S-104

Water Level Information for Surface Navigation Product Specification

Edition 0.0.8 – February 2021

IHO

International Hydrographic Organization

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4b quai Antoine 1er
Principauté de Monaco
Tel: (377) 93.10.81.00
Fax: (377) 93.10.81.40
info@iho.int
www.iho.int

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Version Number	Date	Editor	Purpose
0.0.0	11-Feb-15	Z Jayaswal	Initial Draft
0.0.1	1-May-16	Z Jayaswal	TWCWG 1 – Working group input incorporated from Brazil meeting
0.0.2	Aug-16	Z Jayaswal	TWCWG – incorporate feedback on Portrayal and Attributes
0.0.3	Mar-17	Z Jayaswal	Extract commonality from S-111 v0.1.10 to ensure consistency between standards.
0.0.4	May-17	Z Jayaswal	As edited during TWCWG 2
0.0.5	Nov-17	Z Jayaswal	Feedback from TWCWG and S100 WG
0.0.6	Sep-18	Z Jayaswal	Feedback from TWCWG3 and S-129 WG
0.0.7	Mar 19	Z Jayaswal	Feedback from S100 Test Strategy Working Group Sep 2018
0.0.8	Apr 19	Z Jayaswal, K Hess & G. Seroka	Feedback from NOAA and 4th TWCWG

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IHO S-104 Water Level Information For Surface Navigation

1 Overview

S-104 is the Water Level Information for Surface Navigation Product Specification, produced by the IHO.

The development of electronic navigation with high resolution bathymetric data, and the drive to increase safety of navigation are now demanding time-sensitive data. IHO has identified the requirement for a product specification for dynamic tidal and water level data.

Tidal height information has traditionally been provided as high/low predictions however with increasing drafts and technology, there has been a move to hourly predictions with major ports providing real-time height information to their pilots and web-sites.

There is now a requirement to supply tidal and water level data as a single point time-series and as a surface time series to manage critical depths and provide tidal windows.

1.1 Introduction

This document describes an S-100 compliant product specification for the encapsulation and data transfer of tidal and water level data for use in an Electronic Chart Display and Information System (ECDIS) or any proposed dynamic tide application. Tidal and water level predictions have been fundamental in route planning and entry to ports (SOLAS Chapter V). These have traditionally been supplied as a physical hard copy publication and recently as a separate software installation that may not be integrated with the ECDIS. To improve safety of navigation, this product specification will ensure that tidal and water level data supplied for dynamic capability is consistent by all approved authorities.

1.1.1 Data Types

There are two different data types that can be delivered to a ship and/or to an ECDIS:

1. a time series of water level height relative to a vertical datum and trend. The data can represent either a single point (i.e. one geographic location) or for an array of points contained in a grid. Time and datum information are contained in the metadata. One purpose of this data type is to update water depths for under-keel clearance management.

2. a datum separation (difference) product (“hydroid”), which provides the separation between two vertical datum fields, such as a tidal/chart datum and a defined ellipsoid. Information defining the specific datums is contained in the metadata. The purpose of this data type is to support hydrographic surveying.

1.1.2 Display

There are two different means of displaying water level data to support navigation, route planning, and route monitoring:

1. display of water level at a single point. The portrayal options for this are:
    a. a symbol at the location of the water level data source
    b. a text box containing information on the water level height, trend, etc.
    c. graphic time series plot(s) showing water level height over time at one or more locations

2. display of a single point location from gridded data, where a mouse click on the chart area will display the information at that point from the nearest node in the grid. The display has the qualities as described in type (1) - display of water level at a single point.

1.1.3 Encoding

There is one encoding of water level data:

1. HDF5 (Hierarchical Data Format version 5) is used for encoding time series of water level heights and trends at a single point or at an array of points in a grid, and for encoding the ellipsoid-to-chart datum separation product ("hydroid"). HDF5 promotes compatible data exchange due to its common neutral encoding format. HDF5 is object oriented and suitable for many types of data and forms the basis of the Network Common Data Form (NetCDF), a popular format used for scientific data.

Table 1.1 summarizes Clauses 1.1.1 through 1.1.3.

Table 1.1 – S-104 data variables, formats, encoding and display. Note: O = Overlay: a layer superimposed on and georeferenced to a nautical chart. I = Inset: a graphic that can be placed anywhere on the screen.

Data Variable	Data Format	Encoding	Display
Water Level Height and Trend	Single Location, Single Time (e.g. Obs.)	HDF5	Symbol (O), Text Box (O)
	Single Location, Time Series (e.g. Harmonic Constant Prediction)	HDF5	Symbol (O), Text Box (O), Graphic Plot (I)
	Multiple Locations, Time Series (e.g. Gridded Forecast)	HDF5	Symbol (O), Text Box (O), Graphic Plot (I)
Datum Separation	Multiple Locations (e.g. Gridded Field)	HDF5	None

1.2 References

1.2.1 Normative

S-44 *IHO Standards for Hydrographic Surveys,* 5th Edition February 2008

S-100 *IHO Universal Hydrographic Data Model*, version 3.0.0 (June 2017)

S-101 *IHO Electronic Navigational Chart Product Specification*, July 2014

S-102 *IHO Bathymetric Surface Product Specification*, April 2012

S-111 *IHO Surface Currents Product Specification, December 2018*

netCDF – Network Common Data Form Unidata - www.unidata.ucar.edu/software/netcdf

***HDF5 –** Hierarchical Data Format version 5 – www.hdfgroup.org*

1.2.2 Informative

ISO 8601:2004 *Data elements and interchange formats - Information interchange - Representation of dates and times*

ISO 3166-1:1997 Country Codes

ISO/TS 19103:2005 *Geographic information – Conceptual schema language*

ISO 19111:2003 *Geographic information – Spatial referencing by coordinates*

ISO 19115:2003 *Geographic information – Metadata updated by Corr1 (2006)*

ISO 19115-2:2009 *Geographic information – Metadata: Extensions for imagery and gridded data*

ISO 19123:2005 *Geographic information – Schema for coverage geometry and functions*

ISO 19129:2009 *Geographic information – Imagery gridded and coverage data framework*

ISO 19131:2007 *Geographic information – Data product specifications*

ISO/IEC 19501-1 and 19505-2, *Information technology — Open Distributed Processing – Unified Modelling Language Version 2.4.1*

1.3 Terms, Definitions and Abbreviations

1.3.1 Use of Language

Within this document:

- "Must" indicates a mandatory requirement.
- "Should" indicates an optional requirement, that is the recommended process to be followed, but is not mandatory.
- "May" means "allowed to" or "could possibly", and is not mandatory.

1.3.2 Terms and Definitions

Terms and definitions have been taken from the normative references cited in clause 1.2. Only those which are specific to this document have been included and modified where necessary. Additional terms are defined in this document.

1.3.2.1 Coordinate

one of a sequence of numbers designating the position of a point in N-dimensional space [ISO 19111]

1.3.2.2 coordinate reference system

coordinate system which is related to the real world by a datum [ISO 19111]

1.3.2.3 coverage

feature that acts as a **function** to return values from its **range** for any **direct position** within its spatial, temporal, or spatiotemporal **domain**
EXAMPLE: Examples include a raster **image**, polygon overlay, or digital elevation matrix
NOTE: In other words, a **coverage** is a **feature** that has multiple values for each **attribute** type, where each **direct position** within the geometric representation of the **feature** has a single value for each **attribute** type [ISO 19123]

1.3.2.4 coverage geometry

configuration of the **domain** of a **coverage** described in terms of **coordinates** [ISO 19123]

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1.3.2.5 data product

dataset or **dataset series** that conforms to a **data product specification**
NOTE: The S-104 data product consists of metadata and one or more sets of water level height and trend, and/or vertical datum difference values [ISO 19131]

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1.3.2.6 direct position

position described by a single set of coordinates within a coordinate reference system [ISO 19107]

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1.3.2.7 domain

well-defined set [ISO 19103]
NOTE: Domains are used to define the domain set and range set of operators and functions.

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1.3.2.8 Elevation

the altitude of the ground level of an object, measured from a specified vertical datum. [IHO S100 GFM]

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1.3.2.9 Feature
abstraction of real world phenomena [ISO 19101]
NOTE: a feature may occur as a type or an instance. Feature type or feature instance should be used when only one is meant.

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1.3.2.10 feature attribute

characteristic of a **feature**
EXAMPLE 1: A **feature attribute** named *colour* may have an **attribute** value *green* which belongs to the **data type** *text*
EXAMPLE 2: A **feature attribute** named *length* may have an **attribute** value *82.4* which belongs to the **data type** *real*
NOTE 1: A **feature attribute** may occur as a **type** or an **instance**. **Feature attribute** type or **feature attribute** instance is used when only one is meant
NOTE 2: A **feature attribute** type has a name, a **data type**, and a **domain** associated to it. A **feature attribute** instance has an **attribute** value taken from the **domain** of the **feature attribute** type
NOTE 3: In a **feature catalogue**, a **feature attribute** may include a value **domain** but does not specify **attribute** values for **feature** instances
[ISO 19101, ISO 19109, ISO 19110, ISO 19117]

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1.3.2.11 Height

distance of a point from a chosen reference surface measured upward along a line perpendicular to that surface. [ISO 19111:2006]
NOTE 1: Height is distinguished from elevation in that is a directional measurement.
NOTE 2: Height is used when referring to water level.

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1.3.2.12 georeferenced grid

grid for which cells can be located by the use of specific algorithms. See **ungeorectified grid**.

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1.3.2.13 grid

network composed of a set of elements, or cells, whose vertices, or nodes, have defined positions within a coordinate system. See also **georeferenced grid, regular grid, ungeorectified grid, node,** and **grid point**. [ISO 19123]
NOTE 1: A rectangular grid has axes perpendicular to each other
NOTE 2: A uniform rectangular grid has constant spacing in the X-direction and constant spacing in the Y-direction, although the two spacing values are not necessarily equal

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1.3.2.14 grid cell

element of a grid defined by its vertices, or **nodes**

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1.3.2.15 grid point

point located at the intersection of two or more **grid cells** in a **grid.** Also called a **node**. [ISO 19123]

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1.3.2.16 Record

Finite, named collection of related items (objects or values) [ISO 19107]
NOTE: Logically, a record is a set of pairs <name,item>

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1.3.2.17 uncertainty

The interval (about a given value) that will contain the true value of the measurement at a specific confidence level [IHO S-44].

NOTE: Errors exists and are the differences between the measured value and the true value. Since the true value is never known it follows that the error itself cannot be known. Uncertainty is a statistical assessment of the likely magnitude of this error.

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1.3.2.18 water level trend

Commented [GS1]: Is "Water Level Height", and "Datum Difference Value" needed here too?

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Change of water level at a given time, such as 'increasing', 'decreasing', or 'steady'.
When the average change of the water level over a one hour period is greater than or equal to a value set by the producing authority in m it is considered "increasing". When it is less than or equal to - value set by the producing authority in m, it is "decreasing". When it is between the values set by the producing authority, it is "steady".
In areas of small water level range, e.g. Baltic Sea, use of "not available" is optional.

1.3.2.19 ungeorectified grid

grid with non-uniform point spacing in any coordinate system. Includes triangular irregular networks (TINs) and those curvilinear coordinate grids whose node positions cannot be calculated analytically.

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1.3.3 Abbreviations

CRS	Coordinate Reference System
ECDIS	Electronic Chart Display Information System
EPSG	European Petroleum Survey Group
ENC	Electronic Navigational Chart
IHO	International Hydrographic Organization
IMO	International Maritime Organization

ISO International Organization for Standardization

1.3.3.1 Notation

In this document conceptual schemas are presented in the Unified Modelling Language (UML). Several model elements used in this schema are defined in ISO standards developed by ISO TC 211, or in IHO S-100. In order to ensure that class names in the model are unique ISO TC/211 has adopted a convention of establishing a prefix to the names of classes that define the TC/211 defined UML package in which the UML class is defined. Since the IHO standards and this product specification make use of classes derived directly from the ISO standards this convention is also followed here. In the IHO standards the class names are identified by the name of the standard, such as "S100" as the prefix optionally followed by the bialpha prefix derived from ISO. For the classes defined in this product specification the prefix is *"S104"*. In order to avoid having multiple classes instantiating the same root classes, the ISO classes and S-100 classes have been used where possible; however, a new instantiated class is required if there is a need to alter a class or relationship to prevent a reverse coupling between the model elements introduced in this document and those defined in S-100 or the ISO model.

Table 1.3.3-1 – Sources of externally defined UML classes

Prefix	Standard	Package
CI	ISO 19115	Citation and Responsible Party
CV	ISO 19123	Coverage Core & Discrete Coverages
DQ	ISO 19115	Data Quality Information
DS	ISO 19115	Metadata Application Information
EX	ISO 19115	Metadata Extent information
IF	ISO 19129	Imagery Gridded and Coverage Data Framework
LI	ISO 19115	Linage Information
MD	ISO 19115	Metadata entity set information
MI	ISO 19115-2	Metadata entity set imagery
S100	IHO S-100	IHO Standard for Hydrographic Data
SC	ISO 19111	Spatial Referencing by Coordinates
SD	ISO 19130	Sensor Data
S101	IHO S-101	IHO Electronic Navigational Chart Product Specification
S102	IHO S-102	IHO Bathymetric Surface Product Specification
S111	IHO S-111	IHO Surface Currents Product Specification

1.4 General Data Product Description

Title: Water Level Information for Surface Navigation Product Specification

Abstract: Encodes information and parameters for use in making a tidal and water level product.

Content: Describes the tidal and water level data contained in the product. The specific content is defined by the feature catalogue and schema.

Spatial Extent:

Description: Areas where Tidal Information is available

East Bounding Longitude: 180

West Bounding Longitude: -180

North Bounding Latitude: 90

South Bounding Latitude: -90

Purpose: The data shall be used to produce a dataset to be used for dynamic water level applications, including an ECDIS.

1.5 Data Product Specification Metadata

Title: IHO S-104 Water Level Product Specification

S-100 Version: 5.0.0

S-104 Version: 0.0.8

Date: February 2021

Language: English

Classification: Unclassified (TBC)

Contact: International Hydrographic Organization.
4 quai Antoine 1er
B.P. 445 MC 98011 MONACO CEDEX
Telephone: +377 93 10 81 00
Telefax: + 377 93 10 81 40

URL: www.iho.int

Commented [JZM2]: Need to point to final version of specification once published

Identifier: S-104

Maintenance: Changes to the Product Specification S-104 are coordinated by Tides, Water Level and Currents Working Group (TWCWG) of the IHO and made available via the IHO Publications website. Maintenance of the Product Specification must conform to IHO Technical Resolution 2/2007 (revised 2010). This specification will be a standing agenda item for TWCWG meeting with clarifications, revisions and new editions released as required. A new edition will be released every 5-10 years depending on technological advances.

1.5.1 IHO Product Specification Maintenance

1.5.1.1 Introduction

Changes to S-104 will be released by the IHO as a new edition, revision, or clarification.

1.5.1.2 New Edition

New Editions of S-104 introduce significant changes. *New Editions* enable new concepts, such as the ability to support new functions or applications, or the introduction of new constructs or data types. *New Editions* are likely to have a significant impact on either existing users or future users of S-104.

1.5.1.3 Revisions

Revisions are defined as substantive semantic changes to S-104. Typically, revisions will change S-104 to correct factual errors; introduce necessary changes that have become evident as a result of practical experience or changing circumstances. A *revision* must not be classified as a clarification. *Revisions* could have an impact on either existing users or future users of S-104. All cumulative *clarifications* must be included with the release of approved corrections revisions.

Changes in a revision are minor and ensure backward compatibility with the previous versions within the same Edition. Newer revisions, for example, introduce new features and attributes. Within the same Edition, a dataset of one version could always be processed with a later version of the feature and portrayal catalogues.

In most cases a new feature or portrayal catalogue will result in a revision of S-104.

1.5.1.4 Clarification

Clarifications are non-substantive changes to S-104. Typically, clarifications: remove ambiguity; correct grammatical and spelling errors; amend or update cross references; insert improved graphics in spelling, punctuation and grammar. A clarification must not cause any substantive semantic change to S-104.

Changes in a clarification are minor and ensure backward compatibility with the previous versions within the same Edition. Within the same Edition, a dataset of one clarification version could always be processed with a later version of the feature and portrayal catalogues, and a portrayal catalogue can always rely on earlier versions of the feature catalogues.

Changes in a clarification are minor and ensure backward compatibility with the previous versions

1.5.1.5 Version Numbers

The associated version control numbering to identify changes (n) to S-104 must be as follows:

New Editions denoted as **n**.0.0

Revisions denoted as n.**n**.0

Clarifications denoted as n.n.**n**

2 Specification Scopes

This product specification outlines the types of water level products from the national Hydrographic Office (HO) or authorised producer, to the end user. The data may be historical observation, real-time observation, astronomical prediction, analysis or hybrid method, hindcast or forecast models. Requirements for data and metadata are provided. The two data products are:

~~1.~~a) Time series product, including series of water level heights relative to a vertical datum and the water level trend (rising, falling, etc.). The data products are i) single point product– provision of water level information for a single point in the traditional graphic display mariners are familiar with from hard copy publications and digital tide tables, and ii) gridded data product– provision of water level information for a defined region as a surface, allowing any grid point to be queried as per a traditional single point.

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~~2.~~ b) Datum separation ("hydroid") product– this product will provide the mariner the separation surface between two vertical datum fields, such as a defined ellipsoid and a tidal, or chart, datum for a defined region.

Scope ID: Global
Level: 006- series
Level name: Water Level Dataset

3 Dataset Identification

Title: Water Level Data Product

Alternate Title: None

Abstract: This data product is a file containing water level data for a particular geographic region and set of times, along with the accompanying metadata describing the content, variables, applicable times, locations and structure of the data product. Water level data is the height of the water observed or mathematically-predicted. The data may consist of water level at a small set of points where observations/or predictions are available or may consist of numerous points organized in a grid as from a hydrodynamic model forecast.

Topic Category: Producing authority to choose the most appropriate from the list below:

Name	ISO 19115 Domain Code	Definition
Elevation	006	Height above or below mean sea level Examples: altitude, bathymetry, digital elevation models, slope, derived products
Inland Waters	012	Inland water features, drainage systems and their characteristics Examples: rivers and glaciers, salt lakes, water utilization plans, dams, currents, floods, water quality, Hydrographic charts
Oceans	014	Features and characteristics of salt water bodies (excluding inland waters) Examples: tides, tidal waves, coastal information, reefs

Geographic Description: Areas specific to water navigation

Spatial Resolution: The spatial resolution, or the spatial dimension of the earth covered by the size of a grid matrix cell (nominal ground sample distance), varies according to the model adopted by the producer.

Purpose: Water level data is intended to be used as stand-alone data or as a layer in an ENC.

Language:	English
Classification:	Data can be classified as one of the following: Unclassified Restricted Confidential Secret Top Secret
Spatial Representation Type:	Coverage
Point of Contact:	Producing Authority.
Use Limitation:	Invalid over land

4 Data Content and structure

4.1 Introduction

This section discusses the application schema, which is described in UML; the feature catalogue; dataset types, in which there is an extensive discussion of the water level data; dataset loading and unloading; and geometry.

Water level data consist of two basic types:

1. a time series of water level height and trend relative to a vertical datum. The data can be represented for either a single point (i.e. one geographic location) or for an array of points contained in a grid. Time and datum information are contained in the metadata.

2. a datum separation product (e.g., a hydroid), which provides the separation between a chart datum and a defined ellipsoid. Datum information is contained in the metadata.

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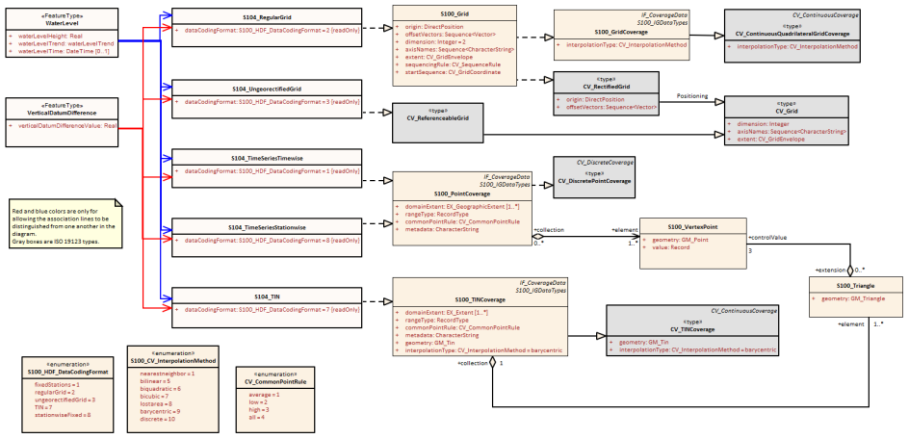

4.2 Figure 4.1 – Spatial Types - Coverages **Application Schema**

Commented [GS3]: These are being updated with the help of S-100WG

This application schema is expressed in UML. The details of the application schema are given in ANNEX C.

4.3 Feature Catalogue

4.3.1 Introduction

The S-104 Feature Catalogue describes the feature types, information types, attributes, attribute values, associations and roles which may be used in the product. See ANNEX D – Feature Catalogue

The S-104 Feature Catalogue is available in an XML document which conforms to the S-100 XML Feature Catalogue Schema and can be downloaded from the IHO website.

4.3.2 Feature Types

4.3.2.1 Geographic

Geographic (geo) feature types form the principle content of S-104 and fully defined by their associated attributes.

4.3.2.2 Meta

Meta features contain information about other features within a data set. Information defined by meta features override the default metadata values defined by the data set descriptive records. Meta attribution on individual features overrides attribution on meta features.

4.3.3 Feature Relationship

A feature relationship links instances of one feature type with instances of the same or a different feature type. There are three common types of feature relationship: Association, Aggregation and Composition. In S-104 there are no relationships used.

4.3.4 Attributes

S-100 defines attributes as either simple or complex. S-104 uses three types of simple attributes; listed in Table 4.1. There are no complex attributes.

Table 4-1 - Simple feature attribute types.

Type	Definition
Enumeration	A fixed list of valid identifiers of named literal values
Real	A signed Real (floating point) number consisting of a mantissa and an exponent
Date and Time	A DateTime is a combination of a date and a time type. Character encoding of a DateTime shall follow ISO 8601:1988 EXAMPLE 19850412T101530

4.3.5 Spatial Quality

Spatial quality attributes (Figure 4.2) are carried in an information class called **spatial quality**. Only points, multipoint and curves can be associated with spatial quality.

