Guidelines for the delimitation of wetland ecosystems

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SWOS

Satellite-based Wetland Observation Service

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Short Summary:

This document is a protocol set for the SWOS Horizon 2020 project that provides an approach for the delimitation of wetland ecosystems to support different purposes such as monitoring, assessing, reporting, research, etc. The protocol defines “wetlands” as ecosystems; where a wetland is a natural unit that determines functioning of the ecosystem. The delimitation of wetland ecosystem as defined here ensures the proper selection of the natural boundaries of the wetland ecosystems selected in SWOS to ensure that the products developed by the project provide useful support to the assessment of wetlands, and the monitoring of the changes in time.

The protocol sets an understanding of the importance of developing a proper delimitation of wetlands based on hydrological and ecological characterization. It sets rules for the delimitation of test sites based on the functioning of wetland ecosystems.

Section 1 defines wetland ecosystems and provides an overview on the purpose of SWOS.

Section 2 provides an understanding on the major pressures wetland ecosystems are subjected to and the justification for the importance of addressing a proper delimitation to support integrated actions.

Section 3 addresses the policy responses that SWOS products will support in achieving.

Section 4 defines the criteria that the delimitation of wetland ecosystem needs to follow in order to provide hydro-ecologically acceptable and politically compliant products.

Section 5 develops a step by step guidance for the delimitation of test sites through show cases applied to some test sites selected by SWOS. Additional practical examples are added in this section to support SWOS partners in the delimitation of their test sites by using regional background data.

On a final note, the delimitation set for wetland ecosystems could be widely applied broader than the context of SWOS, and this document could therefore support any type of stakeholder interested in wetland ecosystems.

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1. Background

According to the Ramsar Convention[1], wetlands are defined as 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters'.

Formulated in a simpler way, ***wetlands are areas where water is the primary factor controlling the environment and the associated habitats including both land and water environments***. Some wetlands can be seasonally aquatic or terrestrial, and typically occur where the water table is at or near the surface of the land, or where the land is covered by shallow water. **Wetlands are complex, dynamic systems, often with fluctuating and undefined borders**.

Inland wetlands are water-logged ecosystems hosting specific plant and animal communities supporting water regulation and peat-related processes. This class includes natural or modified mires, bogs and fens, as well as peat extraction sites.

A global environmental monitoring system for wetland ecosystems is missing and thus only limited information and methods are available for effectively mapping and assessing the condition of wetland ecosystems worldwide. This case is also relevant in Europe especially in the case of wetland ecosystems that do not integrally fall under the scope of the Water Framework Directive[2].

The SWOS project is designed to fill this need by setting a monitoring and an information service for wetland ecosystems. It supports key environmental policies in Europe and elsewhere and supports the provision of baseline information on their condition and trends, on the major pressures affecting this ecosystem function and the impacts they exert on the services these ecosystems provide.

In that sense, the setting of a proper delimitation for wetland ecosystems will support two purposes: 1) for SWOS, it will support the development of useful products that support management and policy; 2) for a wider public, a proper wetland delimitation protocol will set the rules for wetland delimitation independently of the scale and the geographical context supporting any wetland stakeholder.

2. Major pressures on wetland ecosystems

The primary drivers of wetlands degradation and loss are population growth and increasing economic development, which result in pressures on this ecosystem. **Loss, degradation and fragmentation of wetland habitats** are mainly caused from drainage for agriculture, infrastructure development and afforestation purposes causing pollution, blocking and extraction of water inflow and causing over exploitation of groundwater resources.[3]

[1] http://www.ramsar.org
[2] MAES, 2014. http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf
[3] MA, 2005, Ecosystems and Human Well-Being: Synthesis, Millennium Ecosystem Assessment. Washington, DC: Island Press, (http://www.maweb.org/en/index.aspx)

Wetlands are also very sensitive habitats affected by **climate change**, namely the changes in rainfall patterns, in temperature, as well as extreme events. Effects are different depending on the regions where Northward movement of mobile species is observed to follow changes in climate, but less mobile species such as amphibians and fish may not be able to keep up with the speed of change.

Over-exploitation of water resources within and around wetland ecosystems is especially severe in the Mediterranean, with agriculture (including peat extraction) being the main consumer. Inappropriate management increases siltation of wetlands due originating from soil erosion from surrounding agricultural land, and affects hydro-periodicity where permanent water bodies become seasonal and the other way around which affects plant and animal communities that wetland ecosystem host.

Invasive species of flora and fauna are of particular concern to the conservation of wetlands as they may become very dominant, suppressing and outcompeting naturally occurring species. In wetland ecosystems, introduced fish become in many cases predatory fish that in some cases wipe out native species in few years' time causing in some cases a great threat to amphibians.

Pollution and nutrient enrichment is a very important pressure for wetlands affecting their water quality by causing both eutrophication and acidification. Several known sources of pollution on wetlands include pesticides from agriculture; phosphates from domestic wastewater, as well as heavy metals from industry.

3. Policy responses

Wetlands provide a wide range of ecosystem services such as water supply, water purification, groundwater recharging, and flood protection. Depending on their management, they can be either sources or sinks of greenhouse gas emissions.

Wetland ecosystems are particularly vulnerable to land use conflicts mainly between agricultural practices and urban development. In order to take proper decisions, policy-makers need to get a clear understanding of the drivers causing pressures on wetland ecosystems and on the trade-offs between the uses and services they provide. Evidence-based policy would rely on proper information to draw proper responses.

Wetlands are protected by the Ramsar Convention, a global multilateral agreement, as well as by regional policies, of which we cite the most appropriate European legislations including the Birds Directive, the Habitats Directive, and the Convention on the Conservation of European Wildlife and Natural Habitats as well as EC´s Biodiversity Strategy that calls for halting the loss of biodiversity and ecosystem services in the EU by 2020. In addition, most countries have specific national measures for wetland protection that integrate the provisions of the relevant EU directives.

Water quality is a particularly important issue for wetlands, through its effect on species survival and ecosystem condition. Thus the EU's Water Framework Directive, which calls on Member States to ensure good chemical and ecological status of all freshwater bodies, is a key tool to protect and restore wetland biodiversity. Other relevant legislations regulating water quality and quantity include

the Groundwater Directive (2006/118/EC), the Nitrates Directive (91/676/EEC), the Directive on Industrial Emissions (2010/75/EU), and the Directive on Urban Wastewater Treatment (91/271/EEC). Finally, the Flood Risks Management Directive (2007/60/EC) is also of direct relevance to wetlands having a vital role in water retention and acting as an important buffer zone in the prevention of flooding.

4. Criteria for SWOS test sites delimitation

The wetland ecosystem delimitation determines the area and boundaries of a SWOS test site for which products will be produced. Within SWOS, wetland ecosystem is considered the basic functional unit independent of scale.

SWOS follows an ecosystem based approach for the delimitation through the implementation of a **hydro-ecologically acceptable delimitation**; and whenever possible; a politically compliant delimitation that could serve for policy support purposes is additionally applied. The following sections provide the rules set in SWOS for the delimitation of the wetland ecosystem.

