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## OGC<sup>®</sup> Surface Water Interoperability Experiment FINAL REPORT

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## **Pre face**

This report describes the methods, results, issues and recommendations generated by the Surface Water Interoperability Experiment (SW IE), carried out as an activity of the OGC Hydrology Domain Working Group (HDWG). The SW IE is designed to test WaterML2.0, and OGC services with surface water hydrology uses cases.

Suggested additions, changes, and comments on this draft report are welcome and encouraged. Such suggestions may be submitted by email message or by making suggested changes in an edited copy of this document.

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## 1 INTRODUCTION

This report describes the methods, results, issues and recommendations generated by the Surface Water Interoperability Experiment (SW IE), carried out as an activity of the OGC Hydrology Domain Working Group (HDWG). The SW IE was designed to advance the development of WaterML 2.0 and test its use with various OGC service standards (SOS, WFS, WMS and CSW). A secondary aim was to contribute to the development of a hydrology domain feature model and vocabularies, which are essential for interoperability in the hydrology domain, although these are not the main focus for the IE.

The use of O&M compliant WaterML 2.0 and OGC web services for data exchange will allow for easier access to and consistent interpretation of water data. The ultimate use of this data will depend on the context of participating organizations and their driving requirements.

Surface water datasets typically contain a large number of observations at a small number of locations, which has tested WaterML 2.0 in new ways. This contrasts and complements the first HSWG Groundwater IE, in which for groundwater observations, there are typically small in number, taken at many locations.

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## 1.2 Revision history

Date	Release	Editor	Primary clauses modified	Description
12/12/2011	1.0	Peter Fitch	original document	
17/3/2012	1.1	Peter Fitch	Various editorial changes	
20/7/2012	1.2	Peter Fitch	Additional content from IOW Sandre	Additional content from Sylvain Grellet, IOW and final edits.

## 1.3 Future work

Future improvements to this document are desirable to clarify technical details arising from subsequent implementation of OGC standards and related technologies. In particular the finalization of SOS2.0 has occurred during the writing of this report and needs to be more fully tested with WaterML 2.0 as only some aspects were tested during this IE.

Aspects of the SW IE will continue informally amongst participants interested in maintaining and expanding surfacewater data sharing.

## 2 REFERENCES

The following documents are referenced in this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

OGC 01-068r3, Web Map Service Implementation Specification, 1.1.1, 2002-01-16, <http://www.opengeospatial.org/standards/wms>

OGC 04-094, Web Feature Service Implementation Specification, 1.1.0, 2005-05-03, <http://www.opengeospatial.org/standards/wfs>.

OGC 06-009r6, OpenGIS Sensor Observation Service, 1.0, 2007-10-26, <http://www.opengeospatial.org/standards/sos>.

OGC 06-042, OpenGIS Web Map Service (WMS) Implementation Specification, 1.3.0, 2006-03-15, <http://www.opengeospatial.org/standards/wms>.

.OGC 07-022r1, Observations and Measurements – Part 1 - Observation schema 1.0, 2007-12-08 [http://portal.opengeospatial.org/files/?artifact\\_id=22466](http://portal.opengeospatial.org/files/?artifact_id=22466).

OGC 07-036 OpenGIS Geography Markup Language (GML) Encoding Standard, 3.2.1, 2007-08-27, [http://portal.opengeospatial.org/files/?artifact\\_id=20509](http://portal.opengeospatial.org/files/?artifact_id=20509).



OGC 09-001, OpenGIS SWE Service Model Implementation Standard, 2009-09-30.

OGC 09-025r1 and ISO/DIS 19142, OpenGIS Web Feature Service 2.0 Interface Standard, 2010-11-02, <http://www.opengeospatial.org/standards/wfs>

OGC 10-037, OGC SOS 2 Interface Standard, 2010-09-02, <http://www.opengeospatial.org/standards/sos>

OGC 10-037, OGC SOS 2 Interface Standard, 2010-09-02, <http://www.opengeospatial.org/standards/sos>.

OGC 10-126r1, OGC® WaterML2.0: An O&M profile for water observations data, 2010-05-27.

\*OGC 10-004r2 and ISO/DIS 19156, Geographic information - Observations and measurements, 2010-05-03.

OGC 10-025r1, \*.

ITU-T X.891, SERIES X: DATA NETWORKS, OPEN SYSTEM COMMUNICATIONS AND SECURITY, Information technology – Generic applications of ASN.1: Fast infosec, 05/2005; <http://www.itu.int/ITU-T/asn1/xml/finf.htm>

### 3 TERMS AND DEFINITIONS

For the purposes of this report, the definitions specified in Clause 4 of the OWS Common Implementation Specification [OGC 06-121r3], clause 4 of Sensor Observation Service [OGC 06-009r6], and Clause 4 of Observations and Measurements – Part 1 [OGC 07-022r1].

### 4 CONVENTIONS

#### 4.1 Abbreviated terms

API	Application Programming Interface
CSIRO	Australian Commonwealth Scientific and Research Organization
CUAHSI	Consortium of Universities for the Advancement of Hydrologic Science
DMZ	De-Militarized Zone
FI	FastInfosec
FOI	Feature of Interest
GSC	Geological Survey of Canada
GML	Geography Markup Language
GTN-R	Global Terrestrial Network for River Discharge
GW IE	OGC Groundwater Interoperability Experiment

GWML	Groundwater Markup Language
HDWG	OGC Hydrology Domain Working Group
IE	Interoperability Experiment
ISO	International Organization for Standardization
KML	Keyhole Markup Language
KiTSM	KISTERS Time Series Server
KiWIS	KISTERS Web Interoperability Solution
NCSA	National Center for Supercomputing Applications, U Illinois Urbana
NWS	National Weather Service
OGC	Open Geospatial Consortium
OWS	OGC Web Services
O&M	Observations and Measurements
PI	Delft-FEWS Published Interface
SHEF	Standard Hydrologic Exchange Format
SOS	Sensor Observation Service
SWE	Sensor Web Enablement
UML	Unified Modeling Language
USGS	US Geological Survey
WaterML 2	Water Markup Language
WISKI	Water Information System KISTERS
WMC	Web Mapping Context
WMS	Web Mapping Service
WFS	Web Feature Service
XML	eXtensible Markup Language
XSD	XML Schema Definition

## 4.2 UML notation

Class diagrams that appear in this report are presented using the Unified Modeling Language (UML) static structure diagram, as described in Subclause 5.2 of [OGC 06-121r3]

## 5 SWIE OVERVIEW

### 5.1 Background

The Surface Water IE takes place as an experiment conducted by the OGC Hydrology Domain Working group as part of its efforts to advance interoperability with hydrology domain application of OGC standards. It is the second experiment conducted by the working group, following the Ground Water IE.

