Υδατικά Διαμερίσματα/ Other River Basin Districts

Αρ. Χάρτη: 31

0 5 10 20 30 Km



Water resources of Viotikos Kifissos basin:
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VIOTIKOS KIFISSOS BASIN / Suggested measures for environmental protection

Water Resources Management Plan (Special Secretariat for Water Resources)

Basic Measures

(Indicative)

- Delineation of buffer zones for the protection of potable water abstraction boreholes/wells
- Determination of criteria for the implementation of abstraction limits per water body
- Data record of the surface water used for multiple purposes (irrigation, drinking, industrial etc) by major consumers (over 10m³/day)
- Installation of water metering systems to record groundwater abstraction
- Investigation of the possibility to perform artificial recharge in order to improve groundwater quality and quantity
- Compilation of a data base with the potential pollution sources (emissions, discharges and leaching)
- Development of specific tools for the rational and sustainable use of fertilizers and water



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VIOTIKOS KIFISSOS BASIN / Suggested measures for environmental protection

Water Resources Management Plan (Special Secretariat for Water Resources)

Supplementary Measures

(Indicative)

- Rules and limitations for the protection of sinkholes and katavothraes
- Rational management of domestic sewages in residential areas with lack of central sewer system
- Small scale agro-environmental measures for the reduction of nitrate pollution and protection of vulnerable areas
- Rehabilitation of wetlands
- Further monitoring for the characterisation and delineation of water bodies with poor quality due to salinization phenomena
- Modernization and maintenance of irrigation networks
- Reuse of treated effluents (irrigation, industry, parks)
- Public information and awareness for water resources related issues.



**Water resources of Viotikos Kifissos basin:
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ECOPEST



Strategic plan for the adaptation and application of principles for the sustainable use of pesticides in a vulnerable ecosystem



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Hydrogeological setup, evolution, threats and environmental status**

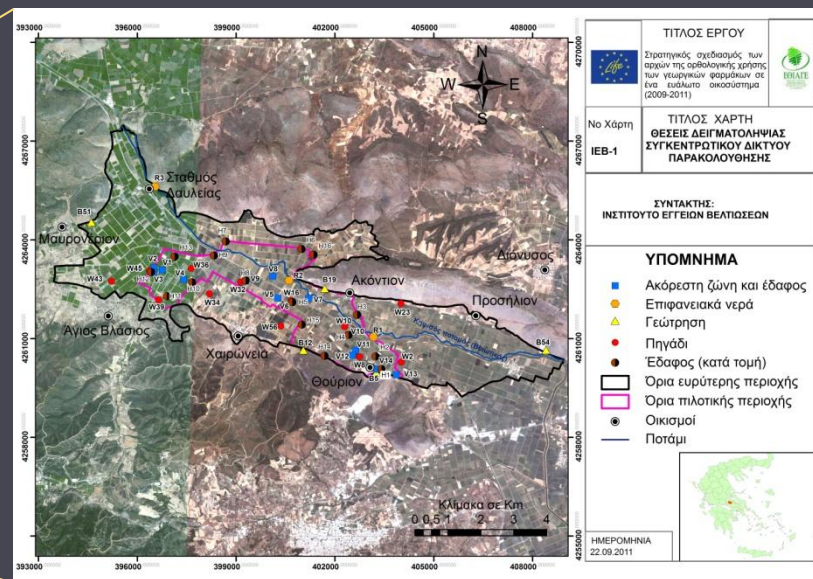
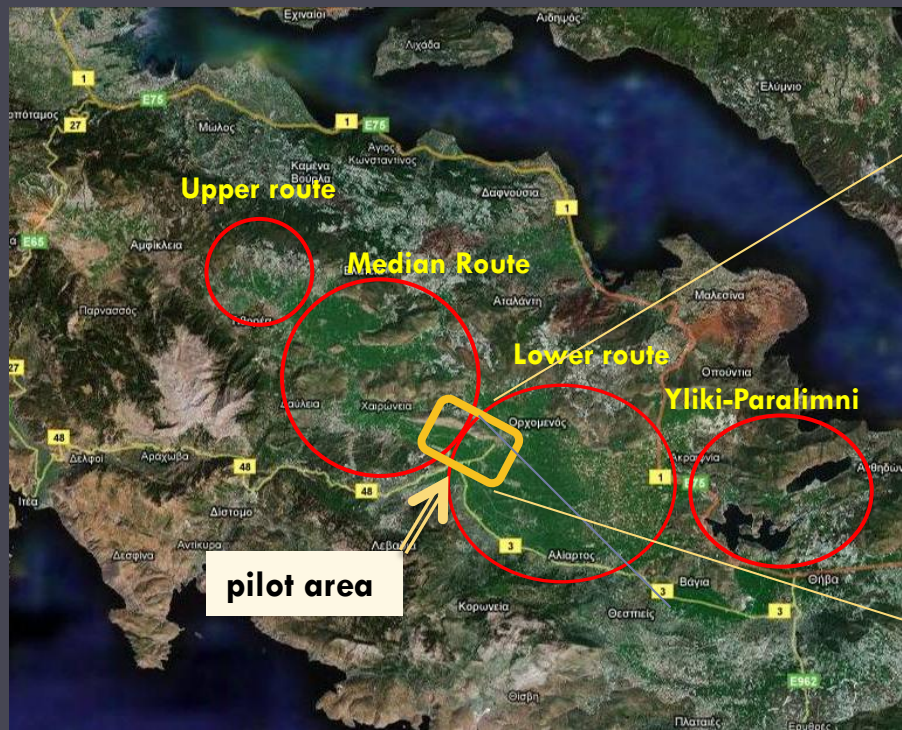
ECOPEST / environmental monitoring goals