> *Wetlands are areas where water is the primary factor controlling the environment and the associated habitats including both land and water environments.*

In practical terms, the delimitation of the test sites within SWOS needs to consider the following two constituents:

- **Hydro-ecological setting**[4]: this component is an “compulsary” element in the delimitation of the test sites. It is based on the functional setting of wetland ecosystems, including the vegetative structure, aquatic barriers, wetness, flow gradient, flow volume, and flow regime; i.e. all the necessary elements that affect the wetland ecosystem condition.
- **Political instruments in place**: this component is an “optional” element for the delimitation of wetland ecosystems that could be added to the first delimitation. The addition of this figure, whenever it exists around the site, is to support the environmental conservation obligations and targets including the Ramsar Convention, designation of nature reserves (Natura 2000 sites, natural parks), surface and groundwater water policies, etc…

Testing of SWOS delimitation

A testing of the application of the criteria set for SWOS wetland delimitation is applied to the test site of, Fuente de Piedra in Southern Spain.

The delimitation is built on hydro-ecological cycle that includes the limits of the watershed and the aquifer above which the wetland is located. In this delimitation, the protected area limits are also

[4] Ecological setting – refers to the principal biophysical characteristics at multiple scales that strongly influence the composition, structure and function of a particular ecosystem (site) over the long term and serve to describe and distinguish it ecologically.

considered as they serve policy purposes and support the managers. This delimitation serves also other reporting purposes such as the EC Habitat Directive, Birds Directive, and Natura 2000, the WFD and the Biodiversity Strategy to 2020.

Delimitation of the hydrologic processes (watershed and groundwater)

The lagoon of Fuente de Piedra owes its water levels to precipitation, runoff and underground water table of the endorheic hydrological basin in which it is located. Agricultural intensification within the wetland uses large amounts of water resources that affect the quantity and quality of the water underneath. The changes in land uses in the last decades, the expansion and intensification of agricultural practices in and around the boundaries are an important pressure on water resources in the area and a major driver of changes in groundwater level.

Figure 1 shows the limits of the area of hydrologic processes (hydrological and hydrogeological basins) of Fuente de Piedra and the direction of surface and groundwater flows. These limits are set by the regional authorities of Andalucía and are based on hydrological and hydrogeological studies.

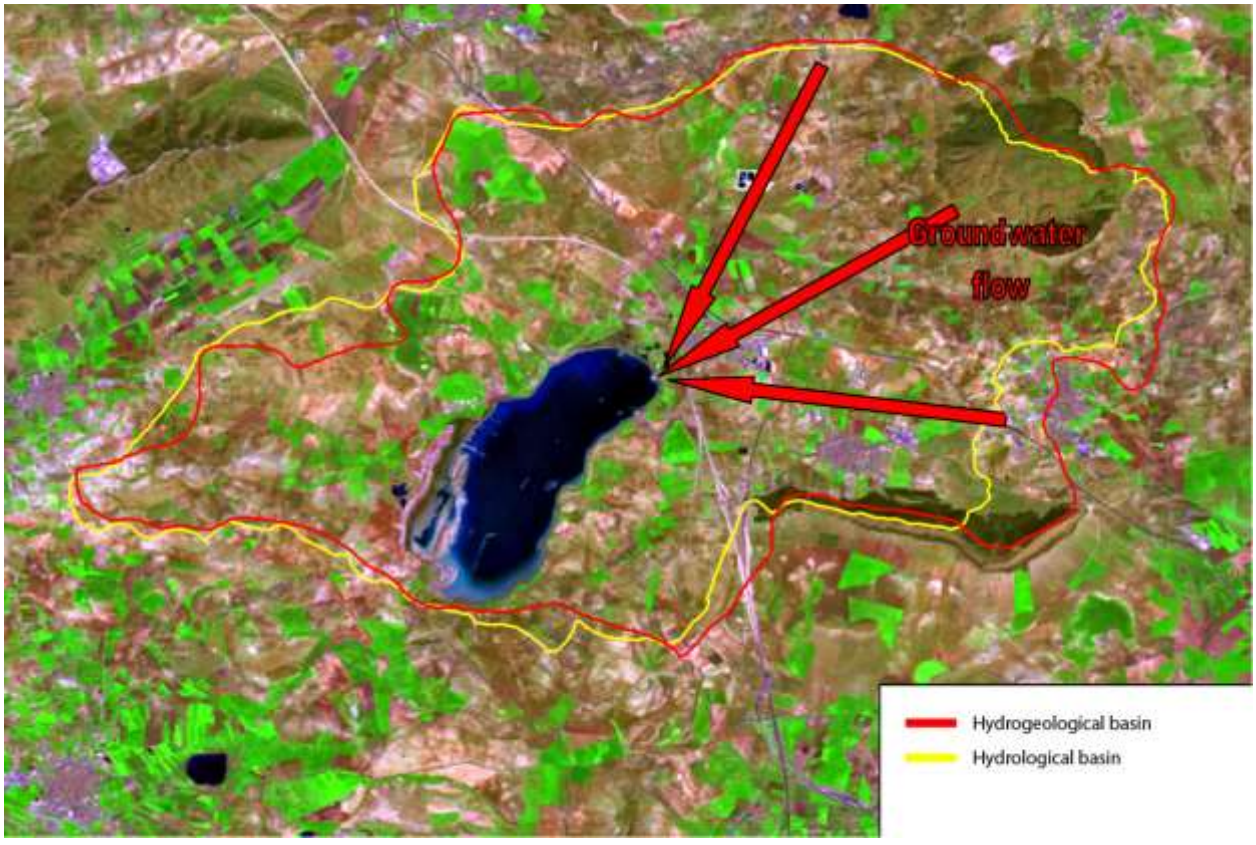

Figure 1 Limits of the natural reserve vs the area of hydric influence

Delimitation of the protected area

Fuente de Piedra is a nature reserve that has defined boundaries for protection. As shown in Figure 2, the boundaries of the waterbody as set by Ramsar (dotted green area), and the boundaries of Natura 2000 of the surrounding area (the dashed green area).
These boundaries do not consider strictly the ecological nor hydrological settings but they are rather influenced by administrative boundaries, related to infrastructure and economic activities. Figure 2 shows the existence of urban settlements around the natural reserve including some industrial areas, roads, and agricultural areas. These pressures are not taken into account within the natural reserve boundaries but have direct effects on the water quality and quantity that reaches the lagoon as they are present within the hydrological basin as shown in figure 1.

Figure 2. Limits of the Fuente de Piedra natural reserve. The dotted green zone is the Ramsar delineation (=Natural Reserve), and the area striped zone in green corresponds to the area of protection of the reserve (= Natura 2000 site).

Combined delimitation

Therefore, a combined delimitation of the natural delimitation (4.1.1.) and the administrative delimitation (4.1.2.) serves stakeholders with ecosystem based management tools. SWOS products developed using this delimitation (figure 3) will support in the provision of products relevant to influence management, policy and reporting obligations.

Within SWOS; the delimitations of both the protection and hydrologic processes within Fuente de Piedra have been selected and the outcomes communicated to regional stakeholders from the Community of Andalucía. This approach is recommended as a protocol to be followed in the test site delimitation of SWOS serving multi-purposes.

The calculation of SWOS products and services using this combined delimitation is of high interest for users as the whole area of the hydrological basin is included (Figure 4). The calculation of SWOS indicators using this delimitation enables the inclusion of SWOS products in the monitoring and reporting to different policies.

