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CUAHSI WATERML 1.0

Specification

Part 1: Introduction to WaterML Schema

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by:

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Distribution

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Scope

Water Markup Language (WaterML) specification defines an information exchange schema, which has been used in water data services within the Hydrologic Information System (HIS) project supported by the U.S. National Science Foundation, and has been adopted by several federal agencies as a format for serving hydrologic data. The goal of the first version of WaterML was to encode the semantics of hydrologic observation discovery and retrieval and implement water data services in a way that is both generic and unambiguous across different data providers, thus creating the least barriers for adoption by the hydrologic research community. This documents WaterML version 1.0 as implemented and utilized in the CUAHSI HIS system. Data sources that can be queried via WaterML-compliant water data services include many national and international repositories of water data, and a growing number of academic observation networks registered by researchers associated with the hydrologic observatories.

[VALIDATE THIS PARAGRAPH AFTER DOCUMENT COMPLETED] The WaterML 1.0 specification consists of SUSPENSE parts. The first part (this document) is a high-level description of WaterML scope, rationale, context and design drivers, main trade-offs in WaterML development, the evolution of WaterML, and the core WaterML constructs. A second part is a detailed technical description of WaterML 1.1 schema.

.A second group of documents describes WaterML version 1.1, as it evolves to reflect the deployment experience at hydrologic observatory testbeds around the U.S., and U.S. federal and state agency practices of serving observational data on the web

Support and questions

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Revision history

Date	Release	Author	Paragraph modified	Description
2007-03-20	0.1.1	Ilya Zaslavsky, David Valentine, Tim Whiteaker	Baseline version	Specification of WaterML 1.0 as implemented in WaterOneFlow 1.0 web services
2009-06-12	2009-06	Valentine	Various	Reworked document into CUAHIS template with goal to be a specification of WaterML 1.0 as in use. Removed Relax-XML specifications and replaced with graphics. Updated XML examples.
			V	

XML conventions

To describe the parts of an XML file in text, this document uses the following conventions:

- Element names are enclosed in brackets, e.g. <element>
- Attributes are prefixed with the @ symbol, e.g. @attribute
- Element text (text content of an element) is enclosed in quotes, e.g. "element text"

The following example XML illustrates these conventions. The example shows a <siteCode> element, with a @network and siteID attributes, and a text value of "010324500".

```
<siteCode network="NWIS" siteID="4622895">010324500</siteCode>
```


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INTRODUCTION

Beginning in 2005, the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI), as part of its Hydrologic Information System (HIS) project, implemented a variety of web services providing access to large repositories of hydrologic observation data, including the USGS National Water Information System (NWIS), and the US Environmental Protection Agency's STORET (Storage and Retrieval) database of water quality information. The services provide access to station and variable metadata, and observations data stored at these sites. As these services were without any formal coordination, their inputs and outputs were different across data sources. Linking together services developed separately in an ad hoc manner does not scale well. As the number and heterogeneity of data streams to be integrated in CUAHSI's hydrologic data access system increased, it would become more and more difficult to develop and maintain a growing set of client applications programmed against the different signatures and keep track of data and metadata semantics of different sources. As a result, WaterML was developed to provide a systematic way to access water information from point observation sites.

In parallel, CUAHSI was also developing an information model for hydrologic observations that is called the Observations Data Model (ODM). Its purpose is to represent observation data in a generic structure that accommodates different source schemas.

While based on the preliminary set of CUAHSI web services, WaterML was further refined through standardization of terminology between WaterML and ODM, and through analysis of access syntax used by different observation data repositories, including USGS NWIS, EPA STORET, NCDC ASOS, Daymet, MODIS, NAM12K, etc. WaterML and ODM, at present, are not identical. WaterML includes detailed information that is not incorporated in ODM, for example source information. Designed to be maximally uniform across both field observation sources and observations made at points, and interoperate with observation data formats common in neighbouring disciplines, it accommodates a variety of spatial types and time representations. WaterML incorporates structures that support on-the-fly translation of spatial and temporal characteristics, and includes structures for SOAP messaging.

WATERML CORE CONCEPTS AND IMPLEMENTATION CONTEXT

The CUAHSI Water Markup Language (WaterML) is an XML schema defining the elements that are designed for WaterOneFlow messaging, in support of the transfer of water data between a server and a client. WaterML generally follows the information model of ODM (Observation Data Model) described at <http://www.cuahsi.org/his/odm.html>. WaterML generally shares terminology with ODM, while providing additional terms to further document aspects of both the data retrieved and the retrieval process itself. The WaterML schema is defined at

<http://water.sdsc.edu/waterOneFlow/documentation/schema/cuahsiTimeSeries.xsd>

The goal of the first version of WaterML was to encode the semantics of hydrologic observations discovery and retrieval and implement WaterOneFlow services in a way that creates the least barriers for adoption by the hydrologic research community. In particular, this implied maintaining a single common representation for the key constructs returned on web service calls. Conformance with OGC specifications was not the goal of this initial version. Hence, throughout this document we accompany WaterML description with notes on possible harmonization of WaterML with the specifications listed below in section 3.

While addressing both point observation and coverage sources, WaterOneFlow web services are primarily built around a Point Observation Information Model illustrated below. This model is further described in Clause 6 of this document.

According to the model, a Data Source operates one or more observation networks; a Network is a set of observation sites; a Site is a point location where water measurements are made; a Variable describes one of the types of measurements; and a time series of Values contains the measured data, wherein each value is characterized by its time of measurement and possibly by a qualifier which supplies additional information about the data, such as a < symbol for interpreting water quality measurements below a detection limit. The WaterOneFlow services GetNetworkInfo, GetSiteInfo and GetVariableInfo describe the networks, sites and variables individually, and the service GetValues is the one that actually goes to the data source and retrieves the observed data.

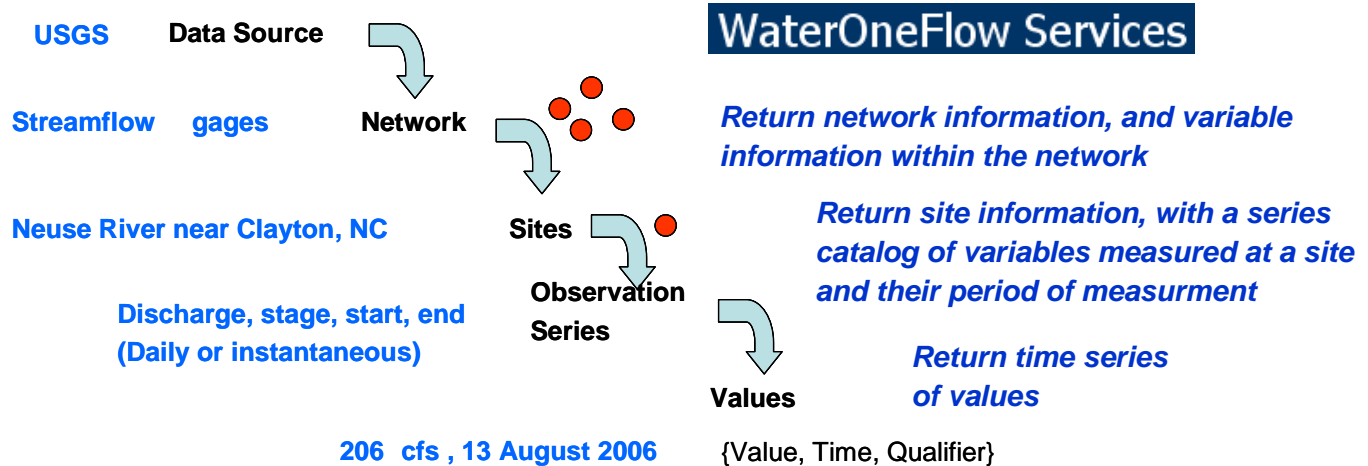


Figure 1. CUAHSI Point Observation Information Model.

CORE CONCEPTS

SPACE, TIME, VARIABLE

An *observation* is considered an act of assigning a number, term or other symbol to a phenomenon; the number, term or symbol is the *result* of the action. For the purposes of this document, the terms *observation* and *measurement* are essentially equivalent, the only difference being that a measurement has a quantitative result, while an observation is generic (see OGC® 05-087r4 “Observations and Measurements”). Hydrologic observations are performed against many different phenomena (*properties* of different *features of interest*), and are related to specific times (time points or time intervals).

The *features of interest* common in hydrologic observations may include points (gauging stations, test sites), linear features (streams, river channels), or polygon features (catchments, watersheds). Spatial properties of the features of interest may be further expressed in 2D or 3D, in particular via vertical offsets against common reference features. The observations are made in a particular *medium* (water, air, sediments) using a *procedure*. The procedure may represent a multi-step processing chain including an instrument (sensor), algorithms for transforming the initially measured property (e.g. “partial pressure of oxygen in the water” may be transformed into a measure of “dissolved oxygen concentration”), and various techniques for aggregating, averaging, interpolating and extrapolating censoring and quality-controlling of the value assignment, including multiple scenarios for assignment of no value. As in OGC® 05-087r4, one of the key ideas is that “the observation *result* is an estimate of the value of some property of the feature of interest, and the other observation properties provide context or metadata to support evaluation, interpretation and use of the result.”.

The practice of hydrologic observations provides ample evidence of complications beyond this concept. These complications are related to huge, complex and incompatible vocabularies used by several federal hydrologic observation systems, to different and not always documented contexts of measurement and value assignment, to often ambiguously defined features of interest, to complex organizational contexts of hydrologic measurement, transformation and aggregation, etc. Some of them are reviewed in the Annex B (Informative). It is in response to this complexity that the CUAHSI WaterML is primarily designed. Note that some of this complexity may be captured within the Sensor Web standards being developed under the OGC’s Sensor Web Enablement (SWE) activity. However, the flexibility inherent in such standards may itself be a barrier to adoption when the target audience is not computer scientists.

At the fundamental level hydrologic observations are identified by the following characteristics:

- The location at which the observations are made (*space*);
- The variable that is observed, such as streamflow, water surface elevation, water quality concentration (*variable*);
- The date and time at which the observations are made (*time*).

Accordingly, elements in WaterML cover those three characteristics, using *sites* and *datasets* to model spatial characteristics, using *variables* to express the variable characteristic; and describing observation *values* via lists of datetime-value pairs representing the temporal dimension of observations.

One of the foundations from which WaterML derives its information model is the CUAHSI Observations Data Model (ODM), as described in the current ODM documentation available at

(<http://his.cuahsi.org/odmdatabases.html>). Within this model, the following represent properties of an observation (Table 1).

Table 1. Observation properties in ODM

Property	Definition
Value	The observation value itself
Accuracy	Quantification of the measurement accuracy associated with the observation value
Date and Time	The date and time of the observation (including time zone offset relative to UTC and daylight savings time factor)
Variable Name	The name of the physical, chemical, or biological quantity that the value represents (e.g. streamflow, precipitation, water quality)
Location	The location at which the observation was made (e.g. latitude and longitude)
Units	The units (e.g. m or m ³ /s) and unit type (e.g. length or volume/time) associated with the variable
Interval	The interval over which each observation was collected or implicitly averaged by the measurement method and whether the observations are regularly recorded on that interval
Offset	Distance from a reference point to the location at which the observation was made (e.g. 5 meters below water surface)
Offset Type/ Reference Point	The reference point from which the offset to the measurement location was measured (e.g. water surface, stream bank, snow surface)
Data Type	An indication of the kind of quantity being measured (currently: instantaneous, continuous, cumulative, incremental, average, maximum, minimum, categorical, constant over interval)
Organization	The organization or entity providing the measurement
Censoring	An indication of whether the observation is censored or not
Data Qualifying Comments	Comments accompanying the data that can affect the way the data is used or interpreted (e.g. holding time exceeded, sample contaminated, provisional data subject to change, etc.)
Analysis Procedure	An indication of what method was used to collect the observation (e.g. dissolved oxygen by field probe or dissolved oxygen by Winkler Titration) including quality control and assurance that it has been subject to
Source	Information on the original source of the observation (e.g. from a specific instrument or investigator 3 rd party database)
Sample Medium	The medium in which the sample was collected (e.g. water, air, sediment, etc.)

Value Category	An indication of whether the value represents an actual measurement, a calculated value, or is the result of a model simulation
----------------	---

Note that WaterML is broader in scope than ODM. ODM is defined over observations made at, or aggregated for, point locations referenced as *sites*, while WaterML is extended to incorporate other spatial feature types.

OBSERVATION NETWORK, OBSERVATION SERIES

Individual observations are organized into an *observation series* (a regular sequences of observations of a specific variable made at a specific site), which are in turn referenced in a *series catalog*. The SeriesCatalog table or view in ODM lists each unique site, variable, source, method and quality control level combination found in ODM's Values table, and identifies each by a unique series identifier, SeriesID. A *series catalog* is an element of an *observation network*, which represents a collection of sites where a particular set of variables is measured. A responsible *organization* can maintain one or more *observation networks*.

In addition to point measurements described in the ODM specification, hydrologic information may be available as observations or model outcomes aggregated over user-defined regions or grid cells. While USGS NWIS and EPA STORET exemplify the former case, sources such as MODIS and Daymet are examples of the latter. In this latter case, as in the case of other remote sensing products or model-generated grids, the observation or model-generated data are treated as *coverages*, and sources of such data are referenced in WaterML as *datasets*, as opposed to *sites*. In other words, WaterML's *dataset* element refers to a type of observations data *source* that is queried by specifying a rectangular region of interest, and the returned time series typically represent some aggregation over the region of interest.

CORE CONCEPT SUMMARY:

Hydrologic observations are identified by the following fundamental characteristics:

- The location at which the observations were made (space)
- The date and time at which the observations were made (time)
- The type of variable that was observed, such as streamflow, water surface elevation, water quality concentration, etc. (variable)

Elements in WaterML covers three characteristics in a similar fashion:

- sites and datasets cover the spatial characteristic
- values, which are lists of dateTime-value pairs, cover the time characteristic
- variables

WaterML is about conveying the message between clients and servers. The messages are simplified and generic. The message may not include the full details that a data source has about the instruments used, or even specific details that might be included, such as a Hydrologic Unit Code (HUC), or a responsible party.

XML SCHEMA NOTES

TYPES IN WATERML

WaterML makes extensive use of *polymorphic typing* to support schema flexibility [BUTEK]. As an example, consider that the time series for a given variable is associated with a location in space. If the variable is measured at a stream gage, then the location can be defined by a point in space. However, the variable may also represent the average of an observed phenomenon over a given area, in which case the location may be defined by a collection (aggregation) zone or a box. To allow for both of these representations of space, the initial version of WaterML specifies that spatial location must be described by a generic `<GeogLocationType>`. This element has only one property, `@srs`, which indicates the spatial reference system to which the coordinates for the location apply. Thus, the element does not include a means of storing the actual coordinates themselves; the coordinate information is included in elements that extend the initial `<GeogLocationType>`.

The key to using XML polymorphism is to create additional elements which extend those types. In WaterML, the `<LatLonPointType>` extends the `<GeogLocationType>` to include child elements providing the latitude and longitude for a point. Because `<LatLonPointType>` extends `<GeogLocationType>`, it must also include the `@srs` attribute. However, `<LatLonPointType>` is free to add its own child elements and attributes, which it does to include `<latitude>` and `<longitude>` child elements.

Similarly, the first version of WaterML defines a `<LatLonBoxType>`, which extends `<GeogLocationType>` by adding four child elements defining the four sides of a bounding box for an area. Thus, by specifying that a location must be defined by a `<GeogLocationType>`, what WaterML is really saying is that *location* may be defined by a `<LatLonBoxType>` or `<LatLonPointType>`. If other means of defining spatial location were to be added to WaterML, the schema and applications built off of the schema would not be broken, so long as the new elements extended the `<GeogLocationType>` element.

Note that the XML type elements themselves are not returned in a WaterML document. The XML types are like blueprints, and what is actually returned are the objects created from the blueprints. For example, to specify the location of an observation site, the WaterML document returned from a

WaterOneFlow web service uses a <geogLocation> element, which is an instance of the <LatLonPointType>. The example XML below shows a <geogLocation> element, which has an @srs attribute from <GeogLocationType>, and <latitude> and <longitude> from <LatLonPointType>. Also notice that it has an @xsi:type attribute that specifies the type of element that <geogLocation> is.

```
<geogLocation xsi:type="LatLonPointType" srs="EPSG:4269">
  <latitude>30.24</latitude>
  <longitude>-97.69</longitude>
</geogLocation>
```

To help distinguish between XML types (which are abstract) and elements which are instances of those types, XML type names begin with an uppercase letter (e.g. <LatLonPointType>) while instances of those types begin with a lowercase letter (e.g. <geogLocation>).

Note: Location descriptions adopted in the initial version of WaterML do not follow OGC's GML specification. However, many WaterML constructs can be aligned with OGC specifications, as described below in Clause 7.

THE BASIC CONTENT, AND EXTENSIBILITY

WaterML is primarily designed for relaying fundamental hydrologic time series data and metadata between clients and servers, and to be generic across different data providers. Different implementations of WaterOneFlow services may add supplemental information to the content of messages. However, regardless of whether or not a given WaterML document includes supplemental information, the client shall be sure that the portion of WaterML pertaining to space, time, and variables will be consistent across any data source.

XML Schema is inherently extendable by allowing users to add additional elements in their own namespaces. Creating mixed-content composite documents is convenient in exchanging multi-domain information. However, adding namespaces can be problematic for clients that may not be designed to handle unanticipated information. Schema developers who extend an existing schema must have clear expectations for how a client application should respond to content from unknown namespaces. WaterML attempts to restrict extensions to clearly defined extensibility points. In some cases, a given source of hydrologic observations data may include additional information, such as the instrument used, the Hydrologic Unit Code (HUC), or the responsible party. The use of these elements is up to the organization maintaining the web service which is making use of WaterML. Advanced clients or customized clients will be able to make use of the supplemental information blocks. All clients shall be able to gracefully handle such information blocks..

ELEMENT NAMING CONVENTIONS IN WATERML

WaterML terminology has been synchronized, to the maximum possible extent, with the CUAHSI Observations Database Model. Following this model, the adopted naming convention scheme is as follows:

- xxID - internal to application codes that uniquely identify a term/site/unit. These are optional, and are assigned by the database or web service creator.
- xxCode - Alphanumeric. These are the codes that are used to retrieve the sites/variables from the data source, and generally match up with public identifiers for sites/variables within a given network.

- xxType - an element block that is used as a type definition. These are used in the development of the XML schema to differentiate object types, and elements that are reused.

Standards used in the element descriptions:

- Element names have the first letter lower-cased;
- XML parent-type have the first letter upper-cased;
- Extension elements can contain any XML content, and are the location where data providers should place any supplemental information, beyond the basic WaterML content

Some confusion may occur when dealing with the term “Type.” Type is used in multiple ways. The first is when referring to an XML information structure that is inherited. These have the first letter capitalized and are suffixed with Type; eg VariableInfoType , UnitsType. Second is when referring to an element name that is often an enumerated reference. These have the first letter lower case, and are suffixed with Type: valueType, unitsType

SECTIONS

There are two sections to this document. The first is an introduction and overview. The second section is the detailed element. The element description is broken into two parts, the Hydrologic Content, and the Computer Content..

WATERML ELEMENT DESCRIPTIONS

WaterML is a schema which defines web service messages used by the CUAHSI hydrologic community. The terminology has been synchronized with the CUAHSI Observations Database Model (Tarboton, et al). Standards used in the element descriptions:

- Enclosed in brackets <element>
- Prefixed with @attribute
- Element names have the first letter lower-cased
- XML complex types have the first letter upper-cased.
- extension elements can contain any XML content, and are the location where data providers should place any additional information.