- 1. Design and implementation of a monitoring network for soil and water resources (surface water, vadose zone leachates and groundwater)**
- 2. Assessment of current quality conditions of soil and water resources and potential environmental pressures (baseline)**
- 3. Evaluation of changes in the concentrations of potential pollutants, as a result of the strategic planning implementation (Low input Crop Management - LCM)**



**Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status**

ECOPEST / Study area



Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status

ECOPEST/ Preparatory actions

- Natural background values & baseline conditions of critical parameters in water resources
→ Reference sampling
- Documentation of system's setup
→ Lithology, hydrology, hydrogeology, climate etc
- Documentation and impact evaluation of environmental pressures
→ Natural (geogenic) or anthropogenic
- Assessment of alluvial aquifer's susceptibility to pollution from surface released pollutants
→ Calculation of Intrinsic vulnerability

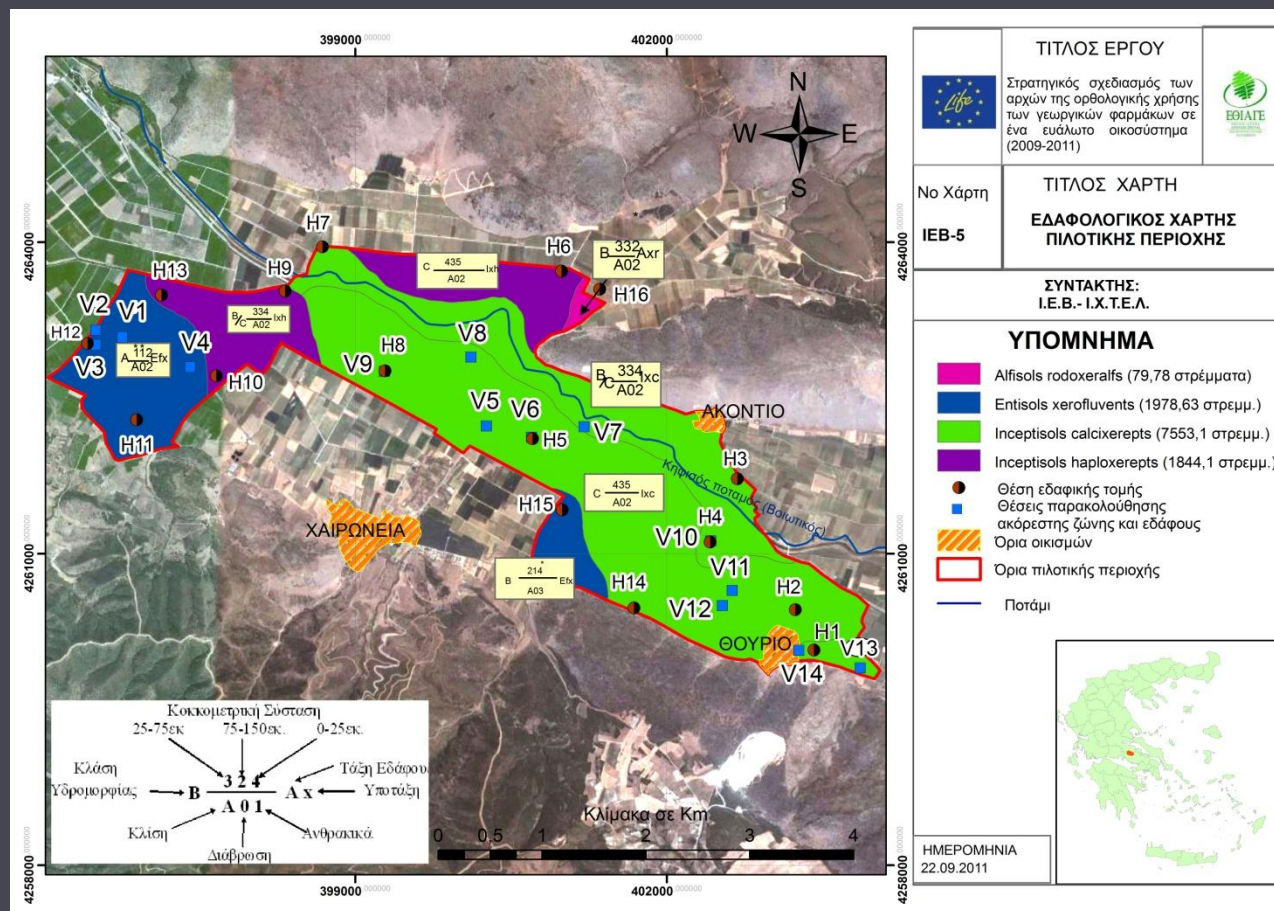


**Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status**

ECOPEST/ Preparatory actions

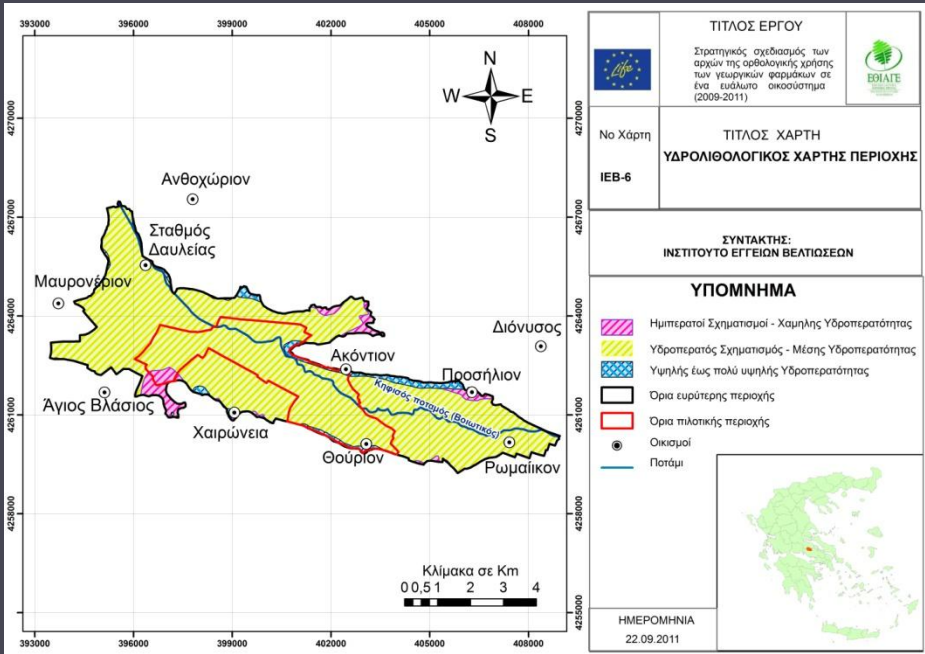
Documentation of the system's setup

Soils

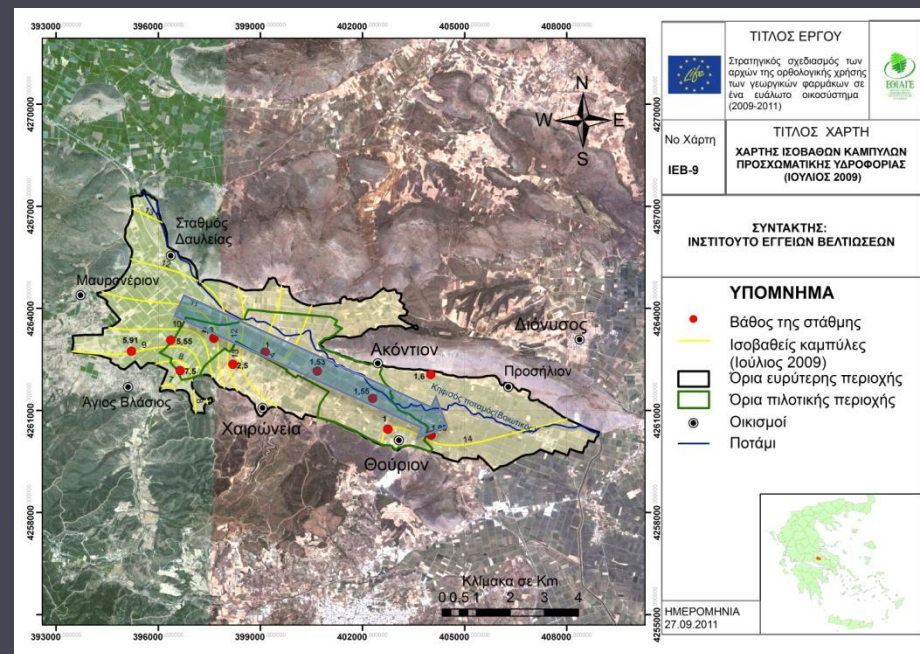


Water resources of Viotikos Kifissos basin:
 Hydrogeological setup, evolution, threats and environmental status

Documentation of system's setup



Hydrology- hydrogeology



ECOPEST/ Preparatory actions

Assessment of alluvial aquifer's susceptibility to pollution from surface released pollutants

Intrinsic aquifer vulnerability

Based on:

