BRGM WFS 3.0

-

Final Report

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Introduction

BRGM has been involved since more than 15 years in the definition of international interoperability standards (INSPIRE, OGC, IUGS-CGI); recently, it has deployed interoperable OGC services on top of the French Groundwater Information Network (GIN). This effort is aligned with INSPIRE requirements on the provision of Boreholes, Environmental Monitoring Facilities/Network description and their associated observations.

Parallel to that dynamic, two important related elements have been more and more visible under the OGC umbrella:

- The recent OGC WFS 3.0 work,
- How to link Environmental Features: especially under the current Interoperability Experiment called ELFIE (Environmental Linked Features IE)[1].

Within this context, BRGM is seeking to test the deployment of an OGC WFS 3.0 draft specification implementation so that it can serve features from the French GIN in a linked data friendly way. Such test will focus on serving borehole descriptions according to the internationally agreed semantics defined in the EPOS model.

GeoSolutions has been working since the beginning of 2018 on a WFS 3.0 implementation for the GeoServer Open Source product which is already available as a community module (some early feedback on the specification is available on GeoSolutions blog post[2]) and it is now working together with OGC as part of the OWS14 interoperability experiment to refine the implementation towards compliance with the current version of the standard.

BRGM[3] is already using GeoServer with App-Schema extension to publish using WFS several data sets that are stored in a PostgreSQL[4] database. App-Schema extension is used to define several mappings between the relational database schemas and the target target XML schemas, the results of this mappings can be simple features or complex features.

GeoSolutions is thinking about a multiphase approach for this work. In our vision, there would be 3 phases in sequence as follows which would be concluded by an in person knowledge transfer workshop:

1. Context Analysis Report preparation
2. Initial Deployment
3. Use case development and final deployment

[1] https://opengeospatial.github.io/ELFIE/temp_er/er
[2] https://www.geo-solutions.it/blog/wfs3-geoserver/
[3] Bureau de Recherches Géologiques et Minières
[4] Spatial support is provided by the PostGIS extension

Context of the assignment

The BRGM ICT division (Direction des Infrastructures et des Services Numériques - DISN) has a strong internationally recognised expertise in interoperability, master data management and hosting services in a virtualized environment. This is in part due to their long involvement in the definition of international interoperability standards (INSPIRE, OGC, IUGS-CGI) paired with their established track record of bringing these abstract standards to life by deploying production services within the French Groundwater Information Network (GIN).

At present, BRGM provides a coherent system of state-of-the-art linked resources, modelled based on European (INSPIRE) and international (OCG/ISO) standards, and served using OGC WFS and SOS services. However, technology continues to progress, introducing new service and data linkage paradigms, foremost:

- Open API Based Services: OGC has been developing a new version of the WFS standard in line with the requirements of Open API. As this standard nears finalization, it is essential to ascertain if the specification as it currently stands supports the requirements from the wider spatial measurement data community:
- Linked Data Approaches: The OGC Environmental Linked Features Interoperability Experiment (ELFIE) has explored the potential of linked data pertaining to spatial measurement data while aligning with relevant best practices from W3C and OGC[5][6]. A focus was set on
    - the ability to semantically describe and use links between features that adhere to domain-specific feature models and
    - the ability to link the above features to observation and measurement data from samples collected on these features.

The *Borehole* feature type as specified within the EPOS standard has been identified as a good candidate for exploration of the potential of the emerging standards described above for use within the BRGM infrastructure. The *Borehole* feature type encompasses descriptive information pertaining to the feature itself together with links to both measurements providing additional descriptive information as well as links providing the necessary semantics towards other features in the GIN. The relevant data for provision of *Borehole* via WFS 3.0 will be made available by BRGM staff in the form of a PostgreSQL/GIS Dump.

[5] "Data on the Web Best Practices" – Best Practices summary (W3C) : https://www.w3.org/TR/dwbp/#bp-summary
[6] "Spatial Data on the Web Best Practices" – Best Practices summary (W3C/OGC) : https://www.w3.org/TR/sdw-bp/#bp-summary

One of the challenges to be faced in the implementation of a prototype for the provision of *Borehole* via WFS 3.0 will be how to provide the required contextual semantic grounding via links to other relevant features at a time when only *Borehole* are available via WFS3. As the existing systems at BRGM employ a coherent pattern for linking available resources via resolvable URIs, utilization of these existing access modalities will serve to illustrate the immense power of a solution based on Open API and Linked Data, especially when integrating to existing data holdings via cross-technology linkages.

Borehole featureType context analysis

Based on the example datasource (PostgreSQL/GIS) as well as the requirements of the EPOS Borehole featureType, together with our existing knowledge of the WFS 3.0 specification and WFS 3.0 developments, a requirements analysis has been performed. This analysis will serve as the basis for a comprehensive description of the way we foresee deployment of a WFS 3.0 implementation for the provision of boreholes together with their contextual information. This analysis has confirmed that the WFS3 solution being developed by GeoSolutions should be able to cover all requirements posed by the provision of Borehole data via WFS3.

The following subsections will detail the requirements of the EPOS Borehole featureType.

EPOS Borehole

The EPOS Borehole feature type (see *Figure 3.1*) will be the core feature type upon which we base our analysis and work. In addition, the following feature types are associated with the EPOS borehole:

- *eposb:locatedOnAdminUnit: xlink*
- *eposb:bholeHeadworks -> gwml-wellconstruction:BoreCollar*
- *eposb:monitoringFacility -> eposb:BoreholeMonitoringFacility*
- *eposb:alias -> eposb:Alias*
- *eposb:georesourceFeature -> eposb:BoreholeGeoresource (multiple, 2 in example)*

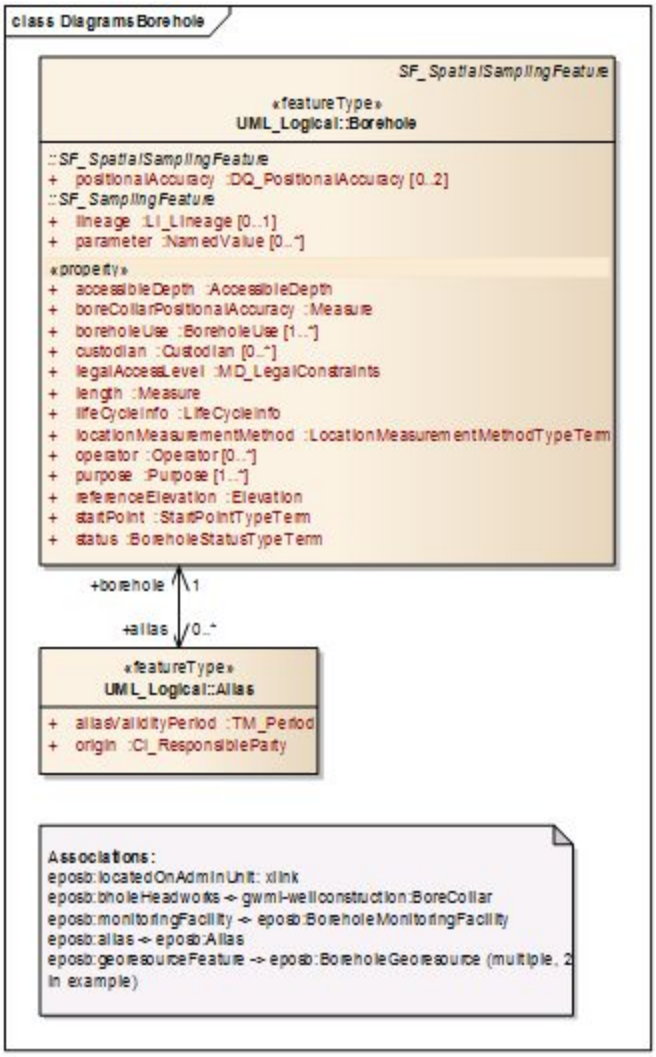

Figure 3.1 - BoreHole class diagram.

Data Types used by Borehole

The Borehole feature type depends on several data types (see *Figure 3.2*), the most relevant ones for this project, i.e. the ones associated with attributes that have *one-to-many* or *many-to-many* relationships with the borehole feature type, are:

- *BoreHoleUse*
- *Custodian*
- *Operator*

- *Purpose*

This relationionships using these feature types, that have a cardinality superior to one, will need to be encoded as nested (simple) feature or links, using the selected linking methodology.

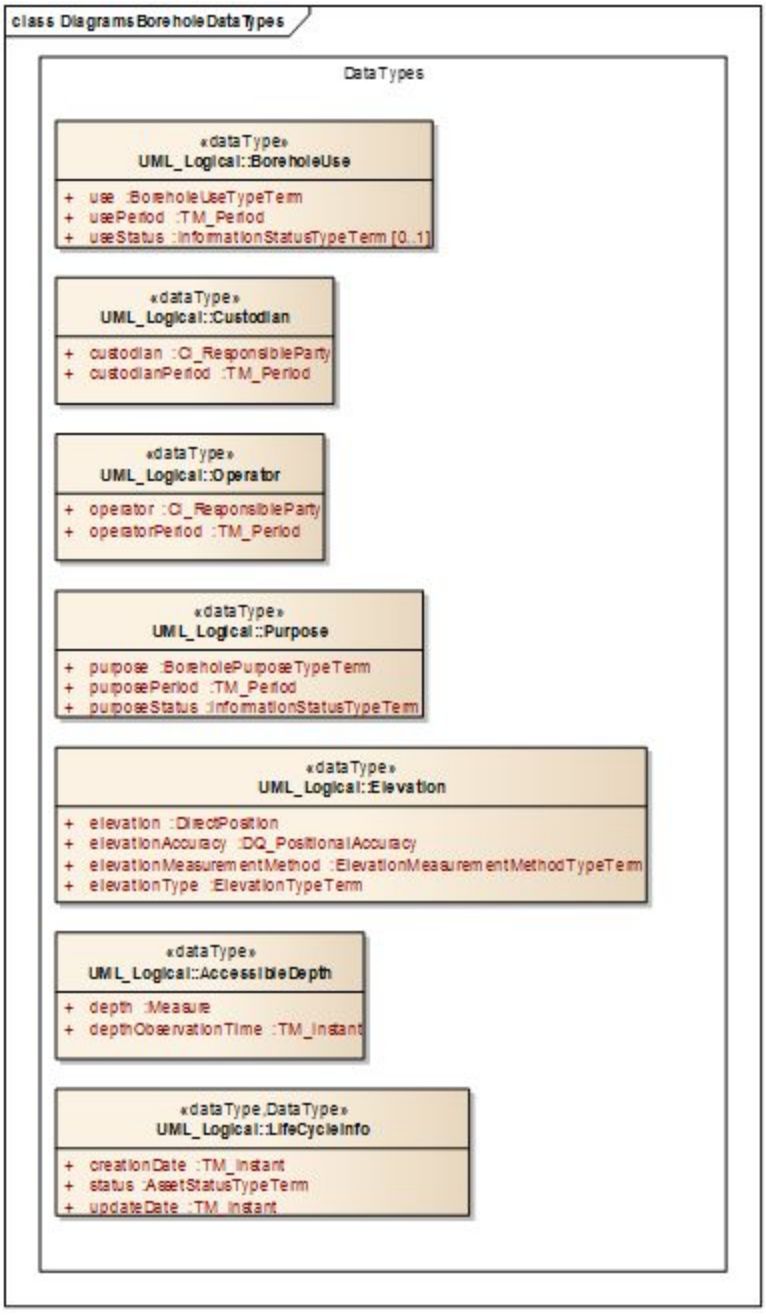

Figure 3.2 - Borehole related data types class diagrams.