Figure 3 Test site area proposed by UMA with the map of the delimitation (left) and map of land use/land cover by (right).

We understand that the selection of the approach developed in this document implies some additional work load among the SWOS mapping partners, but the development of ecosystem based products for SWOS respecting this delimitation are expected to provide long term uses of the SWOS service by wetland managers, policy makers, and the scientific community.

Guidelines for the test mapping case

Reference data

For the development of the delimitation of SWOS test sites, reliable datasets need to be used. The table below suggests some datasets to be used as background data for the development or validation of the delimitation of wetland ecosystems.

Dataset	Theme	Date	Source	Coverage	Source Link	Data access
Data sources for Europe						
Map of European ecosystem types v2.1	Ecosystems	2015	EEA, ETC-SIA	Europe	Link	Link to data
European catchments and Rivers network system (ECRINS)	Rivers and watersheds	2012	EEA	Europe	Link	Link to data
Water Information System for Europe (WISE): Groundwater bodies, Water Framework Directive (WDF)	Aquifers, groundwater bodies	2009 - 2011	EEA	EU Members	Link	Link to data
Data sources for regions outside Europe						

- HydroSHEDS (RIV) - Africa river network (stream lines) at 30s resolution
- Data Basin (a science-based mapping and analysis platform that supports learning, research, and sustainable environmental stewardship.)
- Global HydroBASINS dataset is a global river and lake catchment layer derived from HydroSHEDS and the global lakes and wetlands database (GLWD)

Delimitation process

1) Respect the test site area and buffer zones defined in the SWOS mapping guide, i.e. do not reduce these zones as a result of applying this guide.
2) If the area of the test site matches very accurately with the data proposed in this guide (more than 80-90% of the surface), it is not necessary to expand it.
3) Check data on ecosystems. If a wetland ecosystem is cut by the limits already defined, it should be extended in order to include the adjacent wetland areas.
4) Check data on groundwater bodies:
   a) If both limits match moderately, it would be advisable to extend the test site area to cover the entire area of hydrogeological influence.
   b) If the area is located inside an aquifer, the area should be extended to completely cover it but there is the risk of overextending the test area. So it is recommended to check the data on river basins.
   c) If the test site intersects with several aquifers, it would also be necessary to review the data on watersheds.
5) Check data on river basins:
   a) If both limits match moderately, it would be advisable to extend the test site area to cover the entire area of hydrological influence.
   b) If the area is located inside a river basin, the area should be extended to completely cover it.
   c) If the test site intersects with several watersheds, the area should be extended to cover all of them. In this case, it is important to pay attention to take only rivers basins that are upstream of the wetland.

Note: The level of detail of ECRINS is quite high, so the polygons correspond to sub basins. When extending the area of study, it should be enough to include the watersheds that intersect or are fully adjacent to the wetland (rivers layer can help to better assess the connections between watersheds and test sites). This will avoid unnecessarily overextend the test area

6) Check all the information (ecosystems, aquifers and river basins). The reference layers can be overlapped at the same time to see if there is a match between them. When the limits are similar the reliability of the new delimitation is higher.
7) Check the new area with wetland managers, local/regional authorities or scientific sources in order to verify the new limits for the test site.

Delimitation validation

It is highly recommended to contact the wetland managers or regional/local authorities to get an understanding of the delimitation they use for their wetland conservation management. They probably already have a good delimitation of the ecosystem with a developed ecosystem basis. This is

essential as each test site has its particularities so it is difficult to establish rules that work for all SWOS sites equally.

This report sets some rules to improve the delimitation of SWOS test sites based on some spatial data related to wetland ecosystems function. The data used for the delimitation of the test sites should be reliable and, whenever possible, a validation process is recommended to confirm the delimitation with sources close to the test site (wetland managers, local authorities, etc.).

For the delimitation, data on biodiversity, rivers and watersheds, aquifers and groundwater bodies are used. For Europe, there are validated data with a very good level of detail. In the case of test sites outside Europe, there are global and continental datasets with large scales. It would be necessary to search for specific local and national whenever possible to validate the delimitation.

5. Examples of delimitation according to these guidelines

Fuente de Piedra

The test site of Fuente de Piedra is a case where the wetland is completely within a groundwater body and a river basin (figure 4). Both limits match quite adequate so the union of both areas would be one good basis for the new delimitation. If regional datasets used for the delimitation are compared with European data (ECRINS and WFD), it is observed that the areas are almost identical (figure 5). So in this case, even using data at European level, the delimitation of the area of hydrological influence of the wetland would be quite accurate.

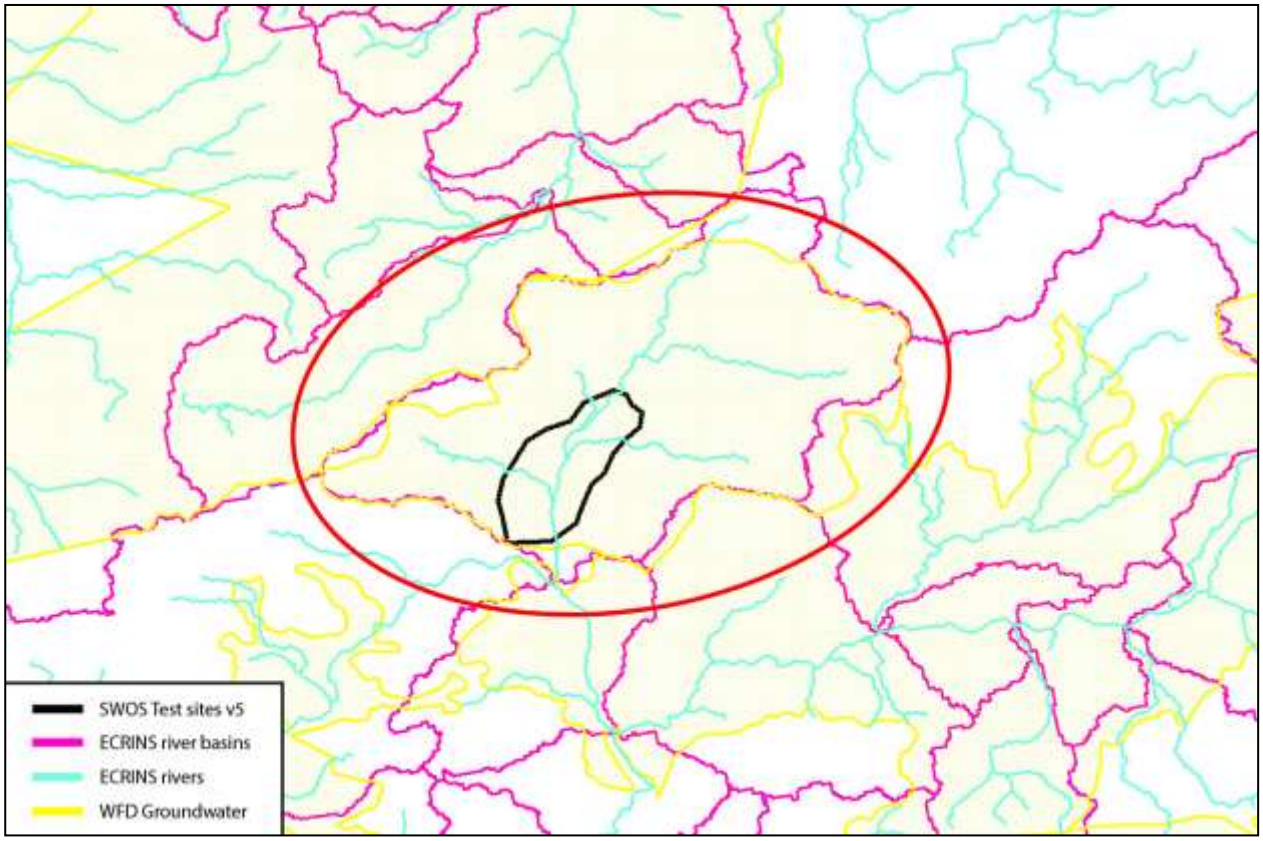

Figure 4 Fuente de Piedra test case vs ECRINS and WFD data.

