ArcGIS Hydro Data Model

(Draft, July 2001)

This document provides an overview of the ArcGIS Hydro Data Model. This model contains geospatial and temporal data describing the surface water flow system of the landscape.

THIS DOCUMENT IS PART OF A BOOK TO BE PUBLISHED BY ESRI DESCRIBING THE ARCGIS HYDRO DATA MODEL. THE TEXT GIVEN HERE MAY BE ALTERED DURING THE BOOK PRODUCTION PROCESS. MATERIAL WILL BE ADDED TO THAT SHOWN HERE TO DESCRIBE HOW TO APPLY AND CUSTOMIZE THE DATA MODEL.

INTRODUCTION

The ArcGIS Hydro data model describes geospatial and temporal data on surface water resource features of the landscape. The data model addresses three issues:

- **Hydro Description** – What are the principal water resource features of the landscape?
- **Hydro Connectivity** – How does water move from feature to feature?
- **Hydro Modeling** – What are the time patterns of water flow and water quality associated with these features?

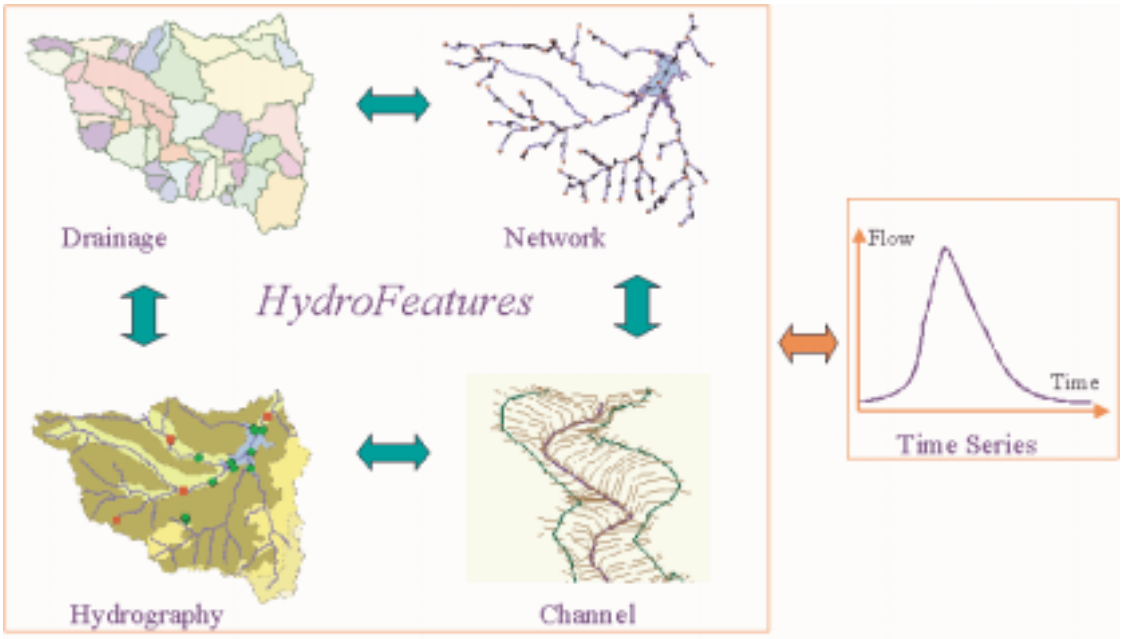
The ArcGIS Hydro data model describes only natural water systems, and does not support constructed water infrastructure, for which there is a separate data model, ArcFM Water. Moreover, features describing aquatic ecology, geomorphology, and groundwater systems are not currently supported by the model. The title *ArcGIS Hydro data model*, is often shortened in this description to *Arc Hydro*, but the two titles for the data model are synonymous.

An Arc Hydro geodatabase consists of *Hydro Features* connected to *Time Series*. Hydro Features describe the physical environment through which water flows, and the Time Series describe the flow and water quality properties of the water within those features. Every Hydro Feature is uniquely defined within an Arc Hydro geodatabase by a *HydroID*, and *associations* are formed between features by storing the HydroID of one feature as an attribute of another. These linkages can be used to trace water movement from one feature to the next, and also to associate several different geospatial representations of the same hydrologic entity with one another. Time series are connected to Hydro Features by storing the HydroID of the feature as an attribute of each time series data value.

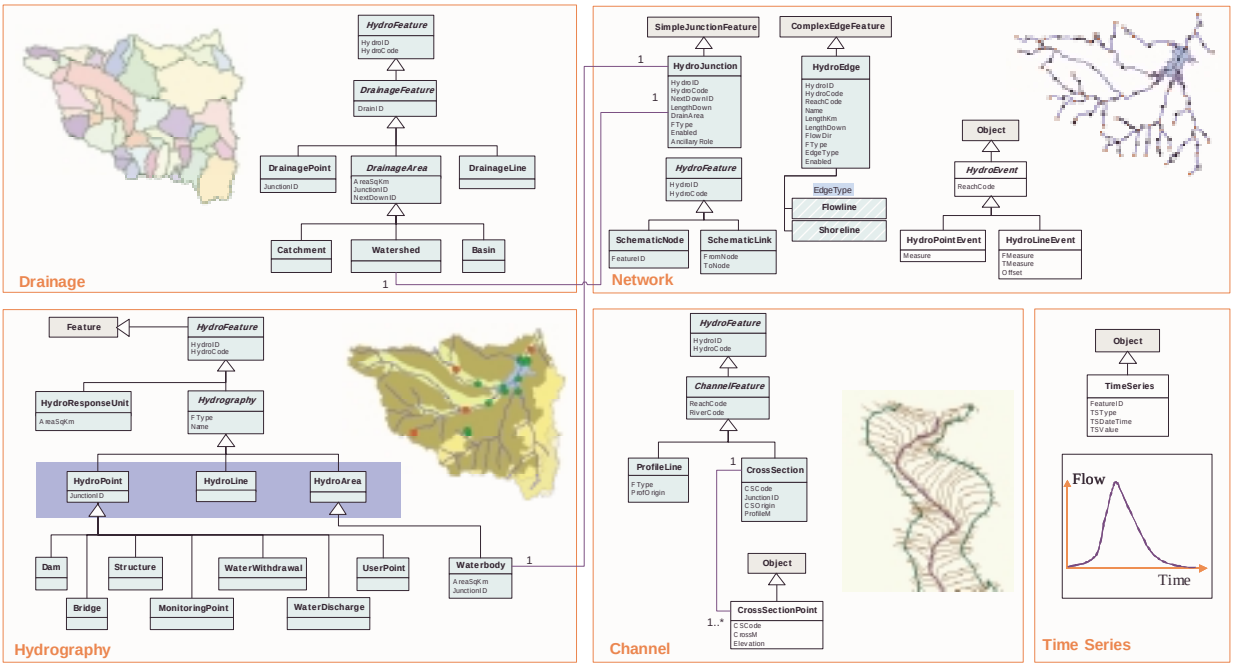
The Arc Hydro data model consists of five components: Network, Drainage, Channels, Hydrography and Time Series:

- The *Network* component contains a water resources network of streams, rivers and the centerlines of water bodies. Its main purpose is to describe the connectivity of water movement through the landscape
- The *Drainage* component defines drainage areas delineated through analysis of land surface topography
- The *Channel* component describes the three-dimensional shape of river and stream channels
- The *Hydrography* component contains base map information on point, line and area water resource features
- The *Time Series* component describes time varying water properties of the features.

A more detailed view of all the feature and object classes in the Arc Hydro model is contained in the following analysis diagram. Each feature and object class in the analysis diagram is described in this book.