The experiment is limited in scope to surface water flow observations. The reason is that time series of flow observations are typical of a broader range of in-situ hydrological observations such as turbidity, electrical conductivity and are very common in the hydrology domain. This allowed the experiment to focus on ensuring that the characteristics of those time series are tested for suitability with WaterML 2.0, without making excessive demands on data providers and limiting unnecessary complexity.

### 5.2 Motivation and Goals

This interoperability experiment was designed to advance the development of WaterML 2.0, test its use with various OGC service standards (SOS, WFS, WMS and CSW) and emerging clients.

#### Objectives

Therefore the aim of this IE was to:

- (1) Extend and complement the work already underway in IE 1, with the goal of advancing the development of WaterML 2.0 to the sub domain of surface water observations.
- (2) Test compatibility of WaterML 2.0 with existing IOW -Sandre, DLZ-IT BMVBS, CUAHSI and USGS services and with implementation of the OGC SOS, WFS, WMS standards;
- (3) Advance exchange of surface water data between Germany and France in the cross-border area of the Rhine/Rhin river, such that participants can dynamically and transparently access the data and utilize it with their respective information systems.
- (4) Test compatibility of WaterML 2.0 for use with hydrological forecasting systems.
- (5) Establish a limited surface water feature model and vocabularies suitable for the provision of surface water data using WaterML 2.0.
- (6) The data will be served by all participants using WaterML 2.0 and OGC services (SOS, WFS, WMS).

The experiment was conducted as a set of 3 use cases. The use cases were:

1. **Cross Border Data Exchange Use Case:** In this use case the user will discover surface water data from cross border or other regions via web map client and then visualize the time-series. Once the data has been inspected and the user is

satisfied that the data is of interest, the user will download the data in an appropriate format.

2. **Forecasting Use Case:** The user will discover and download data suitable for a stream flow forecast. The user will be able to feed a stream flow forecast model with this data, but the modeling itself is not part of the scope of this IE.
3. **Global Runoff Use Case:** The goal for this use case is to provide automated monthly and yearly volume calculations from large rivers discharging to the oceans. Due to slower than expected progress, the use case was amended to a simple to a use case very similar to use case 1, in which data from the GRDC was made available using WaterML 2.0.

The original activity plan use cases can be seen in Appendix 2.

### 5.3 Structure of Report.

The following sections report on the use cases of the experiment, each of which is broken down into a list of use case contributors, use case description and goal, followed by a description of the implementation followed by the results in the form of recommendations for best practice and conclusions. This section is followed a report on the clients developed as part of the experiment. This allows the findings of the client implementation to be reported on separately as there was considerable interest in the development of clients as part of the IE.

## 6 USE CASE 1 – CROSS BORDER DATA EXCHANGE

### 6.1 Contributors

Role	Contributor
SOS service implementer	Kisters (Germany)
SOS service implementer	52° North (Germany)
Data provider	Office International de 'Eau – Sandre (France)
Project coordination Data provider	Service Centre Information Technology of the BMVBS (Germany)
Project coordination	disy Informationssysteme GmbH (Germany)

Table 1: Contributors for Use Case 1

### 6.2 Introduction

The purpose of use case 1 was to test WaterML 2.0 by disseminating surfacewater flow observations of the river Rhine (French: Rhin – German: Rhein) between Germany, the Netherlands and France, to all participants using OGC SOS, WFS and WMS web services. An additional aim was the demonstration of cross border surface water data interoperability in a field with different administrative responsibilities with expected multilingual issues.

For the use case, data from France and Germany was to be displayed in a single client, with data services from the respective jurisdictions. The targeted clients were the web client from 52north and the WISKI client. The proposed SOS implementations were the SOS server from 52north and the SOS server component of the KiWIS package.

### 6.3 Motivation and Goals

The cross-border experiment has the following objectives:

- (1) Advancing the development of WaterML 2.0 to the sub domain of surface water observations.
- (2) Test compatibility of WaterML 2.0 with existing IOW -Sandre, DLZ-IT services and with implementation of the OGC SOS, WFS and WMS standards.
- (3) Advance exchange of surface water data between Germany and France in the cross border area of the river Rhine, such that participants can dynamically and transparently access the data and utilize it with their respective information systems.

### 6.4 Design and Implementation

The setup of the cross border experiment included several server implementations of WaterML2.0 using SOS, WFS and WMS as well as clients able to consume WaterML2.0 data.

A schematic overview of technology and data sources as well as the role of the participants is shown in the figure below. Initially the experiment planned to use a simple setup with service endpoints known to the participants (see SOS implementation in Figure 1). Later in the experiment it was planned to use catalogue services (see CSW implementation in Figure 1 below) for the service and data discovery.