Figure 5 Comparison between regional and European data on the test case of Fuente de Piedra.

La Camargue

Figure 8 presents the test site of the Camargue and the map of ecosystem types of Europe. The western side of the study area has a number of wetland ecosystems that are not included (red circle). In fact, they are directly cut by the edges of the test site.

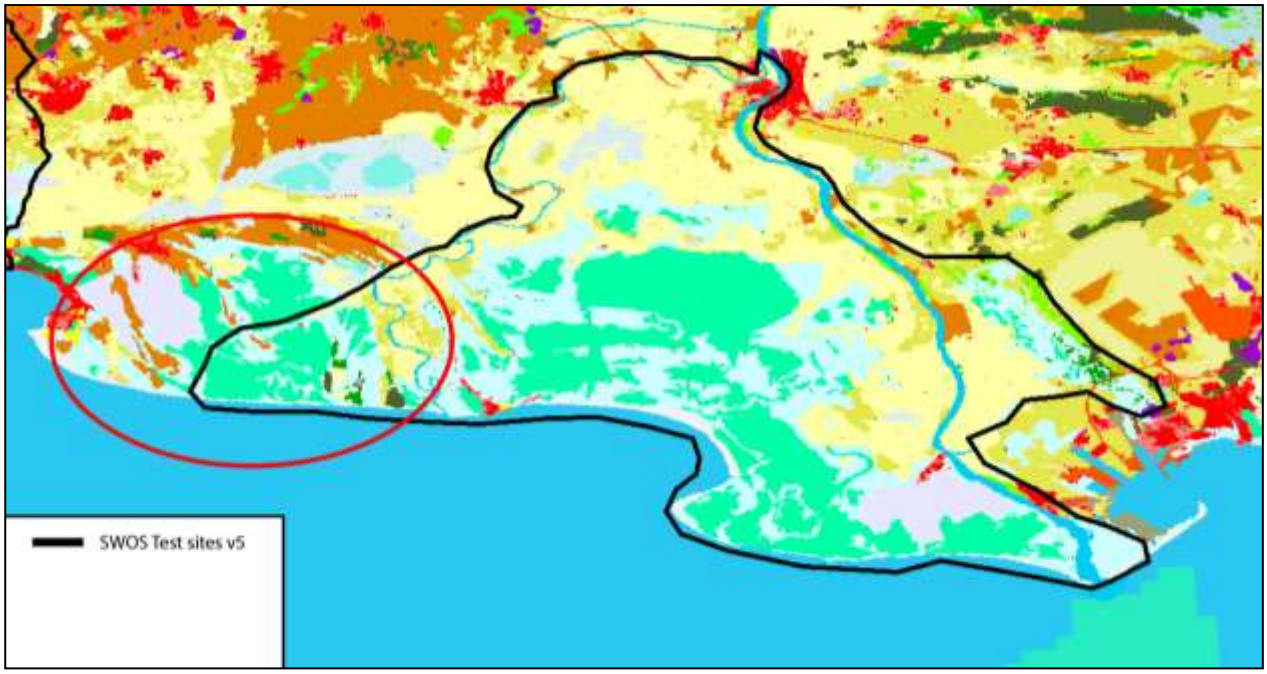

Figure 6 European ecosystem map in the test site of the Camargue (France).

In addition, when comparing the boundaries of groundwater bodies, it is observed that the boundaries of the test site match the aquifer boundaries on which the wetland ecosystem is located. However, there are large areas where they do not match (figure 7).

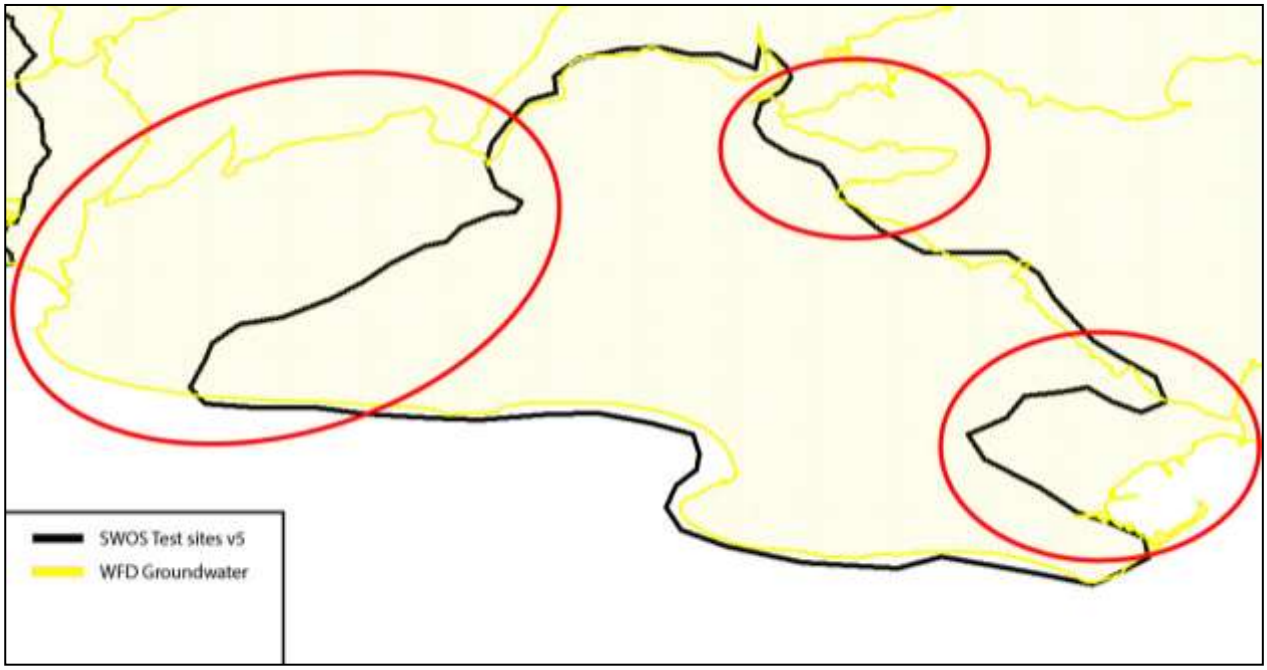

Figure 7 Camargue test site vs. WFD data on groundwater bodies.