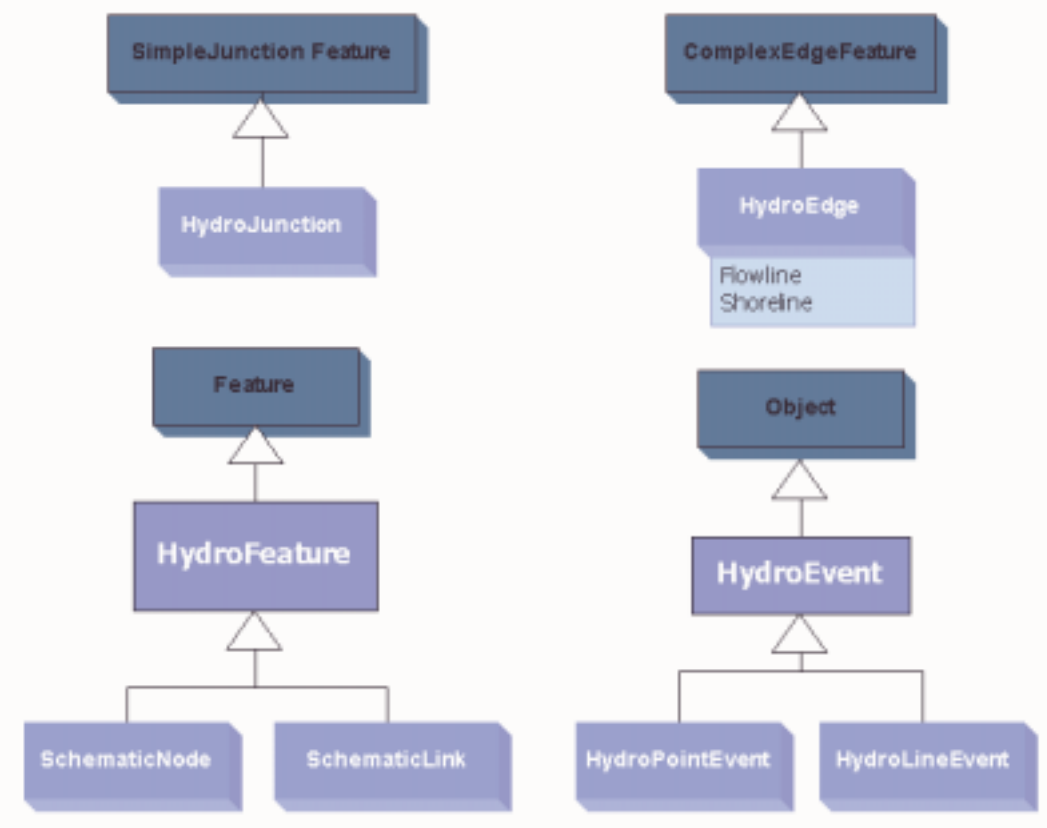


Components of the Arc Hydro data model



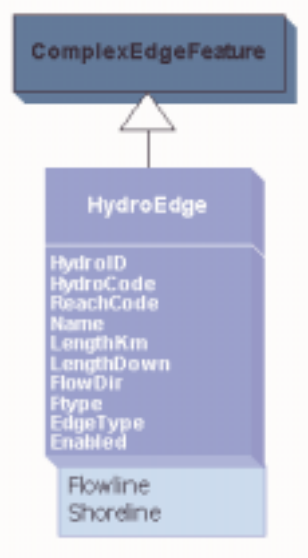
Analysis Diagram of the Arc Hydro data model

NETWORK



The *Network* feature dataset describes the connectivity of water flow through the landscape as a water resources network. The principal feature classes of this dataset are an ArcGIS geometric network called the *HydroNetwork*, whose components are *HydroEdges* and *HydroJunctions*. Water flows along *HydroEdges*, and *HydroEdges* are connected by *HydroJunctions*. The Hydro Network describes flow through rivers and streams, and the centerlines of waterbodies. The *SchematicLink* and *SchematicNode* feature classes are used to symbolize the connection of drainage areas to HydroJunctions, and to provide a simplified view of water flow through the landscape. Tabular information on points or lines associated by linear referencing with the Hydro Network is stored in *HydroEvents*.

HydroEdge



The *HydroEdge* class contains lines connected by junctions in the HydroNetwork. *HydroEdges* are subtyped to be either *Flowlines* (i.e., single-line streams, centerlines of double-line streams, and centerlines of waterbodies) or *Shorelines* (i.e., banks of double-line streams, shorelines of inland waterbodies, or coastlines of the sea or ocean). If the double-line streams and waterbodies in the hydrography dataset do not have flow lines within them, they must be digitized or otherwise generated as part of construction of the HydroNetwork. Water can flow only along *Flowlines* and not along *Shorelines*. The HydroEdge class is built as a ComplexEdgeFeature so that HydroJunctions can be added to the interior of HydroEdges without necessarily splitting the HydroEdges. HydroEdges are PolylineM features, which means that their vertices have (x,y,m) coordinates, where m is the *measure* location along the HydroEdge.

The *HydroEdge* PolylineM Complex Edge feature class defines the following attributes:

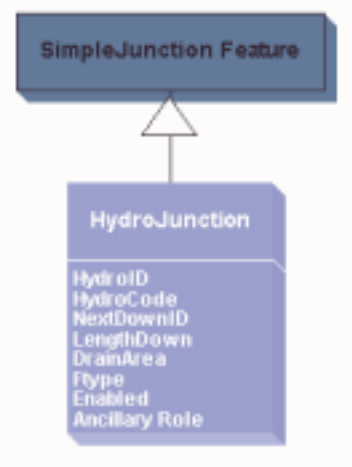
- *HydroID: integer*-A unique feature identifier within a geodatabase.
- *HydroCode: string*- A permanent, public identifier of the Hydro Feature, or a unique identifier of a Hydro Feature among a set of Arc Hydro geodatabases
- *ReachCode*: *string*- This code is unique identifier for each reach, where a reach is a segment of a stream or river between confluences.
- *Name: string*-The geographic name of the feature.
- *LengthKm: double*-The length of the *HydroEdge* given in kilometers independent of the map units. This is to ensure that when length is used as weight in network solvers, a realistic value is available, regardless of the map projection of the data.
- *LengthDown*: *double*-The distance from the downstream end of a HydroEdge along the shortest path to the nearest network sink.

- *FlowDir*: This attribute is defined by the *HydroFlowDirections* Coded Value Domain. It indicates the direction of flow along the *HydroEdge*. The Coded Values are: Uninitialized = 0, WithDigitized = 1, AgainstDigitized = 2, and Indeterminate = 3, where WithDigitized means that the flow direction is in the same direction as the direction in which the HydroEdge was digitized, and AgainstDigitized means the converse, where the flow direction is opposite to the direction of digitizing of the HydroEdge. The initial value given is 1.
- *Ftype*: *string*-Decribes the feature type of the *HydroEdge*. This attribute can be expanded using a Coded Value Domain to represent feature types such as Natural Channel, Constructed Channel, Pipeline, Connector, Bankline, Shoreline and Coastline
- *EdgeType*: *Subtype Coded Value Domain*-Determines if the *HydroEdge* is a *Flowline* or a *Shoreline* with an initial value of 1. Coded Values are: Flowline = 1 and Shoreline = 2
- *Enabled*: *Coded Value Domain*- This attribute is inherited from the *Network Feature* parent class of *HydroEdge*. Coded Values are: Disabled = 0 and Enabled = 1. The initial value is 1. The Enabled attribute is used to disable portions of the stream hydrography that appear in maps but are not needed to trace water movement through the landscape. It provides an alternative to deleting these features from the Hydro Network. Examples are minor loops on streams, and isolated small channel reaches that are unconnected with the rest of the Hydro Network. When a network feature is disabled, no flow can pass through it.

Subtypes: Flowline and Shoreline

Relationships: None

HydroJunction



The *HydroJunction* class includes junctions between *HydroEdges* and other points that are vital to a network analysis, such as outlet points for drainage areas and locations of stream gages or other point features. *HydroJunctions* are points that stand for sources, sinks, stream junctions and other relevant user-defined locations. Among the *HydroJunctions*, sinks play a significant role in the analysis because each feature in the network drains to a single Sink.

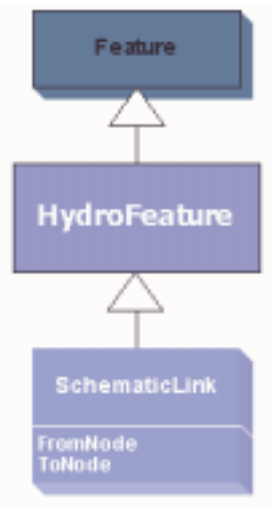
The *HydroJunction* Simple Junction feature class defines the following attributes:

- *HydroID: integer*-A unique feature identifier within a geodatabase.
- *HydroCode: string*- A permanent, public identifier of the Hydro Feature, or a unique identifier of a Hydro Feature among a set of Arc Hydro geodatabases
- *NextDownID: integer*-Identifies the HydroID of the next downstream *HydroJunction.*
- *LengthDown*: *double*- The distance downstream from the *HydroJunction* along the shortest path to the nearest network sink.
- *DrainArea*: *double*-The total drainage area upstream of the *HydroJunction*.
- *Ftype*: *string*-Decribes the feature type of the *HydroJunction*. This attribute can be expanded using a Coded Valued Domain to describe various junction feature types such as Stream Confluence, Drainage Outlet, Monitoring Point, Dam, etc.
- *Enabled*: *Coded Value Domain*- An Attribute inherited from the *Network Feature* parent class of *HydroJunction* that indicates if the junction participates in the network. Coded Values are: Disabled = 0 and Enabled = 1. Initial value = 1. If a junction is disabled, no flow may pass through it. A skeleton Hydro Network of just the main rivers and streams can be identified by selecting a threshold DrainArea, and disabling all junctions having a DrainArea smaller than the threshold value.
- *AncillaryRole*: Coded Value Domain- An Attribute inherited from the *Junction Feature* parent class of *HydroJunction* that describes the role of the junction in the network. Coded Values are: None = 0, Source = 1, and Sink = 2. Initial value is 0. When a geometric network is constructed, those HydroJunctions at the downstream outlets of the network must be selected as sinks and have their Ancillary Role set to Sink or 2. The flow direction on HydroEdges is then assigned using the network analyst tools, and additional editing, if necessary, so as to allow flow towards these Sinks.

Subtypes: None

Relationships: WaterbodyhasJunction is a 1 to 1 relationship between *HydroJunction* (using HydroID) and *Waterbody* (using JunctionID); and WatershedhasJunction is a 1 to 1 relationship between *HydroJunction* (using HydroID) and *Watershed* (using JunctionID).

SchematicLink



The *Schematiclink* and *SchematicNode* classes together make up a *Schematic Network*. A schematic network can be drawn to connect objects among several feature classes of the Arc Hydro geodatabase to provide a simplified but more general type of connectivity among water features than is provided by the Hydro Network. The Schematic Network is made up of simple point and line feature classes, but may be built into a geometric network if the user desires. The Schematic Network is used to symbolize the connection of drainage areas to the HydroJunctions, and to create a simplified view of water movement through the landscape by means of straight-line connections between selected junctions in the Hydro Network. The Schematic Network uses standard FromNode – ToNode topology to describe its connectivity.