Water levels are usually defined at one or more individual locations, so spatial quality applies to these locations. The spatial quality will list the following:

For Single station data product:

1) Port Type- a) Standard/Major or b) Secondary/minor

2) Sigma confidence of predictions/models or

3) Instrument measuring accuracy for observed

For Gridded data product:

1) Sigma confidence of predictions/model

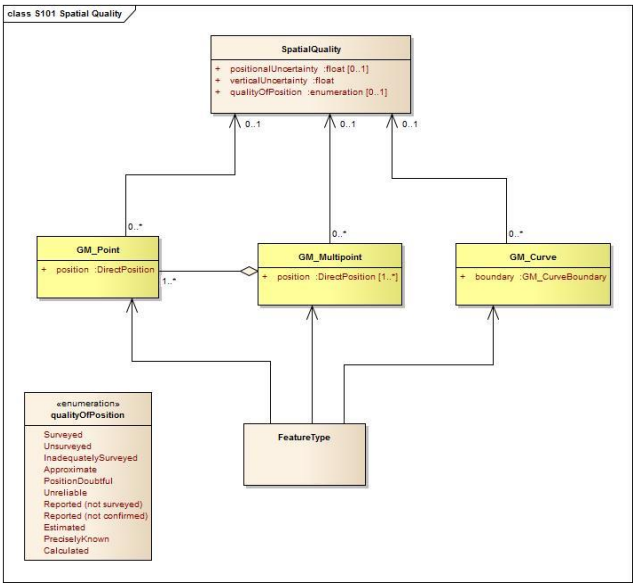

Figure 4.2 - Spatial Quality Information Type

Commented [GS4]: Figure is missing- use same as in S-111, or different?

This may be updated with the help of S-100WG

4.4 Dataset Types

Datasets for S-104 include one basic type:

1. HDF5 files, which may contain (a) time series of predicted or observed water level heights and trends at one or more fixed stations, (b) gridded hydrodynamic model forecast fields, and (c) gridded datum separation (e.g., ellipsoid-to-chart datum) fields.

4.5 Spatial Schema

4.5.1 Coverages

For an ECDIS, water level data and datum separation fields (“hydroid”), are formatted in two ways: arrays of points contained in a regular grid, and sets of points not described by a regular grid. Further details on the data products are given in Clause 10 – Data Product Format.

Water level data have three basic types, based on their sources:

1. observed or predicted values at a number of stationary locations,
2. predicted values (often from hydrodynamic models) arranged in a regular grid, and
3. values at multiple locations but not in a regular grid.

The three types of water level data and the datum separation fields have structures that can be described by two S-100 coverages: S100_PointCoverage and S100_GridCoverage (S-100 v 4.0.0, Clause 8-7).

Grid Coverage The class S100_GridCoverage represents a set of values assigned to the points in a two-dimensional grid. Attributes include *interpolationType, dimension, axisNames, origin, coordinateReferenceSystem, offsetVectors, origin, extent, sequencingRule, startSequence, and rangeType.*

Point Coverage The class S100_PointCoverage represents a set of values, such as water level height and trend values, assigned to a set of arbitrary X,Y points. Each point is identified by a horizontal coordinate geometry pair (X,Y) and assigned one or more values as attribute values. These values are organized in a record for each point. Attributes include *domainExtent, rangeType, metadata, commonPointRule, geometry*, and *value*.

The types of water level data and their corresponding coverages are shown in Table 4.2.

Table 4.2 – Water level data types and their coverages.

N	Type of Data	Coverage
1	Time series data at one or more stationary locations	S100_Point
2	Regularly-gridded data at one or more times	S100_Grid
3	Ungeorectified gridded data, TIN, or point set data at one or more times	S100_Point

The datum separation field data and their corresponding coverages are shown in Table 4.3.

Table 4.3 – Datum separation data types and their coverages.

N	Type of Data	Coverage
1	Separation distance at one location	S100_Point
2	Regularly-gridded separation distance	S100_Grid
3	Ungeorectified gridded data or point set data of separation distance	S100_Point

5 Coordinate Reference Systems (CRS)

The location of a feature in the S-100 standard is defined by means of coordinates, which relate a feature to a position. The S-104 CRS is a compound system, with a two-dimensional ellipsoidal horizontal component and a one-dimensional datum-related vertical component (cf. S-100, Part 6 – Coordinate Reference Systems).

5.1 Horizontal Reference System

For S-104 products, the horizontal CRS must be the ellipsoidal (geodetic) system EPSG:4326 (WGS 84). The full reference to EPSG: 4326 can be found at www.epsg-registry.org.

Horizontal coordinate reference system:	EPSG: 4326 (WGS 84)
Projection:	None
Coordinate reference system registry:	EPSG Geodetic Parameter Registry
Date type (according to ISO 19115):	002 - publication
Responsible party:	International Association of Oil and Gas Producers (IOGP)

5.2 Vertical Reference System

The vertical coordinate is directed upwards (i.e. away from the Earth's centre) from its origin, the vertical datum, and is expressed in units of metres. That is, a positive value for the level of the water level relative to the vertical datum means that the level is above the vertical datum. The vertical datum is not an ellipsoid but is the defined chart datum for the area of interest. The vertical datum must be consistent with the bathymetric CRS in S-102.

5.3 Temporal Reference System

The temporal reference system is the Gregorian calendar for date and UTC for time. Time is measured by reference to Calendar dates and Clock time in accordance with ISO 19108:2002, Temporal Schema clause 5.4.4. A date variable will have the following 8-character format: *yyyymmdd*. A time variable will have the following 7-character format: *hhmmssZ*. A date-time variable will have the following 16-character format: *yyyymmddThhmmssZ*

6 Data Quality

6.1 Introduction

Quality of water level data for navigation consists of quality of the observed/predicted/forecast data, quality of the positional data, and quality of the time stamp. Quality of the observed data depends on the accuracy of the water level gauges and their processing techniques, and is normally available in field survey reports or quality controlled analyses. Quality of predicted/forecast data depends on quality, timeliness, and spatial coverage of the input data as well as the mathematical techniques. Temporal accuracy for observational data is normally available in field survey reports or quality controlled analyses. Temporal accuracy for predicted/forecast data is normally described in technical reports.

Commented [JZM5]: S-100 Review: Add explanation of how data quality is captured and move how data quality is calculated to the Data Classification and Encoding Guide (ection.

6.2 Completeness

A time series is complete when there is a value or a null indicator at every time in the series. A water level coverage data set is complete when the grid or point set coverage value matrix contains height value or null (missing) value for every vertex point defined in the grid, and when all of the mandatory associated metadata is provided. See ANNEX G – Validation Checks

Treatment of null (missing) values for real-time observations (no data sent for that time stamp),. manufacturers to default to predicted/modelled information on ECDIS.

NLD propose the use of "NaN" – not a Number to indicate missing data.

Commented [GS6]: Add other components to this section. See S-111, e.g. Assessment of data, Additional components of data quality, and Validation checks.

7 Data Capture and Classification

The water level product contains data processed from sensors or derived from the output from mathematical models. In most cases, the data collected by the producing authority must be translated, sub-setted, reorganized, or otherwise processed to restructure into a usable data format.

7.1 Data Sources for Water Levels

Water level data comes primarily from a few specific sources: observations, astronomical predictions, analyses, and forecast models. When such data are produced and quality-controlled by an approved producing authority (IHO Resolution A6.3 & A6.9, S-62), they are suitable for inclusion in the Water level data product. See ANNEX F – WATER LEVEL DATA

Commented [GS7]: Ensure this Annex is there, if cited here.

Observational Data: Observational water level data comes initially from *in situ* sensors in the field (.e.g. tide gauges deployed along channel) and are monitored by the data collecting authority. After reception, the data are quality controlled and stored by the producing authority. Some of the observed data may be available for distribution within minutes of being collected and are described as being 'in real time. Other data may be days or years old, and are called historical data.

Astronomical Predictions: Astronomical predictions are produced when a sufficiently long time series of observed water level has been obtained and the data has been harmonically analyzed by the producing authority to produce a set of amplitude and phase constants. The harmonic values can then be used to predict the astronomical component of the water level as a time series covering any desired time interval. Data available for single stations or numerous, may be arranged by the producing authority into a gridded field.

Analyzed and Hybrid Values: Analyzed water level values may be produced from sea-surface topography, data assimilation, statistical correlations or other means. A hybrid method combines two of or more approaches.

Hindcast and Forecast Data: Hydrodynamic models numerically solve a set of fluid dynamic equations in two or three dimensions, and rely on observational data, including water levels and winds, to supply boundary conditions. Model grids may be either regular or irregular. Such models are often run several times per day, and in each run there is usually a hindcast and a forecast. The hindcast is a model simulation that attempts to recreate present conditions by using the most recent observational data, while a forecast is a simulation made for many hours into the future using predicted winds, water levels, etc. The results are saved for a limited number of times, and are stored as arrays that derive from the model's grid. These models and methods are developed, run and monitored by the HO.

These descriptions are summarized in Tables 7.1.

Table 7.1 – Types of water level data, based on the source of the data.

Type	Name	Description
1	Historical observation	Observation made hours, days, etc., in the past
2	Real-time observation	Observation no more than a few minutes old
3	Astronomical prediction	Value computed using harmonic constants only
4	Analysis or hybrid method	Calculation by statistical or other indirect methods, or a combination of methods
5	Hindcast	Gridded data from a two- or three-dimensional dynamic simulation of past conditions using only observed data for boundary forcing, via statistical method or combination
6	Forecast	Gridded data from a two- or three-dimensional dynamic simulation of future conditions using predicted data for boundary forcing, via statistical method or combination

7.2 Data Sources for Datum Separation Fields

For datum separation fields, knowledge of the separation at a number of locations is required, generally at water level stations (where a tidal datum is available). Spatial variations over the regions can be estimated by spatial interpolation methods or with the help of hydrodynamic models.

7.3 The Production Process

Nearly all available information on water level from the Producer must be reformatted to meet the standards of this Product Specification (Figure 10.1 - the S-104 format). This means (a) populating the carrier metadata block (Section 12.3) and values group attributes (Section 12.4) with the relevant metadata and (b) reorganizing the water level data when using the encoding rules (see ANNEX G – HDF5 Encoding for gridded data). Need encoding rules for non-gridded data.

Commented [JZM8]: S100- Review: add production process for point set datasets as its own chapter.

Commented [GS9]: Ensure this Annex is there, if cited.

7.3.1 Metadata

Commented [JZM10]: S100 Review: Add a section on production metadata; such as when the data is valid, when the data was issued, who compiled the data, datums etc.

Metadata is derivable from the information available from the approved authority. The following variables will require additional processing:

1. The bounding rectangle is computable from either the distribution of stations or nodes, or from grid parameters

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Commented [JZM11]: S100 review: add text to state the bounding rectangle is encoded using the E_GeographicBoundingBox type in the bounding box attributes of S100_dataCoverage field in S100_datasetDiscoveryMetadata.

2. Position uncertainties may be available from the approved authority's metadata;

3. Water level uncertainty may be available from the prediction model, specification of the water level gauge or calculated from observations;

7.3.2 Water Level Data

Observational water level and astronomical water level predictions at a single location and gridded forecast data must normally be reformatted to fit the S-104 standard. The following may require additional calculations:

1. For gridded data. If a land mask array is included, the mask value is substituted into the gridded values as appropriate.

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1. Time stamps must be encoded as UTC.

8 Maintenance

Maintenance and Update Frequency: Water level is always moving, so more-or-less- continual revision or updating of the data is essential. For real-time observations, new values are periodically collected (e.g. every 6 minutes). For a forecast, the entire field of water levels is created one or more times per day. New issues of real-time observations or forecasts should be considered new editions.

Commented [JZM12]: S100 Review: Reconsider the use of editions for describing new water level datasets. The issue is highlighted is consider the example of a new edition issued for every real-time observation at 6 minute interval will be ~ 600 edition per day.

Commented [ZJ13]: Consider changing editions to "updates"?

Water level harmonic constant data are updated much less often, typically on an annual basis.

Table 8.1 summarizes this information.

Table 8.1 – Typical update/revision intervals and related information

For S-104 products produced by a single Producer.

Data Types	Interval	Number Of Spatial Locations	Number Of Time Values Per Location
Harmonic Constant Tidal Predictions	1 year	100 to 1,000	52560 (10 minute data) or 8,760 (hourly data)
Model Forecasts	6 hr	100,000 to 1,000,000	1 to 24
Real-time Observations	0.1 hr	1 to 10	1 to 240

Data Source: Data is produced by the producing authority through the collection of observed values, predicting astronomical tides, or running analysis or hindcast/forecast. This data is typically quality-controlled and reformatted to conform to file size limitations and the S-104 standard encoding.

Production Process: S-104 datasets, including the metadata and the coverages for water level, are updated by replacement of the entire data product. Producers routinely collect observational data and maintain an analysis and/or forecast capability. When new data becomes available (often several times per day), the data is reformatted and made available for dissemination.

9 Portrayal

Commented [JZM14]: S100 Review: Create a portrayal catalogue, the different product formats need to be considered.

9.1 Introduction

This section describes means of displaying water level data to support navigation, route planning and route monitoring. Three types of data are discussed in depth. The first is point data, which would apply to historical data, astronomical predictions, forecast/hindcast, and real-time data. The second is regularly gridded data, which would apply to analyses, hindcasts and forecasts. For gridded or point set data, the water level portrayal characteristics used for single-point data can be adapted to displaying data at multiple points.

For example, a point portrayal may be provided to display water level at significant locations such as where real-time observations are available. A gridded portrayal may be provided for voyage planning where a mariner's selection of routes may be influenced by water level at certain way points. Note that not all portrayal categories (point and gridded) may be available for all types of water level data (historical observations, real-time observations, astronomical predictions, and forecast total water level).

All recommended sizes are given assuming a minimum size ECDIS display of 270 by 270 mm or 864 by 864 pixels.

Three portrayal options are provided because of the different types of information that could be supplied. *The options listed below are to allow Members State cater for the information that they have available for their countries. Intent is that the mariner will want to use the data for route planning and real-time navigation.*

9.2 Display of Water Level at a Single Point

Portrayal of water level using single point data should be used in instances where the data source is a water level (e.g. a historical or real-time water level measuring device) at a single geographic location. All text and line colour will be in black unless stated otherwise. The portrayal options are (1) a symbol at the location of the water level data source, (2) a text box containing information on the height, trend, etc., and (3) a graphic plot showing the height over time.

NOTE: All text and line colour will be in black unless stated otherwise.

9.2.1 Symbol

The water level point will be represented by symbol entered in the S-100 GI Registry (see Table 9.1).

Table 9.1 – Beta version of the tide station symbol in the GI Registry.

Symbol	Name	Definition
	TIDEHT01	point for which tide height information is available

9.2.2 Text Box

The information displayed within a window (minimum of 100 x 100 pixels. See Figure 9.2) will be dependent on water level information type. See Table 9.2 for a breakdown of information

Table 9.2 - Numerical information displayed at the location of a water level.

Water Level Type	Information Displayed
All types	UniqueName, date and time stamp (Ship time zone), water level, trend, water level type, additional information (link to create pick report)

Commented [JZM15]: S-100WG Define what a Unique name is and how it first within the Maritime Resource Name concept

Commented [GS16]: Consider adding/naming vertical datum reference

Commented [ZJ17R16]: Why? This data should be supplied on the same datum as the chart in use. There should be a machine check that the tide predictions are on the same datum as S-101 and S-102 products and a warning that the data cannot be loaded if conflicting datum.

Commented [GS18R16]: Agreed!

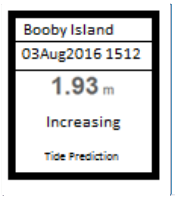

Figure 9.2 – Sample text box for a single water level station.

The numerical value of the water level is a number in metres in black text on white background (or the inverse for night vision). This display should be made available when the cursor is held over the data point.

If available, “Additional information” will be supplied on a priority level or possible via “pick report” (S-100 WG on working on this option via statistical method or combination (see Table 9.3).

Table 9-3 Priority for additional information

Priority Level	Additional Information
1	Only that listed in Table 9.2
2	Data Source, Latitude, Longitude, Graphic plot display
3	Uncertainty in water level, uncertainty in horizontal position, uncertainty in vertical position, uncertainty in time

~~1.~~9.2.3 Graphic Time Series Plot

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The availability of the graphic plot display (605x650 pixels), should be a link in the window mentioned in 9.2.1 that creates another window/tab displaying up to 7 days of water level. The mariner will have the option to change between 3 hours, 6 hours, 12 hours, 1 day, 3, 5 or 7 day display. The display will have the option to display two plots within the one window; a primary plot and a secondary plot. The number of plots shown will depend on dataset availability for the area in question.

Line and text transparency must be adjusted according to ECDIS standard (S-57, S-101); see S-111 section 9.2 for guidance. The colours to be used for lines are shown in Table 9.4. Text colour is black.

Table 9.4 - Data Type Colours for Graphic Plot window.
See Clause 7.1 for definitions of predicted and forecast.

Data Type	Plot Colour
Primary plot	
Observed	Magenta
Predicted	Black
Forecast	Blue
Secondary plot	
Observed minus Predicted	Black
Observed minus Forecast	Blue

A maximum limit of five lines in total are to be plotted: Observed, Predicted (astronomical) and Forecast, and Observed minus Predicted and Observed minus Forecast. The following must be included in the plot space: (1) a Unique Name (for the station) and the water level scenario, (2) date and time information, (3) height scale, and (4) vertical datum reference. A sample plot for one station is shown in Figure 9.3.

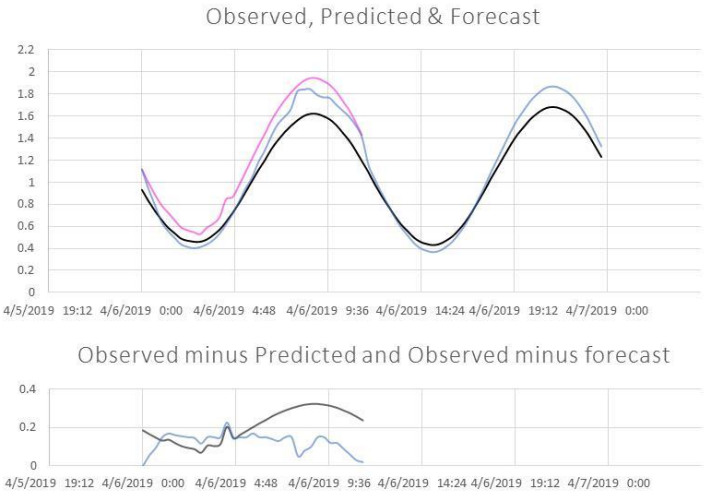

Figure 9.3 – Sample one-day plot of a time series of observed, forecast, and observed minus forecast (Scenario 1) water level heights.

Multiple lines can be plotted on the graphic plot window at the same time and the colours are used to differentiate the data type. Data types with the same colours are plotted on different plots. Note that other ECDIS standards will define when this graphic plot can be displayed, due to the size of the window covering the screen size.

Commented [JZM19]: Note the dashed lines was considered but discounted by the WG members who indicated difficulty following lines on a small plot window.

9.3 Display of Gridded Data

The display of gridded data depicts water level surface information at each individual point having the qualities described in Section 9.2. As with single point water level data, a mouse click on the chart area will display the information from the grid node nearest to that point.

NOTE 1: There is no adjustment of bathymetry data because this option is outside the scope of this Product Specification.

NOTE 2: There are no specifications for the display of a water surface from gridded data in this Product Specification edition.

9.4 Temporal Considerations

The time selected for display (i.e. past, present or future) of the water level by the system will typically not correspond exactly to the timestamp of the input data. For data with only a single record (i.e. the timestamp of the earliest values equals that of the latest value) such as real-time data, the water level values are displayed only if the absolute difference between the display time and the data timestamp is less that a discrimination interval (e.g. 5 minutes). For a single record, the variable *timeRecordInterval* (see Clause 12.3) can be used to set the discrimination interval.

Commented [JZM20]: S100 Review: What happened to data outside of the discrimination interval? Consquences?

For data with multiple times, if selected display time is later than the first timestamp and earlier than the last timestamp, then the closest two timestamps (i.e. one earlier and one later) in the data are found and the water level values are linearly interpolated. However, if the selected display time is earlier than the first timestamp or later than the last timestamp, the water level values at the closest time are displayed only if the absolute time difference between the display time and the data time stamp is less than a discrimination interval (e.g. half the value of the variable *timeRecordInterval*).

9.5 Interoperability

Interoperability principles determine priority in display of elements so that important image elements, such as depth numerals, are not obscured by water level values. Water level portrayal will conform to interoperability rules when they are established.

10 Data Product Format (Encoding)

10.1 Introduction

Commented [JZM21]: S100 Review: need to complete the list of formats for each data type

The Water level Data Products must be encoded using one of the listed formats. The structure of the data product is discussed in the next section. There will be a minimum of one format to handle data:

~~1.~~ a) HDF5 for water level height and trend data, as well as datum separation fields

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Character Set: MD_CharacterSetCode (ISO19115) should be set to utf8

Specification: S-100 profile of HDF5

10.2 AIS ASM Product Structure

Commented [GS22]: Should remove section 10.2 as real-time water level data will go into Ed 2.0.0 or later.

The information that can be delivered through the AIS system is limited to information that can be delivered as part of the AIS FI-31 Meteorological and Hydrographic data.

The AIS FI-31 allows the following fixed order of feature types:

Name: Meteorological and Hydrographic Data AIS Application-Specific Message Dynamic Water Level Data Feature Catalogue

Scope: Catalogue containing features associated with making Dynamic Water Level Data available for transmission in Meteorological and Hydrographic Data AIS Application-Specific Messages

Field of application: Marine navigation (as shown in S-100 Part 11, B-1 Example Product Specification – tbc)

Version Number: 1.0

Version Date: November 2014

Producer: International Hydrographic Organization

Functional Language: English

See ANNEX H for additional information.

A summary of the parameters relating to water level are shown in the table below (the complete table is in ANNEX H). Only one station per message is allowed.

Table 10.1 – Summary of the 14 variables in the Meteorological and Hydrographic Data AIS Application-Specific Message that apply to real-time water levels. Default values are used in the remaining slots (Annex H).