Codelists utilized by Borehole

The model depend on several codelists (see *Figure 3.3*), these items seem to be always associated with attributes that have relationships with a cardinality not bigger than one (1). For relationships with a superior cardinality the will need to be modeled as a list \ array of simple values.

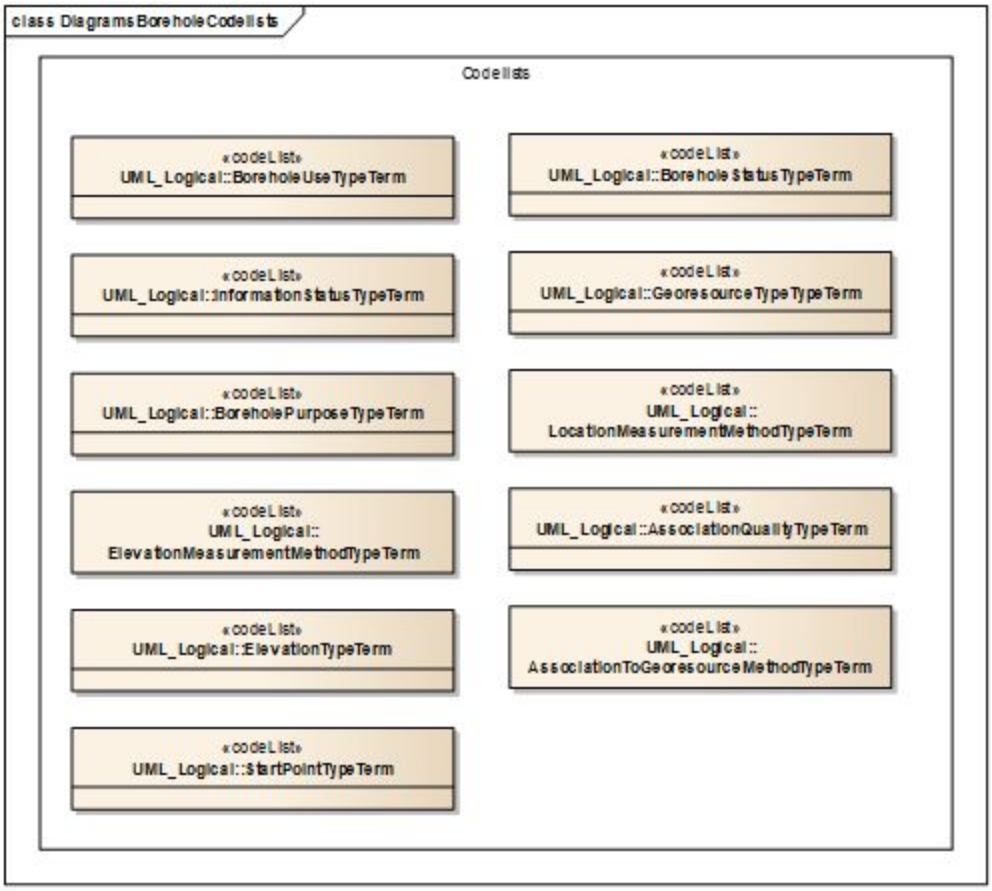

Figure 3.3 - BoreHole Codelist class diagram

Feature Types Associated to Boreholes

The borehole feature type relates with several other feature types (see *Figure 3.4*), special care will need to be taken when mapping these feature type and associated relationships. Each feature type should be mapped once, and then reused.

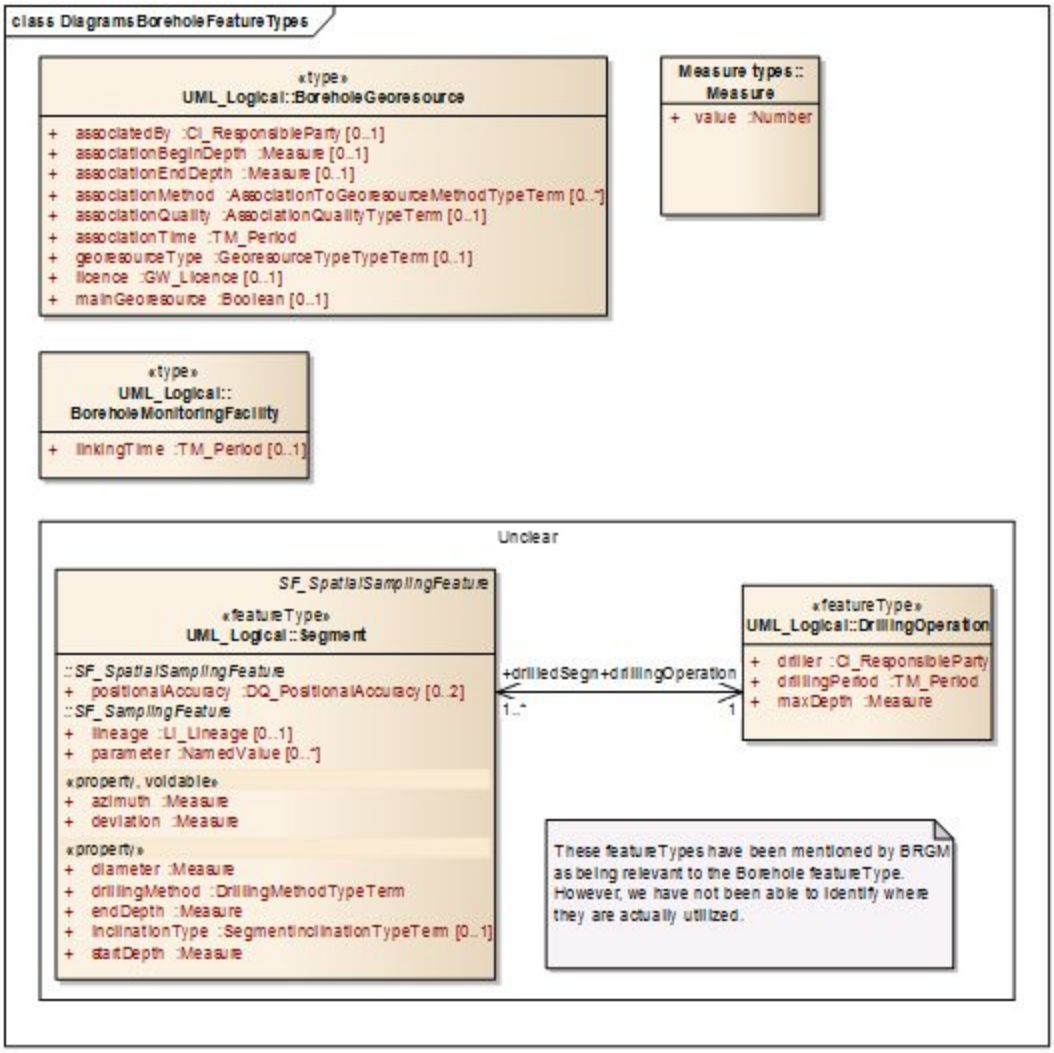

Figure 3.4 - Borehole associated feature types class diagram.

Overview of Borehole Feature Type

In the previous sections we have gone through all the data types, feature types and codelist that need to be used to define a borehole (see *Figure 3.5*). The mapping of the borehole feature type to the target form, i.e. JSON, will involve both feature types a simple values.