Some confusion may occur when dealing with the term “Type” Type is used in multiple ways. The first is when referring to an XML information structure that is inherited. These have the first letter capitalized and are suffixed with Type; eg VariableInfoType , UnitsType. Second is when referring to an element name that is defined by the Observations data model (an enumerated reference). Elements that are defined by the ODM have the first letter lower case, and are suffixed with Type: valueType, unitsType

NAMESPACE

The namespace should be: <http://www.cuahsi.org/waterML/1.0/>

HYDROLOGIC SEMANTICS

The following pages describe an hydrologic XML schema that attempts to synchronize with the CUAHSI Observations Data Model. It includes the characteristics of space (<siteInfo>, and multiple geometry elements), observations over time (<values>, and multiple time descriptive elements), and variables. In addition, includes elements that define the characteristics of a of source, units, and series descriptions. Describing a series is an important for discovering information; eg what observed variables are found at this site.

ELEMENTS DEALING WITH SPACE

GENERAL DESCRIPTION

CUAHSI WaterML currently supports the return of information from two types of sources: collections of observation sites (e.g. stream gages) and datasets where data are typically requested over user-defined region of interest. These spatial components are represented with the <SiteInfoType> and <DatasetInfoType> elements, respectively. Each of these elements has a child element that extends the <GeogLocationType> to express the location of the element in geographic coordinates. The two possible extensions of <GeogLocationType> are <LatLonPointType> for point locations, and <LatLonBoxType> for locations defined by a box in latitude and longitude.

Because <SiteInfoType> represents a site at a discrete location in space, it will have a child element of the <LatLonPointType> type. For <DatasetInfoType>, some datasets return information for a single point, while others return data aggregated over an area. Thus, elements of either <LatLonPointType> type or <LatLonBoxType> type may be child elements of <DatasetInfoType>.

Any element that extends the <GeogLocationType> element will also have an attribute that defines the coordinate system (e.g., vertical datum, spheroid, etc.) that applies to the latitude and longitude coordinates. Note that all <GeogLocationType> elements represent location in geographic (latitude and longitude) coordinates, assuming WGS84 by default (EPSG code 4326). If elevation information is present in site description, then the default datum and coordinate system definition refers to EPSG code 4979, which specifies the (latitude, longitude, altitude) triplet. In OGC specifications, the coordinate systems are referred to by URNs "urn:ogc:def:crs:EPSG::4326" and "urn:ogc:def:crs:EPSG::4979" respectively. For other coordinate systems and datums, both horizontal and vertical datum information will be included. In addition to its location, the <SiteInfoType> element also includes data about the site itself, such as <siteName> and <siteCode>. The <DatasetInfoType> includes a <dataSetIdentifier> element that specifies the name of the dataset, e.g. "Daymet". The <SiteInfoType> and <DatasetInfoType> elements themselves are extensions of the generic <SourceInfoType> element. Thus, when WaterML returns information about the location of a site or measurements, the location is returned with an element that is of the <SourceInfoType> type. The figure below shows the possible ways of expressing location in the current version of WaterML.

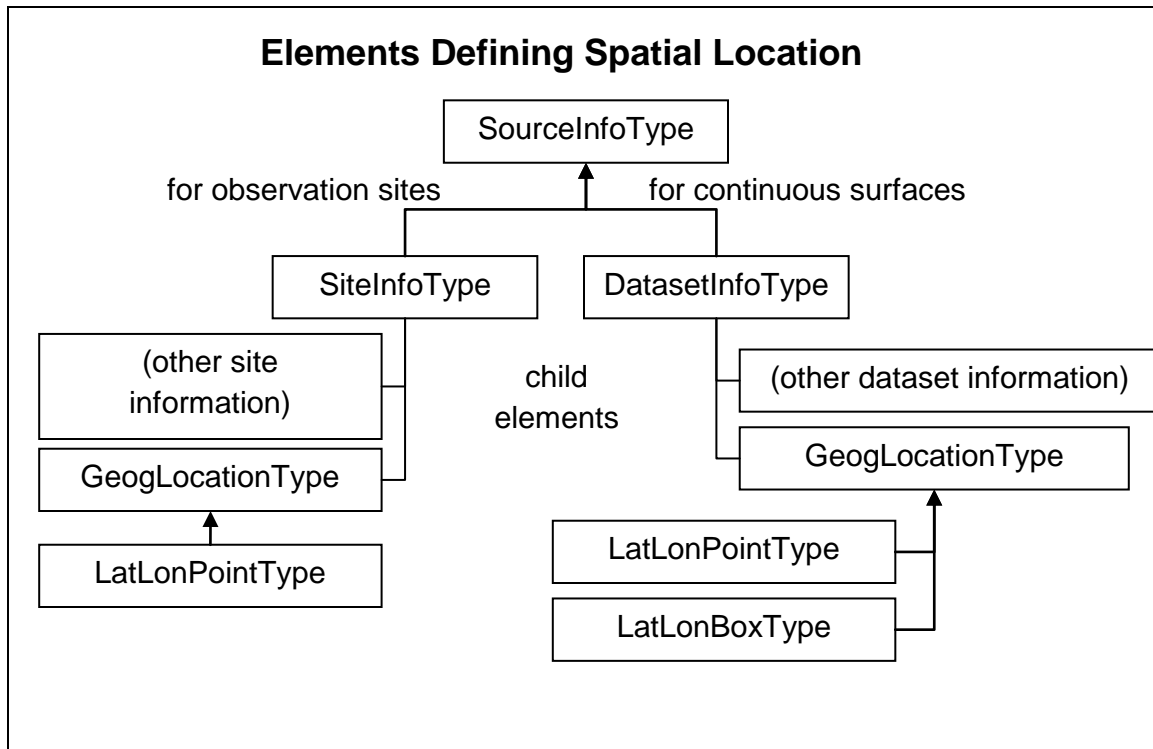


Figure 2. Conceptual Diagram of Elements Defining Spatial Location in WaterML

DATA SOURCE INFORMATION (LOCATION)

DESCRIPTION:

The source that a set of time series values can be derived from is diverse. The CUAHSI OD is intended to handle point observations, or in CUAHSI terminology, sites. Other data sources for the community are from derived grid datasets such as models, and satellite observations. For WaterML, SiteInfoType or <siteInfo> is used to describe the location of a site, and grid datasets are of type DatasetInfoType.



Figure 3. SourceInfoType.

This is the base type for the the source information. The derived types of SiteInfoType, and DatasetInfoType contain location and other information about the source.

SITE INFORMATION

DESCRIPTION

Element `<siteInfo>` is of type `<SiteInfoType>`. The `<siteInfo>` describes a site information, and not the observations at a site. This is done in order to make the `<siteInfo>` element a reusable object that can be used in multiple messages. Element `<siteInfo>` is used as part of a `<timeSeries>`, and `<site>` elements, which themselves are part of the `<timeSeriesResponse>` and `<sitesResponse>` messages. This separation of structure also matches the OD where separate tables for sites and series.

When `<siteInfo>` is used in a `<sitesResponse>`, a `<site>` element includes both the `<siteInfo>` and one or more `<seriesCatalog>` element.

When used in a `<timeSeries>`, polymorphism is used, so the `<sourceInfo>` element will have an `xsi:type="SiteInfoType"`.

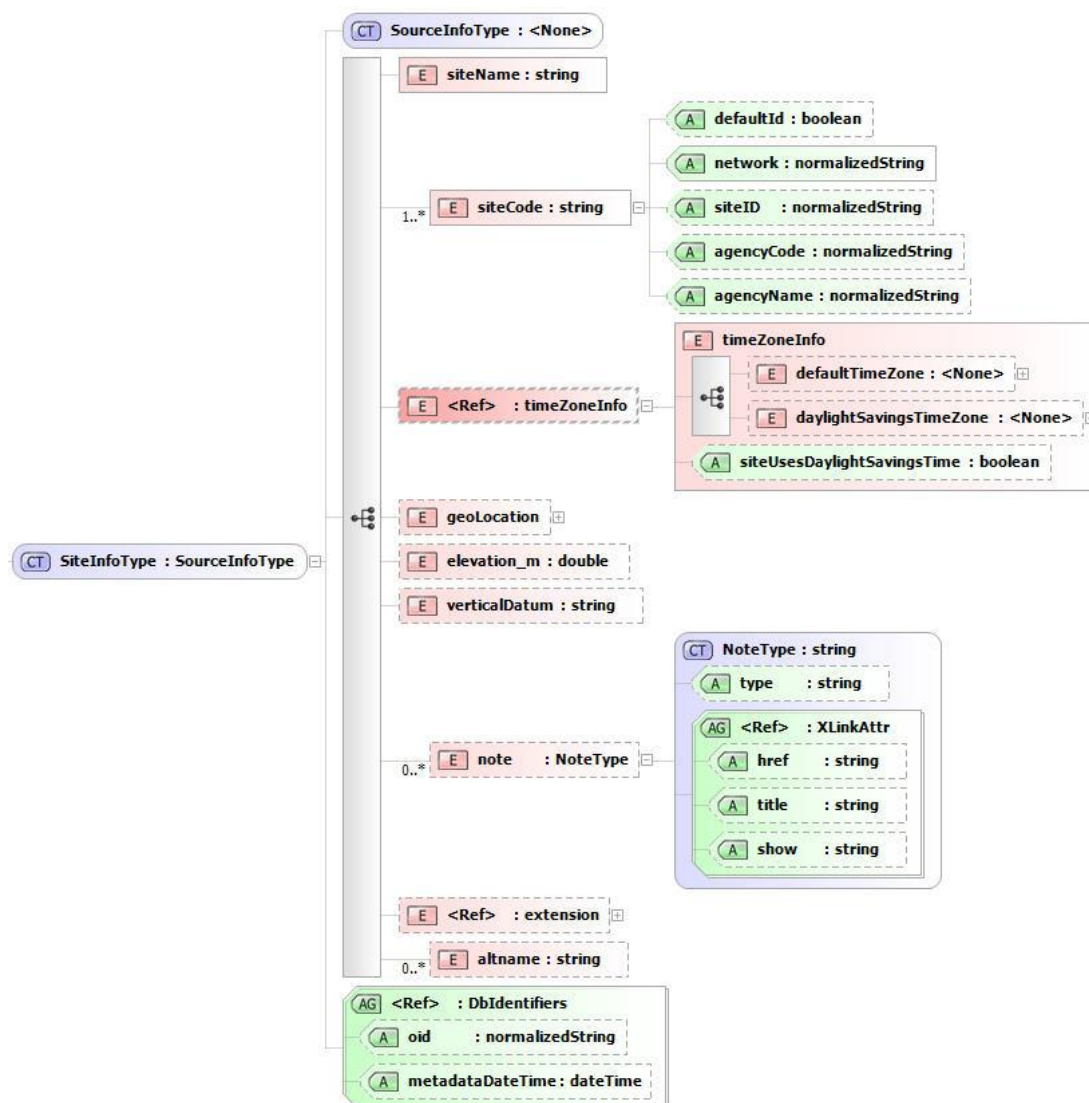


Figure 4. SiteInfoType.

Expanded to show the details of the information. The base type for SiteInfoType is SourceInfoType.

Notes:

- Element <siteInfo> is of type <SiteInfoType>.
- The <siteInfo> describes site information, and not the observations at a site. This is done in order to make the <siteInfo> element a reusable object that can be used in multiple messages.
- Element <siteInfo> is used as part of a <timeSeries>, and <site> elements, which themselves are part of the <timeSeriesResponse> and <sitesResponse> messages. This separation of structure matches the design choices made in ODM which specifies separate tables for sites and series.
- When <siteInfo> is used in a <sitesResponse>, a <site> element includes both the <siteInfo> and one or more <seriesCatalog> elements.
- When used in a <timeSeries>, polymorphism is used, so the <sourceInfo> element will have an xsi:type="SiteInfoType".
- The optional <timeZoneInfo> element, with its <defaultTimeZone> <daylightSavingsTime> components, uses strings to specify time zone and daylight savings time information for a site. If present, this information may be used for local time conversions at the server.

XML REPRESENTATION: EXAMPLE 1

```
<!-- Generic as used in sitesReponse -->
<siteInfo>
  <siteName>Little Bear River near Wellsville, Utah</siteName>
  <siteCode network="LBR" siteID="10">USU-LBR-Wellsville</siteCode>
  <geoLocation>
    <geogLocation xsi:type="LatLonPointType" srs="EPSG:4269">
      <latitude>41.643457</latitude>
      <longitude>-111.917649</longitude>
    </geogLocation>
    <localSiteXY projectionInformation="NAD83 / UTM zone 12N">
      <X>423579.317</X>
      <Y>4610597.583</Y>
    </localSiteXY>
  </geoLocation>
  <elevation_m>1365</elevation_m>
  <verticalDatum>NGVD29</verticalDatum>
  <note title="County">Cache</note>
  <note title="State">Utah</note>
  <note title="Site Comments">Located on the upstream side of State
Highway 101 bridge.</note>
</siteInfo>
```

```
<!-- polymorphic as used on timeSeriesReponse/timeSeries -->
<sourceInfo xsi:type="SiteInfoType">
  <siteName>Little Bear River at Mendon Road near Mendon,
Utah</siteName>
  <siteCode network="LBR" siteID="1">USU-LBR-Mendon</siteCode>
  <geoLocation>
    <geogLocation xsi:type="LatLonPointType" srs="EPSG:4269">
      <latitude>41.718473</latitude>
      <longitude>-111.946402</longitude>
    </geogLocation>
    <localSiteXY projectionInformation="NAD83 / UTM zone 12N">
      <X>421276.323</X>
      <Y>4618952.04</Y>
    </localSiteXY>
  </geoLocation>
  <elevation_m>1345</elevation_m>
  <verticalDatum>NGVD29</verticalDatum>
  <note title="County">Cache</note>
  <note title="State">Utah</note>
  <note title="Site Comments">Located below county road bridge at
Mendon Road crossing</note>
</sourceInfo>
```

DATASET INFORMATION

DESCRIPTION

The type DataSetInfoType conveys information about a dataset. Some services sample field or grid-based timeseries dataset, and return values for a single point or over a region

DataSetInfoType is only used in a polymorphic type inside of <sourceInfo>. <dataSetIdentifier> is the name or reference to the dataset.

<datasetLocation> is for the geometry that was returned. <datasetLocation> is polymorphic and will have xsi:type="LatLonPointType" or xsi:type="LatLonBoxType".

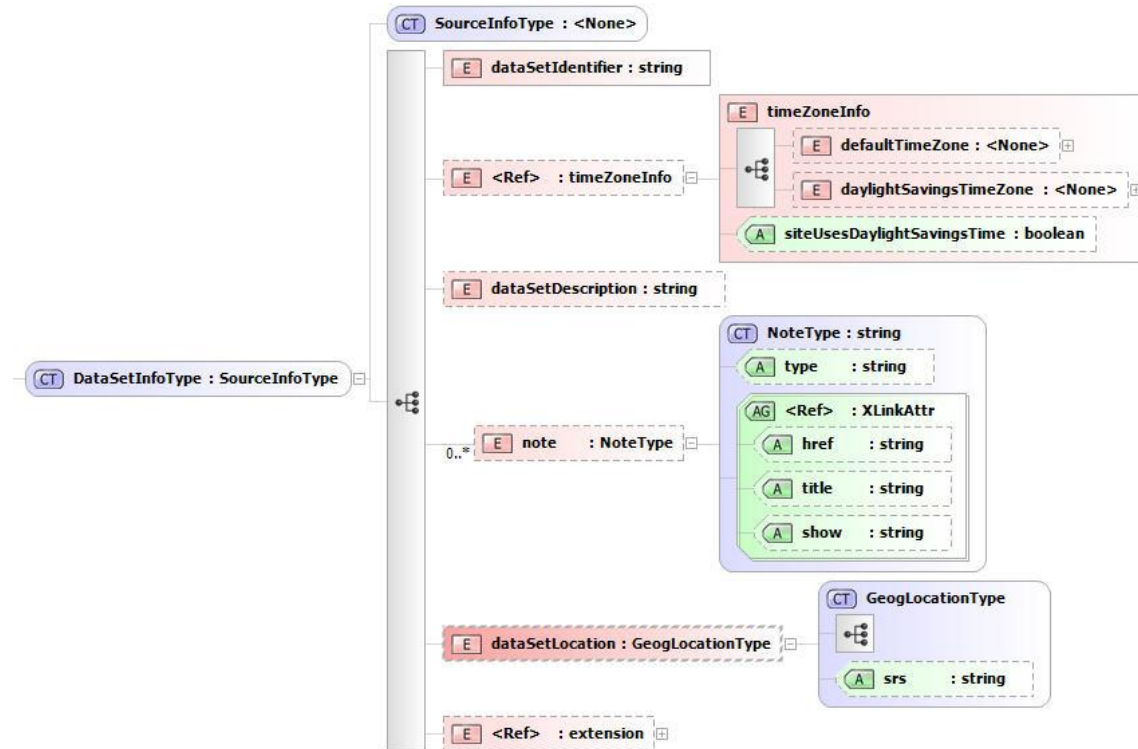


Figure 5. DataSetInfoType.

Expanded to show details. The base type for DataSetInfoType is SourceInfoType.

Notes:

- DataSetInfoType is only used in a polymorphic type inside of <sourceInfo>.
- <dataSetIdentifier> is the name or reference to the dataset.
- <datasetLocation> contains geometry that was returned. <datasetLocation> is polymorphic and will have xsi:type="LatLonPointType" or xsi:type="LatLonBoxType".

XML REPRESENTATION

```

<!-- polymorphic as used in timeSeriesResponse/timeSeries/ -->
<sourceInfo xsi:type="DataSetInfoType">
  <dataSetIdentifier>DAYMET</dataSetIdentifier>
  <dataSetLocation xsi:type="LatLonPointType">
    <latitude>45</latitude>
    <longitude>-113</longitude>
  </dataSetLocation>
</sourceInfo>

```

SITE

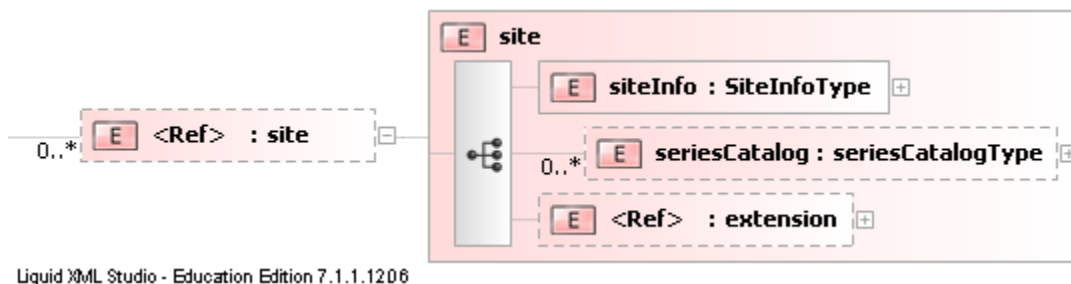
DESCRIPTION

<site> is an element within the <sites>, which is return of a GetSiteInfo response. A site contains two parts: a <siteInfo> element, and

API Call	<siteInfo>	<seriesCatalog>
GetSiteInfo	required	1 or more
GetSites	required	Zero.

When information about a site is return for a GetSites call, zero of more <seriesCatalog> elements. This reduces the size of the response, which could have many site.

When <site> is returned as part of a GetSites API call, a <seriesCatalog> element should be returned.



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Figure 6. Site element from SiteResponseType.

A site element is part of a sitesResponse(SitesResponseType). Incontains a siteInfo (SiteInfoType), and a SeriesCatalog, described below.

Notes:

- <site> is an element within the <sites> element, which is returned on a GetSiteInfo or GetSites API call.
- A site contains two parts: a required <siteInfo> element, and zero or more <seriesCatalog> elements.
- In response to GetSiteInfo request, the number of <seriesCatalog> elements is 1 or more. In response to GetSites request, the number of <seriesCatalog> elements is zero or more (potentially reducing the size of the response).

