The role of geospatial technology in the EU Water Frame Directive implementation

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Hydrology

SUMMARY

Due to the importance of water for human beings' development and in order to protect water and ensure its good ecological condition, a series of Directives was adopted by the European Union. The Water Frame Directive (Directive 2000/60/EC) of the European Parliament has dominant role in water management and establishes a framework for water quality protection. This paper aim to present the current status of water related EU Directive implementation in Serbia regulations and the conceptual mapping between the elements in the WFD spatial data model and the elements in the INSPIRE data models. The implementation of WFD require a large amount of data, over large geographic areas, with high spatial and temporal resolution which is time and money consuming if it is based on traditional methods. The utility of geospatial technologies to support the WFD is largely determined by definitions and requirements for monitoring of surface water status. The role of remote sensing technology in the context of rapid acquisition of water body geometry and water quality parameters defined according to data model was presented. Also, guidelines for automatic aquisition of water body geometry and attributes according to INSPIRE directive by using optical satellite images and GIS was provided. This paper shows that RS data and GIS can form a fundamental component of monitoring to help support WFD implementation while data model in line with INSPIRE provide interoperability and data distribution across-border in order to enable a reporting obligation required by Article 15 of WFD.

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1. INTRODUCTION

Water is life. It is a precondition for human, animal and plant life as well as an indispensable resource for the economy. Water also plays a fundamental role in the climate regulation cycle. Preservation of water quality is one of the priority areas of environment protection in the European Union. In September, 2013 a Stabilisation and Association Agreement between the EU and Serbia entered into force. The focus of the negotiation process is on the harmonization of current Serbian legal regulation with the EU *acquis communautaire* within 35 thematic chapters (Ministry of Foreign Affairs of the Republic of Serbia, 2017). Chapter 27 contain EU environment police. Environmental acquis comprises over 200 major legal acts covering both horizontal issues and legal arrangements on water and air quality, waste management, nature protection and biodiversity, industrial pollution control and risk management, chemicals and genetically modified organisms (GMOs), noise and forestry.

The introduction of the EU Water Framework Directive 2000/60/EC (WFD) and its daughter directives aimed to bring a new era for European water management, focusing on understanding and integrating all aspect of the water environment to be effective and sustainable (Ministry of Foreign Affairs of the Republic of Serbia, 2017). The purpose of WFD, which was adopted in 2000, is to establish a framework for maintain protection of inland surface, transitional, coastal and groundwater (Directive 2000/60/EC, 2003). The main objective of the Directive is to maintain the "good" to "high" ecological status of inland surface waters, transitional, coastal and groundwater and react whenever the status is not achieved.

In addition to the Water Framework Directive, the water management area is regulated by a series of EU legal acts (Directive on environmental quality standards in the field of water policy 2008/105/EC, Drinking Water Directive2007/6/ EC, Urban Wastewater Treatment Directive 91/271/EEC, the Floods Directive 2007/60/EC, etc.), with which national laws must be harmonized.

Water management in Serbia is the responsibility of the Water Directorate and is defined by the Law on Water 30/2010, 93/2012, Law on Environmental Protection 135/04, 36/09, Regulation on water classification 5/68 and Regulation on limit values for pollutants in surface and ground waters and sediments, and the deadlines for their achievement 50/12. Review of EU acquis in area of water management and the period needed for full transposition is presented in Table 1. Strengthening of the existing administrative and institutional capacity in the water sector is a prerequisite for successful transposition and implementation of the Directive and most aid projects are focused on this issue (Transposition and implementation of environmental and climate change acquis-chapter 27: status and plans, 2007).

EU Legislation	Srbia Legislation	Current status	Transition period
2000/60/EC Water Framework	Law on Water 30/2010, 93/12 Decision on the Designation of Water District Boundaries (75/10), Rulebook on Reference Conditions for the Types of Surface Waters (67/11), Rulebook on the Designation of Surface Water and Groundwater Bodies (96/10), Regulation on limit values of pollutants in surface waters, groundwaters and sediment and timelines for reaching of the values (50/12) and Rulebook on parameters of Ecological and Chemical Status of Surface waters, and Quantitative and Chemical Status of Ground waters (74/11), The Regulation on the Establishment of the Water Status Monitoring Programme (100/12, 43/13 and 85/14).	Partially implemented (47%)	2041
2008/105/EC Water Quality Standards	Law on Water, Regulation on limit values of priority and priority hazardous substances polluting surface water and deadlines for their achievement (24/14).	Partially implemented (8%)	2033
2006/118/EC Groundwater	Law on Water (30/10 and 93/15), Regulation on limit values of pollutants in surface waters, groundwaters and sediment and timelines for reaching of the values (Official Gazette RS no. 50/12) and Rulebook on Parameters of Ecological and Chemical Status of Surface waters, and Quantitative and Chemical Status of Ground waters (Official Gazette RS No. 74/11).	In progress (25%)	2032
91/676/EEC Nitrates	Law on Water 30/2010, 93/12	In progress (15%)	2022
91/271/EEC UWWT	Law on Water 30/2010, 93/12	In progress (32%)	2041
98/83/EC Drinking Water	Law on Food Safety 41/09, Law on Water 30/10 and 93/12, Law on Public Health (OG RS 107/05), Law on Communal Activities (OG RS 88/11)	Partially implemented (59%)	2034
2007/6/EC Bathing Water	Regulation on water classification 5/68 and Regulation on limit values for pollutants in surface and ground waters and sediments, and the deadlines for their achievement 50/12.	In progress (23%)	2020
2007/60/EC Floods	Law on Water 30/2010, 93/12, Regulation on establishment of the methodology for Flood risk assessment (1/12)	Partially implemented (71%)	2021

Table 1 Transposition between EU acquis in field of water and Serbain laws

Cost of implementation in water sector are extremely high and require financing planning from national, EU and other sources. It is particularly related to large investment needs especially in implementation of UWWTD, the presence of arsenic in groundwater on the territory of Autonomous Province of Vojvodina and other problems for implementation of Drinking Water

Directive, implementation of environmental quality standards as well as the time required for the implementation of water management plans. Costs of implementation of Urban wastewater directive, Drinking water directive and Nitrates directive are estimate to 2000, 4962 and 819 million euro respectively. In addition, costs for implementation of Floods directive are not currently assessed (Transposition and implementation of environmental and climate change acquis-chapter 27: status and plans, 2007).