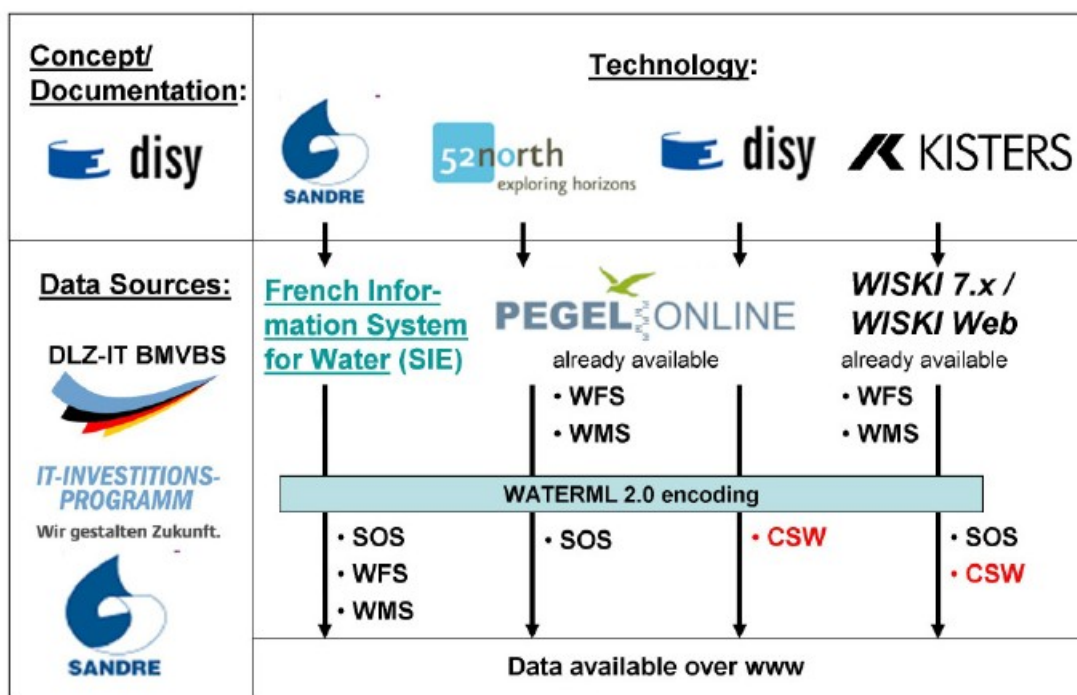


Figure 1: schematic overview of technology and data sources

### 6.5 Results - outstanding issues

Unfortunately as the experiment progressed, the supply of data from the necessary institutions to support the IE became a problem. On the French side this lack of data made it difficult to set up an infrastructure in the planned area, which could be used for the IE. In addition, the German data source was only providing the last four weeks of observation data. As well, only data for some stations in other catchment areas were available late in the experiment, so that a combined view on the data would have been quite meaningless.

The problem of missing data from one of the participants was not due to the lack of willingness to contribute to the IE, but on the fact, that the central database of the French hydrological service was undergoing a major redesign, which delayed the implementation of a real-time or near real-time data exchange. Office International de l'Eau was able to put online data on the Rhine river catchment late in the process :

November 2011 (values start around the end of September 2011) and July 2012. Before that, test data was available on other French areas to validate the architecture.

The Sandre SOS endpoint used for the experiment was :  
[http://services.sandre.eaufrance.fr/52nSOSv3\\_WML/sos](http://services.sandre.eaufrance.fr/52nSOSv3_WML/sos)

For further interoperability experiments it should be considered to have a reasonably good knowledge of the existing and accessible data.

The other issue experienced concerns the rapid development of the underlying specifications SOS 2.0 and WaterML 2.0. Due to the frequent changes in these two specifications, the ability of the software providers to implement and provide consolidated implementations of client and server were very limited.

## 6.6 Recommendations:

### 6.6.1 SOS & OM usage

The work done helped provide feedbacks on :

- the drawbacks of SOS 1.0 getCapabilities (listing all fOI) and offerings,
- best practice on how to use the OM\_Process / procedures (process type VS process instance).

This issue is dealt with in detail in use case 3 and chapter 9.

### 6.6.2 Organizational recommendation

Due to the organizational difficulties related to data availability experienced during this use case, it is recommended that for future experiments, contributors, put time into identifying these organizational barriers as risks, and develop appropriate risk management strategies.

**R1: Future experiments, contributors, put time into identifying organizational barriers as risks to experiments, and develop appropriate risk management strategies.**

## 7 USE CASE 2 - FORECASTING

### 7.1 Contributors

Role	Contributor
SOS service	USGS, KISTERS
SOS client	Deltares & NOAA/NWS, KISTERS

### 7.2 Introduction

This use case looks at the suitability of WaterML 2.0 encoding, delivered using SOS, for incremental feeds of hydrological (time series) data, in real time, from known data sources, to hydrological forecasting systems. This experiment will not address the delivery of hydrological forecasts via an SOS, as this evaluation is foreseen for the follow on interoperability experiment focused on Hydrological Forecasting.

### 7.3 Motivation and Goals

Hydrologic forecasting applications are real time system applications that continuously need to be aware of the latest state of the water and weather systems. Their data feed process is characterized by a incremental data ingest occurring at relative high frequency (1-15 minutes). The record lengths of data transmitted are typically small (i.e. one or a few values per observation). However, given the real time aspect of these systems with high frequency update requirements, they need to be efficient with their data feed as well. This places different requirements on the data encoding and services compared to the other use cases.

These requirements are characterized by the high-frequent exchange of data increments from a known set of monitoring points for a known set of phenomena. The exchange needs to be fast, so that it disrupts the forecast system as little as possible. Data discovery is typically not relevant in this context, and meta-data therefore, should be kept to a minimum to reduce the payload and parsing time.

The goal of this use case is to evaluate the suitability of SOS and the WaterML 2.0 encoding to support high-performance forecasting systems with high frequency, incremental observational data updates. In this evaluation, a comparison is made against other standardized file formats that are commonly used to exchange hydrometeorologic time series for forecasting purposes:

### 7.4 Design and Implementation

To assess the performance of WaterML 2.0 encoded files, a comparison is made against other standardized file formats that are commonly used to exchange hydrometeorologic time series for forecasting:

- SHEF: The US - Standard Hydrometeorological Exchange Format



- PI-xml: the Published Interface format from the Delft-Flood Early Warning System

The following evaluation criteria have been applied:

- ingest time
- file size (compressed/uncompressed) as a proxy for network transportation

The SOS 2.0 service used to deliver the data was hosted by USGS (<http://http://nwisvaws02.er.usgs.gov/ogc-swie/>). Some other tests have been done with a SOS 1.0 service using SWE Common encoding, hosted by 52North.

Deltares implemented the SOS client in the Delft-FEWS software platform. The test application was the NCRFC-CHPS (North Central River Forecasting Center's implementation of the Community Hydrologic Prediction System (CHPS)).

Ingest time was evaluated from the moment of receiving the SOS-response message to the internal data commit for WaterML2 encoded data. From this data set, a set of SHEF and PI-xml files were created and posted to the local disk. These files were then read from disk. For these two formats, ingest time was calculated from the start of file read to internal data commit.

## 7.5 Results – outstanding issues

Having a clear and shared agreement on the SOS-profile is essential for forecasting systems, as these applications are not designed to discover data or figure out by themselves how to query a service. Their purpose is to bring in the data as fast as possible. While FeatureOfInterest and ObservedProperty are rather clear, the use of Offerings and Procedures leaves too much room for mixing one and the other.

Metadata is burdening the performance of xml-encoded WaterML2 messages in high-frequency incremental data exchange. The overhead in a WaterML2 encoded message is 5-10 times the overhead in SHEF and PI-formats. This is reflected both in message size as well as ingest time. The relative overhead shrinks with longer timeseries, but those are not typical within a forecasting context. Reduction of nested data structure complexity is likely to contribute to better performance. It is recognized that both SHEF and PI-xml are highly optimized formats for specific data and uses, and we can expect them to out perform a generalized data format such as WaterML 2.0 and how efficient WaterML 2.0 needs to be for forecasting applications remains an open question. There are a number of options available to assess; profiling WaterML 2.0 in a “simple profile” which limits the amount of metadata transmitted, binary xml encoding such as FastInfoset (FI) and full xml compression using gzip or similar.