XML REPRESENTATION

```
<site>
  <siteInfo>
    <siteName>BIG ROCK C NR VALYERMO CA</siteName>
    <siteCode network="NWIS"
siteID="4622637">10263500</siteCode>
    <!-- removed for clarity see "Site Information", above-->
  </siteInfo>
  <seriesCatalog menuGroupName="USGS Daily Values" serviceWsd1=" ">
    <!-- removed for clarity -->
  </seriesCatalog>
  <seriesCatalog menuGroupName="USGS Unit Values" serviceWsd1=" ">
    <!-- removed for clarity see "Series Information", below-->
  </seriesCatalog>
</site>
```

GEOMETRY REPRESENTATIONS

LATLONGPOINTTYPE

DESCRIPTION

This defines a point in latitude and longitude.

The @srs should be either an EPSG coded value specified as "EPSG:4326"

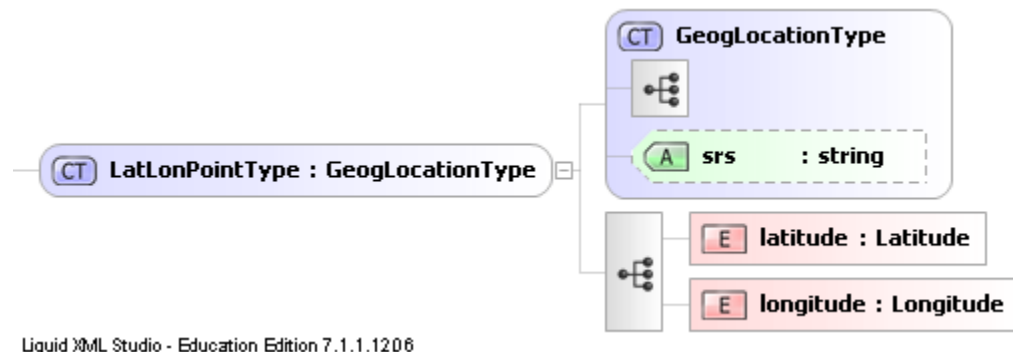


Figure 7. LatLongPoint geometry type

Notes:

- The @srs should be either an EPSG coded value specified as "EPSG:4326" or a projection string.
- In the current implementation, all services are required to return locations in latitude and longitude, and the clients are not expected to have a projection engine. Coordinate transformations shall be handled at the server, following a coordinate system specified by @srs.

XML REPRESENTATION EXAMPLE 1: GENERIC EXAMPLE OF LATLONPOINT

```
<!--Generic Example -->
<LatLonPoint srs="EPSG:4326">
  <latitude>35.64722220</latitude >
  <longitude>-78.40527780</longitude >
</LatLonPoint>
```

XML REPRESENTATION EXAMPLE 2: LATLONPOINT AS USED IN A SITEINFO SOURCE

```
<!-- As used in siteInfo source -->
<geogLocation srs="EPSG:4326">
  <latitude>35.64722220</latitude >
  <longitude>-78.40527780</longitude >
</geogLocation>
```

LATLONGBOXTYPE

DESCRIPTION

A <latLongBox> describes a bounding box. This is defined in terms of North, East, South and West, so that box can cross the international date line (+/-180).

The @srs should be either an EPSG coded value specified as "EPSG:4326" or a projection string.

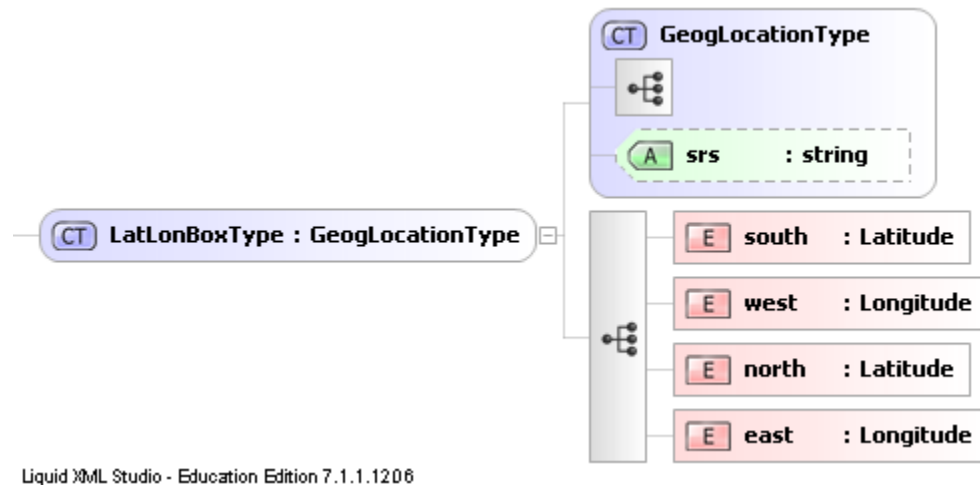


Figure 8. LatLonBox geometry type

Notes:

- A <latLonBox> describes a bounding box. This is defined in terms of North, East, South and West, so that box can cross the international date line (+/-180).
- The @srs should be either an EPSG coded value specified as "EPSG:4326" or a projection string.

XML REPRESENTATION EXAMPLE 1: GENERIC EXAMPLE OF LATLONBOX

```
<!-- Generic Example -->
<latLongBox xsi:type="LatLonBoxType">
  <south>45</south>
  <west>-108</west>
  <north>46</north>
  <east>-107</east>
</latLongBox>
```

XML REPRESENTATION EXAMPLE 2: LATLONBOX AS USED IN A DATASET SOURCE

```
<!-- as used in dataset source -->  
<dataSetLocation srs="EPSG:4326">  
  <latitude>35.64722220</latitude>  
  <longitude>-78.40527780</longitude>  
</dataSetLocation>
```

ELEMENTS DEALING WITH VARIABLES

WaterML categorizes information about variables in two ways: information about the variable in general, and period of record information about the variable as observed at a given site. Information about the variable in general is given by an elements of type `<VariableInfoType>`. This XML type defines a number of possible child elements including, but not limited to:

- `<variableCode>` - Identifier for the variable within an observation network, e.g. "00010"
- `<variableName>` - Name of the variable, e.g. "Water Temperature"
- `<sampleMedium>` - E.g. "Soil"
- `<units>` - An element with child elements giving information about the units, such as the units abbreviation (e.g. "cfs") and units type (e.g. "length")

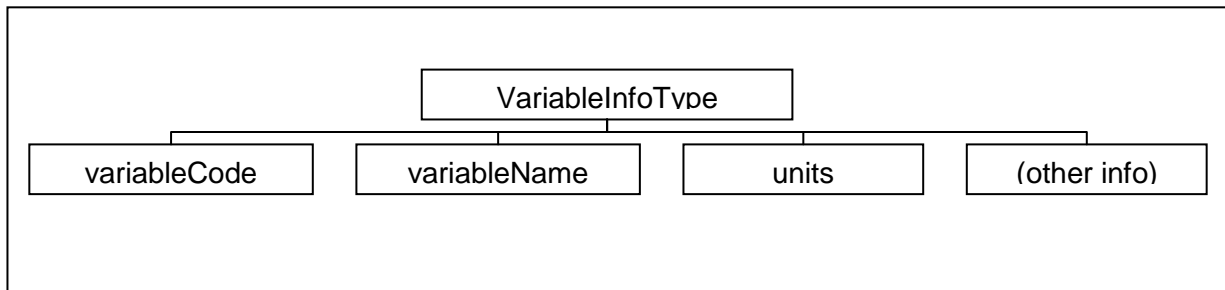


Figure 9. Conceptual Diagram of Elements Defining Variables in WaterML

VARIABLE INFORMATION

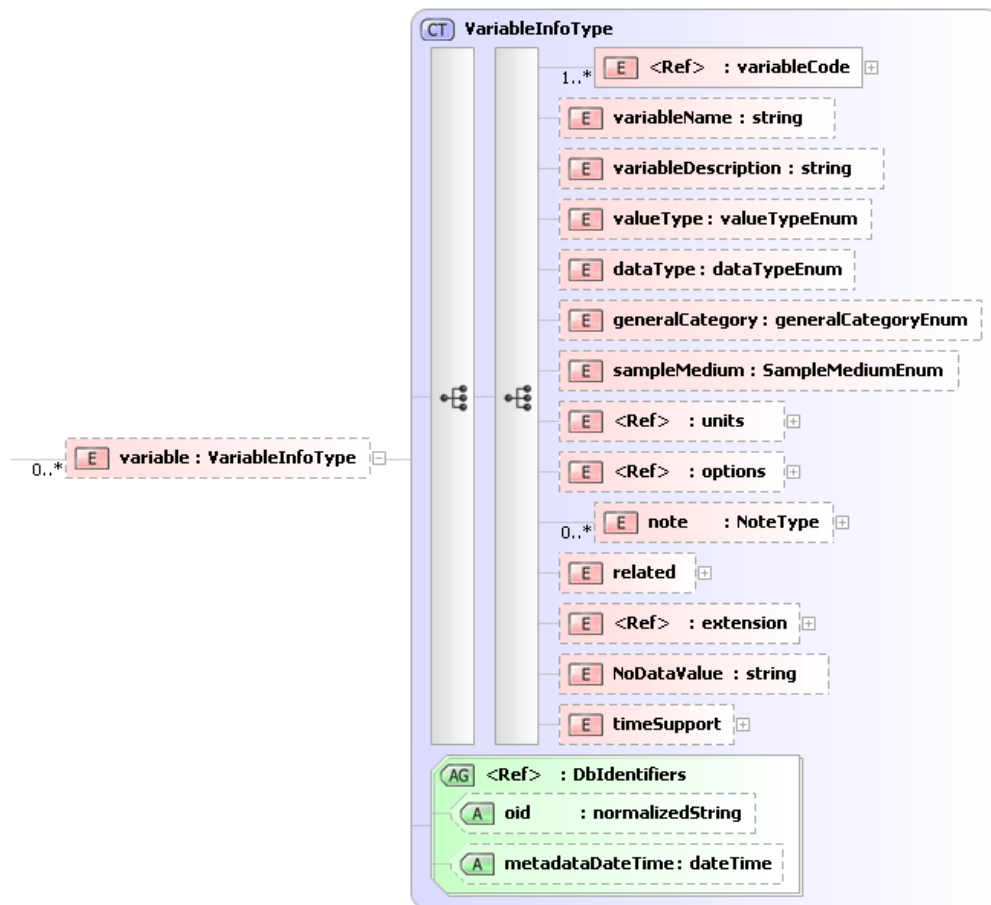
DESCRIPTION

Element `<variable>` (of `VariableInfoType`) contains the descriptive information about a variable that has been observed. In order to allow for direct mapping of `variableCodes` between different vocabularies, multiple `<variableCode>` elements are allowed. The `<variableName>` element should be an abbreviated name, and not contain `<units>` information, if possible. A more detail can be contained in the `<variableDescription>` element (which is not present in the OD).

The attributes `@vocabulary` is for reference to the source of the `variableCode`. If there are multiple `<variableCode>` elements, then an attribute of `@default="true"` should be on the element which is the code that should be used to refer to the variable. Often, a network can be associated with a `<variableCode>`, in which case, the `@network` attribute can be used.

Elements `<valueType>`, `<generalCategory>`, `<sampleMedium>` are controlled vocabularies, as defined by the Observations database.

The `<units>` element is as defined further below, and also includes controlled vocabulary items, and `unitCodes`. To add additional information users can utilize either a `<note>` or if the information is in structured XML, `<extension>`. Elements of type `<extension>` can contain any XML content, and are the location where data providers should place any additional information.



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Figure 10. VariableInfoType

Notes:

- Element <variable> contains the descriptive information about a variable that has been observed.
- The <variableName> element should be an abbreviated name, and not contain <units> information, if possible.
- More detail about a variable can be contained in the <variableDescription> element (Note: this element does not have an equivalent field in the ODM).
- The attributes @vocabulary is for reference to the source of the variableCode. If there are multiple <variableCode> elements, then an attribute of @default="true" should be on the element which is the code that should be used to refer to the variable. Often, a network can be associated with a <variableCode>, in which case, the @network attribute can be used. Multiple <variableCode> elements are supported to allow direct mapping of variableCodes between different vocabularies.
- Elements <valueType>, <generalCategory>, <sampleMedium> are controlled vocabularies, as defined by the Observations database (Annex A)

- <extension> elements can contain any XML content, at the discretion of data providers.

The <timeSupport> element contains the time support (or temporal footprint) of the data values. @isRegular indicates if the spacing is regular. WaterML only communicates the regularity, and the spacing of the observations (timeInterval) and can be used to determine the precision of the observational series. See the ODM paper and “Time Support” Below

XML REPRESENTATION: COMMENTED EXAMPLE

```
<variable>
  <variableCode vocabulary="NWIS" default="true"
variableID="#####">00060</variableCode>
  <variableCode vocabulary="CUAHSI"
variableID="#####">Discharge</variableCode>
  <variableName>Discharge [Time support should be separate element
or attribute, not part of variable name]</variableName>
  <variableDescription>Discharge[units should not be part of
variable description]</variableDescription>
  <!-- controlled vocabulary from OD -->.
  <valueType>From CV
</valueType>
  <dataType>From CV</dataType>
<generalCategory></generalCategory>
  <sampleMedium>from CV</sampleMedium>
  <units unitsCode="35" unitsAbbreviation="cfs" unitsType="flow">
cubic feet per second
</units>
  <NoDataValue>-9999</NoDataValue>
  <timeSupport isRegular="true">
    <unit UnitID="###">
      <UnitDescription>hour</UnitDescription>
      <UnitType>Time</UnitType>
      <UnitAbbreviation>hr</UnitAbbreviation>
    </unit>
    <timeInterval>1</timeInterval>
  </timeSupport>
</variable>
```

XML REPRESENTATION: EXAMPLE POPULATED FROM XML ENUMERATIONS

```
<variable>
  <variableCode vocabulary="LBR" default="true"
variableID="22">USU22</variableCode>
  <variableName>Radiation, incoming shortwave</variableName>
  <valueType>Field Observation</valueType>
  <dataType>Average</dataType>
  <generalCategory>Climate</generalCategory>
  <sampleMedium>Other</sampleMedium>
```

```

    <units unitsAbbreviation="W/m2" unitsCode="33" unitsType="Energy
Flux">watts per square meter</units>
    <NoDataValue>-9999</NoDataValue>
    <timeSupport isRegular="true">
        <unit UnitID="103">
            <UnitDescription>hour</UnitDescription>
            <UnitType>Angle</UnitType>
            <UnitAbbreviation>hr</UnitAbbreviation>
        </unit>
        <timeInterval>1</timeInterval>
    </timeSupport>
</variable>

```

UNITS INFORMATION

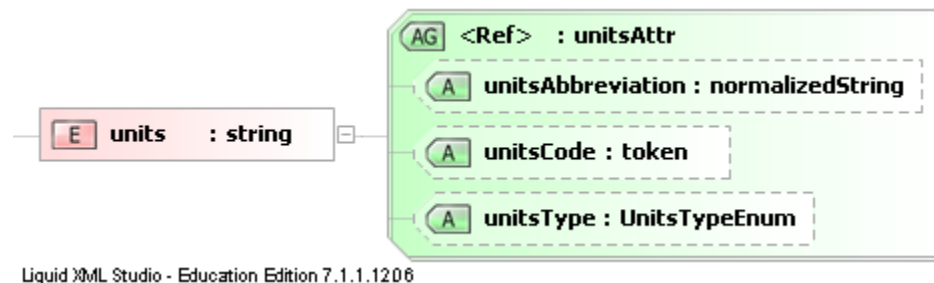
DESCRIPTION

There are two methods to represent units, but they both contain the same information set (This inconsistency is being addressed in WaterML 1.1).

CASE 1. SINGLE ELEMENT

The <units> element is used within the variables element. The <values> element in timeseries, also uses attributes @unitsCode, and @unitsAbbreviation.

There is a CUAHSI controlled vocabulary for <units>



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Figure 11. Units element using attributes.

Notes:

- The <units> element is used within the variables, and values elements.
- The <values> element in timeseries also uses attributes @unitsCode, and @unitsAbbreviation.
- @unitsAbbreviation is the CUAHSI controlled vocabulary abbreviation for this unit
- @unitsID is an internal identifier.
- @unitsType is the CUAHSI controlled vocabulary for unitsType


```
<units unitsCode="35" unitsAbbreviation="cfs" unitsType="flow">
cubic feet per second</units>
```

CASE 2: UNITS PROPERTIES AS ELEMENT (UNITSTYPE)

This is used in variables time support element

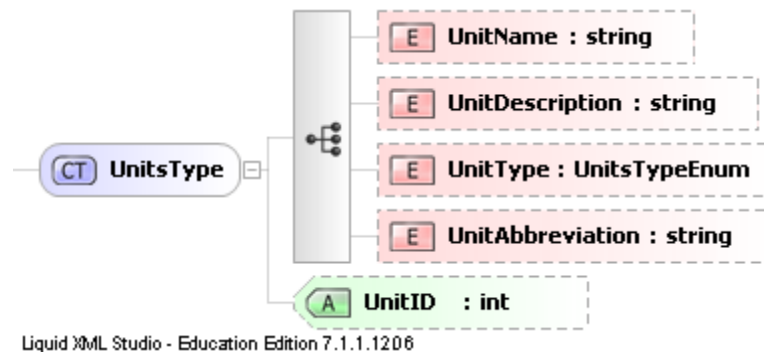
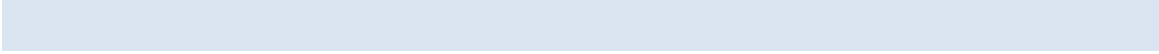


Figure 12. UnitsType complex element. This is designed to be reusable.

```
<timeSupport isRegular="true">
  <unit UnitID="102">
    <UnitDescription>minute</UnitDescription>
    <UnitType>Time</UnitType>
    <UnitAbbreviation>min</UnitAbbreviation>
  </unit>
  <timeInterval>15</timeInterval>
</timeSupport>
```



ELEMENTS DEALING WITH TIME AND MEASURED VALUES

GENERAL DESCRIPTION

The elements described in this section focus on time, and in particular on the time series of hydrologic observations that a user requests from WaterOneFlow. All of the timestamps, values, and supplemental time series information are stored under a single element of type `<TsValuesSingleVariableType>`. This element contains one or more `<value>` elements, as well as optional elements defining such things as the quality control level or qualifiers used.

Each `<value>` element represents a single time series value. The value is stored as the element's text (the data between the opening and closing tags of the element), while the timestamp at which that value occurred is stored in the `@dateTime` attribute of `<value>`. The `<value>` element may contain other attributes to further qualify the value.

The figure below illustrates that one `<TsValuesSingleVariableType>` element may have any `<value>` elements, and that each `<value>` element has a `@dateTime` attribute.

Figure 13. WaterML elements representing a set of values

VALUES INFORMATION

SINGLE VARIABLE

At present, `<values>` can only accommodate a values for a variable in the response.

DESCRIPTION

Element `<values>` contains the actual data values and associated attributes. The `<values>` element contains a list of `<value>` elements, and `<qualifier>` elements. The attributed of `@unitsCode` and `@unitsAbbreviation` may seem redundant, but the inclusion the list of `<value>`'s might be transformed from the original units than the original variable described by the variables.