When comparing both maps, the one on ecosystem (figure 6) and groundwater (figure 7), we see that the wetland ecosystems outside the test site are within the area of the aquifer (figure 8). Therefore, in this case it would be advisable to extend the study area to cover the whole aquifer as these wetlands are also located in the area of hydrological influence.

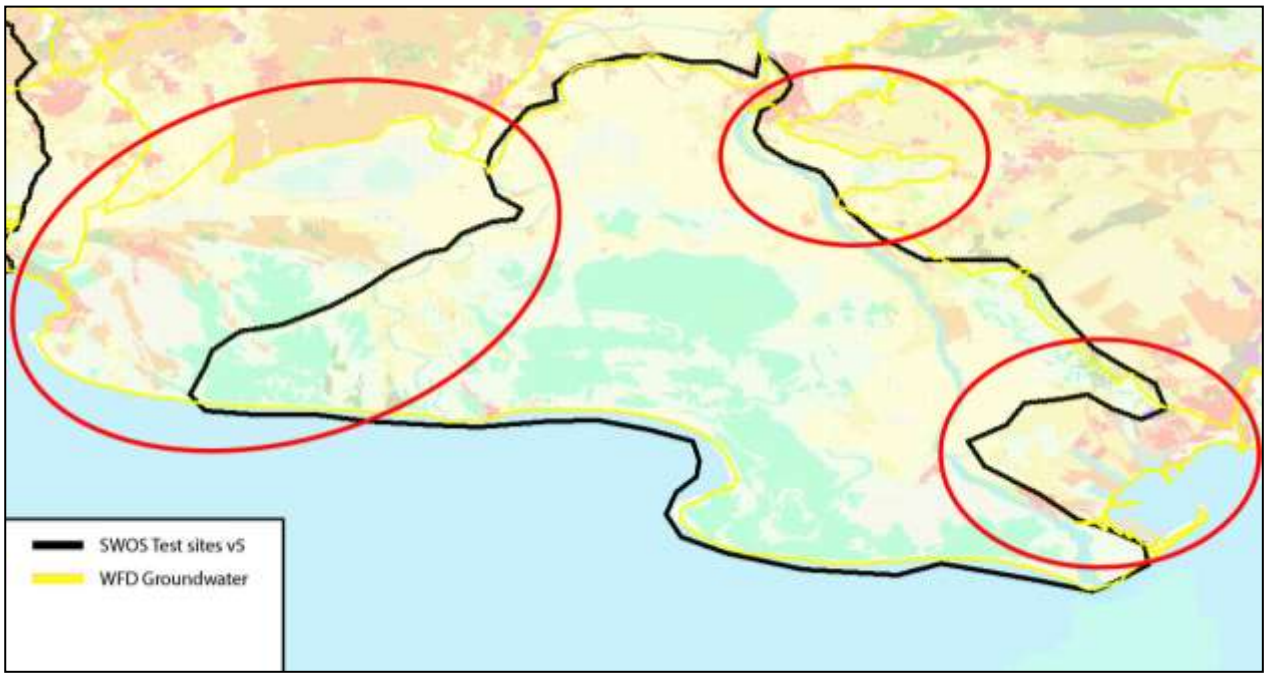

Figure 8 Camargue test site vs European ecosystem map and WFD data on groundwater bodies.

Data on watersheds provides more information to define the area to be delimitated. There are some similarities between the edges of the aquifer and the watersheds intersecting with this. It is possible to

further expand the test site to cover all these areas, but this may be an unnecessary overextension of the test site (figure 9).

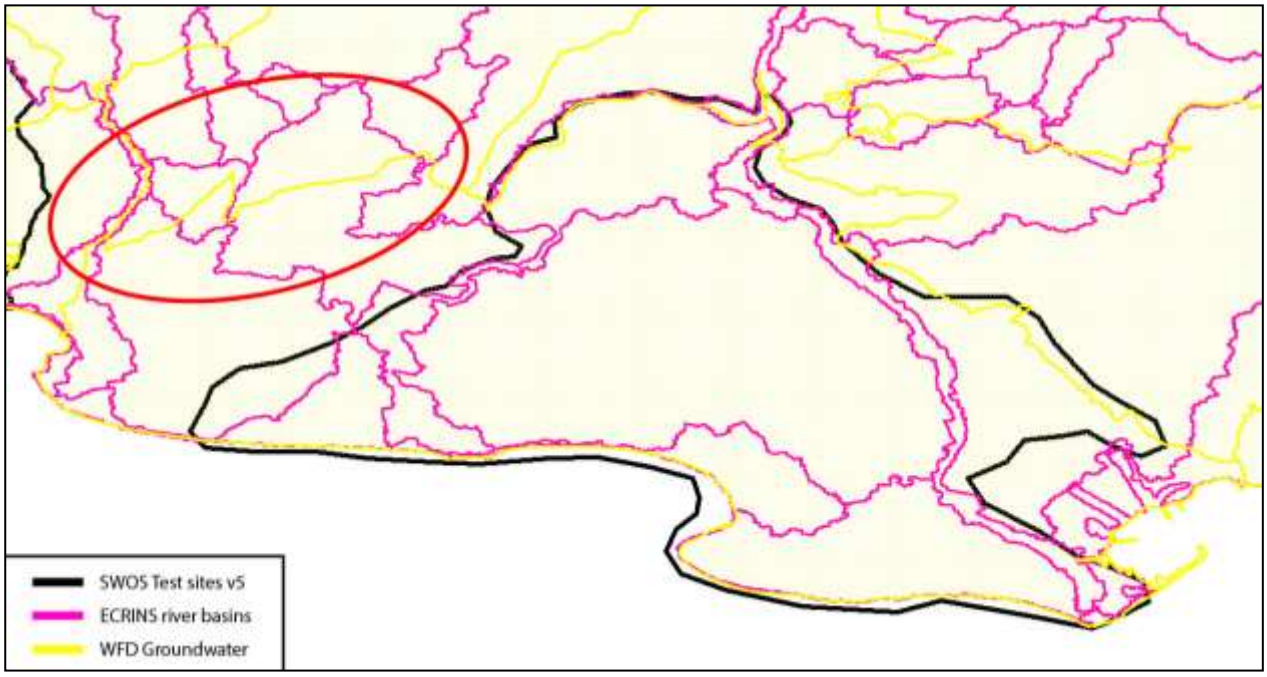

Figure 9 Camargue test site vs. ECRINS and groundwater data.

Etangs Palavasiens and the Lez River Basin

This test site intersects with several groundwater bodies. The wetlands present in the area (along the coast) are within one of them (figure 10). Moreover, watersheds match very well with the current delimitation of the test site (figure 11). So it might be appropriate to keep the study area as it is. It is observed that there is part of the basin and the aquifer outside the test area (red circle in fig. 11), so extending the test site to cover those areas would be acceptable too. In fact, the satellite image shows some wetlands in that region.

Figure 10 Test site of etangs Palavasiens and the Lez River basin vs WFD data on groundwater.

