European Topic Centre
Inland, coastal, marine waters

Groundwater GIS reference layer

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Version History

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1	**05/10/2010**	**Klaus Duscher**	**1st Draft**	**AKU**
1.1	**11/10/2010**	**Klaus Duscher**	**1st Draft with minor updates**	**WG D (13-14 Oct. 2010)**
2	**17/01/2011**	**Klaus Duscher**	**2nd Draft after preparation of Groundwater WISE map**	**BJA**
2.1	**02/02/2011**	**Klaus Duscher**	**2nd Draft with minor updates**	**BJA, AKU**
2.2	**28/03/2011**	**Klaus Duscher**	**2nd Draft with minor updates**	**WG D**
2.3	**11/04/2012**	**Klaus Duscher**	**3rd Draft after 2011 update**	**BJA, AKU, WG C**
2.4	**20/09/2012**	**Klaus Duscher**	**4th Draft after update June2012**	**Public**
3	**08/03/2013**	**Klaus Duscher**	**1st published draft of GIS Layer after update June2012**	**Public**

Abbreviations

AT	Austria
BE	Belgium
BG	Bulgaria
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
CIRCA	Communication & Information Resource Centre Administrator
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
EC	European Commission
EE	Estonia
EEA	European Environment Agency
ERM	EuroRegionalMap
ES	Spain
ETC/ICM	European Topic Centre on Inland, Coastal and Marine Waters
EU	European Union
FI	Finland
FR	France
GWB	Groundwater Body
GR	Greece
HU	Hungary
IE	Ireland
INSPIRE	Infrastructure for Spatial Information in the Europe Community
IT	Italy
LT	Lithuania
LU	Luxemburg
LV	Latvia
MS	Member State
MT	Malta
NL	Netherlands
PL	Poland
PT	Portugal
QA	Quality Assurance
RBD	River Basin District
RBMP	River Basin Management Plan
RO	Romania
SE	Sweden
SK	Slovakia
SI	Slovenia
UK	United Kingdom
WFD	Water Framework Directive
WG C	Working Group C - Groundwater
WISE	Water Information System for Europe
XML	Extensible Markup Language

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1 Introduction

This report offers explanatory notes regarding the GIS layer of GWBs reported with the first RBMP according WFD Article 13.

A GWB is defined in WFD Art 2 as a distinct volume of groundwater within an aquifer or aquifers, whereas an aquifer is defined as a geological layer with significant groundwater flow. This definition of a GWB allows a wide scope of interpretations.

The submission of GWB data to the EEA by EU member states is accomplished via the Reportnet platform, as a part of the dataflow for WFD. Art. 13[1] reporting. GWB data includes spatial data as GIS polygons and GWB characteristics in an XML schema. GWBs are registered to so-called horizons, which represent distinct vertical layers of groundwater resources.

The ATKINS branch office in Copenhagen, a consultant mandated by the EC, collects WFD data and carries out basic quality assurance covering data structure and completeness. ATKINS is also integrating the data from the XML schema into a database for further assessment. BGR is in charge of subsequent data analysis in terms of consistency and hydrogeological aspects. The task objective is the compilation of a GWB reference layer comprising the area of all participating states by merging the polygons of sufficient quality.

The resulting GWB map is published in the WISE internet mapping application “WFD groundwater viewer[2]”.

In accordance with the WISE Implementation Plan 2011-2015, the GWB reference layer will be published and made available for download by other stakeholders.

This report version 2.4 describes the status of the GWB GIS Layer including updates of attribute and spatial data until June 2012.

Several technically critical aspects of GWB delineation were discussed at a Workshop in Berlin on 15th and 16th of December 2011[3] and at a meeting of the CIS Working Group C on 20th of March 2012. Furthermore a document for each MS with comments on selected QA issues was prepared and distributed via the WFD helpdesk function operated by ATKINS. As a result the spatial data according WFD Art. 13 of this GWB layer version cover all MS of the EU for the first time. However contributions of MS are still due and reviews with the next RBMP have already been announced by several MS.

Thus this GIS GWB layer version has to be considered as a first step towards a consistent GWB picture throughout Europe, but it is not yet of a sufficient quality to support spatial analyses as for a fully developed reference GIS dataset. Therefore the layer is published as a preliminary version and use of the data is subject to the quality restriction outlined below (see section 3).

[1] http://rod.eionet.europa.eu/obligations/521

[2] http://www.eea.europa.eu/themes/water/interactive/soe-wfd/wfd-gw/

[3] http://www.bgr.bund.de/EN/Themen/Wasser/Veranstaltungen/workshop_gwbodies_2011/gwbodies_2011_inhalt.html?nn=1559030

2 Groundwater bodies in the INSPIRE directive

INSPIRE directive aims to establish a spatial infrastructure in the European Union to solve problems regarding availability, quality, organisation and sharing of spatial information. INSPIRE Directive is focused on infrastructure components (metadata, spatial datasets and services) together with defining the coherent approaches to data access and sharing to facilitate data exchange between public authorities of all levels.

The topic of GWBs is included in two different INSPIRE spatial data themes and technical guidelines which present different contexts:

- The INSPIRE Area management/restriction/regulation zones and reporting units includes the GWBs as management areas established for the purpose of the Directive 2000/60/EC of the European Parliament and of the Council (Water Framework Directive, WFD).
- The INSPIRE Geology defines the hydrogeological system which includes feature groundwater body.

The INSPIRE Area management/restriction/regulation zones and reporting units (INSPIRE Area management) proposes a common conceptual schema (Application schema Water Framework Directive) which includes the main relationships between these different concepts within the INSPIRE themes[4]. This is shown in Figure 1.a, which presents the relationships between the Water Framework Directive application schema and the INSPIRE spatial data themes Hydrography and Geology. Further specifications for WFDGroundWaterBody are currently not included in INSPIRE implementing rules. Consequently, it would be premature to make an INSPIRE compliance check.

A WFDGroundWaterBody [INSPIRE Area management] is a distinct volume of groundwater within an aquifer or aquifers, which is used as a management area within the Water Framework Directive (WFD).

A *GroundWaterBody [INSPIRE Geology]* is a distinct volume of groundwater within an aquifer or system of aquifers, which is hydraulically isolated from nearby groundwater bodies.

The relationship from the *WFDGroundWaterBody* to the *GroundWaterBody* is modeled through two associations (i.e. every WFDGroundWaterBody may be based on mulitiple GroundWaterBodies and the other way around – in other words a n : m relation).

[4] D2.8.III.11 Data Specification on Area management/restriction/regulation zones and reporting units – Draft Guidelines; Annex D (informative): Application schema Water Framework Directive; http://inspire.jrc.ec.europa.eu/index.cfm/pageid/2

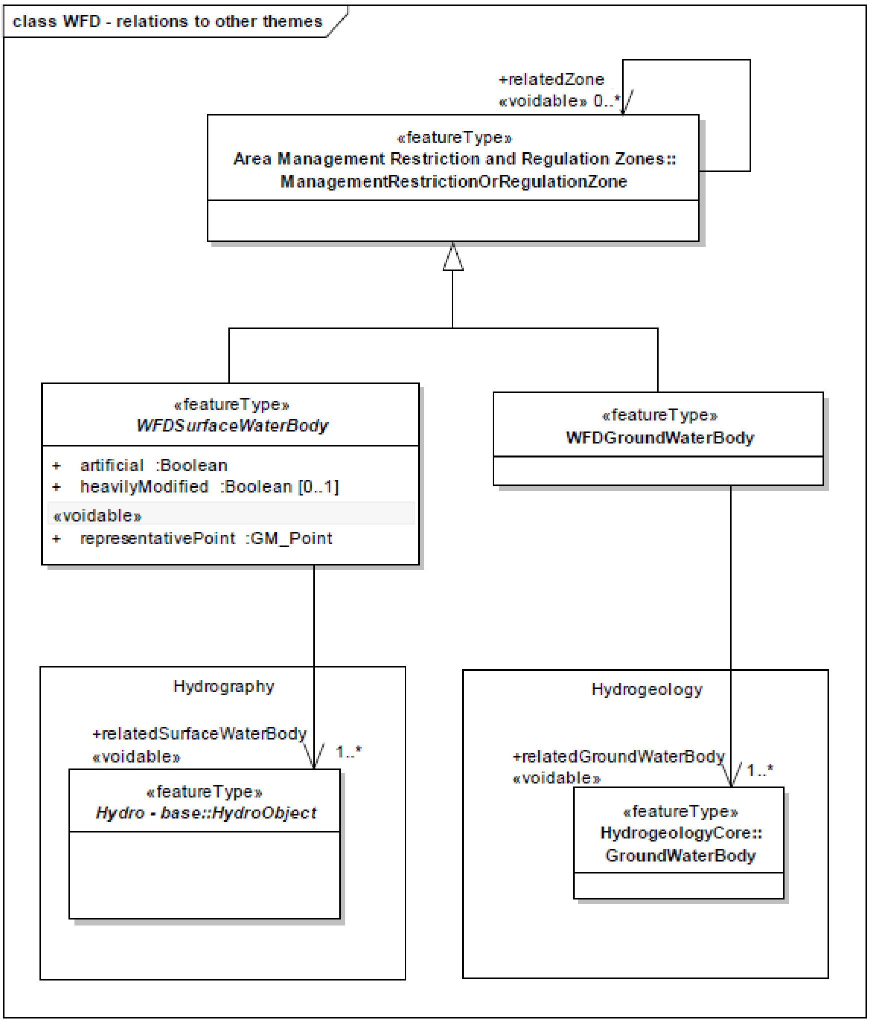

Figure 6 – UML class diagram: Relationships between the Water Framework Directive application schema and the spatial data themes Hydrography and Geology

Figure 1 a: Extract from INSPIRE Data Specifications; class WFD – relation to other themes

Further details are given in the *INSPIRE Area Management data specifications, Annex D*[5].

The GWBs are included in INSPIRE Area management from the perspective of the WFD Directive that those water bodies are management areas. The type of the zone used to describe the WFD GWBs is called “waterBodyForWFD” and has the following definition:

The “water body” is a coherent sub-unit in the river basin (district) to which the environmental objectives of the Water Framework Directive must apply. The identification of water bodies is, first and foremost, based on geographical and hydrological determinants. This would include surface (river, lake, transitional and coastal) and groundwater bodies[6].

[5] http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_AM_v3.0rc3.pdf

[6] see footnote 5, page 119 (version 2013-02-04)

Figure 1.b shows the application schema of the management areas/restriction/regulations zones in the INSPIRE Area management. This schema includes a main class “ManagementRestrictionRegulationZone” to model management areas, restrictions or regulations. This class includes the types of the zones defined by the attribute ZoneType. The values of this attribute are pre-defined in the code list ZoneTypeCode which includes different types of zones, for example: air quality management zone, area for dumping of waste, coastal zone management area, drinking water protection area, flood unit of management, river basin district, water body under the WFD and others. The code list can be extended by the MS and data providers. The zone type code “waterBodyForWFD” means “water body under the Water Framework Directive” and refers to the management areas related to the WFD. More detailed application schema for the water bodies under the Water Framework Directive (including WFDGroundWaterBody) is described in the Application Schema Water Framework in *the INSPIRE Area Management data specifications, Annex D*.

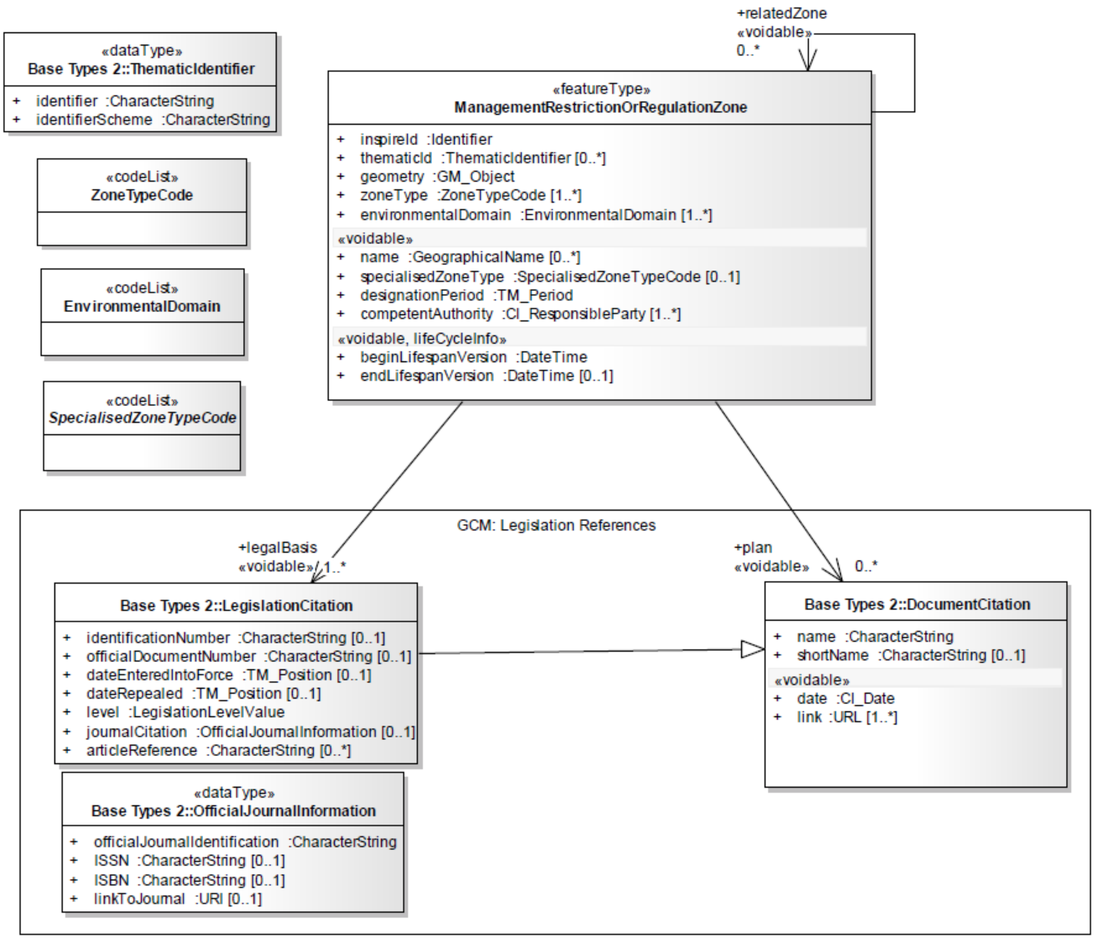

Figure 6 – UML class diagram: Overview of the Area Management Restriction and Regulation Zones application schema

Figure 1 b: Extract from INSPIRE Data Specifications; application schema of the management areas / restriction / regulations zones in the INSPIRE Area management.