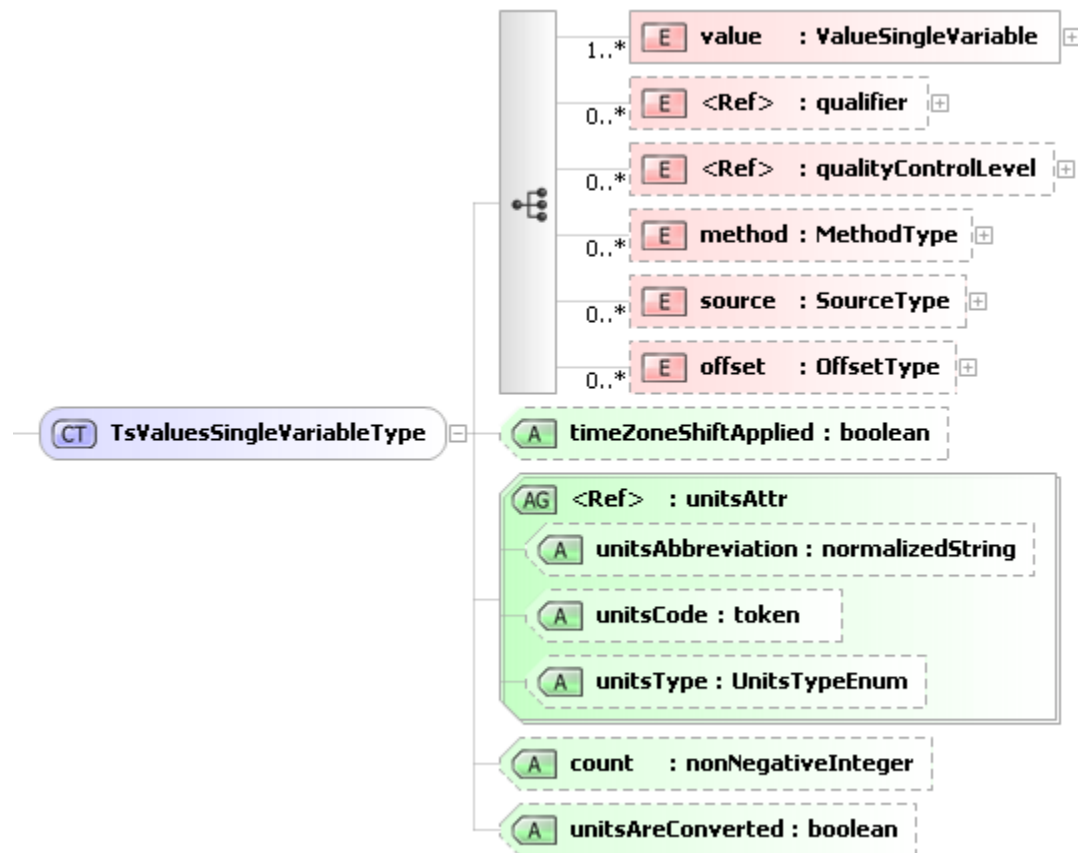
The `<value>` element must have a `@dateTime` attribute. In addition, other can have a set of attributes. The most important are `@censorCode` and `@qualifiers`. `@qualifiers` can contain multiple codes concatenated together. If `qualifiers` is used, the `<qualifier>` elements should be placed within the `<values>`

element, after all <value> elements. This placement is programmatically convenient, so that all qualifiers on a list could be accumulated.

In order to communicate offset information the attributes are used:

```
@offsetValue
@offsetAbbreviation
@offsetDescription
@qualityControlLevel
```

The handling of coded vocabularies is not ideal. We have discovered that some services mix text and numeric content in the returned values. In order to accommodate such services, two codedVocabulary attributes are used. If value is a coded vocabulary, then set @codedVocabulary='true', place the vocabulary term in @codeVocabularyTerm, and place a numeric value in the <value>. Often such terms can and should be recoded as either @censorCode, or @qualifiers. If @qualifiers is used, then insert <qualifier> elements at the end of the <values> element



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Figure 14. TimeSeries values represented in a TsValuesSingleVariableType.

Note:

- Element <values> contains a list of <value> elements that are repeated for the entire series followed by metadata elements <qualifiers>, <qualityControlLevel>, <method>, <source> and <offset>. In WaterML 1.0, the links between the metadata elements a value are done using , and attributes postfixed with ID; eg @methodID, @sourceID.
- The units of a set of values are indicated by the units on the variable.

- The attribute @unitsAreConverted was intended to be used to allow for unit transformation to occur on the server, with the @unitsCode, @unitsAbbreviation, @unitsType containing the transformed unit information. Present clients utilize the units information from the variable, so using these attributes could cause issues. A new variable and data series is the expected method of handling unit transformations.
-



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Figure 15. Result as a value element

Notes:

- Element <value> contains a double value that holds the actual data values. The attributes and @dateTime, @valueAccuracy, @censorCode, @qualifier, @offsetValue, and @qualityControlLevel provide value level information about the data value. The details of these

are elements of the <values> element. In WaterML 1.0, the links between the metadata elements a value are done using , and attributes postfixed with ID; eg @methodID, @sourceID.

- <dateTime> is required, but the other elements are optional.
- Multiple qualifiers should be separated by spaces, and listed in the @qualifiers. Multiple <qualifier> elements in the <values> should contain the descriptions.
- Vertical profiles are represented using offsets; @offsetValue, @offsetUnitsAbbreviation, @offsetUnitsCode, and @offsetDescription. If applicable, @offsetValue, and @offsetUnitsAbbreviation are required.
- The handling of coded vocabularies for categorical variables has significant limitations in the current version. We have discovered that some services mix text and numeric content in the returned values. In order to accommodate such services, two codedVocabulary attributes are used. If value is a coded vocabulary, then set @codedVocabulary='true', place the vocabulary term in @codeVocabularyTerm, and place a numeric value in the <value>. Often such terms can and should be recoded as either @censorCode, or @qualifiers. If @qualifiers is used, then insert <qualifier> elements at the end of the <values> element

The variables element contains a <timeSupport> element. This element can be used to determine the precision of the observational series. See the ODM paper and "Time Support" Below

XML REPRESENTATION - EXAMPLE 1: MINIMAL EXAMPLE

This is minimum set of elements and attributes. A <values> element with @unitsAbbreviation (drawn from the controlled vocabulary, UnitsTypeEnumeration).

Note: @count is not included, and is optional. A programmer can get an array count.

```
<values unitsAbbreviation="cfs">
  <value dateTime="1977-04-04T11:45:00">5.6</value>
  <!-- snip -->
  <value dateTime="1990-08-29T11:45:00">0.38</value>
  <value dateTime="1991-11-01T13:30:00">2.6</value>
</values>
```

XML REPRESENTATION: EXAMPLE 2:

. A <values> element with @unitsAbbreviation (drawn from the controlled vocabulary, UnitsTypeEnumeration).

With @censorCode and @qualifiers

If a @censorCode attribute is present, then the data should be examined, and used only is appropriate. Censor codes are:

- "lt" – less than,
- "gt" greater than,
- "nc" no code

Two letter codes, are used rather than traditional symbols to ensure that user create and decode the XML messages properly.

```
<values unitsAbbreviation="mg/L" unitsCode="199" count="10">
  <value censorCode="nc" dateTime="2007-11-07T13:00:00"
qualityControlLevel="Quality controlled data" methodID="25"
sourceID="3" sampleID="26">10.5</value>
  <value censorCode="nc" dateTime="2007-11-07T13:00:00"
qualityControlLevel="Derived products" methodID="25" sourceID="3"
sampleID="26">10.5</value>
  <!-- snip -->
  <value censorCode="nc" dateTime="2007-12-05T11:00:00"
qualityControlLevel="Quality controlled data" methodID="25"
sourceID="3" sampleID="83">2.5</value>
  <value censorCode="nc" dateTime="2007-12-20T14:05:00"
qualityControlLevel="Quality controlled data" methodID="25"
sourceID="3" sampleID="171">2.5</value>
  <value censorCode="nc" dateTime="2007-12-20T14:05:00"
qualityControlLevel="Derived products" methodID="25" sourceID="3"
sampleID="171">2.5</value>
  <method methodID="25">
    <MethodDescription>Water chemistry grab sample collected by
technicians in the field.</MethodDescription>
  </method>
  <source sourceID="3">
    <Organization>Utah State University Utah Water Research
Laboratory</Organization>
    <SourceDescription>Water chemistry monitoring data
collected by Utah State University as part of a National Science
Foundation funded test bed project.</SourceDescription>
    <ContactInformation>
      <ContactName>Amber Spackman</ContactName>
      <TypeOfContact>main</TypeOfContact>
      <Phone>1-435-797-0045</Phone>
      <Email>amber.s@aggiemail.usu.edu</Email>
      <Address xsi:type="xsd:string">8200 Old Main
Hill ,Logan, Utah 84322-8200</Address>
    </ContactInformation>

    <SourceLink>http://water.usu.edu/littlebearriver</SourceLink>
  </source>
</values>
```

XML REPRESENTATION: EXAMPLE 3: WITH OFFSET

With @offsetXXX attributes

```
<values unitsCode="35" unitsAbbreviation="cfs" count="50">
  <value offsetValue="10" offsetUnitAbbreviation="m"
offsetDescription="10 meter depth" dateTime="1977-04-
04T11:45:00">5.6</value>
  <!-- snip -->
  <value offsetValue="20" offsetUnitAbbreviation="m"
offsetDescription="20 meter depth" dateTime="1990-08-
29T11:45:00">0.38</value>
  <value offsetValue="10" offsetUnitAbbreviation="m"
offsetDescription="10 meter depth" qualifiers="p" dateTime="1991-11-
01T13:30:00">2.6</value>
  <!--qualifier TBD -->
  <qualifier qualifierCode="p">Preliminary Value. USGS</qualifier>
</values>
```

XML REPRESENTATION: EXAMPLE WITH QUALIFIER

With @qualityControlLevel

```
<values unitsCode="35" unitsAbbreviation="cfs" count="50">
  <value qualityControlLevel="Quality controlled data"
qualifiers="Ae" dateTime="1977-04-04T11:45:00">5.6</value>
  <!-- snip -->
  <value qualityControlLevel="Quality controlled data"
qualifiers="Ae"
dateTime="1990-08-29T11:45:00">0.38</value>
  <value qualityControlLevel="Raw Data" qualifiers="p"
dateTime="2007-11-01T13:30:00">2.6</value>
  <!-- qualifier TBD -->
  <qualifier qualifiedCode="A" >Approved. USGS</qualifier>
  <qualifier qualifierCode="e">Value was estimate. USGS</qualifier>
  <qualifier qualifierCode="p">Preliminary Value. USGS</qualifier>
</values>
```


UNITS INFORMATION

DESCRIPTION

There are two methods to represent units, but they both contain the same information set (This inconsistency is being addressed in WaterML 1.1).

CASE 1. SINGLE ELEMENT

The <units> element is used within the variables element. The <values> element in timeseries, also uses attributes @unitsCode, and @unitsAbbreviation.

There is a CUAHSI controlled vocabulary for <units>

<units> should contain a description of the unit..

- @unitsCode is the accepted CUAHSI controlled vocabulary code for this unit.
- @unitsAbbreviation is the CUAHSI controlled vocabulary abbreviation for this unit
- @unitsID is an internal identifier.
- @unitsType CUAHSI controlled vocabulary for unitsType

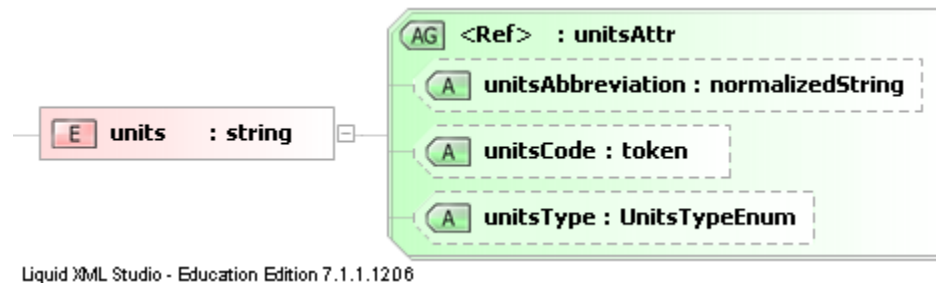


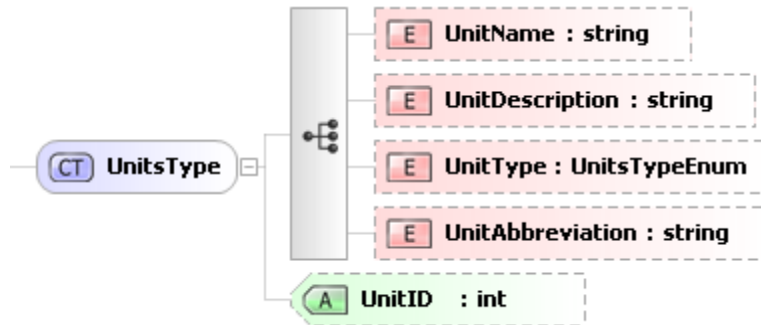
Figure 16. units element

XML REPRESENTATION

```
<units unitsCode="35" unitsAbbreviation="cfs" unitsType="flow">  
cubic feet per second</units>
```

CASE 2: UNITS PROPERTIES AS ELEMENT (UNITSTYPE)

This is used in variables time support element



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Figure 17. UnitsType

XML REPRESENTATION

```

<timeSupport isRegular="true">
  <unit UnitID="102">
    <UnitDescription>minute</UnitDescription>
    <UnitType>Time</UnitType>
    <UnitAbbreviation>min</UnitAbbreviation>
  </unit>
  <timeInterval>15</timeInterval>
</timeSupport>
  
```

TIME INFORMATION

We distinguish between a time range data is available for, a single instant where data was collection, and a floating time range, where the data available for a specified duration counting back from the present. These are common time representations encountered in time series descriptions available from several federal agencies. Most sites, have measurements that we taken over a period of time, so data is available for a time Range. In many cases, measurements have only been taken a single time. For real time stations, the data is only available for a limited time. A base type, `TimeIntervalType`, has two children, `TimePeriodType`, and `TimeInstantType`. `TimePeriodType` can be used to describe both a time range, and a floating time period. Restricting the elements to those outlined above will simplify client implementation.

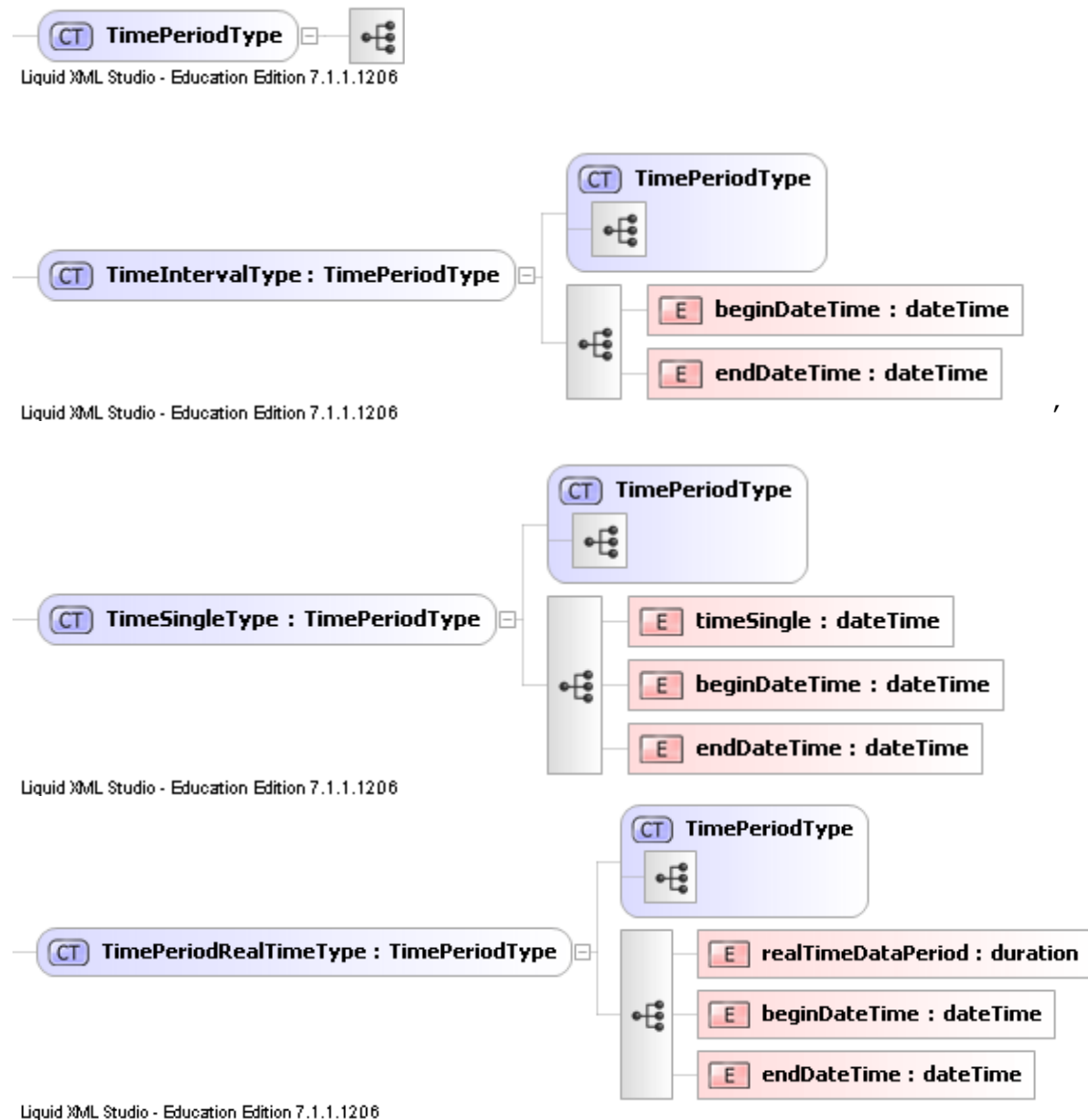


Figure 18. Different representations of time

Notes:

- In the databases we examined, data series appear in three different forms: a time range specified by begin time and end time, a single observation specified by a single time stamp, and a floating time range extending backward, from the current date and time, by a specified number of days (the latter being common when referring to real time observations kept for a limited time). The two XML elements used to describe these situations are derived from the parent type TimeIntervalType. They are TimePeriodType (for a time range, and floating real time data), and TimeInstantType (for a single observation).

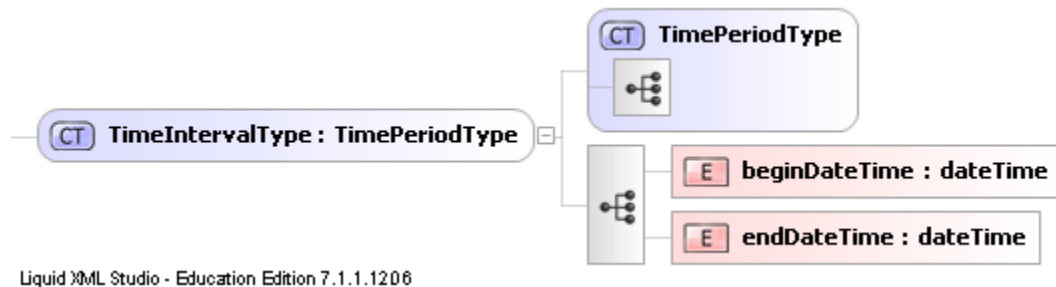
The dateTime type is specified in ISO 8061 format. The following form is the minimum acceptable "YYYY-MM-DDThh:mm:ss" where:

- * YYYY indicates the year
- * MM indicates the month
- * DD indicates the day
- * T indicates the start of the required time section
- * hh indicates the hour
- * mm indicates the minute
- * ss indicates the second

Note: All components are required!