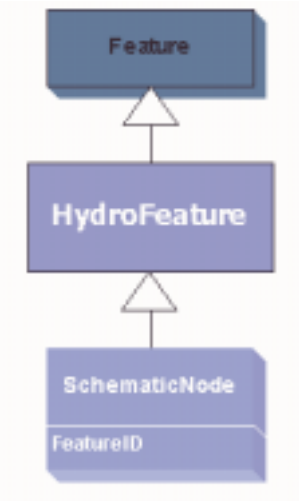
The *SchematicLink* Polyline feature class defines the following attributes:

- *FromNode: integer*-Indicates the HydroID of the SchematicNode at the upstream end of the Link
- *ToNode: integer*-Indicates the HydroID of the SchematicNode at the downstream end of the link.

Subtypes: None

Relationships: None

SchematicNode



The *SchematicNode* Point feature class contains the points in a Schematic Network, which may represent any feature within an ArcHydro geodatabase. Typical types of SchematicNodes are: drainage area centroids, drainage area outlets, and stream confluences.

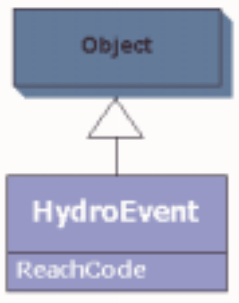
The *SchematicNode* Point feature class defines the following attributes:

- *FeatureID: integer*-HydroID of the HydroFeature from which the node was created. This enables the SchematicNode to connect to the attribute information of the features it describes. If necessary, a relationship can be built using these attributes.

Subtypes: None

Relationships: None

HydroEvent



The *HydroEvent* abstract object class stores attributes and methods for events. In some network applications, it is desirable to specify the location of a point along the river not as a pair of Cartesian coordinates, but as an address on the network, which is called *linear reference.* This address is given by the combination of a *ReachCode* and a *measure* value on that reach, such as the percent distance from the bottom end of the reach at which the point is located. This is analogous to specifying that a house has a street address of 123 Oak Ave., rather than giving its latitude and longitude. Events are located using linear referencing and display tabular information that is of interest to the user. A typical example is a Wastewater discharge event, whose attributes might include the volume of the discharge and its water quality. As a default, it is assumed that HydroEvents are defined on the lines contained in the HydroEdge feature class. However, *ProfileLine* and *CrossSection* also possess the PolylineM geometry type necessary for linear referencing of events, so HydroEvents can be created on those feature classes also.

The *HydroEvent* abstract object class defines the following attributes:

- *ReachCode: string*-The attribute that identifies the line on which the measure is located. This attribute can be changed to *RiverCode* if the measure is in river miles or kilometers and events are defined on ProfileLines rather than on HydroEdges.

Subtypes: None

Relationships: None

HydroPointEvent

HydroPointEvent is a point event, which means a set of attributes attached to a single location on a line. *HydroPointEvents* can represent many things as the user can imagine in relation to natural water systems. Some examples are wastewater discharge points, USGS gage stations, and irrigation diversions.

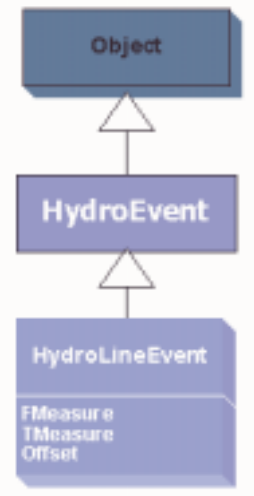
The *HydroPointEvent* abstract object class defines the following attribute:

- *Measure: double*-The measure of the location of the event as determined by linear referencing.

Subtypes: None

Relationships: None

HydroLineEvent



The *HydroLineEvent*, similar to *HydroPointEvent*, inherits from the *HydroEvent* object class and has a ReachCode attribute to locate the event on a specific *HydroEdge*. The FMeasure and TMeasure attributes give the precise location of the event on the *HydroEdge*. When a linear event spans a group of reaches, a separate HydroLineEvent object is needed for each Reach. ArcGIS does not explicitly support the concept of a grouped event, and if the user wants to create such a group, an additional attribute is needed on the HydroLineEvent indicating to which group the event belongs.

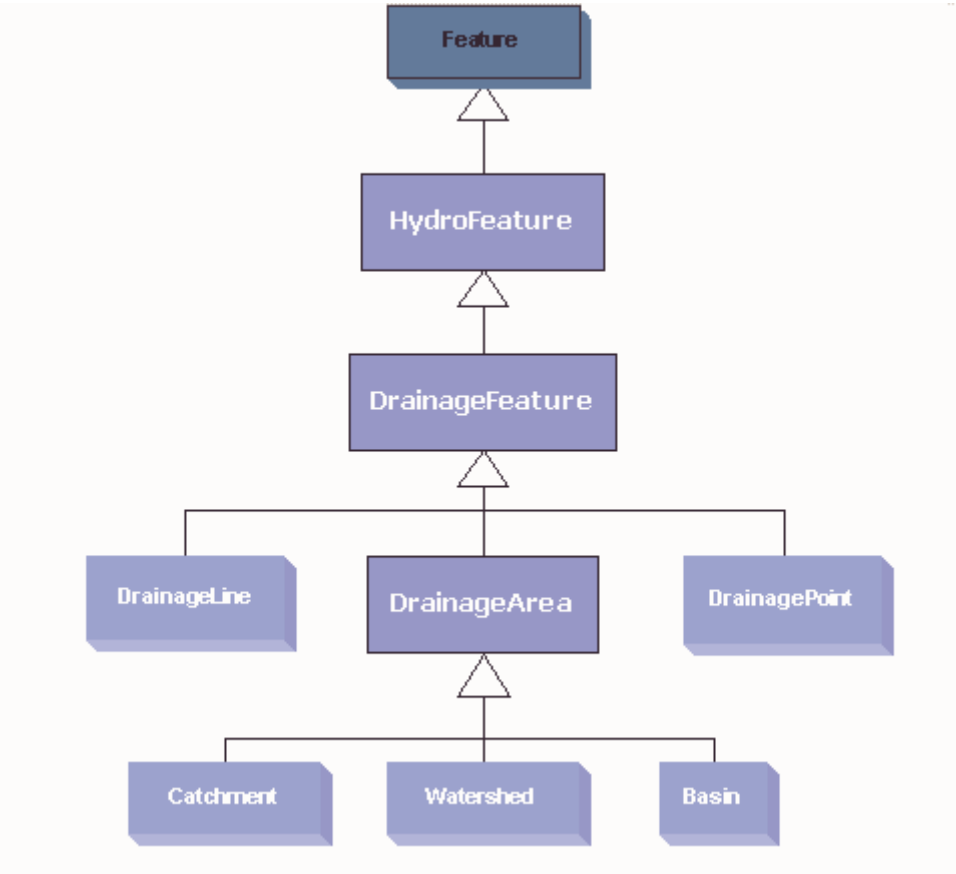
HydroLineEvent abstract object has the following attributes:

- *FMeasure: Double* – Measure location of the start of the line event.
- *TMeasure: Double* – Measure location of the end of the line event.
- *Offset: Double* – Offset distance of the event from the line defining its measures. This is used to allow display of multiple line events on the same line without having them overlapping in the map display. An example might be where an economic analysis of flood damage requires a damage reach defined on the left bank of a channel, and another on the right bank..

Subtypes: None

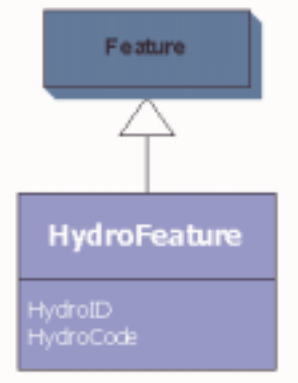
Relationships: None

DRAINAGE



The *Drainage* system of the landscape defines the direction of surface water flow according to land surface topography. Drainage divides defined by ridge lines separate the area draining to one stream from the adjacent areas draining to neighboring streams. *Drainage Area* is a generic term used within the Arc Hydro data model to describe any feature class describing such drainage areas, and it is subclassed into *Catchment*, *Watershed* and *Basin*, to describe specific types of drainage areas. Accurate drainage boundaries are essential for hydrologic modeling studies. Drainage boundaries may be delineated manually from a topographic map, digitized from digital raster graphic map (DRG), or determined through the use of raster data from Digital Elevation Models. As part of terrain analysis using Digital Elevation Models, DrainageLines and Drainage Points are defined, where *DrainageLines* are lines defining the drainage network of the landscape, and *DrainagePoints* are outlet points for the Drainage Areas on the DrainageLines. DrainageLines are closely related to but not necessarily spatially coincident with the HydroEdges in the Hydro Network. Indeed, DrainageLines can be built into an excellent Hydro Network if a suitable mapped stream network is unavailable.

HydroFeature



All simple feature classes in the Arc Hydro data model inherit from the *HydroFeature* abstract class.