Figure 1.c shows the *Hydrogeology System* as part of the *Hydrogeology Core Model* in the current version 3.0 of the INSPIRE Geology data specification[7].

The class GroundWaterBody forms the main class of the groundwater system in this *Hydrogeology System.* This class is linked to other hydrogeological topics as e.g. the *Hydrogeological Objects* or the *Aquifer System*.

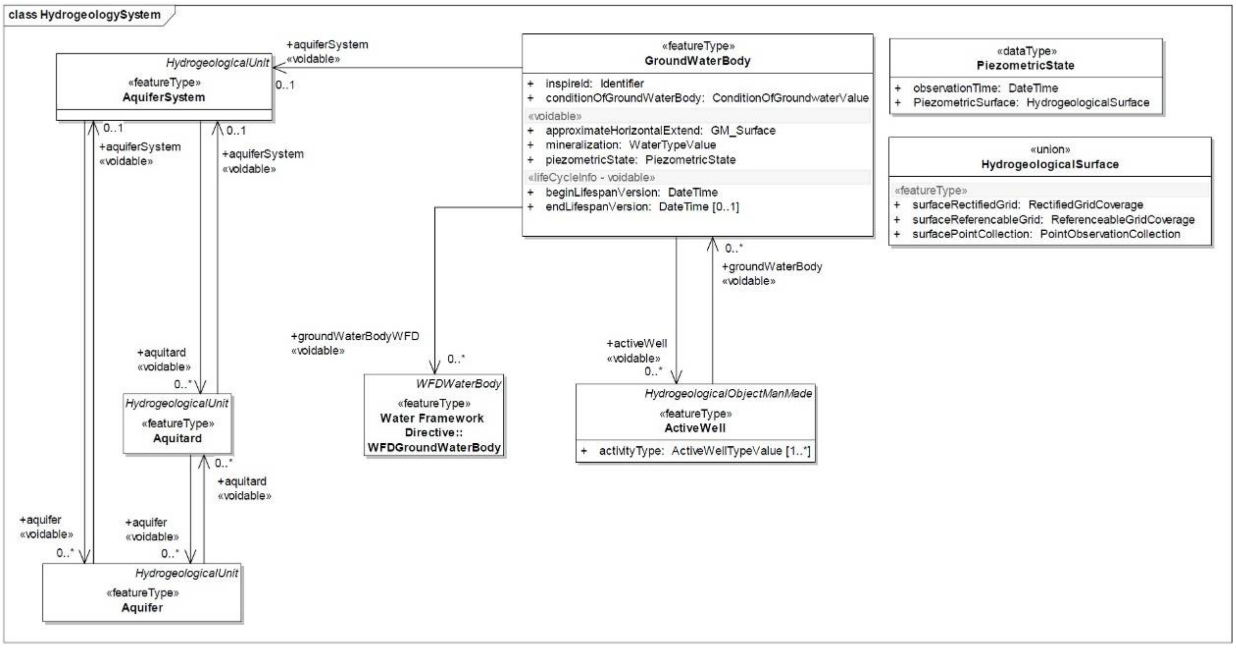

Figure 1 c: INSPIRE model: Hydrogeology system

As mentioned before, the class GroundWaterBody has an association to the WFDGroundWaterBody. Based on the different assumptions established in MS the delineation of a *WFDGroundWaterBody* boundary can differ from the natural *GroundWaterBody* extent.

The dataset described in this report is related to *WFDGroundWaterBody* class*.* This class is a special case of a management area specified in the INSPIRE Area Management application schema.

3 Quality restrictions on data processing

While assembling the GWB layer several QA issues became obvious and most of them are briefly explained in this report.

Main quality feature which restricts the ability to process the GWB layer with other GIS data is a GWB structure with a multitude of in parts very tiny, distinct areas. Even multipart polygons, each of which forms a single GWB, may consist of hundreds of separated areas. This results in a highly detailed and subsequently called fragmented pattern. In certain parts topological errors appear quite frequently.

The delineation methodologies are currently varying between the MS in terms of size and three-dimensional positioning of GWBs. Therefore in many map sections the GWB pattern reflects administrative country borders.

[7] http://inspire.jrc.ec.europa.eu/index.cfm/pageid/2 ; http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DS_Geology_v3.0_rc2.pdf

Only a reduced set of GWB attributes with sufficient entries deriving from the XML schema will be reviewed in this report. According to recent discussions the selection of GWB attributes requested from the MS will probably be diminished.

If the GWB layer is used for spatial analysis the quality restrictions given above and the ongoing reviews expected with further GWB layer versions will have to be considered.

4 Particularities of selected member states in data of 2012

4.1 Belgium

In BE the WFD reporting is divided between Flemish and Wallonian authorities. The attribute tables of the GIS shape files of GWBs in the RBDs of Maas and Schelde comprise the column Horz_Other. This column was discussed to indicate the deepest horizon, if a GWB vertically extents over several horizons. As this method was adapted only in certain parts of BE, it was not implemented in the aggregated shape files and all GWBs are assigned exclusively to the column "Horizon".

4.2 Denmark

DK uploaded GWB attributes and GIS data of GWBs according to WFD Art. 13 on Reportnet for the first time in 2012. The spatial data comprises only 10 polygons. These are considered as a supplement to the data reported according to WFD Art. 5, which had been available since 2009. The attributes are largely matching the GWB polygons. Therefore the polygons of former WFD Art. 5 reporting together with the update of 2012 are accepted as a WFD Art. 13 reporting in this GWB layer version.

4.3 Estonia

In 2012 EE has reported GWB polygons according to WFD Art. 13 via email consisting of 15 distinct overlying groundwater horizons. This exceeds by far the number of a maximum of 5 GWB horizons reported by the MS until 2011. Although there is still no official upload of Estonian GIS GWB data on Reportnet, the Estonian GWB polygons had been integrated to fill the remaining gaps of the GWB map.

Estonia provided a qualified explanation of the applied horizon assignment methodology, but this does not match any of the three-dimensional structures discussed and is hardly displayable in a two-dimensional map. Therefore all of the Estonian GWBs were allocated to horizon 0.

It has to be noted that attribute data provided in 2011 matched the outdated GWBs reported according to WFD Art. 5. As GWB keys were changed the GWB polygons of 2012 do not correspond any more to the attribute dataset.

4.4 Irish / British border

Transboundary GWBs of IE extent into Northern Ireland and are overlying GWBs of UK having identical outlines. The transboundary GWBs of IE probably have to be cut at the state border. For this reason both MS have to agree on spatial data of the state border.

4.5 Latvia

LV delivered GWBs with a horizon allocation for the first time in 2012, but the horizon column contained enumerations of horizons. This was resolved by copying a GWB polygon into each of the enumerated horizon layers. If the column reads e.g. “2,3,4” the GWB polygon appears in each of the three layers.

4.6 Slovenia

SI delivered WFD Art. 13 GWB data in 2012 for the first time with 27 polygons associated to 21 GWBs. Obviously the GWBs were split along RBD borders. The polygons had been merged into single polygons for each GWB resulting in 21 GWB polygons.

5 Status of uploaded data

5.1 Submission updates in 2012

ATKINS provided a Microsoft Access database comprising the complete, most recently reported attribute data of all MS, which includes all updates until June 2012.

Concerning spatial data ATKINS assembled exclusively the updates of 2012 until June in a geodatabase. Thus the revised polygons had to be clipped out from the 2011 version of the GWB layer and subsequently were replaced by the new polygons.

This applies for the whole spatial data of AT, IT, LV and parts of BE, BG.

As the data of DK, EE, LU, PT and SI were reported for the first time these polygons just had to be added to the GWB layer of WFD Art. 13 submissions.

5.2 Status of WFD Art. 13 Data

After integrating the updated GWB data of 2012 a complete reporting was achieved for the first time with spatial as well as attribute data of all 27 MS. Although there are still quality deficits as mentioned above this is a major milestone in generating a GWB GIS layer.

In June 2012 all MS had set the status of reporting to final. Thus apart from minor corrections no further submission of 1st RBMP data is expected.

6 GWB map compilation

6.1 Article 13 data on GWB polygons

The amount of GWB polygons delivered until June 2012 by MS is presented in table 1. They sum up to a total number of 13,345 polygons. This refers to raw data as reported by the 27 MS and includes any displayable GWB polygon. The quantity of GWBs reported by MS varies substantially between 1 by MT and 3616 by FI.

A brief analysis of the spatial GWB data and the attribute data is given in sections 7 and 8.

The attribute tables (dbf) of the provided shape files always implied the mandatory fields GWB code and GWB horizon partially accompanied by varying extra columns defined by the MS.

Country	Number of GIS GWBs	Country	Number of GIS GWBs
AT	136	IT	611
BE	84	LT	20
BG	140	LU	7
CY	20	LV	43
CZ	173	MT	1
DE	989	NL	23
DK	384	PL	161
EE	25	PT	144
ES	712	RO	142
FI	3616	SE	3023
FR	890	SI	21
GR	235	SK	90
HU	176	UK	723
IE	756		
Total		**13345**	

Table 1: Number of GWB polygons reported via RBMP until June 2012

A selection of further GWB characteristics deriving from the reported XML files is provided with the Microsoft Excel file GWB_attributes_2012June.xls. The table includes the column “EU_CD_GW”, which serves as a key for joining spatial and attribute data. There is no corresponding spatial data for GWBs in the attribute table GWB_attributes_2012June.xls without an entry in column “EU_CD_GW”.

6.2 Non member states participating

CH has, on a voluntary basis, provided spatial data on GWBs to the ETC/ICM.

This was delivered in August 2012 and raised the number of Swiss GWBs from 29 (earlier reported to EEA through Eionet) to 124, which are allocated to horizon 1 and cover the whole territory besides the surface of large lakes.

Data of CH is not included in the evaluation of sections 7 and 8, which exclusively refers to WFD Art. 13 submissions.

6.3 GWB map structure

Complete available information about GWB polygons has been assembled in one GWB map to illustrate the state of information. All such GWBs assigned to the same horizon from horizon one to five are merged into one shape file. GWBs of horizon six and seven appear only in Sardinia and are integrated in an extra joint shape file. The GWBs missing any horizon allocation (see section 7.4) are aggregated in a further shape file. Because of the position in the southern hemisphere the GWBs of Reunion Island, all of which in horizon 1, had to be projected in a separate shape file.

In supplement a shape file with GWBs from Switzerland as a non EU member state has been added. Thus the GWB map comprises nine shape files, which can be activated and displayed individually.

The attribute tables (dbf) of the shape files only comprise the mandatory attributes of a GWB identifier and the horizon allocation supplemented by the subsequently added column Polygon_ID providing an artificially generated unique polygon identifier (see section 7.1).

Figure 2 shows the map of GWBs in Europe with eight themes except for the Spanish and Portuguese islands in the Atlantic Sea and the French overseas territories as it is published as WISE map[8] with a different legend.

6.4 Correction of topological problems

The processing of some of the GWB shape files by GIS routines as clip or intersect in combination with a test polygon resulted in errors. Therefore erroneous topological features of the GWB shape files causing routine failures had been repaired (see documentation of topological corrections in Appendix section 10.2).

Nevertheless final tests of processing the whole GWB data of horizon1 occasionally resulted in an error message depending on software and hardware conditions. Clipping of all GWBs in horizon 1 was completed using e. g. ArcCatalog 10.1.

7 Evaluation of WFD Art. 13 spatial data

7.1 GWB code

The GWB code is stored in column EU_CD_GW of the dbf files as a component of the shape files. Because 257 GWBs in BE, BG, FR, LU, LV and IT consist of several polygons with duplicate or multiple GWB code, there is no reported unique polygon identifier.

Many of these duplicate GWB codes result from the French approach to assign a GWB to several horizons by splitting up a single GWB in polygons attached to different horizons (see section 7.4), but with an identical GWB identifier. The four duplicates of Belgian identifiers seem to be generated by GIS operations. LV duplicates had been implemented to consider their multiple horizon assignment. As in 2011 none of the BG GWBs consisted of several polygons, the duplicates of BG have to result from implementing the 2012 update.

An automatically generated polygon identifier was introduced (see section 6.3) for recognition of single polygons.

In total 638 polygons feature duplicate GWB codes. It has to be mentioned, that this affects to some degree the following statistics. For example the 13,345 polygons submitted until June 2012 refer to only 12,964 GWBs (see table 2).

[8] Browse catalogue *Interactive maps* in the EEA *Data center overview* under http://www.eea.europa.eu/themes/water/dc

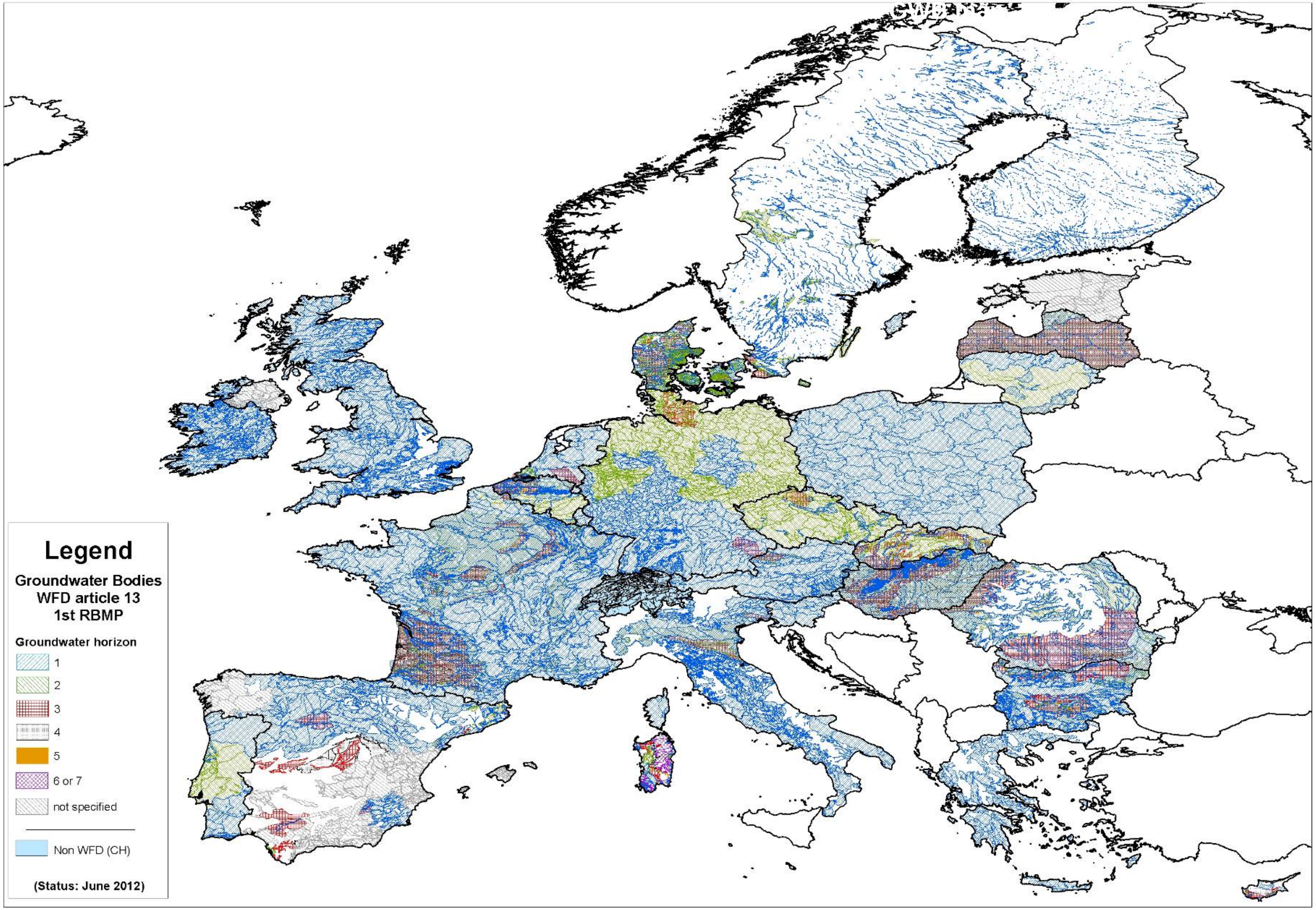

Figure 2: European GWB map

Furthermore, the GWB key EU_MS_CD used in the spatial data does not fully match the corresponding EUGroundWaterBodeCode in the attribute table derived from the XML schema. In case of SI e.g. the EUGroundWaterBodeCode starts with SI, but the EU_MS_CD begins with VT.