XML REPRESENTATION: EXAMPLE TIMERANGE

This represents a time range, with a begin and an end time.



```
<!--Generic -->
<timeInterval>
  <beginDateTime>1982-12-09T00:00:00</beginDateTime>
  <endDateTime>1982-12-09T00:00:00</endDateTime>
</timeInterval>
```

```
<!-- as used in seriesCatalog -->
<variableTimeInterval xsi:type="TimeIntervalType">
```

```

    <beginDateTime>1982-12-09T00:00:00</beginDateTime>
    <endDateTime>1982-12-09T00:00:00</endDateTime>
</variableTimeInterval>

```

XML REPRESENTATION: EXAMPE

This represents a single observation

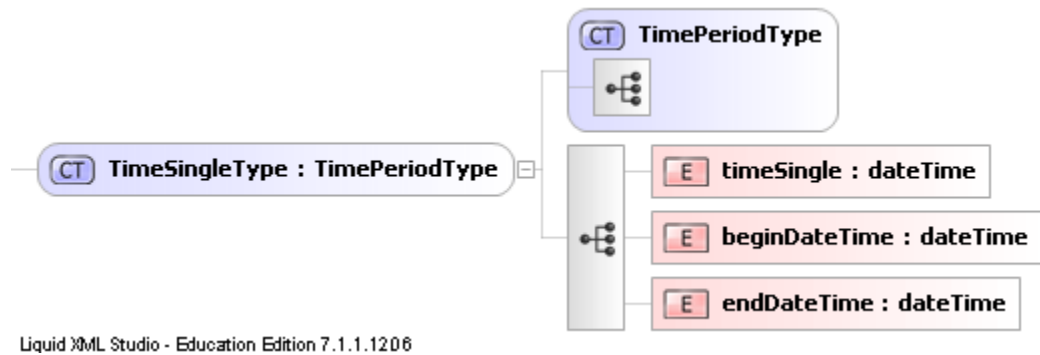


Figure 19. TimeSingleType for single events.

```

<!--generic -->
<timePeriodSingle>
    <timeSingle>1982-12-09T00:00:00</timeSingle>
    <beginDateTime>1982-12-09T00:00:00</beginDateTime>
    <endDateTime>1982-12-09T00:00:00</endDateTime>
</timePeriodSingle>

```

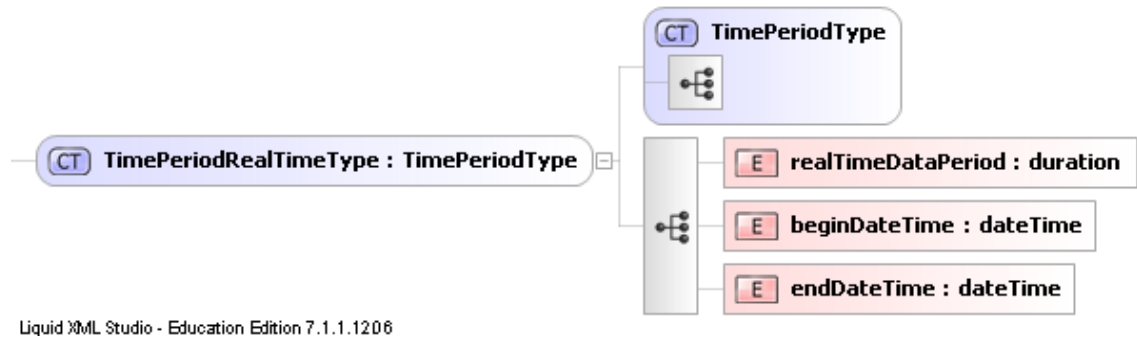
```

<!--as used in seriesCatalog -->
<variableTimeInterval xsi:type="TimePeriodSingleType">
    <beginDateTime>1982-12-09T00:00:00</beginDateTime>
    <endDateTime>1982-12-09T00:00:00</endDateTime>
</variableTimeInterval>

```

XML REPRESENTATION

This represents real time observations where data is only available for a limited time.



Note. If <site> with a <series> containing the <variableTimeInterval xsi:type="TimePeriodRealTimeType"> is stored locally or cached, then it will be necessary to recalculate the <beginDateTime> and <endDateTime>..

Duration Data Type

The duration data type is used to specify a time interval.

The time interval is specified in the following form

"PnYnMnDTnHnMnS"; where:

- * P indicates the period (required)
- * nY indicates the number of years
- * nM indicates the number of months
- * nD indicates the number of days
- * T indicates the start of a time section (required if you are going to specify hours, minutes, or seconds)
- * nH indicates the number of hours
- * nM indicates the number of minutes
- * nS indicates the number of seconds

```
<timePeriodRealTime>
  <realTimeDataPeriod>P31D</realTimeDataPeriod>
  <beginDateTime>1982-12-09T00:00:00</beginDateTime>
  <endDateTime>1982-12-09T00:00:00</endDateTime>
</timePeriodRealTime>
```

```
<!--as used in seriesCatalog -->
<variableTimeInterval xsi:type="TimePeriodRealTimeType">
  <realTimeDataPeriod>P31D</realTimeDataPeriod>
  <beginDateTime>1982-12-09T00:00:00</beginDateTime>
  <endDateTime>1982-12-09T00:00:00</endDateTime>
</variableTimeInterval>
```

SERIES INFORMATION AND SERIES CATALOGS

The <seriesCatalog> contains a list of <series>, which are unique combinations of site, variable and time intervals that specify a sequence of observations. Multiple <seriesCatalog> elements can be included where multiple dataSeries are available for a site. This treatment is different from the ODM, where data in a single database instance are served via a single web service. For some data providers, the same variable codes are utilized for different services. For example the USGS has a daily values service, where values are for a 24 hour period, and real-time observations, where data is available in 15 minute increments. A common siteCode, and variableCode are used between the data services. Hence inclusion of multiple <seriesCatalog> elements, reflecting <series> with different time scales or method within the same organization, or from different source organizations, is allowed in WaterML. See the ODM document for a discussion of the support, spacing and extent of observations that define time scale and for how series are identified based on a unique combination of site, variable, method, source, quality control level. As stated in the ODM documentation, the notion of data series used in WaterML does not distinguish between different series of the same variable at the same site but measured with different offsets. If for example temperature was measured at two different offsets by two different sensors at one site, both sets of data would fall into one data series for the purposes of the series catalog. In these cases, interpretation or analysis software will need to specifically examine and parse the offsets by examining the offset associated with each value. The series catalog does not do this because the principal purpose of the series catalog is data discovery, which we did not want to be overly complicated.

SERIES

DESCRIPTION

A series contains a set or summary information about a set of observations at a site. The observations have a <variable>, and are observed over a time interval specified by <variableTimeInterval>.

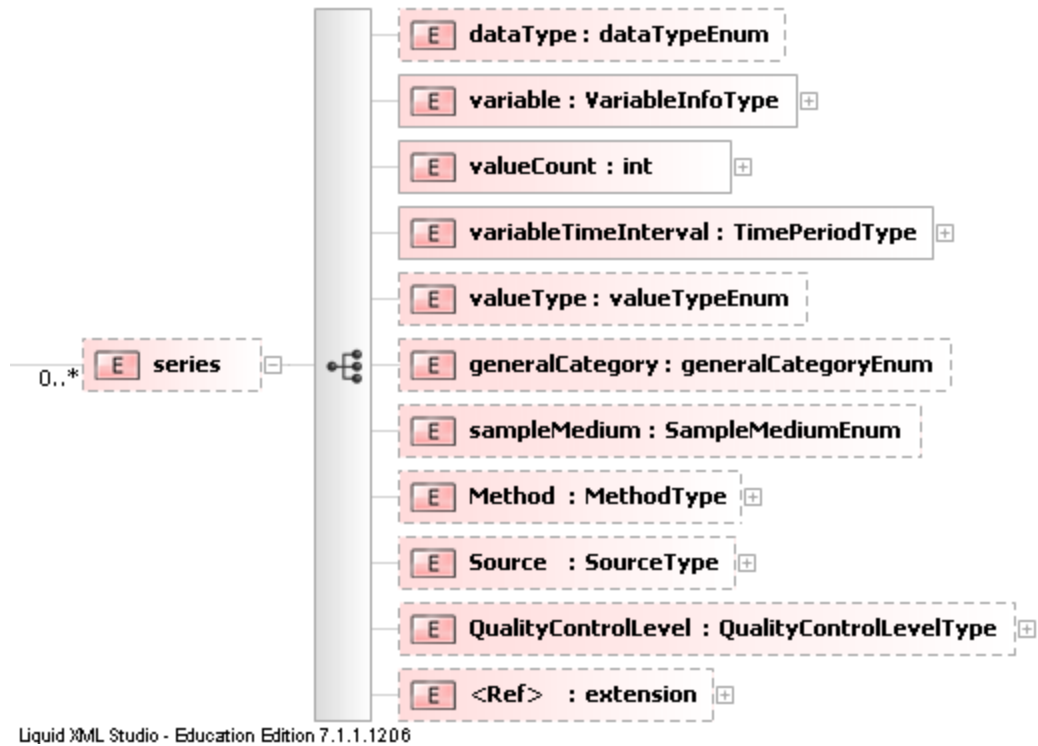


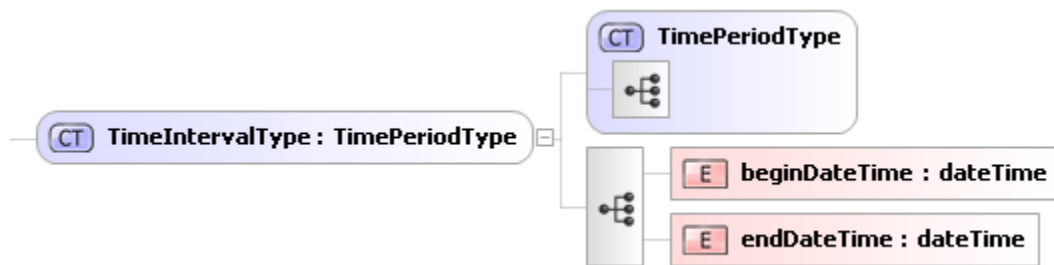
Figure 20. series element.

Note:

- From the client perspective, it is desirable to include a count of values, <valueCount>. In some cases may be an estimate, in which case @countIsEstimated="true"
- The supported time intervals for <variableTimeInterval> are described in "Time Information." In review, there can be three types.
 - timeIntervalType is a time range containing a beginDateTime and endDateTime
 - timeSingleType is a single event, containing an additional element, timeSingle
 - TimePeriodRealTimeType - is an ISO 8601 time interval description, containing an additional element, realTimeDataPeriod
P31D should be interpreted, as Period 31 Days. Data is available for 31 Days prior.

XML REPRESENTATION: EXAMPLE 1: OBSERVATION TIME PERIOD IS A KNOWN RANGE

Example where element variableTimeInterval = TimeIntervalType



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The dateTime type is specified in ISO 8061 format. The following form is the minimum acceptable "YYYY-MM-DDThh:mm:ss" where:

- * YYYY indicates the year
- * MM indicates the month
- * DD indicates the day
- * T indicates the start of the required time section
- * hh indicates the hour
- * mm indicates the minute
- * ss indicates the second

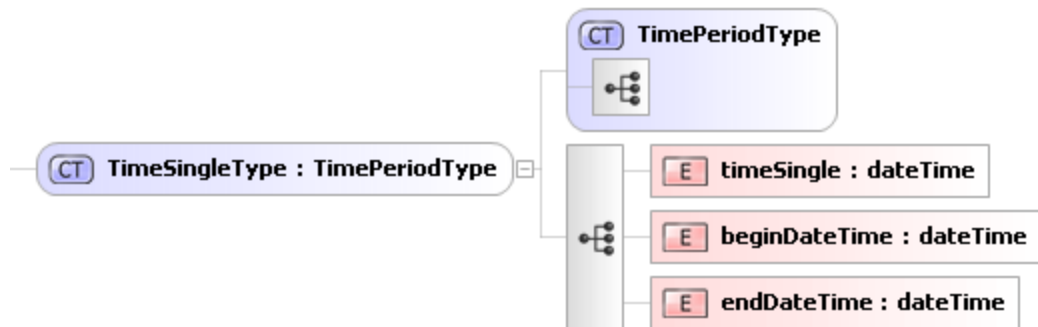
Note: All components are required!

```

<series>
  <variable>
    <variableCode vocabulary="NWIS" default="true"
variableID="7597">00065</variableCode>
    <variableName>feet</variableName>
    <variableDescription>feet.
USGS Parameter Group:physical property USGS Subgroup:Gage
height</variableDescription>
    <units unitsAbbreviation="ft" unitsCode="48">international
foot</units>
  </variable>
  <valueCount countIsEstimated="true">14237</valueCount>
  <variableTimeInterval xsi:type="TimeIntervalType">
    <beginDateTime>1967-10-01T00:00:00</beginDateTime>
    <endDateTime>2006-09-25T00:00:00</endDateTime>
  </variableTimeInterval>
</series>
  
```

XML REPRESENTATION: OBSERVATION TIME PERIOD IS A SINGLE EVENT

Example where element variableTimeInterval = TimeSingleType



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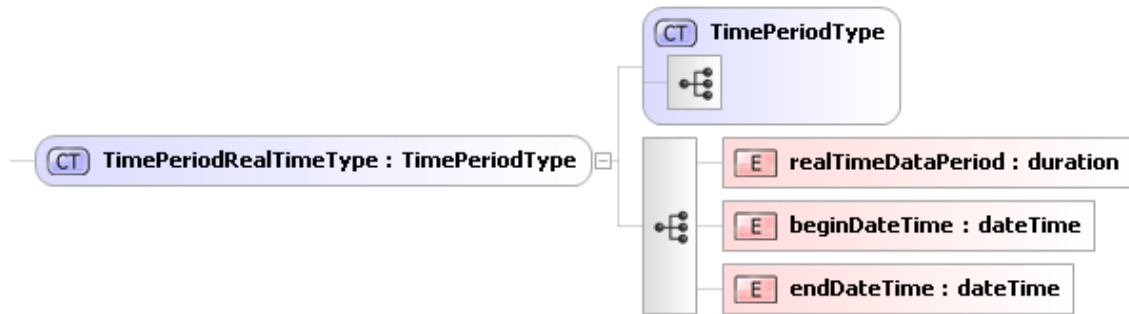
```

<series>
  <variable>
    <variableCode vocabulary="NWIS" default="true"
variableID="1369">01056</variableCode>
    <variableName>water</variableName>
    <variableDescription>water.
USGS Parameter Group:minor and trace inorganics USGS
Subgroup:Manganese</variableDescription>
    <units unitsAbbreviation="mg/L" unitsCode="199">milligrams
per liter</units>
    <note type="nwis:ParameterDescription">Manganese, water,
filtered, micrograms per liter</note>
  </variable>
  <valueCount>1</valueCount>
  <variableTimeInterval xsi:type="TimeSingleType">
    <timeSingle>1972-06-16T00:00:00</timeSingle>
    <beginDateTime>1972-06-16T00:00:00</beginDateTime>
    <endDateTime>1972-06-16T00:00:00</endDateTime>
  </variableTimeInterval>
</series>
  
```

XML REPRESENTATION: OBSERVATION TIME PERIOD IS FLOATING RELATIVE TO TODAY

Example where element variableTimeInterval = TimePeriodRealTimeType

Note. If <site> with a <series> containing the <variableTimeInterval
xsi:type="TimePeriodRealTimeType"> is stored locally or cached, then it will be necessary to recalculate
the <beginDateTime> and <endDateTime>..



Liquid XML Studio - Education Edition 7.1.1.1206

Duration Data Type

The duration data type is used to specify a time interval. The time interval is specified in the following form

"PnYnMnDnHnMnS" where:

- * P indicates the period (required)
- * nY indicates the number of years
- * nM indicates the number of months
- * nD indicates the number of days
- * T indicates the start of a time section (required if you are going to specify hours, minutes, or seconds)
- * nH indicates the number of hours
- * nM indicates the number of minutes
- * nS indicates the number of seconds

```

<series>
  <variable>
    <variableCode vocabulary="NWIS" default="true"
variableID="7579">72019</variableCode>
    <variableName>feet below land surface</variableName>
    <variableDescription>feet below land surface.USGS Parameter
Group:physical property USGS Subgroup:Depth to water
level</variableDescription>
    <units unitsAbbreviation="ft" unitsCode="48">international
foot</units>
  </variable>
  <valueCount countIsEstimated="true">2976</valueCount>
  <variableTimeInterval xsi:type="TimePeriodRealTimeType">
    <realTimeDataPeriod>P31D</realTimeDataPeriod>
    <beginDateTime>2006-09-25T00:00:00</beginDateTime>
    <endDateTime>2006-10-25T00:00:00</endDateTime>
  </variableTimeInterval>

```

```

</series>

```

DESCRIPTION

<seriesCatalog> is an element within the <site>, which is return of a GetSiteInfo response. A <seriesCatalog> contains <series> which are summary information about a set of observations at a site. The observations have a <variable>, and are observed over a time interval specified by <variableTimeInterval>

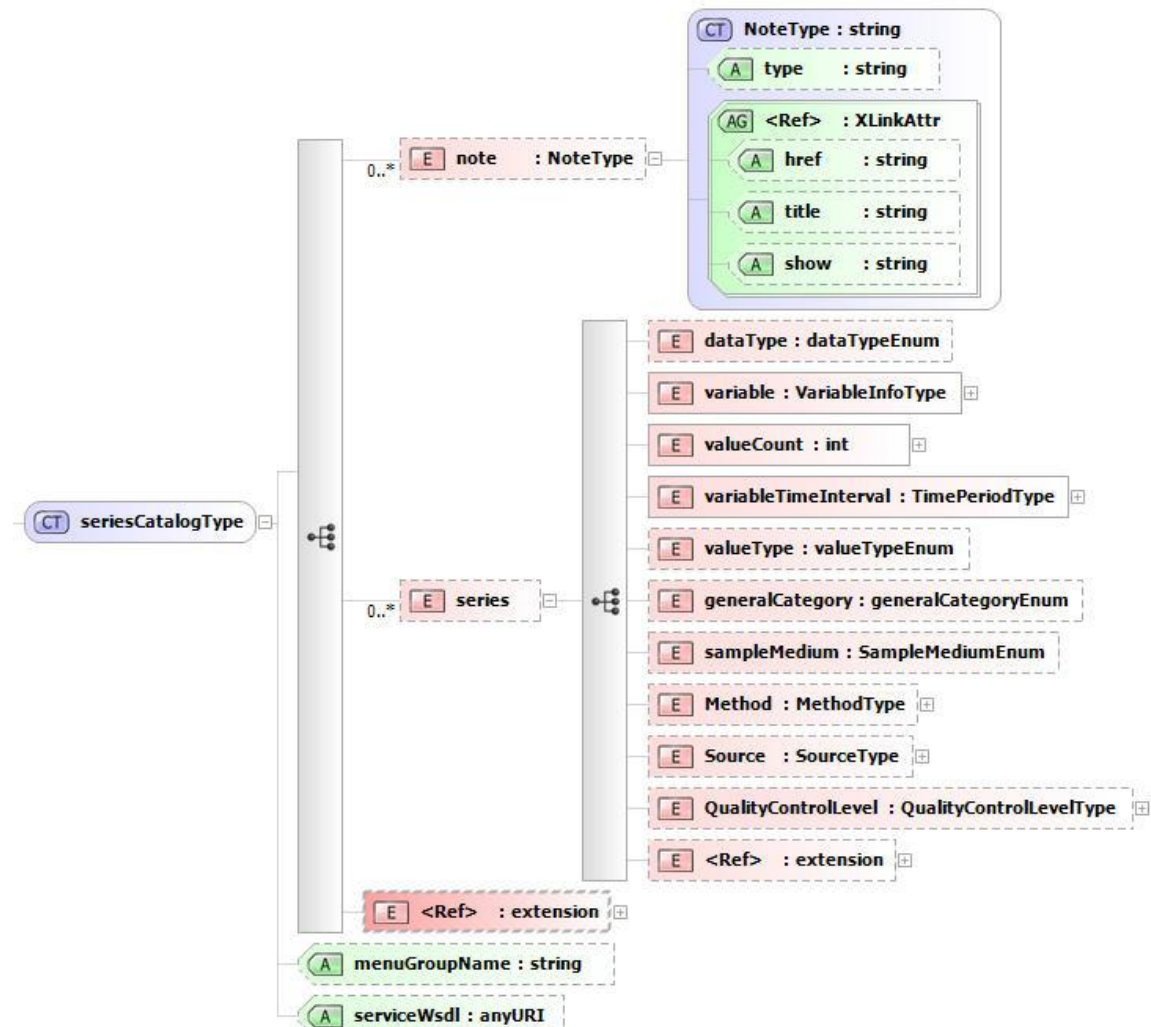


Figure 21. SeriesCatalogType element

- A series contains summary information about a set of observations at a site. The observations have a <variable>, and are observed over a time interval specified by <variableTimeInterval>(see time information, above). In addition, a series has a count of values, <valueCount> which in some cases may be an estimate, in which case @countIsEstimated="true"

- Multiple <seriesCatalog> elements are allowed. This is useful when a location uses the same descriptive codes (site and variable) for different data services. Each <seriesCatalog> can contain multiple <series> elements, the details of <series> are discussed below.
- The attribute @menuGroupName and @serviceWsdL are intended as hints to applications. There use will be depreciated.
 - @serviceWSDL provides where this service getValues is located.
 - @menuGroupName is for the name to be displayed in an HTML select list group.