NWS and USGS use different identifiers for the same stations. An Identification Mapping service (ID Mapping) would be highly desirable to accommodate the mixed usage of station identifiers from either organization (and others).

## 7.6 Recommendations

### 7.6.1 Services Profile

SWIE-compliant SOS-services need to be clear on the interpretation of the terms 'Offering' and 'Procedure'. Currently too much variation exists between services that use these items.

This issue is dealt with in detail in use case 3.

One of the other issues that arose during the IE was that WaterML2.0 requires GML 3.2, and SOS2.0. At the time of the IE, SOS2.0 was still under development, and the specification was not available for implementation. The IE, therefore, initially used SOS 1.0 for the SWIE. This recommendation is located in 9.3 SWIE SOS hydrology profile.

### 7.6.2 Issues and Recommendations

**R2: Any reduction of metadata transmission will be beneficial for incremental high frequency data exchange.**

**R3: Additional research will be needed to evaluate to assess if binary encodings can overcome some of the poor performance problems from WaterML2 in full xml-encoding.**

## 8 USE CASE 3 – GLOBAL RUNOFF

### 8.1 Contributors

Role	Contributor
SOS Services	KISTERS
SOS Client	KISTERS
Data Provider	GRDC
Data Provider	USGS
Service Provider	USGS

Table 2: Contributors for Use Case 3.

### 8.2 Introduction

The original plan for this use case was to provide calculated monthly and yearly volume discharge estimates from a few large rivers discharging to the oceans. This was an ambitious plan in which processing tasks were to be included as part of a workflow that would totalize the discharge measurement for a selected year and then display aggregated values. Candidate locations for the experiment were to be selected from the Global Runoff Data Center (GRDC) database.

The plan was adjusted during the experiment as a result of the slower than expected progress due to the difficulties with developing services concurrently with the WaterML2.0 development. The original plan for this use case can be seen in Appendix 2.

### 8.3 Motivation and Goals

The goal of the use case was adjusted to two tasks:

- (1) to make data from the GTN-R Station network provided by Global Runoff Data Center available using WaterML2 and SOS and
- (2) to enable the GRDC to ingest data from the USGS (Mississippi Area) using WaterML2 and SOS.

### 8.4 Design and Implementation

The implementation was based on establishing an instance of the KISTERS WISKI/KiTSM to provide the underlying data repository for the GRDC data. This was setup by KISTERS within the KISTERS DMZ for the purpose of the experiment.

The GRDC data was migrated into this data management system but required some modification to support delivery by WaterML2.0. The data was extended to include gauge name, WMO gauge identifier, country the gauge is in, time zone information and spatial references as well as the WMO catchment name and associated size.

On top of the WISKI/KiTSM system the KISTERS Interoperability Solution KiWIS provided the support for SOS/WaterML2.0 (<http://kiwis.kisters.de>).

The WISKI Desktop application was also extended to consume metadata and time series data through new SOS consumer classes. For this use case, a dedicated consumer class has been developed to ingest data from the USGS NWIS Services which can be found at <http://nwisvaws02.er.usgs.gov/ogc-swie/>.

The diagram below shows the architecture of the system for use case 3.

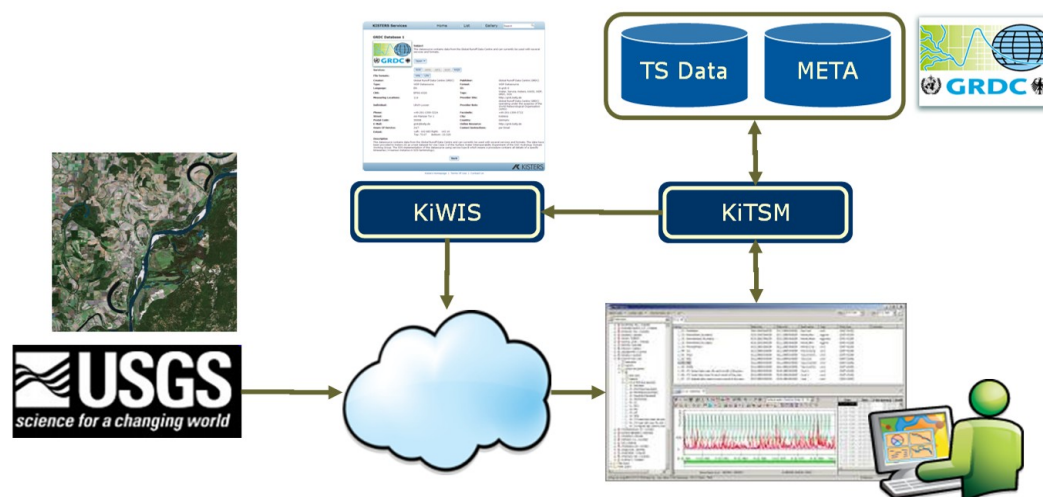


Figure 2: Architecture of the system for use case 3

## 8.5 USGS SOS Services

The experimental WaterML 2.0 service created by the United States Geological Survey (USGS) provided runoff data from the Mississippi to GRDC. USGS had an additional goal to evaluate how feasible it would be to serve hydrological time series data from the entire United States using WaterML 2.0.

This service was built to deliver WaterML 2.0 using initially SOS1.0 as required by SWIE. It was able to offer a GetCapabilities, DescribeSensor, GetDataAvailability, and GetObservation output for all of the real-time water data that is available in the USGS National Water Information System (NWIS), as well as historic daily data. Discharge, gage height, temperature, precipitation, dissolved oxygen, turbidity, and pH were the properties that were specifically tested, although all properties are available using a 5-digit parameter code. A very elementary WebFeatureService (wfs) was also provided. GetObservation data using WaterML 2.0 was the main output being investigated. The service is available here: <http://nwisvaws02.er.usgs.gov/ogc-swie/>. It will continue to evolve with the changing WaterML 2.0 requirements.

## 8.6 USGS SOS Service Results

During the Surface Water Interoperability Experiment (SWIE), the experiences of creating and using this service contributed to a number of changes made in the

WaterML 2.0 requirements. For example, there were several fields in the WaterML 2.0 specification document that had very limited output options. These were typically not appropriate for USGS needs (there are certain qualifiers and phrases that must be included in USGS data by law).