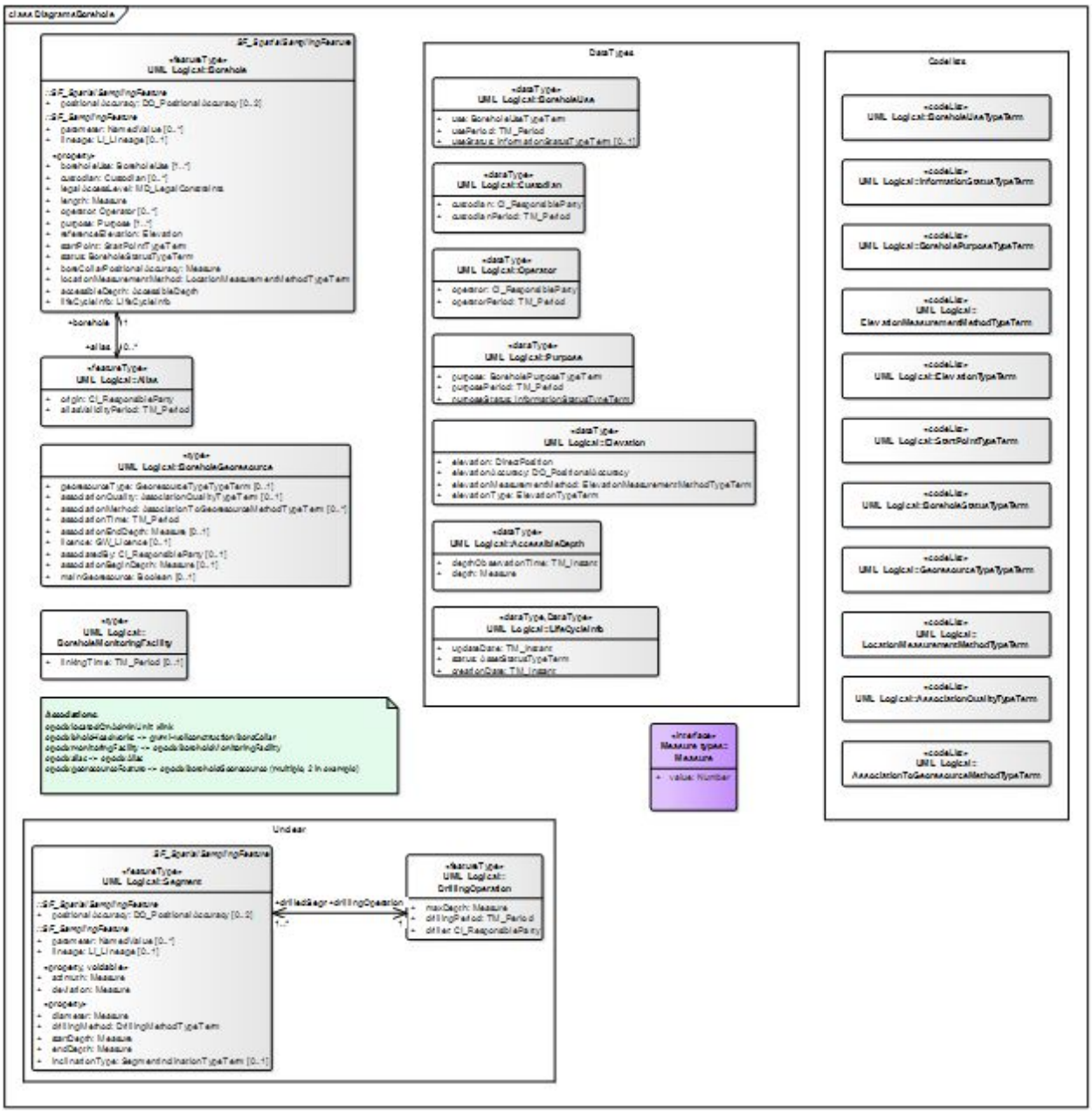

Figure 3.5 - Borehole overall class diagram.

Technical solution

In this section we will roughly identify the possible solutions for each one of the identified technical requirements and define the detailed scheduling and plan for this work.

As already mentioned in the previous sections, the overall goal is to serve the EPOS data set complex features through WFS 3.0 using the defined linking methodology targeting JSON as the main output format.

There was already a significant modeling effort done by BRGM to serve EPOS complex features as GML 3.2 documents through WFS 2.0 using GeoServer. Mappings between the data source, PostgreSQL database, and the target GML schema where defined using GeoServer App-Schema extension.

We will strive to reuse most of the modeling work that has already been done, i.e. the reusing the target GML schema and the App-Schema mappings. The goal is to have GeoServer capable of serving from the same mappings both JSON and GML 3.2.

WFS 3.0 support in GeoServer

GeoServer WFS 3.0 implementation was kick-started in March 2018 by participating to the OGC sponsored WFS 3.0 hackaton, a two day intense collaboration and coding exercise that helped participants to get involved in the specification early draft, provide feedback, and perform some basic interoperability checks.

At the end of the exercise an initial version was ready and could be used by the correspondent prototype driver in GDAL/OGR. The code was donated to the GeoServer community as a community module and it's available for download in nightly builds. The exercise also provided insights on what part of the first implementation needed optimizing.

The WFS 3.0 implementation was resumed a few months later as part of GeoSolutions participation into Testbed 14, with the objective to implement the WFS 3.0 core fully, along with GML SF0 and GeoJSON extensions support, and assist in the validation of the WFS 3.0 CITE compliance tests. This allowed to improve the underlying implementation and improve various little details, which eventually brought GeoServer WFS 3.0 to compliance in late September 2018.

Finally, GeoSolutions has participated in the OGC vector tiles pilot and extending the WFS 3.0 module to support tiled requests in Mapbox Vector Tile format.

Presently the WFS 3.0 module supports the following:

- WFS 3.0 core based on the first draft release (the same used to write the compliance tests)
- WFS 3.0 OpenAPI 3 conformance class, by returning a valid OpenAPI 3 document describing the available resources
- WFS 3.0 HTML output (only for simple features)
- WFS GeoJSON output
- WFS GML-SF0 output

However, the implementation is currently an internal proxy to the WFS 2.0 machinery and the ability to encode complex features is present, but incomplete.

WFS 3.0 limitations

The WFS 3.0 implementation philosophy is to have a basic core that most servers can implement quickly and a set of extensions to handle other requirements. In particular the WFS 3.0 core first draft is:

- Fully REST and OpenAPI based
- Schemaless, features can have any structure, the server is not required to describe it
- Feature geometries and filters are only supported in CRS84, that is, WGS84 coordinates in longitude/latitude order
- Limited filtering support, space filtering by bbox and time filtering are required, attribute equality may be supported in a limited way too (only for attributes whose domain can be enumerated), but it's not a requirement[7]
- Result paging provided by links. In order to reach a certain page the client has to go through all previous ones following the links, random page jumps are not part of core.
- Access to single feature by identifier

The WFS 3.0 final specification is yet to be revealed, and above lines are not under discussion, but some details in the specification will likely change requiring modifications both in the service code and in the compliance tests.

Currently the specification contains no formal extension, but there are discussions on a few directions that might become extensions later in the future:

[7] GeoServer only supports space filtering, attribute filter has not been added, waiting for a more comprehensive filtering extension to be defined

- *Multiple coordinate reference system support*, allowing the server to declare which CRS are supported, and the client to ask for reprojected outputs and to specify spatial filters in a CRS other than CRS84.
- *Explicit complex features support.* The overall topic of complex features is being discussed at a large in the Testbed 14 complex feature handling engineering report[8]. It is to be noted that the core specification does not restrict to simple features, but just ignores schemas, while the output can be simple or complex, both in the GeoJSON output and in the GML-SF2 profile.
- *Schema declaration support*, currently discussion is ongoing on the topic, the direction seems to be based on a new OpenAPI 3.0 release that will allow to link schemas from the API definition itself. Other proposals include linking to the schemas from the collection description document (the current discussion papers mention it as a stopgap measure).
- *Inline query*, allowing the server to advertise one or more query languages and support complex filters in the "items" request, within the limits of what can be included in a URL[9]. There is no official documentation yet, but from internal discussions the primary candidates for query languages are CQL, as implemented in GeoServer, and Filter encoding, with other languages being considered such as Falcor and GraphQL as well.
- *Stored query.* In order to support large, complex queries that would not fit a URL, as well as improving ease of use for common queries, an extension will be devised that mimics the WFS 2.0 stored query support, using the same languages as the inline query, but with parameters support, and the ability to refer to the query by id and provide parameter values in the *items* path.
- *Feature identifiers.* The core WFS 3.0 specification states that features can be queried by identifier using the "/collections/{collectionId}/items/{id}" resource, but it's targeting simple features, or at the very least, top level features in a complex structure. The discussion is still ongoing on whether ids are required for all features (e.g., nested ones), their persistence and the like. No clear direction is established yet.

GeoServer WFS 3.0 can be extended to provide an early implementation of the extension above, with the understanding that none of the above has a firm specification and what is being implemented will not necessarily match the final specification, but will be based on a best effort internal design. There is no way to know when the above extensions will be released, the best

[8] It is to be noted that an engineering report does not equate to a specification, in particular, it reports on the activity carried out in Testbed 14 and provides suggestions to the WFS SWG, which will use them as inputs for the development of the WFS 3.0 specification and its extensions
[9] WFS 3.0 supports no POST requests to request data, as it would be against the REST architectural guidelines, where POST requests should be used only for new resource creation

approach to expedite them would be to actively participate in the WFS SWG after the work of finalizing the core spec is settled down.

On serving the borehole database

The representation of borehole data requires several relatable entities to be linked together, hence producing complex features. Those relations are usually encoded as nested objects or as *navigable* links, e.g. in WFS 2.0 the relations encoding, as nested object or as *x-links*, can be controlled at runtime using *resolve* and *resolveDepth* parameters.