N	Parameter	No. bits	Description
1	Message ID	6	Identifier for Message 8, always 8.
2	Repeat Indicator	2	Used by the repeater to indicate how many times a message has been repeated. 0 - 3 0 = default 3 = do not repeat anymore
3	Source ID	30	MMSI number of source station
4	Spare	2	Not used. Set to zero.
5	IAI	16	DAC = 001; FI = 31
6	Longitude	25	Longitude in 1/1,000 min, ±180 degrees as per 2's complement (East = positive, West = negative). 181 = not available = default
7	Latitude	24	Latitude in 1/1,000 min, ±90 degrees as per 2's complement (North = positive, South = negative). 91 = not available = default
8	Position Accuracy	1	1 = high (<10 m; Differential Mode of, e.g., DGNSS receiver) 0 = low (>10 m; Autonomous Mode of, e.g., GNSS receiver or of other electronic position fixing device) default = 0
9	UTC Day	5	1 - 31

			0 = not available = default
10	UTC Hour	5	0 - 23 24 = not available = default
11	UTC Minute	6	0 - 59 60 = not available = default
22	Water Level (incl. tide)	12	Deviation from local chart datum, in 0.01 metre steps. -10.0 to +30.0 metres A value representing 0 - 4,000 is sent by the 12 binary bits. The water level is achieved by adding -10.0 to the sent value. Water level = (Integer value /100) – 10 for Integer = 0-4,000 4,001 = not available = default 4,002 – 4,095 (reserved for future use)
23	Water Level Trend	2	0 = steady 1 = decreasing 2 = increasing 3 = not available = default

10.3 HDF5 Product Structure for Time Series and Gridded Data

The key idea at the core of the structure is this: the organization of the information is substantially the same for each of the various types of data, but the information itself will be interpreted differently.

10.3.1 Data Type Definition

HDF5 will be used for all water level data types for dissemination methods other than AIS, as well as for datum separation fields.

Format Name: HDF5
Character Set: MD_CharacterSetCode (ISO 19115)
Specification: S-100 profile of HDF5

This product format is designed to be flexible enough to apply to water level and datum difference values in the form of (a) data at one or more times for one or more individual, fixed stations, (b) regularly-gridded data for one or more times, and (c) ungeorectified gridded data for one or more times. This approach contains, for each type, data in a similar format but which is interpreted differently. Since each type of data will be interpreted differently, the type of data must be identified by the variable *dataCodingFormat,* as shown in Table 10.1.

Table 10.1 – S-104 data types and values of the variable *dataCodingFormat.* (see S-100 Ed 5.0.0, Table 10c-4).

dataCodingFormat	Type of Data
1	Time series data at one or more fixed stations (organized by time)
2	Regularly-gridded data at one or more times
3	Ungeorectified gridded data or point set data at one or more times
7	TIN data
8	Stationwise time series at one or more fixed stations (organized by station)

Commented [GS23]: This is probably a question for S-100WG: Do we release S-104 Ed 1.0.0 compliant with S-100 Ed 4.0.0 or Ed 5.0.0? For example, Ed 5.0.0 will have dataCodingFormat = 8.

For the use of HDF5, the following key concepts (10c-5.1) are important:

1. *File* - a contiguous string of bytes in a computer store (memory, disk, etc.), and the bytes represent zero or more objects of the model;
2. *Group* - a collection of objects (including groups);
3. *Dataset* - a multidimensional array of data elements with attributes and other metadata;
4. *Dataspace* - a description of the dimensions of a multidimensional array;
5. *Datatype* - a description of a specific class of data element including its storage layout as a pattern of bits;
6. *Attribute* - a named data value associated with a group, dataset, or named datatype;
7. *Property List* - a collection of parameters (some permanent and some transient) controlling options in the library;
8. *Link* - the way objects are connected.

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In addition, a dataset may have one, two, or more dimensions, and each element in the dataset may be a compound. That is, each element may itself be an array of possibly different datatypes (float, integer, string, etc).

For all data types, the product structure in HDF5 includes (a) a metadata block, which is followed by (b) one or more Groups which contain the actual water level data. The water level information is saved in arrays that hold either gridded data or a time series.

10.3.2 Product structure

The structure of the data product follows the form given in S-100 Part 10c – HDF5 Data Model and File Format. The general structure, which was designed for several S-100 products, not just water levels, is given in Figure 10.1.

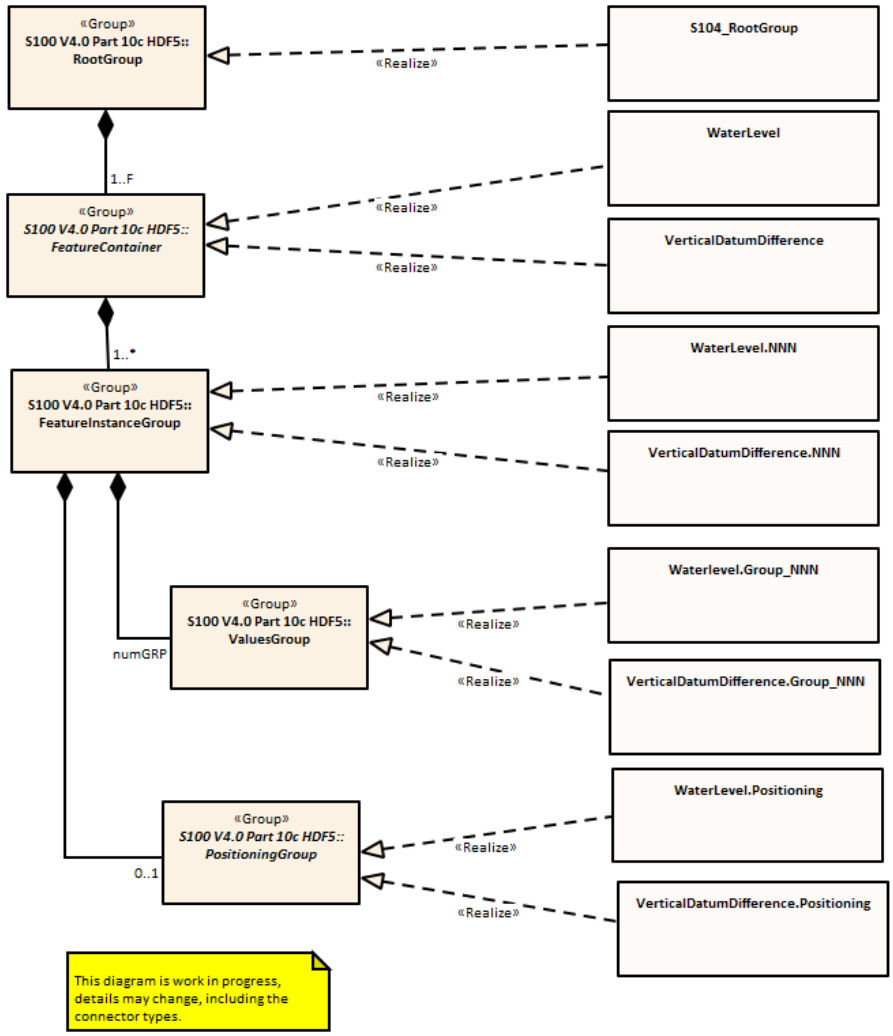


Figure 10.1 – Outline of the data file structure for S-104 data files, showing the realization of S-104 structure from the generic structure described in S-100 (see Part 10c – Figure 10c-7). Note that there are four levels from top to bottom.

In Figure 10.1 there are four levels:

Level 1: At the top level lies the Root Group, and it contains the Root Metadata (Table 12.1) and two subsidiary groups. The Root Metadata applies to all S-100 type products.

Level 2: The next Level contains the Feature Information Group and the Feature Container Group. The Feature Information Group contains two datasets: the featureCode, which has the name of the S-100 feature (here WaterLevel), and the feature information dataset (WaterLevel) which contains a compound array with eight parameters for each S-100 feature attribute (height, trend, and time). The

Feature Container Group contains the Feature Metadata (Table 12.2) and one or more Feature Instance Groups. The Feature Metadata is common to all water level products.

Level 3: This contains one or more Feature Instances. A feature instance is, for example, a time series of gridded data for a single region, or a time series of astronomical predictions for a set of stations.

Level 4: This contains the actual data for the feature. S-104 uses only the Values Group and, for only some data, the Positioning Group.

The basic structure of the S-104 data product is shown in Table 10.2. Levels refer to HDF5 structuring. (C.f. S-100 Part 10c, Fig. 10c-9). Naming in each box below header line is as follows: **Generic name**; S-100 or S-104 name; and (*HDF5 type*) group, attribute or attribute list, or dataset.

Table 10.2 – Overview of an S-104 data product

LEVEL 1 (ROOT) CONTENT	LEVEL 2 CONTENT	LEVEL 3 CONTENT	LEVEL 4 CONTENT
General Metadata (see Table 12.1) *(h5_attribute)*			
Feature Codes Group_F (*h5_group)*	**Feature Name** WaterLevel *(h5_dataset)*		
	Feature Codes featureCode *(h5_dataset)*		
Feature Type WaterLevel *(h5_group)*	**Type Metadata** (see Table 12.2) *(h5_attribute)*		
	Horz. & vert. Axis Names axisNames *(h5_dataset)*		
	First Feature Instance WaterLevel.01 *(h5_group)*	**Instance Metadata** (see Table 12.3) *(h5_attribute)*	
		Location Data Positioning *(h5_group)*	**Lon+lat Array** geometryValues *(h5_dataset)*
		Uncertainty Data uncertainty *(h5_dataset)*	
		First data group Group_001 *(h5_group)*	**Time Attribute** timePoint *(h5_attribute)*
			Height+trend Array values *(h5_dataset)*
		Second data group Group_002 *(h5_group)*	**Time Attribute** timePoint *(h5_attribute)*
			Height+trend Array values *(h5_dataset)*
		Third data group Group_003 *(h5_group)*	**Time Attribute** timePoint *(h5_attribute)*
			Height+trend Array values *(h5_dataset)*
	Second Feature Instance WaterLevel.02 *(h5_group)*	**Instance Metadata** (see Table 12.3) *(h5_attribute)*	

The following sections explain entries in Table 10.2 in more detail.

10.3.2.1 Root group

The Root Group contains the Feature Codes group, the Feature Type group, and the simple attributes shown in Table 12.1.

10.3.2.2 Feature Codes (Group F)

This group specifies the S-100 feature to which the data applies. The group has no attributes and consists of two components:

featureCode – a dataset with the name(s) of the S-100 feature(s) contained in the data product. For S-104, the dataset has a single element, the string “WaterLevel”.

WaterLevel – this is a dataset with the name contained in the featureCode dataset. The dataset contains a one-dimensional compound array of length 3 (one for each of the three water level attributes: height, trend, and time). Each of the three elements of string values has 8 values, as shown in Table 10.3.

NOTE 1: This dataset has a single attribute, named *chunking*, which is a string containing the HDF5 chunking values used in creating the values arrays (for example ’0,0’). These chunking values can be overridden at the feature instance level by the attribute *instanceChunking* (see Table 12.3).

NOTE 2: Values provided in Table 10.3 for code (waterLevelHeight, waterLevelTrend, and waterLevelTime), uom.name (meters and DateTime), and fillValue (-9999. and 0) are required.

Commented [GS24]: OEM feedback (U.S. NIWC) suggests requiring code, uom.name, and fillValue for all S-104 datasets.

Table 10.3 – Sample contents of the one-dimensional compound array (length = 3, compound elements = 8) WaterLevel. All values are strings.

N	Name	Explanation	S-100 Attribute 1	S-100 Attribute 2	S-100 Attribute 3
1	code	Camel Case Name	waterLevelHeight	waterLevelTrend	waterLevelTime
2	name	plain text	Water level height	Water level trend	Water level time
3	uom.name	Units of Measurement	meters		DateTime
4	fillValue	Denotes missing data	-9999.	0	
5	datatype	HDF5 datatype	H5T_FLOAT	H5T_ENUM	H5T_C_S1
6	lower	Lower bound on attribute	-99.99		19000101T000000Z
7	upper	Upper bound on attribute	99.99		21500101T000000Z
8	closure	Open or Closed data interval. See S100_IntervalType in Part 1.	closedInterval		closedInterval

10.3.2.3 Type group (WaterLevel)

This group contains a dataset called axisNames and one or more instances of the single feature WaterLevel. A single instance may contain a gridded forecast at multiple hours, or a set of time series predictions or observations at several stations. This group has the simple attributes shown in Table 12.2. For S-104, axisNames consists of two elements, the strings ‘longitude’ and ‘latitude’.

10.3.2.4 Instance group (WaterLevel.nn)

This group contains a single instance of the feature (see clause 10.3.2.3). The groups are numbered from 01 to 99. This group has the simple attributes shown in Table 12.3, as well as the (water level, trend, and time) values groups, the (conditional) positioning group, and a dataset called ‘uncertainty’.

Uncertainty Dataset – The (optional) uncertainty data is contained in a compound HDF5 dataset named ‘uncertainty’. There is a name and an uncertainty value for water level height, which is

waterLevelHeight. The units of height uncertainty are meters. The default, denoting a missing value, is -1.0.

10.3.2.5 Value groups (Group_nnn)

These groups each contain an attribute (the date-time stamp), and the compound data arrays containing water level height and trend, and optionally water level time. These groups have the simple attributes shown in Table 12.4. These components are explained below.

Date-Time Stamp - The date-time stamp is an attribute named *timePoint* with a single (string) value. For gridded (regular, ungeorectified, and TINs: *dataCodingFormat* = 2, 3, or 7), the time stamp is the time of validity for all points in the grid. For a time series at fixed stations (*dataCodingFormat* = 1), the time stamp is valid for all stations in that Value group.

Value Arrays - The height and trend values (waterLevelHeight and waterLevelTrend) are stored in arrays named *values,* with a prescribed number of rows (*numROWS*) and, if two-dimensional, columns (*numCOLS*).

For a time series of fixed stations (*dataCodingFormat* = 1 and 8), the height and trend values will be for times in the series as determined by the starting date-time and the data time interval. If the time intervals are non-uniform (only for *dataCodingFormat* = 8), then the time for each height and trend value is given by waterLevelTime.

For a regular grid (*dataCodingFormat* = 2), the height and trend values will be for each point in the grid, the data array *values* is two-dimensional, and the time for all points in the grid is given by the date-time stamp.

For an ungeorectified grid and TINs (*dataCodingFormat* = 3 and 7, respectively), the height and trend values will be for each point in the grid, the data array *values* is one-dimensional, and the time for all points in the grid is given by the date-time stamp.

10.3.2.6 Conditional geography group (Positioning)

The group named Positioning contains all the locations (longitude and latitude values) that have associated data values. This group has no attributes. In S-104, this group is present in the data product only for *dataCodingFormat* values of 1, 3, 7, or 8.

The geographic values are stored in the single, one-dimensional compound array named *geometryValues*, of size *numPOS*. Each element in the compound array *geometryValues* contains the pair of float values (longitude, latitude). The value of *numPOS* and the interpretation of the kinds of locations depends on the *dataCodingFormat* as well. The values and number of stations (respectively) for each data type are explained in Table 10.4.

For *dataCodingFormat* = 7, the Positioning group also contains the required *triangles* and optional *adjacency* arrays. Each row in the *triangles* array encodes a triangle as the indexes of 3 coordinates in the *geometryValues* dataset. Each row in the *adjacency* array encodes the triangles adjacent to any given triangle by specifying their indexes in the *triangles* dataset. Elements for edges without adjacent triangles are filled with the value -1. See S-100 Table 10c-16.

NOTE: the variable names in this Group (longitude, latitude) must match in case and spelling those in axisNames.

Table 10.4 - Values of numPOS for the group Positioning

Data Coding Format	Data Type	Location Data	Array Size: Value of numPOS

1	Time series at fixed stations	Position of stations	*numberOfStations*
2	Regular grid	(Not applicable)	(Not applicable)
3	Ungeorectified gridded data	Location of the grid nodes	*numberOfNodes*
7	TINs	Location of the grid nodes	*numberOfNodes*
8	Stationwise time series at fixed stations	Position of stations	*numberOfStations*

10.3.2.7 Summary of generalized dimensions

To summarize, for non-regularly gridded data only, there is an initial Positioning Group with X and Y position, stored in one-dimensional arrays of size *numPOS*. Following that, there are data Groups containing water level and trend data, which are stored in either one-dimensional arrays of size *numROWS* or two-dimensional arrays of size *numROWS* by *numCOLS*. The total number of data Groups is *numGRP*.

The four variables that determine the array sizes (*numROWS*, *numCOLS*. *numPOS,* and *numGRP)* are different, depending upon which data coding format is used. Their descriptions are given in Table 10.5.

Table 10.5 – The array dimensions used in the data product

Data Coding Format	**Data Type**	**Positioning**	**Data Values**		
		numPOS	**numCOLS**	**numROWS**	**numGRP**
1	Fixed Stations	numberOfStations	1	numberOfStations	numberOfTimes
2	Regular Grid	(not used)	numPointsLongitudinal	numPointsLatitudinal	numberOfTimes
3	Ungeorectified Grid	numberOfNodes	1	numberOfNodes	numberOfTimes
7	TIN	numberOfNodes	1	numberOfNodes	numberOfTimes
8	Fixed Stations (Stationwise)	numberOfStations	1	numberOfTimes	numberOfStations

10.3.2.8 Mandatory naming conventions

The following group and dataset names are mandatory in S-100: 'Group_F', 'featureCode', and (for S-104) 'WaterLevel', 'axisNames', 'Positioning', (for S-104) 'WaterLevel.nn', and 'Group_nnn' (n is an integer from 0 to 9). Attribute names shown in Clause 12.3 and 12.4 are also mandatory.

10.3.2.9 Summary of product structure

For regularly gridded data, the water level array is two dimensional, with dimensions *numPointsLongitudinal* and *numPointsLatitudinal*. By knowing the grid origin and the grid spacings, the position of every point in the grid can be computed by simple formulae.

However, for time series data, TINs, and ungeorectified gridded data (i.e., when *dataCodingFormat* is 1, 3, 7, or 8), the location of each point must be specified individually. This is accomplished by the data in Positioning Group, which gives the individual longitude (X) and latitude (Y) for each location. For time series data, the X and Y values are the positions of the stations; the number of stations is

numberOfStations. For TINs and ungeorectified-gridded data, the X and Y values are the positions of each point in the grid; the number of grid points is *numberOfNodes*.

NOTE: If *dataCodingFormat* is 2, the Positioning Group is not present.

The remaining Groups each contain a title, a date-time value (except for *dataCodingFormat* = 8), and the water level array. The title can be used to identify each individual station with time-series data. For *dataCodingFormat* = 2 or 3, the date-time is for the entire grid. The water level array is a two dimensional, with a number of columns (*numCOLS*) and rows (*numROWS*). For a time series, the water level value will be for each time in the series. For a grid, the water value will be for each point in the grid.

The Groups are numbered 1, 2, etc., up to the maximum number of Groups, *numGRP*. For fixed station stationwise data (*dataCodingFormat* = 8), the number of Groups is the number of stations. For regular and ungeorectified grids and TINs(*dataCodingFormat* = 2, 3, and 7), and for fixed station timewise data (*dataCodingFormat* = 1) the number of Groups is the number of time records.

The overall structure of the water level data product is created by assembling the data and metadata. The product structure is compliant with the HDF5 data architecture, which allows multi-dimensional arrays of data to be grouped with metadata. The format of the data product (cf. Figure F.5) described above is portrayed in Figure 10.2. The Carrier Metadata is discussed in Clause 12.3, and the Values Group attributes are discussed in Clause 12.4.

Commented [GS25]: Where is this?

NOTE: The name of each Group is the 'Group_nnn', where nnn is numbered from 1 to *numGRP*.

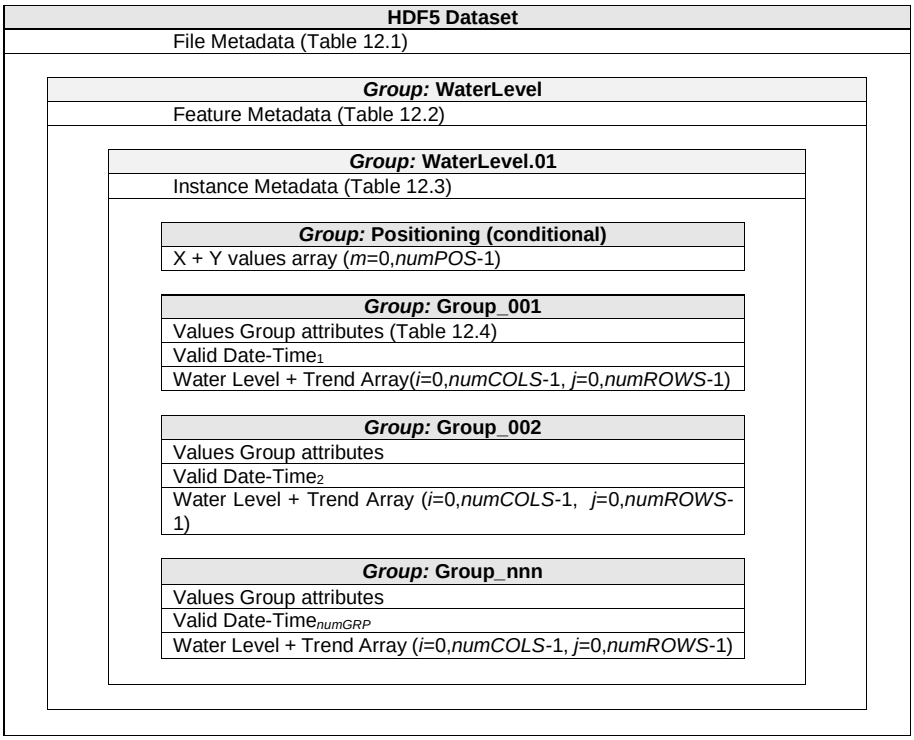


Figure 10.2 - Schematic of the S-104 HDF5 data product structure. The four parameters *numPOS,*

numCOLS, numROWS, and *numGRP* are explained in Table 10.5.
Group 'Positioning' appears only for *dataCodingFormat* = 1, 3, 7, or 8 (Table 10.5).

10.3.2.10 Digital Certification Block

Information here is used to certify the validity or integrity of the data.

10.3.3 Encoding of Latitude and Longitude

Commented [GS26]: Should probably remove 10.3.3 and 10.3.4. I think I suggested this as part of the GML specification (for the areas of influence).

Values of latitude and longitude must be accurate to 7 decimal places. Coordinates must be encoded as decimals in the format described below. The encoding is indicated by multiplication factor fields defined in the dataset identification record.

10.3.4 Encoding of Coordinates as Decimals

Values should be coded as decimal numbers with 7 or fewer digits after the decimal. The normative encoding is in degrees, with an accuracy of 10^{-7} degrees, i.e., up to 7 digits after the decimal point.