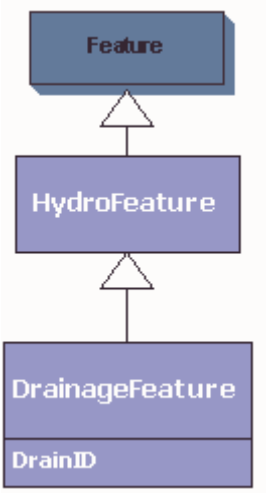
The *HydroFeature* abstract feature class defines the following attributes:

- *HydroID: integer*-A feature identifier unique across all feature classes and objects within a geodatabase. For a particular feature object, the HydroID is formed by concatenating a number representing the feature class with the ObjectID of the object within that feature class. The HydroID is the database tag used to support most relationships in the Arc Hydro data model
- *HydroCode: string*- A permanent, public identifier of the Hydro Feature, or a unique identifier of a Hydro Feature among a set of Arc Hydro geodatabases. The HydroCode may be formed by concatenating the HydroID with the name of the Arc Hydro geodatabase.

Subtypes: None

Relationships: None

DrainageFeature



DrainageFeature is an abstract class, which inherits from *HydroFeature*.

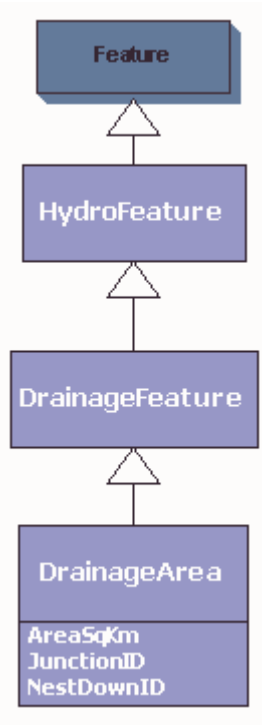
DrainageFeature abstract feature class defines one attribute:

- *DrainID: Integer* - provides a link between point, line and area features of a drainage system, and allows the vector features in the Arc Hydro data model to be linked numerically to the raster cells used to create them in Digital Elevation Model analysis. Examples include GridCode for DEM processing in the ArcGIS spatial analyst, and integer equivalents of the Pfaffstetter Code, Hydrologic Unit Code, and ReachCode, which are standard hydrologic descriptors of Catchments, Watersheds and Reaches, respectively.

Subtypes: None

Relationships: None

DrainageArea



DrainageArea is an abstract class containing common drainage attributes of *Catchment*, *Watershed* and *Basin* subclasses. These are defined, respectively, as:

- *Catchment* – An elementary drainage area produced by subdivision of the landscape using a consistent set of physical rules.
- *Watershed* – A drainage area produced by a human-selected subdivision of the landscape. Watersheds can be defined by the area draining to a point on a river network, to a river segment, or to a waterbody.
- *Basin* – An administratively chosen standardized watershed used for reference and data cataloging. Basins are usually named after the principal rivers and streams of a region. The Basin feature class may be used to store the geographic extent of an Arc Hydro geodatabase.

DrainageArea abstract feature class defines three attributes:

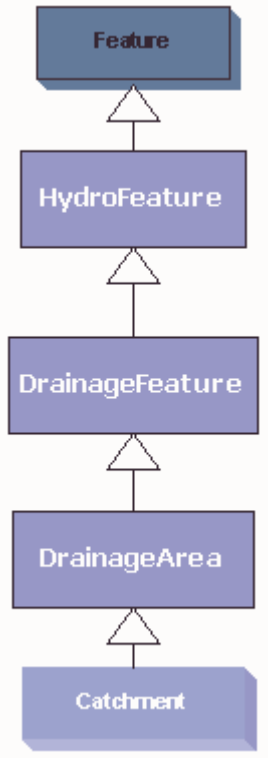
- *AreaSqKm: Double* - Drainage Area in square kilometers. This is so that the earth surface area is known for the Drainage Area regardless of the map projection of the data.
- *JunctionID: Integer* – the HydroID of the associated HydroJunction, which is the outlet on the Hydro Network where flow from this Drainage Area discharges to the stream or river system.

- *NextDownID: Integer* – The HydroID of the next downstream area in this drainage area class. This is used to support Area to Area navigation within a set of drainage areas.

Subtypes: None

Relationships: None

Catchment



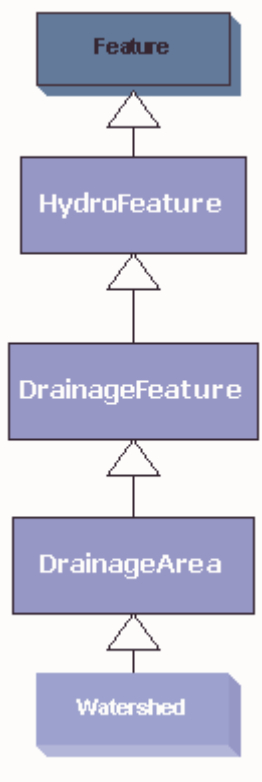
Catchment is a polygon subclass of *DrainageArea*. A *Catchment* feature class is an elementary drainage area produced by subdivision of the landscape using a consistent set of physical rules. Typically, this subdivision is carried out by defining a stream network from a threshold flow accumulation on a Digital Elevation Model, and then delineating a Catchment for each stream segment in the network.

The *Catchment* Polygon feature class does not define any additional attributes. The user can add attributes as necessary.

Subtypes: None

Relationships: None

Watershed



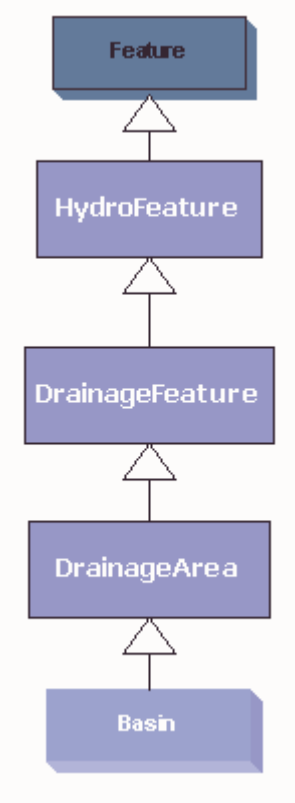
The *Watershed* feature class is a subclass of Drainage Area, which contains a landscape subdivision into human-selected drainage areas, which may drain to a point on a river network, to a river segment or to a waterbody. By contrast to Catchments, which can be automatically delineated using a set of rules applied to a terrain model, the definition of Watersheds requires a human intervention process, where the analyst selects and edits the Watershed subdivision of the landscape unit the desired arrangement is obtained.

The *Watershed* Polygon feature class does not define any additional attributes. The user can add attributes as necessary.

Subtypes: None

Relationships: WatershedhasJunction is a 1 to 1 relationship between *HydroJunction* (using HydroID) and *Watershed* (using JunctionID).

Basin



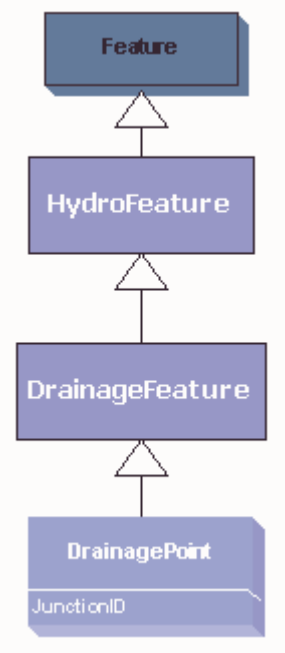
Basin is an administratively chosen standardized watershed used for reference and data cataloging , usually named after the principal rivers and streams of a region. Basins may define the geographic extent of an Arc Hydro dataset, and thus constitute standardized watershed template for data archiving and delivery. Basin is a polygon subclass of *DrainageArea*. Basins usually contain sets of Watersheds and Catchments.

The *Basin* Polygon feature class does not define any additional attributes. The user can add attributes as necessary.

Subtypes: None

Relationships: None

DrainagePoint



DrainagePoint is a subclass of *DrainageFeature.* A *DrainagePoint* represents the point at the center of a Digital Elevation Model cell at the most downstream location within a Drainage Area. The Drainage Area is associated with its Drainage Point using the *DrainID* attribute that both classes inherit from the *Drainage Feature* class. Drainage Points are also known as *Seed Points, Outlet Points,* or *Pour Points* of Drainage Area.

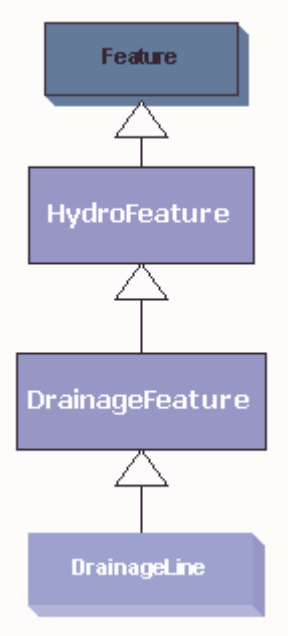
The *DrainagePoint* Point feature class defines one attribute:

- *JunctionID: Integer* – the HydroID of the HydroJunction associated with this DrainagePoint. This is the HydroJunction, which serves as the outlet of this Drainage Area onto the Hydro Network.