Current connection rate to wastewater treatment is around 13.6% (in 2010) while about 3% receive adequate tertiary treatment. Approximately 75% of the population in towns and only 9% of the population in rural areas is connected the public sewerage system, so 35.8% of households in central Serbia and 23.4% in Vojvodina use the public sewerage system. Only 5% of industrial wastewater is treated in three phases (Đereg & Marković, 2016) and (Institut za vodoprivredu "Jaroslav Černi", 2016).

Water quality monitoring is in jurisdiction of the Agency for Environmental Protection and the Republican Hydrometeorological Institute. Systematic monitoring of surface water bodies quality is performed at 103, of the total of 500 defined according to the law. Water quality is classified at the five classes. Majority of the observed water body (over 80%) belongs to the II and III quality class, 20% of the water body belongs to the IV and V class (Figure 1). Monitoring stations are mainly located at large rivers and artificial water bodies while the smallest amount of data refers to small and medium waterways (altitude over 500 m) and small watercourses outside the Pannonia basin (Institut za vodoprivredu "Jaroslav Černi", 2016).

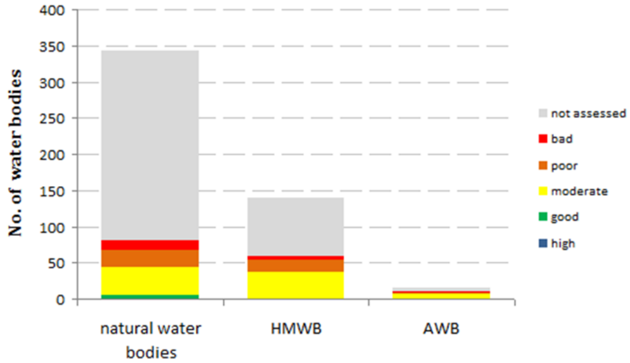

Figure 1 Percentage participation of natural water bodies, Heavily Modified Water Bodies (HAWB) and Artificial Water Bodies (AWB) (Čađo et. al., 2017)

The deviation from good ecological status (middle ecological potential) and chemical status is due to various anthropogenic pressures, of which, according to data, the dominant wastewater of settlements and industry, farms, mines and agriculture. The major derivation of physical-chemical parameter is noted for ortophosphor. Among the priority and specific pollutants, mercury and arsenic are distinguished in certain samples. Low water quality by biological parameters was estimated for 25% of water bodies (Institut za vodoprivredu "Jaroslav Černi", 2016).

2. WATER FRAMEWORK DIRECTIVE

The Water Framework Directive covers all waters bodies including inland surface and groundwaters, transitional and coastal waters. Body of surface water means a discrete and significant elements of surface water such as a lake, a reservoir, a stream, river or canal, part of stream ricere or canal, transitional water or a stretch of coastal water (Directive 2000/60/EC, 2003). The main aim of Directive is to prevent further deterioration of, and protect and enhance the status of aquatic ecosystems, and with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic. The success of the Directive in achieving this purpose and its related objectives will be mainly measured by the status of "water bodies" (Guidance document no 7, 2003). A process of surface water body identification, categorization and typefication is described in Annex II of Directive.

Ecological status is expression of the quality of the structure and functioning of aquatic ecosystem while chemical status is expressed by concentrations of pollutants. For each type of water body ecological status is classified in five classes from „poor" to „high" while chemical status is classified in two classes (Directive 2000/60/EC, 2003).

Good status determined by "good ecological status" and by "good chemical status". Good ecological status is defined as the values of the biological and physico-chemical quality elements for surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions (Directive 2000/60/EC, 2003).

Article 8 of the Directive establishes the requirements for the monitoring of surface water status, groundwater status and protected areas. Monitoring programs are required to establish a coherent and comprehensive overview of water status within each river basin district.

A key Article in relation to monitoring and the design of appropriate programs for surface waters and groundwater is Article 5. Article 5 requires river basin districts to be characterized and the environmental impact of human activities to be reviewed in accordance with Annex II. Three types of monitoring of of parameters that provide the best representation of pressures for quality element are described in Annex V (surveillance, operational and investigative monitoring). Classification of ecological status is based on Ecological Quality Ratio (EQR) and assessment ecological quality of physico-chemical elements. EQR is defined as ratio of observed biological value and reference biological value (Guidance document no 10, 2003).. Monitoring of biological quality elements such as abundance of fish is a very onerous task therefore the Directive specifies quality elements for the classification of ecological status that include hydromorphological elements supporting (indicative) the biological elements and chemical and physicochemical elements supporting the biological elements (Guidance document no 7, 2003).

Water quality elements and parameters for classification of ecological status for the river, lakes, transitional and coastal waters has been primarily selected in Annex V of the WFD while list of priority substances is defined in Annex X. Additional, Member State should use specific sub-elements which are vulnerable at defined pressures on the water body.

The Fig. 2 and Fig. 3 shows the quality elements specified in Annex V and additional recommended quality parameters which have been identified by Member States for the particular water body (Guidance document no 7, 2003).