XML REPRESENTATION EXAMPLE 1:

The example below includes two <seriesCatalog>, each with one <series>. In the first series, the <valueCount>of 14327 is flagged a estimated bysetting the @countIsEstimated="true" This is due to the system being accessed not directly providing a full details of the measured variables.

In the second <seriesCatalog> no @countIsEstimated is seen. This means that this is an exact count.

The polymorphic character of variableTimeInterval is also demonstrated. The first series has an @xsi:type="TimeIntervalType", and represents a range.

The second has an @xsi:type="TimeSingleType" because only a single measurement has been observe red for that variable.

```
<seriesCatalog menuGroupName="USGS Daily Values"
serviceWsdL="http://water.sdsc.edu/waterOneFlow/NWISDV/Service.asmx ">
  <note
type="sourceUrl">http://waterdata.usgs.gov/nwis/dv?[snip]</note>
  <series>
    <variable>
      <variableCode vocabulary="NWIS" default="true"
variableID="7597">00065</variableCode>
      <variableName>feet</variableName>
      <variableDescription>feet.
USGS Parameter Group:physical property USGS Subgroup:Gage
height</variableDescription>
      <units unitsAbbreviation="ft"
unitsCode="48">international foot</units>
    </variable>
    <valueCount countIsEstimated="true">14237</valueCount>
    <variableTimeInterval xsi:type="TimeIntervalType">
      <beginDateTime>1967-10-01T00:00:00</beginDateTime>
      <endDateTime>2006-09-25T00:00:00</endDateTime>
    </variableTimeInterval>
  </series>
</seriesCatalog>
<!-- NOTE series catalog is repeatable -->
<seriesCatalog menuGroupName="USGS Instantaneous Irregular Data"
serviceWsdL="http://water.sdsc.edu/waterOneFlow/NWISIID/Service.asmx ">
  <series>
    <variable>
      <variableCode vocabulary="NWIS" default="true"
variableID="1369">01056</variableCode>
      <variableName>water</variableName>
      <variableDescription>water.
```

```

USGS Parameter Group:minor and trace inorganics USGS
Subgroup:Manganese</variableDescription>
    <units unitsAbbreviation="mg/L"
unitsCode="199">milligrams per liter</units>
    <note type="nwis:ParameterDescription">Manganese,
water, filtered, micrograms per liter</note>
</variable>
<valueCount>1</valueCount>
<variableTimeInterval xsi:type="TimeSingleType">
    <timeSingle>1972-06-16T00:00:00</timeSingle>
    <beginDateTime>1972-06-16T00:00:00</beginDateTime>
    <endDateTime>1972-06-16T00:00:00</endDateTime>
</variableTimeInterval>
</series>
</seriesCatalog>

```

XML REPRESENTATION EXAMPLE 2: DIFFERENT SERIES WITH VARIABLE NAME. AND DIFFERENT PROPERTIES OF THE VARIABLE

```

<seriesCatalog menuGroupName="Local OD GetValues"
serviceWsd1="http://localhost:6278/genericODws/cuahsi_1_0.asmx">
    <series>
        <variable>
            <variableCode vocabulary="LBR" default="true"
variableID="3">USU3</variableCode>
            <variableName>Battery voltage</variableName>
            <valueType>Field Observation</valueType>
            <dataType>Minimum</dataType>
            <generalCategory>Instrumentation</generalCategory>
            <sampleMedium>Other</sampleMedium>
            <units unitsAbbreviation="V"
unitsCode="168">volts</units>
            <NoDataValue>-9999</NoDataValue>
            <timeSupport isRegular="true">
                <unit UnitID="102">
                    <UnitDescription>minute</UnitDescription>
                    <UnitType>Angle</UnitType>
                    <UnitAbbreviation>min</UnitAbbreviation>
                </unit>
                <timeInterval>30</timeInterval>
            </timeSupport>
        </variable>
        <valueCount>7309</valueCount>
        <variableTimeInterval xsi:type="TimeIntervalType">
            <beginDateTime>2007-11-05T14:30:00</beginDateTime>
            <endDateTime>2008-04-05T20:30:00</endDateTime>
        </variableTimeInterval>
        <Method methodID="4">

```

```

        <MethodDescription>Battery voltage measured by
Campbell Scientific CR206 datalogger.</MethodDescription>
    </Method>
    <Source sourceID="2">
        <Organization>Utah State University Utah Water
Research Laboratory</Organization>
        <SourceDescription>Continuous monitoring data
collected by Utah State University as part of a National Science
Foundation funded test bed project.</SourceDescription>
    </Source>
    <QualityControlLevel QualityControlLevelID="0" />
</series>
<series>
    <variable>
        <variableCode vocabulary="LBR" default="true"
variableID="4">USU4</variableCode>
        <variableName>Turbidity</variableName>
        <valueType>Field Observation</valueType>
        <dataType>Average</dataType>
        <generalCategory>Water Quality</generalCategory>
        <sampleMedium>Surface Water</sampleMedium>
        <units unitsAbbreviation="NTU"
unitsCode="221">nephelometric turbidity units</units>
        <NoDataValue>-9999</NoDataValue>
        <timeSupport isRegular="true">
            <unit UnitID="100">
                <UnitDescription>second</UnitDescription>
                <UnitType>Angle</UnitType>
                <UnitAbbreviation>s</UnitAbbreviation>
            </unit>
            <timeInterval>5</timeInterval>
        </timeSupport>
    </variable>
    <valueCount>7309</valueCount>
    <variableTimeInterval xsi:type="TimeIntervalType">
        <beginDateTime>2007-11-05T14:30:00</beginDateTime>
        <endDateTime>2008-04-05T20:30:00</endDateTime>
    </variableTimeInterval>
    <Method methodID="2">
        <MethodDescription>Turbidity measured using a Forest
Technology Systems DTS-12 turbidity sensor.</MethodDescription>
    </Method>
    <Source sourceID="2">
        <Organization>Utah State University Utah Water
Research Laboratory</Organization>
        <SourceDescription>Continuous monitoring data
collected by Utah State University as part of a National Science
Foundation funded test bed project.</SourceDescription>
    </Source>
    <QualityControlLevel QualityControlLevelID="0" />
</series>
<series>
    <variable>
        <variableCode vocabulary="LBR" default="true"
variableID="5">USU5</variableCode>

```

```

        <variableName>Turbidity</variableName>
        <valueType>Field Observation</valueType>
        <dataType>Variance</dataType>
        <generalCategory>Water Quality</generalCategory>
        <sampleMedium>Surface Water</sampleMedium>
        <units unitsAbbreviation="NTU"
unitsCode="221">nephelometric turbidity units</units>
        <NoDataValue>-9999</NoDataValue>
        <timeSupport isRegular="true">
            <unit UnitID="100">
                <UnitDescription>second</UnitDescription>
                <UnitType>Angle</UnitType>
                <UnitAbbreviation>s</UnitAbbreviation>
            </unit>
            <timeInterval>5</timeInterval>
        </timeSupport>
    </variable>
    <valueCount>7309</valueCount>
    <variableTimeInterval xsi:type="TimeIntervalType">
        <beginDateTime>2007-11-05T14:30:00</beginDateTime>
        <endDateTime>2008-04-05T20:30:00</endDateTime>
    </variableTimeInterval>
    <Method methodID="2">
        <MethodDescription>Turbidity measured using a Forest
Technology Systems DTS-12 turbidity sensor.</MethodDescription>
    </Method>
    <Source sourceID="2">
        <Organization>Utah State University Utah Water
Research Laboratory</Organization>
        <SourceDescription>Continuous monitoring data
collected by Utah State University as part of a National Science
Foundation funded test bed project.</SourceDescription>
    </Source>
    <QualityControlLevel QualityControlLevelID="0" />
</series>
</seriesCatalog>

```

XML REPRESENTATION EXAMPLE 3: QUALITY CONTROL LEVEL 1

```

<seriesCatalog menuGroupName="Local OD GetValues"
serviceWsd1="http://localhost:6278/genericODws/cuahsi_1_0.asmx">
    <series>
        <variable>
            <variableCode vocabulary="LBR" default="true"
variableID="39">USU39</variableCode>
            <variableName>Phosphorus, total as P</variableName>
            <valueType>Sample</valueType>
            <dataType>Sporadic</dataType>
            <generalCategory>Water Quality</generalCategory>
            <sampleMedium>Surface Water</sampleMedium>

```



```

        <units unitsAbbreviation="mg/L"
unitsCode="199">milligrams per liter</units>
        <NoDataValue>-9999</NoDataValue>
        <timeSupport isRegular="false" />
    </variable>
    <valueCount>12</valueCount>
    <variableTimeInterval xsi:type="TimeIntervalType">
        <beginDateTime>2007-11-07T13:00:00</beginDateTime>
        <endDateTime>2008-02-12T14:40:00</endDateTime>
    </variableTimeInterval>
    <Method methodID="25">
        <MethodDescription>Water chemistry grab sample
collected by technicians in the field.</MethodDescription>
    </Method>
    <Source sourceID="3">
        <Organization>Utah State University Utah Water
Research Laboratory</Organization>
        <SourceDescription>Water chemistry monitoring data
collected by Utah State University as part of a National Science
Foundation funded test bed project.</SourceDescription>
    </Source>
    <QualityControlLevel QualityControlLevelID="1" />
</series>
<series>
    <variable>
        <variableCode vocabulary="LBR" default="true"
variableID="40">USU40</variableCode>
        <variableName>Phosphorus, total as P,
filtered</variableName>
        <valueType>Sample</valueType>
        <dataType>Sporadic</dataType>
        <generalCategory>Water Quality</generalCategory>
        <sampleMedium>Surface Water</sampleMedium>
        <units unitsAbbreviation="mg/L"
unitsCode="199">milligrams per liter</units>
        <NoDataValue>-9999</NoDataValue>
        <timeSupport isRegular="false" />
    </variable>
    <valueCount>11</valueCount>
    <variableTimeInterval xsi:type="TimeIntervalType">
        <beginDateTime>2007-11-07T13:00:00</beginDateTime>
        <endDateTime>2008-02-12T14:40:00</endDateTime>
    </variableTimeInterval>
    <Method methodID="25">
        <MethodDescription>Water chemistry grab sample
collected by technicians in the field.</MethodDescription>
    </Method>
    <Source sourceID="3">
        <Organization>Utah State University Utah Water
Research Laboratory</Organization>
        <SourceDescription>Water chemistry monitoring data
collected by Utah State University as part of a National Science
Foundation funded test bed project.</SourceDescription>
    </Source>
    <QualityControlLevel QualityControlLevelID="1" />

```

```
</series>  
</seriesCatalog>
```


TIME SUPPORT

The VariableInfoType (<variable> element) contains information on the time support (or temporal footprint) of the data values. @isRegular indicates if the spacing is regular. In waterML 1.0, there is a divergence of mean between ODM, and WaterML. WaterML only communicates the regularity, and the spacing of the observations (timeInterval). Whereas timesupport in the ODM is associated with the dataType, and time support. This will be addressed in 1.1

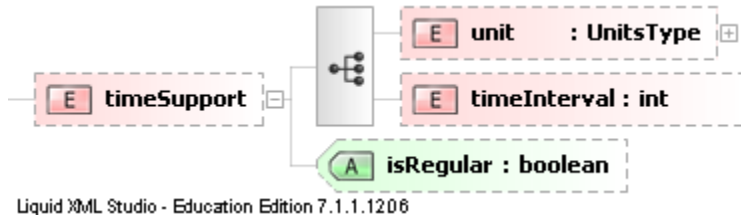


Figure 22. timeSupport

In WaterML 1.0, if attribute @isRegular=false indicates that the data is instantaneous. If @isRegular=true, this indicates if the spacing is regular, and the timeInterval indicates the spacing between the observation. The default for the TimeSupport field is 0, which corresponds to instantaneous values. If the TimeSupport field is set to a value other than 0, an appropriate units of time must be specified; it can only reference valid Units from the Units controlled vocabulary table. If the TimeSupport field is set to 0, any time units can be used (i.e., seconds, minutes, hours, etc.), however a default value of 103 has been used, which corresponds with hours

This differs from ODM. In ODM, timesupport of 0 is used to indicate data values that are instantaneous.. Other values indicate the time over which the data values are implicitly or explicitly averaged or aggregated. The only method to determine spacing of a set of values is to retrieve the values. In ODM, the default for the TimeSupport field is 0, which corresponds to instantaneous values.

XML REPRESENTATION: EXAMPLE 1: HOURLY VALUE

```
<variable>
  <variableCode vocabulary="LBR" default="true"
variableID="19">USU19</variableCode>
  <variableName>Wind direction</variableName>
  <valueType>Field Observation</valueType>
  <dataType>Average</dataType>
  <generalCategory>Climate</generalCategory>
  <sampleMedium>Air</sampleMedium>
  <units unitsAbbreviation="deg" unitsCode="2"
unitsType="Angle">degree</units>
  <NoDataValue>-9999</NoDataValue>
  <timeSupport isRegular="true">
    <unit UnitID="103">
      <UnitDescription>hour</UnitDescription>
      <UnitType>Time</UnitType>
      <UnitAbbreviation>hr</UnitAbbreviation>
    </unit>
  </timeSupport>
</variable>
```

```

        <timeInterval>1</timeInterval>
    </timeSupport>
</variable>

```

XML REPRESENTATION: EXAMPLE 2: 15 MINUTE INTERVAL

```

<variable>
    <variableCode vocabulary="LBR" default="true"
variableID="43">USU43</variableCode>
    <variableName>Discharge</variableName>
    <valueType>Field Observation</valueType>
    <dataType>Average</dataType>
    <generalCategory>Hydrology</generalCategory>
    <sampleMedium>Surface Water</sampleMedium>
    <units unitsAbbreviation="cfs" unitsCode="35"
unitsType="Flow">cubic feet per second</units>
    <NoDataValue>-9999</NoDataValue>
    <timeSupport isRegular="true">
        <unit UnitID="102">
            <UnitDescription>minute</UnitDescription>
            <UnitType>Time</UnitType>
            <UnitAbbreviation>min</UnitAbbreviation>
        </unit>
        <timeInterval>15</timeInterval>
    </timeSupport>
</variable>

```

XML REPRESENTATION: EXAMPLE 3: INSTANTANEOUS

```

<variable>
    <variableCode vocabulary="LBR" default="true"
variableID="41">USU41</variableCode>
    <variableName>Solids, total Suspended</variableName>
    <valueType>Sample</valueType>
    <dataType>Sporadic</dataType>
    <generalCategory>Water Quality</generalCategory>
    <sampleMedium>Surface Water</sampleMedium>
    <units unitsAbbreviation="mg/L" unitsCode="199">milligrams per
liter</units>
    <NoDataValue>-9999</NoDataValue>
    <timeSupport isRegular="false" />
</variable>

```

ELEMENTS DEALING WITH WEB METHOD QUERIES

In addition to elements describing hydrologic information, WaterML also defines elements which keep track of the queries that the user made to the WaterOneFlow web service. This provides a means of quality control, so that the user can check to see which inputs a given web method actually received from the client application. This information is stored in an element of the `<QueryInfoType>` type. For example, if the client asked for information about site “147”, the element would return information essentially saying, “you have requested information about site 147”. All of the parameters that the user sent to the web service are stored in a child element of `<QueryInfoType>` called `<criteria>`.

In some cases, a WaterOneFlow web service retrieves information from a data source by navigating to a single URL, and then parsing the information that is returned from that URL. When this scenario occurs, the service may return the URL that it used to retrieve the information. This provides another level of quality control. If the client does not receive the information it expects from the web service, it can navigate to the URL directly to see what information is being returned from the original data source, before being reformatted into WaterML by the web service. When present, the URL is stored in an element named `<queryURL>`.

The `GetSiteInfo`, `GetVariableInfo` and `GetValues` methods of WaterOneFlow services, return, respectively, documents of `SiteInfoResponse`, `VariableResponse`, and `TimeSeriesResponse` types. Each of the response types includes the `queryInfo` element, and the information about sites, variables, and time series respectively. The returned content is described in the following clauses

RESPONSES

Responses are the root elements that are returned by CUAHSI WaterOneFlow web service calls. The responses use the hydrologic elements.

Method	Response
GetValues	timeSeriesResponse
GetVariables	variablesResponse
GetSiteInfo	sitesResponse
GetSites	siteResponse

SITESRESPONSE

DESCRIPTION

Information about point locations is returned in `<sitesResponse>` of the `<SiteInfoResponseType>` type. This element includes information about a site, such as site name and location, and also a catalog of the variables that are measured at the site.

The `<SiteInfoResponseType>` element contains a `<queryInfo>` element of type `<QueryInfoType>`, and a `<site>` element. The `<site>` element contains a `<siteInfo>` element of type `<SiteInfoType>` which gives the basic information about a site such as name and location, and a `<seriesCatalog>` element that lists the variables measured at the site.

The `<seriesCatalog>` element contains one or more `<series>` elements, where each is associated with a single variable at a site. Within the `<series>` element is a `<variable>` element of type `<VariableInfoType>`, and `<variableTimeInterval>` element of type `<TimePeriodType>`. Other elements may also be present to further qualify the series.

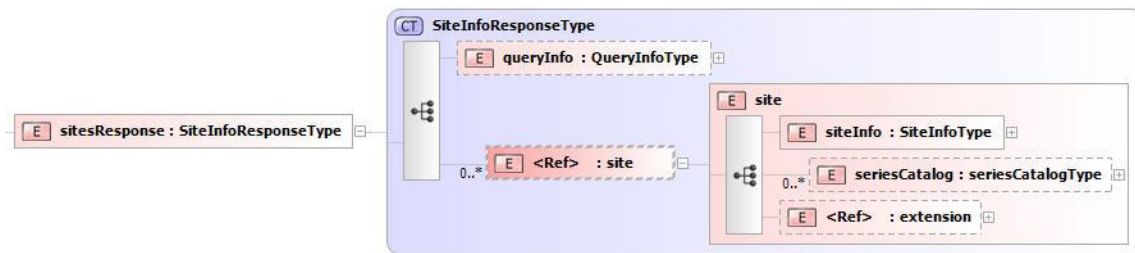


Figure 23. sitesResponse element.

Note:

- The `<siteResponse>` is returned in two forms.
 - A lightweight form intended for communicating location only includes multiple `<site>` elements containing `<siteInfo>` elements (no `<seriesCatalog>`).
 - The complete form is intended to fully describe the observed series at a single `<site>`. A single element `<site>` contains both a `<siteInfo>` element, and one or more `<seriesCatalog>` elements.