D- Depth to Water

R- Net Recharge

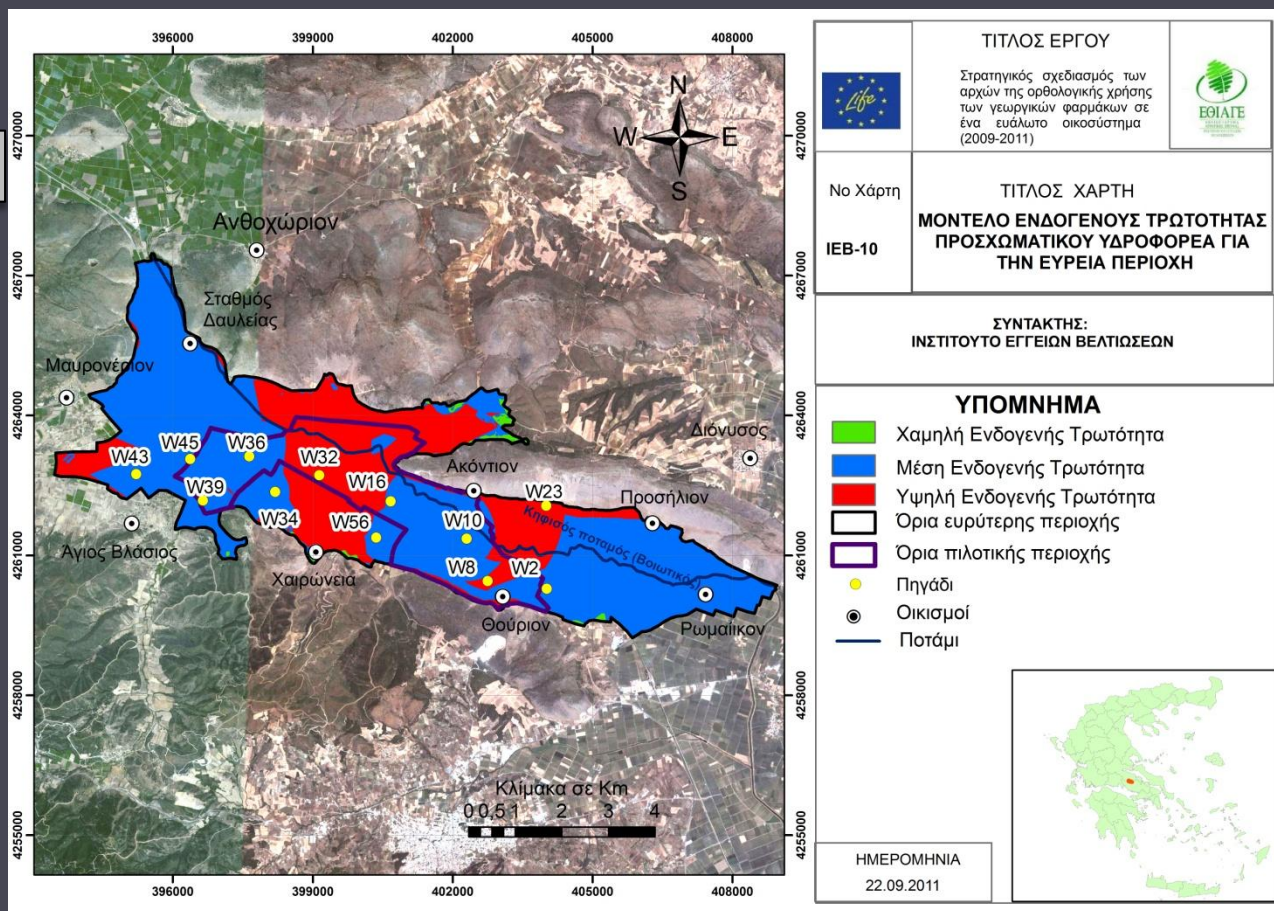
A- Aquifer Media

S- Soils

T- Topography

I- Impact of Vadose Zone

C- Hydraulic Conductivity



Water resources of Viotikos Kifissos basin:
 Hydrogeological setup, evolution, threats and environmental status

ECOPEST / Monitoring network of water systems

- Design of monitoring network based on project requirements and study area's specific characteristics
- The reference monitoring network (2009) is expanded compared with the operational network of 2010 and 2011 which is more focused
- The main goal is the assessment of reference environmental status (prior to project implementation) in order to be compared with the conditions after the implementation of project's actions

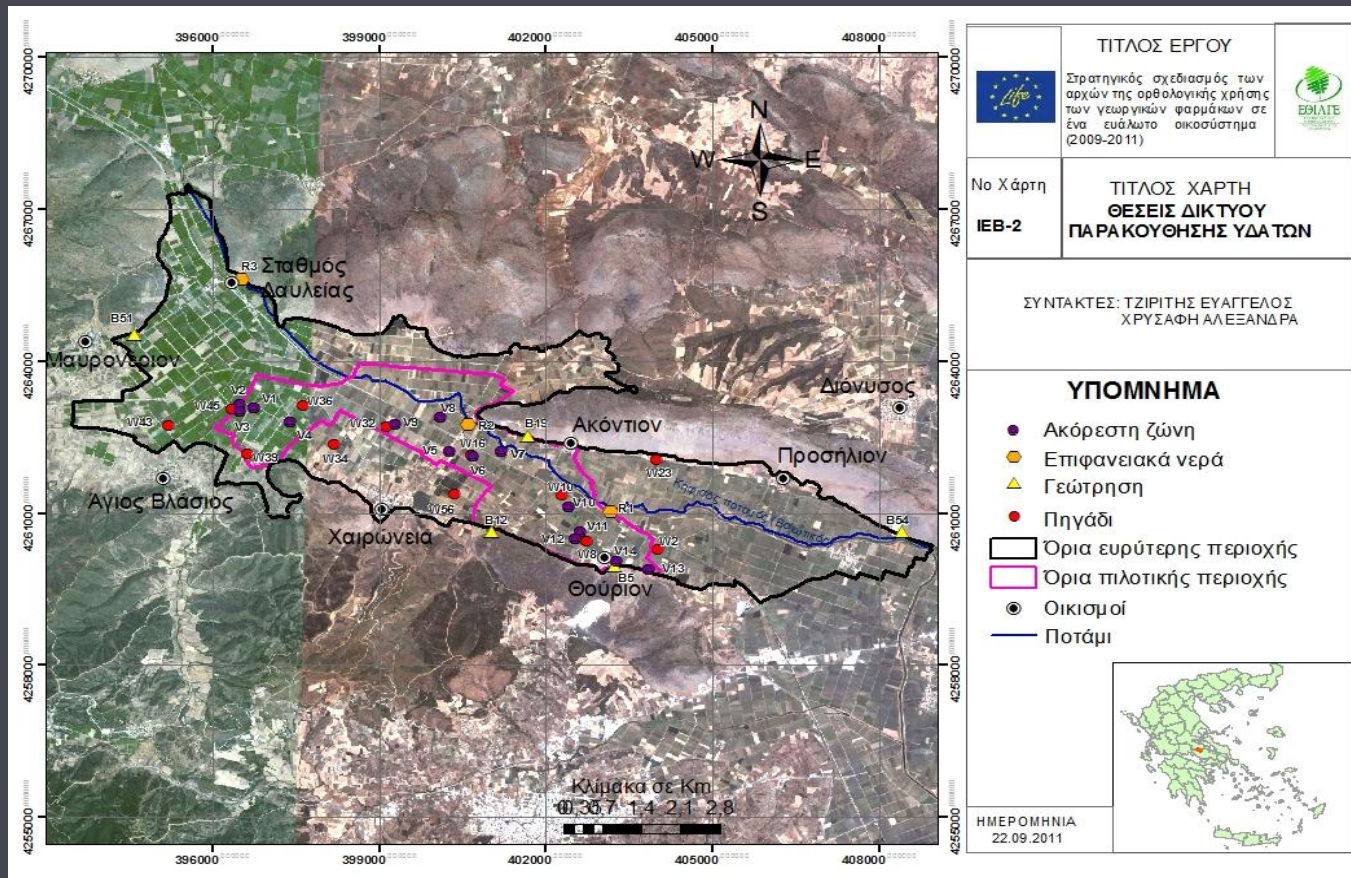
- Due to project's duration, potential noticeable changes in the concentrations of the environmental critical parameters are recorded mainly in the vadose zone leachates, which is the direct receptor of agricultural inputs
- In order to assess the impacts which are related solely to the agricultural activities, the assessment focused on nitrogen compounds (NO_3 and NH_4)



**Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status**

ECOPEST / Monitoring network of water systems

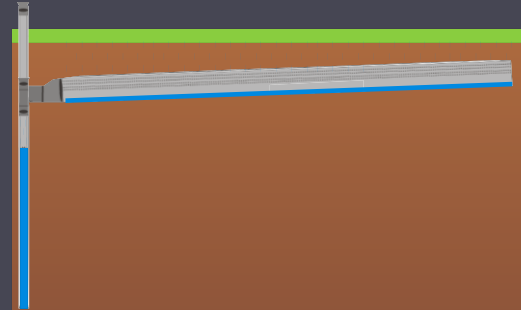
- 3 years of sampling – 2009 (reference), 2010 and 2011
- 4 sampling campaigns per year during wet and dry hydrological periods
- 34 sampling points: 5 in karstic aquifer , 12 in alluvial aquifer, 3 in Viotikos Kifissos River and 14 in the vadose zone of pilot area



Water resources of Viotikos Kifissos basin:
 Hydrogeological setup, evolution, threats and environmental status

ECOPEST / Sampling and analyses

Prototype system for the monitoring of vadose zone leachates



Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status

ECOPEST / Sampling and analyses



vadose zone sampling



Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status

ECOPEST / Sampling and analyses

- Analyses were performed at LRI (inorganic) & BPI (organic)
- Totally 20 parameters were calculated:

-> major and minor ions

NO_3^- , NH_4^+ , SO_4^{2-} , P, Ca^{2+} , Mg^{2+} , Na^+ , K^+ , Cl^- , HCO_3^- and CO_3^{2-}

-> Trace metals

Mn, Ni, Cd, Pb, Cu, Fe και Zn

-> Physico-chemical parameters

(measured in situ by means of portable instruments)

pH and EC



**Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status**

Analyses results/ Viotikos Kifissos River

! The assessment of Viotikos Kifissos River water quality may only be indicative, due to small number of samples (3)

- Good overall quality conditions (across pilot area)
- NO_3 and NH_4 concentrations are low (7.4-11.6 mg/L and 0.13-0.17 mg/L respectively)
- Individual elevated values of heavy metals (e.g. 938 $\mu\text{g/L}$ Mn and 45 $\mu\text{g/L}$ Ni) are considered as outliers related with random events and thus not representative.



**Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status**

Analyses results/ Vadose zone

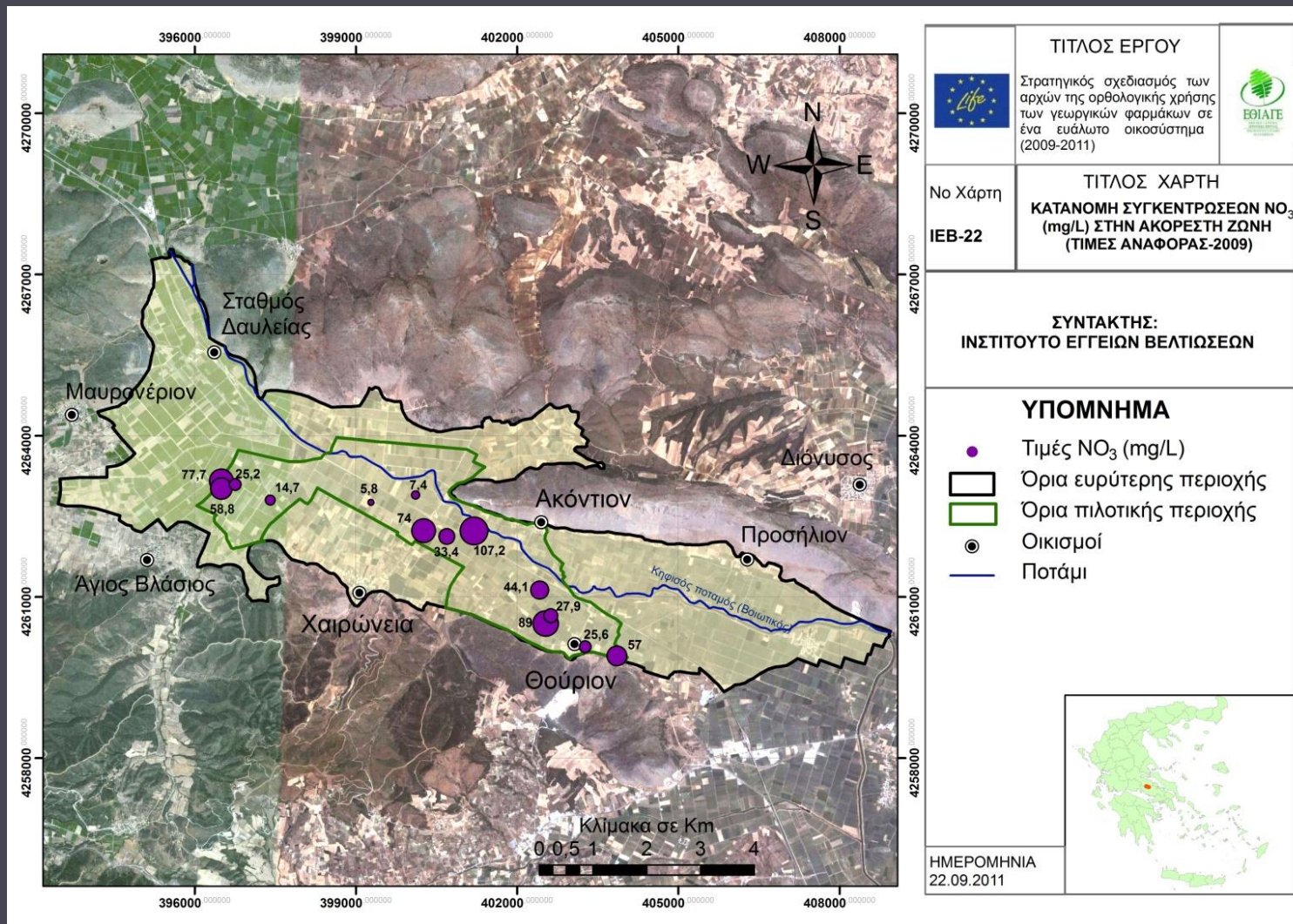
! Vadose zone leachates are considered as the most representative samples to identify the potential effects of the agricultural activities