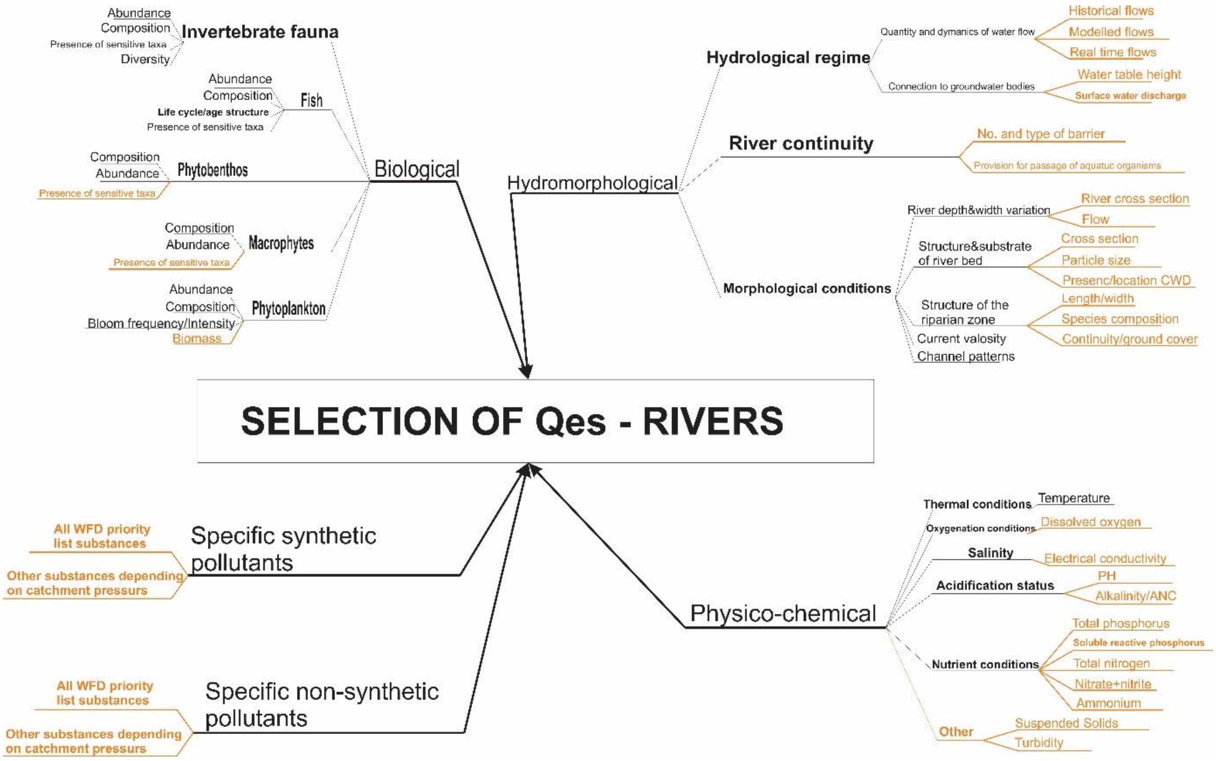

Figure 2 Quality elements for rivers (Guidance document no 7, 2003)

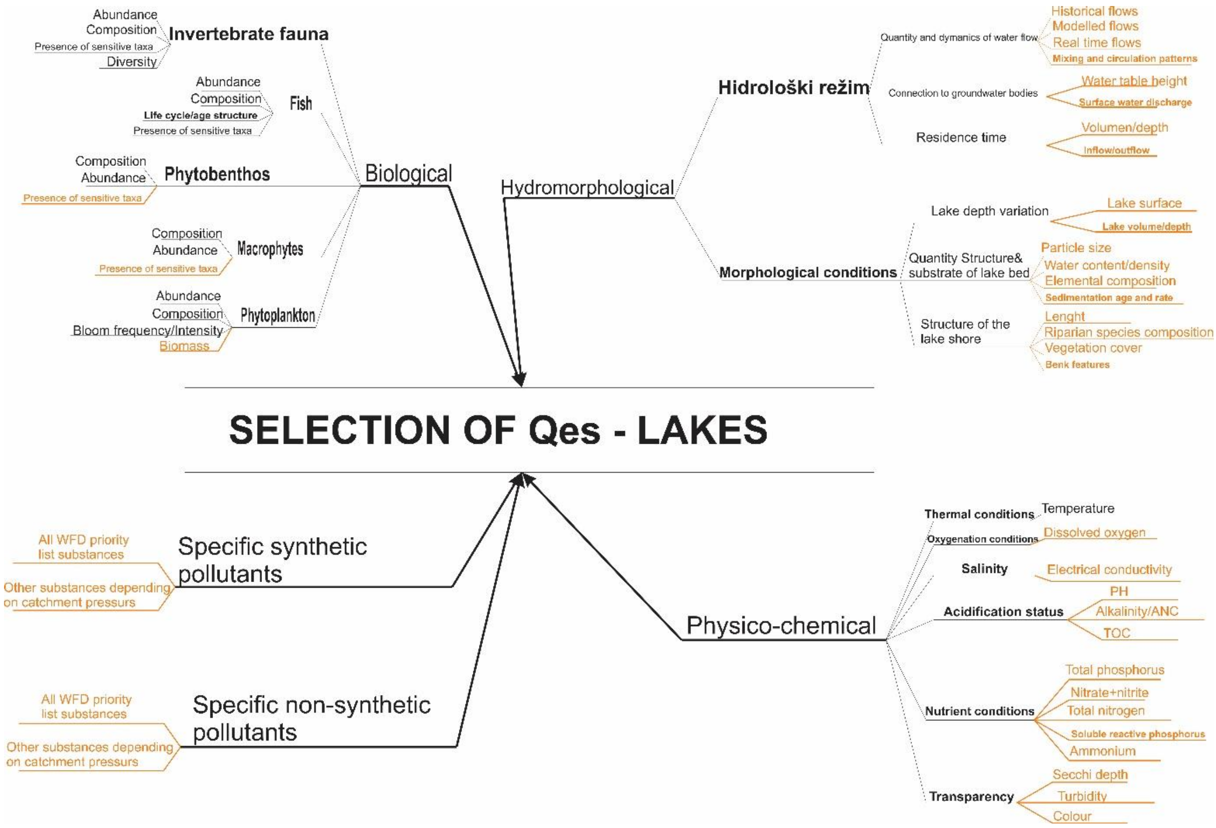

Figure 3 Quality parameters for lakes (Guidance document no 7, 2003)

3. GEOSPATIAL TECHNOLOGIES IN MONITOIRING OF WATER QUALITY PARAMETERS

The Directive requires that sufficient surface water bodies are monitored in surveillance programs to provide an assessment of the overall surface water status within each catchment. Feature more, the WFD implies that rivers with catchment areas greater than 10 km^2 and lakes greater than 0.5 km^2 in surface area need to be included within the water status assessment and monitoring (Directive 2000/60/EC, 2003). This is a very ambitious goal and requires a major financial resource if monitoring is based on traditional methods.