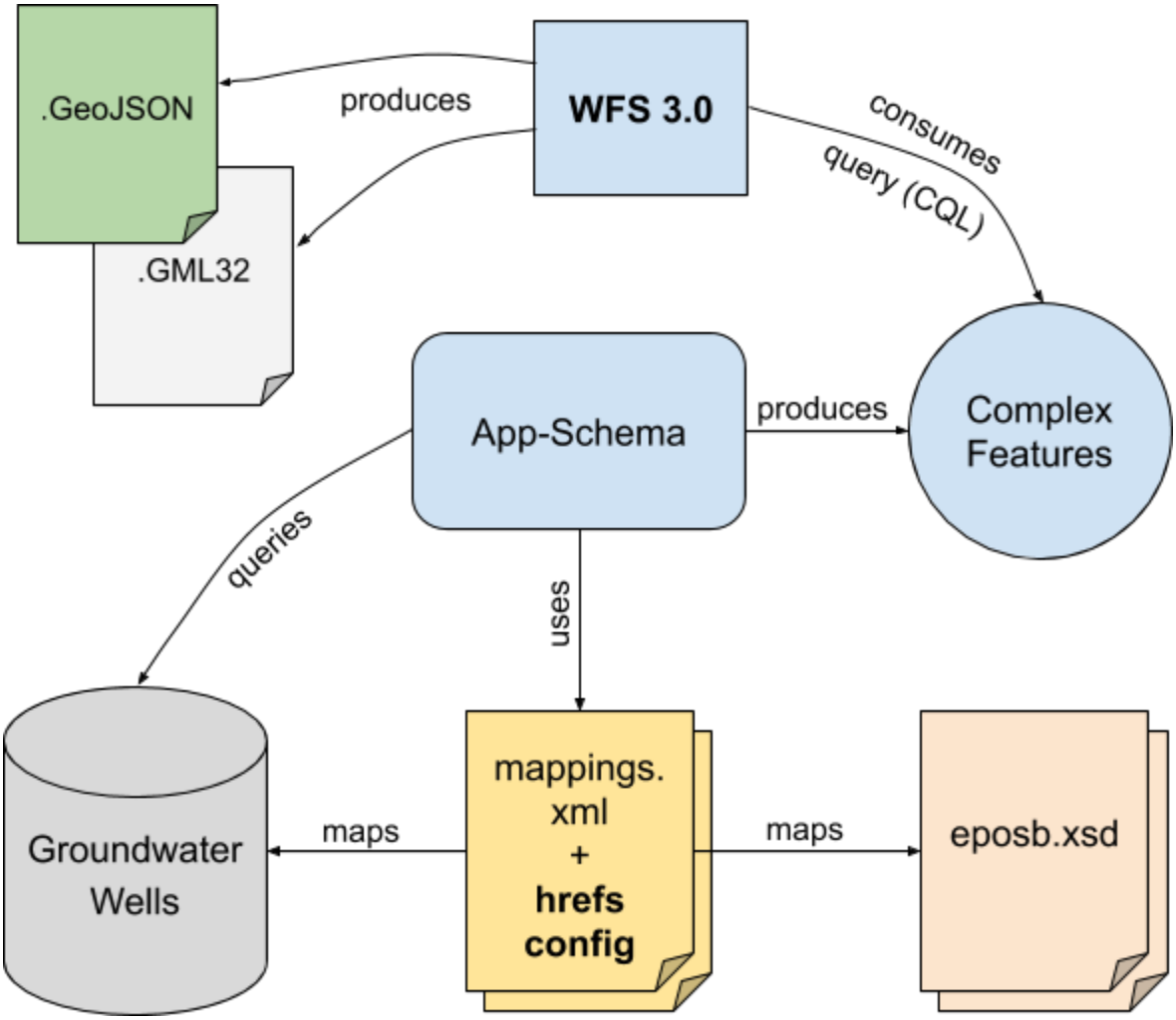

Figure 4.1 - Main components that will be used to retrieve \ query Borehole relational database and publish it through WFS 3.0. App-Schema mappings will use EPOS Borehole schemas as

the target and define which relations can be encoded as references \ links. The produced complex features will then be encoded by GeoServer in GML32 or GeoJSON as needed.

It should also be possible to query such complex representations based on the available attributes, querying based solely on spatial and time criteria is not enough. We need at least some basic equality comparison support on the root entities attributes as well on the related entities attributes. This will be done using WFS 3.0 inline queries suggested approach based on CQL syntax.

The idea is to leverage on GeoServer App-Schema extension to build Borehole data complex features and then to publish them thought WFS 3.0, respecting the selected linking semantics. Instead of creating a new application silo we will reuse, extend and improve the existing GeoServer complex features support ecosystem (see *Figure 4.1*). In practical terms this means that:

1. the existing App-Schema mappings between the boreholes relational database and EPOS Borehole GML schemas can be reused, at least a significant part of them
2. the produced complex feature can be used by GeoServer to answer both WFS 2.0 and WFS 3.0 requests
3. GeoServer will be able to use the produced complex features to encode both GML32 and GeoJSON response formats
4. the same GeoServer instance, using the same configuration, can be used to answer both WFS 3.0 and INSPIRE requirements

The points above will allow BRGM to reuse most of the existing infrastructure in a seamless way and take advantage of the modeling effort that has already be done for INSPIRE. The ability to reuse the same, or at least a significant part, of the existing App-Schema configuration and functionalities will reduce the system operability and maintainability costs.

Implementing this solution will require development work to be done in the existing GeoServer WFS 3.0 implementation, as well on the existing App-Schema extension. Is worth mentioning that App-Schema will always require a target GML schema to be used for the mappings[10].

Work foreseen

As already mentioned on a previous section, the existing WFS 3.0 GeoServer implementation was not build with complex features in mind, this means that the ability to encode complex features is not denied, but instead not completely supported, e.g. we can already retrieved and

[10] In the future, this limitation can be removed with some extra development work.

visualize complex features through WFS 3.0 (see *Listing 4.1*) but it is not yet possible to retrieve a complex feature by its identifier.

Taking into account the existing WFS 3.0 limitations on complex features support and the functionalities required to support this use case, we can already foresee several tasks:

- improve the WFS 3.0 support of complex features based on the ongoing OGC initiatives, it should be possible to correctly visualize and query a single complex feature by its identifier
- implement support for the selected linking methodology \ format (based on OGC ELFIE), this should be backwards compatible with the existing GML32 mappings for EPOS Borehole schemas
- implement basic support, at least equality based criterias should be supported, in WFS 3.0 for inline queries using CQL syntax:
    - it should be possible to use root entities attributes as well attributes of the linked entities
    - App-Schema should delegate (when possible) the queries execution to the relational database

```
{
  type: "FeatureCollection",
 ▾ features: [
   ▾ {
       type: "Feature",
       id: "7",
       geometry: null,
     ▾ properties: {
         stationName: "1_Bologna",
       ▾ observation: [
         ▾ {
           ▾ parameter: {
             ▾ Parameter: {
                 parameter: "temperature"
               }
             },
             value: 35
           },
         ▸ {…},
         ▸ {…},
         ▸ {…},
         ▸ {…}
       ]
     }
   },
   ▸ {…},
   ▸ {…},
   ▸ {…}
 ],
 numberReturned: 4,
 timeStamp: "2018-10-24T14:26:34.924Z",
 ▾ links: [
   ▾ {
```


Listing 4.1 - Complex features GeoJSON response produced by current GeoServer WFS 3.0 implementation, we can already see several nested entities, but it is not yet possible to retrieve a complex feature by its identifier.

The developed code that will be specific to this initiative will be isolated on a GeoServer extension, this will improve the overall maintainability of the produced solution.

Results

This section describes and provides a critical analysis of the obtained results, it also introduces the discussion about future improvements.

Mappings Rules

Before moving forward it is important to mention that the rules \ patterns that have been discussed, and will keep being discussed, to convert a GML document to a JSON \ JSONLD document, will be summarized in a document[11].

Target GeoJSON

GeoServer WFS3 already had the ability to encode complex GeoJSON at the beginning of the project, however, the results were considered not satisfactory due to a number of reasons:

1. The output was too strictly mimicking the GML structure, producing an overly deep and convoluted JSON data structure tree
2. Elements with XML attributes were encoded as containing array of objects, one per attribute
3. The generated GeoJSON provided no hint about the data type of each JSON object, compounded by the lack of a schema, meaning no actual information about the expected date structure was provided to the clients
4. Nested features were missing both their identifier and their status of feature, being demoted to a simple JSON object.

Several changes were performed in the code to improve on the above situation. In particular:

1. The property/element GML alternation pattern has been identified and removed from the JSON output, reducing the number of nested and duplicated objects, while preserving the same amount of information
2. All XML attributes are now encoded at the same level as the elements, both as JSON properties, with attributes names being prefixed by a “@”, e.g. “@href”, “@title”
3. Every nested feature is encoded as a full blown GeoJSON feature, preserving its identifier, top level geometry, and list of properties
4. Every complex object gets either a “@dataType” attribute or a “@featureType” attribute indicating the type as provided in the GML schema, with the “Type” suffix removed at the end for simplicity

[11] https://github.com/INSIDE-information-systems/WFS3/issues/6

5. As an exception to the above rule, the dataType is skipped from “complex elements with simple content”, such as codelists and measures, where the main content is meant to be just a value, with eventual attributes to explain its meaning better.

Here is an annotated excerpt of the output (a bigger example can be consulted in Annex A):


```
{
  "type": "FeatureCollection",
  "features": [
    {
      "type": "Feature",
      "id": "0001000001",
      "geometry": {
        "type": "Point",
        "coordinates": [
          51.0684,
          1.4298
        ]
      },
      "properties": {
        "@featureType": "Borehole",
        "sampledFeature": [
          {
            "@href": "https://sweet.jpl.nasa.gov/2.3/realmEarthReference.owl#EarthLithosphere",
            "@title": "Lithosphere"
          }
        ],
        "referenceElevation": {
          "@dataType": "Elevation",
          "elevationMeasurementMethod": {
            "@dataType": "Reference",
            "@href": "http://id.eaufrance.fr/nsa/892#XXX",
            "@title": "DGPS as Dummy"
          },
          "elevationType": {
            "@dataType": "Reference",
            "@href": "http://resource.europe-geology.eu/vocabs/elevationtype/groundSurface",
            "@title": "Ground surface"
          },
          "elevation": {
            "value": -32,
            "@srsName": "http://www.opengis.net/def/crs/EPSG/0/5720",
            "@srsDimension": "1",
            "@uomLabels": "m"
          }
        },
        ...
        "bholeHeadworks": [
          {
            "type": "Feature",
            "geometry": {
```

```
            "type": "Point",
            "coordinates": [
              51.0684,
              1.4298
            ]
          },
          "properties": {
            "@featureType": "BoreCollar",
            "collarElevation": {
              "value": -32,
              "@srsName": "http://www.opengis.net/def/crs/EPSG/0/5720",
              "@srsDimension": "1",
              "@uomLabels": "m"
            }
          }
        }
      ],
      ...
  ],
  ...
}
```


It is worth noting that the output is obtained without any further mapping, but simply applying the following translation rules to the features generated by the application-schema data store (which are meant primarily for GML encoding, and thus mimics its structure very closely):

- If attributes are found, encoded them as part of the properties prefixing them with "@"
- If the complex type being encoded is a "complex type with simple content", then encode it as a straight value, unless it has attributes, in which case encode it as an object with attributes and the value in a property called *value*
- If the type of the attribute being encoded ends with <X>PropertyType or <X>_PropertyType, contains a single element whose type is X, skip property indirection and encode its content directly
- If the type is a complex, encode its XML type (as @featureType or @dataType), removing the "Type" suffix at the end
- If the attribute is an instance of Feature (which app-schema should produce when the underlying data type extends GML AbstractFeature) then encode it as a fully blown GeoJSON feature, including its identifier, otherwise use a plain JSON object
- Chained features are always contained inside an array

The above machinery allows to get a suitable GeoJSON output from any app-schema generated complex feature. At the same time, it provides no control on the generated output, and won't allow generating JSON-LD: for this we planned future activities based on a mapping configuration instead.