The decimal point must be indicated by the "." character.

Trailing zeroes after the decimal point (and the decimal point itself if appropriate) may be omitted at producer discretion, but the accuracy must still be as indicated (e.g., 10^{-7} degrees for coordinates of default accuracy).

Latitude and longitude multiplication factors held in the Dataset Structure Information field under [coordMultFactorX] and [coordMultFactorY] must be set to a value corresponding to the encoding, i.e., {1} for coordinates encoded in decimal degrees.

EXAMPLE 1 A longitude = 42.0000 is converted into X = longitude * coordMultFactorX = 42.0000 * 1 = 42.0000000.

10.4 Sample HDF5 encoding

The product structure has been designed for compatibility with the HDF5 capabilities. The HDF5 encoding of the data set is discussed in Annex E – Sample HDF5 Encoding.

11 Data Product Delivery

11.1 Introduction

This section describes how the water level data product is to be packaged by the Producer.

Due to the cost of transmitting data via the internet, it is desirable to limit file size and updating frequency whenever possible. The exchange data file size, as created by the Producer and after compression, is recommended to be limited to 10 MB. Another quantity to be aware of is the total MB to be transferred per year. S-100 (Sec. 15-5.2) allows one data compression scheme: Zip. In addition, the file may be encrypted.

Updating of files typically means issuing a new forecast, or disseminating the latest observed water level for a specific geographic region. This may occur several times per day. Therefore, all files must contain a date-time of issuance of the product. Because of the potentially high frequency (that is, hourly or less) availability of new datasets, the ECDIS system must check for new data at a similar frequency.

11.2 HDF5

The HDF5-formatted datasets are packaged with metadata and an exchange catalogue, and then combined into an exchange dataset. The HDF5 files for datum differences may be transferred via media or internet, since they typically do not often change. HDF5 files for time series or gridded water level data may require internet, since they change several or more times a day.

11.2.1 Exchange Datasets

Datasets, or data products, produced by the Producer consist of files containing both the exchange catalogue and one or more data products (of possibly different S-100 types), with each product covering a specific geographic region and specific period of time (Figure 11.1). The Exchange Catalogue lists the products and contains the discovery metadata.

The name of the exchange set will have the character string 'S104' somewhere in it (e.g., 'S104_ExchangeSet'), and this will identify the data as containing water level.

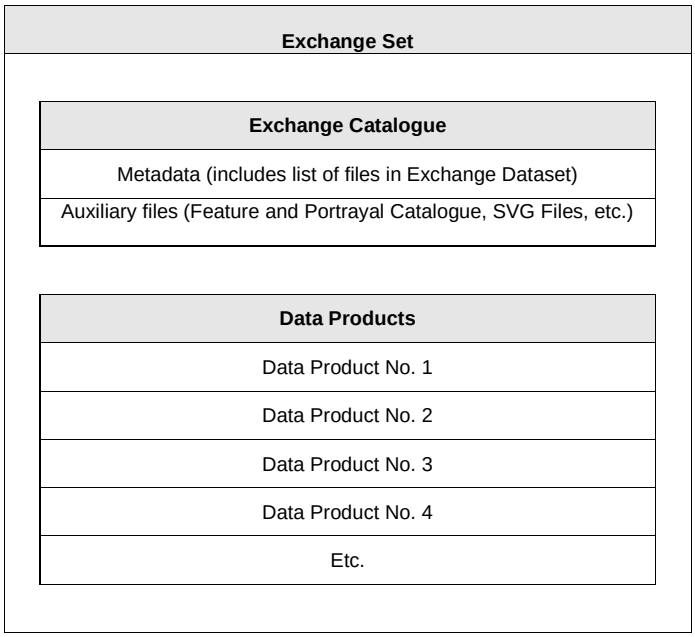


Figure 11.1 – Schematic diagram of the Exchange Set.

The dataset size is limited to 10 MB. The size of each file can vary widely, depending on the data. Using the sample HDF5 file (see Figure F.3), a file containing, along with metadata, a single water level height array and a single water level trend array, each with 100,000 grid points would have a size of approximately 0.21 Mbytes. Exchange files may be compressed using zip methodology. Doing so can reduce file size by 80% or more.

11.2.2 Exchange Catalogue

The exchange catalogue normally in XML format acts as the table of contents for the exchange set. The catalogue file of the exchange set must be named CATALOG.XML; no other file in the exchange set may have the same name. The contents of the exchange catalogue are described in Clause 12.

11.2.3 Dataset File Naming

The dataset file contains both metadata and one or more sets of height and trend arrays (see CLAUSE 10 – DATA PRODUCT FORMAT). The dataset name must begin with the three character product specification, followed by the two-character producer code (CC). Thus water level files begin with the five-character string '104CC'. The unrestricted characters may be used to denote geographical region, valid time, source of the data, version numbers, and/or any other relevant information. Characters may be lower or upper case. For real-time and forecast data, it is recommended that the dateTime of the first record be part of the dataset name, to help distinguish the most recent files.

The filename extension for HDF5 (e.g., .h5 or .hdf5) must be used to denote the file format.

~~1.~~11.2.4 Support Files

This Data Product requires no support files.

Formatted: Indent: Hanging: 2.06 cm, Outline numbered + Level: 3 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.79 cm + Indent at: 2.06 cm, Tab stops: Not at 3.81 cm

12 Metadata <S-100 Part 4>

12.1 Introduction

For information exchange, there are several categories of metadata required: metadata about the overall exchange dataset and catalogue, discovery metadata about each of the datasets contained in the catalogue, and discovery metadata about the support files that make up the package. The discovery metadata classes have numerous attributes which enable important information about the datasets and accompanying support files to be examined without the need to process the data, e.g. decrypt, decompress, load, etc. Other catalogues can be included in the exchange set in support of the datasets such as feature, portrayal, coordinate reference systems, codelists, etc. The attribute “purpose” of the support file metadata provides a mechanism to update support files more easily.

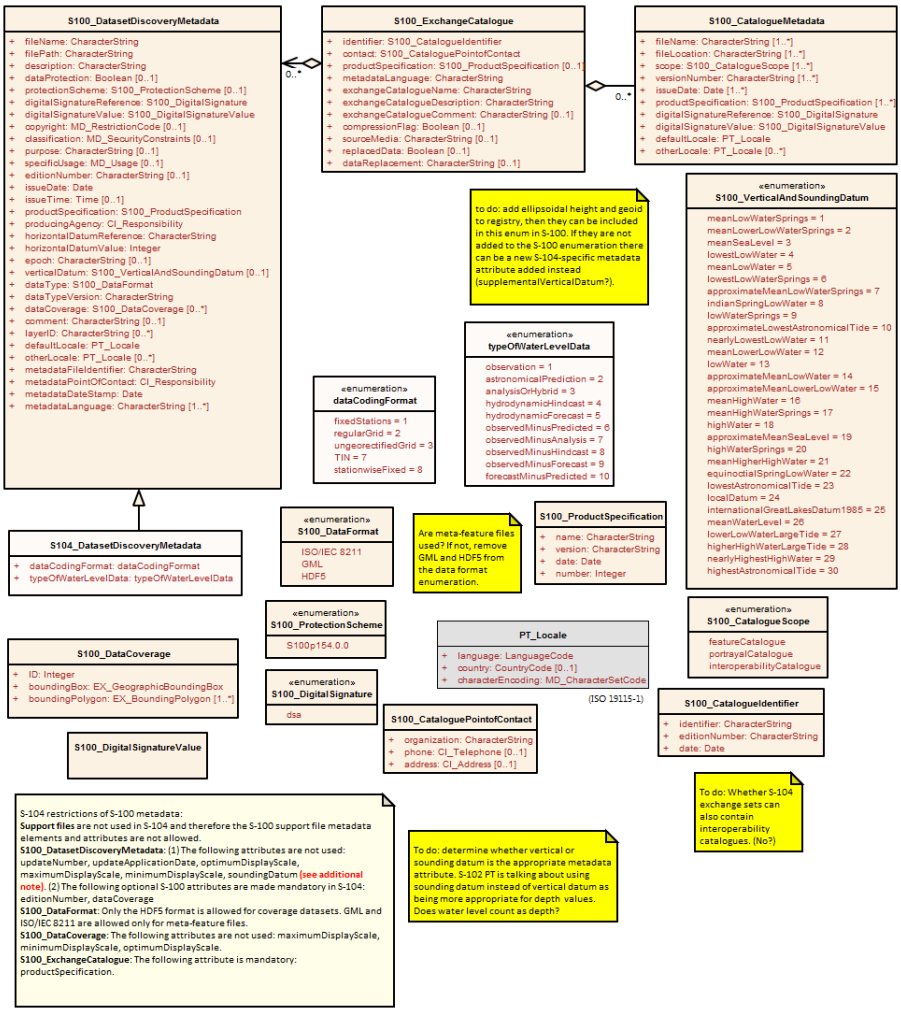
This clause defines the mandatory and optional metadata needed for S-104. In some cases the metadata may be repeated in a national language.

12.2 Discovery Metadata

An outline of the overall concept of an S-104 exchange set for the interchange of geospatial data and its relevant metadata is explained in the following figures. Figure 12.1 depicts the realization of the ISO 19139 classes which form the foundation of the exchange set. The overall structure of the S-104 metadata for exchange sets is modelled in ANNEX C.. More detailed information about the various classes and a textual description are in the tables at Clause 12.3.

Figure 12.1 - Realization of the exchange set classes. Note that there are no support files.

Commented [GS27]: This was updated with the help of S-100WG.



The discovery metadata classes have numerous attributes which enable important information about the datasets to be examined without the need to process the data, e.g. decrypt, decompress, load etc. Other catalogues can be included in the exchange set in support of the datasets such as feature, portrayal, coordinate reference systems, codelists, etc.

The language used for the metadata is English.

Time reference for all **data will be UTC.**

All water level values to be given in metres (up to two decimal places for real values).

12.2.1 S100_ExchangeCatalogue

Each exchange set has a single S100_ExchangeCatalogue which contains meta information for the data in the exchange set.

Name	Description	Mult	Value	Type	Remarks
S100_ExchangeCatalogue	An exchange catalogue contains the discovery metadata about the exchange datasets and support files	-		-	-
Identifier	Uniquely identifies this exchange catalogue	1		S100_CatalogueIdentifier	
Contact	Details about the issuer of this exchange catalogue	1		S100_CataloguePointOfContact	
productSpecification	Details about the product specifications used for the datasets contained in the exchange catalogue	0..1		S100_ProductSpecification	Conditional on all the datasets using the same product specification
exchangeCatalogueName	Catalogue filename	1		CharacterString	In S-104 it would be CATLOG.104
exchangeCatalogueDescription	Description of what the exchange catalogue contains	1		CharacterString	
exchangeCatalogueComment	Any additional Information	0..1		CharacterString	

Commented [GS28]: Ensure all S-100 tables (and their correct attributes) are here. There seem to be several missing, e.g. S100_ExchangeSet, S100_Dataset, S100_DigitalSignature, S100_DigitalSignatureValue, S100_ProtectionScheme, S100_DatasetDiscoveryMetadata, PT_Locale, and S104_DatasetDiscoveryMetadata.

These will have to follow S-100 Edition 4.0.0 for now, and we can always update them once S-100 Edition 5.0.0 is released.

Name	Description	Mult	Value	Type	Remarks
compressionFlag	Is the data compressed	0..1		Boolean	Yes or No
algorithmMethod	Type of compression algorithm	0..1		CharacterString	Eg. RAR or ZIP
sourceMedia	Distribution media	0..1		CharacterString	
replacedData	If a data file is cancelled is it replaced by another data file	0..1		Boolean	
dataReplacement	Cell name	0..1		CharacterString	

12.2.2 S100_CatalogueIdentifier

Commented [JZM29]: Does this need to remain? Use of file naming convention to assist with identifying latest replacement file.

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_CatalogueIdentifier	An exchange catalogue contains the discovery metadata about the exchange datasets and support files	-	-	-
Attribute	identifier	Uniquely identifies this exchange catalogue	1	CharacterString	
Attribute	editionNumber	The edition number of this exchange catalogue	1	CharacterString	
Attribute	date	Creation date of the exchange catalogue	1	Date	

12.2.3 S100_CataloguePointofContact

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_CataloguePointOfContact	Contact details of the issuer of	-	-	-

		this exchange catalogue			
Attribute	organization	The organization distributing this exchange catalogue	1	CharacterString	This could be an individual producer, value added reseller, etc.
Attribute	phone	The phone number of the organization	0..1	CI_Telephone	
Attribute	address	The address of the organization	0..1	CI_Address	

12.2.4 S100_DatasetDiscoveryMetadata

Data in the Discovery Metadata are used to identify the relevance of the dataset to the particular application.

Name	Description	Mult	Value	Type	Remarks
S100_DatasetDiscoveryMetadata	Metadata about the individual datasets in the exchange catalogue	-		-	-
fileName	Dataset file name	1		CharacterString	
filePath	Full path from the exchange set root directory	1		CharacterString	Path relative to the root directory of the exchange set. The location of the file after the exchange set is unpacked into directory <EXCH_ROOT> will be <EXCH_ROOT>/<filePath>/<filename>
description	Short description giving the area or location covered by the dataset	1		CharacterString	E.g. a harbour or port name, between two named locations etc.
dataProtection	Indicates if the data is encrypted	0..1		Boolean	0 indicates an unencrypted dataset 1 indicates an encrypted dataset
protectionScheme	specification or method used for data protection	0..1		CharacterString	Eg S-63
digitalSignature	Indicates if the data has a digital signature	0..1		Boolean	0: unsigned 1: datafile is digitally signed [to be reconciled when S-100 finalizes digital signature elements]
digitalSignatureValue	Digital signature	0..1		CharacterString	This contains a base64 encoding of the hexadecimal numbers comprising the digital signature itself. The content of these fields are defined, along with the algorithms for their calculation, in S-63 ed2.0 Part (C).

Name	Description	Mult	Value	Type	Remarks
					[to be reconciled when S-100 finalizes digital signature elements]
classification	Indicates the security classification of the dataset	0..1		Enumeration	One of the following from ISO 19115 MD_SecurityConstraints> MD_ClassificationCode (codelist) 1. unclassified 2. restricted 3. confidential 4. secret 5. top secret
purpose	The purpose for which the dataset has been issued	1		MD_Identification>purpose CharacterString	E.g. new, re-issue, new edition, update etc.
specificUsage	The use for which the dataset is intended	1		CharacterString	E.g. in the case of ENCs this would be a navigation purpose classification.
editionNumber	The edition number of the dataset	1		CharacterString	When a data set is initially created, the edition number 1 is assigned to it. The edition number is increased by 1 at each new edition. Edition number remains the same for a re-issue.
issueDate	date on which the data was made available by the data producer	1		Date	
productSpecification	The product specification used to create this dataset	1		S100_ProductSpecification	
producingAgency	Agency responsible for producing the data	1		CI_ResponsibleParty	
horizontalDatumReference	Reference to the register from which the horizontal datum value is taken	1		characterString	EPSG
horizontalDatumValue	Horizontal Datum of the entire dataset	1		Integer	4326
verticalDatum	Vertical Datum of the entire dataset	0..1		S100_VerticalAndSoundingDatum	
dataType	The encoding format of the dataset	1		S100_DataFormat	
otherDataTypeDescription	Encoding format other than those listed.	0..1		CharacterString	

Name	Description	Mult	Value	Type	Remarks
dataTypeVersion	The version number of the dataType.	1		CharacterString	
dataCoverage	Area covered by the dataset	1		S100_DataCoverage	
comment	Any additional information	0..1		CharacterString	

12.2.5 S100_DataCoverage

Name	Description	Mult	Value	Type	Remarks
S100_DataCoverage		-		-	-
ID	Uniquely identifies the coverage	1		Integer	-
boundingBox	The extent of the dataset limits	1		EX_GeographicBoundingBox	-
boundingPolygon	A polygon which defines the actual data limit	1..*		EX_BoundingPolygon	-
optimumDisplayScale	The scale with which the data is optimally displayed	0..1		Integer	
maximumDisplayScale	The maximum scale with which the data is displayed	0..1		Integer	
minimumDisplayScale	The minimum scale with which the data is displayed	0..1		Integer	

12.2.6 EX_GeographicBoundingBox

From ISO 19115:2003 Corr. 1 (2006).

Name	Description	Mult	Type	Remarks
EX_GeographicBoundingBox	geographic position of the dataset	-	-	Defined in ISO 19115
westBoundLongitude	western-most coordinate of the limit of the dataset extent, expressed in longitude in decimal degrees (positive east)	1	Real	Arc degrees
eastBoundLongitude	eastern-most coordinate of the limit of the dataset extent, expressed in longitude in decimal degrees (positive east)	1	Real	Arc degrees

Name	Description	Mult	Type	Remarks
southBoundLatitude	southern-most coordinate of the limit of the dataset extent, expressed in latitude in decimal degrees (positive north)	1	Real	Arc degrees
northBoundLatitude	northern-most, coordinate of the limit of the dataset extent expressed in latitude in decimal degrees (positive north)	1	Real	Arc degrees

12.2.7 EX_BoundingPolygon

From ISO 19115:2003 Corr. 1 (2006).

Name	Description	Mult	Type	Remarks
EX_BoundingPolygon	boundary enclosing the dataset, expressed as the closed set of (x,y) coordinates of the polygon (last point replicates first point)	-	-	Defined in ISO 19115
polygon	sets of points defining the bounding polygon	1	GM_Object	Must be a GM_Polygon (See S-100 Part 7, ISO 19107, ISO 19136)

12.2.8 S100_VerticalAndSoundingDatum

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_VerticalAndSoundingDatum	Allowable vertical and sounding datums	-	-	-
Value	meanLowWaterSprings		-	-	1
Value	meanSeaLevel		-	-	2
Value	meanLowerLowWaterSprings		-	-	3
Value	lowestLowWater		-	-	4
Value	meanLowWater		-	-	5
Value	lowestLowWaterSprings		-	-	6
Value	approximateMeanLowWaterSprings		-	-	7
Value	indianSpringLowWater		-	-	8
Value	lowWaterSprings		-	-	9
Value	approximateLowestAstronomicalTide		-	-	10
Value	nearlyLowestLowWater		-	-	11
Value	meanLowerLowWater		-	-	12
Value	lowWater		-	-	13
Value	approximateMeanLowWater		-	-	14
Value	approximateMeanLowerLowWater		-	-	15
Value	meanHighWater		-	-	16
Value	meanHighWaterSprings		-	-	17
Value	highWater		-	-	18
Value	approximateMeanSeaLevel		-	-	19
Value	highWaterSprings		-	-	20
Value	meanHigherHighWater		-	-	21
Value	equinoctialSpringLowWater		-	-	22
Value	lowestAstronomicalTide		-	-	23
Value	localDatum		-	-	24
Value	internationalGreatLakesDatum1985		-	-	25
Value	meanWaterLevel		-	-	26
Value	lowerLowWaterLargeTide		-	-	27
Value	higherHighWaterLargeTide		-	-	28
Value	nearlyHighestHighWater		-		29

Value	highestAstronomicalTide		-		30(HAT)
Value	Ellipsoidal Height	Not in S100!			31
Value	Geoid	Not in S100			32

Commented [JZM30]: S100 Review: Ask for an extension to the S-100 list

Commented [GS31]: IGLD-2000 and other vertical datums were also requested. There is a way to use datums not on this list, as long as there is an EPSG code for it. See verticalDatumReference and verticalDatum in Table 12.1, which describes how to do so for the carrier (file) metadata.

However, using a vertical datum that is not on this list for exchange dataset metadata is trickier. Technically it can be left out of the exchange dataset metadata, since vertical datum is optional there.

But this would force the ECDIS to read the dataset to find out the vertical datum. We may want to ask S-100 to cover situations when the datum is not in this S100_VerticalAndSoundingDatum list, so that the ECDIS can know what vertical datum is used in a dataset without actually reading the dataset.

12.2.9 S100_DataFormat

Role Name	Name	Description	Code	Remarks
Enumeration	S100_DataFormat	Encoding format	-	ISO/IEC 8211 and GML are allow only for metafeature files, if includ in the exchange set. The S-100 v 'undefined' is not used
Value	ISO/IEC 8211	The ISO 8211 data format as defined in Part 10a	-	-
Value	GML	The GML data format as defined in Part 10b	-	-
Value	HDF5	The HDF5 data format as defined in Part 10c	-	-
			-	

12.2.10 S100_ProductSpecification

Name	Description	Mult	Type	Remarks
S100_ProductSpecification	The Product Specification contains the information needed to build the specified product	-	-	-
name	The name of the product specification used to create the datasets	1	CharacterString	S-104 Water Level Product Specification
version	The version number of the product specification	1	CharacterString	1.0.0
date	The version date of the product specification	1	Date	

12.2.11 S100_CatalogueMetadata

Commented [JZM32]: S100 Review: add explanation for class. This class is used to provide metadata about feature and portrayal catalogues.