Since the 1980s, the use of remote sensing data in combination with in situ quality measurement has provided a powerful source of data for synoptic and multi-temporal monitoring of water quality parameters over large temporal and spatial scales (Devil et.al., 2015), (Kaabi et. al., 2016). Since relativly few in situ data points are necessary to create image-based water quality models, RS can greatly reduce the cost of training, equipment, lab testing, and field sampling necessary for ground water body monitoring (Nelson et. al., 2003). In addition, RS approaches are suitable for constant monitoring of spatial and temporal variability of large number of water bodies at a regional or nacional scale (Knight & Voth, 2012). Empirical and physical-based algorithms can be used to retrieve water constituents, water depths and bottom substrates. Table 2. Provide reviews of remote sensing application in water quality parameters monitoring.

	Author	Parameter	Parameter in WFD	Platform	Water body type	RMSE	RE
1.	(Giardino et. al., 2014)	Chl-a SPM CDOM Depth	B- Phytoplankton PC-Secchi disk depth PC-Color HM-Lake depth variation	MODIS Landsat OLI RapidEye	Lake	$\pm 0.1\ mg/m^3$ $\pm 0{,}08\ g/m^3$ $\pm 0{,}004\ m^{-1}$	0.72
2.	(Nazeer & Nichol, 2016)	Chl-a	B- Phytoplankton abundance/biomass	Landsat TM	Sea	1.78 $\mu g/l$	0.84
3.	(Smith & Varicat, 2014)	Depth	HM-River depth/length variation	TLS	River	<10 mm	
4.	(Toming, et. al., 2016)	Chl-a DOC Color CDOM	B- Phytoplankton FH – Oxygen conditions PC-Color PC-Secchi disk depth	Sentinel 2	Lake		0,83 0,92 0,52 0,72
5.	(Heine et. al., 2015)	Water level	HM-Quantity and dynamic of water flow	Rapideye	Lake	12 cm	
6.	(Liu et. al., 2015)	TN TP	PC- Nutrient conditions	IKONOS	Lake, River		0,98 0,94
7.	(Palmer et. al., 2013)	TSM CDOM Chl-a	PC- Secchi disk depth PC-Color B- Phytoplankton	Ultraviolet Fluorescence LiDAR (UFL)	Lake	0.9, 0.82, 0.83	
8.	(Abdelmalik, 2016)	pH Electrical conductivity Turbidity TDS Salinity Temperature Alkalinity Orthophosphorus TOC	PC- Acidification status PC-Other PC- Salinity PC-Temperature PC- Acidification status	ASTER	Lake		0.045, 0.575, 0.891 0.296, 0.693, 0.426, 0.117, 0.014, 0.87
9.	(Mandlurger et. al., 2015)	Cross section Riparian zone	HM-Structure of river bed HM-Structure of riparian	Topo-bathymetry Lidar	River	2 cm	
10.	(Simon, et. al., 2015)	Geometry Water level	HM-Lake surface HM-Quantity and dynamic of water flow	Pleiades COSMO-SkyMed TerraSAR-X	Lake	98% klas 0.42m	 0.963

11.	(Zhao et. al., 2017)	Water level Depth	HM-Quantity and dynamic of water flow HM-Morphological	ALB LiDAR		5.03 cm 1.30	
12.	(Feyisa et. al., 2014)	SAV	B-macrophyte	RapidEye	Lake		0.72

Table 2 Provide reviews of remote sensing application in water quality parameters monitoirng in context of WFD.

Optical images are widely used for monitoring of water quality parameters. Most studies are focused on optical active parameters (Table 2), which can be determined directly based on measured amount of radiation at various wavelengths reflected from the water's surface, such as chlorophyll-a (chl-a), total suspended solids (TSS), turbidity, Secchi Disk Depth (SDD), Colored Dissolved Organic Matters (CDOM), Total Organic Carbon (TOC), Total Suspended Matters (TSM) and Electrical Conductivity (EC). There are several other important parameters such as pH, total nitrogen (TN), ammonium nitrogen (NH3-N), total phosphorus (TP), which are optically inactive. Therefore, remote estimation of optical inactive parameters has been based on their high correlation with optically active constituents.

LiDAR (Light Detection and Ranging) data provide reliable information of hydromorphological parameters. They can be effective used for: water body delineation, structure of riparian zone, channel morphology (Zhao et. al., 2017), water level (Zhao et. al., 2017) as well as water quality parameters (Palmer et. al., 2013). Also, LiDAR provide high resolution topographic data sets which are crucial in flood modeling and management.
Synthetic-Aperture Radar (SAR) images can be employed for water delineation, change monitoring and flood mapping. Due to its all weather capabilities, during day or night or in cloudy condition, SAR imagery can offer better alternatives for water body mapping than optical imagery. Altho, SARs are widly used for water pollution detection like oil pollution, ocean topography and regional ice monitoring, they capablities for monitoring of water qaulity paramenter, in contex of WFD, are limited.