Future Work

As noted in the previous section, it's now possible to get a suitable complex GeoJSON output from services configured to build and return complex features in GML, with no extra configuration effort.

However, this poses a limitation when the output requirements are more demanding, which is typically the case of JSON-LD, where feature and geometry encoding are different, and a higher level of customization is desirable, like manually setting up the JSON-LD context, encoding values in a different way, building ids as direct links to other JSON-LD documents, and renaming attributes.

The JSON-LD output format would act as yet another output format for GeoServer WFS, as displayed in the following diagram:

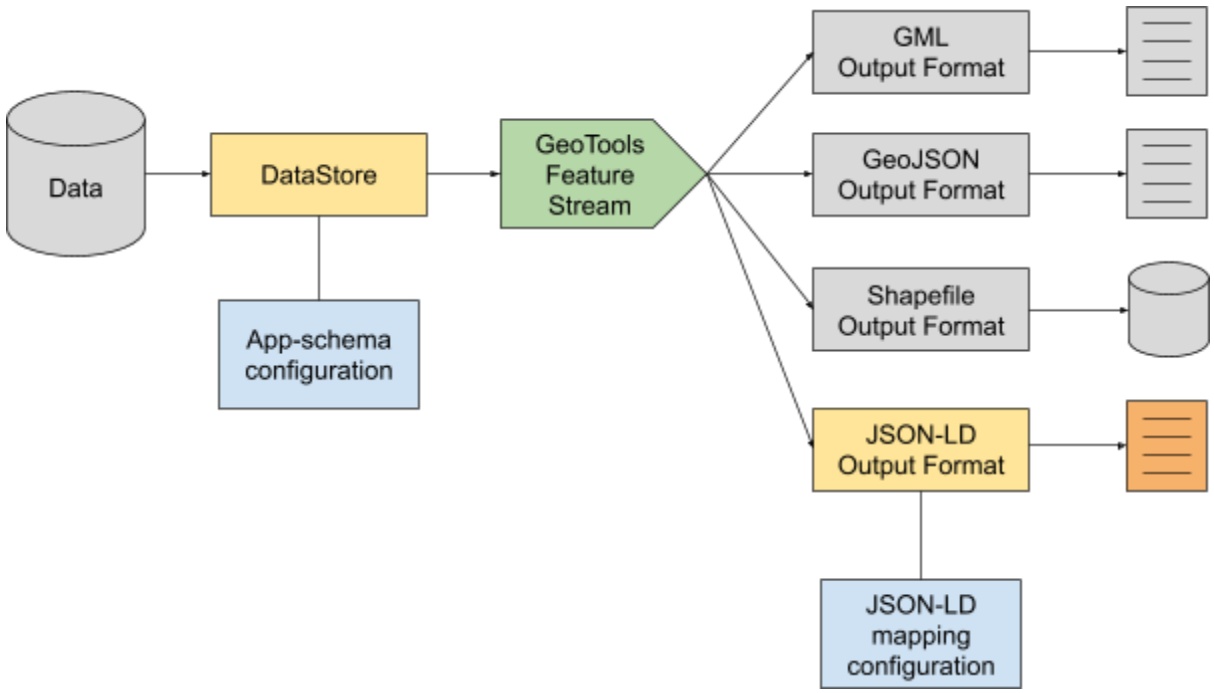

Figure 5.1 - Generation of complex features output in GeoServer WFS, with the planned JSON-LD output format.

The JSON-LD format would be based on a mapping file including all the specifications required to build the desired JSON-LD format. In particular, a mapping file for the Boreholes would look as follows (directives are in bold):

```
{
  "@context": {
    "gsp": "http://www.opengis.net/ont/geosparql#",
    "sf": "http://www.opengis.net/ont/sf#",
    "sam": "http://def.seegrid.csiro.au/ontology/om/sam-lite#",
    "om": "http://def.seegrid.csiro.au/ontology/om/om-lite#",
    "eposb": "https://data.geoscience.earth/def/eposb#",
    "ci": "http://def.seegrid.csiro.au/isotc211/iso19115/2003/citation#",
    "md": "http://def.seegrid.csiro.au/isotc211/iso19115/2003/metadata#",
    "mdex": "http://def.seegrid.csiro.au/isotc211/iso19115/2003/extent#",
    "time": "http://www.w3.org/2006/time#",
    "gml": "http://www.opengis.net/gml/3.2#",
    "gwmlwc": "http://www.opengis.net/gwml-wellconstruction/2.2#",
    "schema": "https://schema.org/",
    "Feature": "gsp:Feature",
    "FeatureCollection": "schema:Collection",
    "GeometryCollection": "sf:GeometryCollection",
    "Geometry": "sf:Geometry",
    "LineString": "sf:LineString",
    "MultiLineString": "sf:MultiLineString",
    "MultiPoint": "sf:MultiPoint",
    "MultiPolygon": "sf:MultiPolygon",
    "Point": "sf:Point",
    "Polygon": "sf:Polygon",
    "bbox": "sf:envelope",
    "wkt": "gsp:asWKT",
    "features": {
      "@container": "@set",
      "@id": "schema:hasPart"
    },
    "geometry": "sf:geometry",
    "description": "http://purl.org/dc/terms/description",
    "title": "http://purl.org/dc/terms/title",
    "name": "schema:name"
  },
  "type": "FeatureCollection",
  "features": [
    {
      "$source": "eposb:Borehole"
    },
    {
      "@id": "${@id}",
```

```
      "@type": [
        "Feature",
        "eposb:Borehole",
        "http://vocabulary.odm2.org/samplingfeaturetype/borehole"
      ],
      "name": "${gml:identifier}",
      "geometry": {
        "@type": "Point",
        "wkt":
"<http://www.opengis.net/def/crs/OGC/1.3/CRS84>$${wkt(xpath('eposb:bholeHeadworks/gwml-wellcon
struction:BoreCollar/gwml-wellconstruction:collarLocation')}"
      },
      "sam:sampledFeature": {
        "@id": "https://sweet.jpl.nasa.gov/2.3/realmEarthReference.owl#EarthLithosphere",
        "name": "Lithosphere"
      },
      "eposb:custodian": [
        {
          "$source": "eposb:custodian"
        },
        {
          "@type": "eposb:Custodian",
          "eposb:custodian": {
            "@type": "ci:ResponsibleParty",
            "ci:organisationName": "BRGM",
            "ci:role": {
              "@type": "ci:RoleCode",
              "@id": "http://def.seegrid.csiro.au/isotc211/iso19115/2003/code/Role/custodian"
            }
          },
          "eposb:custodianPeriod": {
            "@type": "time:Period",
            "time:hasBeginning": {
              "time:inXSDDateTime": "${eposdb:custodianPeriod/gml:beginPosition}"
            },
            "time:hasEnd": {
              "time:inXSDDateTime": "${eposdb:custodianPeriod/gml:beginPosition}"
            }
          }
        }
      ],
      "eposb:legalAccessLevel": {
        "@type": "md:LegalConstraints",
        "md:accessConstraints": {
          "@type": "md:RestrictionCode",
          "@id": "http://purl.org/eprint/accessRights/openAccess"
        },
```

```
    "md:Constraints": {
      "@type": "md:RestrictionCode",
      "@id": "http://purl.org/eprint/accessRights/openAccess"
    }
  },
  "eposb:length": {
    "@type": "om:SimpleMeasure",
    "om:amount": "${eposb:length}",
    "om:uom": "http://qudt.org/vocab/unit/M"
  },
  "eposb:operator": {
    "@type": "eposb:Operator",
    "eposb:operator": {
      "@type": "ci:ResponsibleParty",
      "ci:organisationName": "BRGM",
      "ci:role": {
        "@type": "ci:RoleCode",
        "@id": "http://def.seegrid.csiro.au/isotc211/iso19115/2003/code/Role/owner"
      }
    }
  },
  "eposb:referenceElevation": {
    "$source": "eposb:referenceElevation",
    "@type": "eposb:Elevation",
    "eposb:elevation": "${eposb:Elevation/eposb:elevation}",
    "mdex:verticalCRS": "http://www.opengis.net/def/crs/EPSG/0/5720",
    "om:uom": "http://qudt.org/vocab/unit/M",
    "eposb:elevationMeasurementMethod": {
      "@id": "${eposb:Elevation/eposb:elevationlMeasurementMethod@xlink:href}",
      "name": "DGPS as Dummy"
    },
    "eposb:elevationType": {
      "@id": "https://data.geoscience.earth/ncl/ElevationType/groundSurface",
      "name": "Ground surface"
    }
  },
  "eposb:startPoint": {
    "@id": "https://data.geoscience.earth/ncl/StartPoint/naturalLandSurface",
    "name": "natural land surface"
  },
  "eposb:status": {
    "@id": "${epsdb:status/xlink:href}",
    "name": "Opérationnel"
  },
  "eposb:boreCollarPositionalAccuracy": {
    "om:uom": "http://qudt.org/vocab/unit/CM"
  },
```

```
      "eposb:locationMeasurementMethod": {
        "@id": "${eposb:locationMeasurementMethod/xlink:href}",
        "name": "DGPS as Dummy"
      },
      "eposb:accessibleDepth": {
        "@type": "eposb:AccessibleDepth",
        "eposb:depthObservationTime": {
          "@type": "time:Instant",
          "time:inXSDDateTime":
"${eposb:accessibleDepth/eposb:AccessibleDepth/eposb:depthObservationTime/gml:TimeInstant/gml:
timePosition}"
        }
      },
      "eposb:lifeCycleInfo": {
        "$source": "eposb:lifeCycleInfo/eposb:LifeCycleInfo",
        "@type": "LifeCycleInfo",
        "eposb:updateDate": {
          "@type": "time:Instant",
          "time:inXSDDateTime": "${eposb:updateDate/gml:TimeInstant/gml:timePosition}"
        },
        "status": {
          "@id": "${eposb:lifeCycleInfo/eposb:LifeCycleInfo/eposb:status}",
          "name": "Validé"
        },
        "eposb:creationDate": {
          "@type": "time:Instant",
          "time:inXSDDateTime": "$eposb:creationDate/gml:TimeInstant/gml:timePosition}"
        }
      },
      "eposb:locatedOnAdminUnit": {
        "@id": "${eposb:locatedOnAdminUnit}",
        "name": "SANGATTE"
      },
      "bholeHeadworks": [
        {
          "$source": "eposb:bholeHeadworks/gwml-wellconstruction:BoreCollar"
        },
        {
          "@type": [
            "gwmlwc:BoreCollar",
            "Feature"
          ],
          "gwmlwc:collarElevation": {
            "om:amount": "${gwml-wellconstruction:collarElevation}",
            "mdex:verticalCRS": "http://www.opengis.net/def/crs/EPSG/0/5720",
            "om:uom": "http://qudt.org/vocab/unit/M"
          },
```

```
          "gsp:hasGeometry": {
            "@type": "Point",
            "wkt":
"<http://www.opengis.net/def/crs/OGC/1.3/CRS84>$${wkt(xpath('eposb:bholeHeadworks/gwml-wellcon
struction:BoreCollar/gwml-wellconstruction:collarLocation')}"
          }
        }
      ]
    }
  ]
}
```