7.2 GWB size

Calculation of GWB sizes was done by the ArcGIS standard feature 'Calculate Geometry' after mapping the polygons using the projected coordinate system ETRS 1989-LAEA, which is an equal-area projection for Europe. GWBs of French Reunion Island in the Southern Hemisphere were mapped using the projected coordinate system World_Cylindrical_Equal_Area.

Table 2 shows the amount of single polygons and GWBs (see 6.1) subdivided in nine classes of area. Nearly half (43 to 44 %) of the GWBs or polygons are smaller than five square kilometres. More than 90% of those small GWBs or polygons are located in FI and SE.

Area (km^2)	**Number of polygons**	**Number of GWBs**
< 1	2433	2421
< 5 and > 1	3340	3322
< 10 and > 5	856	840
< 50 and > 10	1537	1464
< 100 and > 50	781	746
< 500 and > 100	2480	2375
< 1000 and > 500	815	793
< 5000 and > 1000	975	871
> 5000	128	132
Total	**13345**	**12964**

Table 2: GWB statistics by area

Table 3 illustrates the wide range of polygon and GWB sizes reported by many MS showing maximum and minimum values. As pointed out in the previous section these extrema differ between polygons and GWBs for several MS like BE, FR or IT.
The smallest GWB has a size of about 0.002 and the smallest polygon of 0.00002 km^2. The largest single polygon comprises around 53,454 km^2 while the most extensive French GWB consisting of several polygons has an area of about 60,940 km^2.

MS	Min polygon (km^2)	Max polygon (km^2)	Min GWB (km^2)	Max GWB (km^2)
AT	12.06	9569.26	12.06	9569.26
BE	0.00002	6049.67	21.23	6049.67
BG	101.21	13043.29	101.21	13043.29
CY	1.99	2391.15	1.99	2391.15
CZ	12.47	5833.39	12.47	5833.39
DE	0.01	5574.51	0.01	5574.51
DK	2.41	2934.72	2.41	2934.72
EE	1.40	33557.14	1.40	33557.14
ES	2.54	7788.90	2.54	7788.90
FI	0.05	97.39	0.05	97.39
FR	0.22	53453.70	1.85	60940.39
GR	4.12	3536.73	4.12	3536.73
HU	114.88	13601.70	114.88	13601.70
IE	0.02	1866.23	0.02	1866.23
IT	2.11	9028.89	2.11	9168.72
LT	332.31	19824.00	332.31	19824.00
LU	7.68	830.91	18.74	830.91
LV	327.93	10173.23	327.93	30519.68
MT	220.40	220.40	220.40	220.40
NL	26.32	6277.55	26.32	6277.55
PL	24.62	8931.20	24.62	8931.20
PT	0.42	18733.69	0.42	18733.69
RO	21.76	42493.29	21.76	42493.29
SE	0.002	5153.46	0.002	5153.46
SI	96.80	3355.27	96.80	3355.27
SK	109.83	6680.89	109.83	6680.89
UK	1.88	4066.88	1.88	4066.88

Table 3: Minimum and maximum polygon / GWB area in member states

7.3 Surface coverage

The territory of some MS like FI, ES, SK and IT is not fully covered by GWBs. In case of FI exclusively groundwater resources in alluvial deposits are considered as relevant. An enquiry proposes that there are as well no important groundwater supplies in those areas of ES, which are not covered by GWBs.
According *Guidance Document No. 21*[9], p. 16, it is only required to report spatial data for GWBs or groups of GWBs larger than 100 km^2. This was applied for example by SK, which delivered more XML attribute datasets than GWB polygons along with small uncovered areas. Apart from that many MS delivered polygons for such small GWBs as was pointed out in section 7.2.
IT obviously did not submit GWB data for Sicily. Thus uncovered areas are admitted, but it has to be approved whether this is intentional.

[9] Open pdf file Guidance Document No. 21 on website https://circabc.europa.eu/faces/jsp/extension/wai/navigation/container.jsp?FormPrincipal:_idcl=FormPrincipal:_id3&FormPrincipal_SUBMIT=1&id=a3c92123-1013-47ff-b832-16e1caaafc9a&javax.faces.ViewState=rO0ABXVyABNbTGphdmEubGFuZy5PYmplY3Q7kM5YnxBzKWwCAAB4cAAAAAN0AAIxMnB0ACsvanNwL2V4dGVuc2lvbi93YWkvbmF2aWdhdGlvbi9jb250YWluZXIuanNw

7.4 Horizon assignment

Table 4 presents the amount of polygons assigned to distinct horizons by each MS. Because some GWBs comprise several horizons, this can not be done on a GWB level.

The reporting of GWB horizons became mandatory with WFD Article 13 submissions for the first time in order to reflect the three-dimensionality of real groundwater structures. GWB polygons of up to 7 different horizons have been considered, whereas the subdivision into 15 horizons in EE was not taken into account. The GWBs of EE and those GWBs of ES and UK (Northern Ireland) without any horizon registration are classified as horizon 0, in total 441 GWBs. GWBs of horizon 6 and 7 only occur in Sardinia.

Nine countries did not implement a subdivision and assigned all GWBs to horizon 1 and/or horizon 0. The majority of 10,871 GWB polygons are assigned to horizon 1, followed by 1,584 polygons allocated to horizon 2.

Because the GWB map is subdivided in separate shape files for each horizon, it is important to achieve a coherent horizon classification by all MS. Recommendations referring to this are given for example on page 29 in the *Guidance Document No. 22, Appendix13.3: Guidance on the reporting of geographical data*[10] or on page 21 of the older version of Appendix 13.3 of the *Guidance Document No. 22* [11] (see figure A1 in Appendix of this document). However a look on the map reveals several discrepancies probably resulting from deviating interpretations by the national editors.

A map section of CZ and adjacent MS in figure 3 illustrates the effects of divergent horizon interpretations as on the opposite sides of administrative borders GWB polygons commonly are allocated to different horizons. This is of high impact particularly concerning GWBs of horizon 1 and 2 as they form the major part in terms of number and area and because the numbering of underlying GWB polygons depends on them.

The French approach to implement the current assignment guidance causes GWBs which partly extent over multiple horizons by splitting them up in several sections respectively polygons (see figure A2 in Appendix).

[10] Open pdf file of Document No.3: WFD reporting on River Basin Management Plans: Guidance on reporting spatial data v3.0 on website http://icm.eionet.europa.eu/schemas/dir200060ec/resources/

[11] http://eea.eionet.europa.eu/Public/irc/eionet-circle/eionet-telematics/library?l=/technical_developments/wise_technical_group/updated_2nd-edition/appendices_updated/appendix_13/geographical_groundwater/_EN_1.0_&a=d
(Document is archived and needs to be requested by the interest group, which is displayed following the link above)

MS	Polygons total	Horizon 0	Horizon 1	Horizon 2	Horizon 3	Horizon 4	Horizon 5	Horizon 6	Horizon 7
AT	136		127	8	1				
BE	84		38	38	8				
BG	140		101	24	10	5			
CY	20		11	6	1	2			
CZ	173		38	132	3				
DE	989		434	545	10				
DK	384		67	256	61				
EE	25	25							
ES	712	349	303	13	34	13			
FI	3616		3616						
FR	890		533	223	64	69	1		
GR	235		235						
HU	176		72	68	28	8			
IE	756		756						
IT	611		485	50	24	17	4	25	6
LT	20		14	6					
LU	7		7						
LV	43		14	13	12	4			
MT	1		1						
NL	23		20	1	2				
PL	161		161						
PT	144		105	39					
RO	142		114	22	4	2			
SE	3023		2929	87	7				
SI	21		21						
SK	90		13	53	24				
UK	723	67	656						
Total	**13345**	**441**	**10871**	**1584**	**293**	**120**	**5**	**25**	**6**

Table 4: Horizon assignment by member states

A feasible approach regarding horizon 1 to 3 could follow for example the method of horizon assignment in CZ based on the older guidance version in figure A1 of the Appendix. Thus horizon 1 represents shallow GWBs of smaller size, which altogether are not covering the entire state territory. Usually these GWBs consist of alluvial porous aquifers. The GWBs of underlying horizon 2 generally cover a larger area and in many states probably the whole territory regardless whether formed by porous or fissured aquifers. The GWBs of the deeper horizons mostly cover again only smaller parts of a MS.

Preferably overlying GWBs should always refer to different horizons. Furthermore GWBs may consist of a single polygon assigned to one horizon to achieve consistent GWB data.

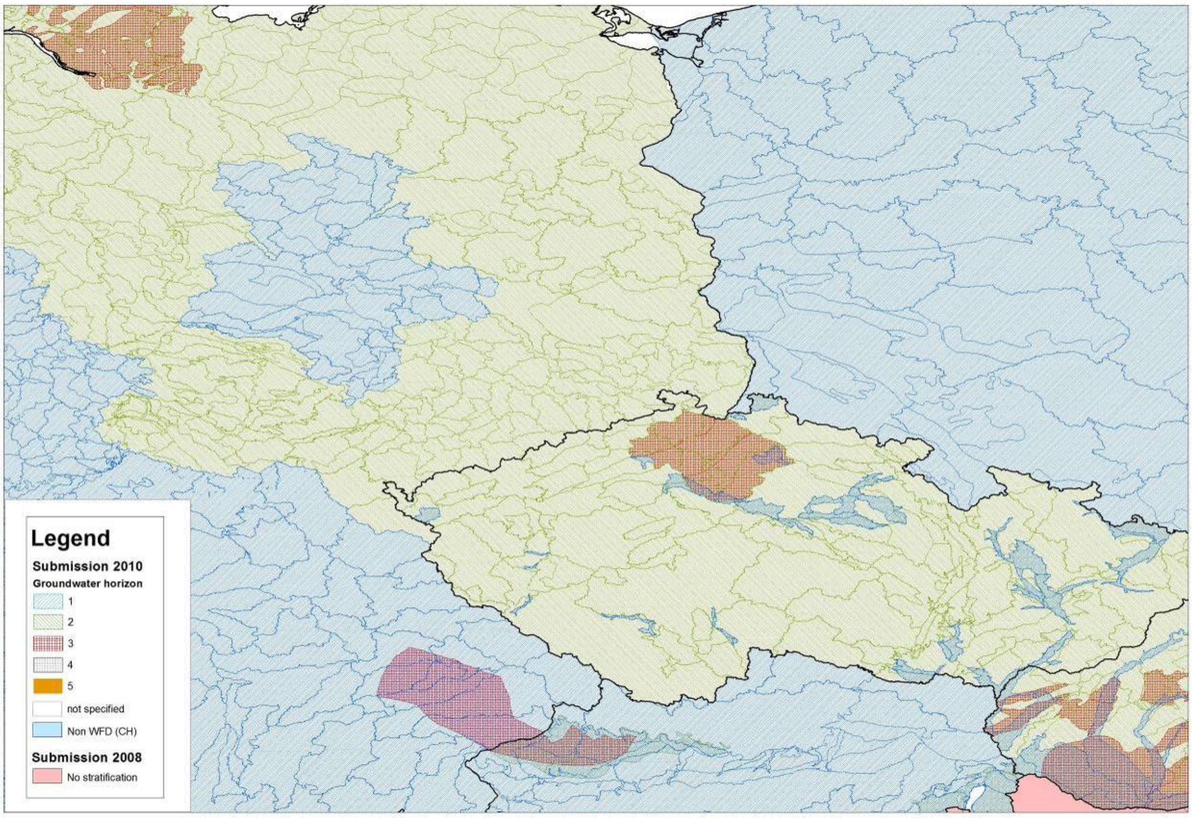

Figure 3: Diverging concepts of horizon assignment

The number of horizons should be limited to a maximum of five different layers in order to enable both a comparability of vertical positioning and a clear mapping.

CIS Working Group C Groundwater has announced activities to review the guidance on WFD reporting relating to groundwater aiming on an improvement of definitions for the next reporting cycle according to the 2nd RBMP. A particular emphasis will be given to specifications on horizon assignment.

7.5 Spatial and topological inconsistencies

Probably due to GIS operations like intersection of incongruent polygons topological errors are found all over the region. Many of them are evident only on a small scale and do not cause a problem in terms of map visualisation, but for use as a reference layer to process with other spatial data.

7.5.1 Segmented GWBs

Figure 4 shows two examples of segmented GWBs composed of several spatially separated and partially very small areas. The respective GWB polygons are saved as one single multipart element. The multipart polygons in figure 4 are outlined in red color on the right or by a blue to violet color wash on the left. Many MS reported analogous multipart elements, which cause problems to spatial data processing, if they consist of a multitude of tiny segments as portrayed above. Some multipart polygons encompass hundreds of segments.

GWB mapping using multipart elements is permitted, but at least small segments should be eliminated.