3. THE WATER FRAMEWORK DIRECTIVE DATA MODEL

The WFD data model is proposed in (Directive 2000/60/EC, 2003). The data model aims to satisfy the requirements defined by Directive and extends the basic distinctions between "Surface Water" and "Groundwater" and "Protected Areas" adding the "Monitoirng Network", Management/Administration" and "Ecological Status" (Guidance document no 9, 2003). Within the model, logically related features are grouped together into four packages: Water Bodies, Monitoring Status, Administration and Status. Package Water Bodies define classification of water bodies and all information relative for them. According to the type, WFD distinguishes Surface and groundwater bodies. Thus, the abstract class SurfaceWaterBody is classified into FreshWater and Saline Water. Package Management Units contain classes related to the management and administration. This units are: river basin district, river basin, sub basin, ecoregion and protected area. River basin district means the area of land and sea, made up of one or more neighboring river basins together with their associated groundwaters and coastal waters, and represent the main unit for management of river basins. A WaterBody or a Monitoring station may belong to a single RiverBasineDistric. Monitoring station are defined in Monitoring Station packages. According to water body type WFD distinguish monitoring of surface water and groundwater therefore class Monitoirng station is divided in two subclasses: SurfaceMonitoirngStations and GroundwaterMonitoringStations. The status parameters are stored in Status package. For SurfaceWater bodies four classes are defined: FreshWaterEchologicalStatus, PhysicoChemicalClassification, SalineWaterEcologicalStatus and SWStatus. The GWStatus class provides status reports for a given date for a given Groundwater Body. The UML diagram of WFD data model is shown in Fig. 4.

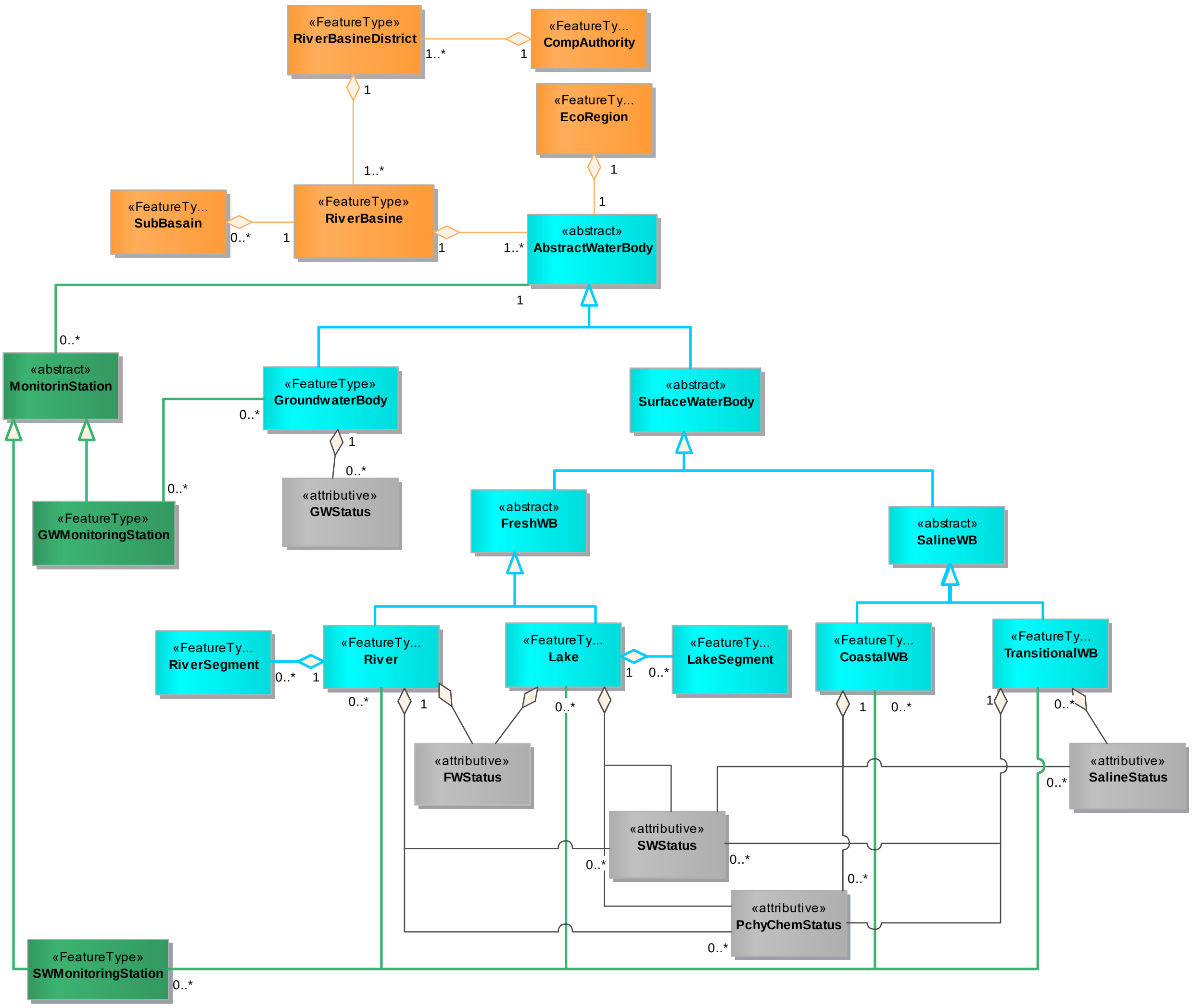

Figure 4 WFD data model

4. INSPIRE Directive

The horizontal sector of Chapter 27 provide for methods and mechanisms aimed at improving decision making and legislative development and implementation. The legislation in this sector covers: environmental impact assessment (EIA), strategic environmental assessment of proposed plans and programmes, public access to environmental information, reporting requirements, the European Pollutant Release and Transfer Register, infrastructure for spatial information (INSPIRE Directive), the establishment of a European Environment Agency (EEA) and participation therein, minimum requirements for environmental inspections, environmental liability and the LIFE+ (L'Instrument Financier pour l'Environnement) programme to fund certain environmental improvement projects.