In summary, the file is a valid JSON document, with static elements that are going to be reproduced in the output, and “property interpolations” that are mapping to the source features (which, while being in memory objects, have the same structure as a GML document). In particular, the following rules apply:

- Simple variable interpolations look like `${xpath}`, where the xpath refers to a property in the GML based object model produced by app-schema, assuming standard xml prefixes used in the app-schema configuration
- Complex interpolations are possible via a `$${CQL}` syntax, where the CQL is a full blown CQL expression, free to use all functions and operators available. Since attribute references in CQL cannot use a XPATH syntax, a new `xpath('path')` function will be added to cover the more complex needs
- If the output contains JSON arrays the first element will be an object, indicating which list of objects to peek from GML model in order to build the JSON array, in the form of `{ "$source" : "xpath"}`. XPath references inside the array would refer to the array source objects by relative paths.
- Nested objects can have a `"$source" : "xpath"` attribute, when present it will have two effects:
    - If the xpath evaluates to null, the entire object will be skipped
    - The source will be the context against which all xpath expressions are evaluated, thus the xpath interpolations and CQL expressions inside the object will be relative to its source (as with the arrays)

The mapping file provides a good balance between simplicity and power, and should be suitable for most common JSON-LD production needs.

Is worth mentioning that simple features (non App-Schema defined feature types) will also be able to be encoded in JSON-LD, although only simple attributes will be supported (no nested attributes or multiple cardinality attributes).

The output will process features in a streaming manner, loading each input feature from the store and mapping it out to a JSON-LD feature in output. **This implies that the simple feature input case** will have to include all the attributes required to build an output feature in a single database record, including everything needed to produce arrays, e.g:

Simple feature structure (simple attributes, no nested properties)	**JSON-LD structure, the array positions are hardcoded for c11, c12, c21 and c23 attributes.**

a
b1
b2
c11
c12
c21
c22
d
	{
	a,
	{
	b1,
	b2,
	},
	[
	{
	c11,
	c12
	},
	{
	c21,
	c22
	}
	],
	d
	}

Deployment at BRGM

BRGM will deploy the system on their own infrastructure using GeoSolutions DEV server as a reference. During this migration \ setup BRGM will also validate the database created views and perform data validity checks.

Conclusions

By reusing some of the modeling effort already done by BRGM for the EPOS use case and reusing the technologies well known to BRGM, e.g. GeoServer and App-Schema, the cost of bringing this to BRGM infrastructure and consequently to production was significantly reduced.

This practical exercise helped BRGM to get a practical feeling of WFS 3.0 standard, which will help orientate the WFS 3.0 standard related ongoing initiatives in the right direction. This exercise also started new activities and discussions about the representation of information in JSON based formats, in this case GeoJSON and JSON-LD.

Last but not least, all the GeoServer improvements where contributed back to GeoServer, making this work *de facto* available to all other initiatives that would like to put in practice WFS 3.0 and GeoJSON format. It also provides a common practical platform for the discussion around these topics.

Appendix A: Target Structure

Is worth mentioning that both examples use the same feature **(access protected)**:

- [GML3.2] http://brgm-dev.geo-solutions.it/geoserver/wfs3/collections/eposb__Borehole/items/06268X0017?f=application/gml+xml; version=3.2
- [GeoJSON] http://brgm-dev.geo-solutions.it/geoserver/wfs3/collections/eposb__Borehole/items/06268X0017?f=application/json