Name	Description	Mult	Value	Type	Remarks
S100_CatalogueMetadata		-		-	-

filename	The name for the catalogue	1..*		CharacterString	
fileLocation	Full location from the exchange set root directory	1..*		CharacterString	Path relative to the root directory of the exchange set. The location of the file after the exchange set is unpacked into directory <EXCH_ROOT> will be <EXCH_ROOT>/<filePath>/<file name>
scope	Subject domain of the catalogue	1..*		S100_CatalogueScope	
versionNumber	The version number of the product specification	1..*		CharacterString	
issueDate	The version date of the product specification	1..*		Date	
productSpecification	The product specification used to create this file	1..*		S100_ProductSpecification	
digitalSignatureReference	Digital Signature of the file	1		CharacterString	Reference to the appropriate digital signature algorithm
digitalSignatureValue	Value derived from the digital signature	1		CharacterString	

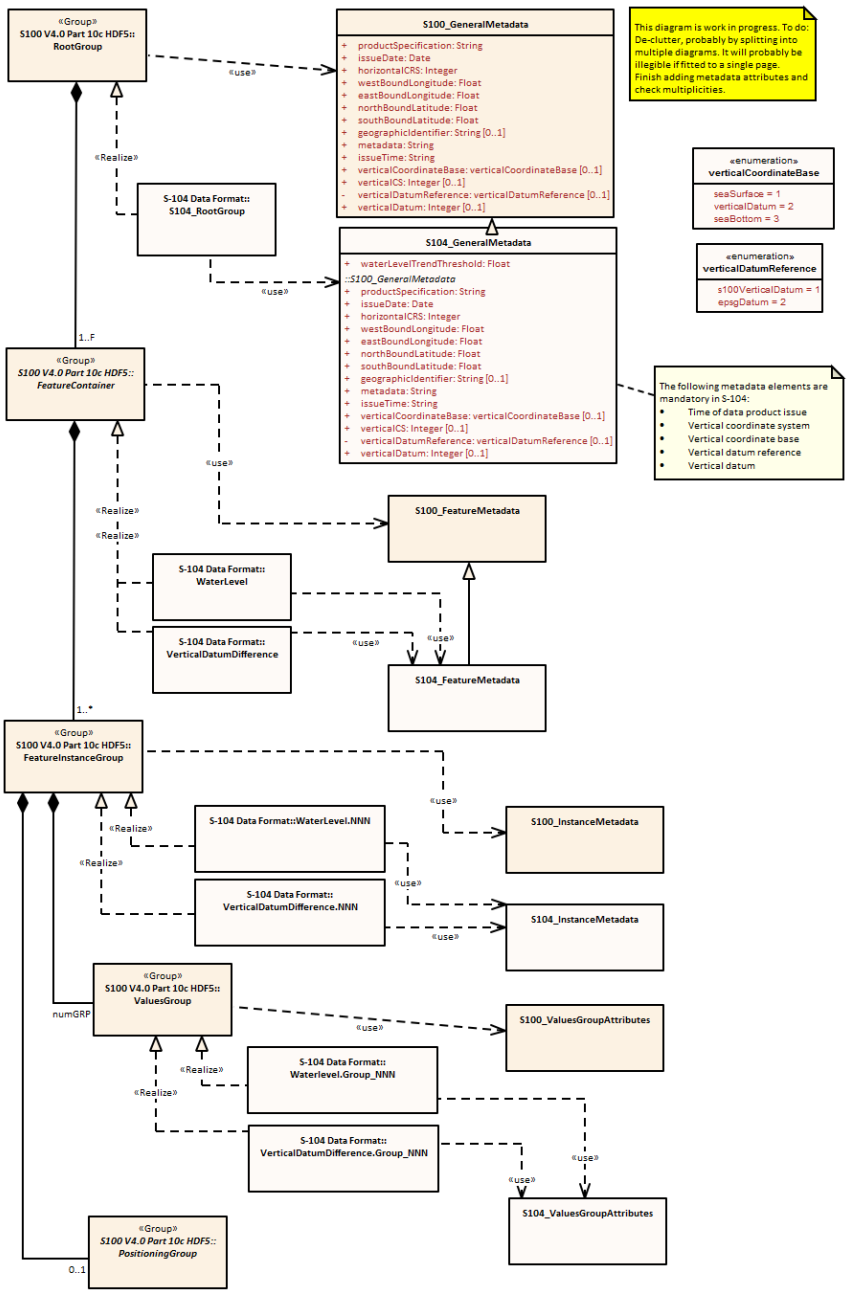
12.2.12 S100_CatalogueScope

Role Name	Name	Description	Mult	Type	Remarks
Class	S100_CatalogueScope		-	-	-
Value	featureCatalogue				
Value	portrayalCatalogue				

12.3 Carrier Metadata

The metadata for the S-104 product is divided in three sections, corresponding to the General Metadata (Table 12.1), the Feature Metadata (Table 12.2), and the Instance Metadata (Table 12.3). Since these values do not reside in the Metadata blocks, but are in the HDF5 files, they are referred to as Carrier Metadata. The Carrier Metadata consists of the data and parameters needed to read and interpret the information in the Water Level product even if the other S-104 Metadata files are unavailable.

Note that in Tables 12.1, 12.2, and 12.3, some of the metadata variables have restrictions on their core values (i.e., whether they are optional or mandatory, the specific values allowed, etc.) that are not imposed in S-100. These are grouped under the heading '*Additional restrictions on core metadata for S-104*.' It is suggested for any enumeration in S-104, to use native integer type H5T_NATIVE_UINT8 for the base type of the numeric code when creating the enumeration.



Commented [GS33]: This figure is a work in progress by S-100WG

Figure 12.2 – Carrier metadata for the S-104 HDF5 group hierarchy.

Table 12.1 – General Metadata, related to the entire HDF5 file (see S-100 Table 10c-6). Latitude and longitude values precise to 10^{-7} deg. All times are in UTC format.

No	Name	Camel Case	Mult.	Data Type	Remarks and/or Units
1	Product specification number and version	productSpecification	1	String	This must be encoded as 'INT.IHO.S-104.X.Y', with X representing the edition number and Y the revision number
2	Date of data product issue	issueDate	1	String	Date must be consistent with issueDate in discovery metadata.
3	Horizontal Coord. Ref. Sys.	horizontalCRS	1	Integer	EPSG code. E.g., 4326 (for WGS84) See https://spatialreference.org/ref/epsg/?page=1
4	Bounding box	westBoundLongitude	1	Float	Area encompassing all feature instances
5		eastBoundLongitude	1	Float	Units are Degrees.
6		southBoundLatitude	1	Float	
7		northBoundLatitude	1	Float	
8	Geographic locator	geographicIdentifier	0..1	String	Description
9	Metadata file name	metadata	1	String	Name of XML metadata file for the HDF5 file. Form: MD_<hdf file name>.XML.
Additional metadata for S-104					
10	Water level trend threshold	waterLevelTrendThreshold	1	Float	Critical value used to determine steady water level trend. Units are meters/hour (m/hr). E.g., 0.2. See Annex A (DCEG).
Additional restrictions on core general metadata for S-104					
11	Time of data product issue	issueTime	1	String	Mandatory for S-104. S-100 Time format. All times are in UTC. E.g., 123000Z
12	Vertical coordinate system	verticalCS	1	Integer	Mandatory for S-104. EPSG Code; Allowed Values • 6498 (Depth– Metres–Orientation Down) • 6499 (Height– Metres– Orientation Up)
13	Vertical coordinate base	verticalCoordinateBase	1	Enumeration	Mandatory for S-104. 1: Sea Surface 2: Vertical Datum 3: Sea Bottom
14	Vertical datum reference	verticalDatumReference	1	Enumeration	Mandatory for S-104. Only if verticalCoordinateBase = 2. 1: S-100 vertical datum 2: EPSG
15	Vertical datum	verticalDatum	1	Integer	Mandatory for S-104. Only if verticalCoordinateBase = 2. If verticalDatumReference = 1 this is a value from S100_VerticalAndSoundingDatum. If verticalDatumReference = 2 this is an EPSG code for vertical datum

No	Name	Camel Case	Mult	Data Type	Remarks and/or Units
1	Data organization index (Used to read the data. See Table 10.1)	dataCodingFormat	1	Enumeration	1: Time series at fixed stations 2: Regularly-gridded arrays 3: Ungeorectified gridded arrays 4: Moving platform 5: Irregular grid 6: Variable cell size 7: TIN 8: Time series at fixed stations (stationwise) This Product Specification only covers the use of only 1-3 and 7-8.
2	Dimension	dimension	1	Integer	The (spatial) dimension of the feature instances. For water levels, use 2.
3	Common Point Rule	commonPointRule	1	Enumeration	The procedure used for evaluating the coverage at a position that falls on the boundary or in an area of overlap between geometric objects. 1: average 2: low 3: high 4: all (recommended)
4	Horizontal position uncertainty	horizontalPositionUncertainty	1	Float	-1.0 (unknown) or positive value (m)
5	Vertical position uncertainty	verticalUncertainty	1	Float	-1.0 (unknown) or positive value (m)
6	Time uncertainty	timeUncertainty	0..1	Float	-1.0 (unknown) or positive value (s)
7	Number of feature instances	numInstances	1	Integer	
Additional metadata for S-104					
8	Methodology	methodWaterLevelProduct	0..1	String	Brief description of tide gauge type, forecast method or model, etc.
9	Min. water level height in dataset	minDatasetHeight	1	Float	Height in verticalCS in Table 12.1
10	Max. water level height in dataset	maxDatasetHeight	1	Float	Height in verticalCS in Table 12.1
dataCodingFormat = 2					
11	Sequencing Rule	sequencingRule.type	1	Enumeration	Method to be used to assign values from the sequence of values to the grid coordinates. Components: type: Enumeration CV_SequenceType For example 1 (for 'linear')
12		sequencingRule.scanDirection	1	String	scanDirection: String <axisNames entry> (comma-separated). For example "latitude,longitude"
13	Interpolation Type	interpolationType	1	Enumeration	Interpolation method recommended for evaluation of the S100_GridCoverage Values: S100_CV_InterpolationMethod (ISO 19123).
dataCodingFormat = 3					
Additional restrictions on core feature metadata for S-104 for dataCodingFormat = 3					
11	Interpolation Type	interpolationType	1	Enumeration	Interpolation method recommended for evaluation of the S100_GridCoverage Values: S100_CV_InterpolationMethod (ISO 19123). For S-104 dataCodingFormat = 3, use 10 (for 'discrete').
dataCodingFormat = 7					
11	Interpolation Type	interpolationType	1	Enumeration	Interpolation method recommended for evaluation of the S100_GridCoverage Values: S100_CV_InterpolationMethod (ISO 19123).
dataCodingFormat = 8					
Additional metadata for S-104 for dataCodingFormat = 8					

11	Order of series in pick report	pickPriorityType	1	String	Default priority of series for pick report. Use “0” for differences (*typeOfWaterLevelData* = 6, 7, 8, 9, 10). E.g., “2,1,4,5,3,0,0,0,0,0” (without quotes). See Table 12.3. Total numbers (here 10) must be equal to numInstances.

Table 12.2 – Feature metadata, pertaining to the Water Level feature (see S-100 Table 10c-10)Table 12.3 – Instance metadata, pertaining to the feature instance (see S-100 Table 10c-12). All times are in UTC format.

No	Name	Camel Case	Mult.	Data Type	Remarks and/or Units
1	Bounding box	westBoundLongitude	0..1	Float	Area of grid, set of stations, etc.
2		eastBoundLongitude	0..1	Float	Units are decimal degrees.
3		southBoundLatitude	0..1	Float	
4		northBoundLatitude	0..1	Float	
5	Number of time records	numberOfTimes	0..1	Integer	The total number of time records. For dataCodingFormat = 8, this variable migrates to the values group attributes (Table 12.4).
6	Time interval	timeRecordInterval	0..1	Integer	The interval between time records. Units: Seconds. For dataCodingFormat = 8, this variable migrates to the values group attributes (Table 12.4).
7	Valid time of earliest value	dateTimeOfFirstRecord	0..1	String	DateTime format. First record in the Instance. All times are in UTC.
8	Valid time of latest value	dateTimeOfLastRecord	0..1	String	DateTime format.
9	Number of values groups	numGRP	1	Integer	Number of Values Groups. For dataCodingFormat = 1, 2, 3, and 7, equals the number of time points. For dataCodingFormat = 8, equals the number of stations.
10	Instance chunking value	instanceChunking	0..1	String	For example “1,256” (without quotes). If present, overrides attribute value in Group_F.
Additional metadata for S-104					
11	Type of water level data	typeOfWaterLevelData	1	Enumeration	1: Observation 2: Astronomical prediction 3: Analysis or hybrid method 4: Hydrodynamic model hindcast 5: Hydrodynamic model forecast 6: Observed minus predicted 7: Observed minus analysis 8: Observed minus hindcast 9: Observed minus forecast 10: Forecast minus predicted Note: if a difference is provided (6-10), suggested to also provide the other two series.
dataCodingFormat = 1					
12	Number of fixed stations	numberOfStations	1	Integer	Number of individual fixed stations in this instance.
dataCodingFormat = 2					
12	Longitude of grid origin	gridOriginLongitude	1	Float-Double	Degrees
13	Latitude of grid origin	gridOriginLatitude	1	Float-Double	Degrees
14	Grid spacing, long.	gridSpacingLongitudinal	1	Float-Double	Degrees
15	Grid spacing, lat.	gridSpacingLatitudinal	1	Float-Double	Degrees
16	Number of points, long.	numPointsLongitudinal	1	Integer	numCOLS
17	Number of points, lat.	numPointsLatitudinal	1	Integer	numROWS
18	Start sequence	startSequence	1	String	E.g., “0,0” (without quotes) for scans starting at lower left corner i=0, j=0. For upper left, “0,n”, where n is the value of numROWS-1. First character represents first axis in sequencingRule.scanDirection. (Table 12.2), which here is latitude.

dataCodingFormat = 3					
12	Number of nodes	numberOfNodes	1	Integer	The total number of grid points
dataCodingFormat = 7					
12	Number of nodes	numberOfNodes	1	Integer	The total number of grid points
13	Number of triangles	numberOfTriangles	1	Integer	The total number of triangles in the TIN
dataCodingFormat = 8					
12	Number of fixed stations	numberOfStations	1	Integer	Number of individual fixed stations in this instance. Must equal numGRP.

12.4 Values Group Attributes

An expanded new metadata block is required for the Values Groups (Table 12.4). The variables *stationName* and *stationIdentification* have been added for both identification and possibly for inclusion in the text of the graph. Note that additional variables such as Marine Resource Names (MRN) and station category (e.g. high or long-term, medium, or low) can be added here. The series start and end times, number of records, and time interval index are included since they may differ for each series.

NOTE: These attributes will be incorporated in S-100 Ed 5.0.0.

Table 12.4 – Values Group attributes (see S-100 Table 10c-18). All times are in UTC format.

No	Name	Camel Case	Mult.	Data Type	Remarks and/or Units
dataCodingFormat = 1, 2, 3, or 7					
1	Time stamp	timePoint	1	String	DateTime. All times are in UTC.
dataCodingFormat = 8					
1	Index for time interval	timeIntervalIndex	1	(Integer)	1 (TRUE) denotes uniform time interval; interval provided by *timeRecordInterval*. 0 (FALSE) denotes non-uniform time interval. This is a boolean data type implemented as described in S-100 Table 10c-1.
2	Time interval	timeRecordInterval	0..1	Integer	Only if *timeIntervalIndex* = 1. The uniform interval between time records. Units: Seconds. Value here overrides corresponding value at Instance level.
Additional restrictions on core values group metadata for S-104 for dataCodingFormat = 8					
3	Name of the station	stationName	1	String	Mandatory for S-104. E.g., a geographic description or 'Not Available'
4	Station identification	stationIdentification	1	String	Mandatory for S-104. E.g., a letter-number combination for the station or 'Not Available'
5	Number of time records	numberOfTimes	1	Integer	Mandatory for S-104. Value here overrides corresponding value at Instance level
6	Valid time of earliest value	startDateTime	1	String	Mandatory for S-104. DateTime format. All times are in UTC.
7	Valid time of latest value	endDateTime	1	String	Mandatory for S-104. DateTime format.

12.5 Language

The language used for the Discovery Metadata and the Carrier Metadata is English.

12.6 Data Type Specific Metadata

Single point metadata

Name/Role	Source	Multiplicity	Value	Type	Remarks
Time_interval (delivery)		1		Real	
Unique Identifier		1		Character/numerical	Port Number as given in Tide Table
Unique Name		1		Character string	Port Name as given in Tide Table
MNR unique code		1		Character/numerical	
Port Quality type		1		Boolean	0 – Standard / Major 1 – Secondary / Minor
Value for missing data		1		Real	

Feature Type: WaterLevel

Name/Role	Source	Multiplicity	Value	Type	Remarks
Position (x,y)	S100	1			Latitude and Longitude of the entity
Water level Height including tide		1			metres Maximum 2 decimal places

Commented [JZM34]: S100 Review: clarify text or move to correct section.

Commented [GS35R34]: Agreed, not sure how it fits into S-104 product so clarifying text would help. These might now be in the above metadata, e.g. Tables 12.1-12.4.

Commented [ZJ36]: Add port quality, for that countries that provided additional information to standard port.

					Observed/ predicted
Water level uncertainty		1		Real	metres – maximum 2 decimetres -99 if uncertainty is unknown
Water level trend	ASM	1	* to be confirmed in enumeration list starts at 1 or 0 0 1 2 3	Enumerate	0 = steady 1 = decreasing 2 = increasing 3 = not available

ANNEX A – DATA CLASSIFICATION AND ENCODING GUIDE

A.1 Features

Water Level (*WaterLevel*)

IHO Definition: FEATURE: **WATER LEVEL:** The vertical position of a water surface			
S-104 Geo Feature: Water Level			
Primitives: pointSet, coverage			
S-104 Attribute	**Allowable Encoding Value**	**Type**	**Multiplicity**
Water Level Height	must be in decimal metres, maximum resolution of 0.01 metres	RE	1
Water Level Trend	1: Decreasing 2: Increasing 3: Steady ~~4: Not available~~	EN	1
Water Level Time	YYYYMMDDTHHMMSSZ	DT	0..1

A.2 Feature Attributes

The number of attributes for *Water Level* is three: water level height, water level trend, and water level time.

1. Water Level Height (*waterLevelHeight*)

Water Level Height: The height of a water surface relative to a vertical datum

Unit: metre (m)
Minimum Resolution: 0.01 m
Format: xxx.xx
Example: 10.54
Remarks:

~~1.~~• Land mask or missing value is denoted by a unique number as specified in the metadata.
~~1.~~• The height is relative to some vertical datum, which is defined in the metadata.
~~2.~~• 0.01 m equals 0.3937 in (1 cm)

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~~3.~~2. Water Level Trend (*waterLevelTrend*)

Water Level Trend: The tendency of water level to change in a particular direction.

1: Decreasing (*decreasing*)
2: Increasing (*increasing*)
3: Steady (*steady*)

Unit: none (enumeration)
Minimum Resolution: N/A (enumeration)
Format: x
Example: 3: Steady
Remarks:

~~1.~~• To determine category, use metadata variable *waterLevelTrendThreshold* (See Table 12.1):
- ~~1.~~○ Decreasing: trend <= -*waterLevelTrendThreshold*
- ~~2.~~○ Increasing: trend >= +*waterLevelTrendThreshold*
- ~~3.~~○ Steady: -*waterLevelTrendThreshold* < trend < +*waterLevelTrendThreshold*

~~2.~~• Where a value is not known, the fill value must be populated, which is 0: Unknown. The fill value may be used in non-tidal or similar regions.

~~1.~~• The fill value of 0: Unknown is recommended for all difference series (*typeOfWaterLevelData* = 6, 7, 8, 9, or 10).

~~2.~~• Native integer type H5T_NATIVE_UINT8 should be used for the base type of the numeric code (1, 2, or 3 here) when creating the enumeration.

3. Water Level Time (*waterLevelTime*)

Water Level Time: The time of the water level height, expressed in Date-time format as specified by ISO 8601.

Unit: Years, months, days, hours, minutes, seconds

Resolution: 1 second

Format: YYYYMMDDTHHMMSSZ, where Y is year, M is month, D is day, H is hour, M is minute, and S is second

Example: 19850412T101530Z denotes 10 hours, 15 minutes, and 30 seconds on 12 April 1985.

Remarks:

~~4.~~• Required only for fixed station (stationwise) time series data (*dataCodingFormat* = 8) with non-uniform time intervals.
~~5.~~• All times are in UTC (Universal Time Coordinated).

A.2 Vertical Datum Difference

Feature: Vertical Datum Difference (*VerticalDatumDifference*)

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Commented [GS37]: Should we remove this feature? It is not currently included in the Feature Catalogue, IHO Registry, or metadata.

IHO Definition: FEATURE: **VERTICAL DATUM DIFFERENCE:** the separation distance between an ellipsoid and a chart datum			
S-104 Geo Feature: Datum Difference			
Primitives: S100_GridCoverage, S100_PointCoverage			
S-104 Attribute	**Allowable Encoding Value**	**Type**	**Multiplicity**
Vertical Datum Difference Value	must be in decimal metres, maximum resolution of 0.01 metres	RE	1

The number of attributes for *Vertical Datum Difference* is one.

Vertical Datum Difference Value (*verticalDatumDifferenceValue*)

Vertical Datum Difference Value: The value of the separation distance between two vertical datums, such as an ellipsoid and a tidal datum.

Unit: metre (m)
Minimum Resolution: 0.01 m
Format: xxx.xx
Example: 8.37
Remarks:

6. Land mask or missing value is denoted by a unique number as specified in the metadata.
7. Datum information is contained in the metadata.
8. 0.01 m equals 0.3937 in (1 cm)

Commented [GS38]: Should this be verticalDatumDifferenceValue? If not, definition may need to read something like "The value of the separation distance between two datums, such as an ellipsoid and a tidal datum in the vertical."