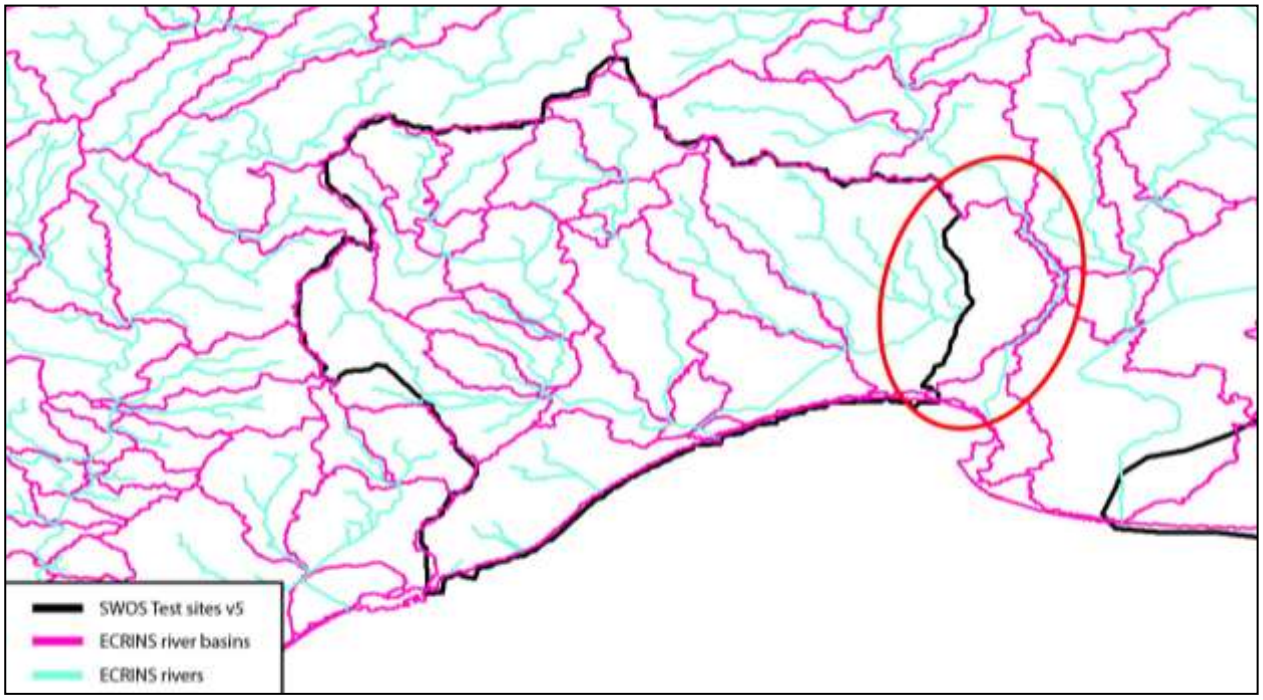

Figure 11 Test site of etangs Palavasiens and the Lez River basin vs ECRINS data.

Guadalhorce

The test site in the mouth of the Guadalhorce do not match with aquifer limits defined in the WFD data (figure 12), but it fits very well with the watersheds delimited by ECRINS. So in this case it would not be necessary to extend the area. As this wetland is strongly influenced by surface water, this limitation based on the river basin should be appropriate.

Figure 12 Guadalhorce test site vs ECRINS data.

Pesa Valley

The Pesa valley is another case where the limits of the test site match almost perfectly with the watersheds delimited by ECRINS (figure 13). As in the previous case, a delimitation based on the watershed is right. So this area would remain without any change.

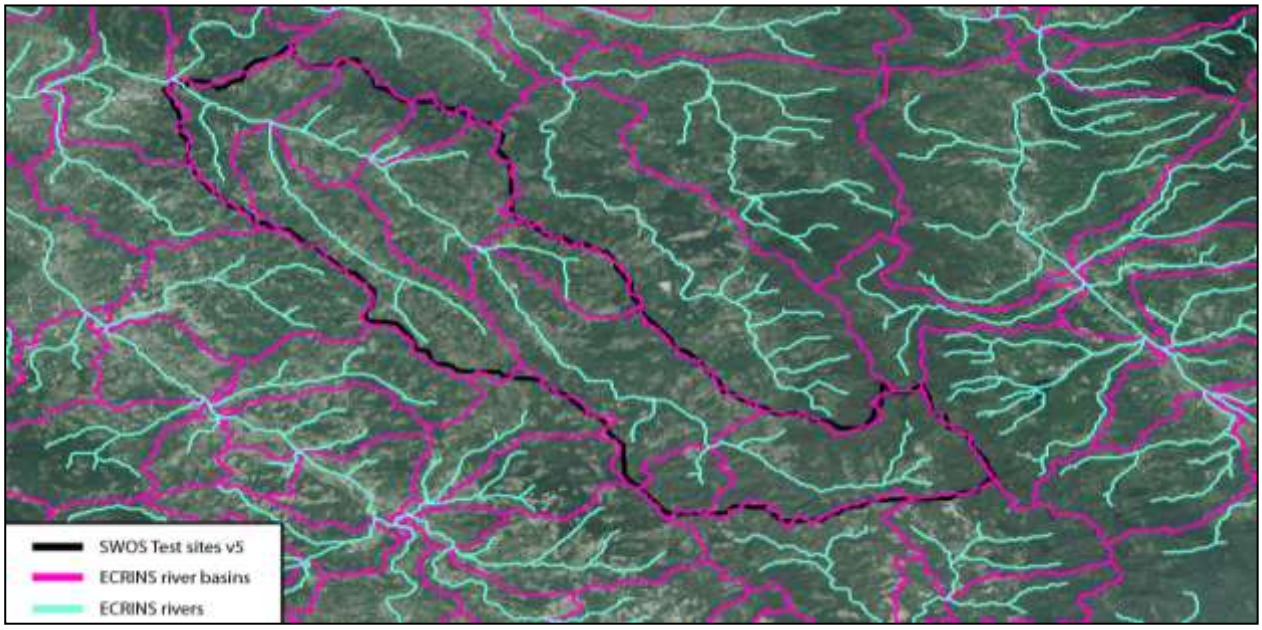

Figure 13 Pesa valley test site vs ECRINS data.

Fucecchio wetlands

According to the European ecosystem map, most wetlands in Fucecchio are inside the test area. The test site intersects with two groundwater bodies according to WFD data (figure 14).