Another outcome of the creating the test service was to analyze how WaterML 2.0 could handle non-standard cases. Multiple sensors at a single location, variable depths, and unique conditions (ice, adjusted values, etc.) were found and discussed within the WaterML 2.0 standards working group.

An additional important aspect of the USGS service was dealing with huge amounts of data. Aside from simply serving WaterML2 time series data, we attempted to provide a complete SOS 2.0 service. A requirement for SOS 2.0 is a complete GetCapabilities document. This document should theoretically give information about all of the possible offerings of the service. Since the USGS service covers the entire United States, there was no way to include all of that information. We followed the general guidelines developed by Kisters using their SOS Type C implementation described above. Using the Type C implementation made it possible to provide a complete SOS service, but we still found the data discovery to be lacking. Eventually we implemented a SOS 2.0 optional extension called GetDataAvailability. This was a very useful and powerful extension. A user can request information on featureID's, properties, offerings, and time periods. For example, a user could ask what featureID's have certain unique properties and/or offerings during a specific time period. Another example might be what properties are measured at a certain featureID and over what time period.

## 9 RESULTS AND OUTSTANDING ISSUES

The IE has contributed to the goal of further advancing WaterML2.0, which was the primary objective. The project teams have worked closely with the WaterML2.0 design team relating experiences that could be included into the design considerations. As indicated earlier, this has been both advantageous – being able to quickly react to issues as they arose, but also a hindrance, as the services relied on having a relatively fixed standard to work with.

### 9.1 SOS Version

As SOS 2.0 is still under development a decision was made to use SOS 1.0 which specifies the use of GML3.1.1, despite WaterML2.0 requiring GML3.2. This was reported on in 7.6.1.

The USGS was able to build a prototype SOS2.0 service during the experiment, and some experience with WaterML2.0 and SOS2.0 was obtained.

Further investigation is needed on the compatibility of the SOS1.0 and SOS2.0 implementations.

### 9.2 SOS Usage

The SOS 1 specification requires that the list of features-of-interest be explicitly serialized in the [GetCapabilities](#) document. This list is either used for discovery (harvesting by catalog) or to provide a valid list of feature identifiers to be used in GetObservation (the feature-of-interest id being one of the parameters of this operation).

The SOS 2 draft specification includes a relatedFeature property for the observation (no more information is provided, beside the property cardinality in Table 17 of OGC 10-037), which seems to play a slightly more restricted role.

The Capabilities document of SOS 2.0 lists related features instead of all features-of-interest. The related features are selected by the service provider and serve discovery purposes.

In the current WaterML2.0 model, it has been decided that the feature-of-interest should be constrained to a WaterML2.0 sampling feature and some systems can contain large quantities of features-of-interest, so it is impractical for performance reasons to serialize them individually.

Nonetheless, the service is still required to publish a collection of feature-of-interest that can be used in GetObservation requests to extract observations related to a specific feature-of-interest.

#### 9.2.1 Proposed Solution

We propose that the profile element SOS2.0 be formally part of the SOS specification. The capabilities document should be allowed to provide a composite feature as feature-of-interest. The composite feature shall be a gml:FeatureCollection nesting other

`gml:FeatureCollections`. The collection would be composed of a list of sub-collections. If the sub-collection contains a reasonable amount of features-of-interest, the list would be serialized explicitly; otherwise the composite feature is serialized. The nesting logic within collections is up to the server. It can follow a purely geometric partitioning (e.g. quad-tree) or follow an administrative structure (state/county/city/zip).

### 9.3 SWIESOS Hydrology Profile

#### 9.3.1 Overview

Experience with the existing SOS services shows that there is a range of ways to understand the generic SOS terminology. In different domain implementation areas the SOS standards have been interpreted differently and this has led to different implementations. These different SOS implementations cause ambiguous client/server interactions that are syntactically correct but create a semantically incorrect request/response patterns.

To ensure consistent interpretation a common process of development or “alignment” is required typical of which you will find in an OGC IE.

This is because SOS (and many other OGC standards) is an abstract specification designed to support a broad range of use cases ranging from fixed in-situ sensors to tracking applications or even complex remote sensing systems. Thus, flexibility is absolutely necessary to accomplish this. It is therefore up to the application domain to specialise the abstract standards suitable for implementation.

In this chapter we therefore propose a specialisation of SOS usage (with respect to the WaterML2 proposal) – a profile for use in the IE. It should be seen as a “SOS Usage Profile for the Hydrology Domain” to which data providers and data consumer in the hydrological world can agree and comply with their software systems. This is necessary because just “SOS compliance” will not ensure that the client knows how the specific server understands the main SOS terms (“procedure”, “observed property”, “feature of interest”, “offering”).

It is worth noting that this profile has been developed using SOS 1.0 and will possibly need to be extended or adjusted for use by SOS 2.0.

#### 9.3.2 Definitions

General definitions as taken from the SOS 1.0 and O&M 1.0 specification documents:

##### **Observation Offering:**

An observation offering is a logical grouping of observations offered by a service that are related in some way. The parameters that constrain the offering should be

defined in such a way that the offering is 'dense' in the sense that requests for observations that are within the specified parameters should be unlikely to result in an empty set.

**Procedure:**

Method, algorithm or instrument. (O&M: ...which is often an instrument or sensor but may be a process chain, human observer, an algorithm, a computation or simulator.)

**ObservedProperty:**

The observedProperty identifies or describes the phenomenon for which the observation result provides an estimate of its value. It must be a property associated with the type of the feature of interest.

**FeatureOfInterest:**

The featureOfInterest is a feature of any type (ISO 19109, ISO 19101), which is a representation of the observation target, being the real-world object regarding which the observation is made.

### 9.3.3 Analysis

This section contains the analysis of different SOS types that have been implemented in different domains. The objective is to try and assess which type is better suited to the needs of the hydrology domain.

#### 1. SOS Server Type A (procedure == sensor-type)

A SOS service which serves more than raw data or medium/larger networks should use the following structure for the getCapabilities response – A procedure is seen as a sensor-type (==time-series type) and NOT as a sensor instance (==time-series instance). This structure should be homogeneously used and not be used with other encodings.

**Example:**

<http://kiwis.kisters.de/KiWIS/KiWIS?service=SOS&request=getCapabilities&datasource=0>

#### 2. SOS Server Type B (procedure == sensor-instance)

A SOS service which is a bit more as originally intended by SOS specification should use the following structure for the getCapabilities response - A procedure is seen as a sensor-instance (==complete identification of a single timeseries) . This structure encodes a path into the procedure field but allows inconsistent requests with features and properties.