- Increased MI concentrations due to irrigation water reuse (compared to karstic and alluvial water)
- Impact of the geological substrate, reflected on the elevated values of Mn (9-1134 $\mu\text{g/L}$) και Ni (6-196 $\mu\text{g/L}$)
- Elevated values of NO_3 and NH_4 (5-81 mg/L and 0.3-7.5 mg/L respectively) as a result of irrational agricultural practices
- Elevated values of Pb (3-24 $\mu\text{g/L}$) possibly related with car traffic and/or geogenic factors



**Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status**

Analyses results/ Vadose zone



**Water resources of Viotikos Kifissos basin:
 Hydrogeological setup, evolution, threats and environmental status**

Analyses results/ Alluvial aquifer

! Alluvial aquifer extends beyond the limits of the pilot and the wider area, hence the quality status of groundwater is not exclusively related with the activities within the study area

- Elevated values nitrates and ammonium (10-83 mg/L and 0.1-1.9 mg/L respectively) due to irrational use of N-fertilizers
- Specifically for nitrates, the annual median values of two out of the three monitoring years exceed the maximum parametric limit of 50 mg/L for potable water consumption
- Impact of the geological substrate as documented by elevated values of Mn (0-956 $\mu\text{g/L}$) and Ni (3-92 $\mu\text{g/L}$).



**Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status**

Analyses results/ Karstic aquifer

! The quality status of karstic aquifer cannot be assessed safely due to the small number of samples (5), hence it is only indicative

- Good quality conditions
- Significantly lower concentrations of nitrates and ammonium values compared to the alluvial aquifer
- Low values of Mn and Ni



**Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status**

Trends in surface water quality (2009-2011)

Ions	Trend
HCO ₃	increase
K, Na, Mg, P	stable
CO ₃ , SO ₄ , Cl, Ca	decrease

Physical	Trend
pH	increase
-	stable
EC	decrease

Heavy metals	Trend
-	increase
Fe, Zn, Cd	stable
Mn, Cu, Pb, Ni	decrease



Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status

Trends in vadose zone leachates quality (2009-2011)

Changes in values (2009-2010)

- Decrease of NO_3 concentrations in 8 out of the 13 sampling points (-52.6%)
- Decrease of NH_4 concentrations in 10 out of the 13 sampling points (-73.2%)

Changes in values (2009-2011)

- Decrease of NO_3 concentrations in 7 out of the 13 sampling points (-53.8%)
- Decrease of NH_4 concentrations in 8 out of the 13 sampling points (-61.5%)

ions	trend
Mg, Cl, CO_3 , HCO_3	increase
-	stable
K, Na, Ca, SO_4 , P	decrease

physical	trend
EC	increase
-	stable
pH	decrease

heavy metals	trend
-	increase
-	stable
Fe, Cu, Zn, Mn, Ni, Pb, Cd	decrease



Trends in vadose zone leachates quality (2009-2011)

ID	2009				2010				2011				change 2009-2010			change 2010-2011			change 2009-2011		
	Καλλιέρ-γεια	λίπανση N kg/στρ	NO3 (mg/L)	NH4 (mg/L)	Καλλιέρ-γεια	λίπανση N kg/στρ	NO3 (mg/L)	NH4 (mg/L)	Καλλιέρ-γεια	λίπανση N kg/στρ	NO3 (mg/L)	NH4 (mg/L)	λίπανσηN kg/στρ	NO3 (mg/L)	NH4 (mg/L)	λίπανσηN kg/στρ	NO3 (mg/L)	NH4 (mg/L)	λίπανσηN kg/στρ	NO3 (mg/L)	NH4 (mg/L)
V01	M	9,1	25,2	3,3	C	7,7	18,4	0,4	C	8,8	2,3	0,8	-1,4	-6,9	-3,0	1,0	-16,1	0,4	-0,3	-22,9	-2,5
V02	C	10,1	62,0	4,4	C	12,4	41,5	1,4	C	12,2	70,2	1,1	2,3	-20,5	-3,0	-0,2	28,7	-0,3	2,1	8,2	-3,3
V04	M	10,9	14,8	7,5	M	18,6	32,4	0,5	C	13,5	29,0	1,0	7,7	17,6	-7,0	-5,1	-3,4	0,5	2,6	14,2	-6,6
V05	T	9,1	8,2	2,0	T	10,1	3,3	0,4	C	10,3	143,0	1,1	1,0	-4,8	-1,6	0,2	139,7	0,7	1,2	134,9	-0,9
V06	C	9,1	33,5	1,2	C	7,7	9,2	0,5	W	-	20,9	0,9	-1,4	-24,2	-0,7	-	11,7	0,4	-	-12,5	-0,3
V07	C	10,1	4,8	1,8	T	25,9	16,2	1,1	C	6,7	7,3	1,0	15,8	11,4	-0,7	-19,3	-8,9	-0,1	-3,5	2,5	-0,9
V08	T	9,1	7,4	3,3	C	10,1	8,9	0,6	-	18,6	68,2	9,1	1,0	1,5	-2,7	8,5	59,2	8,5	9,5	60,7	5,9
V09	C	9,1	5,8	3,4	C	7,7	8,9	0,6	C	8,3	14,4	1,9	-1,4	3,1	-2,8	0,6	5,4	1,3	-0,8	8,5	-1,5
V10	C	10,1	44,1	1,0	C	6,7	35,1	0,5	C	5,6	35,1	2,3	-3,4	-9,1	-0,5	-1,2	0,0	1,8	-4,5	-9,1	1,3
V11	M	9,1	27,9	1,1	W	11,5	33,9	2,7	W	-	20,5	1,6	2,4	6,0	1,5	-	-13,5	-1,1	-	-7,5	0,4
V12	M	10,1	89,1	5,8	C	5,7	126,0	0,4	C	6,7	35,7	0,6	-4,5	36,9	-5,4	1,0	-90,2	0,2	-3,5	-53,4	-5,2
V13	C	10,1	57,1	0,4	C	5,7	47,9	0,5	C	6,7	33,2	1,4	-4,5	-9,2	0,0	1,0	-14,7	1,0	-3,5	-23,9	1,0
V14	C	10,1	25,6	0,3	C	8,4	4,4	0,4	C	9,2	2,8	0,6	-1,7	-21,3	0,1	0,8	-1,6	0,2	-0,9	-22,9	0,3



Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status

Environmental Monitoring Assessment/ Vadose zone leachates

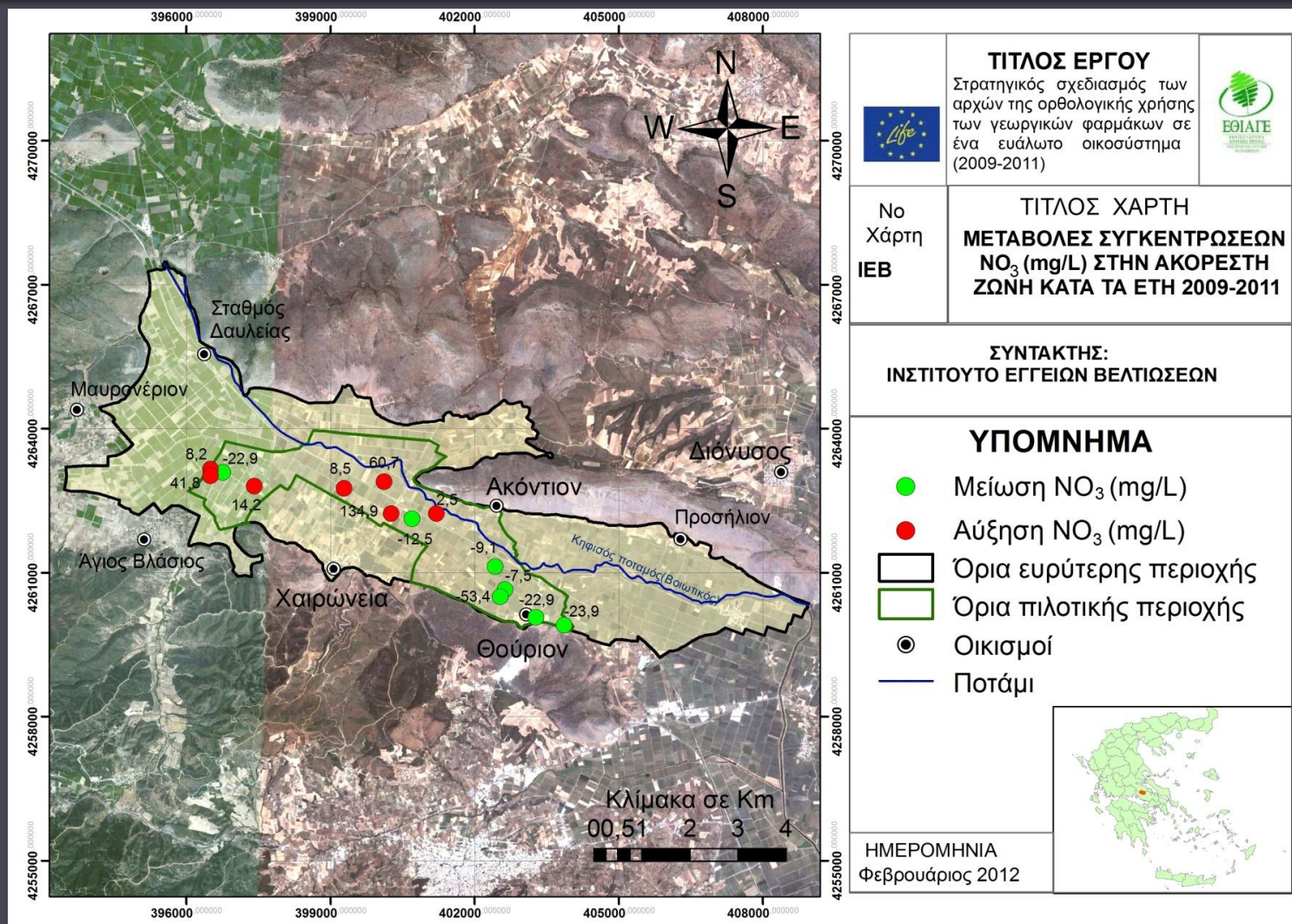
Based on overall data assessment:

- a) Proper functioning of the environmental monitoring system is certified
- b) Documented decrease in the overall amounts of applied fertilizers leading to decreased NO_3 and NH_4 concentrations