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Annex B – Additional Terms and Definitions

Terms that are defined in this Annex or in Clause 1.4.2 are highlighted in **bold**.

accuracy
closeness of agreement between an observed value and the true value or a reference value accepted as true
NOTE 1: A test result can be observations or measurements
NOTE 2: For positioning services, the test result is a measured value or set of values
NOTE 3: For observations and measurements, true values are not obtainable. In their place reference values which are accepted as true values are used
[ISO 19157, ISO 19116]

application
manipulation and processing of **data** in support of user requirements
[ISO 19101]

application schema
conceptual **schema** for **data** required by one or more **applications**
[ISO 19101]

attribute
a named element within a classifier that describes a **range** of values that **instances** of the classifier may hold
NOTE: An **attribute** is semantically equivalent to a composition association; however, the intent and usage are normally different
[ISO/TS 19103]
named property of an entity
NOTE: Describes a geometrical, topological, thematic, or other **characteristic** of an entity
[ISO/TS 19130]

attribute <**UML**>
feature within a classifier that describes a **range** of values that **instances** of the classifier may hold
[ISO/TS 19103]

characteristic
abstraction of a property of an **object** or of a set of **objects**
NOTE: **Characteristics** are used for describing concepts
[ISO 1087-1, ISO 19146]
distinguishing **feature**
NOTE 1: A **characteristic** can be inherent or assigned
NOTE 2: A **characteristic** can be qualitative or Quantitative
NOTE 3: There are various classes of **characteristics**, such as the following: physical (e.g., mechanical, electrical, chemical, or biological), sensory (e.g., related to smell, touch, taste, sight, or hearing), behavioral (e.g., courtesy, honesty, or veracity), temporal (e.g., punctuality, reliability, or availability), ergonomic (e.g., physiological, or related to human safety), and functional (e.g., maximum speed of an aircraft)
[ISO 19113]

class <**UML**>
description of a set of **objects** that share the same **attributes**, operations, methods, relationships, and semantics
NOTE: A **class** may use a set of interfaces to specify collections of operations it provides to its environment. See: interface
[ISO/TS 19103-2]

classification
abstract representation of real-world phenomena using **classifiers**
[ISO 19144-1]

classifier
a **model** element that describes behavioral and structural features
[ISO/TS 19103]
definition used to assign **objects** to legend **classes**
NOTE: **Classifiers** can be defined algorithmically or according to a set of classification system-specific rules
[ISO 19144-1]

classifier <**UML**>
mechanism that describes behavioral and structural features
NOTE: Classifiers include interfaces, classes, data types, and components
[ISO/TS 19103-2]

conceptual model
model that defines concepts of a universe of discourse
[ISO 19101]

confidence
accuracy of a **data** quality result
[ISO 19157]

conformance
fulfilment of specified requirements
[ISO 19105]

constraint
condition or restriction expressed in natural-language text or in a machine-readable language for the purpose of declaring some of the semantics of an element
[ISO/TS 19103]
restriction on how a link or turn may be traversed by a vehicle, such as a vehicle **classification**, or physical or temporal **constraint**
[ISO 19133]

constraint <**UML**>
condition or restriction expressed in natural-language text or in a machine-readable language for the purpose of declaring some of the semantics of an element
[ISO/TS 19103]
NOTE: Certain **constraints** are predefined in the UML; others may be user defined. **Constraints** are one of three extensibility mechanisms in UML. See: tagged value, stereotype
[retired version of ISO/TS 19103]

content model
information view of an **application schema**
NOTE: The term "information view" comes from the ISO Reference **model** for Open distributed processing (RM-ODP) as specified in ISO 19101-2
[ISO/TS 19129]

continuous coverage
coverage that returns different values for the same **feature attribute** at different **direct positions** within a single spatial **object**, temporal **object**, or spatiotemporal **object** in its **domain**
NOTE: Although the **domain** of a **continuous coverage** is ordinarily bounded in terms of its spatial and/or temporal extent, it can be subdivided into an infinite number of **direct positions**

[ISO 19123]

coverage domain
Consists of a collection of **direct positions** in a coordinate space that may be defined in terms of up to three spatial dimensions as well as a temporal dimension.
[Springer 2012]

curve
one-dimensional **geometric primitive**, representing the continuous **image** of a line
NOTE: The boundary of a **curve** is the set of **points** at either end of the **curve**. If the **curve** is a cycle, the two ends are identical, and the **curve** (if topologically closed) is considered to not have a boundary. The first **point** is called the start **point**, and the last is the end **point**. Connectivity of the **curve** is guaranteed by the *continuous **image** of a line* clause. A topological theorem states that a continuous **image** of a connected set is connected
[ISO 19107]

data
reinterpretable representation of **information** in a formalized manner suitable for communication, interpretation, or processing
[ISO 19115]

data product specification
detailed description of a **dataset** or **dataset series** together with additional **information** that will enable it to be created, and supplied to and used by another party
NOTE: A **data product specification** provides a description of the universe of discourse and a specification for mapping the universe of discourse to a **dataset**. It may be used for production, sales, end-use, or other purpose
[ISO 19131]

data type
a descriptor of a set of values that lack identity (independent existence and the possibility of side-effects)
EXAMPLE: Integer, Real, Boolean, String, and Date
NOTE: **Data types** include primitive predefined **types** and user-definable **types**
[ISO/TS 19103]
specification of a value **domain** with operations allowed on values in this **domain**
EXAMPLE: Integer, Real, Boolean, String, and Date
NOTE 1: **Data types** include primitive predefined ***types*** and user-definable **types**
NOTE 2: A **data type** is identified by a term, e.g., Integer. Values of the **data types** are of the specified value **domain**, e.g., all integer numbers between −65 537 and 65 536. The set of operations can be +, -, *, and /, and is semantically well defined. A **data type** can be simple or complex. A simple **data type** defines a value **domain** where values are considered atomic in a certain context, e.g., Integer. A complex **data type** is a collection of **data types** which are grouped together. A complex **data type** may represent an **object** and can thus have identity
[ISO 19118]

data value
an **instance** of a **data type**; a value without identity
NOTE: A value may describe a possible state of an **object** within a **class** or **type** (**domain**)
[ISO/TS 19103]

dataset
identifiable collection of **data**
NOTE: A **dataset** may be a smaller grouping of **data** which, though limited by some **constraint** such as spatial extent or **feature type**, is located physically within a larger **dataset**. Theoretically, a **dataset** may be as small as a single **feature** or **feature attribute** contained within a larger **dataset**. A hard-copy map or chart may be considered a **dataset**
NOTE: The principles which apply to **datasets** may also be applied to **dataset series** and reporting groups
[ISO 19101, ISO 19115, ISO 19117]

dataset series
collection of **datasets** sharing the same **product specification**
[ISO 19115]

datum
parameter or set of parameters that define the **position** of the origin, the scale, and the orientation of a **coordinate** system
NOTE 1: A **datum** defines the **position** of the origin, the scale, and the orientation of the axes of a **coordinate** system
NOTE 2: A **datum** may be a geodetic **datum**, a **vertical datum**, an engineering **datum**, an **image datum**, or a temporal **datum**
[ISO 19111, ISO 19116]

depth
distance of a **point** from a chosen reference surface measured downward along a line perpendicular to that surface
NOTE: A **depth** above the reference surface will have a negative value
[ISO 19111]

element <**XML**>
basic **information** item of an XML document containing child **elements**, **attributes**, and character **data**
NOTE: From the XML **information** set: “Each XML document contains one or more **elements**, the boundaries of which are either delimited by start-tags and end-tags, or, for empty **elements**, by an empty-element tag. Each **element** has a **type**, identified by name, sometimes called its *generic identifier* (GI), and may have a set of **attribute** specifications. Each **attribute** specification has a name and a value.”
[ISO 19136]

elevation
the altitude of the ground level of an object, measured from a specified vertical datum.
[IHO:S100 GFM]

encoding
conversion of **data** into a series of codes
[ISO 19118]

error
discrepancy with the universe of discourse
[ISO 19138]

feature catalog
catalog containing definitions and descriptions of the **feature types**, **feature attributes**, and feature relationships occurring in one or more sets of geographic **data**, together with any **feature** operations that may be applied
[ISO 19101, ISO 19110]

feature type
classifier for **features**, defined by the set of **characteristic** properties that all **features** of this type carry
[ISO 19109]
class of **features** having common **characteristics**
[ISO 19156]

format
a language construct that specifies the representation, in character form, of **data objects** in a record, file, message, storage device, or transmission channel
[ISO 19145]

framework
relationship between the elements of the **content model** and the separate **encoding** and **portrayal** mechanisms
[ISO/TS 19129]

geographic location
longitude, latitude, and **elevation** of a ground or elevated **point**
[ISO/TS 19130-2]
NOTE: For the purpose of this document elevated **point** will be a **depth** based on a specified **datum**.
[CARL 2015]

geometric complex
set of disjoint **geometric primitive**s where the boundary of each **geometric primitive** can be represented as the union of other **geometric primitives** of smaller dimension within the same set
NOTE: The **geometric primitives** in the set are disjoint in the sense that no **direct position** is interior to more than one **geometric primitive**. The set is closed under boundary operations, meaning that, for each element in the **geometric complex**, there is a collection (also a **geometric complex**) of **geometric primitives** that represents the boundary of that element. Recall that the boundary of a **point** (the only 0-D primitive **object** type in geometry) is empty. Thus, if the largest dimension **geometric primitive** is a solid (3-D), the composition of the boundary operator in this definition terminates after at most three steps. It is also the case that the boundary of any **object** is a cycle
[ISO 19107]

geometric object
spatial **object** representing a geometric set
NOTE: A **geometric object** consists of a **geometric primitive**, a collection of **geometric primitives**, or a **geometric complex** treated as a single entity. A **geometric object** may be the spatial representation of an **object** such as a ***feature*** or a significant part of a ***feature***
[ISO 19107]

geometric primitive
geometric object representing a single, connected, homogeneous element of space
NOTE: **Geometric primitives** are non-decomposed **objects** that present **information** about geometric configuration. They include **points**, **curves**, surfaces, and solids
[ISO 19107]

georectified
corrected for positional displacement with respect to the surface of the Earth
[ISO 19115-2]

gridded data
data whose **attribute** values are associated with **positions** on a **grid coordinate** system
[ISO 19115-2]

image
gridded **coverage** whose **attribute** values are a numerical representation of a physical parameter
NOTE: The physical parameters are the result of measurement by a sensor or a prediction from a **model**
[ISO 19115-2]

implementation
realization of a specification
NOTE: In the context of the ISO geographic **information** standards, this includes specifications of geographic **information** services and **datasets**
[ISO 19105]

information
knowledge concerning objects, such as facts, events, things, processes, or ideas, including concepts, that within a certain context has a particular meaning
[ISO 19118]

instance
individual entity having its own identity and value
NOTE: A classifier specifies the form and behavior of a set of **instances** with similar properties
[ISO/TS 19103]
object that realizes a **class**
[ISO 19107]

layer
basic unit of geographic **information** that may be requested as a map from a server
[ISO 19128]

lineage
chain of legal ownership of content; history of ownership
[ISO 19153]

metadata
data about **data**
[ISO 19115]

metamodel <**UML**>
model that defines the language for expressing other models
NOTE: A **metamodel** is an instance of a meta-metamodel
[ISO/TS 19103]

model
abstraction of some aspects of reality
[ISO 19109]

navigation
combination of routing, route transversal, and tracking
NOTE: This is essentially the common term **navigation**, but the definition decomposes the process in terms used in the packages defined in this international standard
[ISO 19133]

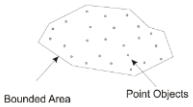
object
entity with a well-defined boundary and identity that encapsulates state and behavior
NOTE 1: An **object** is an **instance** of a **class**
NOTE 2: This term was first used in this way in the general theory of object-oriented programming, and later adopted for use in this same sense in UML. **Attributes** and relationships represent state. Operations, methods, and state machines represent behavior
NOTE 3: A GML **object** is an XML **element** of a **type** derived from AbstractGMLType
[ISO 19107]

object <**UML**>
a discrete entity with a well-defined boundary and identity that encapsulates state and behavior; an **instance** of a **class**
[ISO/TS 19103]

point
zero-dimensional **geometric primitive**, representing a **position**
NOTE: The boundary of a **point** is the empty set
[ISO 19107]

point coverage
coverage that has a **domain** composed of **points**
[ISO 19123]

point set
set of 2, 3 or n dimensional points in space.
[S-100]



point set coverage
coverage function associated with point value pairs in 2 dimensions.
[S-100]
NOTE: a coverage function is driven by a set of points (with X, Y position) together with a record of one or more values at that position.

portrayal
presentation of **information** to humans
[ISO 19109, ISO 19117]

portrayal catalogue
collection of defined **portrayals** for a feature catalogue
NOTE: Content of a portrayal catalogue includes **portrayal functions**, **symbols**, and **portrayal context.**
[ISO 19117]

portrayal context
circumstances, imposed by factors extrinsic to a geographic dataset, that affect the **portrayal** of that dataset.
EXAMPLE: Factors contributing to portrayal context may include the proposed display or map scale, the viewing conditions (day/night/dusk), and the display orientation requirements (north not necessarily at the top of the screen or page), among others
NOTE: Portrayal context may influence the selection of portrayal functions and construction of symbols
[ISO 19117]

portrayal function
function that maps geographic features to symbols
NOTE: Portrayal functions can also include parameters and other computations that are not dependent on geographic feature properties
[ISO 19117]

portrayal function set
function that maps a feature catalog to a symbol set
[ISO 19117]

portrayal rule
specific kind of portrayal function expressed in a declarative language
NOTE: A declarative language is rule based and includes decision and branching statements
[ISO 19117]

portrayal service
generic interface used to portray features
[ISO 19117]

portrayal specification
collection of operations applied to the feature instance to portray it
[ISO 19117]

position
data type that describes a **point** or geometry potentially occupied by an **object** or person
NOTE: A **direct position** is a semantic subtype of **position**. **Direct positions** as described can only define a **point**, and therefore not all **positions** can be represented by a **direct position**. That is consistent with the *is type of* relation. An ISO 19107 geometry is also a **position**, but not a **direct position**
[ISO 19132]

positional accuracy
closeness of **coordinate** value to the true or accepted value in a specified reference system
NOTE: The term *absolute accuracy* is sometimes used for this concept to distinguish it from relative **positional accuracy**. Where the true **coordinate** value may not be perfectly known, **accuracy** is normally tested by comparison with available values that can best be accepted as true
[ISO 19116]

product
result of a process
[ISO 19158]

product specification
description of the universe of discourse and a **specification** for mapping the universe of discourse to a **dataset**
[ISO 19158]

profile
set of one or more base standards or subsets of base standards, and, where applicable, the identification of chosen clauses, classes, options, and parameters of those base standards, that are necessary for accomplishing a particular **function**
NOTE: A **profile** is derived from base standards so that, by definition, **conformance** to a **profile** is **conformance** to the base standards from which it is derived
[ISO 19101, ISO 19106]

profile <**UML**>
definition of a limited extension to a reference **metamodel** with the purpose of adapting the **metamodel** to a specific platform or **domain**
[ISO/TS 19103]

quadrilateral grid coverage
may be a **rectified grid** or a **referenceable grid**.
[Springer 2012]

quality
totality of **characteristics** of a **product** that bear on its ability to satisfy stated and implied needs
[ISO 19101, ISO 19109]
Degree to which a set of inherent **characteristics** fulfills requirements
NOTE 1: The term ***quality*** can be used with adjectives such as poor, good or excellent
NOTE 2: *Inherent*, as opposed to *assigned*, means existing in something, especially as a permanent **characteristic**
[ISO 19157]
NOTE 3: For the purposes of this technical specification the quality **characteristics** of **product** include:
– **Data** quality (the elements of which are described by ISO 19113)
– Volume of delivery
– Schedule of delivery
– Cost of production and/or update
[ISO 19158]

range
set of all values a **function** *f* can take as its arguments vary over its **domain**
[ISO 19136]

referenceable grid
requires a formula of higher order that transforms into a coordinate reference system.
EXAMPLE: the perspective transformation with eight parameters.
[Springer 2012]

render
conversion of digital graphics data into visual form
EXAMPLE Generation of an image on a video display
[ISO 19117]

schema
formal description of a **model**
NOTE: In general, a **schema** is an abstract representation of an **object**'s **characteristics** and relationship to other **objects**. An XML **schema** represents the relationship between the **attributes** and **elements** of an XML **object** (for example, a document or a portion of a document)
[ISO 19101]

sequence
finite, ordered collection of related items (**objects** or values) that may be repeated
NOTE: Logically, a **sequence** is a set of pairs <item, offset>. LISP syntax, which delimits **sequences** with parentheses and separates elements in the **sequence** with commas, is used in this international standard
[ISO 19107]

set
unordered collection of related items (**objects** or values) with no repetition
[ISO 19107]

specification
declarative description of what something is or does
NOTE: Contrast: **implementation**
[retired version of ISO/TS 19103]

timestamp
value of time at which an **object**'s state is measured and recorded
[ISO 19132]

symbol
portrayal primitive that can be graphic, audible, or tactile in nature, or a combination of these
[ISO 19117]

tuple
ordered list of values
NOTE 1: The number of values in a tuple is immutable
NOTE 2: the ordered list will generally be a finite **sequence** of **features,** each of a specific **feature type**
[ISO 19136, ISO 19142]

type
a specification of the general structure and behavior of a **domain** of **objects** without providing a physical **implementation**
NOTE: A **type** may have **attributes** and associations
[ISO/TS 19103]

UML
The Unified Modeling Language (**UML**) is a general-purpose modeling language in the field of software engineering, which is designed to provide a standard way to visualize the design of a system.

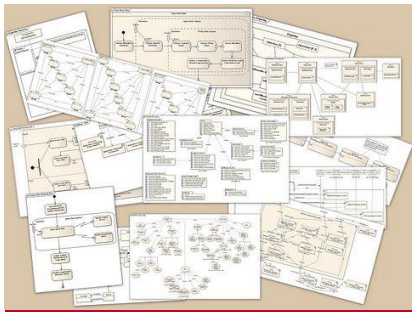


image courtesy of Kishorekumar 62
[Wikipedia 2015]

UML application schema
application schema written in UML in accordance with ISO 19109
[ISO 19136]

valid time
time when a fact is true in the abstracted reality
[ISO 19108]

vertical coordinate system
one-dimensional **coordinate** system used for gravity-related height or **depth** measurements
[ISO 19111]

vertical datum
datum describing the relation of gravity-related heights or **depths** to the Earth
NOTE: In most cases the **vertical datum** will be related to mean sea level. Ellipsoidal heights are treated as related to a three-dimensional ellipsoidal **coordinate** system referenced to a geodetic **datum**. **Vertical datums** include sounding **datums** (used for hydrographic purposes), in which case the heights may be negative heights or **depths**
[ISO 19111]

Annex C – Application Schema (UML Diagrams)

Commented [GS39]: These are being updated with the help of S-100WG.

Figure C.1 Spatial Types – Coverages

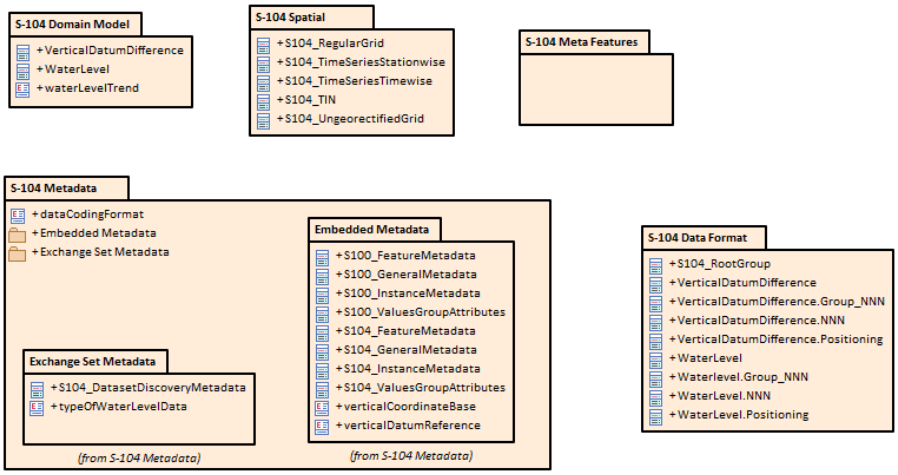


Figure C.2 Domain Model

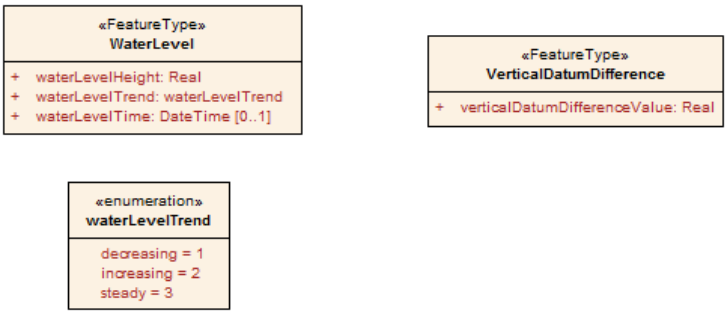


Figure C.3 Domain Objects

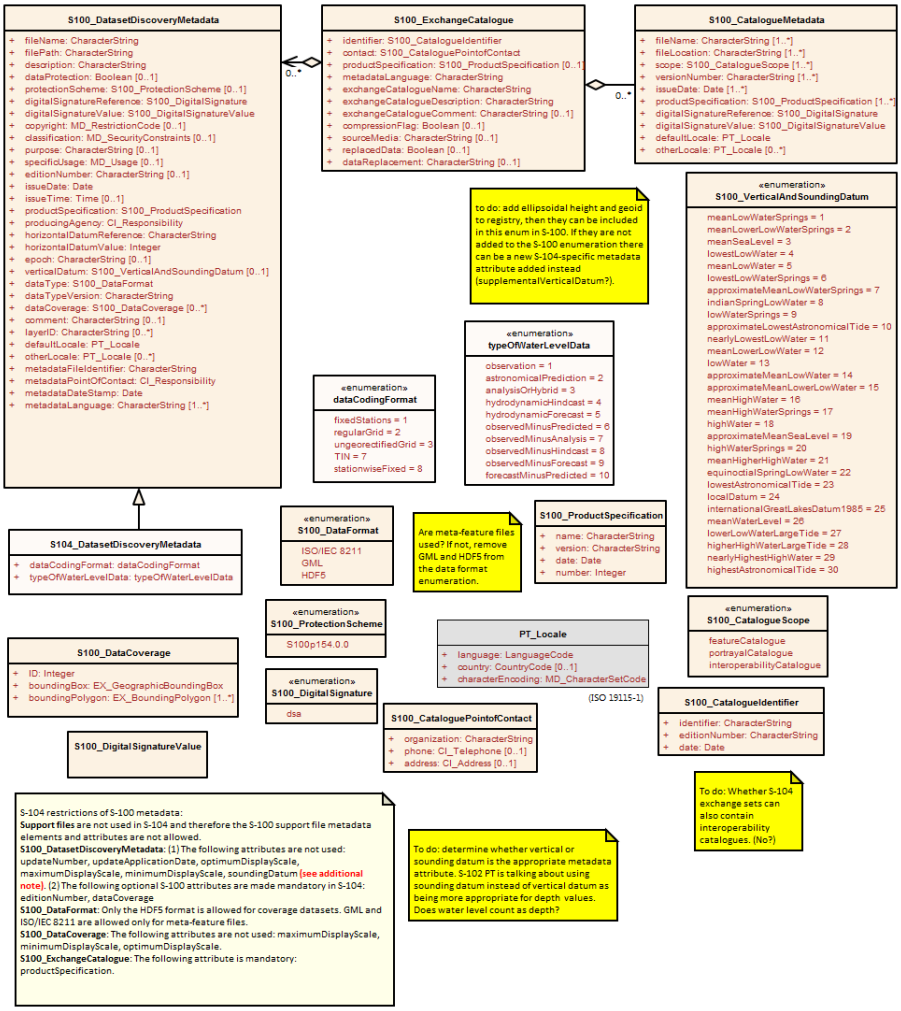


Figure C.4 Exchange set class details

Annex D – Feature Catalogue

D.1. Meta Feature Types

D.2. Geo Feature Types

D.2.1. Water Level

IHO S-104 Water Level Information For Surface Navigation

Definition: The vertical position of a water surface.

CamelCase: WaterLevel

Alias:

Super type:

Feature use type: geographic

Primitive: pointSet, coverage

Remarks: No remarks.

