Appendix 6 Data Systems and Data Standards

6.1.1.1 ASTM Standards D 5254, D 5408, D 5409, D 5410 (last updated 2004)

ASTM has established four standards that collectively contain data elements that enable data users to identify monitoring locations and the data collected for a very broad range of data needs. These standards contain the most comprehensive list of data elements of all the standards examined in this data standard's assessment. These ASTM standards differ from other standards in that more informative descriptions, practical examples, and notes that give better insight into the meaning of a data element are provided, and exhaustive references are given to other organizations' standards and data systems that can be used to describe data elements. The data elements in these standards are listed in Appendix A The main disadvantage of the ASTM standards is that they were not designed strictly for a computerized database strictly, rather for input of the data into any permanent file and, therefore, lack data elements of a computer database-oriented standard, such as eXtensible Markup Language (XML) tags and data formats. Many of the suggested components and representative codes for coded data elements are those established by the USGS and used in the NWIS computerized database.

6.1.1.2 U.S. Geological Survey's (USGS) National Water Information System (NWIS) Data Dictionary

The USGS NWIS contains 850,000 records of wells, springs, test holes, tunnels, drains, and excavations in the United States. The data elements of this database are widely used by state geological surveys in the United States and allow a measure of comparability and share-ability among these data sets by those agencies that use similar naming conventions and formats. Thus, the NWIS elements could be considered a data model for wide use among external users in other agencies. Real-time data are available for a limited number of sites. In describing the data available for these sites, the complete NWIS data dictionary contains data elements for level and quality data organized in 75 tables, including data elements for well construction, sampling location and time, elevation, sample results, and quality control.

An abbreviated set of data from NWIS is available online from NWISWeb at http://waterdata.usgs.gov/nwis and the data elements that are accessible for data sets in NWIS are listed in table 6.1.1.2.1..

Table 6.1.1.2.1 - USGS NWIS Web Data Elements for Data Accessibility Online

Data Elements

Agency Code
USGS site number
Begin date
Begin time
End date
End time
Time datum
Time datum reliability code
Agency collecting sample code
Sample medium code
Project identifier
Geologic unit code
Taxonomic unit code
Body-part code
Analysis-source code
Hydrologic-condition code
Sample-type code
Hydrologic-event code
Message from lab
Parameter code
Remark code
Parameter value
Result value qualifier codes
Method code
Data-quality indicator code
Reporting level
Reporting-level type code
Lab standard deviation
Preparation set identifier
Result preparation date
Analysis set number
Result analysis date
Lab result comment
Analyzing entity code

6.1.1.3 U.S. Environmental Protection Agency's (USEPA's) Water-Quality Data Exchange (WDX)

During the 1960s, the USEPA established a database to allow the water-quality monitoring community to store data in a central place. This database is the Storage and Retrieval System (STORET). Since 2000, USEPA has been engaged in changing the approach and format of this system, and as of 2007, has established a WQX to allow water-quality data to be exchanged in a standard format. The water-level and -quality data categories available through the USEPA WQX are listed in table 6.1.1.3.1. Reporting the data elements that can be mapped to the schema presented in table 6.1.1.3.1 allows users of WQX to share water data. The WQX relies on the National Environmental Information Exchange Network (NEIEN) for electronic data exchange among data users.

Table 6.1.1.3.1 - EPA WQX Data Elements--Water data tables and data categories accessible through the USEPA WQX (abstracted from *http://www.epa.gov/STORET/WQX_factsheet.pdf*)

Organization
ORG Description
ORG Electronic Address
ORG Phone
ORG Address

Activity Group
Activity Group Name
Activity Group Type
Activity IDs

Project
Project Description
Project Binary Object

Monitoring Location
Monitoring Location
Identity
Monitoring Location
Geospatial
Monitoring Location
Binary Object

Monitoring Activity
Activity Description
Activity Location
Sample Description
Sample Prep
Subsample Description
Activity Binary Object

Result
Result Description
Result Binary Object
Result Analytical Method
Result Lab Info
Result Detection
Quantitation Level
Lab Sample Prep

6.1.1.4 Environmental Data Standards Council (EDSC) Environmental Sampling and Analysis Results (ESAR) Standards

In 2006, EDSC developed a suite of standards designed to improve environmental reporting when exchanging information over the NEIEN. They describe data elements and data groupings that are used to exchange information over the Internet. The advantage of the EDSC standards as compared to the ASTM standards is that they are specifically designed for electronic database development and contain all of the requisite elements needed for that task: data groupings and data elements, definitions, XML tags, notes, example lists of values and format for each level (table 6.1.1.4.1). EDSC data standards include sampling, analysis, results, field activity, and well information.