INSPIRE DIRECTIVE (2007/2/EC) serves to establish the necessary infrastructure for spatial information within the EU to ensure the better integration of environmental policy. The INSPIRE Directive responds to the need for quality geo-referenced information to support understanding of the complexity of, and interactions between, human activities and environmental pressures and impacts (Sector 2, 2017).
INSPIRE data specification specify common data models, code lists, map layers and additional metadata on the interoperability to be used when exchanging spatial dataset. Dataset in scope of INSPIRE are organised in three annexes and 34 spatial data themes.
Data required by WFD sholud be collected once and shered among public sector organisations across boundaries therefore WFD data sholud be created and maintained compatible with the INSPIRE dateset and should be available in INSPIRE model.
Associations have been defined between WFD spatial object types within INSPIRE themes to represent explicit relationship between the themes:

•WFD Surface Water Body are related to one or more HydroObject (Annex I INSPIRE thema Hydrography (Data specification on Hydrology, 2013))

• WFD Ground Water Body are related to one or more GroundWater Body and/or Hydrogeological Units (Annex I INSPIRE theme Geology)

•WFD Monitoring stations are related to Environmental Monitoring Facilities Objects (Annex III INSPIRE thema Environmental Monitoring Facilities (Data specification on Environmental Monitoring Facilities, 2013)),

•WFD sub units and RiverDistricBasin are related to Management Regulation or Restrict zone (Annex III INSPIRE theme Area Management/Restriction/Regulation Zones and Reporting (Data specification on Area Management/Restriction/Regulation Zones and Reporting, 2013)). Also, surface water bodeis deffined according to WFD are represented as Reporting units.

•Elevation data are part of Annex II INSPIRE theme Elevation.

The Annex I theme Hydrograpy is involved with description of the sea, lakes, rivers and other waters, with their phenomena and all hydrographic-related elements (Data specification on Hydrology, 2013)). Geographically, the theme ―Hydrography covers all inland water and marine areas covered by river basin districts as defined by WFD. The INSPIRE HY theme is based on physical water objects that form part of the hydrological network (watercourses, standing water, wetlands). Altho, WFD water bodies, follow the geometry of the surface waters, the nodes can differ from the nodes od the physical watercourse segment. Also, number of watercoures forme a single waterbody for the WFD. Since Inspire HY don't specify on how a watercourse should be broken into smaller pieces it is possible to build a reporting unit e.g. from sections of watercourse and/or standing water, through a common identification in the base HydroObject (Data specification on Hydrology, 2013)). A number of these sections would then form e.g. a WFDRiver or WFDLake (Annex III Area Management/Restriction/Regulation Zones and Reporting – Reporting Units)

The drainage basin and river basin in HY pertain to the physical catchment area and not to the RiverBasinDistrict (RBD) or SubUnit as defined in the Water Framework Directive. These last two are administrative units that have no direct relation to the physical catchment and basin therefore RBD more a reporting unit then a physical feature and there are not modelled by Annex I theme but is deemed to be part of Annex III theme management and reporting units.
Additionaly, INSPIRE has adopted use of ISO 19156:2011 standard on Observations and Measurements for the reporting of observation and measurements, which includes the process of taking samples and measurements taken directly on some feature of interest or indirectly on a spacimen taken at a feature of interest. The integration of INSPIRE and WFD model is shown at Figure 5.