- The WaterOneFlow 1.0 API contains no method of returning the full details multiple sites in a GetSiteInfo method call, but there is no restriction in WaterML.

```
<sitesResponse xmlns:xlink="http://www.w3.org/1999/xlink "
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance "
xmlns:wtr="http://www.cuahsi.org/waterML/"
xmlns="http://www.cuahsi.org/waterML/1.0/">
  <queryInfo>
    <criteria>
      <locationParam>NWIS:10263500</locationParam>
    </criteria>
  </queryInfo>
  <site>
    <siteInfo>
      <siteName>BIG ROCK C NR VALYERMO CA</siteName>
      <siteCode network="NWIS"
siteID="4622637">10263500</siteCode>
      <geoLocation>
        <geogLocation xsi:type="LatLonPointType"
srs="EPSG:4269">
          <latitude>34.42083115</latitude>
          <longitude>-117.8395072</longitude>
        </geogLocation>
      </geoLocation>
    </siteInfo>
    <seriesCatalog menuGroupName="USGS Daily Values"
serviceWsdl=" http://water.sdsc.edu/WaterOneFlowDev/DailyValues.asmx">
      <note type="sourceUrl">
http://waterdata.usgs.gov/nwis/dv[snip]&amp;begin_date=2006-12-
09&amp;site_no=10263500</note>
      <series>
        <variable>
          <variableCode vocabulary="NWIS"
default="true" variableID="12578">00060</variableCode>
          <variableName>Discharge, cubic feet per
second</variableName>
          <units unitsAbbreviation="cfs"
unitsCode="35">cubic feet per second</units>
        </variable>
        <valueCount
countIsEstimated="true">30563</valueCount>
        <variableTimeInterval
xsi:type="TimeIntervalType">
          <beginDateTime>1923-02-
01T00:00:00</beginDateTime>
          <endDateTime>2006-10-
07T00:00:00</endDateTime>
        </variableTimeInterval>
      </series>
    </seriesCatalog>
  </site>
</sitesResponse>
```



```

        <seriesCatalog menuGroupName="USGS Unit Values"
serviceWsd1=" http://water.sdsc.edu/WaterOneFlowDev/UnitValues.asmx">
        <note type="sourceUrl">
http://waterdata.usgs.gov/nwis/uv?format=rdb[snip]&amp;begin_date=2006-
12-09&amp;site_no=10263500</note>
        <series>
            <variable>
                <variableCode vocabulary="NWIS"
default="true" variableID="12582">00065</variableCode>
                <variableName>Gage height,
feet</variableName>
                <units unitsAbbreviation="ft"
unitsCode="48">international foot</units>
            </variable>
            <valueCount
countIsEstimated="true">2976</valueCount>
            <variableTimeInterval
xsi:type="TimePeriodRealTimeType">

            <realTimeDataPeriod>P31D</realTimeDataPeriod>
            </variableTimeInterval>
        </series>
        <series>
            <variable>
                <variableCode vocabulary="NWIS"
default="true" variableID="12578">00060</variableCode>
                <variableName>Discharge, cubic feet per
second</variableName>
                <units unitsAbbreviation="cfs"
unitsCode="35">cubic feet per second</units>
            </variable>
            <valueCount
countIsEstimated="true">2976</valueCount>
            <variableTimeInterval
xsi:type="TimePeriodRealTimeType">

            <realTimeDataPeriod>P31D</realTimeDataPeriod>
            </variableTimeInterval>
        </series>
    </seriesCatalog>
</site>
</sitesResponse>

```

VARIABLESRESPONSE

DESCRIPTION

WaterML returns variable information in element called <variablesResponse> of the <VariablesResponseType> type. This element includes information about a variable, such as the name of the variable and its units of measure.

The <variablesResponse> element contains a <variables> element, which contains one or more <variable> elements which are of the <VariableInfoType> type. These <variable> elements are the same building blocks used as the <variable> elements that are returned as part of the SiteInfoResponseType.

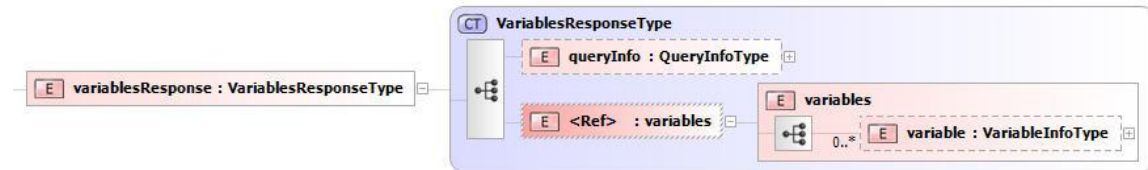


Figure 24. variablesResponse

Note:

- <variablesResponse> may contain more than one variable returned on a single GetVariables call even though a single variable code was requested. This occurs when a service has multiple medium, time intervals, or other variable characteristics

```

<variablesResponse xmlns:gml="http://www.opengis.net/gml"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:wtr="http://www.cuahsi.org/waterML/"
xmlns="http://www.cuahsi.org/waterML/1.0/">
  <variable>
    <variableCode vocabulary="NWIS" default="true"
variableID="1369">01056</variableCode>
    <variableName>water</variableName>
    <variableDescription>water. USGS Parameter Group:minor and
trace inorganics USGS Subgroup:Manganese</variableDescription>
    <units unitsAbbreviation="mg/L" unitsCode="199">milligrams
per liter</units>
    <note type="nwis:ParameterDescription">Manganese, water,
filtered, micrograms per liter</note>
  </variable>
</variablesResponse>
  
```

TIMESERIESRESPONSE

DESCRIPTION

WaterML returns requests for a time series list of values as an element called `<timeSeriesResponse>` of the `<TimeSeriesResponseType>` type. This element includes a time series of values for a given variable at a given site, as well as information about the variable and the site.

The `<timeSeriesResponse>` element contains a `<queryInfo>` element of type `<QueryInfoType>`, and a `<timeSeries>` element of type `<TimeSeriesType>`. The `<queryInfo>` element serves the same purpose as in the `<SiteInfoResponseType>` element.

The `<timeSeries>` element contains three child elements: `<sourceInfo>` of type `<SourceInfoType>`, `<variable>` of type `<VariableInfoType>`, and `<values>` of type `<TsValuesSingleVariableType>`. Each of these XML types were described above as building blocks of WaterML. The `<sourceInfo>` element provides information about the location to which the time series values apply. The `<variable>` element provides information about the variable observed, such as units and name. The `<values>` element contains the time series consisting of datetimes and values.

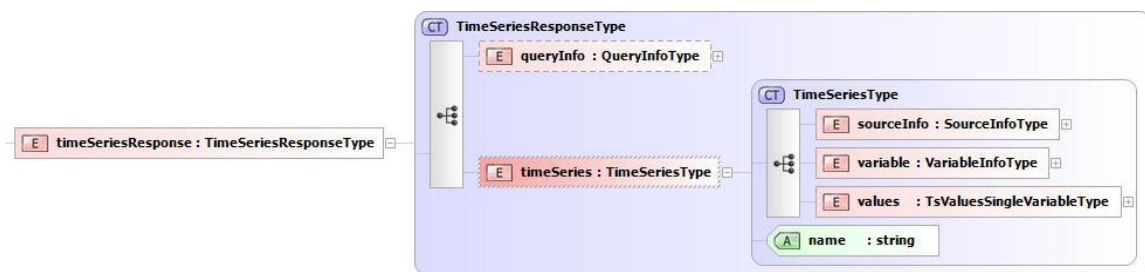


Figure 25. timeSeriesResponse

- A `<timeSeriesResponse>` is a self-contained document that is can be stored on for future retrieval; essential variable, source (site or dataset), and values information are contained in the document.
- In `<timeSeries>`, polymorphism is used on the element `<sourceInfo>`. The `<sourceInfo>` element will have an `xsi:type="SiteInfoType"` or `xsi:type="datasetInfoType"`. If a datasource is site based, then it should return `xsi:type="SiteInfoType"`. Examples of site-based services are the CUAHSI ODM web services, USGS NWIS, EPA STORET, and NCDC ASOS. If a dataset is used to generate the time series, then `xsi:type="datasetInfoType"` should be used. Examples of such latter type of services are DAYMET, and MODIS.
- Populating `<queryInfo>` is encouraged though not required. Using `<queryInfo>` allows users to re-examine the source of information if needed. Often, a single URL is not sufficient to define a source of returned data completely. In this case, additional `<note>` elements with `@type="sourceUrl"` are suggested.
- Elements `<note>` are allowed at the top of the `<timeSeries>`. This makes `<note>` elements more visible that if they were at the end of the message, past the `<values>` element. Elements `<note>` are useful for other content, such as "all values are preliminary" (note: services should also flag such preliminary `<value>`'s with `@qualifiers` and `<qualifiers>` elements).

- WaterML allows for multiple <timeSeries> to be returned in a single response. Clients may not expect this, since in WaterOneFlow API, there are no methods defined to return such responses.

XML REPRESENTATION: EXAMPLE 1: BASIC TIMESERIESRESPONSE

```
<timeSeriesResponse
xmlns:xlink="http://www.w3.org/1999/xlink "
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance "
xmlns:wtr="http://www.cuahsi.org/waterML/"
xmlns="http://www.cuahsi.org/waterML/1.0/">  <queryInfo>

<queryURL>http://nwis.waterdata.usgs.gov/nwis/qwdata?&site_no=01578
310&parameter_cd=00530&format=rdb[snip] </queryURL>
  <criteria>
    <locationParam>NWIS:01578310</locationParam>
    <variableParam>NWIS:00530</variableParam>
    <timeParam>
      <beginDateTime>2001-01-01T00:00:00</beginDateTime>
      <endDateTime>2001-12-31T00:00:00</endDateTime>
    </timeParam>
  </criteria>
</queryInfo>
<timeSeries>
  <sourceInfo xsi:type="SiteInfoType">
    <siteName>SUSQUEHANNA RIVER AT CONOWINGO, MD</siteName>
    <siteCode siteID="4605410">01578310</siteCode>
    <geoLocation>
      <geogLocation xsi:type="LatLonPointType" srs="EPSG:4269">
        <latitude>39.65732996</latitude>
        <longitude>-76.1749532</longitude>
      </geogLocation>
    </geoLocation>
  </sourceInfo>
  <variable>
    <variableCode vocabulary="NWIS" default="true"
variableID="12658">00530</variableCode>
    <variableName>Residue, total nonfilterable, milligrams per
liter</variableName>
    <units unitsAbbreviation="mg/L" unitsCode="199">milligrams per
liter</units>
  </variable>
  <values count="28">
    <value censorCode="lt" dateTime="2001-01-03T11:45:00">10</value>
    <!-- snip -->
    <value dateTime="2001-05-01T11:30:00">12</value>
    <value censorCode="lt" dateTime="2001-05-16T08:45:00">10</value>
    <value censorCode="lt" dateTime="2001-06-12T09:00:00">10</value>
    <value dateTime="2001-06-27T09:20:00">16</value>
    <value dateTime="2001-11-07T11:15:00">42</value>
    <value dateTime="2001-12-11T09:45:00">20</value>
    <!-- needs to have qualifier elements added -->
  </values>
</timeSeries>
```

```
</timeSeriesResponse>
```

XML REPRESENTATION: EXAMPLE 2: MULTIPLE QUALITY CONTROL LEVELS

```
<timeSeriesResponse xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns="http://www.cuahsi.org/waterML/1.0/">
  <queryInfo>
    <creationTime>2009-06-12T17:48:03.640625Z</creationTime>
    <criteria>
      <locationParam>LBR_TEST:USU-LBR-Wellsville</locationParam>
      <variableParam>LBR_TEST:USU41</variableParam>
      <timeParam>
        <beginDateTime>2007-10-04</beginDateTime>
        <endDateTime>2007-12-31</endDateTime>
      </timeParam>
    </criteria>
    <note>OD Web Service</note>
  </queryInfo>
  <timeSeries>
    <sourceInfo xsi:type="SiteInfoType">
      <siteName>Little Bear River near Wellsville, Utah</siteName>
      <siteCode network="LBR" siteID="10">USU-LBR-Wellsville</siteCode>
      <geoLocation>
        <geogLocation xsi:type="LatLonPointType" srs="EPSG:4269">
          <latitude>41.643457</latitude>
          <longitude>-111.917649</longitude>
        </geogLocation>
        <localSiteXY projectionInformation=" NAD83 / UTM zone 12N">
          <X>423579.317</X>
          <Y>4610597.583</Y>
        </localSiteXY>
      </geoLocation>
      <elevation_m>1365</elevation_m>
      <verticalDatum>NGVD29</verticalDatum>
      <note title="County">Cache</note>
      <note title="State">Utah</note>
      <note title="Site Comments">Located on the upstream side of State
Highway 101 bridge.</note>
    </sourceInfo>
    <variable>
      <variableCode vocabulary="LBR" default="true"
variableID="41">USU41</variableCode>
      <variableName>Solids, total Suspended</variableName>
      <valueType>Sample</valueType>
      <dataType>Sporadic</dataType>
      <generalCategory>Water Quality</generalCategory>
      <sampleMedium>Surface Water</sampleMedium>
      <units unitsAbbreviation="mg/L" unitsCode="199">milligrams per
liter</units>
      <NoDataValue>-9999</NoDataValue>
    </variable>
  </timeSeries>
</timeSeriesResponse>
```

```

    <timeSupport isRegular="false" />
  </variable>
  <values unitsAbbreviation="mg/L" unitsCode="199" unitsType="Angle"
count="10">
    <value censorCode="nc" dateTime="2007-11-07T13:00:00"
qualityControlLevel="Quality controlled data" methodID="25"
sourceID="3" sampleID="26">10.5</value>
    <value censorCode="nc" dateTime="2007-11-07T13:00:00"
qualityControlLevel="Derived products" methodID="25" sourceID="3"
sampleID="26">10.5</value>
    <value censorCode="nc" dateTime="2007-11-13T12:30:00"
qualityControlLevel="Derived products" methodID="25" sourceID="3"
sampleID="32">2.5</value>
    <value censorCode="nc" dateTime="2007-11-13T12:30:00"
qualityControlLevel="Quality controlled data" methodID="25"
sourceID="3" sampleID="32">2.5</value>
    <value censorCode="nc" dateTime="2007-11-21T14:00:00"
qualityControlLevel="Quality controlled data" methodID="25"
sourceID="3" sampleID="38">7.2</value>
    <value censorCode="nc" dateTime="2007-11-21T14:00:00"
qualityControlLevel="Derived products" methodID="25" sourceID="3"
sampleID="38">7.2</value>
    <value censorCode="nc" dateTime="2007-12-05T11:00:00"
qualityControlLevel="Derived products" methodID="25" sourceID="3"
sampleID="83">2.5</value>
    <value censorCode="nc" dateTime="2007-12-05T11:00:00"
qualityControlLevel="Quality controlled data" methodID="25"
sourceID="3" sampleID="83">2.5</value>
    <value censorCode="nc" dateTime="2007-12-20T14:05:00"
qualityControlLevel="Quality controlled data" methodID="25"
sourceID="3" sampleID="171">2.5</value>
    <value censorCode="nc" dateTime="2007-12-20T14:05:00"
qualityControlLevel="Derived products" methodID="25" sourceID="3"
sampleID="171">2.5</value>
    <method methodID="25">
      <MethodDescription>Water chemistry grab sample collected by
technicians in the field.</MethodDescription>
    </method>
    <source sourceID="3">
      <Organization>Utah State University Utah Water Research
Laboratory</Organization>
      <SourceDescription>Water chemistry monitoring data collected by
Utah State University as part of a National Science Foundation funded
test bed project.</SourceDescription>
      <ContactInformation>
        <ContactName>Amber Spackman</ContactName>
        <TypeOfContact>main</TypeOfContact>
        <Phone>1-435-797-0045</Phone>
        <Email>amber.s@aggiemail.usu.edu</Email>
        <Address xsi:type="xsd:string">8200 Old Main Hill
, Logan, Utah 84322-8200</Address>
      </ContactInformation>
      <SourceLink>http://water.usu.edu/littlebearriver</SourceLink>
    </source>
  </values>

```

```

    </timeSeries>
</timeSeriesResponse>

```

XML REPRESENTATION EXAMPLE 3: QUALITY CONTROL WITH RAW DATA

```

<timeSeriesResponse xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns="http://www.cuahsi.org/waterML/1.0/">
  <queryInfo>
    <creationTime>2009-06-12T17:48:01.8125Z</creationTime>
    <criteria>
      <locationParam>LBR_TEST:USU-LBR-Mendon</locationParam>
      <variableParam>LBR_TEST:USU3</variableParam>
      <timeParam>
        <beginDateTime>2005-08-05</beginDateTime>
        <endDateTime>2005-08-06</endDateTime>
      </timeParam>
    </criteria>
    <note>OD Web Service</note>
  </queryInfo>
  <timeSeries>
    <sourceInfo xsi:type="SiteInfoType">
      <siteName>Little Bear River at Mendon Road near Mendon,
Utah</siteName>
      <siteCode network="LBR" siteID="1">USU-LBR-Mendon</siteCode>
      <geoLocation>
        <geogLocation xsi:type="LatLonPointType" srs="EPSG:4269">
          <latitude>41.718473</latitude>
          <longitude>-111.946402</longitude>
        </geogLocation>
        <localSiteXY projectionInformation=" NAD83 / UTM zone 12N">
          <X>421276.323</X>
          <Y>4618952.04</Y>
        </localSiteXY>
      </geoLocation>
      <elevation_m>1345</elevation_m>
      <verticalDatum>NGVD29</verticalDatum>
      <note title="County">Cache</note>
      <note title="State">Utah</note>
      <note title="Site Comments">Located below county road bridge at
Mendon Road crossing</note>
    </sourceInfo>
    <variable>
      <variableCode vocabulary="LBR" default="true"
variableID="3">USU3</variableCode>
      <variableName>Battery voltage</variableName>
      <valueType>Field Observation</valueType>
      <dataType>Minimum</dataType>
      <generalCategory>Instrumentation</generalCategory>
      <sampleMedium>Other</sampleMedium>
      <units unitsAbbreviation="V" unitsCode="168">volts</units>
      <NoDataValue>-9999</NoDataValue>
    </variable>
  </timeSeries>

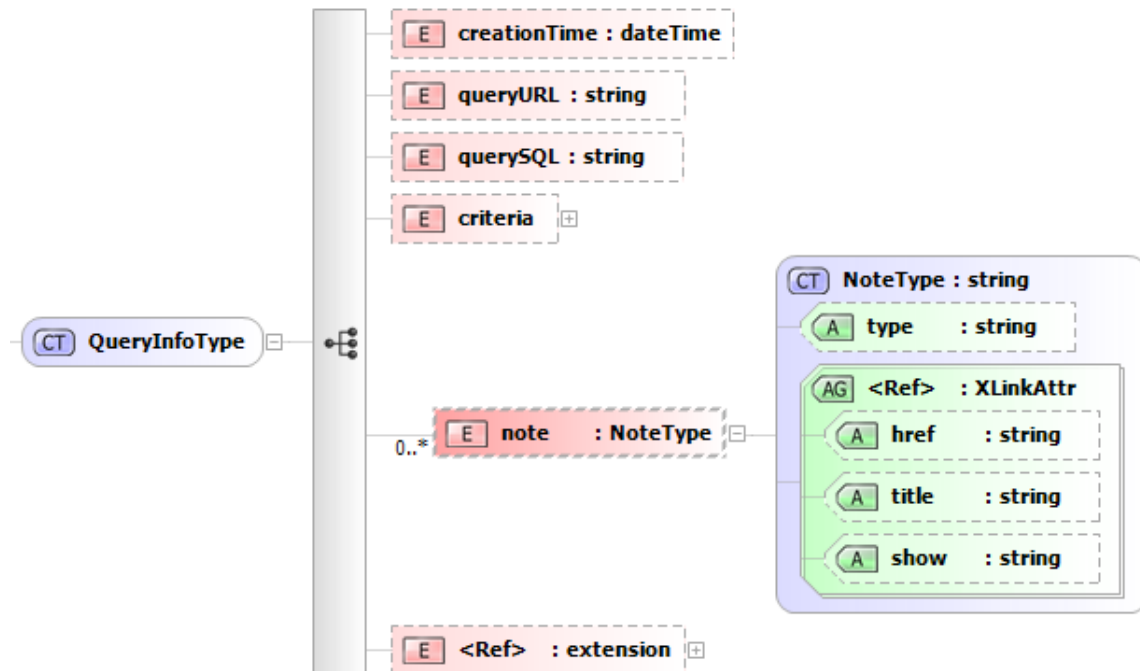
```

```

    <timeSupport isRegular="true">
      <unit UnitID="102">
        <UnitDescription>minute</UnitDescription>
        <UnitType>Time</UnitType>
        <UnitAbbreviation>min</UnitAbbreviation>
      </unit>
      <timeInterval>30</timeInterval>
    </timeSupport>
  </variable>
  <values unitsAbbreviation="V" unitsCode="168" unitsType="Angle"
count="49">
    <value censorCode="nc" dateTime="2005-08-05T00:00:00"
qualityControlLevel="Raw data" methodID="4"
sourceID="1">12.91645</value>
    <value censorCode="nc" dateTime="2005-08-05T00:30:00"
qualityControlLevel="Raw data" methodID="4"
sourceID="1">12.91477</value>
    <!-- snip -->
    <value censorCode="nc" dateTime="2005-08-05T23:30:00"
qualityControlLevel="Raw data" methodID="4"
sourceID="1">12.97437</value>
    <value censorCode="nc" dateTime="2005-08-06T00:00:00"
qualityControlLevel="Raw data" methodID="4"
sourceID="1">12.95674</value>
    <method methodID="4">
      <MethodDescription>Battery voltage measured by Campbell
Scientific CR206 datalogger.</MethodDescription>
      <MethodLink>http://www.campbellsci.com</MethodLink>
    </method>
    <source sourceID="1">
      <Organization>Utah State University Utah Water Research
Laboratory</Organization>
      <SourceDescription>Continuous water quality monitoring by Utah
State University as part of the USDA CEAP Grant</SourceDescription>
      <ContactInformation>
        <ContactName>Jeff Horsburgh</ContactName>
        <TypeOfContact>main</TypeOfContact>
        <Phone>1-435-797-2946</Phone>
        <Email>jeff.horsburgh@usu.edu</Email>
        <Address xsi:type="xsd:string">8200 Old Main Hill
, Logan, UT 84322-8200</Address>
      </ContactInformation>
      <SourceLink>http://www.bearriverinfo.org</SourceLink>
    </source>
  </values>
</timeSeries>
</timeSeriesResponse>

```


QUERYINFO ELEMENT



Notes:

- Each GetValues response includes additional information about the sources of the information. This is called the <queryInfo> block.
- If the service is scraping a web site, the queryURL should be supplied, so that users can go back to the information source.
- The <beginDateTime> and <endDateTime> need not be specified.