The table below is a portion of the description of data elements from the EDSC approved data standards for Environmental Sampling, Analysis and Results: Analysis and Results (Standard No. EX000005.1, January 6, 2006). The first entry in the table is the name of the data table, its definition and its XML tag. The XML tag is a plain language data format allowing data to be more easily understood. XML is the electronic data language widely used among businesses and governments. The second entry, which is within the

"Laboratory Identification" data table is the data element name, "Laboratory Identifier," including its definition, notes explaining important data relationships, format (in this case, "A" stands for "alphabetical"), and XML tag. Other data elements may be described in this data table for "Laboratory Identification."

Table 6.1.1.4.1 EDSC data description example

Data Table Name	**Data Table Definition**			**Data Table XML Tag**
1.0 Laboratory Identification	Identifying information of the entity or person responsible for the analysis.			LaboratoryIdentification
Data Element Name	**Data Element Definitions**	**Notes**	**Format**	**XML Tags**
1.1 Laboratory Identifier	A designator used to uniquely identify the laboratory doing the analysis.	*Note:* Based on the business need, additional metadata may be required to sufficiently describe an identifier. This additional metadata is described in the Introduction section 1.6.d.	A	LaboratoryIdentifier

The EDSC standards include detailed Environmental Sampling, Analysis and Results Data Standards (Standard No. EX000001.1, January 6, 2006) applicable to ground water which follow the business processes used to collect, analyze and report environmental data. They include the following component standards:

(a) Analysis and Results: This standard includes the data groupings and elements required for describing the information resulting from the analyses that are performed on environmental samples and the results that are determined from the analyses.
(b) Field Activity Data Standard: This standard provides a group of data elements that are used to exchange information about field activities.
(c) Monitoring Location: This standard identifies and describes the elements required for describing monitoring location information. Additionally, the Well Information Data Standard includes information about well ownership, location, use, and construction.
(d) Project: This standard describes data groupings that are used to exchange data related to environmental projects.

The proposed minimum data elements for ground-water monitoring of levels and quality and comparison to existing data models and standards are listed in the table at the end of this appendix.

6.1.1.5 Locational Data

6.1.1.5.1 International Organization for Standardization (ISO)

The ISO technical committee TC211 develops standards relating to geographic information. ISO standard 19115, *Geographic Information—Metadata,* was designed for international use. It attempts to satisfy the requirements of all well-known metadata standards. ISO 19115 is a content standard that defines the schema required for describing geographic information and services. It provides information about the identification, the extent, quality, spatial and temporal schema, spatial reference, and distribution of digital geographic data. ISO standard 19139, *Geographic Information—Metadata—Implementation Specification,* provides a schema in XML format that indicates how ISO 19115 metadata should be stored in XML format. ISO 19139 provides an encoding schema for describing, validating, and exchanging metadata about geographic data sets, data-set series, individual geographic features, feature data elements, feature types, feature properties, etc.

6.1.1.5.2 National Efforts

The FGDC (http://www.fgdc.gov/) and Open Geospatial Consortium (OGC; http://www.opengeospatial.org/) have developed standards for geographic databases, data, and metadata that are to be shared among Federal agencies and among GIS researchers, most commonly data sets to be used in GIS applications. It provides information and XML tags describing the identification, extent, quality, spatial and temporal schema, spatial reference, and distribution of digital geographic data. With respect to SOGW and ground-water monitoring, FGDC and OGC standards apply to several aspects of locational attributes of monitoring stations and monitoring networks and the metadata used to describe those attributes.

The FGDC and OGC standards for geographic metadata, however, are far more comprehensive than what would typically be available for ground-water monitoring stations largely because many of the metadata elements in the standards are not useful to the design of ground-water monitoring networks or the interpretation of ground-water data. As a result, FGDC and OGC metadata formats and standards are not widely used in ground-water science. For example, although ground-water monitoring stations have geographic attributes (x, y, and z coordinates), and many State and Federal databases include geographic metadata, such as coordinate datum, coordinate units, method used for determining location, accuracy of the location, date of measurement, and the organization responsible for determining the location, these metadata are not stored or readily transferrable in a format compliant with applicable metadata standards. The challenge is to provide translation tools to convert the geographic metadata applicable to ground-water monitoring into a format compliant with national standards.