**Example:**

<http://kiwis.kisters.de/KiWIS/KiWIS?service=SOS&request=getCapabilities&datasource=1>



### 3. SOS Server Type C (procedure==sensor-type/system)

A SOS as intended by the GroundWater IE should use the following structure for the getCapabilities response - A procedure is seen as a sensor-type or system. This structure requires additional requests or knowledge to “drill” into the data if you want to do it by sensor instance. Also refer to:

[http://external.opengis.org/twiki\\_public/bin/view/HydrologyDWG/GwIeGetCapabilitiesBestPractices](http://external.opengis.org/twiki_public/bin/view/HydrologyDWG/GwIeGetCapabilitiesBestPractices),

[http://external.opengis.org/twiki\\_public/bin/view/HydrologyDWG/SOSLargeCollectionSensorDiscussion](http://external.opengis.org/twiki_public/bin/view/HydrologyDWG/SOSLargeCollectionSensorDiscussion))

**Example:**

<http://kiwis.kisters.de/KiWIS/KiWIS?service=SOS&request=getCapabilities&datasource=2>

### 4. SOS Server Type D “MIXED” (procedure==sensor-instance AND derived timeseries type)

In addition to all types above there is also the option to use everything together in a “MIXED” way. A procedure is seen as a sensor-instance or a derived timeseries type. In this way actual sensor timeseries and derived timeseries can be distinguished. There is one procedure, one relatedFeature and one observedProperty per offering as long as there are different properties. This is a clear language but it results in very large getCapabilities documents.

Also refer to:

[https://wiki.csiro.au/confluence/display/WaterML20/Adapting+to+SOS+\(2.0\)](https://wiki.csiro.au/confluence/display/WaterML20/Adapting+to+SOS+(2.0))

With reference to tables in Appendix 1, which describe the size of a GetCapabilities document for the different implementation options, we find that the document size consists of:

- A couple of lines for the ServiceIdentification / ServiceProvider sections
- Variable lines depending on the amount of FOI
- Variable lines for Procedure
- A rough estimate of 55-75 Bytes per line

It was found that, depending on the SOS service type, the size is document size grows exponentially. At the HydroDWG workshop on Sept, 21<sup>st</sup> 2010, at the Toulouse TC, it was sensibly decided that the GetCapabilities document for the IE should be a quick handshake document and not a full listing of database content (that just excludes the time-series values and some metadata from the full description).

The consequence of this was that only the network itself was advertised, with the clients then required to further query the SOS with `GetFeatureOfInterest` calls with a filter query specification to return the sampling points of interest. This approach is practical but semantically inconsistent as the feature of interest changes from the network in `GetCapabilities` to `SamplingPoints` in the `GetFeatureOfInterest`.

### 9.3.4 Recommendation

Based on discussions held as part of the IE and the above analysis there are several problems that have to be addressed to achieve interoperability. The biggest discrepancy lies with the interpretation of the normative definitions of O&M (for example, what is the `featureOfInterest`)

Most database and timeseries management system architectures require a unique identification of timeseries, which in SOS must be accomplished by suitable mapping between system definitions of this information items and O&M.

Further issues include that the SOS definition by default allows large bulk requests for data (e.g. complete data of all timeseries for one property) and the usage of the `featureOfInterest` in form of a real world feature like a river does not enable you to request data of a specific station, which requires some constraint of the feature of interest.

Therefore the following set of rules has been agreed on to provide an interoperable SOS profile for the `SurfaceWaterIE`

### 9.3.5 SWIE WaterML 2 Profile

1. SWIE-compliant SOS services shall use the SOS 1.0 specification, even if the resulting Observation collection is GML 3.2.
2. SWIE-compliant SOS services shall use the procedure as sensor or algorithm type like described in Type C, not as instance.
3. SWIE-compliant SOS services shall use the `featureOfInterest` as `samplingFeature` in the sense of a site or station, not as the actual observed object (e.g. a river). This is consistent with WaterML2.0.
4. SWIE-compliant SOS services shall use a global `featureOfInterest` in the `GetCapabilities` document and not list all existing `samplingFeatures`.
5. SWIE-compliant SOS services shall use a mandatory `GetFeatureOfInterest` request to identify actual `samplingFeatures` either by filters or as complete list based on the global `featureOfInterest`.

6. SWIE-compliant SOS services shall use a GetObservation request that either answers the full amount of data requested, or with an appropriate error message if the service provider wants to prevent large bulk requests.
7. SWIE Should use the profile element in SOS2 to announce a SWIE/Type C SOS

## 10 SW IE CLIENT IMPLEMENTATION

### 10.1 DelftFEWS SOS Client – Deltares

#### 10.1.1 Motivation and goals

As a major supplier of forecasting system applications based on its Delft-FEWS software platform, Deltares would like to contribute to a WaterML2 standard that is suitable for hydrologic forecasting. As such the first step is to evaluate the suitability of SOS-services and WaterML2 encodings as a data feed to a forecasting system.

To enable this evaluation, Deltares implemented a SOS client in the Delft-FEWS software platform. The test application was the NCRFC-CHPS (North Central River Forecasting Center's application of the Community Hydrologic Prediction System (CHPS)).

#### 10.1.2 Design and Implementation

Forecasting agencies rely on data feeds they trust. These data feeds change infrequently, data discovery needs are infrequent and often require action by the user (i.e. configuration). Given this context, Delft-FEWS requires the customization of the SOS client to query a specific SOS-service for the observations within a moving time window for a specific set of features of interest, observed property(s) and, if required by the service, offering and procedure. The variability in the usage of offering and procedure by SOS services makes it hard to setup these clients.

After implementation of the SOS client and customization for a data feed from USGS, a set of observations (with 15 minute interval) was retrieved for a 1-day period and a 10-day period. Ingest times were derived. The data sets were exported to local disk in two other file formats for comparison: SHEF.E and PI-xml file format.

#### 10.1.3 Results

Below, three data samples are displayed, all providing 8 observation values with a 15-minute interval for the Escanaba River at Cornell, MI (NWS id CRNM4, USGS id 04059000).