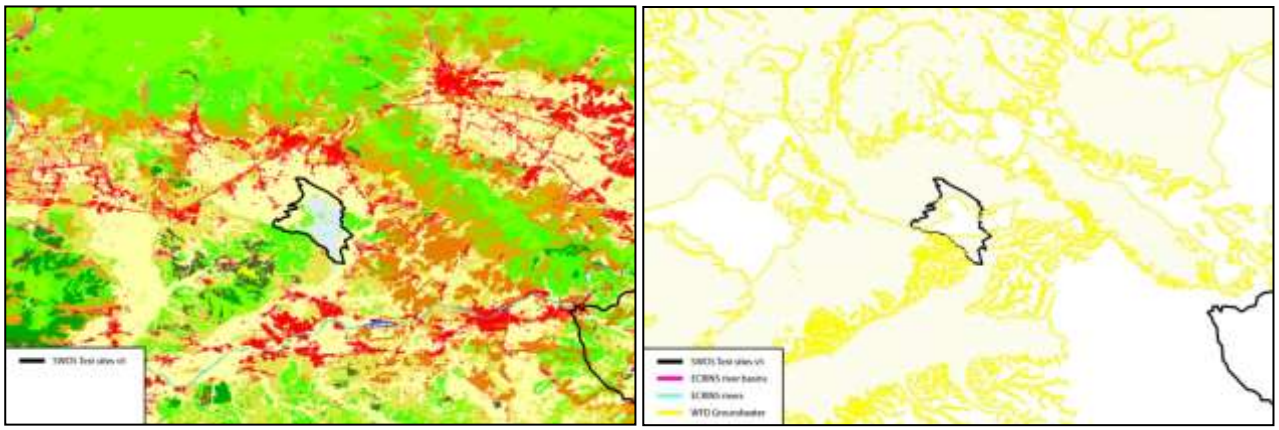

Figure 14 Test site in Fucecchio vs ecosystem map (left) and groundwater bodies of the WFD (right).

ECRINS shows that the wetland also intersect with several river basins; however, the one located in the south of the test site is downstream the main water path (green line), so it would not have influences at hydrological level in the wetland (figure 15). Therefore, the extension of the site should cover only those areas upstream the wetland (red line). Other upstream regions may be included, but more data is needed to support this decision.

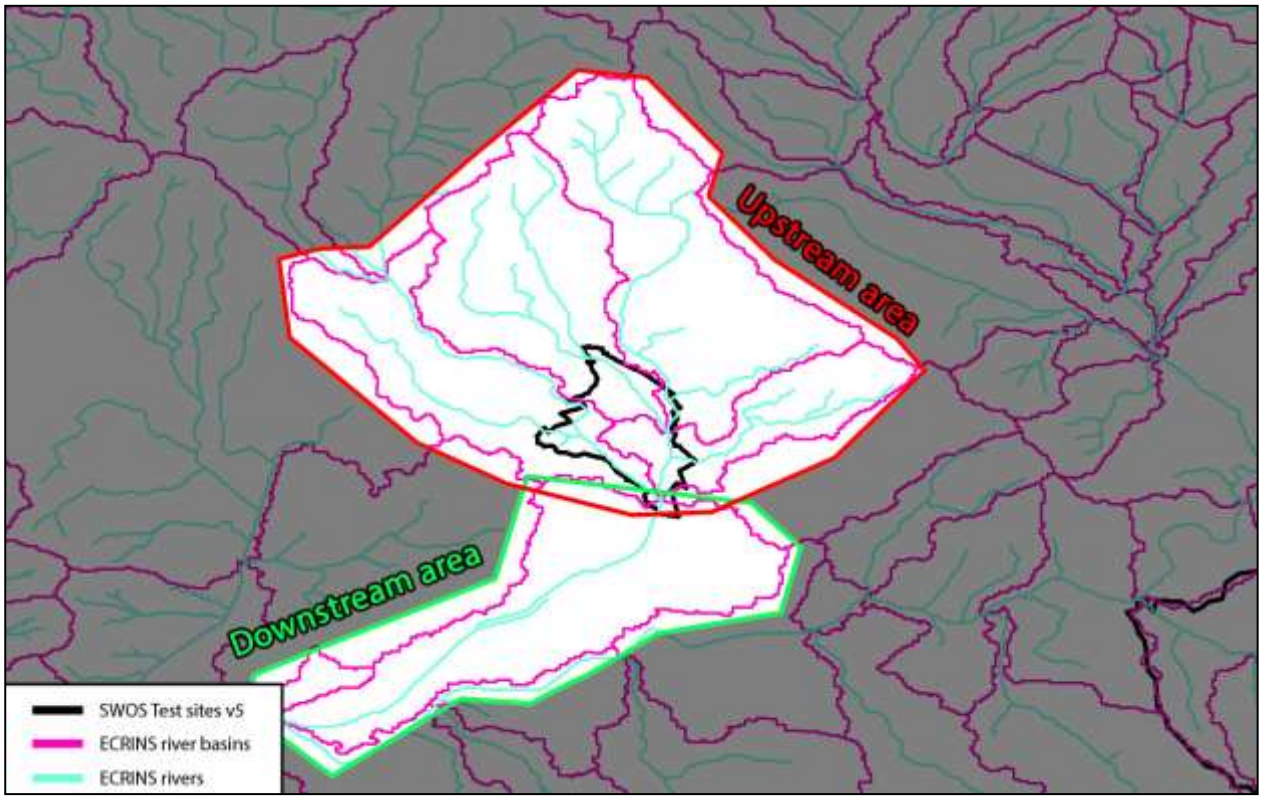

Figure 15 Test site in Fucecchio vs ECRINS data.

Cerknisko jezero z okolico

This example is quite similar to the previous one. According to reference data, wetlands ecosystems corresponds well with the boundaries of the test site which is inside the limits of a big groundwater body (figure 16). In order to not overextend the test site area (including all the aquifer), ECRINS data is checked to support the new delimitation (figure 17). The wetland intersects with four sub basins. River data could be used to detect areas up and downstream.

In this case, additional upstream regions may be included too, but this decision must be based on more scientific evidence (bibliography, additional data, experts, etc.)

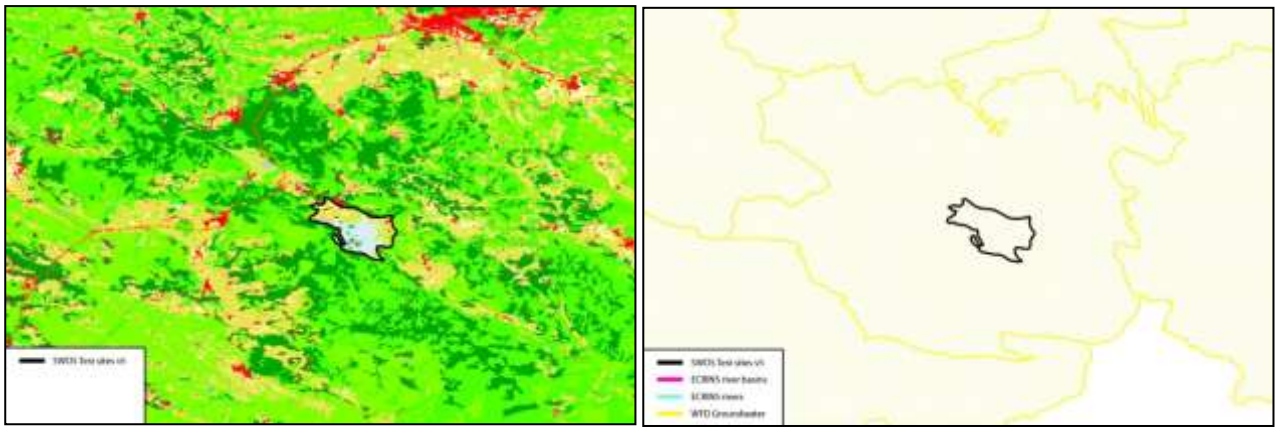

Figure 16 Test site Cerknisko jezero z okolico vs ecosystem map (left) and groundwater bodies of the WFD (right).