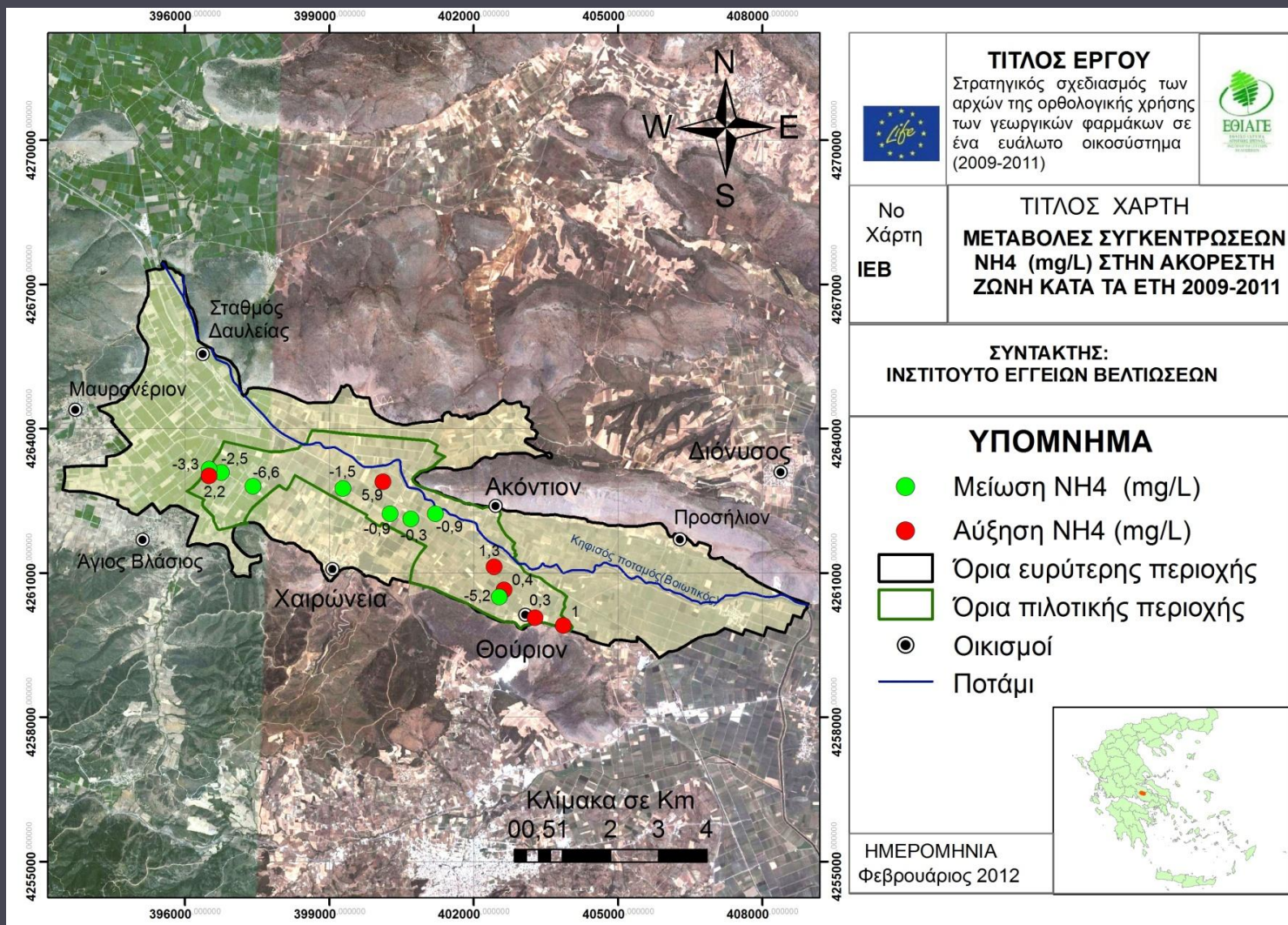
**Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status**

Environmental Monitoring Assessment/ Vadose zone leachates



Water resources of Viotikos Kifissos basin:
 Hydrogeological setup, evolution, threats and environmental status

Environmental Monitoring Assessment/ Vadose zone leachates



**Water resources of Viotikos Kifissos basin:
 Hydrogeological setup, evolution, threats and environmental status**

Trends in alluvial aquifer water quality (2009-2011)

ions	Trend
NO ₃ , NH ₄ , CO ₃ , HCO ₃	increase
-	stable
K, Na, Ca, SO ₄ , Mg, Cl, P	decrease

Ph/cal	Trend
pH	increase
-	stable
EC	decrease

Heavy metals	Trend
-	increase
-	stable
Fe, Cu, Zn, Mn, Ni, Pb, Cd	decrease



Water resources of Viotikos Kifissos basin:
Hydrogeological setup, evolution, threats and environmental status

Trends in alluvial aquifer water quality (2009-2011)

Concentrations of NO_3 and NH_4 are increased (2009-2011)

The increase is not uniquely related with the potential change of fertilization, because:

- Alluvial aquifer is the direct receptor of all surface agricultural activities which act cumulatively towards environmental deterioration.
- Changes in fertilization plans would require sufficient time (out of project's duration) in order their impacts to be identified in the alluvial water quality
- The hydrogeological basin of the alluvial aquifer is extended spatially to a much wider area that embraces plots which are not included in the project

- The quality of the alluvial aquifer is not individually sufficient to justify project's success
- Hence, the documentation of the beneficial impacts should be focused in the vadose zone system which is the most representative.



Environmental Monitoring / Conclusions

1. In general the quality characteristics of water systems are good with some exceptions mainly related with the nitrogen compounds of the alluvial aquifer.
2. LCM application has beneficial effects which are documented in the decrease of NO_3 and NH_4 values in the vadose zone leachates.
3. The alluvial and the karstic aquifers are receiving the cumulative impacts from the upstream areas, hence the assessment of their water quality may not be evaluated uniquely
4. The operation of the environmental monitoring system:
 - i) set up the basis for the assessment and documentation of the current environmental status
 - ii) developed the conditions for a continuous assessment of the qualitative characteristics
5. LCM application has a positive impact to the study area, even though in many plots the agricultural loads were already decreased due to their participation in the “National Program of Nitrates Reduction (Directive 91/676/EEC)”





Water resources of Viotikos Kifissos basin: hydrogeological setup, evolution, threats and environmental status



**Hellenic Agricultural Organization
Land Reclamation Institute**