The ACWI Subcommittee on Spatial Water Data (SOSWD) (*http://acwi.gov/spatial/index.html*) is jointly sponsored by the FGDC. "The purpose of the Subcommittee is to coordinate spatial water data and information activities among all levels of government and the private sector." The efforts of this group have been largely focused on development of data, data models, data standards, and tools for evaluating surface and surface-water features (Hydrologic Unit code (HUC), National Hydrography Dataset (NHD), National Elevation Dataset (NED), land use).

6.1.1.5.3 Geographic Components of the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI), Hydrologic Information System (HIS)

The ArcHydro data model for ground water has been developed in parallel with CUAHSI and currently (October 2007) is nearing the review stage. In addition, CUAHSI staff have been actively participating in the ACWI SOSWD. The ArcHydro data model has added a robust geographic context to hydrologic data management. It couples WaterML, an extension of XML specific to hydrology, with OGC standards to facilitate storage and exchange of geographic and hydrologic data and metadata. This model has capabilities for storing geographically referenced data on lines (wells), polygons (aquifer outcrop areas), grids (aquifer top and bottom surfaces), and volumes (transmissivity, porosity) as well as time series data on water levels and chemistry and, with application of web services, is designed to work to display and analyze these data in database, spreadsheet, and graphical GIS environments. Though the map-based display and analysis capabilities are not necessary components of a ground-water monitoring network, the data model provides a framework to make ground-water data readily available to advanced data-processing software.

6.1.2 State Systems

States have evolved their own databases and have set their own standards or used established standards of other organizations. Naming conventions for data elements are not consistent among states or even agencies within states as described in the case studies cited in the introduction to this chapter. The case study appearing below highlights issues with data collected and reported that impede data sharing and exchange among states or between states and agencies with which they share data.

Case Study – Montana, Florida, and Washington: Comparison of State Databases

Databases

For this case study, the SOGW reviewed information about the following three databases:

- Ground-Water Information Center (GWIC), Montana
- Watershed Monitoring Program, Florida
- Washington Department of Ecology online database, Washington

Each of the three databases appears to be storing and delivering (in general) either the same or a very similar set of fields. This makes a fair amount of sense because a well has the same characteristics regardless of whether it was drilled in Montana or Florida.

Identification

Each state reviewed had some form of unique identifier for their wells. Some used a character field and others used an integer field. Ideally an identifier, or primary key, should be an auto-generated numeric value with absolutely no relation to the data.

Locations

All three States appear to be storing at least one form of locating the well on the ground surface using some sort of coordinate system.

Florida is storing:

- latitude and longitude (as a floating point)

- county

Montana is storing:

- township, range, and section (along with determined quarter sections)
- latitude, longitude (as decimal), method, and datum
- well address
- subdivision, lot, block
- geocode (cadastral)
- county

Washington is storing:

- township, range, and section
- well address
- UTM or latitude and longitude
- County

There are some differences in the way that the latitude and longitude values were stored. Florida is storing their values in a floating point field, which only stores an approximate value. Montana is storing their values in a numeric field with up to 6-decimal precision.

The retrieval interface for Florida makes it seem like most of the identifying fields are controlled by validation lists. Montana is also controlling the majority of fields for location to only allow values that make sense for the State.

Construction and Completion

Both Montana and Florida store the details of the construction of the well, including casing and perforated/screened intervals. The most common and intuitive information includes storing the start of the interval, end of the interval, and description of material used.

Water-Level History

The data structures provided indicate that Florida tracks water-level histories, where monitored, but it was not immediately obvious that the data were stored in the tables provided.

Montana stores both the static water level reported by the driller at the time of completion and long-term water levels measured by field technicians. Montana maintains a statewide network of 900 wells that are measured at frequencies ranging from hourly to quarterly. Data from other projects at the MBMG and other agencies across the State increasingly are being stored in the GWIC database.

Both States appear to be tracking water-level measuring-point changes over time.

Hydrogeology

The Florida database includes whether or not lithologic details are available, including a CHAR field of length one entitled “WELL_LITHOLOGIC_LOG.” Florida stores the top and bottom of the aquifer in FLOAT fields, as well as carrying the name of the subaquifer in a VARCHAR field of 60 characters in length.