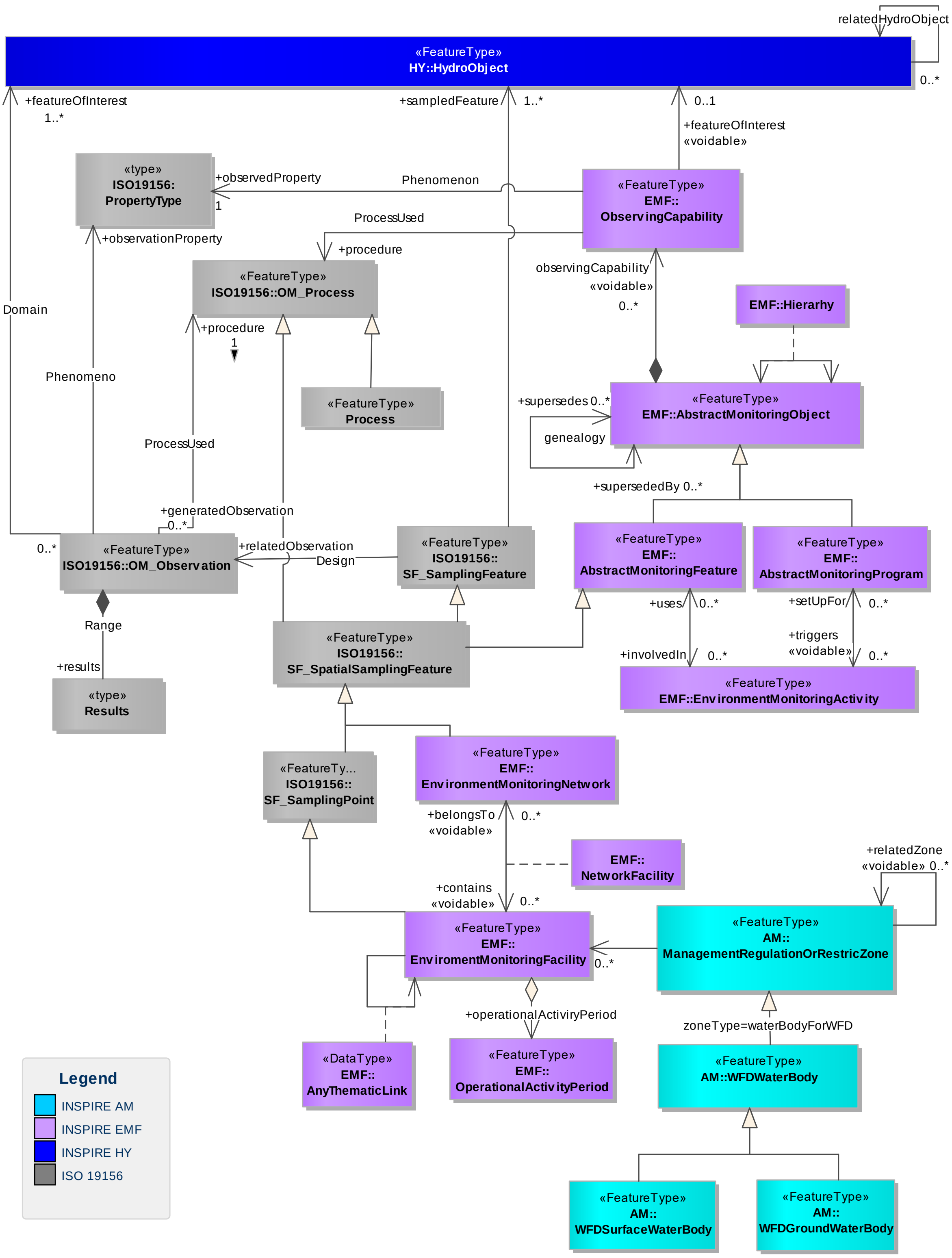

Figure 5 Integration of INSPIRE and WFD data model

Conceptually mapping between INSPIRE AM and WFD data mode for River Water body is presented at Figure 6. River, as defined in the WFD can be described using the generic ManagementRestrictionOrRegulationZone spatial object with the value *waterBody ForWFD* as the *zoneTypeCode*. The *EnvironmentalDomains* has a value *water*. River, as specific type of water, is defined using the *specialisedZoneTypeCode*. Additionally, several attributes in WFD reporting schema can be conceptually mapped as INSPIRE attribute. WFD data specification, *EUCode* and *MSCode* identifier are assigned to a River. Those code properties should be encoded as a thematicIds. The thematicId is encoded using the *euSurfaceWaterBodyCode* for *thematicIdIdentifierScheme* attribute. A thematic identifier may form part of the *inspireId*.

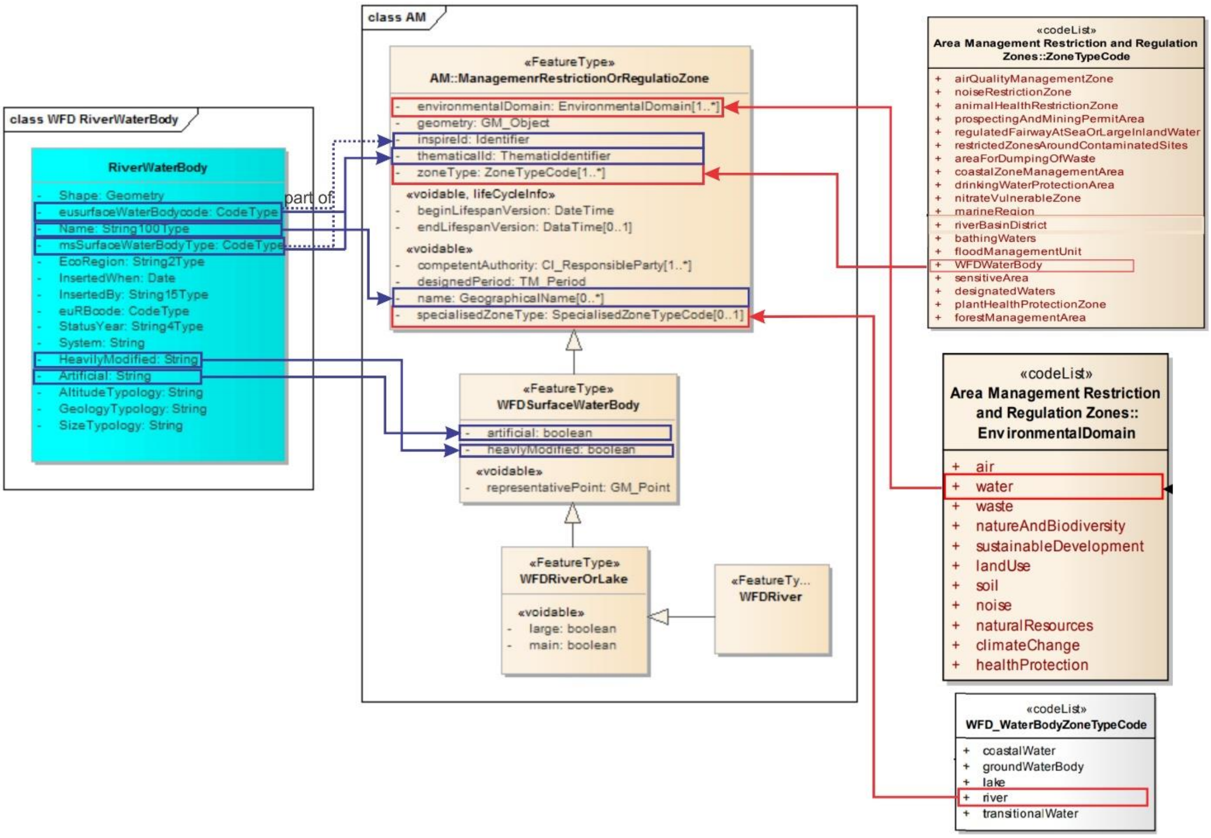

Figure 6 Conceptuall mapping between INSPIRE and WFD

INSPIRE specify the geometry of the water body in addition to generic attributes. The actual value as WFD status that needs to be reported on is not included therefore INSPIRE base model must be extend in such way that the information to be reported on is included. A extension of INSPIRE AM with WFD Status package is presented at Figure 8. All status parameters are linked to the relavant water body via the euSurfaceWaterBodycode.

Figure 7 Extension of INSPIRE AM with WFD status

5. RECOMMENDATION FOR AUTOMATIC WATER BODY DETECTION AND WATER QUALITY PARAMETERS MONITORING

Figure 8 summarizes the suggested approach for water body delineation and water qulity parameters monitoring.