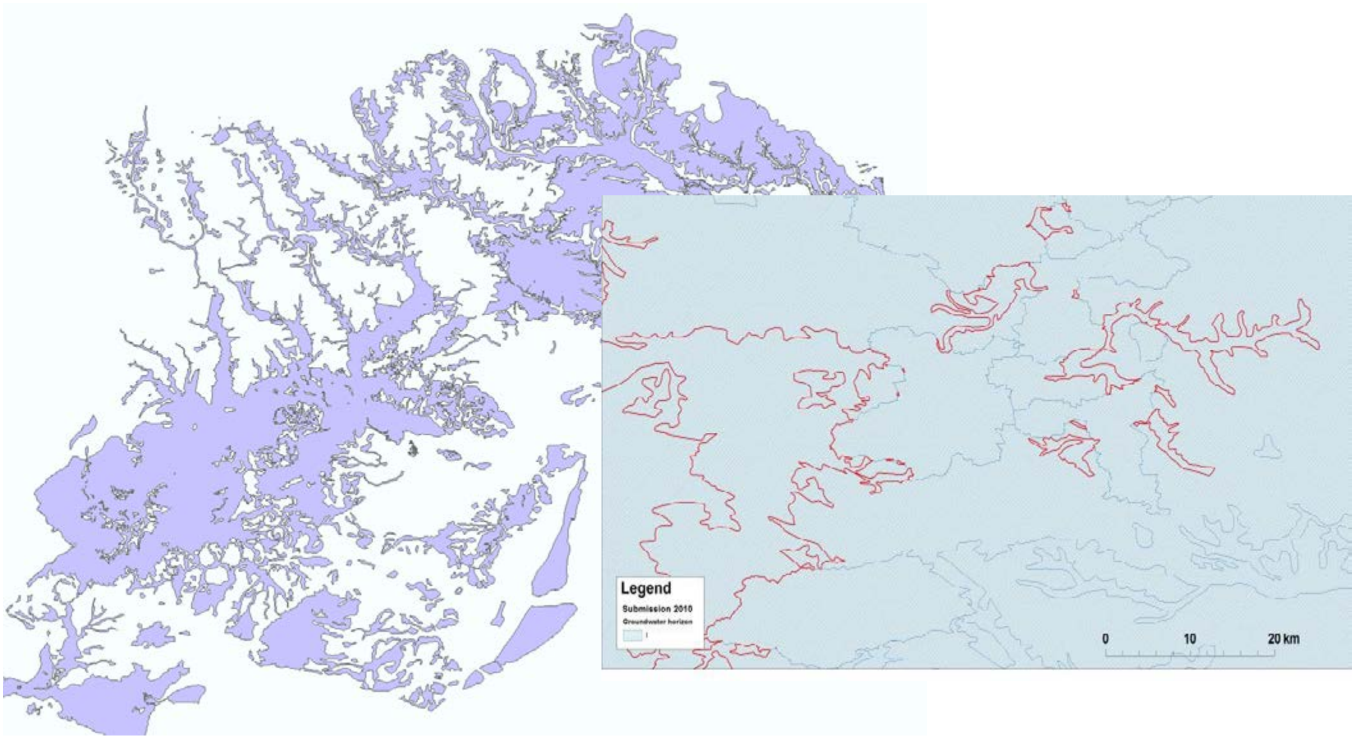

Figure 4: Segmented GWBs

7.5.2 Fractional GWBs and topological errors

Figures 5 to 7 demonstrate the fractioning of GWBs probably created by automatic generation of GWB polygons, which is also causing topological errors.

Figure 5 shows a tiny, fractioned GWB of only 0.02 km^2 within the red color outlines. There is also a gap between the green and the blue colored area which should adjoin seamlessly.

Map section in figure 6 zooms to another topological inconsistent GWB delineation with gaps and overlaps along polygon borders.

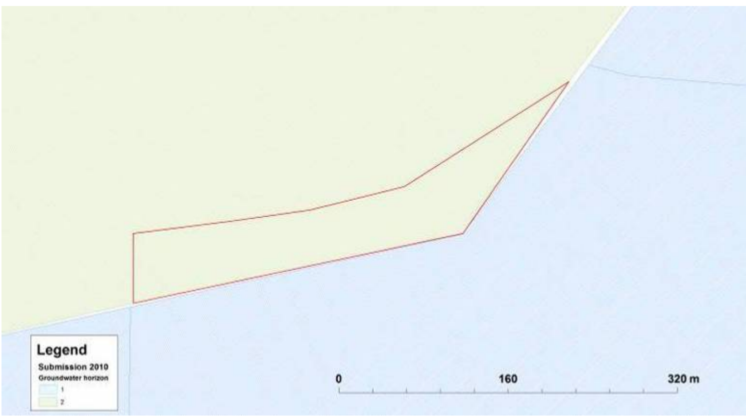

Figure 5: Isolated fractional GWB with topological error

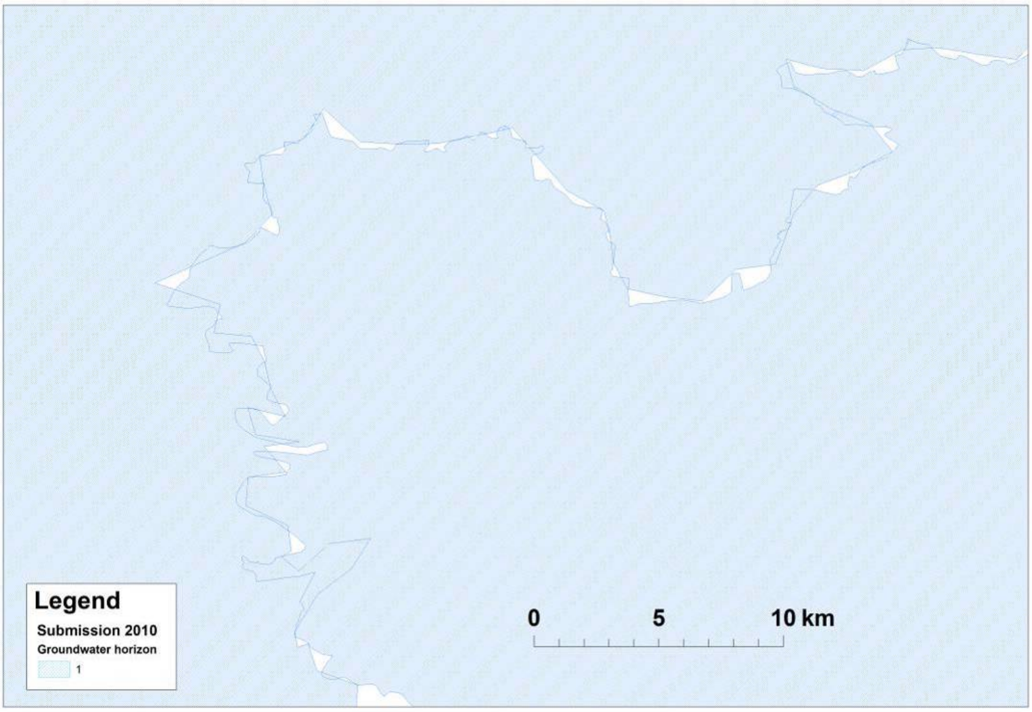

Figure 6: Topological incorrect GWB delineation

Figure 7 displays a section with several overlying deep GWBs in horizon 4, which are fractioned, segmented and form a disordered pattern. The red lines confine a single polygon.

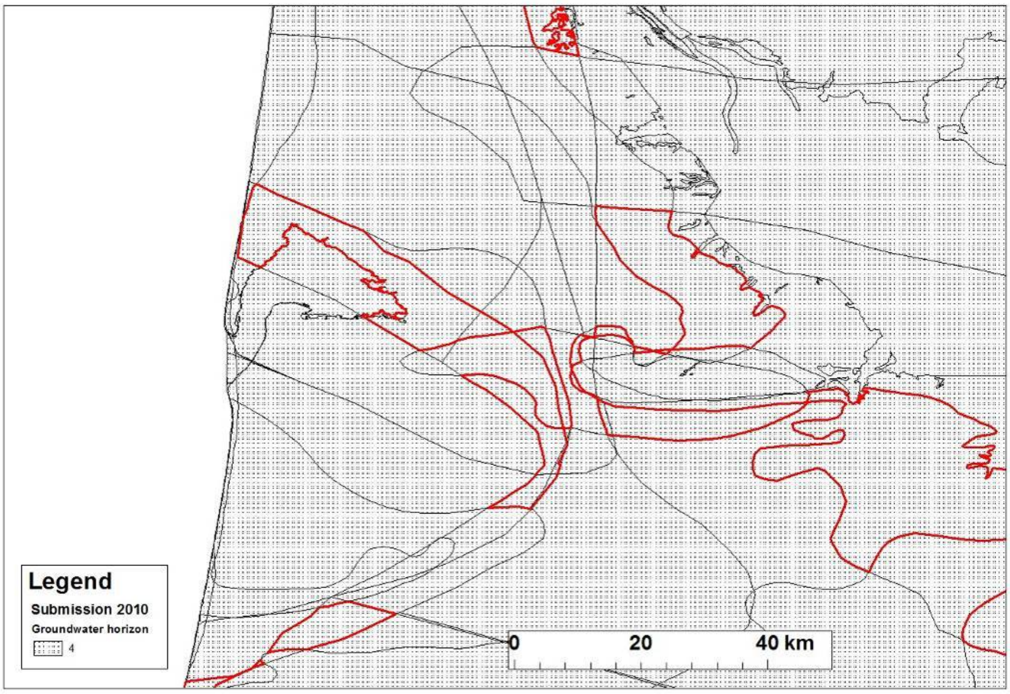

Figure 7: Multiple overlying and intersecting fractional GWBs

7.5.3 Country border

Another topological inconsistency refers to the mismatch of polygon outlines and country borders. This may result in unintended overlays of GWBs as it is illustrated in the map section of figure 8 with the country border depicted in a red color. In fact GWBs may extend beyond coastlines, but country borders have to be considered.

Preferably country borders from the ERM-Model may be used. Because ERM data is fee-based and the borders do not outline all MS yet, this is not mandatory. Therefore neighboring countries are asked to agree on a certain dataset of country borders.

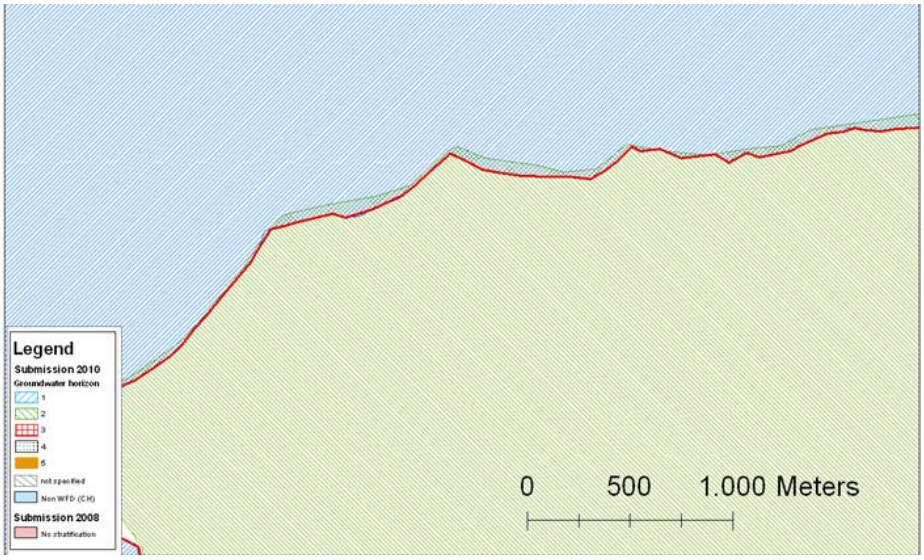

Figure 8: GWBs not matching borders of ERM-Model

8 Evaluation of XML attributes

8.1 Datasets and alignment with GIS GWBs

The structure of the database containing GWB attributes from the XML files is explained with several documents prepared by ATKINS[12]. ATKINS also supplied exemplary views to select attributes of RBDs and GWBs.

Table 5 shows the number of mapped GWBs in relation with the amount of XML attribute datasets by MS. A GWB consisting of several polygons counts as a single spatial GWB.

The partial lack of WFD Article 13 data combined with the draft status of several MS indicates that the assessed database has to be considered as a temporary sketch.

The last column of table 5 shows the number of mapped GIS GWBs matching the XML datasets. Both items are collated by linking their feature tables using the unique identifier EU_CD_GW as the key column. In fact the GWB identifier EU_CD_GW (see section 7.1) is provided with the spatial objects and occasionally deviating from the column EU_GroundwaterBodyCode, which serves as the key column in the XML

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12 Follow link Updated WFD Reporting database model diagrams on website http://icm.eionet.europa.eu/schemas/dir200060ec/resources/

files. The Microsoft Excel table providing selected GWB characteristics as a component of the published GWB GIS dataset includes both keys.

Country	GWBs spatial	GWBs XML	GWBs spatial with XML
AT	136	136	136
BE	80	42	42
BG	127	177	125
CY	20	20	20
CZ	173	173	173
DE	989	989	989
DK	384	385	323
EE	25	26	0
ES	712	674	672
FI	3616	3804	3603
FR	574	574	574
GR	235	236	235
HU	176	185	176
IE	756	756	756
IT	592	680	381
LT	20	20	20
LU	5	5	5
LV	16	16	16
MT	1	15	1
NL	23	23	23
PL	161	161	161
PT	144	145	144
RO	142	142	142
SE	3023	3021	3021
SI	21	21	21
SK	90	101	90
UK	723	723	723
Total	12964	13250	12572

Table 5: Comparison of reported GIS GWBs and XML datasets[13]

There is no complete agreement of XML attribute datasets and polygons. Fourteen MS reported an attribute dataset for each GIS GWB and are marked in a green color. Six MS with a small deviation between number of spatial GWBs and XML datasets are colored blue. Seven countries are highlighted in a red color, because the difference between quantity of mapped GWBs and attribute datasets exceeds 10 % of total amount.

A mismatch is mostly incident to a higher number of attribute datasets than the respective amount of spatial polygons. This may partially result from *Guidance Document No. 21* [14], p. 16, which appoints the mapping of GWBs smaller than 100 km^2 as not mandatory. The dispensing of mapping small GWBs is probably the only reason for the detected discrepancies in several MS like SK, MT and HU. But in case of BE, BG, ES and IT the deviations seem to be caused by miscellaneous rationales.

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[13] green font – complete match of XML and GIS data
blue font- XML and GIS data mostly match with deviation less than 10%
red font– XML and GIS data often mismatch with deviation over than 10%

[14] Open pdf file Guidance Document No. 21 (see footnote 9)

Figure 9 displays the centroids of those GWBs without spatial data having displayable centroid coordinates.