Subtypes: None

Relationships: None

DrainageLine



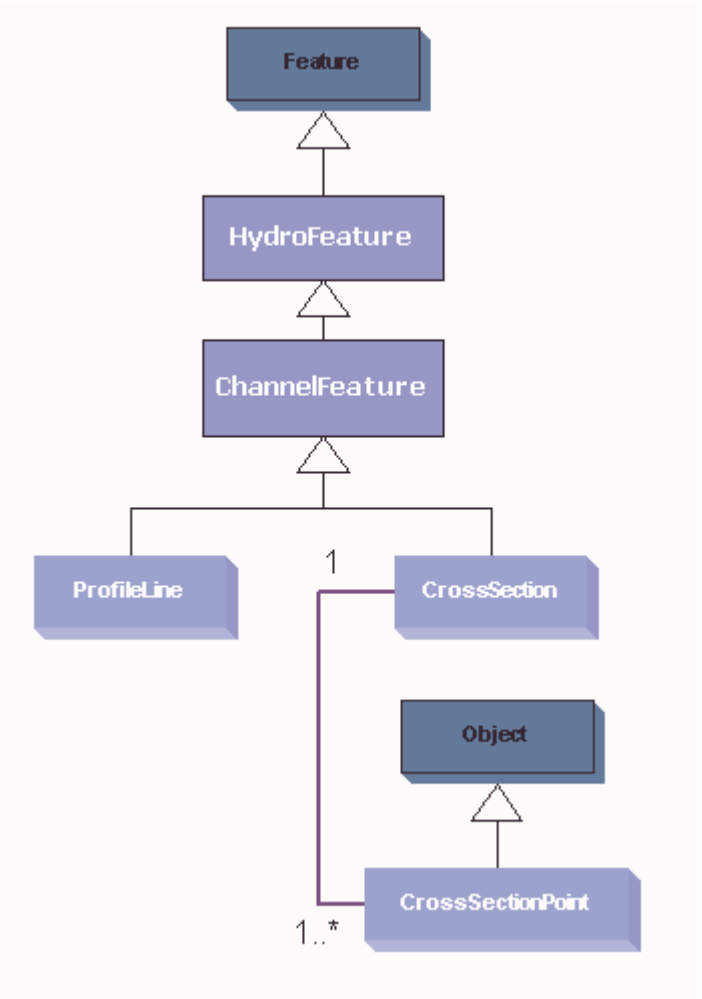
The *DrainageLine* is the line through the centers of the Digital Elevation Model (DEM) cells on a drainage path. It is produced when the DEM-based drainage paths are vectorized. DrainagePoints lie on DrainageLines. If necessary, the DrainageLines and DrainagePoints can be built into a geometric network and used as the Hydro Network for an Arc Hydro geodatabase.

The *DrainageLine* Polyline feature class does not define any additional attributes. The user can add attributes as necessary.

Subtypes: None

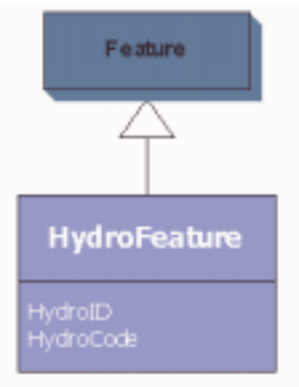
Relationships: None

CHANNEL



The Channel feature dataset provides a three-dimensional representation of the river and stream channel shape, which is used for studies of flood inundation, stream ecology and morphology. Two feature classes are defined under Channel feature *ProfileLine* and *CrossSection*, and one object class, *CrossSectionPoint*. *ProfileLines* are lines drawn parallel to the stream flow, such as the stream thalweg line and banklines. *CrossSections* are drawn transverse to the streamflow. Both feature classes are derived from the *ChannelFeature* abstract class, which is itself derived from the *HydroFeature* class. Channel information can be collected in the field using surveying techniques, or by extracting the data from digital terrain models (DTMs) in the form of a triangulated irregular network (TIN), or digital elevation model (DEM).

HydroFeature



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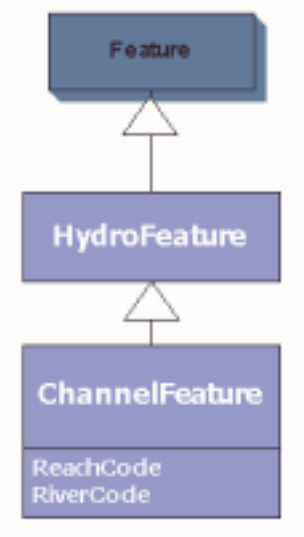
The *HydroFeature* abstract feature class defines the following attributes:

- *HydroID: integer*-A feature identifier unique across all feature classes and objects within a geodatabase. For a particular feature object, the HydroID is formed by concatenating a number representing the feature class with the ObjectID of the object within that feature class. The HydroID is the database tag used to support most relationships in the Arc Hydro data model
- *HydroCode: string*- A permanent, public identifier of the Hydro Feature, or a unique identifier of a Hydro Feature among a set of Arc Hydro geodatabases. The HydroCode may be formed by concatenating the HydroID with the name of the Arc Hydro geodatabase.

Subtypes: None

Relationships: None

ChannelFeature



The purpose of the *ChannelFeature* abstract class is to gather attributes that are common to channel features.

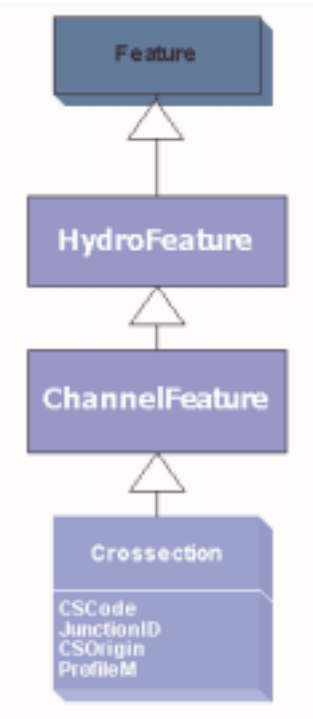
The *ChannelFeature* abstract feature class defines the following attributes:

- *ReachCode: string*-This code is a unique identifier for each channel reach, where a reach is a length of stream or river, between confluences. The ReachCode may be a descriptive term, such as "Lower Branch, Waller Creek", or it may be more formally defined by concatenating an identifier for the drainage area within which the reach is located with a segment number for the reach itself.
- *RiverCode: string*-A unique feature identifier for a river in the geodatabase. A river is a linear sequence of reaches running from a source in the headwaters to a terminus where the river drains into the sea or into a larger river. The RiverCode may be a descriptive term, such as the geographic name of the river, or it may be more formally defined by concatenating the latitude and longitude of the terminus point of the river.

Subtypes: None

Relationships: None

CrossSection



A *CrossSection* in ArcGIS is a 3-D PolylineM feature, where each vertex in the line is defined by four coordinates: x,y,z,m. The (*x,y*) coordinates give the location of the vertex in the horizontal plane, *z* represents the elevation above a vertical datum, and *m* is the CrossSection measure (*CrossM*), or distance along the CrossSection in the (x,y) plane.

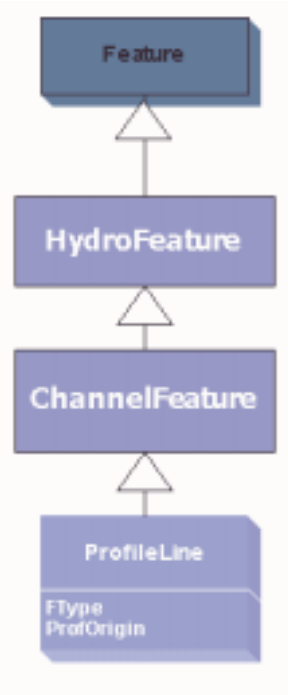
The *CrossSection* 3-D PolylineM feature class defines the following attributes:

- *CSCode*: *string*-This is a user defined cross section identifier that is unique for each cross section, usually formed as the concatenation of the river, reach, and ProfileLine measure value e.g. "Waller Creek, Middle Fork, 132.3"
- *JunctionID*: *integer* – the HydroID of the HydroJunction at the equivalent hydrologic location to this CrossSection. This attribute is provided so that the CrossSections can be related to the corresponding location on the Hydro Network for purposes of linking hydrologic and hydraulic modeling of water flow.
- *CSOrigin*: *string*-Describes the source of the data and the method used to construct the CrossSection. Possible subtypes associated with CSOrigin are the following: 3Dtype, PolylineType, LineType, PointType, and LocationType.
- *ProfileM: double*- The location of the CrossSection using the ProfileLine measure (River Stationing or Chainage).

Subtypes: None

Relationships: CrossSectionHasPoints is a 1 to Many relationship between *CrossSection* (using CSCode) and *CrossSectionPoint* (using CSCode). This is intended to cover the situation where the (m,z) values and the ProfileLine measure are known for the CrossSection but its true (x,y) points are unknown. In that event, the CrossSection feature is simply a marker line drawn transverse to the ProfileLine which symbolizes the general location of the CrossSection, and the detailed CrossSection data are contained in the CrossSectionPoint object class. This situation is fairly common in extraction of stream CrossSections from historical data used in river hydraulic models.

ProfileLine



A *ProfileLine* is a longitudinal view of a channel, using lines drawn parallel to the stream flow. Various types of ProfileLines can be drawn:

- The *Thalweg* is the ProfileLine through the lowest point of the stream channel at each CrossSection.
- *Banklines* show the intersection of the water surface and the land surface on each side of the channel.
- *Floodlines* can be drawn in the flood plain to symbolize the main direction of water flow when the flood plain is inundated.
- *Streamlines* can be drawn anywhere in a water flow, for example to depict the water surface profile for a particular design discharge in the channel.