XML REPRESENTATION:

```
<queryInfo xmlns="http://www.cuahsi.org/waterML/1.0/">
  <creationTime>2007-04-04T00:00:00</creationTime>
  <queryURL>
    http://nwis.waterdata.usgs.gov/nwis/qwdata?
      &site_no=10324500&parameter_cd=00061&format=rdb&date_format=
      YYYY-MM-DD&begin_date=1977-04-04&end_date=1991-11-01
  </queryURL>
</queryInfo>
```

BIBLIOGRAPHY

- [BUTEK] [Russell Butek](http://www-128.ibm.com/developerworks/xml/library/ws-tip-xsdchoice.html), 2005, *Use polymorphism as an alternative to xsd:choice* retrieved from <http://www-128.ibm.com/developerworks/xml/library/ws-tip-xsdchoice.html>

ANNEX A (NORMATIVE)

CONTROLLED VOCABULARIES (XML ENUMERATIONS)

A1 INTRODUCTION

Controlled vocabularies for the fields are required to maintain consistency and avoid the use of synonyms that can lead to ambiguity. Controlled vocabularies are implemented as XML schema Enumerations. For the enumerations, we use the standards established for the CUAHSI ODM. The following controlled vocabularies in the ODM are mapped to enumerations.

A2 CENSOR CODE CV: <CENSORCODECVENUMERATION>

Term	Definition
(@censored is empty or not present)	not censored
Lt	less than
Gt	greater than
Nc	not censored
Nd	non-detect
pnq	present but not quantified

A3 DATATYPE CV: <DATATYPECVENUMERATION>

Term	Definition
Continuous	A quantity specified at a particular instant in time measured with sufficient frequency (small spacing) to be interpreted as a continuous record of the phenomenon.
Sporadic	The phenomenon is sampled at a particular instant in time but with a frequency that is too coarse for interpreting the record as continuous. This would be the case when the spacing is significantly larger than the support and the time scale of fluctuation of the phenomenon, such as for example infrequent water quality samples.
Cumulative	The values represent the cumulative value of a variable measured or calculated up to a given instant of time, such as cumulative volume of flow or cumulative precipitation.
Incremental	The values represent the incremental value of a variable over a time interval, such as the incremental volume of flow or incremental precipitation.
Average	The values represent the average over a time interval, such as daily mean

	discharge or daily mean temperature.
Maximum	The values are the maximum values occurring at some time during a time interval, such as annual maximum discharge or a daily maximum air temperature.
Minimum	The values are the minimum values occurring at some time during a time interval, such as 7-day low flow for a year or the daily minimum temperature.
Constant Over Interval	The values are quantities that can be interpreted as constant over the time interval from the previous measurement.
Categorical	The values are categorical rather than continuous valued quantities. Mapping from Value values to categories is through the CategoryDefinitions table.

A4 GENERAL CATEGORY CV: <GENERALCATEGORYCVENUMERATION>

Term	Definition
Water Quality	Data associated with water quality variables or processes
Climate	Data associated with the climate, weather, or atmospheric processes
Hydrology	Data associated with hydrologic variables or processes
Biota	Data associated with biological organisms
Geology	Data associated with geology or geological processes

A5 QUALITY CONTROL LEVELS CV: <QUALITYCONTROLLEVELENUMERATION>

QualityControlLevelID	Definition	Explanation
0	Raw data	Raw data is defined as unprocessed data and data products that have not undergone quality control. Depending on the data type and data transmission system, raw data may be available within seconds or minutes after real-time. Examples include real time precipitation, streamflow and water quality measurements.
1	Quality controlled data	Quality controlled data have passed quality assurance procedures such as routine estimation of timing and sensor calibration or visual inspection and removal of obvious errors. An example is USGS published streamflow records following parsing through USGS quality control procedures.
2	Derived products	Derived products require scientific and technical interpretation and include multiple-sensor data. An example might be basin average precipitation derived from rain gages using an interpolation procedure.
3	Interpreted products	These products require researcher (PI) driven analysis and interpretation, model-based interpretation using other data and/or

		strong prior assumptions. An example is basin average precipitation derived from the combination of rain gages and radar return data.
4	Knowledge products	These products require researcher (PI) driven scientific interpretation and multidisciplinary data integration and include model-based interpretation using other data and/or strong prior assumptions. An example is percentages of old or new water in a hydrograph inferred from an isotope analysis.

A6 SAMPLE MEDIUM CV: <SAMPLEMEDIUMCVENUMERATION>

Term	Definition
Surface Water	Sample taken from surface water such as a stream, river, lake, pond, reservoir, ocean, etc.
Ground Water	Sample taken from water located below the surface of the ground, such as from a well or spring
Sediment	Sample taken from the sediment beneath the water column
Soil	Sample taken from the soil
Air	Sample taken from the atmosphere
Tissue	Sample taken from the tissue of a biological organism
Precipitation	Sample taken from solid or liquid precipitation

A7 SAMPLE TYPE CV: <SAMPLETYPECVENUMERATION>

Term	Definition
FD	Foliage Digestion
FF	Forest Floor Digestion
FL	Foliage Leaching
LF	Litter Fall Digestion
GW	Groundwater
PB	Precipitation Bulk
PD	Petri Dish (Dry Deposition)
PE	Precipitation Event
PI	Precipitation Increment
PW	Precipitation Weekly
RE	Rock Extraction
SE	Stemflow Event
SR	Standard Reference
SS	Streamwater Suspended Sediment
SW	Streamwater
TE	Throughfall Event

TI	Throughfall Increment
TW	Throughfall Weekly
VE	Vadose Water Event
VI	Vadose Water Increment
VW	Vadose Water Weekly
Grab	Grab sample

A8 TOPIC CATEGORY CV: <TOPICCATEGORYCVENUMERATION>

Term	Definition
farming	Data associated with agricultural production
Biota	Data associated with biological organisms
boundaries	Data associated with boundaries
climatology/meteorology/atmosphere	Data associated with climatology, meteorology, or the atmosphere
economy	Data associated with the economy
elevation	Data associated with elevation
environment	Data associated with the environment
geoscientificInformation	Data associated with geoscientific information
health	Data associated with health
imageryBaseMapsEarthCover	Data associated with imagery, base maps, or earth cover
intelligenceMilitary	Data associated with intelligence or the military
inlandWaters	Data associated with inland waters
location	Data associated with location
oceans	Data associated with oceans
planningCadastre	Data associated with planning or cadastre
society	Data associated with society
structure	Data associated with structure
transportation	Data associated with transportation
utilitiesCommunication	Data associated with utilities or communication

A9 UNITS CV: <UNITSCVENUMERATION>

UnitsID	UnitsName	UnitsType	UnitsAbbreviation
1	percent	Dimensionless	%
2	degree	Angle	deg
3	grad	Angle	grad
4	radian	Angle	rad
5	degree north	Angle	degN
6	degree south	Angle	degS
7	degree west	Angle	degW
8	degree east	Angle	degE

9	arcminute	Angle	arcmin
10	arcsecond	Angle	arcsec
11	steradian	Angle	sr
12	acre	Area	ac
13	hectare	Area	ha
14	square centimeter	Area	cm ²
15	square foot	Area	ft ²
16	square kilometer	Area	km ²
17	square meter	Area	m ²
18	square mile	Area	mi ²
19	hertz	Frequency	Hz
20	darcy	Permeability	D
21	british thermal unit	Energy	BTU
22	calorie	Energy	cal
23	erg	Energy	erg
24	foot pound force	Energy	lbf ft
25	joule	Energy	J
26	kilowatt hour	Energy	kW h
27	electronvolt	Energy	eV
28	langley's per day	Energy Flux	Ly/d
29	langley's per minute	Energy Flux	Ly/m
30	langley's per second	Energy Flux	Ly/s
31	megajoules per square meter per day	Energy Flux	MJ/m ² d
32	watts per square centimeter	Energy Flux	W/cm ²
33	watts per square meter	Energy Flux	W/m ²
34	acre feet per year	Flow	ac ft/yr
35	cubic feet per second	Flow	cfs
36	cubic meters per second	Flow	m ³ /s
37	cubic meters per day	Flow	m ³ /d
38	gallons per minute	Flow	gpm
39	liters per second	Flow	l/s
40	million gallons per day	Flow	MGD
41	dyne	Force	dyn
42	kilogram force	Force	kgf
43	newton	Force	N
44	pound force	Force	lbf
45	kilo pound force	Force	kip
46	ounce force	Force	ozf
47	centimeter	Length	cm
48	international foot	Length	ft
49	international inch	Length	in
50	international yard	Length	yd
51	kilometer	Length	km
52	meter	Length	m
53	international mile	Length	mi

54	millimeter	Length	mm
55	micron	Length	um
56	angstrom	Length	Å
57	femtometer	Length	fm
58	nautical mile	Length	nmi
59	lumen	Light	lm
60	lux	Light	lx
61	lambert	Light	La
62	stilb	Light	sb
63	phot	Light	ph
64	langley	Light	Ly
65	gram	Mass	gr
66	kilogram	Mass	kg
67	milligram	Mass	mg
68	microgram	Mass	mg
69	pound mass (avoirdupois)	Mass	lb
70	slug	Mass	slug
71	metric ton	Mass	tonne
72	grain	Mass	grain
73	carat	Mass	car
74	atomic mass unit	Mass	amu
75	short ton	Mass	ton
76	BTU per hour	Power	BTU/hr
77	foot pound force per second	Power	lbf/s
78	horse power (shaft)	Power	hp
79	kilowatt	Power	kW
80	watt	Power	W
81	voltampere	Power	VA
82	atmospheres	Pressure/Stress	atm
83	pascal	Pressure/Stress	Pa
84	inch of mercury	Pressure/Stress	inch Hg
85	inch of water	Pressure/Stress	inch H2O
86	millimeter of mercury	Pressure/Stress	mmHg
87	millimeter of water	Pressure/Stress	mmH2O
88	centimeter of mercury	Pressure/Stress	cmHg
89	centimeter of water	Pressure/Stress	cmH2O
90	millibar	Pressure/Stress	mbar
91	pound force per square inch	Pressure/Stress	psi
92	torr	Pressure/Stress	torr
93	barie	Pressure/Stress	barie
94	meters per pixel	Resolution	
95	meters per meter	Scale	
96	degree celcius	Temperature	degC
97	degree fahrenheit	Temperature	degF
98	degree rankine	Temperature	degR
99	degree kelvin	Temperature	degK

100	second	Time	sec
101	millisecond	Time	millisec
102	minute	Time	min
103	hour	Time	hr
104	day	Time	d
105	week	Time	week
106	month	Time	month
107	common year (365 days)	Time	yr
108	leap year (366 days)	Time	leap yr
109	Julian year (365.25 days)	Time	jul yr
110	Gregorian year (365.2425 days)	Time	greg yr
111	centimeters per hour	Velocity	cm/hr
112	centimeters per second	Velocity	cm/s
113	feet per second	Velocity	ft/s
114	gallons per day per square foot	Velocity	gpd/ft2
115	inches per hour	Velocity	in/hr
116	kilometers per hour	Velocity	km/h
117	meters per day	Velocity	m/d
118	meters per hour	Velocity	m/hr
119	meters per second	Velocity	m/s
120	miles per hour	Velocity	mph
121	millimeters per hour	Velocity	mm/hr
122	nautical mile per hour	Velocity	knot
123	acre foot	Volume	ac ft
124	cubic centimeter	Volume	cc
125	cubic foot	Volume	ft3
126	cubic meter	Volume	m3
127	hectare meter	Volume	hec m
128	liter	Volume	L
129	US gallon	Volume	gal
130	barrel	Volume	bbl
131	pint	Volume	pt
132	bushel	Volume	bu
133	teaspoon	Volume	tsp
134	tablespoon	Volume	tbsp
135	quart	Volume	qrt
136	ounce	Volume	oz
137	dimensionless	Dimensionless	-

A10 VALUE TYPE CV: <VALUETYPECVENUMERATION>

Term	Definition
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Field Observation	Observation of a variable using a field instrument
Sample	Observation that is the result of analyzing a sample in a laboratory
Model Simulation Result	Values generated by a simulation model
Derived Value	Value that is directly derived from an observation or set of observations

A11 VARIABLE NAME CV: <VARIABLENAMECVENUMERATION>

Term	Term
Nitrogen, nitrate (NO3) nitrogen as NO3	Biochemical oxygen demand, ultimate carbonaceous
Nitrogen, nitrite (NO2) nitrogen as N	Chemical oxygen demand
Nitrogen, nitrite (NO2) nitrogen as NO2	Oxygen, dissolved
Nitrogen, nitrite (NO2) + nitrate (NO3) nitrogen as N	Light attenuation coefficient
Nitrogen, albuminoid	Secchi depth
Nitrogen, gas	Turbidity
Phosphorus, total as P	Color
Phosphorus, total as PO4	Coliform, total
Phosphorus, organic as P	Coliform, fecal
Phosphorus, inorganic as P	Streptococci, fecal
Phosphorus, phosphate (PO4) as P	Escherichia coli
Discharge, daily average	Iron sulphide
Temperature	Iron, ferrous
Gage height	Iron, ferric
Discharge	Molybdenum
Precipitation	Boron
Evaporation	Chloride
Transpiration	Manganese
Evapotranspiration	Zinc
H2O Flux	Copper
CO2 Flux	Calcium as Ca
CO2 Storage Flux	Calcium as CaCO3
Latent Heat Flux	Phosphorus, phosphate (PO4) as PO4
Sensible Heat Flux	Phosphorus, ortophosphate as P
Radiation, total photosynthetically-active	Phosphorus, ortophosphate as PO4
Radiation, incoming photosynthetically-active	Phosphorus, polyphosphate as PO4
Radiation, outgoing photosynthetically-active	Carlson's Trophic State Index
Radiation, net photosynthetically-active	Oxygen, dissolved percent of saturation
Radiation, total shortwave	Alkalinity, carbonate as CaCO3
Radiation, incoming shortwave	Alkalinity, hydroxide as CaCO3
Radiation, outgoing shortwave	Alkalinity, bicarbonate as CaCO3

Radiation, net shortwave	Carbon, suspended inorganic as C
Radiation, incoming longwave	Carbon, suspended organic as C
Radiation, outgoing longwave	Carbon, dissolved inorganic as C
Radiation, net longwave	Carbon, dissolved organic as C
Radiation, incoming UV-A	Carbon, suspended total as C
Radiation, incoming UV-B	Carbon, total as C
Radiation, net	Langelier Index
Wind speed	Silicon as SiO ₂
Friction velocity	Silicon as Si
Wind direction	Silicate as SiO ₂
Momentum flux	Silicate as Si
Dew point temperature	Sulfur
Relative humidity	Sulfur dioxide
Water vapor density	Sulfur, pyretic
Vapor pressure deficit	Sulfur, rganic
Barometric pressure	Sulfate as SO ₄
Snow depth	Sulfate as S
Visibility	Potassium
Sunshine duration	Magnesium
Hardness, total	Carbon, total inorganic as C
Hardness, carbonate	Carbon, total organic as C
Hardness, non-carbonate	Methylmercury
Bicarbonate	Mercury
Carbonate	Lead
Alkalinity, total	Chromium, total
pH	Chromium, hexavalent
Specific conductance	Chromium, trivalent
Salinity	Cadmium
Solids, total	Chlorophyll a
Solids, total Volatile	Chlorophyll b
Solids, total Fixed	Chlorophyll c
Solids, total Dissolved	Chlorophyll (a+b+c)
Solids, volatile Dissolved	Pheophytin
Solids, fixed Dissolved	Nitrogen, ammonia (NH ₃) as NH ₃
Solids, total Suspended	Nitrogen, ammonia (NH ₃) as N
Solids, volatile Suspended	Nitrogen, ammonium (NH ₄) as NH ₄
Solids, fixed Suspended	Nitrogen, ammonium (NH ₄) as N
Biochemical oxygen demand, 5-day	Nitrogen, ammonia (NH ₃) + ammonium (NH ₄) as N
Biochemical oxygen demand, 5-day carbonaceous	Nitrogen, ammonia (NH ₃) + ammonium (NH ₄) as NH ₄
Biochemical oxygen demand, 5-day nitrogenous	Nitrogen, organic as N
Biochemical oxygen demand, 20-day	Nitrogen, inorganic as N
Biochemical oxygen demand, 20-day nitrogenous	Nitrogen, total as N
Biochemical oxygen demand, ultimate	Nitrogen, kjeldahl as N

Biochemical oxygen demand, ultimate nitrogenous	Nitrogen, nitrate (NO3) as N
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A12 VERTICAL DATUM CV: <VERTICALDATUMCVENUMERATION>

Term	Definition
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
MSL	Mean Sea Level

A13 SPATIAL REFERENCE SYSTEMS

Spatial reference systems specification follows the definitions and the numbering system adopted by EPSG.

CONTROL VOCABULARIES (XML ENUMERATIONS)

Controlled vocabularies for the fields are required to maintain consistency and avoid the use of synonyms that can lead to ambiguity (OD Doc). Controlled vocabularies are implemented as XML schema Enumerations. For the enumerations, we use the standards established for the CUAHSI OD. The following controlled vocabularies in the OD mapped to enumerations. The details of the values are discussed in the OD document (??do we want to repeat here, or extract into a separate document for all??)

- Units <Units Enumeration>
There are 301 units elements. See appendix for description.
- CensorCodeCV <CensorCodeCVEnumeration>
- QualityControlLevel <QualityControlLevelEnumeration>
- SpatialReferences <SpatialReferencesEnumeration>
- SampleMediumCV <SampleMediumCVEnumeration>
- SampleTypeCV <SampleTypeCVEnumeration>
- GeneralCategoryCV <GeneralCategoryCVEnumeration>
- TopicCategoryCV <TopicCategoryCVEnumeration>
- ValueTypeCV <ValueTypeCVEnumeration>
- VerticalDatumCV <VerticalDatumCVEnumeration>
- DataTypeCV <DataTypeCVEnumeration>
- VariableNameCV <VariableNameCVEnumeration>