The Montana database stores all available intervals and descriptions as provided by the driller/contractor who constructed the well/borehole. Montana also stores geologic source/aquifer codes on wells where they have been determined by a qualified professional.

Land Use

Neither the Florida nor the Montana database currently tracks a marker for LAND USE. Montana is considering how to implement this.

Conclusion

This comparison demonstrates that states that regularly monitor ground water may collect similar data stored under different names and also that data stored about ground water are variable from state to state.

6.1.3 Data Exchange

Data exchange is defined as "the storing, accessing, and transmitting of data" (CERN Engineering Data Management Service, 2001). When considering the significance of data sharing through voluntary exchange, the ACWI NWQMC noted that: "When common data elements are used by data generator organizations, the information collected and reported increases its value to other agencies, to the public, and even to the agency that originally collected the data because the data continues to be understood. Such data can then be used in subsequent studies and shared with others, potentially increasing the geographic or temporal coverage of water quality characterizations and providing better information upon which to base management decisions" (National Water Quality Monitoring Council, 2006).

The Federal government has participated in or led several efforts to establish agreements to facilitate data exchange nationally. These efforts include:

1. The USGS's NWIS web data dictionary available online at http://waterdata.usgs.gov/nwis/help/?codes_help
2. USEPA's WQX accessible online at http://www.exchangenetwork.net/schema/WQX/1/WQX_DET_v1.0.xls
3. USEPA's NEIEN accessible online at http://www.exchangenetwork.net/
4. U.S. National Science Foundation funded HIS developed through the CUAHSI, accessible online at http://river.sdsc.edu/dash/

There are two general models for exchange and distribution of water data at the national and regional levels. The first model encompasses legacy sites that contain massive data sets with a national spatial context and a long period of record. Data users can retrieve data via the Internet from the various data sources through data exchange nodes, which host the data sets outside the respective agency's firewall and provide public access to the data. The first model is exemplified by both the USGS-NWIS and USEPA-STORET database systems, which have been in operation since before the advent of the Internet and each contain results from millions of water measurements for levels and quality. These systems also now have multifeatured websites for search and retrieval of information. A key difference between the systems is that many State, Tribal, and local agencies provide data for EPA-STORET while the USGS-NWIS data are predominately generated by USGS personnel, including some comparable State data.

At this time only the USGS-NWIS database contains level and quality data with a national spatial context and long-term time context. The USEPA-STORET databases (legacy and modern) contain vast quantities of surface-water data but relatively limited ground-water quality data. Ground-water data holdings in STORET-Legacy Data Center (LDC) vary state by state and primarily consist of water-quality data. Water-level data appear to be restricted to those measurements associated with water-quality samples. Metadata on wells in STORET-LDC are very limited and in many cases do not meet the minimum set of data elements recommended for sampling stations.

The current NWIS data dictionary used by the USGS is based on the Ground Water Site Inventory (GWSI) database. The GWSI dictionary appears to contain data elements needed for almost all purposes. However, the list of searchable fields available to NWIS-Web users is very limited, requiring many users needing to search or retrieve data from those fields to contact the USGS. A revision to this dictionary that will allow Internet users to search on additional terms has been proposed.

The second model for exchange and distribution of water data encompasses systems that are service-heavy portal-type sites that have capabilities for users to search distributed data sets to bring all of the data to the user, through the systems of the CUAHSI and the EPA WQX. Web services or other web-based programming tools are the means by which users enter text or map-based search terms. A variation of this approach includes the USEPA Region V electronic data delivery (EDD) and electronic data preparation (EDP) and STORET data entry and reporting module applications that use web-based or stand-alone programs to help laboratories, States, and consultants prepare, QA/QC, and submit data to regional exchange node databases and/or to STORET. These applications ensure standardized metadata entries and vocabularies.

Recent developments in technology, especially in GIS, are blurring the boundaries between the two general models and resulting in systems with both types of functions. For example, there are indications that the USGS is moving toward developing data services for users to access NWIS more easily. The USEPA STORET website now contains a map interface to help users refine spatial search parameters.

In addition to map-based search and analytical tools, the HIS, developed by CUAHSI, has implemented a robust data model and XML scheme that will permit and encourage development of a large central database as well as a network of distributed databases that encompass data from the entire country. To test this concept, HIS participants have built, tested, and published web-service tools that allow users to retrieve and analyze data from USEPA-STORET and USGS-NWIS.