In SHEF, the US - Standard Hydrometeorological Data Exchange Format, it looks like:

```
: Date/time forecast: 20110415
.ER CRNM4 20110413 Z DH06/DC201104161002/STG /DIN15
.E1 405.00/ 403.00/ 403.00/ 404.00/ 405.00/ 404.00/ 404.00/ 403.00/
```

PI-xml, the Deltares FEWS Published Interface encoding looks like:

```
<?xml version="1.0" encoding="UTF-8"?>

<TimeSeries xmlns="http://www.wldelft.nl/fews/PI"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.wldelft.nl/fews/PI
http://fews.wldelft.nl/schemas/version1.0/pi-schemas/pi\_timeseries.xsd"
version="1.2">

  <timeZone>0.0</timeZone>
  <series>
    <header>
      <type>instantaneous</type>
```

```

<locationId>CRNM4</locationId>
<parameterId>STG</parameterId>
<timeStep unit="nonequidistant"/>
<startDate date="2011-04-13" time="06:00:00"/>
<endDate date="2011-04-15" time="06:00:00"/>
<missVal>-999.0</missVal>
<stationName>Cornell</stationName>
<units>M</units>
</header>
<event date="2011-04-13" time="06:00:00" value="405.0" flag="0"/>
<event date="2011-04-13" time="06:15:00" value="403.0" flag="0"/>
<event date="2011-04-13" time="06:30:00" value="403.0" flag="0"/>
<event date="2011-04-13" time="06:45:00" value="404.0" flag="0"/>
<event date="2011-04-13" time="07:00:00" value="405.0" flag="0"/>
<event date="2011-04-13" time="07:15:00" value="404.0" flag="0"/>
<event date="2011-04-13" time="07:30:00" value="404.0" flag="0"/>
<event date="2011-04-13" time="07:45:00" value="403.0" flag="0"/>

```

The associated WaterML2 encoding (same station, discharge instead of stage) looks like:

```

<wml2:TimeseriesObservation xmlns:gml="http://www.opengis.net/gml/3.2"
  xmlns:om="http://www.opengis.net/om/2.0"
  xmlns:sa="http://www.opengis.net/sampling/2.0"
  xmlns:swe="http://www.opengis.net/swe/2.0"
  xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:wml2="http://www.opengis.net/waterml/2.0"
  xmlns:gmd="http://www.isotc211.org/2005/gmd"
  xmlns:gco="http://www.isotc211.org/2005/gco"
  xmlns:sf="http://www.opengis.net/sampling/2.0"
  xmlns:sams="http://www.opengis.net/samplingSpatial/2.0" gml:id="USGS"
  xsi:schemaLocation="http://www.opengis.net/waterml/2.0 ../waterml2.xsd">
  <gml:identifier codeSpace="http://nwis.waterdata.usgs.gov/MI/nwis"
    >USGS.04059000</gml:identifier>
  <gml:name codeSpace="http://nwis.waterdata.usgs.gov/MI/nwis">ESCANABA RIVER AT
  CORNELL,
  MI</gml:name>
  <om:metadata>
  <wml2:ObservationMetadata>
  <gmd:contact xlink:href="http://cida.usgs.gov"/>
  <gmd:dateStamp>
  <gco>Date>2011-04-15</gco>Date>
  </gmd:dateStamp>
  <gmd:identificationInfo xlink:href="urn:OGC:unknown"/>
  <wml2:status
  xlink:href="http://waterdata.usgs.gov/MI/nwis/help/?provisional"/>
  </wml2:ObservationMetadata>
  </om:metadata>
  <om:phenomenonTime>
  <gml:TimePeriod gml:id="ts_period">
  <gml:beginPosition>2011-04-14T00:00:00-05:00</gml:beginPosition>
  <gml:endPosition>2011-04-15T03:45:00-05:00</gml:endPosition>
  </gml:TimePeriod>
  </om:phenomenonTime>
  <om:resultTime>
  <gml:TimeInstant gml:id="result_time">
  <gml:timePosition>2011-04-15T05:30:14</gml:timePosition>
  </gml:TimeInstant>
  </om:resultTime>
  <om:procedure xlink:href="http://www.nemi.gov" xlink:title="Discharge"/>
  <om:observedProperty xlink:href="urn:ogc:def:phenomenon:OGC:Discharge"
  xlink:title="Discharge"/>
  <om:featureOfInterest>
  <wml2:MonitoringPoint gml:id="USGS.WMP.04059000">

```

```

<sf:sampledFeature
  xlink:href="http://nwisvaws02.er.usgs.gov/ogc-
swie/wfs?request=GetFeature&featureId=04059000"/>
  <sf:parameter>
    <om:NamedValue>
      <om:name xlink:title="Watershed"/>
      <om:value>Escanaba</om:value>
    </om:NamedValue>
  </sf:parameter>
  <sams:shape>
    <gml:Point gml:id="USGS.P.04059000">
      <gml:pos srsName="urn:ogc:def:crs:EPSG:4269">45.90857270 -
87.21374820</gml:pos>
    </gml:Point>
  </sams:shape>
  <wml2:descriptionReference
xlink:href="http://external.opengis.org/twiki_public/bin/view/HydrologyDWG/Surface
waterInteroperabilityExperiment#Use_Case_2"
  xlink:title="This wiki page describes the IE"/>
  <wml2:timeZone>
    <wml2:TimeZone>
      <wml2:zoneOffset>-05:00</wml2:zoneOffset>
      <wml2:zoneAbbreviation>EST</wml2:zoneAbbreviation>
    </wml2:TimeZone>
  </wml2:timeZone>
  </wml2:MonitoringPoint>
</om:featureOfInterest>
<om:result>
  <wml2:owner>
    <gmd:organisationName>
      <gmd:CharacterString>Michigan Water Science
Center</gmd:CharacterString>
    </gmd:organisationName>
  </wml2:owner>
  <wml2:Timeseries gml:id="time_series_loc_0">
    <wml2:domainExtent xlink:href="ts_period">
      <gml:TimePeriod gml:id="USGS.TP.04059000">
        <gml:beginPosition>2011-04-14T00:00:00-
05:00</gml:beginPosition>
        <gml:endPosition>2011-04-15T03:45:00-05:00</gml:endPosition>
      </gml:TimePeriod>
    </wml2:domainExtent>
    <wml2:defaultTimeValuePair>
      <wml2:TimeValuePair>
        <wml2:unitOfMeasure uom="cfs"/>
        <wml2:dataType
xlink:href="http://www.opengis.net/def/timeseriesType/WaterML/2.0/Continuous"
  xlink:title="Continuous/Instantaneous"/>
        <wml2:qualifier
xlink:href="http://waterdata.usgs.gov/MI/nwis/help/?provisional"
  xlink:title="Provisional data subject to revision."/>
      </wml2:TimeValuePair>
    </wml2:defaultTimeValuePair>
    <wml2:Point>
      <wml2:TimeValuePair>
        <wml2:time>2011-04-15T03:45:00-05:00</wml2:time>
        <wml2:value>2860</wml2:value>
      </wml2:TimeValuePair>
    </wml2:Point>
    <wml2:Point>
      <wml2:TimeValuePair>
        <wml2:time>2011-04-15T03:30:00-05:00</wml2:time>
        <wml2:value>2860</wml2:value>
      </wml2:TimeValuePair>
    </wml2:Point>
    <wml2:Point>
      <wml2:TimeValuePair>
        <wml2:time>2011-04-15T03:15:00-05:00</wml2:time>
        <wml2:value>2860</wml2:value>
      </wml2:TimeValuePair>
    </wml2:Point>
    <wml2:Point>
      <wml2:TimeValuePair>