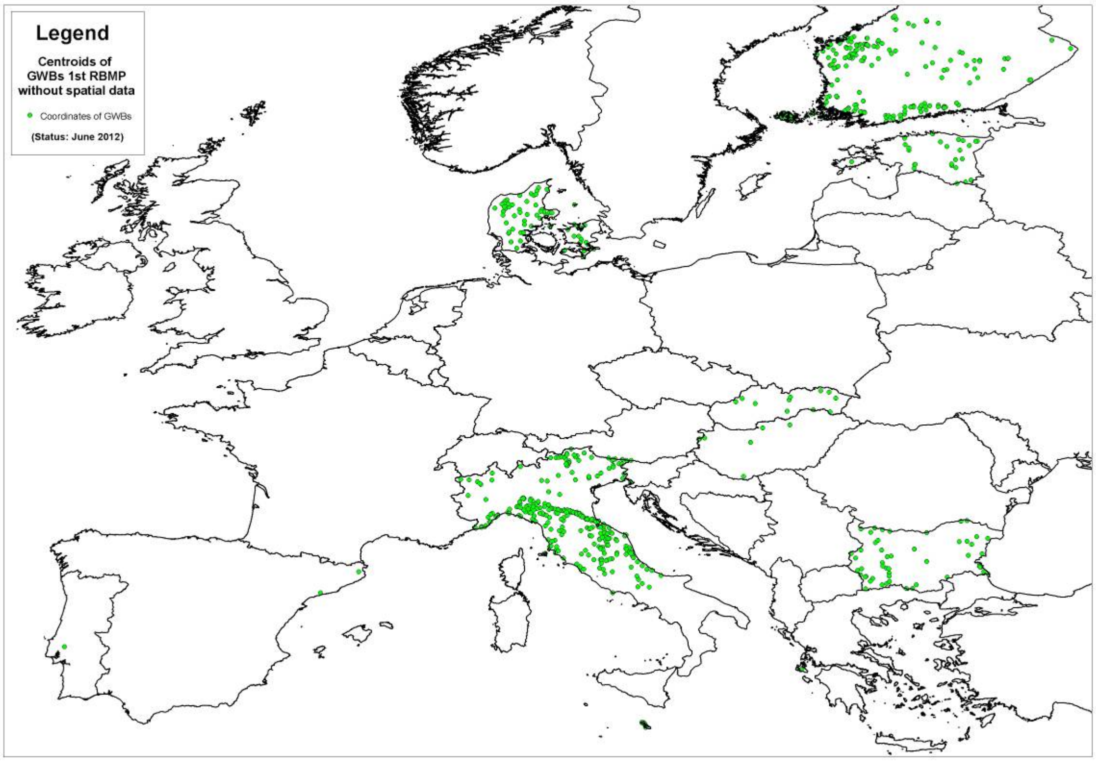

Figure 9: Centroids showing the locations of GWBs without polygons

As a whole spatial and attribute data are matching quite well, but improvements are needed for several MS.

The assessment of XML data in the following sections is carried out using all attribute datasets and not only those in alignment with spatial data. Therefore the number of statistic values given in tables and the text may not completely match the amount of GIS GWBs displayed in the related maps.

8.2 Attribute entries

Table 6 presents the number of entries made by the individual MS in relevant columns of the table GWB_GROUNDWATERBODY, which comprises fundamental GWB characteristics in the database provided by ATKINS. Names of columns / attributes in table 6 are sorted by percentage of total entries in the second column.

Out of 23 attributes 9 characteristics are written in a red color. They will be disregarded throughout the following review, because a total rate of completed entries below 50 % is considered insufficient. The attribute table GWB_attributes_2012June.xls accompanying the published GIS layer only includes the fourteen characteristics written in black color.

It is noticeable that all six entirely filled columns are explicitly mentioned on page 35 of *Guidance Document No. 21* [15] for use as mapping elements or assessment indicators. The field *Area* determining the spatial extent of a GWB is filled in 91 % of cases.

[15] See footnote 10

Column / MS	Total	%	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
EUGround Water BodyCode	13250	100	136	42	177	20	173	989	385	26	674	3804	574	236	185	756	680	20	5	16	15	23	161	145	142	3021	21	101	723
Protected_Area Associated	13250	100	136	42	177	20	173	989	385	26	674	3804	574	236	185	756	680	20	5	16	15	23	161	145	142	3021	21	101	723
Quantitative Status Values	13250	100	136	42	177	20	173	989	385	26	674	3804	574	236	185	756	680	20	5	16	15	23	161	145	142	3021	21	101	723
Chemical Status Value	13250	100	136	42	177	20	173	989	385	26	674	3804	574	236	185	756	680	20	5	16	15	23	161	145	142	3021	21	101	723
Upward Trend	13250	100	136	42	177	20	173	989	385	26	674	3804	574	236	185	756	680	20	5	16	15	23	161	145	142	3021	21	101	723
Trend Reversal	13250	100	136	42	177	20	173	989	385	26	674	3804	574	236	185	756	680	20	5	16	15	23	161	145	142	3021	21	101	723
Lat / Lon	13161	99	136	42	177	20	173	989	385	26	674	3804	574	236	185	756	591	20	5	16	15	23	161	145	142	3021	21	101	723
Area	12025	91	136	42	176	20	173	989	0	26	181	3641	574	193	185	756	678	20	5	16	15	23	161	95	142	3021	0	101	656
GWB Name	11357	86	136	42	129	20	173	989	385	26	674	3804	574	236	185	756	680	20	5	16	15	23	161	145	142	1176	21	101	723
Layered	10793	81	0	42	176	20	173	989	0	26	181	3804	97	0	185	756	542	20	5	16	15	23	161	95	142	3021	0	0	304
Geological Formation	9547	72	136	0	89	20	170	0	0	26	52	3804	71	0	185	756	675	20	5	3	15	0	161	95	142	3021	0	101	0
Out_of_RBD	8931	67	136	0	177	20	173	989	0	26	470	3804	574	236	185	756	520	20	5	16	15	23	161	91	142	0	21	0	371
Transboundary	8193	62	136	42	177	20	173	0	0	26	488	3804	574	236	185	756	610	20	5	16	15	23	161	91	142	0	21	101	371
Scale	7069	53	136	0	87	20	173	989	0	26	108	0	113	193	185	756	645	20	5	16	15	23	0	95	142	3018	0	0	304
Link Surface WaterBodies	5906	45	0	0	128	20	173	0	0	26	57	0	285	193	185	756	506	20	5	16	15	0	0	95	0	3021	0	101	304
Link Terrestrial Ecosystems	5539	42	0	0	176	20	173	0	0	26	52	0	286	193	185	756	482	20	0	16	15	23	0	95	0	3021	0	0	0
Depth Range	4166	31	54	42	53	20	0	4	0	26	41	0	71	0	185	0	399	20	0	16	0	0	161	53	0	3021	0	0	0
Average Thickness	3989	30	69	0	70	2	0	0	0	26	14	0	53	0	185	0	427	20	0	16	0	23	10	53	0	3021	0	0	0
Vertical Orientation	3955	30	0	41	50	20	0	0	0	26	0	0	53	0	185	0	450	20	5	16	15	0	0	53	0	3021	0	0	0
Average Depth	3950	30	58	0	34	7	0	0	0	26	34	0	53	0	185	0	431	20	0	16	0	11	1	53	0	3021	0	0	0
Capacity	3511	26	0	0	0	19	0	0	0	0	0	0	53	105	0	0	221	0	0	16	0	23	0	53	0	3021	0	0	0
Other Presure Description	310	2	0	0	0	0	33	0	0	1	0	0	5	0	86	0	18	0	0	2	0	0	0	0	0	165	0	0	0
Other Impact Description	195	1	3	0	0	0	0	0	0	1	43	0	0	0	86	0	1	0	0	4	15	0	0	1	0	0	0	0	41

Table 6: Number of all attribute entries per member states

Whereas the attributes *Scale* and *Lat / Lon* contain numerical information and *Geological Formation* as well as *GWB Name* give a textual description, the three remaining attributes completed over 50% are boolean (Yes/No) fields, which to some extent may be filled by default values.

Selected attributes associated to a specific GWB can be queried using the information tool of the WISE groundwater viewer[16] after zooming to a scale above 1 : 2,500,000, which activates the water body level.

8.2.1 GWB code, status and trend

The attributes *GWB code*, *Chemical and Quantitative Status*, *Upward Trend* and *Trend Reversal* are completely available and previous map versions had been published in the WISE groundwater viewer since December 2010.

8.2.2 GWB name and coordinates

GWB names are lacking only for about a third of the Swedish GWBs resulting in a total filling rate of 81 %. Coordinates are missing for 89 Italian GWBs including a few GWBs without spatial data (see section 8.1).

8.2.3 Scale

The attribute *Scale* indicates the spatial resolution of original GIS data (see table 7) and is thought to improve the ability to interpret the particularity of polygon outlines in case of a need to rework. Entries are provided only with about a half of the XML datasets and about a half of which contain the recommended scale of 1 : 250,000. Spatial data of other scales may be processed for map optimization.

Scale	Number of Scale
1:10,000	122
1:20,000	5
1:25,000	221
1:50,000	1453
1:100,000	1398
1:200,000	142
1:250,000	3649
1:400,000	26
1:1,000,000	53
Not reported	6181

Table 7: Scale statistics

8.2.4 Geological formation

The assignment to five different classes of *Geological Formation* types is the only attribute related to the aquifer properties, which is sufficiently reported having entries in more than 70 % of datasets. Table 8 points out that the GWBs predominantly consist of porous aquifers with a moderate productivity. Fissured aquifers including karst are of minor relevance and form less than 20% of the GWBs having entries.

16 http://www.eea.europa.eu/themes/water/interactive/soe-wfd/wfd-gw/

Name	Number of datasets
Porous - highly productive	1254
Porous - moderately productive	6500
Fissured aquifers including karst - highly productive	580
Fissured aquifers including karst - moderately productive	839
Insignificant aquifers - local and limited groundwater	374
Not reported	3703

Table 8: Geological formation of GWBs

8.2.5 Yes/No (boolean) attributes

8.2.5.1 Transboundary

Out of 8193 GWBs holding an information about an transboundary location only 268 transnational GWBs have been reported. Thirteen attribute datasets of transboundary GWB do not match any polygon. In case of 5057 datasets the column is left empty.

As illustrated in figure 10 *Transboundary* GWBs accumulate on certain borders and in certain cases merely on one side of a border (e.g. Austria to Germany). This indicates a gap of information concerning *Transboundary* GWBs, which continue over an administrative border.

This attribute is of particular interest for the assessment of transboundary aquifers by the UNECE.

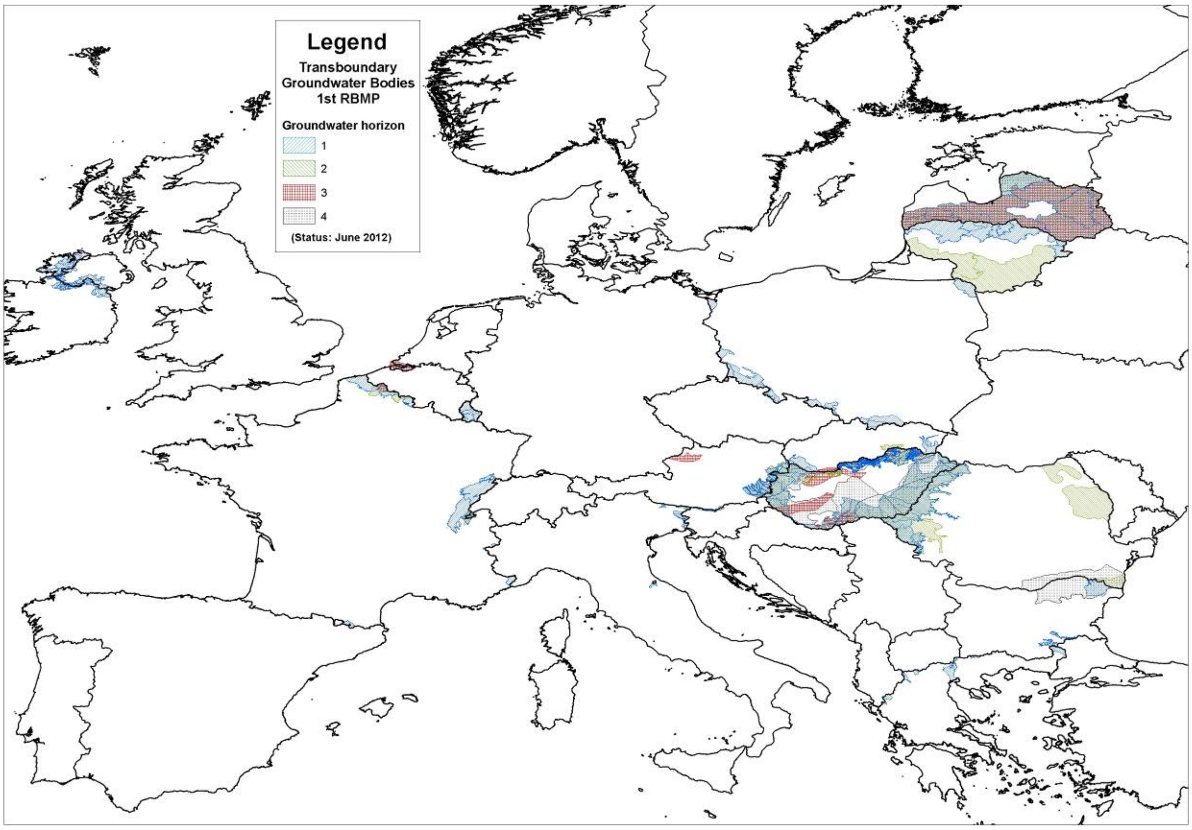

Figure 10: Transboundary GWBs

8.2.5.2 Out of RBD

411 datasets of GWBs are reported to stretch across an RBD border, of which 32 GWBs have no corresponding spatial data. The GWBs with polygons crossing an RBD border are displayed in figure 11. In total 8931 GWBs have entries in the respective column and 4319 do not. Disregarding minor overlays of GWBs and RBD borders spot tests did not reveal a distinctive false or missing reporting concerning this attribute. This attribute facilitates the QA to prevent false-error indication of GWBs having spatial extend beyond the corresponding RBD boundaries.