Attribute Bindings:

S-104 Attribute	Allowable Encoding Value	Type	Multiplicity
Water Level Height		RE	1, 1
Water Level Trend	1 : Decreasing 2 : Increasing 3 : Steady	EN	1, 1
Water Level Time		DT	0, 1

D.3. Carto Feature Types

D.4. Information Types

D.5. Simple Attributes

D.5.1. Water Level Height

Definition: The height of a water surface relative to a vertical datum.

CamelCase: waterLevelHeight

Alias:

Value type: real

Remarks: No remarks.

D.5.2. Water Level Time

Definition: The time of the water level height, expressed in Date-time format as specified by ISO 8601.

CamelCase: waterLevelTime

Alias:

Value type: dateTime

Remarks: Unit: Years, months, days, hours, minutes, seconds; Resolution: 1 second; Format: YYYYMMDDTHHMMSSZ, where Y is year, M is month, D is day, H is hour, M is minute, and S is second; Example: 19850412T101530Z denotes 10 hours, 15 minutes, and 30 seconds on 12 April 1985.

D.5.3. Water Level Trend

Definition: The tendency of water level to change in a particular direction.

CamelCase: waterLevelTrend

Alias:

IHO S-104 Water Level Information For Surface Navigation

Value type: enumeration

Remarks: No remarks.

Listed Values:

Code	Label	Definition
1	Decreasing	Becoming smaller in magnitude.
2	Increasing	Becoming larger in magnitude.
3	Steady	Constant.

D.6. Complex Attributes

D.7. Roles

D.8. Information Associations

D.9. Feature Associations

D.10. Feature Catalogue XML


```
<?xml version="1.0" encoding="utf-8" ?>
- <S100FC:S100_FC_FeatureCatalogue xmlns:S100FC="http://www.iho.int/S100FC"
    xmlns:S100Base="http://www.iho.int/S100Base"
    xmlns:S100CI="http://www.iho.int/S100CI"
    xmlns:xlink="http://www.w3.org/1999/xlink"
    xmlns:S100FD="http://www.iho.int/S100FD"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.iho.int/S100FC S100FC.xsd">
  <S100FC:name>S-104</S100FC:name>
  <S100FC:scope>Water level data are intended to be used as stand-alone data or as
    a layer in an ENC.</S100FC:scope>
  <S100FC:fieldOfApplication>Marine navigation</S100FC:fieldOfApplication>
  <S100FC:versionNumber>0.0.7</S100FC:versionNumber>
  <S100FC:versionDate>2020-07-30</S100FC:versionDate>
- <S100FC:producer>
  <S100CI:role>owner</S100CI:role>
- <S100CI:party>
- <S100CI:CI_Organisation>
  <S100CI:name>International Hydrographic Organization</S100CI:name>
- <S100CI:contactInfo>
- <S100CI:phone>
  <S100CI:number>+377 93 10 81 00</S100CI:number>
  <S100CI:numberType>voice</S100CI:numberType>
    </S100CI:phone>
- <S100CI:address>
  <S100CI:administrativeArea>4b quai Antoine 1er</S100CI:administrativeArea>
  <S100CI:postalCode>B.P.445</S100CI:postalCode>
  <S100CI:country>MONACO</S100CI:country>
  <S100CI:electronicMailAddress>info@iho.int</S100CI:electronicMailAddress>
    </S100CI:address>
  <S100CI:hoursOfService>24h</S100CI:hoursOfService>
    </S100CI:contactInfo>
    </S100CI:CI_Organisation>
    </S100CI:party>
    </S100FC:producer>
  <S100FC:classification>unclassified</S100FC:classification>
- <S100FC:S100_FC_SimpleAttributes>
- <S100FC:S100_FC_SimpleAttribute>
  <S100FC:name>Water Level Height</S100FC:name>
  <S100FC:definition>The height of a water surface relative to a vertical
    datum.</S100FC:definition>
```

<S100FC:code>**waterLevelHeight**</S100FC:code>
- <S100FC:definitionReference>
<S100FC:sourceIdentifier>**324**</S100FC:sourceIdentifier>
<S100FC:definitionSource>**IHO:DDR**</S100FC:definitionSource>
</S100FC:definitionReference>
<S100FC:valueType>**real**</S100FC:valueType>
</S100FC:S100_FC_SimpleAttribute>
- <S100FC:S100_FC_SimpleAttribute>
<S100FC:name>**Water Level Time**</S100FC:name>
<S100FC:definition>**The time of the water level height, expressed in Date-time format as specified by ISO 8601.**</S100FC:definition>
<S100FC:code>**waterLevelTime**</S100FC:code>
<S100FC:remarks>**Unit: Years, months, days, hours, minutes, seconds; Resolution: 1 second; Format: YYYYMMDDTHHMMSSZ, where Y is year, M is month, D is day, H is hour, M is minute, and S is second; Example: 19850412T101530Z denotes 10 hours, 15 minutes, and 30 seconds on 12 April 1985.**</S100FC:remarks>
- <S100FC:definitionReference>
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</S100FC:definitionReference>
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</S100FC:S100_FC_SimpleAttribute>
- <S100FC:S100_FC_SimpleAttribute>
<S100FC:name>**Water Level Trend**</S100FC:name>
<S100FC:definition>**The tendency of water level to change in a particular direction.**</S100FC:definition>
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- <S100FC:definitionReference>
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- <S100FC:listedValues>
- <S100FC:listedValue>
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<S100FC:code>**1**</S100FC:code>
- <S100FC:definitionReference>
<S100FC:sourceIdentifier>**2070**</S100FC:sourceIdentifier>
<S100FC:definitionSource>**IHO:DDR**</S100FC:definitionSource>
</S100FC:definitionReference>
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- <S100FC:listedValue>
<S100FC:label>**Increasing**</S100FC:label>
<S100FC:definition>**Becoming larger in magnitude.**</S100FC:definition>
<S100FC:code>**2**</S100FC:code>
- <S100FC:definitionReference>
<S100FC:sourceIdentifier>**2071**</S100FC:sourceIdentifier>
<S100FC:definitionSource>**IHO:DDR**</S100FC:definitionSource>
</S100FC:definitionReference>
</S100FC:listedValue>
- <S100FC:listedValue>

```
<S100FC:label>Steady</S100FC:label>
<S100FC:definition>Constant.</S100FC:definition>
<S100FC:code>3</S100FC:code>
- <S100FC:definitionReference>
<S100FC:sourceIdentifier>2072</S100FC:sourceIdentifier>
<S100FC:definitionSource>IHO:DDR</S100FC:definitionSource>
  </S100FC:definitionReference>
  </S100FC:listedValue>
  </S100FC:listedValues>
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  </S100FC:S100_FC_SimpleAttributes>
- <S100FC:S100_FC_FeatureTypes>
- <S100FC:S100_FC_FeatureType isAbstract="false">
<S100FC:name>Water Level</S100FC:name>
<S100FC:definition>The vertical position of a water surface.</S100FC:definition>
<S100FC:code>WaterLevel</S100FC:code>
- <S100FC:definitionReference>
<S100FC:sourceIdentifier>369</S100FC:sourceIdentifier>
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  </S100FC:definitionReference>
- <S100FC:attributeBinding sequential="false">
- <S100FC:multiplicity>
<S100Base:lower>1</S100Base:lower>
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  </S100FC:multiplicity>
<S100FC:attribute ref="waterLevelHeight" />
  </S100FC:attributeBinding>
- <S100FC:attributeBinding sequential="false">
- <S100FC:multiplicity>
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  </S100FC:multiplicity>
- <S100FC:permittedValues>
<S100FC:value>1</S100FC:value>
<S100FC:value>2</S100FC:value>
<S100FC:value>3</S100FC:value>
  </S100FC:permittedValues>
<S100FC:attribute ref="waterLevelTrend" />
  </S100FC:attributeBinding>
- <S100FC:attributeBinding sequential="false">
- <S100FC:multiplicity>
<S100Base:lower>0</S100Base:lower>
<S100Base:upper xsi:nil="false" infinite="false">1</S100Base:upper>
  </S100FC:multiplicity>
<S100FC:attribute ref="waterLevelTime" />
  </S100FC:attributeBinding>
<S100FC:featureUseType>geographic</S100FC:featureUseType>
<S100FC:permittedPrimitives>pointSet</S100FC:permittedPrimitives>
<S100FC:permittedPrimitives>coverage</S100FC:permittedPrimitives>
  </S100FC:S100_FC_FeatureType>
  </S100FC:S100_FC_FeatureTypes>
  </S100FC:S100_FC_FeatureCatalogue>
```

Annex E – Sample HDF5 Encoding

The following are examples of HDF5 water level data files for each of the five data coding formats. The general structure of the data product is shown in Table 10.2, and the specific variables contained in the attributes are explained in Tables 12.1, 12.2, 12.3 and 12.4. The sample HDF5 files were produced by MATLAB® and were displayed in HDFView version 2.14.

E.1 Common Groups and Attributes

Information shown in Figures E.1 through E.4 is common to all the data coding formats.

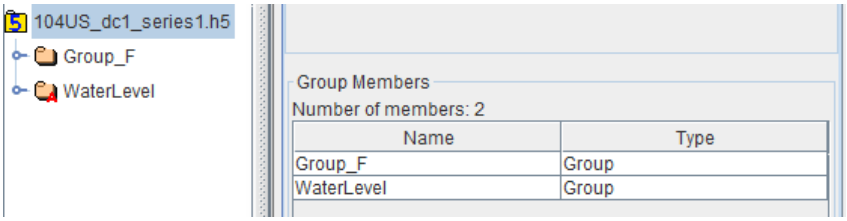


Figure E.1 - Typical HDF5 file (left) and its two groups, 'Group_F' and 'WaterLevel' (right)

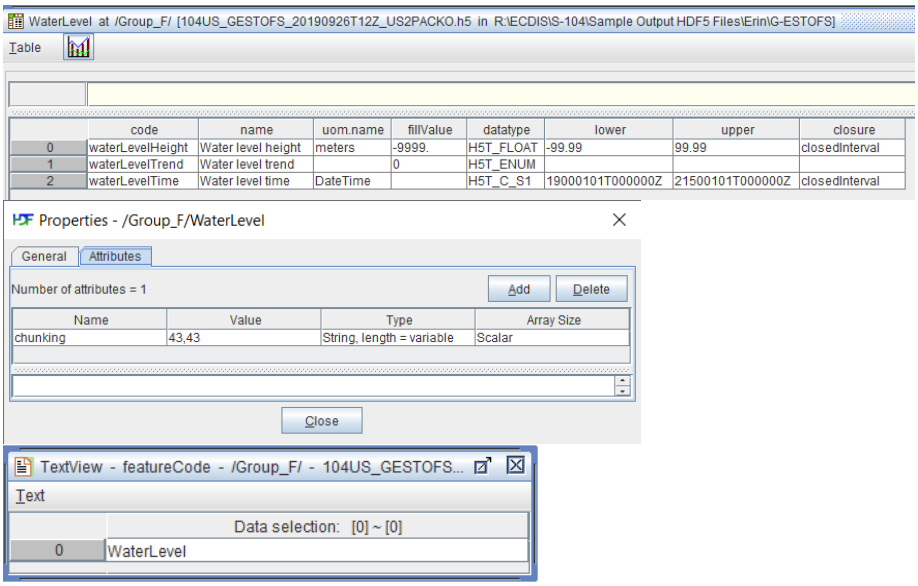


Figure E.2 - Group_F includes the (top panel) compound dataset 'WaterLevel' and (bottom panel) the scalar dataset 'featureCode'. The dataset 'WaterLevel' (middle panel) contains the attribute 'chunking'. Values provided here for code (waterLevelHeight, waterLevelTrend, and waterLevelTime), uom.name (meters and DateTime), and fillValue (-9999. and 0) are required.

Commented [GS40]: OEM feedback (U.S. NIWC) suggests requiring code, uom.name, and fillValue for all S-104 datasets.

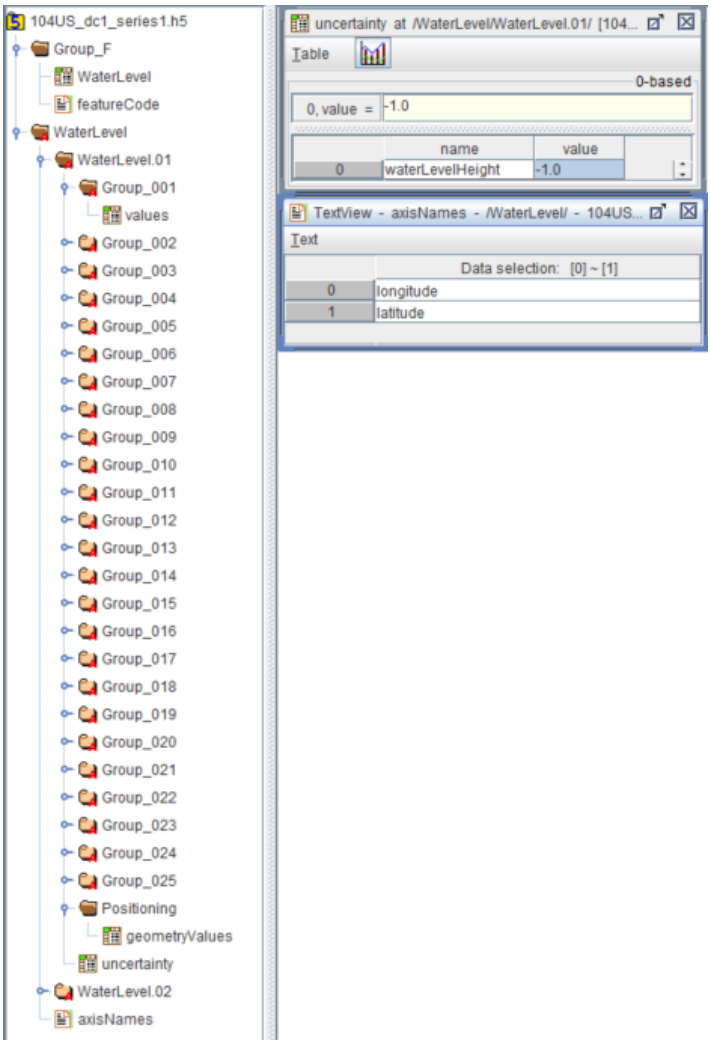
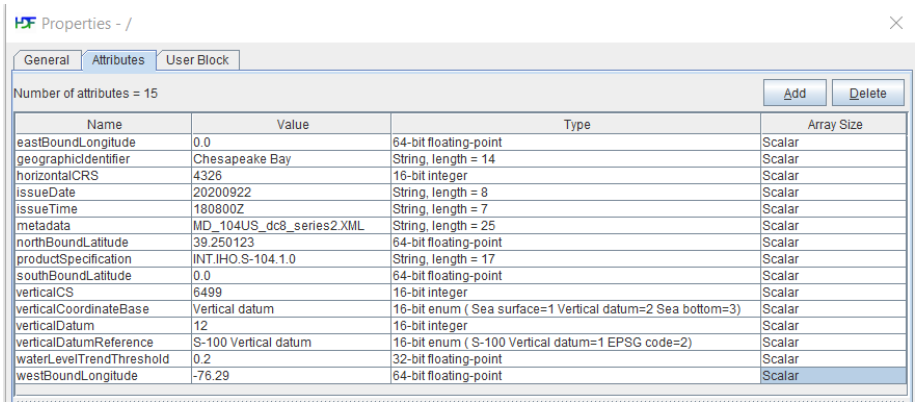


Figure E.3 – General structure of the HDF5 dataset (left panel); however, for dataCodingFormat =2, the group 'Positioning' is absent. On the right, the contents of the datasets 'uncertainty' (top right panel) within the group WaterLevel.01, and 'axisNames' (bottom right panel) within the group WaterLevel

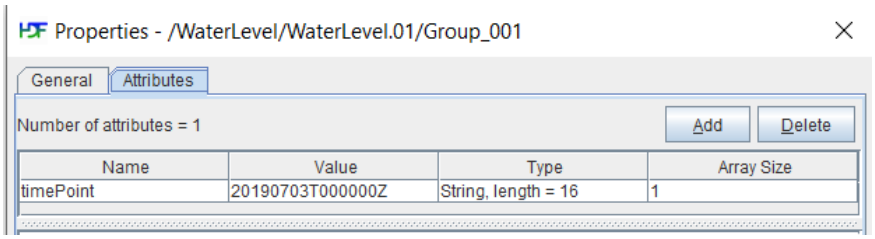


Name	Value	Type	Array Size
eastBoundLongitude	0.0	64-bit floating-point	Scalar
geographicIdentifier	Chesapeake Bay	String, length = 14	Scalar
horizontalCRS	4326	16-bit integer	Scalar
issueDate	20200922	String, length = 8	Scalar
issueTime	180800Z	String, length = 7	Scalar
metadata	MD_104US_dc8_series2.XML	String, length = 25	Scalar
northBoundLatitude	39.250123	64-bit floating-point	Scalar
productSpecification	INT.IHO.S-104.1.0	String, length = 17	Scalar
southBoundLatitude	0.0	64-bit floating-point	Scalar
verticalCS	6499	16-bit integer	Scalar
verticalCoordinateBase	Vertical datum	16-bit enum (Sea surface=1 Vertical datum=2 Sea bottom=3)	Scalar
verticalDatum	12	16-bit integer	Scalar
verticalDatumReference	S-100 Vertical datum	16-bit enum (S-100 Vertical datum=1 EPSG code=2)	Scalar
waterLevelTrendThreshold	0.2	32-bit floating-point	Scalar
westBoundLongitude	-76.29	64-bit floating-point	Scalar

Figure E.4 – Sample HDF5 attributes (cf. Table 12.1) of the root group

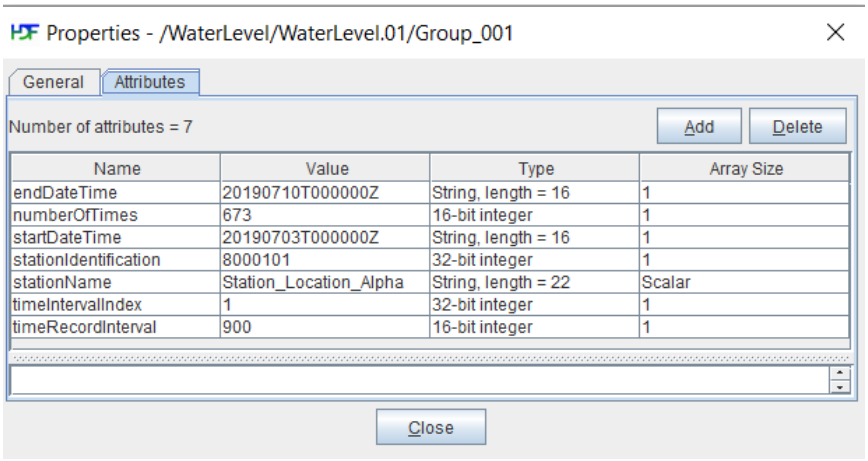
E.2 Values Groups Attributes

Attributes for the values groups have two forms: a short form for *dataCodingFormat* 1 through 7 (Figure E.5), and a longer form for *dataCodingFormat* 8 (Figure E.6).



Name	Value	Type	Array Size
timePoint	20190703T000000Z	String, length = 16	1

Figure E.5 – Short form of attributes of the values group 'Group_001.' Used for dataCodingFormat = 1 to 7.



Name	Value	Type	Array Size
endDateTime	20190710T000000Z	String, length = 16	1
numberOfTimes	673	16-bit integer	1
startDateTime	20190703T000000Z	String, length = 16	1
stationIdentification	8000101	32-bit integer	1
stationName	Station_Location_Alpha	String, length = 22	Scalar
timeIntervalIndex	1	32-bit integer	1
timeRecordInterval	900	16-bit integer	1

Figure E.6 - Long form of attributes of the values group 'Group_001'. Used for dataCodingFormat = 8.

E.3 Fixed Stations (dataCodingFormat=1)

For this coding format, the height and trend are stored in the one-dimensional compound array 'values', corresponding to data at all stations at one point in time. In each element of the array, the first variable is 'waterLevelHeight' and the second is 'waterLevelTrend'. The spelling and order of variable names are important.

values at /WaterLevel/WaterLevel.01/Group_00...

Table

0-based

0, waterLev... 0

	waterLevelHeight	waterLevelTrend
0	1.465	0
1	1.464	0
2	1.378	0
3	1.965	0

geometryValues at /WaterLevel...