```

```
<wml2:time>2011-04-15T03:00:00-05:00</wml2:time>
  <wml2:value>2860</wml2:value>
</wml2:TimeValuePair>
</wml2:Point>
<wml2:Point>
  <wml2:TimeValuePair>
    <wml2:time>2011-04-15T02:45:00-05:00</wml2:time>
    <wml2:value>2890</wml2:value>
  </wml2:TimeValuePair>
</wml2:Point>
<wml2:Point>
  <wml2:TimeValuePair>
    <wml2:time>2011-04-15T02:30:00-05:00</wml2:time>
    <wml2:value>2890</wml2:value>
  </wml2:TimeValuePair>
</wml2:Point>
<wml2:Point>
  <wml2:TimeValuePair>
    <wml2:time>2011-04-15T02:15:00-05:00</wml2:time>
    <wml2:value>2890</wml2:value>
  </wml2:TimeValuePair>
</wml2:Point>
<wml2:Point>
  <wml2:TimeValuePair>
    <wml2:time>2011-04-15T02:00:00-05:00</wml2:time>
    <wml2:value>2920</wml2:value>
  </wml2:TimeValuePair>
</wml2:Point>
```

### File size (compressed/uncompressed)

In terms of file size, it is clear that SHEF (not an xml-based format) is tiny compared to PI-xml and WaterML2. PI xml is about half the size of a WaterML2 encoding, but the difference becomes less when compressed using a normal zip-algorithm. WaterML2 compresses significantly, its compressed file is not much larger than the zipped PI-xml file.

### Ingest time.

The average ingest time of the WaterML2 encoded messages for a 1-day period with 15 minute interval data, was a factor 3 slower than the same dataset in SHEF and a factor 6 slower than the PI-xml encoding. The average ingest time per value reduces with larger timeseries, but the reduction for the PI-xml and SHEF encoded formats is higher than the reduction for WaterML2.

### Issues

The above results are from limited experiments only. Due to the ongoing evolvement of WaterML2 and the USGS-SOS service, the SOS client was often broken, hindering the ability to conduct more experiment

## 11 ACKNOWLEDGEMENTS

The SWIE is grateful for the invaluable guidance provided by the OGC, and for the commitment and dedication of SWIE participants.



**APPENDIX 1 - GETCAPABILITIES DOCUMENT SIZE**

This appendix contains the table of getCapabilities file size with increasing numbers of sampling points and phenomena

Stations/ Sites/ FOI	TS per Station	Lines per Proc	Lines per FOI	Lines per ObsProp	Lines	File size (kB)
0 (Info only)	0	0	0	0	100	4
1	20	3	2	2	164	7
10	20	3	2	2	182	9
100	20	3	2	2	362	20
1,000	20	3	2	2	2,162	134
10,000	20	3	2	2	20,162	1,277
50,000	20	3	2	2	100,162	6,355
100,000	20	3	2	2	200,162	12,703
500,000	20	3	2	2	1,000,162	63,484
1,000,000	20	3	2	2	2,000,162	126,960

**Table 3: GetCapabilities filesize for SOS A – procedure is sensor type**

Stations/ Sites/ FOI	TS per Station	Lines per Proc	Lines per FOI	Lines per ObsProp	Lines	File size (kB)
0 (Info only)	0	0	0	0	100	4
1	20	3	2	2	164	9
10	20	3	2	2	722	49
100	20	3	2	2	6,302	456
1,000	20	3	2	2	62,102	4,526
10,000	20	3	2	2	620,102	45,219
50,000	20	3	2	2	3,100,102	226,078
100,000	20	3	2	2	6,200,102	452,153
500,000	20	3	2	2	31,000,102	2,260,746
1,000,000	20	3	2	2	62,000,102	4,521,488

**Table 4: GetCapabilities filesize for SOS B – procedure is sensor instance**

Stations/ Sites/ FOI	TS per Station	Lines per Proc	Lines per FOI	Lines per ObsProp	Lines	File size (kB)
0 (Info only)	0	0	0	0	100	4
1	20	3	2	2	107	4
10	20	3	2	2	107	4
100	20	3	2	2	107	4
1,000	20	3	2	2	107	4
10,000	20	3	2	2	107	4
50,000	20	3	2	2	107	4
100,000	20	3	2	2	107	4
500,000	20	3	2	2	107	4

1,000,000	20	3	2	2	107	4
-----------	----	---	---	---	-----	---

Table 5: GetCapabilities filesize for SOS C – procedure is sensor network

## APPENDIX 2 - ACTIVITY PLAN USE CASES

1. Cross Border Data Exchange Use Case: The user will discover surface water data from cross border or other regions via web map client and then visualize the time-series via web sparklines or charts. Once the data has been inspected and the user is satisfied that the data is of interest, the user will download the data in an appropriate format.
2. Forecasting Use Case: The user will discover and download data suitable for a streamflow forecast. The user will be able to feed a streamflow forecast model with this data, but the modeling itself is not part of the scope of this IE.
3. Global Runoff Use Case: The goal for this use case is to provide automated monthly and yearly volume calculations from large rivers discharging to the oceans. Candidate locations for the experiment are from the Global Runoff Data Center (GRDC) database. A website is developed from which users can view station locations participating in the experiment. The locations are found by interrogating a federated catalog of stream gages (gage has phenomena discharge for the time period of interest). Once the map is displayed, users can identify a gage of interest and some basic information is displayed in a popup, the watershed (catchment) is delineated and displayed. The user is presented with two buttons and a start and end date form. The user enters a start and end date and chooses either (1) Monthly volumes or (2) Yearly volumes. Once a button is pressed, the client application requests the daily or instantaneous discharge values (in various units) and the website displays a timeseries of monthly or yearly calculated volumes in both m<sup>3</sup> and cubic feet. The timeseries is displayed in a table and in a graph with the graph showing gaging station information including name, id and basin size.

The initial set of stations might include the Rhine and the Mississippi Rivers.