Similar systems in various levels of development exist within the states, regional water management agencies, and local water authorities such as the Montana system that is described in a preceding section. Many of these systems include data-rich, well-documented databases to serve their stakeholders. In addition to traditional point-and-click lists and text-based and drop-down box functions, some systems have sophisticated

GIS applications for web-based data search and retrieval along with Internet-accessible, customized data services for GIS users. There have been presentations on several of these systems at the National Ground Water Association (NGWA) Annual Expos over the past 5 years. What is lacking is a publicly accessible data exchange or service mechanism that will pull data from these multiple sources.

At the other end of the spectrum, there are many agencies holding water data that have no Internet-accessible or even computerized data resources. Data access requires visiting, writing, or phoning the office to obtain hard-copy data sheets or reports. In some cases, a written request for information is needed. Internet access to these data would be a valuable service for consultants, regulators, and researchers. These agencies will require resources to make their data Internet accessible.

In all cases, data storage and exchange systems that make use of clearly defined metadata standards and standard vocabularies are a necessity for the long-term viability of any national or regional database or data service. EDSC and ASTM provide standard frameworks for state and local entities to make their data accessible to data services such as CUAHSI-HIS.

6.1.3.1 U.S. Geological Survey's (USGS) National Water Information System (NWIS) and NWISWeb

The USGS NWISWeb application is a publicly accessible web-browser data distribution system for the USGS NWIS database. The content offered on USGS NWISWeb pages is readable if the following conditions are met on the data user's computer:

- A browser that supports the Hypertext Markup Language (HTML) 3.2 specifications;
- A graphics viewing capability, either built into the browser, or via an external program, such as the Unix "xv" program or the PC Windows "Lview" program, for looking at figures and images; and
- An Adobe Acrobat ® Portable Document Format (PDF) viewer, or the ability to capture and print PDF files.

The USGS released several web-browser-based data distribution applications in 2007. These applications have packaged existing NWISWeb data distribution applications in a portal with simple map interfaces. The Ground-Water Watch portal (*http://groundwaterwatch.usgs.gov/*) provides access to data from the Active Water-Level, Climate Response, and Real-Time Ground-Water Level Networks. "Water-resources data for the United States, Water Year 2006" [http://wdr.water.usgs.gov] is another such portal.

The movement of data from State and local agencies to the USGS and into USGS is controlled by USGS policies that require that data generators, whether Federal or State, use the same data element names to enter data into the system. Typically, these data generators are USGS Water Science Centers and State cooperators such as Natural Resource Departments, State Engineers, and Geological Surveys. A significant percentage of the wells with water level data in NWIS each year are provided by cooperators.

6.1.3.2 U.S. Environmental Protection Agency's (USEPA's) National Environmental Information Exchange Network (NEIEN)

The Exchange Network is a secure Internet- and standards-based approach for exchanging environmental data and improving environmental decisions. The USEPA, State environmental departments, and Tribes and territories are partnering to build the Exchange Network to increase access to environmental data and make the exchange of data more efficient.

A Network Node is a web server that facilitates the interface between database systems and the network. It is an entity's "point of presence" on the Exchange Network. Using standards-based web services and XML schema, Nodes securely initiate and respond to requests for information. With properly configured Nodes, network trading partners can seamlessly exchange data regardless of hardware, operating system, or programming environment.

Nodes are defined by their specific function, rather than what they are in a physical hardware sense. Network participants may use several different hardware and software approaches and combinations to establish a Node. For example, a network participant could implement a Node with (1) specialized Node software on a dedicated server, (2) one or more types of software on more than one server, or (3) existing enterprise software on an existing server. Network partners are free to choose their own approach to Node establishment–what is important is that the Node performs its functions as outlined in the Network Node Functional Specification, which has principles, assumptions, constraints, and requirements outlined below in the "Exchange Network."

The Exchange Network relies on data exchangers to have resolved differences in data element naming conventions to allow data sharing in meaningful ways. These data exchangers typically are State environmental agencies and the USEPA, although other Federal agencies are utilizing the Exchange Network also. One approach to resolving data element names is to use the data standards of the EDSC.