Table

0-based

	longitude	latitude
0	-76.29	39.250123
1	-76.41	38.74
2	-76.33	38.25
3	-76.19	38.21

Figure E.7 – (left) For dataCodingFormat=1, sample contents of the dataset 'values' in Group_001 and (right) the geometry group 'Positioning', which contains location information on four fixed stations in the dataset 'geometryValues'. The HDF5 file structure is shown in Figure E.3

Number of attributes = 10 — Add — Delete

Name	Value	Type	Array Size
commonPointRule	all	8-bit enum (all=4 average=1 high=3 low=2)	Scalar
dataCodingFormat	Time series at fixed stations	8-bit enum (Regularly-gridded arrays=2 TIN=7 Time series at fixed stations=1 Time series at fixed stations (stationwise)=8 Ungeorectified gridded arrays=3)	Scalar
dimension	2	8-bit unsigned integer	Scalar
horizontalPositionUncertainty	-1.0	32-bit floating-point	Scalar
maxDatasetHeight	1.0	32-bit floating-point	Scalar
methodWaterLevelProduct	prediction or obs	String, length = variable	Scalar
minDatasetHeight	-0.43	32-bit floating-point	Scalar
numInstances	2	32-bit integer	Scalar
timeUncertainty	-1.0	32-bit floating-point	Scalar
verticalUncertainty	-1.0	32-bit floating-point	Scalar

General | Attributes

Number of attributes = 9 — Add — Delete

Name	Value	Type	Array Size
dateTimeOfFirstRecord	20190703T000000Z	String, length = 16	1
dateTimeOfLastRecord	20190710T000000Z	String, length = 16	1
eastBoundLongitude	-76.19	64-bit floating-point	1
northBoundLatitude	39.250123	64-bit floating-point	1
numGRP	4	16-bit integer	1
numberOfStations	4	16-bit integer	1
southBoundLatitude	38.21	64-bit floating-point	1
typeOfWaterLevelData	Astronomical prediction	32-bit enum (Observation=1 Astronomical prediction=2 Analysis or ...	1
westBoundLongitude	-76.41	64-bit floating-point	1

Figure E.8 – Attributes for (top panel) the feature metadata (cf. Table 12.2) and (bottom panel) the instance metadata (cf. Table 12.3)

E.4 Regular Grid (dataCodingFormat=2)

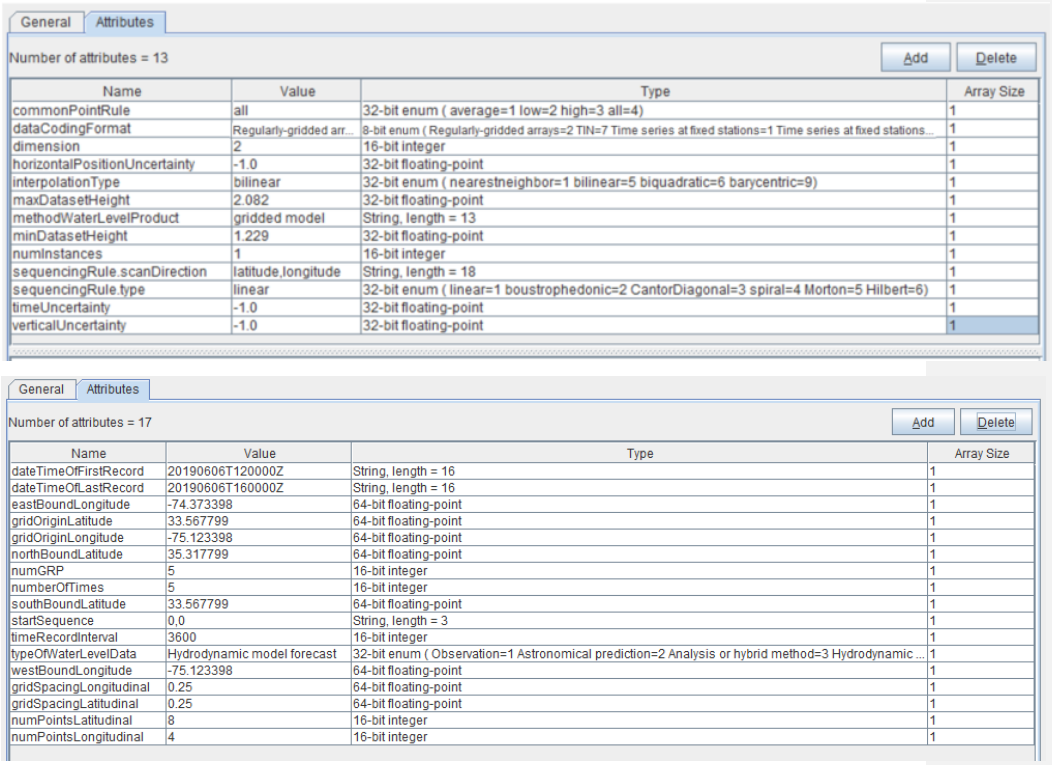
For this coding format, the height and trend are stored in the two-dimensional compound array 'values'. The entire array in the values group represents one point in time. In each element of the array, the first variable is 'waterLevelHeight' and the second is 'waterLevelTrend'. The spelling and order of variable names are important.

Using the values in the metadata, the longitude and latitude of any point (*i_index* and *j_index*) in the grid is computed by

longitude = gridOriginLongitude + (i_index)(gridSpacingLongitudinal)

latitude = gridOriginLatitude + (j_index)(gridSpacingLatitudinal).

The values of *i_index* start at 0 and increase up to *numPointsLongitudinal-1,* and similarly for *j_index.*



General | Attributes

Number of attributes = 13 — Add | Delete

Name	Value	Type	Array Size
commonPointRule	all	32-bit enum (average=1 low=2 high=3 all=4)	1
dataCodingFormat	Regularly-gridded arr...	8-bit enum (Regularly-gridded arrays=2 TIN=7 Time series at fixed stations=1 Time series at fixed stations...	1
dimension	2	16-bit integer	1
horizontalPositionUncertainty	-1.0	32-bit floating-point	1
interpolationType	bilinear	32-bit enum (nearestneighbor=1 bilinear=5 biquadratic=6 barycentric=9)	1
maxDatasetHeight	2.082	32-bit floating-point	1
methodWaterLevelProduct	gridded model	String, length = 13	1
minDatasetHeight	1.229	32-bit floating-point	1
numInstances	1	16-bit integer	1
sequencingRule.scanDirection	latitude,longitude	String, length = 18	1
sequencingRule.type	linear	32-bit enum (linear=1 boustrophedonic=2 CantorDiagonal=3 spiral=4 Morton=5 Hilbert=6)	1
timeUncertainty	-1.0	32-bit floating-point	1
verticalUncertainty	-1.0	32-bit floating-point	1

General | Attributes

Number of attributes = 17 — Add | Delete

Name	Value	Type	Array Size
dateTimeOfFirstRecord	20190606T120000Z	String, length = 16	1
dateTimeOfLastRecord	20190606T160000Z	String, length = 16	1
eastBoundLongitude	-74.373398	64-bit floating-point	1
gridOriginLatitude	33.567799	64-bit floating-point	1
gridOriginLongitude	-75.123398	64-bit floating-point	1
northBoundLatitude	35.317799	64-bit floating-point	1
numGRP	5	16-bit integer	1
numberOfTimes	5	16-bit integer	1
southBoundLatitude	33.567799	64-bit floating-point	1
startSequence	0,0	String, length = 3	1
timeRecordInterval	3600	16-bit integer	1
typeOfWaterLevelData	Hydrodynamic model forecast	32-bit enum (Observation=1 Astronomical prediction=2 Analysis or hybrid method=3 Hydrodynamic ...	1
westBoundLongitude	-75.123398	64-bit floating-point	1
gridSpacingLongitudinal	0.25	64-bit floating-point	1
gridSpacingLatitudinal	0.25	64-bit floating-point	1
numPointsLatitudinal	8	16-bit integer	1
numPointsLongitudinal	4	16-bit integer	1

Figure E.9 – Attributes for (top panel) the feature metadata (cf. Table 12.2) and (bottom panel) the instance metadata (cf. Table 12.3)

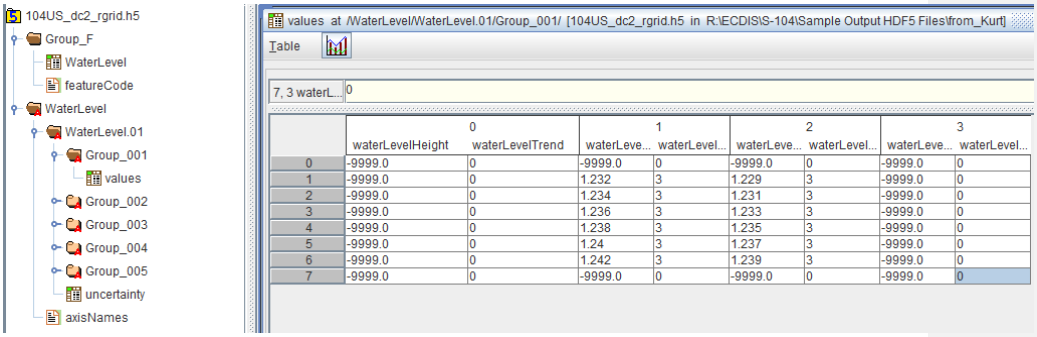


Figure E.10 – Sample HDF5 structure (left panel) and the dataset 'values' (right panel) for a two-dimensional array of regularly gridded data.

E.5 Ungeorectified Grid (dataCodingFormat=3)

For this coding format, the height and trend are stored in the one-dimensional compound array 'values'. Data in the values group is for all nodes in the grid at one time point. In each element of the array, the first variable is 'waterLevelHeight' and the second is 'waterLevelTrend'. The spelling and order of variable names are important.

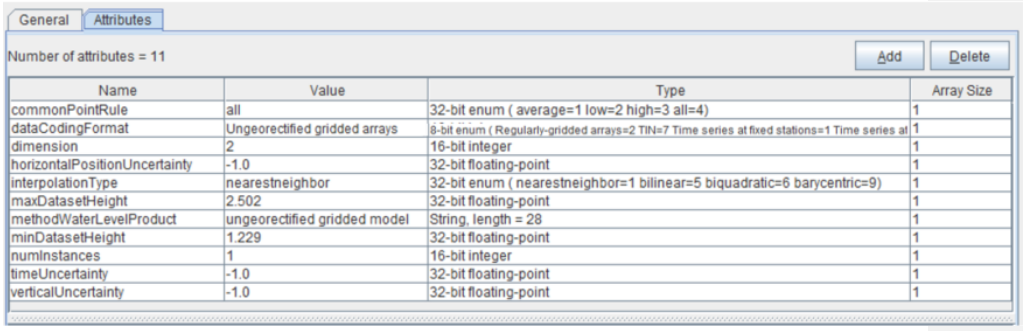


Figure E.11 – Attributes for the feature metadata (cf. Table 12.2).

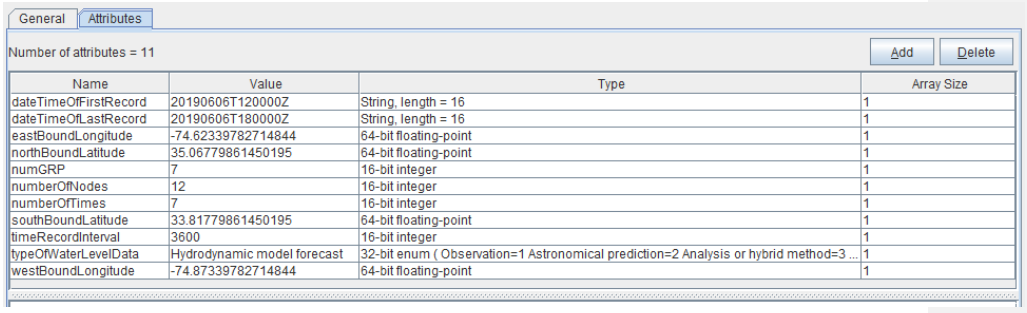


Figure E.12 – Attributes for the instance metadata (cf. Table 12.3).

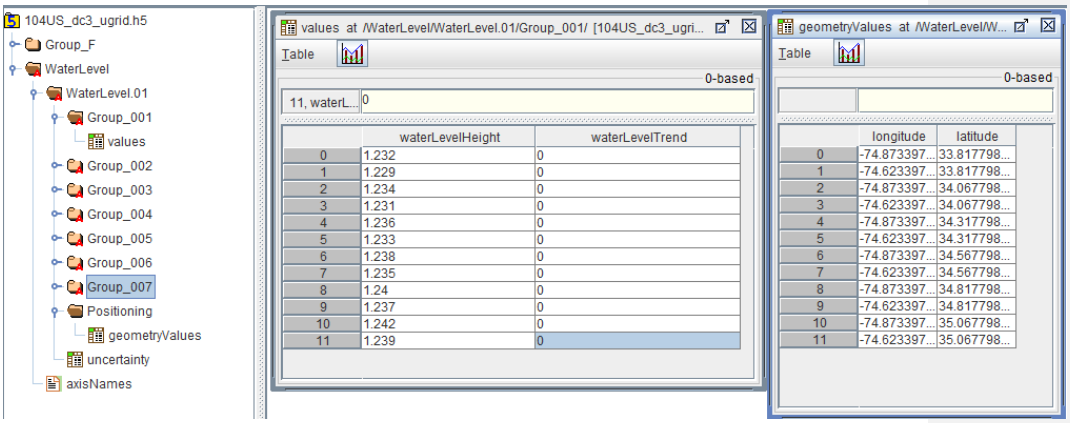


Figure E.13 – Sample HDF5 file (left panel) for ungeorectified gridded data. The middle panel shows the dataset 'values' and the right panel the dataset 'geometryValues'

E.6 TINs (dataCodingFormat=7)

For this coding format, the height and trend are stored in the one-dimensional compound array 'values'. Data in the values group is for all nodes in the TIN grid at one time point. In each element of the array, the first variable is 'waterLevelHeight' and the second is 'waterLevelTrend'. There are also the required *triangles* and optional *adjacency* arrays for TINs. The spelling and order of variable names are important.

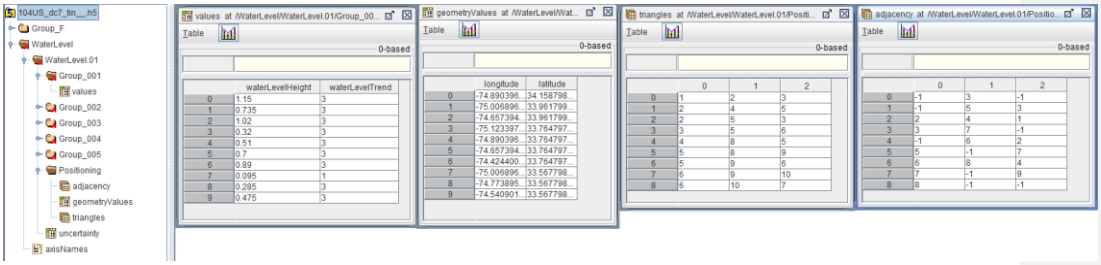


Figure E.14 – Sample HDF5 file (left panel) for a TIN. The second panel shows the dataset 'values', the third panel the dataset 'geometryValues', the fourth panel the dataset 'triangles', and the fifth panel the dataset 'adjacency'

General | Attributes

Number of attributes = 11 — Add | Delete

Name	Value	Type	Array Size
commonPointRule	all	32-bit enum (average=1 low=2 high=3 all=4)	1
dataCodingFormat	TIN	8-bit enum (Regularly-gridded arrays=2 TIN=7 Time series at fixed s!	1
dimension	2	16-bit integer	1
horizontalPositionUncertainty	-1.0	32-bit floating-point	1
interpolationType	barycentric	32-bit enum (nearestneighbor=1 bilinear=5 biquadratic=6 barycentric=9)	1
maxDatasetHeight	2.1486	32-bit floating-point	1
methodWaterLevelProduct	TIN model	String, length = 9	1
minDatasetHeight	0.095	32-bit floating-point	1
numInstances	1	16-bit integer	1
timeUncertainty	-1.0	32-bit floating-point	1
verticalUncertainty	-1.0	32-bit floating-point	1

Figure E.15 – Attributes for the feature metadata (cf. Table 12.2).

General | Attributes

Number of attributes = 12 — Add | Delete

Name	Value	Type	Array Size
dateTimeOfFirstRecord	20190606T120000Z	String, length = 16	1
dateTimeOfLastRecord	20190606T160000Z	String, length = 16	1
eastBoundLongitude	-74.42440032958984	64-bit floating-point	1
northBoundLatitude	34.15879821777344	64-bit floating-point	1
numGRP	5	16-bit integer	1
numberOfNodes	10	16-bit integer	1
numberOfTimes	5	16-bit integer	1
numberOfTriangles	9	16-bit integer	1
southBoundLatitude	33.56779861450195	64-bit floating-point	1
timeRecordInterval	3600	16-bit integer	1
typeOfWaterLevelData	Hydrodynamic model forecast	32-bit enum (Observation=1 Astronomical prediction=2 Analysis or hybrid method=3 Hydrodynamic model hin...	1
westBoundLongitude	-75.12339782714844	64-bit floating-point	1

Figure E.16 – Attributes for the instance metadata (cf. Table 12.3).

E.7 Stationwise Fixed Stations (dataCodingFormat=8)

For this coding format, the height and trend are stored in the one-dimensional compound array ‘values’, corresponding to data at one station for all time points (c.f., d*ataCodingFormat*=1, where the data is for all stations for one time point.)

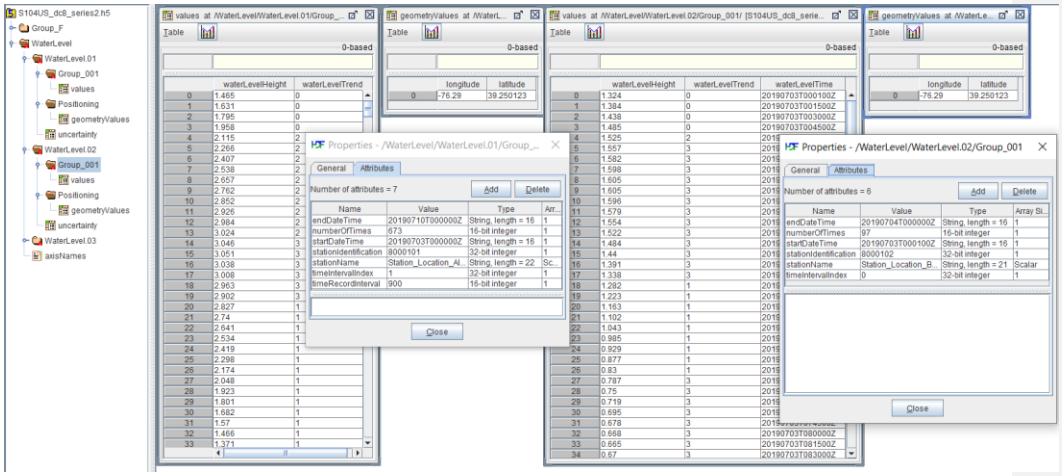
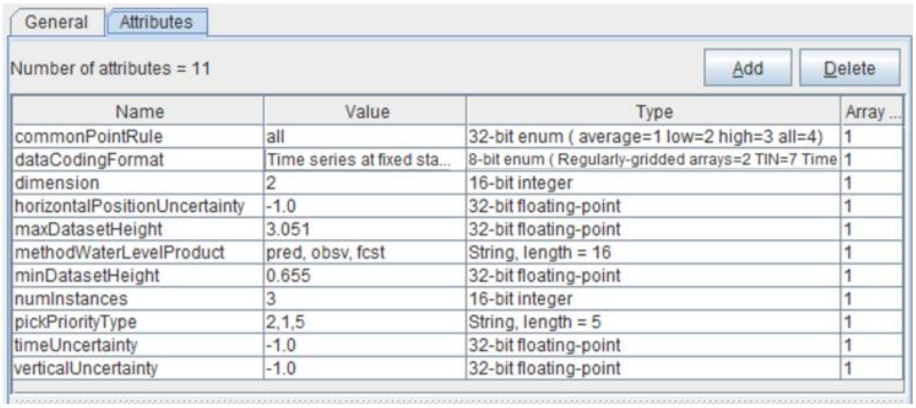


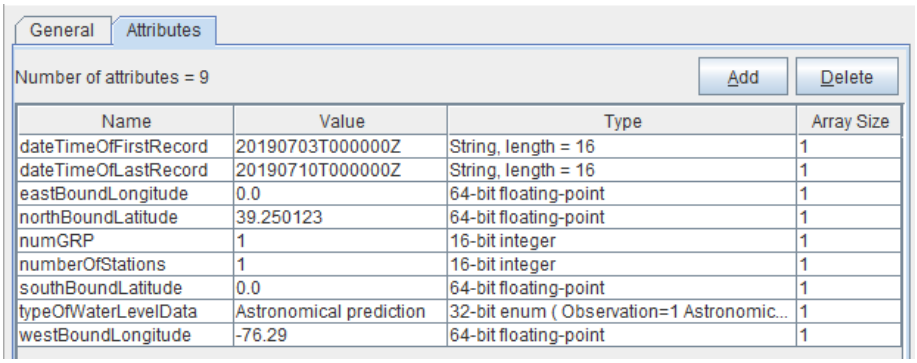
Figure E.17 – Sample HDF5 file (left panel) for stationwise fixed stations data. The second panel shows the dataset ‘values’ (for one station), and the third panel the dataset ‘geometryValues’. The fourth panel shows the dataset ‘values’ (for a station but different type of time series) but with non-uniform time

interval data so waterLevelTime at each element is provided. The fifth panel shows the dataset 'geometryValues' for that second station. Also shown in foreground are the Values Group Attributes for each station time series.



Name	Value	Type	Array ...
commonPointRule	all	32-bit enum (average=1 low=2 high=3 all=4)	1
dataCodingFormat	Time series at fixed sta...	8-bit enum (Regularly-gridded arrays=2 TIN=7 Time	1
dimension	2	16-bit integer	1
horizontalPositionUncertainty	-1.0	32-bit floating-point	1
maxDatasetHeight	3.051	32-bit floating-point	1
methodWaterLevelProduct	pred, obsv, fcst	String, length = 16	1
minDatasetHeight	0.655	32-bit floating-point	1
numInstances	3	16-bit integer	1
pickPriorityType	2,1,5	String, length = 5	1
timeUncertainty	-1.0	32-bit floating-point	1
verticalUncertainty	-1.0	32-bit floating-point	1

Figure E.18 – Attributes for the feature metadata (cf. Table 12.2.)



Name	Value	Type	Array Size
dateTimeOfFirstRecord	20190703T000000Z	String, length = 16	1
dateTimeOfLastRecord	20190710T000000Z	String, length = 16	1
eastBoundLongitude	0.0	64-bit floating-point	1
northBoundLatitude	39.250123	64-bit floating-point	1
numGRP	1	16-bit integer	1
numberOfStations	1	16-bit integer	1
southBoundLatitude	0.0	64-bit floating-point	1
typeOfWaterLevelData	Astronomical prediction	32-bit enum (Observation=1 Astronomic...	1
westBoundLongitude	-76.29	64-bit floating-point	1

Figure E.19 - Attributes for the instance metadata (cf. Table 12.3)

Annex F – Portrayal Catalogue

Annex G – Validation Checks

Commented [GS41]: Do we need to add an Annex for Tests of Completeness? See S-111 Annex D.

Commented [JZM42R41]: Agree, validation check should be done.

Annex H – Bibliography

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2. IALA Guideline No. 1028 - The Automatic Identification System (AIS) Volume 1, Part 1 Operational Issues, December 2004

3. IALA Guideline No. 1082 - An Overview of AIS, June 2011

4. IALA Guideline No. 1095 - Harmonised Implementation of Application-Specific Messages, May 2013

5. IALA Recommendation A-124 - The AIS Service, December 2012

6. IALA Recommendation A-126 - The Use of the Automatic Identification System (AIS) in Marine Aids to Navigation Services, June 2011

7. AIS Binary Message updates IMO SN.1/Circ.289 and IMO SN.1/Circ.290 review, US Hydro conference 2011 - Tampa - Ted Read MRIN

8. Tide and Metrological data over AIS - E.F.Read & W.S.Heaps

9. Dynamic Application of Tides in ECDIS - submitted by IHB, TWLWG 5/4.4/1

10. Proposed AIS Binary Message Format Using XML for Providing Hydrographic-related Information - Kurt Schwehr and Lee Alexander

11. Providing Meteorological and Hydrographic Information via AIS Application-Specific Messages: Challenges and Opportunities - Dr. Lee Alexander

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