XML Encoding

GML 3.2.1 example encoding of a borehole feature type:

```
<?xml version="1.0" encoding="UTF-8"?>
<wfs:FeatureCollection numberMatched="unknown" numberReturned="1"
timeStamp="2019-06-25T17:53:53.403Z"
xmlns:eposb="https://forge.brgm.fr/svnrepository/epos/trunk/schemas/eposb"
xmlns:gco="http://www.isotc211.org/2005/gco"
xmlns:geosolutions="https://www.geo-solutions.it/"
xmlns:gmd="http://www.isotc211.org/2005/gmd"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:gwml-wellconstruction="http://www.opengis.net/gwml-wellconstruction/2.2"
xmlns:om="http://www.opengis.net/om/2.0"
xmlns:sam="http://www.opengis.net/sampling/2.0"
xmlns:sams="http://www.opengis.net/samplingSpatial/2.0"
xmlns:wfs="http://www.opengis.net/wfs/2.0"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/wfs/2.0
http://brgm-dev.geo-solutions.it:80/geoserver/schemas/wfs/2.0/wfs.xsd
https://forge.brgm.fr/svnrepository/epos/trunk/schemas/eposb
http://info.datacove.eu/epos-borehole.xsd http://www.opengis.net/gml/3.2
http://brgm-dev.geo-solutions.it:80/geoserver/schemas/gml/3.2.1/gml.xsd">
 <wfs:boundedBy>
   <gml:Envelope>
     <gml:lowerCorner>10.3427 25.3596</gml:lowerCorner>
     <gml:upperCorner>10.3427 25.3596</gml:upperCorner>
   </gml:Envelope>
 </wfs:boundedBy>
 <wfs:member>
   <eposb:Borehole gml:id="06268X0017">
     <gml:identifier
```

```
codeSpace="http://www.ietf.org/rfc/rfc2616">BSS001QACB</gml:identifier>
     <gml:name>SOURCE DU LAC</gml:name>
     <gml:boundedBy>
       <gml:Envelope>
         <gml:lowerCorner>10.3427 25.3596</gml:lowerCorner>
         <gml:upperCorner>10.3427 25.3596</gml:upperCorner>
       </gml:Envelope>
     </gml:boundedBy>
     <sam:type
xlink:href="http://vocabulary.odm2.org/samplingfeaturetype/borehole/"
xlink:title="borehole"/>
     <sam:sampledFeature
xlink:href="https://sweet.jpl.nasa.gov/2.3/realmEarthReference.owl#EarthLithosphere
" xlink:title="Lithosphere"/>
     <sams:shape>
       <gml:Point gml:id="gml.shape.point.BSS001QACB" srsDimension="2"
srsName="http://www.opengis.net/gml/srs/epsg.xml#4326">
         <gml:pos>46.3427 5.3596</gml:pos>
       </gml:Point>
     </sams:shape>
     <eposb:boreholeUse>
       <eposb:BoreholeUse>
         <eposb:use xlink:href="http://id.eaufrance.fr/nsa/148#4"
xlink:title="missing in mapping"/>
         <eposb:usePeriod>
           <gml:TimePeriod>
             <gml:beginPosition>1995-02-14T23:00:00Z</gml:beginPosition>
           </gml:TimePeriod>
         </eposb:usePeriod>
       </eposb:BoreholeUse>
     </eposb:boreholeUse>
     <eposb:boreholeUse>
       <eposb:BoreholeUse>
         <eposb:use xlink:href="http://id.eaufrance.fr/nsa/148#3"
xlink:title="missing in mapping"/>
         <eposb:usePeriod>
           <gml:TimePeriod>
             <gml:beginPosition>1966-12-31T23:00:00Z</gml:beginPosition>
           </gml:TimePeriod>
         </eposb:usePeriod>
       </eposb:BoreholeUse>
     </eposb:boreholeUse>
     <eposb:boreholeUse>
       <eposb:BoreholeUse>
         <eposb:use xlink:href="http://id.eaufrance.fr/nsa/148#3"
xlink:title="missing in mapping"/>
         <eposb:usePeriod>
           <gml:TimePeriod>
             <gml:beginPosition>1984-12-26T23:00:00Z</gml:beginPosition>
```

```
            </gml:TimePeriod>
          </eposb:usePeriod>
        </eposb:BoreholeUse>
      </eposb:boreholeUse>
      <eposb:custodian>
        <eposb:Custodian>
          <eposb:custodian>
            <gmd:CI_ResponsibleParty>
              <gmd:organisationName>
                <gco:CharacterString>BRGM</gco:CharacterString>
              </gmd:organisationName>
              <gmd:role>
                <gmd:CI_RoleCode
codeList="http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml"
codeListValue="custodian"/>
              </gmd:role>
            </gmd:CI_ResponsibleParty>
          </eposb:custodian>
        </eposb:Custodian>
      </eposb:custodian>
      <eposb:legalAccessLevel>
        <gmd:MD_LegalConstraints>
          <gmd:accessConstraints>
            <gmd:MD_RestrictionCode codeList="" codeListValue="openaccess"/>
          </gmd:accessConstraints>
          <gmd:useConstraints>
            <gmd:MD_RestrictionCode codeList="" codeListValue="openaccess"/>
          </gmd:useConstraints>
        </gmd:MD_LegalConstraints>
      </eposb:legalAccessLevel>
      <eposb:length uom="http://qudt.org/vocab/unit/M"/>
      <eposb:operator>
        <eposb:Operator>
          <eposb:operator>
            <gmd:CI_ResponsibleParty>
              <gmd:organisationName>
                <gco:CharacterString>BRGM</gco:CharacterString>
              </gmd:organisationName>
              <gmd:role>
                <gmd:CI_RoleCode
codeList="http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml"
codeListValue="owner"/>
              </gmd:role>
            </gmd:CI_ResponsibleParty>
          </eposb:operator>
        </eposb:Operator>
      </eposb:operator>
      <eposb:purpose>
        <eposb:Purpose>
```

```
        <eposb:purpose xlink:href="http://id.eaufrance.fr/nsa/148#4"
xlink:title="missing in mapping"/>
        <eposb:purposePeriod>
          <gml:TimePeriod>
            <gml:beginPosition>1995-02-14T23:00:00Z</gml:beginPosition>
          </gml:TimePeriod>
        </eposb:purposePeriod>
        <eposb:purposeStatus xlink:href="http://id.eaufrance.fr/nsa/914#1"
xlink:title="Declare"/>
      </eposb:Purpose>
    </eposb:purpose>
    <eposb:purpose>
      <eposb:Purpose>
        <eposb:purpose xlink:href="http://id.eaufrance.fr/nsa/148#3"
xlink:title="missing in mapping"/>
        <eposb:purposePeriod>
          <gml:TimePeriod>
            <gml:beginPosition>1966-12-31T23:00:00Z</gml:beginPosition>
          </gml:TimePeriod>
        </eposb:purposePeriod>
        <eposb:purposeStatus xlink:href="http://id.eaufrance.fr/nsa/914#1"
xlink:title="Declare"/>
      </eposb:Purpose>
    </eposb:purpose>
    <eposb:purpose>
      <eposb:Purpose>
        <eposb:purpose xlink:href="http://id.eaufrance.fr/nsa/148#3"
xlink:title="missing in mapping"/>
        <eposb:purposePeriod>
          <gml:TimePeriod>
            <gml:beginPosition>1984-12-26T23:00:00Z</gml:beginPosition>
          </gml:TimePeriod>
        </eposb:purposePeriod>
        <eposb:purposeStatus xlink:href="http://id.eaufrance.fr/nsa/914#1"
xlink:title="Declare"/>
      </eposb:Purpose>
    </eposb:purpose>
    <eposb:referenceElevation>
      <eposb:Elevation>
        <eposb:elevation srsDimension="1"
srsName="http://www.opengis.net/def/crs/EPSG/0/5720"
uomLabels="m">230.0</eposb:elevation>
        <eposb:elevationMeasurementMethod
xlink:href="http://id.eaufrance.fr/nsa/892#XXX" xlink:title="DGPS as Dummy"/>
        <eposb:elevationType
xlink:href="http://resource.europe-geology.eu/vocabs/elevationtype/groundSurface"
xlink:title="Ground surface"/>
      </eposb:Elevation>
    </eposb:referenceElevation>
```

```
      <eposb:startPoint
xlink:href="http://resource.europe-geology.eu/vocabs/StartPoint/naturalLandSurface"
xlink:title="naturalLandSurface"/>
      <eposb:status xlink:href="http://id.eaufrance.fr/nsa/146#XXX"
xlink:title="Opérationnel"/>
      <eposb:boreCollarPositionalAccuracy uom="http://qudt.org/vocab/unit/CM"/>
      <eposb:locationMeasurementMethod
xlink:href="http://id.eaufrance.fr/nsa/917#XXX" xlink:title="DGPS as Dummy"/>
      <eposb:accessibleDepth>
        <eposb:AccessibleDepth>
          <eposb:depthObservationTime>
            <gml:TimeInstant>
              <gml:timePosition>1998-05-03T22:00:00Z</gml:timePosition>
            </gml:TimeInstant>
          </eposb:depthObservationTime>
        </eposb:AccessibleDepth>
      </eposb:accessibleDepth>
      <eposb:lifeCycleInfo>
        <eposb:LifeCycleInfo>
          <eposb:updateDate>
            <gml:TimeInstant>
              <gml:timePosition>1998-05-04T15:30:31Z</gml:timePosition>
            </gml:TimeInstant>
          </eposb:updateDate>
          <eposb:status xlink:href="http://id.eaufrance.fr/nsa/390#1"
xlink:title="Validé"/>
          <eposb:creationDate>
            <gml:TimeInstant>
              <gml:timePosition>1998-05-03T22:00:00Z</gml:timePosition>
            </gml:TimeInstant>
          </eposb:creationDate>
        </eposb:LifeCycleInfo>
      </eposb:lifeCycleInfo>
      <eposb:locatedOnAdminUnit xlink:href="0101432" xlink:title="VERJON"/>
      <eposb:bholeHeadworks>
        <gwml-wellconstruction:BoreCollar>
          <gml:boundedBy>
            <gml:Envelope srsDimension="2"
srsName="http://www.opengis.net/gml/srs/epsg.xml#4326">
              <gml:lowerCorner>10.3427 25.3596</gml:lowerCorner>
              <gml:upperCorner>10.3427 25.3596</gml:upperCorner>
            </gml:Envelope>
          </gml:boundedBy>
          <gwml-wellconstruction:collarElevation srsDimension="1"
srsName="http://www.opengis.net/def/crs/EPSG/0/5720"
uomLabels="m">230.0</gwml-wellconstruction:collarElevation>
          <gwml-wellconstruction:collarLocation>
            <gml:Point gml:id="gml.point.collar.BSS001QACB" srsDimension="2"
srsName="http://www.opengis.net/gml/srs/epsg.xml#4326">
```

```
            <gml:pos>10.3427 25.3596</gml:pos>
          </gml:Point>
        </gwml-wellconstruction:collarLocation>
      </gwml-wellconstruction:BoreCollar>
    </eposb:bholeHeadworks>
    <eposb:monitoringFacility>
      <eposb:BoreholeMonitoringFacility
gml:id="ks_pe_sh_mv.fid-17fea969_16b8a1071db_-d4a">
        <eposb:linkingTime>
          <gml:TimePeriod>
            <gml:beginPosition>1899-12-31T23:00:00Z</gml:beginPosition>
            <gml:endPosition indeterminatePosition="unknown"/>
          </gml:TimePeriod>
        </eposb:linkingTime>
      </eposb:BoreholeMonitoringFacility>
    </eposb:monitoringFacility>
    <eposb:monitoringFacility>
      <eposb:BoreholeMonitoringFacility
gml:id="ks_pe_sh_mv.fid-17fea969_16b8a1071db_-d49">
        <eposb:linkingTime>
          <gml:TimePeriod>
            <gml:beginPosition>1984-12-31T23:00:00Z</gml:beginPosition>
            <gml:endPosition indeterminatePosition="unknown"/>
          </gml:TimePeriod>
        </eposb:linkingTime>
      </eposb:BoreholeMonitoringFacility>
    </eposb:monitoringFacility>
    <eposb:monitoringFacility>
      <eposb:BoreholeMonitoringFacility
gml:id="ks_pe_sh_mv.fid-17fea969_16b8a1071db_-d48">
        <eposb:linkingTime>
          <gml:TimePeriod>
            <gml:beginPosition>1966-12-31T23:00:00Z</gml:beginPosition>
            <gml:endPosition>1984-12-30T23:00:00Z</gml:endPosition>
          </gml:TimePeriod>
        </eposb:linkingTime>
      </eposb:BoreholeMonitoringFacility>
    </eposb:monitoringFacility>
    <eposb:monitoringFacility>
      <eposb:BoreholeMonitoringFacility
gml:id="ks_pe_sh_mv.fid-17fea969_16b8a1071db_-d47">
        <eposb:linkingTime>
          <gml:TimePeriod>
            <gml:beginPosition>1984-12-26T23:00:00Z</gml:beginPosition>
            <gml:endPosition indeterminatePosition="unknown"/>
          </gml:TimePeriod>
        </eposb:linkingTime>
      </eposb:BoreholeMonitoringFacility>
    </eposb:monitoringFacility>
```

```
      <eposb:alias>
        <eposb:Alias gml:id="ks_alias_mv.fid-17fea969_16b8a1071db_-d46">
          <gml:identifier codeSpace="BRGM">Calcaires jurassiques du
Revermont</gml:identifier>
          <gml:name>BRGM</gml:name>
          <eposb:origin>
            <gmd:CI_ResponsibleParty>
              <gmd:organisationName>
                <gco:CharacterString>BRGM</gco:CharacterString>
              </gmd:organisationName>
              <gmd:role>
                <gmd:CI_RoleCode
codeList="http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml"
codeListValue="owner"/>
              </gmd:role>
            </gmd:CI_ResponsibleParty>
          </eposb:origin>
          <eposb:aliasValidityPeriod>
            <gml:TimePeriod>
              <gml:beginPosition>2018-07-06T08:02:07.620Z</gml:beginPosition>
            </gml:TimePeriod>
          </eposb:aliasValidityPeriod>
          <eposb:borehole xlink:href="http://boreholes.fr/BSS001QACB"
xlink:title="BSS001QACB"/>
        </eposb:Alias>
      </eposb:alias>
      <eposb:georesourceFeature>
        <eposb:BoreholeGeoresource
gml:id="ks_georesource_mv.fid-17fea969_16b8a1071db_-d45">
          <eposb:georesourceType
xlink:href="https://data.geoscience.earth/linktovocab/HydrogeologicUnit"/>
          <eposb:associationQuality xlink:href="http://id.eaufrance.fr/nsa/607#2"/>
          <eposb:associationMethod xlink:href="http://id.eaufrance.fr/nsa/607#0"/>
          <eposb:associationTime>
            <gml:TimePeriod>
              <gml:beginPosition>2018-11-21T23:00:00Z</gml:beginPosition>
            </gml:TimePeriod>
          </eposb:associationTime>
          <eposb:georesourceFeature
xlink:href="https://data.geoscience.fr/id/hydrogeounit/515AR02"
xlink:title="Système karstique du Lac"/>
        </eposb:BoreholeGeoresource>
      </eposb:georesourceFeature>
      <eposb:georesourceFeature>
        <eposb:BoreholeGeoresource
gml:id="ks_georesource_mv.fid-17fea969_16b8a1071db_-d44">
          <eposb:georesourceType
xlink:href="https://data.geoscience.earth/linktovocab/HydrogeologicUnit"/>
          <eposb:associationQuality xlink:href="http://id.eaufrance.fr/nsa/607#2"/>
```

```
        <eposb:associationMethod xlink:href="http://id.eaufrance.fr/nsa/607#0"/>
        <eposb:associationTime>
          <gml:TimePeriod>
            <gml:beginPosition>2018-11-21T23:00:00Z</gml:beginPosition>
          </gml:TimePeriod>
        </eposb:associationTime>
        <eposb:georesourceFeature
xlink:href="https://data.geoscience.fr/id/hydrogeounit/515AR02"
xlink:title="Système karstique du Lac"/>
      </eposb:BoreholeGeoresource>
    </eposb:georesourceFeature>
  </eposb:Borehole>
 </wfs:member>
</wfs:FeatureCollection>
```