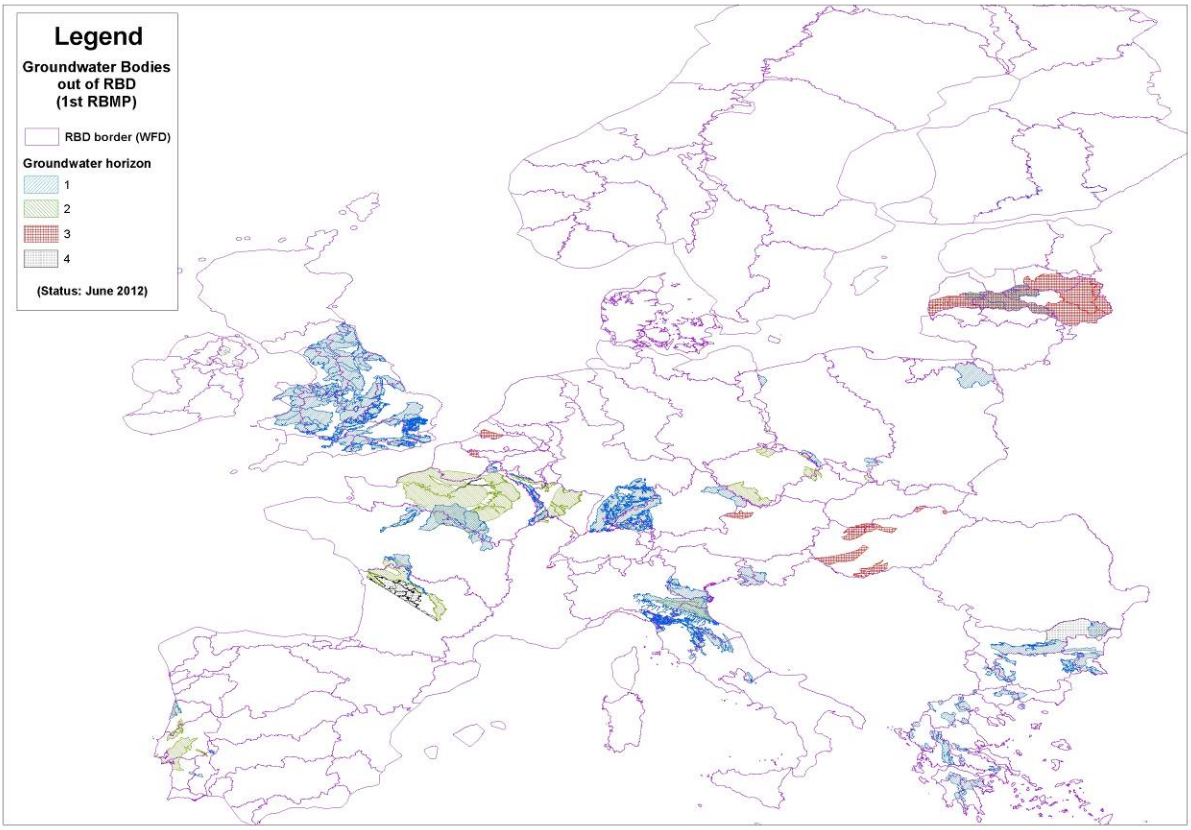

Figure 11: GWBs crossing RBD borders

8.2.5.3 Association to protected areas

7937 GWBs, which are associated to a protected area, prevail in comparison to 5063 GWBs, which are supposed to have no relevant effects on protected zones. In case of 250 GWBs the *Association to Protection Areas* is reported as unclear. Information is provided for all GWB attribute datasets, but 594 do not match any GWB polygon.

As expected most of the mapped GWBs are assigned to either horizon 1 or horizon 2 (see table 9). But it is remarkable that also GWBs in deeper horizons are reported as associated to protected areas. In case of FR this probably results from delineation of GWBs encompassing several horizons, but in general this might as well indicate the entry of standard values.

Horizon	Spatial GWBs associated to Protected Areas
0	66
1	5947
2	1267
3	131
4	50
5	1

Table 9: Mapped GWBs associated to protected areas (grouped by EUGroundwaterBodyCode and Horizon)

Figure 12 illustrates that in many MS GWBs linked to protected areas nearly extend to the whole territory covered by GWBs. On the contrary IE reported GWBs linked to protected areas only in smaller regions. This suggests different methodologies in the MS and a possible use of default values by several countries.

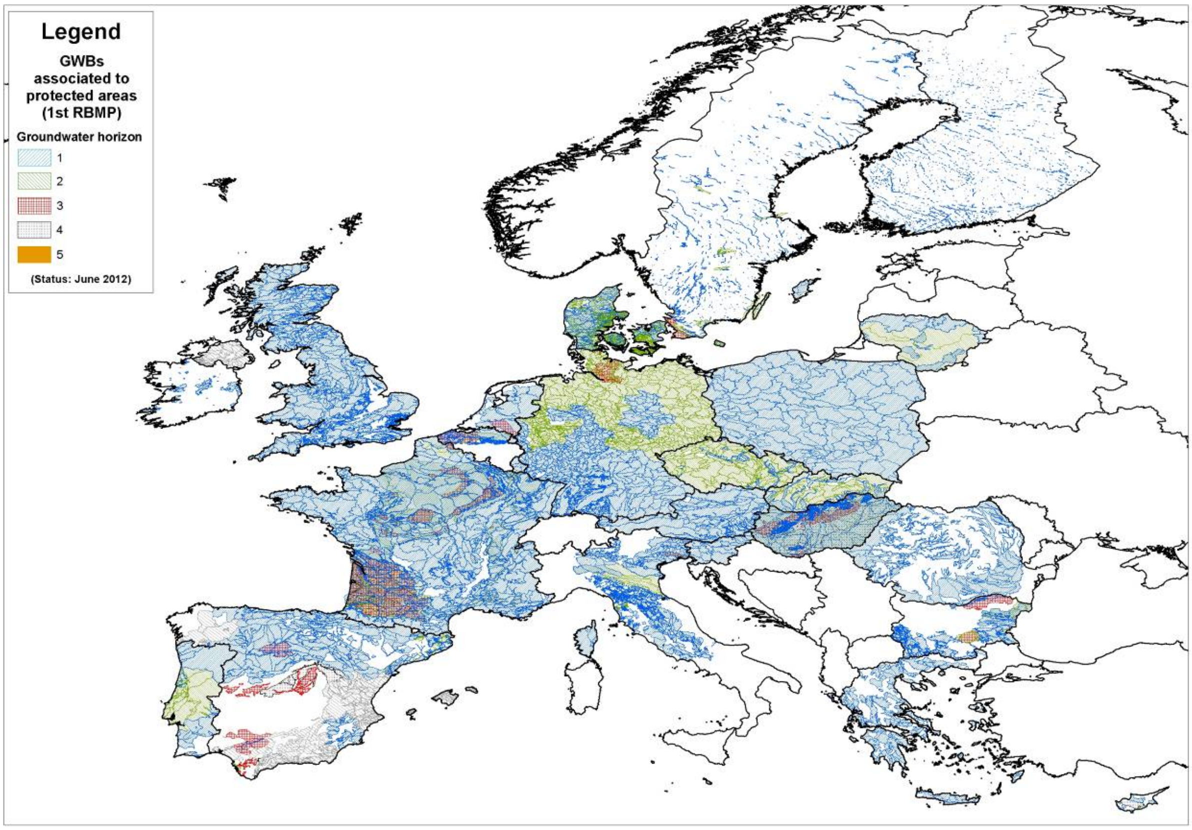

Figure 12: Map of GWBs with association to protected areas

8.2.5.4 Layered GWBs

A *Layered* GWB is defined in Appendix 13.3 of the *Guideline Document No. 22* on page 10[17] as a GWB with deeper relevant layers or more precisely on page 44 of the

[17] Open pdf file of Document No.3: WFD reporting on River Basin Management Plans: Guidance on reporting spatial data v3.0 on website http://icm.eionet.europa.eu/schemas/dir200060ec/resources/

same document as either overlying or underlying another GWB. Figure 13 displays the 5140 GWBs, which are labelled as layered, while 5653 GWBs are characterised as not layered. 566 labelled attribute datasets do not correspond with spatial data and no data is reported in case of 2457 GWBs.

The entries relating to this feature are not consistent, possibly due to erroneous assignment of default values. SE for instance has reported all GWBs as layered and in areas of DE GWBs of horizon 1 without underlying GWBs are also classified as layered. On the contrary areas with several overlying horizons in FR, SK and ES are not designated as layered.

Figure 13 displays only GWBs assigned as layered. It shows blank areas in the Southwest of FR and in SK, but also reflects blue marked GWBs of horizon 1 without underlying GWBs in SE, DE and PL.

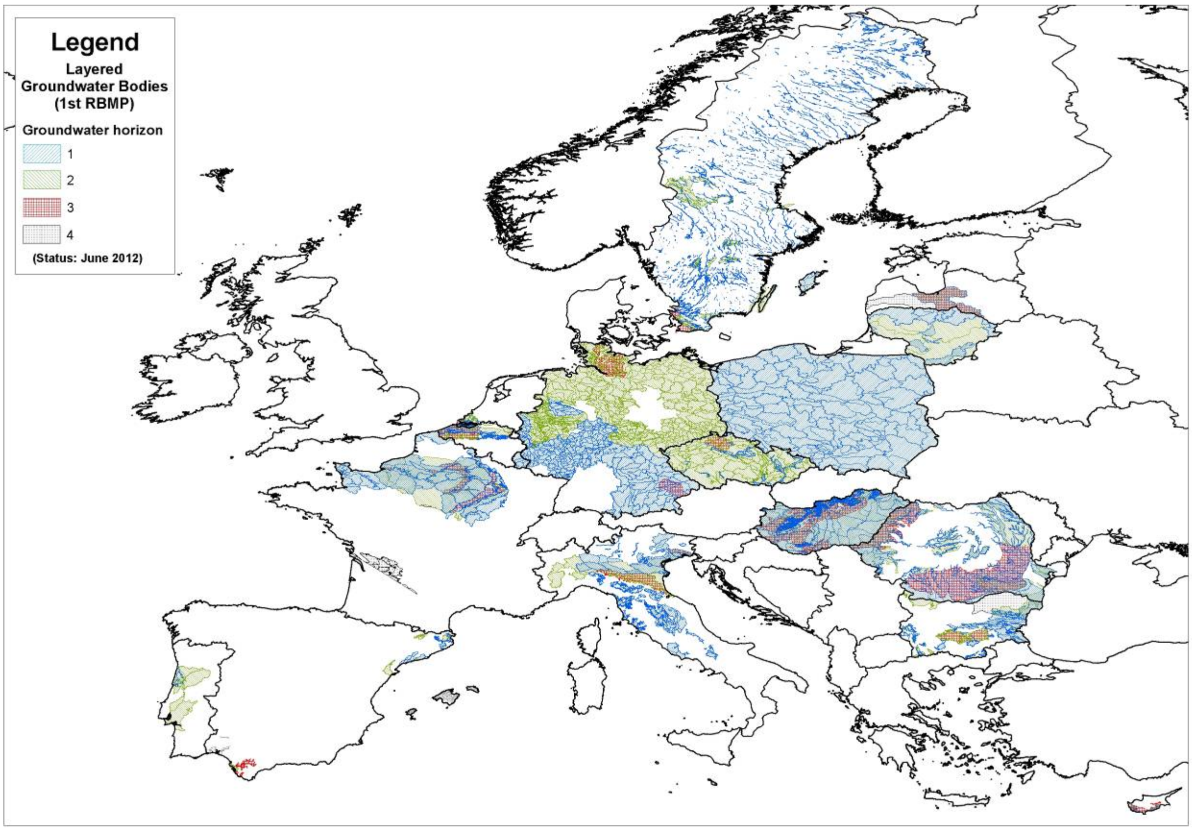

Figure 13: Layered GWBs

9 Conclusions and preview

A GWB draft map has been compiled on the basis of RBMP data according WFD Article 13. It presents a first picture of European GWBs covering territory of all EU MS. Besides the presentation of the map in the WISE groundwater viewer, the EEA intends to publish as well the GIS data of this GWB layer as a preliminary version despite the technical shortcomings described in this document.

The spatial data of the GWB layer implicates substantial restrictions for the use as a reference layer due to topological errors as well as a great number of tiny GWBs respectively GWB segments.

Furthermore the GWB data is still not completed for some MS and spatial data does not fully match the attribute data. Reporting of most GWB attributes is optional and is in parts declined by a majority of MS. Therefore only the most accepted characteristics with entries in more than 50% of cases had been reviewed in this report.
The submitted attribute data is to some degree not consistent with regard to contents. This is reflected in particular by the mandatory horizon assignment of GWBs. Nevertheless the overall data situation has improved remarkable compared to last version of December 2011 and a further significant step forward can be expected with reporting of GWBs according to the next RBMP by 2015.

10 Appendix

10.1 Horizon methodology

Horizon Code	Brief description
1	First horizon from the surface
2	Second horizon from the surface
3	Third horizon from the surface
4	Fourth and deeper horizons from the surface

Horizon Assignment - Current Guidance Verison

Code of horizon name	Name of horizon	Brief description
UP	upper	Alluvial deposits, locally delineated
M	main	Different geological age of GWBs including quarternary sediments, in principle the entire area of RBD/country
D1	deep	Locally delineated Cretaceous sediments (Turon and Cenoman)
TH	thermal water	Locally delineated thermal waters

Horizon Assignment - Older Guidance Version

Figure A1: Two versions of Guidance No.22 section referring to horizon assignment[18]