Exchange Network

The USEPA NEIEN Principles, Assumptions, Constraints and Requirements for facilitating data exchange among States and the USEPA include:

<u>Principles, assumptions, and constraints</u> for the Network Node Functional Specification V1.0 are:

1. The specification is expected to have a life of 18-24 months. During this time, actual network usage information will be used to develop V2.0.
2. The specification will be kept as simple as possible. This is to ensure interoperability without unreasonable network participation criteria.
3. Immediate development of the specification is required because:
    - Network participants need the specification to assist their Node implementations.

- The network Implementation Plan calls for ten (10) Nodes implemented by Q2 2003. However, a few dozen State agencies began establishing Nodes in 2002.

- Even if the initial specification is imperfect and incomplete, the network will work more efficiently and effectively with network standardized expectations, functional performance standards, and "rules."

- Given the flexibility of network technologies, implementers will be looking for all practical guidance available.

4. The specification must be consistent with the Network Exchange Protocol V1.0.
5. The specification must be consistent with the Network Security Guidelines provided in a separate document.
6. The specification must be consistent with the Network Registry Guidelines and operation.

Requirements describe what will be delivered as part of the Network Node Functional Specification Version 1.0. The Network Node Functional Specification V1.0 shall:

1. Support all critical requirements for dataflows including the ability to "package" the relevant data using XML schemas developed by exchange partners and network participants.
2. Use HTTP, Web Services Description Language (WSDL), and Simple Object Access Protocol (SOAP). Emerging industry standards will be used as consistently as possible in the application of these protocols.
3. Implement, and be compliant with, security procedures identified in the Network Exchange Protocol V1.0. If the Network Security Guidelines become available during the shelf life of the protocol, they will supersede security measures outlined herein.
4. Be implemented using the most common toolsets in use by Node implementers. A high degree of customization will be avoided.

6.1.3.3 Consortium of Universities for the Advancement of Hydrologic Science, inc. (CUAHSI), Hydrologic Information System (HIS)

The HIS takes a different approach to data exchange than the two previous systems (table 6.1.3.3.1). The CUAHSI approach leaves the data element naming convention unresolved, allowing organizations to continue with their current data element names. Rather than building and maintaining a single massive database, automated data retrieval services access data from diverse, distributed databases through "mapping" of the data elements with common definitions (e.g., "constituent" and "substance") of the various systems. At this time HIS has the capability to access, manage, and distribute data from NWIS, STORET, and several of the CUAHSI observatories. The CUAHSI observatories also include data sets from State and regional programs.

HIS members have developed a variety of automated data retrieval services and data analysis tools. Some of the services and tools are web based, others can be installed with GIS and spreadsheet applications. The Data Access System for Hydrology (DASH) and HydroSeek are web-browser-based tools developed by HIS that aggregate, report, and deliver these data to the end user in a seamless tabular or map display. Data search tools enable analysts to query databases for similar data using keywords or other search criteria.

"HydroSeek is a global search allows data discovery over multiple and heterogeneous data sources. It relies on several web technologies such as Web Services, AJAX and OWL. CUAHSI Controlled Vocabulary and several other service ontologies comprise an important part of the search wizard. The current coverage includes USGS NWIS and EPA STORET as well some regional data centers like the Chesapeake Bay Information Management System (CIMS) and the Texas Commission of Environmental Quality (TCEQ) databases, in addition to some smaller local data sets like the Real-Time Hydrologic Data Network (RTH_NET) in Pennsylvania."

"DASH is a software system that enables you to query networks of hydrologic observation sites and extract hydrologic observation data from them in the form of time series of measurements at individual sites or collections of them. The National HIS Server provides access to observation data sources such

as the USGS National Water Information System (NWIS) and the EPA Storage and Retrieval System (STORET). Regional HIS Servers provide additional information about observation networks for state, local or academic investigator observation data sources in particular areas. Development of DASH is a joint effort between the CUAHSI (Consortium of Universities for the Advancement of Hydrologic Science, Inc) Hydrologic Information System project and the ESRI Water Resources Applications group in Redlands, CA. A prototype version of DASH is operational at http://river.sdsc.edu/DASH/. The national version of DASH will eventually operate from the San Diego Supercomputer Center, and regional versions will operate at 10 testbed site locations in academic institutions that the National Science Foundation is supporting as part of the Waters Network Information System, and at similar water research centers at other locations."

6.1.3.3.1 Hydrologic Information System (HIS)

The CUAHSI Data Elements for the HIS are presented by data table in database model format.