GeoJSON Encoding

GeoJSON example encoding of a borehole feature type:

```
{
 "bbox": [
   10.3427,
   25.3596,
   10.3427,
   25.3596
 ],
 "crs": {
   "properties": {
     "name": "urn:ogc:def:crs:EPSG::4326"
   },
   "type": "name"
 },
 "features": [
   {
     "geometry": {
       "coordinates": [
         10.3427,
         25.3596
       ],
       "type": "Point"
     },
     "id": "06268X0017",
     "properties": {
       "@featureType": "Borehole",
       "accessibleDepth": {
         "@dataType": "AccessibleDepth",
```

```
        "depthObservationTime": {
          "@dataType": "TimeInstant",
          "timePosition": "1998-05-03T22:00:00Z"
        }
      },
      "alias": [
        {
          "aliasValidityPeriod": {
            "@dataType": "TimePeriod",
            "beginPosition": "2018-07-06T08:02:07.620Z"
          },
          "borehole": {
            "@href": "http://boreholes.fr/BSS001QACB",
            "@title": "BSS001QACB"
          },
          "identifier": {
            "@codeSpace": "BRGM",
            "value": "Calcaires jurassiques du Revermont"
          },
          "name": "BRGM",
          "origin": {
            "@dataType": "CI_ResponsibleParty",
            "organisationName": "BRGM",
            "role": {
              "@codeList":
"http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml",
              "@codeListValue": "owner"
            }
          }
        }
      ],
      "bholeHeadworks": [
        {
          "geometry": {
            "coordinates": [
              10.3427,
              25.3596
            ],
            "type": "Point"
          },
          "properties": {
            "@featureType": "BoreCollar",
            "collarElevation": {
              "@srsDimension": "1",
              "@srsName": "http://www.opengis.net/def/crs/EPSG/0/5720",
              "@uomLabels": "m",
              "value": 230
            }
          },
```

```
          "type": "Feature"
        }
      ],
      "boreCollarPositionalAccuracy": {
        "@uom": "http://qudt.org/vocab/unit/CM"
      },
      "boreholeUse": [
        {
          "use": {
            "@href": "http://id.eaufrance.fr/nsa/148#4",
            "@title": "missing in mapping"
          },
          "usePeriod": {
            "@dataType": "TimePeriod",
            "beginPosition": "1995-02-14T23:00:00Z"
          }
        },
        {
          "use": {
            "@href": "http://id.eaufrance.fr/nsa/148#3",
            "@title": "missing in mapping"
          },
          "usePeriod": {
            "@dataType": "TimePeriod",
            "beginPosition": "1966-12-31T23:00:00Z"
          }
        },
        {
          "use": {
            "@href": "http://id.eaufrance.fr/nsa/148#3",
            "@title": "missing in mapping"
          },
          "usePeriod": {
            "@dataType": "TimePeriod",
            "beginPosition": "1984-12-26T23:00:00Z"
          }
        }
      ],
      "custodian": {
        "@dataType": "Custodian",
        "custodian": {
          "@dataType": "CI_ResponsibleParty",
          "organisationName": "BRGM",
          "role": {
            "@codeList":
"http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml",
            "@codeListValue": "custodian"
          }
        }
```

```
    },
    "georesourceFeature": [
      {
        "associationMethod": [
          {
            "@href": "http://id.eaufrance.fr/nsa/607#0"
          }
        ],
        "associationQuality": {
          "@href": "http://id.eaufrance.fr/nsa/607#2"
        },
        "associationTime": {
          "@dataType": "TimePeriod",
          "beginPosition": "2018-11-21T23:00:00Z"
        },
        "georesourceFeature": {
          "@href": "https://data.geoscience.fr/id/hydrogeounit/515AR02",
          "@title": "Système karstique du Lac"
        },
        "georesourceType": {
          "@href": "https://data.geoscience.earth/linktovocab/HydrogeologicUnit"
        }
      },
      {
        "associationMethod": [
          {
            "@href": "http://id.eaufrance.fr/nsa/607#0"
          }
        ],
        "associationQuality": {
          "@href": "http://id.eaufrance.fr/nsa/607#2"
        },
        "associationTime": {
          "@dataType": "TimePeriod",
          "beginPosition": "2018-11-21T23:00:00Z"
        },
        "georesourceFeature": {
          "@href": "https://data.geoscience.fr/id/hydrogeounit/515AR02",
          "@title": "Système karstique du Lac"
        },
        "georesourceType": {
          "@href": "https://data.geoscience.earth/linktovocab/HydrogeologicUnit"
        }
      }
    ],
    "identifier": {
      "@codeSpace": "http://www.ietf.org/rfc/rfc2616",
      "value": "BSS001QACB"
    },
```

```
      "legalAccessLevel": {
        "@dataType": "MD_LegalConstraints",
        "accessConstraints": {
          "@codeList": "",
          "@codeListValue": "openaccess"
        },
        "useConstraints": {
          "@codeList": "",
          "@codeListValue": "openaccess"
        }
      },
      "length": {
        "@uom": "http://qudt.org/vocab/unit/M"
      },
      "lifeCycleInfo": {
        "@dataType": "LifeCycleInfo",
        "creationDate": {
          "@dataType": "TimeInstant",
          "timePosition": "1998-05-03T22:00:00Z"
        },
        "status": {
          "@href": "http://id.eaufrance.fr/nsa/390#1",
          "@title": "Validé"
        },
        "updateDate": {
          "@dataType": "TimeInstant",
          "timePosition": "1998-05-04T15:30:31Z"
        }
      },
      "locatedOnAdminUnit": {
        "@href": "0101432",
        "@title": "VERJON"
      },
      "locationMeasurementMethod": {
        "@href": "http://id.eaufrance.fr/nsa/917#XXX",
        "@title": "DGPS as Dummy"
      },
      "monitoringFacility": [
        {
          "linkingTime": {
            "@dataType": "TimePeriod",
            "beginPosition": "1899-12-31T23:00:00Z",
            "endPosition": {
              "@indeterminatePosition": "unknown"
            }
          }
        },
        {
          "linkingTime": {
```

```
            "@dataType": "TimePeriod",
            "beginPosition": "1984-12-31T23:00:00Z",
            "endPosition": {
              "@indeterminatePosition": "unknown"
            }
          }
        },
        {
          "linkingTime": {
            "@dataType": "TimePeriod",
            "beginPosition": "1966-12-31T23:00:00Z",
            "endPosition": "1984-12-30T23:00:00Z"
          }
        },
        {
          "linkingTime": {
            "@dataType": "TimePeriod",
            "beginPosition": "1984-12-26T23:00:00Z",
            "endPosition": {
              "@indeterminatePosition": "unknown"
            }
          }
        }
      ],
      "name": "SOURCE DU LAC",
      "operator": {
        "@dataType": "Operator",
        "operator": {
          "@dataType": "CI_ResponsibleParty",
          "organisationName": "BRGM",
          "role": {
            "@codeList":
"http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml",
            "@codeListValue": "owner"
          }
        }
      },
      "purpose": [
        {
          "purpose": {
            "@href": "http://id.eaufrance.fr/nsa/148#4",
            "@title": "missing in mapping"
          },
          "purposePeriod": {
            "@dataType": "TimePeriod",
            "beginPosition": "1995-02-14T23:00:00Z"
          },
          "purposeStatus": {
            "@href": "http://id.eaufrance.fr/nsa/914#1",
```

```
            "@title": "Declare"
          }
        },
        {
          "purpose": {
            "@href": "http://id.eaufrance.fr/nsa/148#3",
            "@title": "missing in mapping"
          },
          "purposePeriod": {
            "@dataType": "TimePeriod",
            "beginPosition": "1966-12-31T23:00:00Z"
          },
          "purposeStatus": {
            "@href": "http://id.eaufrance.fr/nsa/914#1",
            "@title": "Declare"
          }
        },
        {
          "purpose": {
            "@href": "http://id.eaufrance.fr/nsa/148#3",
            "@title": "missing in mapping"
          },
          "purposePeriod": {
            "@dataType": "TimePeriod",
            "beginPosition": "1984-12-26T23:00:00Z"
          },
          "purposeStatus": {
            "@href": "http://id.eaufrance.fr/nsa/914#1",
            "@title": "Declare"
          }
        }
      ],
      "referenceElevation": {
        "@dataType": "Elevation",
        "elevation": {
          "@srsDimension": "1",
          "@srsName": "http://www.opengis.net/def/crs/EPSG/0/5720",
          "@uomLabels": "m",
          "value": 230
        },
        "elevationMeasurementMethod": {
          "@href": "http://id.eaufrance.fr/nsa/892#XXX",
          "@title": "DGPS as Dummy"
        },
        "elevationType": {
          "@href":
"http://resource.europe-geology.eu/vocabs/elevationtype/groundSurface",
          "@title": "Ground surface"
        }
```

```
      },
      "sampledFeature": [
        {
          "@href":
"https://sweet.jpl.nasa.gov/2.3/realmEarthReference.owl#EarthLithosphere",
          "@title": "Lithosphere"
        }
      ],
      "shape": {
        "@dataType": "shape",
        "Point": {
          "coordinates": [
            10.3427,
            25.3596
          ],
          "type": "Point"
        }
      },
      "startPoint": {
        "@href":
"http://resource.europe-geology.eu/vocabs/StartPoint/naturalLandSurface",
        "@title": "naturalLandSurface"
      },
      "status": {
        "@href": "http://id.eaufrance.fr/nsa/146#XXX",
        "@title": "Opérationnel"
      },
      "type": {
        "@href": "http://vocabulary.odm2.org/samplingfeaturetype/borehole/",
        "@title": "borehole"
      }
    },
    "type": "Feature"
  }
 ],
 "numberReturned": 1,
 "timeStamp": "2019-06-25T18:00:38.527Z",
 "totalFeatures": "unknown",
 "type": "FeatureCollection"
}
```