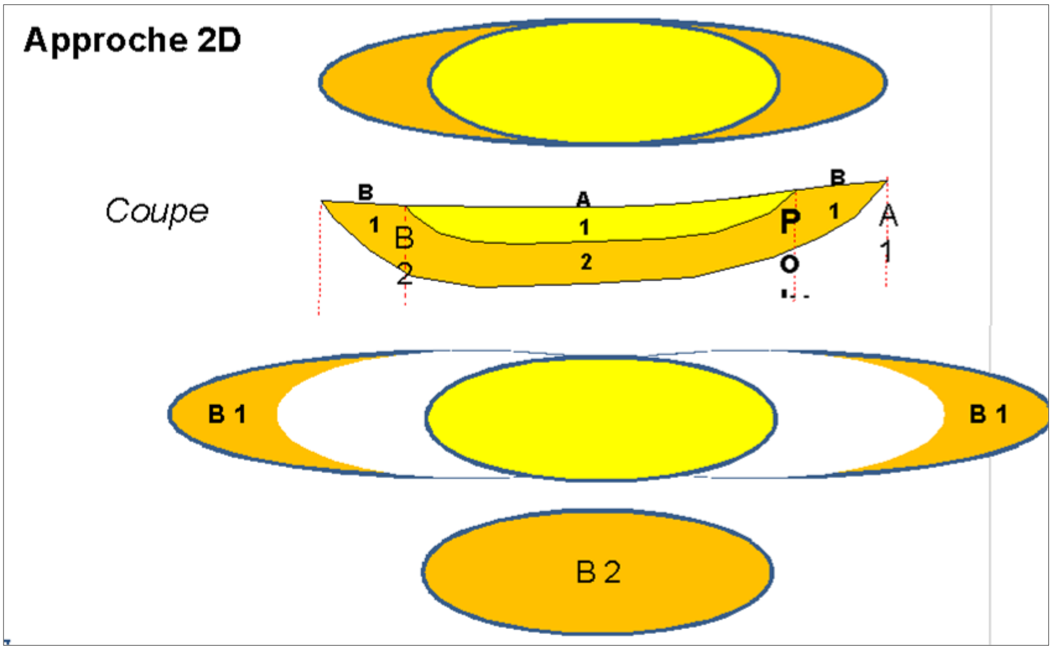

Figure A2: Sketch of French approach how to allocate horizons

[18] See footnote 6 and 7 on page 13

10.2 Documentation of topological corrections

```
postgis=# select a.eu_cd_gw, st_isvalidreason(a.geom) as test from gwb.gwb_2012_h0 a where
st_isvalid(geom) = false;
    eu_cd_gw     |                   test
------------------+----------------------------------------------------------
 ES014MSBT014.003 | Ring Self-intersection[-8.90053854831513 42.640699989613]
 ES014MSBT014.001 | Ring Self-intersection[-8.61103362100459 42.2893989411084]
 ES010MSBT011.005 | Ring Self-intersection[-8.78729429839296 41.9274402015042]
 ES014MSBT014.006 | Ring Self-intersection[-8.88799225573774 42.7798549658342]
 ES014MSBT014.009 | Ring Self-intersection[-9.14471809866109 43.1276270683347]
(5 rows)

postgis=# select a.eu_cd_gw, st_isvalidreason(a.geom) as test from gwb.gwb_2012_h1 a where
st_isvalid(geom) = false;
     eu_cd_gw      |                   test
-----------------------+----------------------------------------------------------
 IEWE_G_0008        | Ring Self-intersection[-8.96913372044469 53.2388557556887]
 IEWE_G_0057        | Ring Self-intersection[-9.50753419164948 54.2385965456942]
 IEWE_G_0006        | Ring Self-intersection[-9.41336720543205 53.471704043407]
 IEWE_G_0020        | Ring Self-intersection[-8.81029126892673 53.5915472783844]
 IEWE_G_0063        | Ring Self-intersection[-8.75907234321392 53.7620095858738]
 IESW_G_023         | Ring Self-intersection[-10.404934354137 51.8792615578748]
 IESW_G_072         | Ring Self-intersection[-8.35065233343829 51.8363154327112]
 FRGG030            | Ring Self-intersection[-0.402993766648876 46.4972764947146]
 BG4G00000PG038       | Ring Self-intersection[22.9549010012803 42.3176000005398]
 BG4G00000PG039       | Ring Self-intersection[22.5273990009633 42.1693000018938]
 BG4G0PZC2PG019       | Ring Self-intersection[23.5167999994206 41.8095020004171]
 IESH_G_041         | Ring Self-intersection[-7.91874901325622 53.0999421476122]
 BG4G00000PZ022       | Ring Self-intersection[22.9014000009095 41.9564020010517]
 BG4G000PTPZ027       | Ring Self-intersection[22.7439540004769 42.5226140002361]
 IESH_G_096         | Ring Self-intersection[-7.90513057591517 53.1026013080041]
 IESH_G_102         | Ring Self-intersection[-7.23700923438849 53.716336183868]
 BG4G000PTPZ026       | Ring Self-intersection[24.1252989998491 41.6162990003987]
 BG4G0T1T2T3037       | Ring Self-intersection[23.0338000010694 42.5321010015601]
 BG3G000000Q004       | Self-intersection[26.0844689997447 42.6666979996132]
 BG3G00000NQ005       | Ring Self-intersection[27.0848715684683 42.6778437276061]
 BG3G000000Q010       | Self-intersection[25.5376201704583 41.6666979999945]
 IESH_G_205         | Ring Self-intersection[-7.90575659938742 53.0818416276891]
 IESH_G_213         | Ring Self-intersection[-8.35161541292081 52.6276475395025]
 IENW_G_071         | Ring Self-intersection[-8.11863141390847 54.6270093262196]
 FRGG051            | Ring Self-intersection[3.46110123173662 45.8987265349018]
 FRGG074            | Ring Self-intersection[1.50166964873546 46.6971886962015]
 FRGG081            | Ring Self-intersection[0.828156686282227 48.3433705393191]
 UKGB41002G201400     | Ring Self-intersection[-3.32248164960828 51.4555988353181]
 FRGG088            | Hole lies outside shell[1.00231203996884 47.4900205259267]
 FRGG095            | Ring Self-intersection[1.00537634494253 47.4895160143528]
 FRGG137            | Ring Self-intersection[-0.200947159183897 47.4216423530124]
 SE658611-160314      | Ring Self-intersection[17.6025578085961 59.3965780437419]
 SE656536-151685      | Ring Self-intersection[16.1000870052113 59.2156684784177]
 FRFG044            | Ring Self-intersection[-1.02545482727828 43.6925044951865]
 FRFG089            | Ring Self-intersection[2.22887243681367 43.7684826714383]
 FRFG105            | Ring Self-intersection[-1.24740603156295 44.600095305654]
 FRDG402            | Ring Self-intersection[5.91814715786518 44.3143045379243]
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UKGB41202G101800 | Ring Self-intersection[-2.14220721269254 53.4829960623186]
UKGB41202G991700 | Ring Self-intersection[-2.30560411793556 53.2679905353351]
UKGB40902G204900 | Ring Self-intersection[-2.40909536415955 51.8797961274894]
UKGB41102G204800 | Ring Self-intersection[-3.16940246475178 53.215390607091]
UKGB41002G200500 | Ring Self-intersection[-4.29996851773274 51.7440901790187]
UKGB41002G200600 | Ring Self-intersection[-3.93257742780588 51.8338915871272]
UKGB40902G302200 | Ring Self-intersection[-1.57000168263141 52.3130927187541]
UKGB40902G303100 | Ring Self-intersection[-2.40649398520907 51.6616990910404]
UKGB40902G804700 | Ring Self-intersection[-2.72548758168637 51.2000073630495]
UKGB40902G804800 | Ring Self-intersection[-2.55799187142759 51.5420005983491]
UKGB40802G806400 | Ring Self-intersection[-2.71338699041712 51.0521118174066]
UKGB40802G801600 | Ring Self-intersection[-3.58557365929676 50.4538370249589]
UKGB40801G802000 | Ring Self-intersection[-3.31927680577979 50.8857143034725]
UKGB40702G502200 | Ring Self-intersection[0.311957121923797 50.9782202985281]
UKGB40601G600400 | Ring Self-intersection[-1.76520016315686 51.9546961578016]
UKGB40702G502000 | Ring Self-intersection[0.201561274933056 51.0029195139246]
UKGB40603G000200 | Ring Self-intersection[-1.48040980306979 51.723986212394]
UKGB40602G600300 | Ring Self-intersection[-1.58859619295976 51.9382954869473]
UKGB40602G502300 | Ring Self-intersection[0.461555043730471 51.0965161779794]
UKGB40502G446000 | Ring Self-intersection[-0.584402283938118 52.8498891843386]
UKGB40503G000400 | Ring Self-intersection[0.770430851702599 51.9934552283763]
UKGB40501G445900 | Ring Self-intersection[-0.565603706645561 52.6602898513957]
UKGB40502G304000 | Ring Self-intersection[-0.767203761144515 52.5768905334715]
UKGB40502G400900 | Ring Self-intersection[0.66555241920895 52.0231577949964]
UKGB40501G400700 | Ring Self-intersection[0.872133206082765 52.0688576802379]
UKGB40401G301200 | Ring Self-intersection[-1.48290223185234 52.8105902156661]
SE641895-136028 | Ring Self-intersection[13.4202142426933 57.8676242187829]
UKGB40201G100400 | Ring Self-intersection[-3.07305500118719 54.9538461620709]
UKGB40202G100900 | Ring Self-intersection[-3.28580431711538 54.8655477980926]
UKSC150326 | Ring Self-intersection[-3.65472762607891 57.2940888513196]
IT14AP I027 017 PC AL | Ring Self-intersection[14.6077525514393 41.9952083067182]
IT14AP N011 MC CC | Ring Self-intersection[14.0811620609805 41.5141532514716]
SE635852-141933 | Ring Self-intersection[14.4738681671823 57.3610876287912]
SE656732-161312 | Ring Self-intersection[17.7806488320781 59.2219916387033]
SE656428-159313 | Ring Self-intersection[17.4355298645118 59.2005873099566]
HUAIQ668 | Ring Self-intersection[21.1942957900189 48.3142480192309]
HUAIQ506 | Ring Self-intersection[20.343865327623 47.9765109909896]
HUAIQ510 | Ring Self-intersection[20.5482849321041 48.2746106257799]
SE708115-162935 | Ring Self-intersection[18.4299227622259 63.9163668519489]
SE734920-185514 | Ring Self-intersection[23.7089186158016 66.027850745116]
SE710526-167366 | Ring Self-intersection[19.3507295993917 64.0149546301522]
BG2G00000PG027 | Ring Self-intersection[27.1916820010237 43.2489100018952]
NLGWSC0003 | Ring Self-intersection[3.97049537795948 51.2536879769187]
NLGW0006 | Ring Self-intersection[5.02595059774205 51.7125385855874]
LT004031100 | Self-intersection[22.8832485367225 54.8156171641247]
BG4G000000Q002 | Ring Self-intersection[23.1651330005877 41.6666980016117]
LT004011100 | Self-intersection[21.3099280145212 55.2624714596656]
BG3G000000Q012 | Ring Self-intersection[26.0755998560487 42.4633936821729]
BG3G0000PGN020 | Self-intersection[24.2932000003799 41.9999999998003]
BG3G00PTPG2023 | Ring Self-intersection[25.4626009997365 41.3399999995005]
BG3G00000PT046 | Self-intersection[24.5004928704498 41.596500000175]
BG3G00000PT047 | Self-intersection[24.0865989955739 41.9999999984752]
BG3G00000PG028 | Ring Self-intersection[25.98420000013 41.6096990009083]
BG3G00000PT045 | Ring Self-intersection[26.3117008387229 41.8591997462714]
BG2G000PTPZ043 | Ring Self-intersection[27.8276604727528 41.9973025813492]
BG1G00000NQ030 | Ring Self-intersection[23.1564009999064 42.7392009994268]
PLGW6220112 | Ring Self-intersection[16.7264419792141 50.5295410374891]

ES050MSBT000000571 | Ring Self-intersection[-5.29955659835815 37.7141025957583]
PLGW2100135 | Ring Self-intersection[19.480653903555 50.1845967605323]
FRKG010 | Ring Self-intersection[-54.1237840002313 5.40554999973284]
FRKG008 | Self-intersection[-52.3628075440502 4.92130131608944]
FRKG006 | Self-intersection[-53.421868328499 5.53271035448744]
MT001 | Self-intersection[14.5341413530269 35.8079336956265]
HUAIQ548 | Ring Self-intersection[18.2610182756731 47.3898848777851]
HUAIQ544 | Ring Self-intersection[18.8401057255989 47.8057147877075]
HUAIQ546 | Ring Self-intersection[18.9388944060522 47.5607793445913]
HUAIQ550 | Ring Self-intersection[18.9370735424102 47.5770740708119]
HUAIQ556 | Ring Self-intersection[17.9262005816917 47.2051907287693]
HUAIQ541 | Ring Self-intersection[17.3918658033643 46.9224691250503]
HUAIQ555 | Ring Self-intersection[17.6541678054 47.2258515978731]
HUAIQ609 | Ring Self-intersection[18.6611668087014 46.2173296529413]
CY_15 | Ring Self-intersection[32.4559545425682 35.0473562074232]
HUAIQ500 | Ring Self-intersection[18.8516284098234 47.8655985464359]
HUAIQ501 | Ring Self-intersection[18.9847603025461 47.8962124500447]
HUAIQ489 | Ring Self-intersection[17.8738577768151 46.945475891899]
HUAIQ513 | Ring Self-intersection[19.3978267532023 47.8829307890248]
BEVL002 | Ring Self-intersection[4.21475981801137 50.7059876254287]
BEVL021 | Ring Self-intersection[4.28540493898691 51.0062355445349]
BEVL024 | Ring Self-intersection[3.93037534084948 51.0129448053586]
BG1G0000TJK045 | Ring Self-intersection[25.4414009996566 43.0632020030702]
ROIL02 | Ring Self-intersection[25.738862366705 45.3351865573139]
DK1.4.1.5 | Ring Self-intersection[8.71270287783568 56.4039243606209]
DK1.5.1.1 | Self-intersection[10.3752843851154 56.4143491137638]
DK2.3.1.1 | Ring Self-intersection[12.5840850530829 55.6643549986844]
DK2.4.1.1 | Ring Self-intersection[12.5668095055544 55.6710903074719]
IT086220ER-LOC1-CIM | Ring Self-intersection[10.2976520663899 44.5597084405922]
IT085010ER-AV2-VA | Ring Self-intersection[12.5734171043161 43.9181358475915]
IT086050ER-LOC1-CIM | Ring Self-intersection[10.5817291984439 44.1435137773391]
IT086100ER-LOC3-CIM | Ring Self-intersection[10.8866885839112 44.2797174178247]
IT086160ER-LOC1-CIM | Ring Self-intersection[10.7982458742479 44.3390807361872]
IT086420ER-LOC1-CIM | Ring Self-intersection[9.62535805493047 44.7456333460023]
IT0933TN010 | Ring Self-intersection[10.061294875858 44.0640525654737]
IT0999MM011 | Ring Self-intersection[10.3695589964507 43.8636871416484]
IT0999MM013 | Ring Self-intersection[10.2758647316722 43.9823826780183]
IT03GWBA3BLO | Ring Self-intersection[9.28502009020514 45.1249245026638]
IT03GWBA4ALO | Ring Self-intersection[9.6001241925776 45.7410401411897]
IT0999MM931 | Ring Self-intersection[11.4845402228532 44.1740167936403]
IT0913TE010 | Ring Self-intersection[12.1006953775898 43.4903748380285]
IT080660ER-DET1-CMSG | Ring Self-intersection[11.666247871742 44.3529867497389]
IT086020ER-LOC1-CIM | Ring Self-intersection[12.148186396685 43.9134205195415]
IT0999MM934 | Ring Self-intersection[11.7407522893868 43.2954566519031]
IT0999MM932 | Ring Self-intersection[11.1479327071289 43.7150940485517]
IT0911AR041 | Ring Self-intersection[11.4760905562343 43.6567839936865]
IT0911AR027 | Ring Self-intersection[10.697550625661 43.7197085715935]
IT0912SE011 | Ring Self-intersection[10.4412165490047 43.8280810986639]
IT0931OM020 | Ring Self-intersection[11.3704421053191 42.6384888777596]
IT0933TN010 | Ring Self-intersection[10.0612948749587 44.064052566373]
IT0999MM011 | Ring Self-intersection[10.36955899735 43.8636871416484]
IT0999MM013 | Ring Self-intersection[10.2758647316722 43.9823826780183]
IT0912SE011 | Ring Self-intersection[10.4412165490047 43.8280810986639]
ITG20_111 | Interior is disconnected[8.27390578652302 40.8620453749942]
IT15MNV | Ring Self-intersection[14.0811620609805 41.5141532514716]