Typically, the representative ProfileLine is the channel thalweg. Thalwegs and bank lines can be digitized from high-resolution digital orthographic photos or maps, or manually surveyed. As with the CrossSection feature class, the

ProfileLine feature class is a 3-D PolylineM class, which means that its vertices have (x,y,z,m) coordinates. In this case, the m-coordinate is the *ProfileM* or measure value such as river mile or kilometer, or stationing or chainage in feet or meters from some upstream or downstream reference point on the channel.

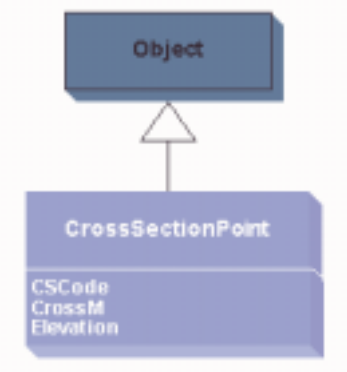
The *ProfileLine* 3-D PolylineM feature class defines the following attributes:

- *Ftype: string*-A descriptor specifying the type of feature represented by a *Profile Line.* Possible values are thalweg, bankline, floodline or streamline. If necessary, these values can be specified as a coded value domain, and used to subtype the ProfileLine features.
- *ProfOrigin*: *string*- Describes the origin of the data used to form the *Profile Line*.

Subtypes: None

Relationships: None

CrossSectionPoint



The *CrossSectionPoint* object class stores cross-sectional point data, and by means of the CSCode, can be associated with a *CrossSection* feature. While a single cross-sectional line represents the location of a cross section, several cross section points (a one-to-many relationship exits between *CrossSection* feature line and *CrossSectionPoints*) allow for a geometric description of the channel. If the cross section geometry is stored as *CrossSectionPoints*, the elevation (*z*) and measure (*m*) field values of a *CrossSection* feature line should be set to NaN (not a number) to avoid confusion.

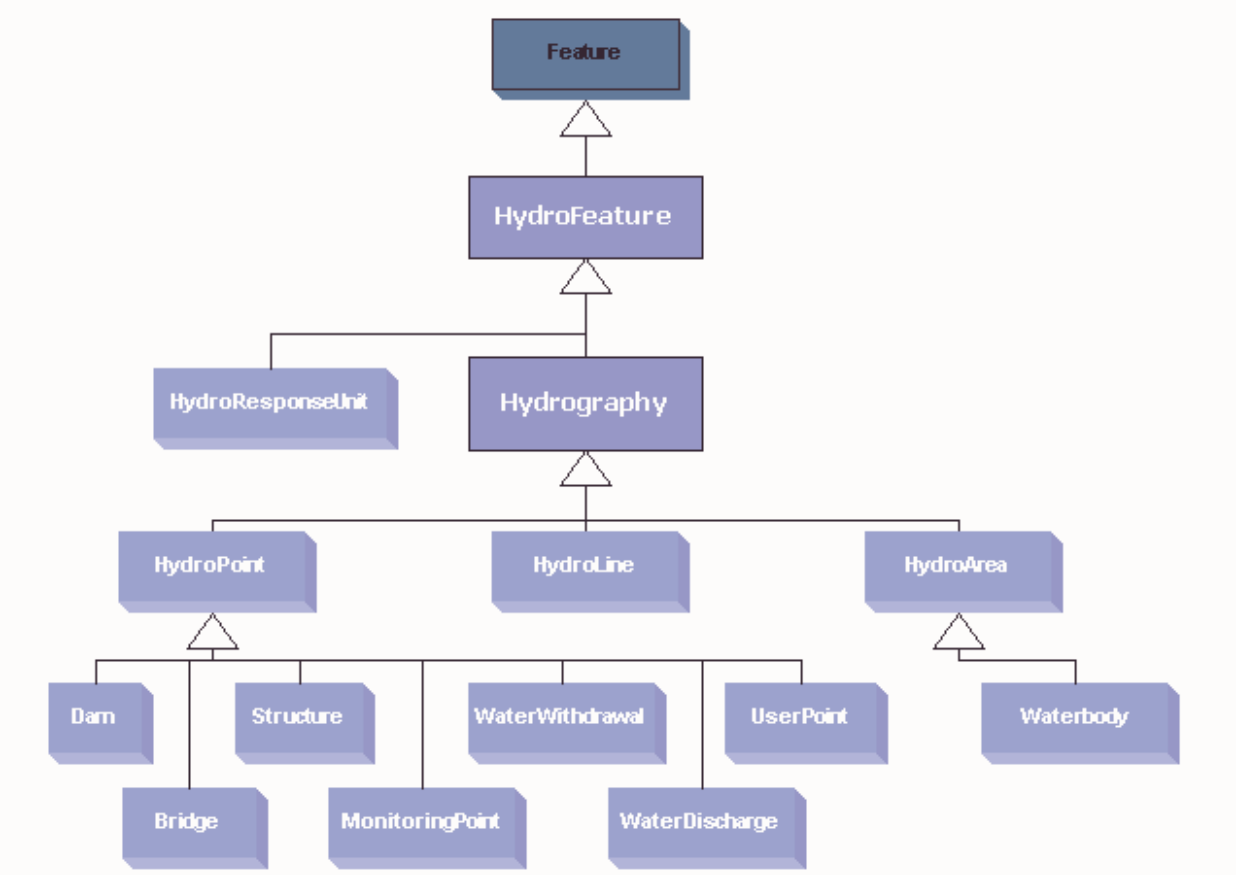
The *CrossSectionPoint* object class defines the following attributes:

- *CSCode*: *string*-A user-defined cross section identifier that is unique for each cross section.
- *CrossM: double*-The measure, or *m* value, in feet or meters or percent distance, of a *Cross Section Point* along a cross section for which elevation values are known.
- *Elevation: double*-Stores the elevation, or *z* value, of a CrossSectionPoint above a vertical datum.

Subtypes: None

Relationships: CrossSectionHasPoints is a 1 to many relationship between *CrossSection* (using CSCode) and *CrossSectionPoint* (using CSCode).

HYDROGRAPHY



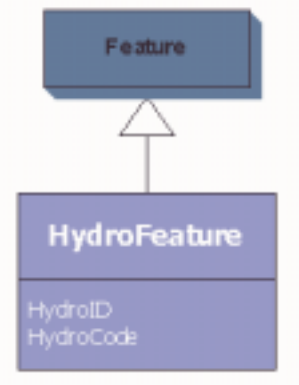
The *Hydrography* feature dataset contains the map representation of the surface water features. It contains several kinds of simple point, line and area features:

- *HydroPoint*, *HydroLine* and *HydroArea* features which are derived from the "blue lines" or hydrography layer of topographic maps
- *Waterbody* features, such as lakes, bays and estuaries
- Point features derived from tabular data inventories, such as *dams*, *bridges*, *structures*, *monitoring points* (gages and sampling points), points of *water withdrawal* and *water discharge*, and *user points* for any other purpose. The latitude and longitude attributes of these tabular data inventories are used to define the location of the point features.

- *HydroResponseUnit* features which describe the hydrologic character of the land surface from the viewpoint of the partitioning of surface water balance accounting.

These feature classes in the Hydrography feature dataset are now reviewed in greater detail.

HydroFeature



All simple feature classes in the Arc Hydro data model inherit from the *HydroFeature* abstract class.

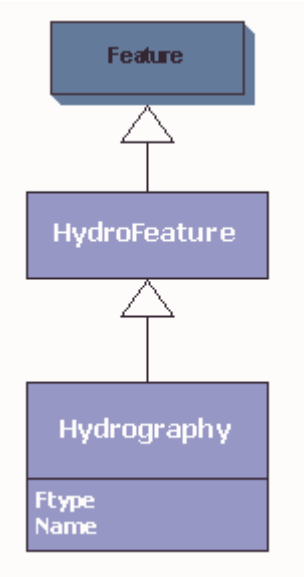
The *HydroFeature* abstract feature class defines the following attributes:

- *HydroID: integer*-A feature identifier unique across all feature classes and objects within a geodatabase. For a particular feature object, the HydroID is formed by concatenating a number representing the feature class with the ObjectID of the object within that feature class. The HydroID is the database tag used to support most relationships in the Arc Hydro data model
- *HydroCode: string*- A permanent, public identifier of the Hydro Feature, or a unique identifier of a Hydro Feature among a set of Arc Hydro geodatabases. The HydroCode may be formed by concatenating the HydroID with the name of the Arc Hydro geodatabase.

Subtypes: None

Relationships: None

Hydrography



The *Hydrography* abstract class contains attributes and methods particular to *Hydrography* features.

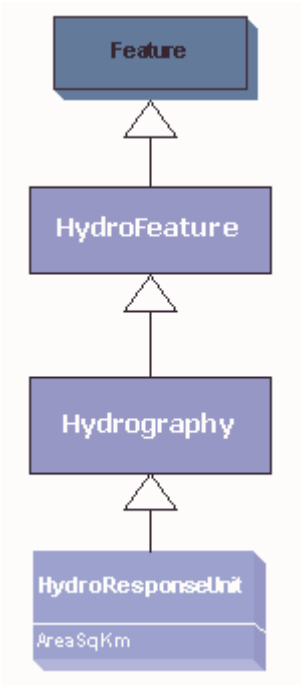
Hydrography abstract feature class defines the following attributes:

- *FType: string*-This is a descriptor for the type of feature. It may be defined on the basis of the *function* of the features, such as stream, river, canal, or on the basis of its *cartographic representation*, such as a bank line or closure line. In a detailed cartographic database where an extensive description of feature types exists, this attribute can be expanded into a coded value domain with numerical values and a text description for each feature type. The Ftype attribute is inherited by all Hydrography feature classes and it can be defined differently for each class if necessary. For example, there may be several types of MonitoringPoint features (e.g. rain gage, stream gage, water quality sampling point), and this feature classification is independent of how a separate class of features might be classified, such as water bodies.
- *Name: string*-The geographic name of the feature. This attribute may be linked to a unique identifier in a Geographic Names Information System so that where many features in different areas have the same name, they can be individually distinguished.