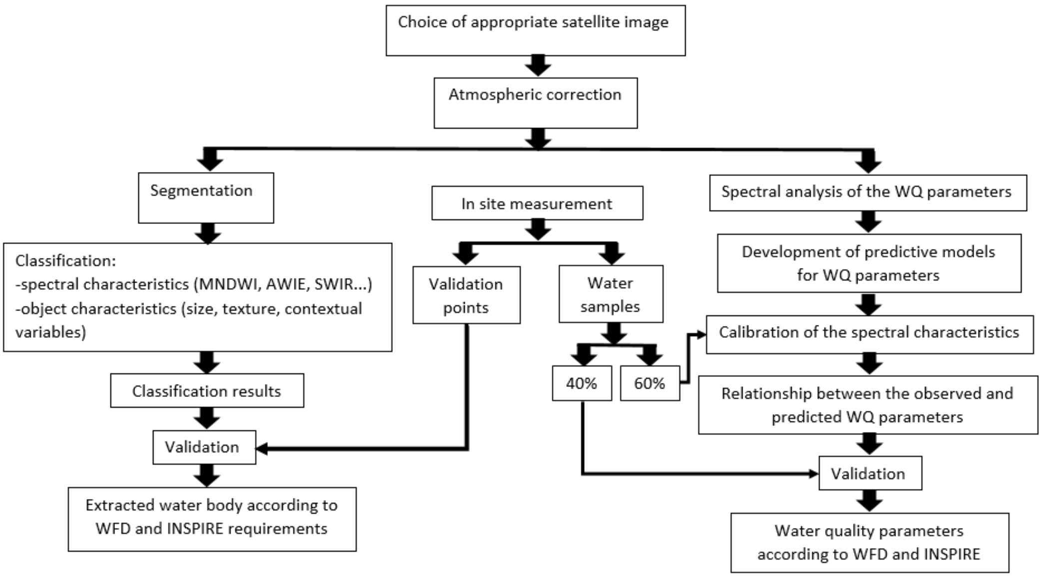

Figure 8 Suggested workflow

Depending on water body type appropriated resolution of satellite images need to be provided. Water bodies in urban areas are smalle, with complex morphology which results in increasing number of mixed pixels therefore usages of high resolution satellite images is necessary in order to increas accuracy. In order to retrive geometry and water quality parameters from satellite images it is necessary to remove atmospheric effects using and efficient and reliable atmospheric correction model. Atmospheric correction is important for applications where small difference in surface reflectance are significant, such as monitoring of water quality parameters, or when band ratio are used, such as NDWI, Modified Normalized Difference Water Index (MNDWI) etc.

Using objects, as smallest unit, instead of pixels minimize ”salt-paper” effects. Featuremore, unlike pixel-based methodes which only use spectral information, object-based approach incorporate objec-level shape, texture and contextual variables in classification producing higer classification accuracy compared with pixel-based methodes therefore object-based image analysis is prefered for water body delineation.
Clear water absorb relatively little energy with wavelengths smaller then 0.6 μm, resulting in high transmittance in the blue-green portion of the spectrum therefore detect clear water by introducing a spectral index, such as Normalized Difference Water Index (NDWI), can be easy. However, water is almost never clear in real world, due do pollution, changing the spectral signature and making it difficult to delineate water bodies with a single threshold.
Increases in chlorophyll concentration tend to decrease reflectance in blue wavelengths and increase it in green wavelengths, the increase in the CDOM concentration mainly affects the reflectance values in the blue and green region of spectrum (especially below 500 nm) and its absorption increase with decreasing wavelength while increase of dissolved inorganic materials cause the peak of visible reflectance to shift from green region toward the red region. In the SWIR part of the spectrum, the pure-water absorption is very high, and at very long SWIR wavelengths (λ>1600 nm) even extremely turbid waters are effectively black (Shi & Wang, 2009) (the radiation completely absorbed by the water body). This is especially important for delineation between water and low albedo surfaces (e.g. asphalt, built up areas) as their spectral signatures are very similar in VNIR therefore MDWI (Xu, 2006) and Automated Water Extraction Index (AWEI) (Feyisa et. al., 2014) should be used. Also, improvements in water detection can be achieved by combining optical imagery with elevation data since water bodies are most often located in valleys.
The water quality parameters monitoring is based on combination of remote sensing and in site data for calibrating the algorithm. In order to obtain reliable results the time gap between gathering in site data and remote sensing data should be as small as possible. Usually, 60% of in situ data are used for calibration while 40% is used for validation of produced results.
The accuracy of water body mapping may be reduced especially in areas where the background land cover includes low albedo surfaces such as asphalt roads and dark object in urban areas, snow and shadows from mountains, buildings and clouds (Feyisa et. al., 2014). In that case, water bodies and shadows cannot be easily separated due to their similar spectral pattern (Dare, 2005).

6. CONCLUSION

By increasing the anthropogenic activities and industrial development, water quality has dramatically degraded. A series of Directives, in order to prevent feature degradation of water quality, was adopted by European Union. The full transposition of EU *acquis communautaire* and Serbian Law, in field of water, is expected in 2041. Water Framework Directive require large amount of geospatial data and monitoring of large number of water bodies which require a major financial resource. Remote sensing techniques in conuction with in site measuremet make it possible to have spatial and temporal view of surface water geometry and quality parameters as well as more effectively monitoring of the waterbodies, and quantify water quality issues. In order to retrive geometry and water quality parameters from satellite images in preprocesing phase atmospheric corection need to be carried out. In site data, used for calibration of algorithms for water quality parameters monitoring and validation of results, should be gained in same time as satellite image. Object-based image analysis and water indexes are recommended for automatic water body delineation. All data required by WFD should be provided in line with INSPIRE directive. INSPIRE data specification provide the framework for reporting therefore base model defined by INSPIRE need to be extended it such a way that the information to be reported are included. Also, INSPIRE code list should be extended in to meet specific need of WFD directive.

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