IT16CANE | Ring Self-intersection[15.8941309063164 40.8822229061624]
ITG20_1132 | Ring Self-intersection[9.57172634979139 39.2431494214088]

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 ITG20_1411         | Ring Self-intersection[8.49064065404309 39.0833784081872]
 ITG20_1713         | Self-intersection[8.71251658327384 39.6534236317954]
 VTPodV_1011        | Ring Self-intersection[15.3066186110602 45.6914213621063]
(154 rows)

postgis=# select a.eu_cd_gw, st_isvalidreason(a.geom) as test from gwb.gwb_2012_h2 a where
st_isvalid(geom) = false;
    eu_cd_gw      |                    test
------------------+-----------------------------------------------------------
 DK1.7.2.6       | Ring Self-intersection[10.016962575468 56.1826608285053]
 FRB1G009        | Ring Self-intersection[4.44057794161887 49.7107970956097]
 FRCG010         | Ring Self-intersection[5.97141434079936 48.7138156675592]
 FRFG104         | Ring Self-intersection[-1.24740603156289 44.6000953056541]
 DK1.6.2.8       | Ring Self-intersection[10.7443772855605 56.2351937458137]
 DK1.6.2.11      | Ring Self-intersection[10.7947809900807 56.4501401667992]
 DK1.7.2.2       | Ring Self-intersection[9.95092191756419 56.1180437291434]
 DK1.7.2.3       | Ring Self-intersection[10.2467699442744 56.1895424706649]
 LT006001100     | Self-intersection[23.2848283315434 55.2763528134415]
 LT003001100     | Self-intersection[21.384570808833 56.1100880468223]
 LT004001100     | Self-intersection[23.3017954071805 55.2797927973835]
 LT005001100     | Self-intersection[26.073323812277 55.4767814580339]
 LT001001100     | Self-intersection[25.6752094379195 55.9528221621062]
 BG3G00000NQ018  | Self-intersection[24.9923989998142 42.0321009998614]
 BG1G000000N033  | Ring Self-intersection[23.1564009945106 42.7392009994269]
 HUAIQ505        | Ring Self-intersection[20.4441239312401 48.0499905943939]
 HUAIQ545        | Ring Self-intersection[18.8550692771176 47.6070274150272]
 HUAIQ509        | Ring Self-intersection[20.7241154004698 48.0698124726611]
 HUAIQ551        | Ring Self-intersection[18.937073542569 47.5770740528328]
 HUAIQ549        | Ring Self-intersection[17.8565459046204 47.2692458136306]
 FRHG208         | Ring Self-intersection[3.85774895584979 49.0803223659847]
 FRGG064         | Ring Self-intersection[-0.142449931119245 46.7913853870262]
 FRDG219         | Ring Self-intersection[5.60509032975506 45.6337604522832]
 FRGG085         | Ring Self-intersection[0.815407923037355 47.3563648068905]
 FRGG088         | Ring Self-intersection[1.00537634494265 47.4895160143528]
 FRGG141         | Ring Self-intersection[0.828156686282284 48.3433705393192]
 FRGG142         | Hole lies outside shell[1.00231203996879 47.4900205259268]
 FRFG071         | Ring Self-intersection[-0.867517895034609 45.2705446304305]
 FRFG072         | Ring Self-intersection[-0.586762932363229 44.5805845111665]
 FRFG073         | Ring Self-intersection[-0.497326851352909 45.3424818937246]
 FRFG075         | Ring Self-intersection[-1.01659869767161 45.9240194287539]
 FRFG081         | Ring Self-intersection[-1.1697726926555 43.6851085399273]
 FRFG082         | Ring Self-intersection[0.834468980958945 43.2084620908531]
 FRB1G018        | Ring Self-intersection[4.75370874256464 49.7458979597233]
 FRKG006         | Self-intersection[-53.4218683287483 5.53271035455429]
 FRKG005         | Ring Self-intersection[-54.123784 5.40554999999995]
 BG2G000J3K1040  | Ring Self-intersection[28.4454306040524 43.7145897007582]
 DK1.5.2.1       | Ring Self-intersection[10.0592365258505 56.4582074853342]
 DK1.5.2.2       | Ring Self-intersection[10.356235616536 56.3223347257012]
 DK1.5.2.3       | Ring Self-intersection[10.0822483319187 56.2971772986473]
 DK1.5.2.4       | Ring Self-intersection[9.42126020285974 56.4350582699185]
 DK1.5.2.5       | Ring Self-intersection[9.80636074077501 56.2408790224024]
 DK1.5.2.6       | Ring Self-intersection[9.43173573747214 56.073778490337]
 DK1.5.2.10      | Ring Self-intersection[10.0774775922349 56.2999144317487]
 DK1.5.2.13      | Ring Self-intersection[9.6813547960495 56.1085933997729]
 HUAIQ547        | Ring Self-intersection[18.9388944061333 47.5607793261282]
 HUAIQ557        | Ring Self-intersection[17.9262005684811 47.2051907194799]
 DK1.9.2.1       | Ring Self-intersection[10.1895086486853 56.0041661233449]
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 DK1.9.2.2       | Ring Self-intersection[9.84939470029371 55.851529892746]
 DK1.9.2.3       | Ring Self-intersection[9.94902476108371 55.7447707050476]
 DK1.9.2.5       | Ring Self-intersection[9.85745930279256 55.8550681787232]
 BEVL014         | Ring Self-intersection[5.57275975525874 50.8089856240875]
 BG3G00000PG028    | Ring Self-intersection[25.9841999991729 41.6096990007689]
 BG3G00000PT045    | Ring Self-intersection[26.3117008387329 41.8591997466522]
 DK1.12.2.3       | Ring Self-intersection[10.1680159125876 55.2227377670852]
 DK1.13.2.5       | Ring Self-intersection[10.2765097143914 55.3776992936579]
 DK1.13.2.10       | Ring Self-intersection[10.1914453453703 55.5082822982334]
 DK1.1.2.4       | Ring Self-intersection[10.1050068800809 56.8185282875999]
 DK1.2.2.1       | Self-intersection[8.83877887359562 56.8196600922678]
 DK1.2.2.17       | Ring Self-intersection[9.11024150517017 56.4918892412533]
 DK1.2.2.23       | Ring Self-intersection[8.83031024612814 56.7473336068862]
 DK1.2.2.24       | Ring Self-intersection[9.00000000000011 56.6888408456015]
 DK1.6.2.1       | Ring Self-intersection[10.7165960964738 56.4966847232128]
 DK1.6.2.2       | Ring Self-intersection[10.5924662476819 56.364452062896]
 DK1.6.2.3       | Ring Self-intersection[10.8942561549703 56.3295934604818]
 DK1.6.2.4       | Ring Self-intersection[10.5825169467642 56.2414737925695]
 DK1.6.2.6       | Ring Self-intersection[10.3606694282471 56.561234565378]
 DK1.11.2.7       | Ring Self-intersection[9.59879397482081 55.3619043728184]
 DK1.11.2.12       | Ring Self-intersection[9.53057304256816 54.9838219781095]
 DK1.15.2.11       | Ring Self-intersection[10.2636495613539 54.9343730072217]
 DK2.2.2.11       | Ring Self-intersection[11.9358912553499 55.8213672375916]
 DK2.2.2.14       | Ring Self-intersection[11.9029897805507 55.9581152712682]
 DK2.3.2.2       | Self-intersection[12.5520560382611 55.8423154633422]
 DK2.4.2.1       | Ring Self-intersection[12.5668095051117 55.6710903075216]
 DK2.5.2.10       | Ring Self-intersection[11.2413859717724 54.8697349652607]
 DK2.6.2.10       | Ring Self-intersection[12.0295059447481 55.2639159825902]
 DK3.1.2.3       | Ring Self-intersection[15.14446630161 55.1087843788541]
 DK3.1.2.5       | Self-intersection[14.9678426540547 55.0289516617733]
 DK4.1.2.2.Kliplev | Ring Self-intersection[9.45347480019825 54.873468016121]
 IT03GWBB3BLO      | Ring Self-intersection[9.28502009020519 45.1249245026639]
(80 rows)

postgis=# select a.eu_cd_gw, st_isvalidreason(a.geom) as test from gwb.gwb_2012_h3 a where
st_isvalid(geom) = false;
     eu_cd_gw     |                          test
-------------------+-----------------------------------------------------------------------
 FRHG218          | Ring Self-intersection[3.81256276785763 49.0827933918018]
 FRFG103          | Ring Self-intersection[-1.24160398523554 44.6359386410556]
 FRGG142          | Ring Self-intersection[1.00537634494253 47.4895160143528]
 FRFG072          | Ring Self-intersection[-0.867517895034666 45.2705446304305]
 FRFG073          | Ring Self-intersection[-0.586762932363285 44.5805845111664]
 FRFG075          | Ring Self-intersection[-0.497326851352966 45.3424818937246]
 FRFG078          | Ring Self-intersection[-1.01659869767161 45.9240194287538]
 FRFG081          | Ring Self-intersection[0.834468980958889 43.208462090853]
 FRFG091          | Ring Self-intersection[-1.1697726926555 43.6851085399273]
 BG3G000PGN026     | Ring Self-intersection[25.2127289153074 42.2955550082572]
 BG3G00000PT039     | Ring Self-intersection[24.4482000004298 41.6053999996105]
 BG3G00000PT041     | Too few points in geometry component[24.8209453984116 41.8387837841445]
 BG3G00000PT044     | Ring Self-intersection[24.2485864889754 42.3508158379807]
 BG1G000K1HB050     | Ring Self-intersection[26.9454192592916 43.6171274482733]
 BG1G0000K1B041     | Ring Self-intersection[27.3710162994628 43.8235713925059]
 BG3G00000NQ018     | Self-intersection[24.9928079999238 42.0321009996948]
 DK1.2.3.14       | Ring Self-intersection[8.79326996713542 56.778872294521]
 IT082410ER-DQ2-CCI | Ring Self-intersection[10.9977981166899 44.5094748013212]
 ITG20_2341       | Ring Self-intersection[8.67346431662509 40.8437345063426]
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 ITG20_2313       | Ring Self-intersection[8.33306591745827 40.8186200038103]
(20 rows)

postgis=# select a.eu_cd_gw, st_isvalidreason(a.geom) as test from gwb.gwb_2012_h4 a where
st_isvalid(geom) = false;
   eu_cd_gw    |                          test
----------------+--------------------------------------------------------------------------
 FRFG102       | Ring Self-intersection[-1.24740603156289 44.6000953056541]
 FRFG073       | Ring Self-intersection[-0.867517895034609 45.2705446304305]
 FRFG075       | Ring Self-intersection[-0.586762932363229 44.5805845111665]
 FRFG091       | Ring Self-intersection[0.834468980958945 43.2084620908531]
 FRFG075       | Ring Self-intersection[-0.867517895034609 45.2705446304305]
 FRFG080       | Ring Self-intersection[-1.06072175570426 43.7111114089645]
 FRFG101       | Ring Self-intersection[-1.24740603156289 44.6000953056541]
 BG3G00000PT041 | Too few points in geometry component[24.8209453977657 41.8387837841144]
 BG3G00000PT044 | Ring Self-intersection[24.2485864891971 42.3508158384]
 BG3G0000PGN026 | Ring Self-intersection[25.2127289144501 42.2955550080718]
 BG3G00000PT039 | Ring Self-intersection[24.4481999995444 41.6053999997528]
(11 rows)

postgis=# select a.eu_cd_gw, st_isvalidreason(a.geom) as test from gwb.gwb_2012_h5 a where
st_isvalid(geom) = false;
 eu_cd_gw | test
----------+------
(0 rows)


postgis=# select a.eu_cd_gw, st_isvalidreason(a.geom) as test from gwb.gwb_2012_h6_h7 a where
st_isvalid(geom) = false;
NOTICE:  Ring Self-intersection at or near point 9.5791557283542943 40.394713425584371
NOTICE:  Ring Self-intersection at or near point 8.5058155498479096 39.483836022014998
NOTICE:  Ring Self-intersection at or near point 9.7064302862288514 39.936495945031936
NOTICE:  Ring Self-intersection at or near point 9.3444617080415924 41.139092556976152
NOTICE:  Ring Self-intersection at or near point 8.2506958781125377 40.583285460256036
  eu_cd_gw  |                        test
------------+-----------------------------------------------------------
 ITG20_3831 | Ring Self-intersection[9.57915572835429 40.3947134255844]
 ITG20_3851 | Ring Self-intersection[8.50581554984791 39.483836022015]
 ITG20_3821 | Ring Self-intersection[9.70643028622885 39.9364959450319]
 ITG20_3832 | Ring Self-intersection[9.34446170804159 41.1390925569762]
 ITG20_3221 | Ring Self-intersection[8.25069587811254 40.583285460256]
(5 rows)


postgis=# select a.gwb_code, st_isvalidreason(a.geom) as test from gwb.gwb_ch_2012_nonWFD a where
st_isvalid(geom) = false;
NOTICE:  Ring Self-intersection at or near point 7.0202447363264922 46.267884601301311
NOTICE:  Ring Self-intersection at or near point 7.7073379358370842 47.396753294307629
NOTICE:  Ring Self-intersection at or near point 7.7495253468239316 47.399878943300855
NOTICE:  Ring Self-intersection at or near point 8.5445002280783235 47.508236419791373
NOTICE:  Ring Self-intersection at or near point 8.8561713816134358 47.261853537895703
 gwb_code |                        test
----------+-----------------------------------------------------------
 CH1302   | Ring Self-intersection[7.02024473632649 46.2678846013013]
 CH3201   | Ring Self-intersection[7.70733793583708 47.3967532943076]
 CH3302   | Ring Self-intersection[7.74952534682393 47.3998789433009]
 CH3303   | Ring Self-intersection[8.54450022807832 47.5082364197914]
```

```
 CH5302   | Ring Self-intersection[8.85617138161344 47.2618535378957]
(5 rows)

postgis=# select a.eu_cd_gw, st_isvalidreason(a.geom) as test from gwb.reunion a where st_isvalid(geom) =
false;
 eu_cd_gw | test
----------+------
(0 rows)
```