Subtypes: None

Relationships: None

HydroResponseUnit



HydroResponseUnit describes the hydrologic character of the land surface for surface water balance accounting. Typically, HydroResponseUnits are formed by the intersection of soil and land cover polygons, but these units may also be defined by climate cells, administrative or drainage basin boundaries, and aquifer boundaries. Each HydroResponseUnit is considered to have uniform and representative properties to describe the partitioning at the land surface of precipitation into runoff, evaporation and infiltration.

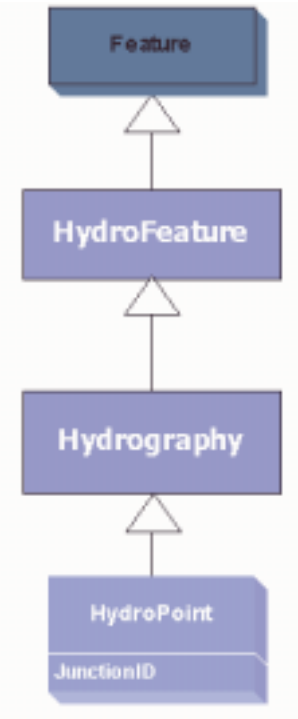
The *HydroResponseUnit* Polygon feature class defines the following attribute:

- *AreaSqKm: double*-The area calculated in square kilometers independent of map units. This attribute is included so that regardless of the map projection, the earth surface area is known for each unit to permit correct computation of the surface water balance.

Subtypes: None

Relationships: None

HydroPoint



The *HydroPoint* class contains point features that are derived from map hydrography data layers.

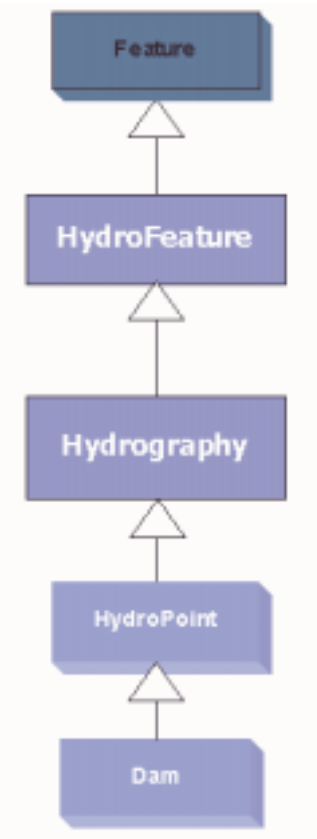
HydroPoint Point feature class defines the following attribute:

- *JunctionID: integer*-HydroID of the HydroJunction with which this point is associated..

Subtypes: None

Relationships: None, although the JunctionID attribute is placed on this feature class and all the point feature classes that inherit from it, to permit the construction of a relationship between these features and corresponding junctions on the Hydro Network, in the same manner as the relationships built into Arc Hydro for Watersheds and Waterbodies.

Dam



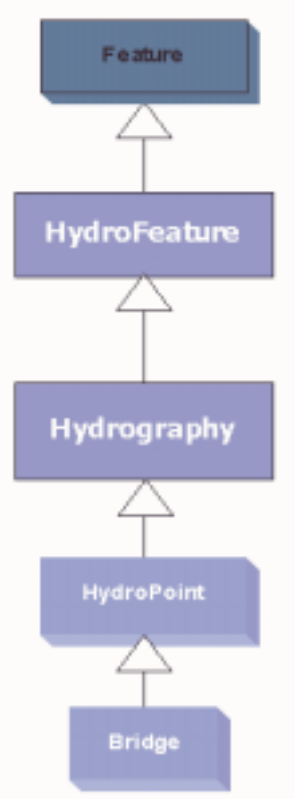
A dam is a structure that creates an artificial lake, or reservoir, by blocking a river or stream. Dams may harness the energy of falling water or provide flood control. They also store water for municipal water supply and crop irrigation, raise the water level to allow for navigation, and divert water into a pipe or channel. Dams are such important structures that it is common for them to be described by a tabular data inventory containing the latitude and longitude, from which the point feature can be created.

The *Dam* Point feature class does not define any additional attributes. Dams are complex objects that typically have many descriptive attributes. The user can add these as necessary.

Subtypes: None

Relationships: None

Bridge



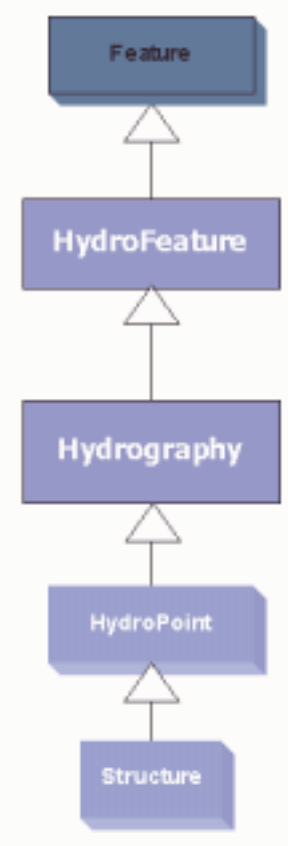
A bridge is a structure that allows passage over an obstacle. Bridges carry railroad lines, highways, and pathways over water and deep gorges. Bridges impede water flow by narrowing the stream cross-sectional area, which increases the water surface elevation and produces backwater effects upstream of the bridge. Information on bridge features is also maintained as part of the transportation network, and a simple definition of bridge locations is the set of points created by the intersection of the transportation and stream networks. A *culvert* is a road conveyance over a stream formed by a set of pipes inserted into the road embankment. A bridge differs from a culvert in that it is a formal structure crossing the stream, and connected to road embankments at both ends of the structure. In the Arc Hydro data model, culverts are considered a subset of bridges, and the FType attribute inherited from the Hydrography abstract feature class can be used to distinguish bridges and culverts, or different types of bridges, if necessary.

The *Bridge* Point feature class does not define any additional attributes.

Subtypes: None

Relationships: None

Structure



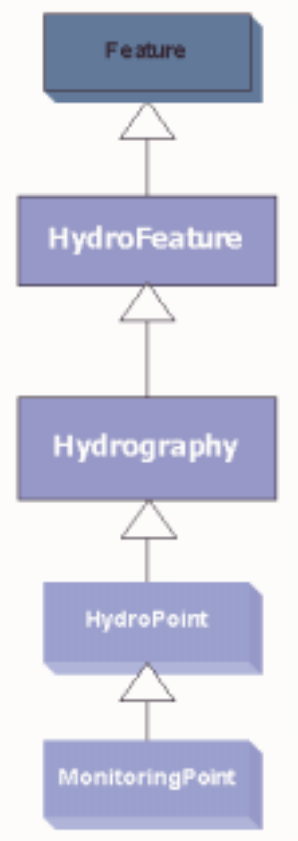
The *Structure* class contains any other kind of water resource structure that is not represented by *Dam* or *Bridge* classes. Structures change the hydraulic properties of the flow through the network by their presence. Typical examples of structures include detention ponds on small streams, levees designed to hold back floodwaters, and weirs. These can also be natural features like waterfalls if they have significant effect on the hydraulic properties of the network. The Structure class can also be used to describe buildings and other physical structures in the flood plain for purposes of economic analysis of the effects of flood damage.

The *Structure* Point feature class does not define any additional attributes.

Subtypes: None

Relationships: None

MonitoringPoint



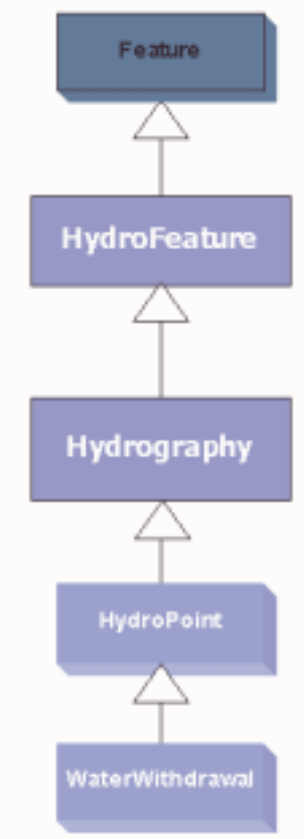
Monitoring points are intended to store the locations of gages that measure water quantity or quality, and may have time series data associated with them for analysis purposes. *Monitoring points* may also be subtyped or subclassed by the user. Examples of monitoring points include water quality monitoring stations, stream gage stations, rain gage stations, and any other type of fixed-location data collection points.

The *MonitoringPoint* Point feature class does not define any additional attributes, although typically there are many such attributes, including the name of the agency maintaining the monitoring site. The user can add such attributes as necessary.