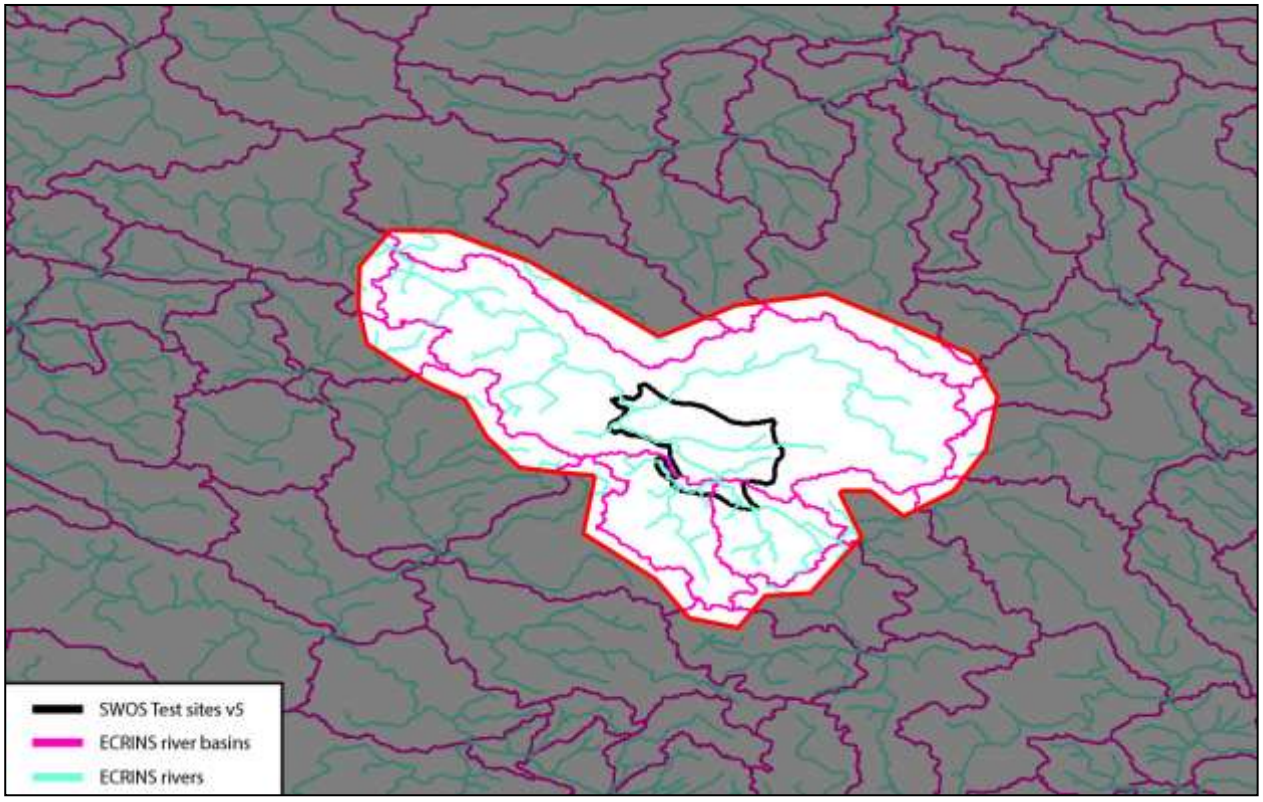

Figure 17 Test site Cerknisko jezero z okolico vs ECRINS data.

Test sites in Greece

This is a visual example on how some test sites located in Greece match in many areas with de limits of the water basins included in ECRINS and the groundwater bodies defined by the WFD data (figure 18). At first glance, it seems that these test sites can remain unchanged.

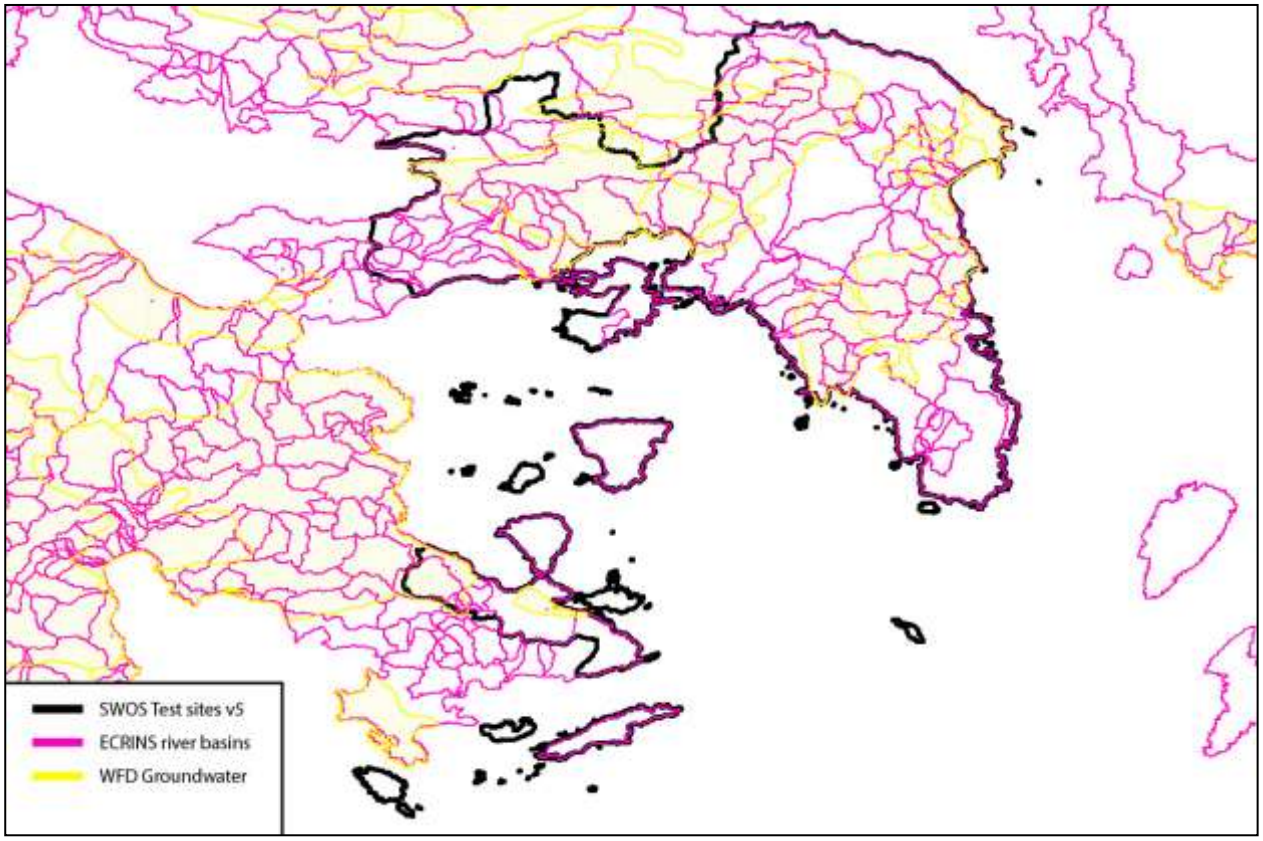

Figure 18 Some test areas in Greece vs ECRINS water basins and WFD groundwater data.

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