Subtypes: None

Relationships: None

WaterWithdrawal



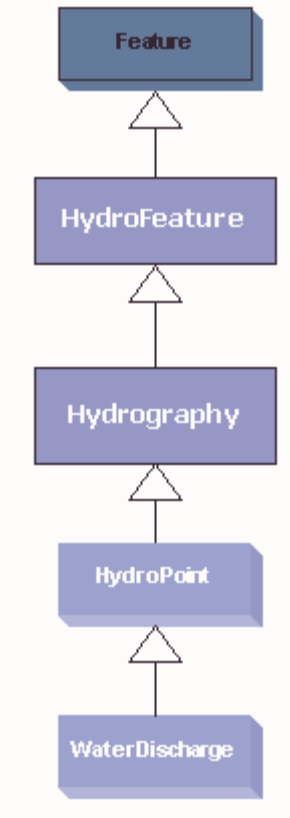
The *WaterWithdrawal* feature class represents points at which flow is diverted or pumped from surface water systems, or pumped from aquifers through groundwater wells. The point locations and associated flow data are maintained by government agencies that issue water rights, or the legal authority for individuals or institutions to withdraw water from natural water systems. These points are significant because they represent an interface between the human use of water and the natural water system, and they are important in computing the water balance.

The *WaterWithdrawal* Point feature class does not define any additional attributes.

Subtypes: None

Relationships: None

WaterDischarge



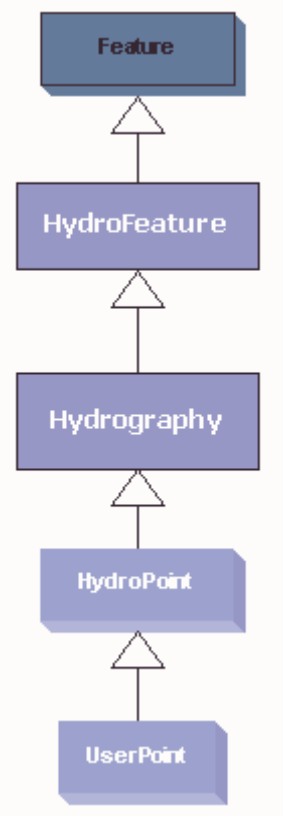
Water discharge points add flow to the stream network. Data on water discharge points is maintained by government agencies issuing permits for such discharges. Water can be discharged from wastewater treatment plants, by return flow from irrigation systems, or other sources. Typically, water discharges degrade the quality of the receiving waters, so these points are important for computing the water balance and water quality of natural water systems.

The *WaterDischarge* Point feature class does not define any additional attributes.

Subtypes: None

Relationships: None

UserPoint



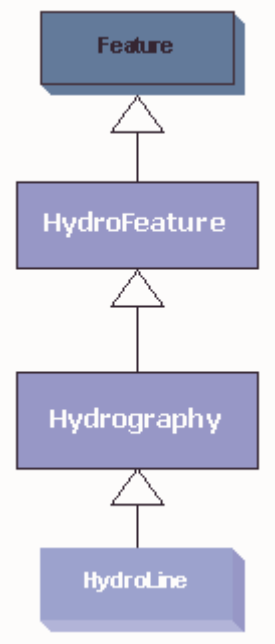
The *UserPoint* class contains any points of interest not described by other point hydrography feature classes. User points may include locations where rivers crosses aquifer, political or administrative boundaries, or define major confluence points on the river network. The *UserPoint* class is a good place to load large data sets of various kinds of points so that after application of the Arc Hydro schema, the points can be organized and exported to other classes as appropriate.

The *UserPoint* Point feature class does not define any additional attributes.

Subtypes: None

Relationships: None

HydroLine



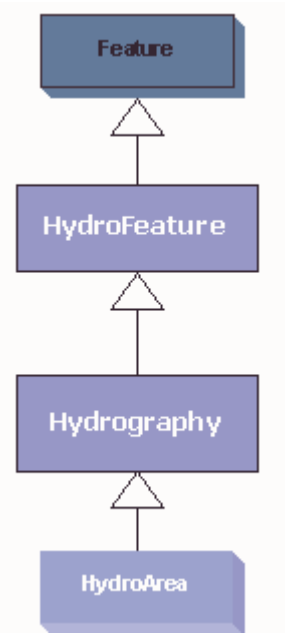
The *HydroLine* class is designed to contain line features that are important for the cartographic representation of the area of study and are not contained in the Hydro Network. Some examples of hydrographic lines are natural streams and rivers, manmade canals or ditches, pipelines that carry water underground, connectors that are used when the original data had some obstruction covering the hydrologic feature, and artificial paths which represent the centerlines of lakes and other water bodies. Isolated ponds and lakes which are not part of the river network, shorelines, island boundaries, no wake zones, swimming and recreation areas, roads, county and state boundary lines, jurisdictional boundaries for river authorities, and city limits are all marked off by lines which are important for cartography. They serve to provide a spatial reference for viewers of the data and so are necessary in the model. These types of lines are stored in the *Hydrography* subclass *HydroLine*. A subset of the above features may be built into the Hydro Network, in which case these features should be deleted from the HydroLine feature class to avoid duplicate representation of the same features.

The *HydroLine* Polyline feature class does not define any additional attributes.

Subtypes: None

Relationships: None

HydroArea



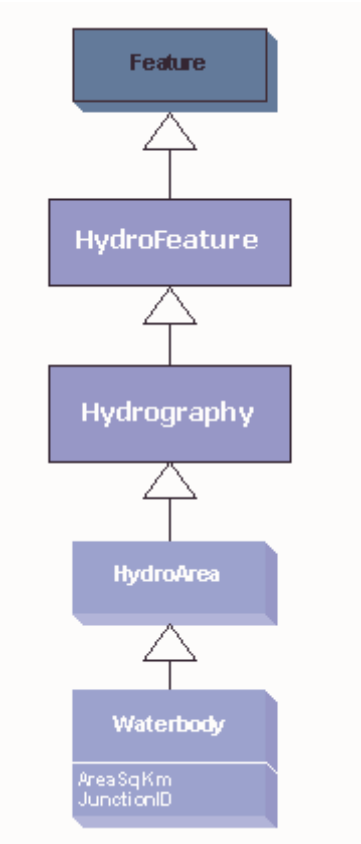
HydroArea contains area features from map hydrography. A *HydroArea* is a polygon representation of ordinary landmarks already mentioned in the description of *HydroLine*. Some examples of *HydroArea* features are no-wake zones within water bodies, extents of counties or other jurisdictional areas, and inundation areas or islands within waterbodies.

The *HydroArea* Polygon feature class does not define any additional attributes.

Subtypes: None

Relationships: None

Waterbody



The *Waterbody* class is subclass of *HydroArea*, which represents water bodies such as lakes, bays and estuaries. The distinction between the *Waterbody* and *HydroArea* feature classes is that a waterbody may be a very complex spatial feature with many islands, and even component water bodies. The Waterbody feature class provides a generalized representation of waterbodies, for which additional detail is contained in the HydroArea class, if necessary.

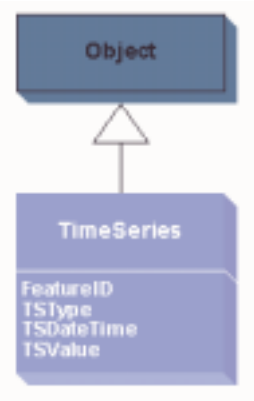
The *Waterbody* Polygon feature class defines the following attributes:

- *AreaSqKm: double*-The waterbody area calculated in square kilometers independent of map units.
- *JunctionID: integer*-HydroID of the HydroJunction, which is the outlet of this waterbody.

Subtypes: None

Relationships: WaterbodyhasJunction is a 1 to 1 relationship between *HydroJunction* (using HydroID) and *Waterbody* (using JunctionID).

TIME SERIES



The geospatial features of the Arc Hydro data model describe the *water environment*, that is, the physical environment through which water flows. Also important are the *water properties* at any geographic location: its discharge, water surface elevation, and water quality. These properties are contained in the TimeSeries component of the data model. At present, this component consists of a single object representing time series in a very generalized way. Any number of time series data of any type describing any Arc Hydro feature can be stored in this object. ArcGIS version 8.1 does not have functions specifically designed to support manipulation of time series so full implementation of time series requires custom coding of a time series toolset operating on top of the Arc Hydro data model. A time series connected to a spatial feature can be thought of as a time-varying attribute value of that feature. Within the geodatabase, time series data are treated like any other tabular data. It should be noted that this TimeSeries object exists to connect temporal and geospatial water resources data in a single geodatabase. It is not intended to be a fully configured water resources time series database, which requires a more complicated structure than the one described here.

The *TimeSeries* object class defines four attributes:

- *FeatureID: Integer* – the HydroID of the HydroFeature described by a time series.
- *TSType: String* - the type of time series data (such as precipitation, streamflow or evaporation).
- *TSDateTime*: *DateTime* - the date and time of the beginning of the time interval for which the TSValue applies. The format is
    - YYYY-MM-DD hh:mm:sss.sss TZ where:
    - ***YYYY*** is for the 4-digit year
    - ***MM*** is for the month (01 to 12)
    - ***DD*** is for the day (01 to 31)
    - ***hh*** is for the hour (00 to 23)
    - ***mm*** is for the minutes (00 to 59)
    - ***ss.sss*** is for the seconds with milliseconds (00.000 to 59.999)
    - ***TZ*** is for time zone, which can be local time zone, or ISO format (+0800, -0500, etc.)

- *TSValue – Double*: TSValue contains the actual time series data value.

Subtypes: None

Relationships: None. A relationship can be built between the feature and the time series associated with that feature if necessary.