# Spatial Data Standards for the California Department of Water Resources

Enterprise GIS Committee

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# Spatial Data Standards for the California Department of Water Resources

This document describes spatial data standards for enterprise data sets from this time forward. DWR endorses these standards to ensure that enterprise spatial data has superior quality, and to provide consistency between spatial data sets.

There is an essential link between having superior quality data, and convincing others that the quality is good. That link is metadata. Without metadata, it does not matter how good the quality of the data is. Other people using the data will be highly skeptical until you convince them otherwise. While this document sets forth standards for DWR's spatial data; the motivation for the standards was documentation of the quality of the data. For all enterprise data sets, DWR requires spatial data to meet or exceed the standards of quality set forth in this document, and requires complete metadata.

Each section discusses an important topic to define the quality of spatial data. The discussion is intended to be in sufficient detail that a reader can understand the issues, and know how to assess the quality of spatial data with respect to the topic. There are associated examples and workbooks where appropriate. Each section contains sub-sections detailing the standards DWR endorses; where to report the information in the metadata (using the DWR and Federal Geographic Data Committee metadata standards), and relation to other standards if applicable.

The standards are documented in the Standards sub-section of each section. Each standard is numbered with the format X,Y, where X is the number of the section and Y is the ordinal value of the standard. In some cases, standards from one section are applicable to another section. In these cases, X refers to the parent section where it is defined.

Department defines two types of data sets: enterprise and program. Enterprise data sets are generally available to everyone (certain restrictions may apply), while program data sets are only used by a limited number of people. These standards apply only to enterprise data sets; not to program data sets. The standards are intended only as recommendations for program data sets.

The spatial data standards are applicable to enterprise "DWR created data"; and not to enterprise data from outside DWR. The term "DWR created spatial data" refers to spatial data created by DWR staff, spatial data acquired by DWR, or submitted to DWR by contractors and consultants.

Legacy spatial data is a special case. In many cases, it does not have metadata. To promote legacy data to enterprise data, metadata will have to be created. When the metadata is created, the legacy data may remain as it is, and does not have to be converted to meet the enterprise standards.

If the legacy data continues to be used, or extended, then these standards shall apply. This will probably require reprojecting the data, performing a formal quality assurance of the data, and developing metadata that meets DWR standards.

This document is intended to be a living document. As such it will be updated periodically. The effort to compile these standards was large. Inevitably something has been left out. Technology also changes. These standards should be updated by DWR as necessary, and not less than once every three years.

The GIS Data Subcommittee has a companion document, *General Framework for Managing Spatial Data at the California Department of Water Resources.* This document is referred to as the Framework Document.

This document shamelessly uses the works of others. When this happens, credit is respectfully given. In the main body of this document, we include a citation, and change the formatting.

# 1. Names

This section applies to field names, table names, file names and directory names. These topics are covered in other sections of this document.

## 1.1. Standards

DWR endorses the following standards for names:

1.1. Names shall be restricted to alphabetic characters [a-zA-Z], digits [0-9], underscores [_], and dots [.]. All other characters are not allowed.

1.1.1. Names shall not contain spaces.

1.2. Names shall begin with a character.

1.3. Words shall be written separating words by underscores, or in “Camel Case” (where the first letter of a word is capitalized, the remaining characters are lower case, and no spaces are used; such as ExampleDirectoryName.) All uppercase words are especially straining to the human eye. Mixed case text presents a readable format that is more easily and quickly read.

1.4. Avoid abbreviations. Different disciplines may use the same abbreviation, such as ppt. For people working in water quality, this would be the abbreviation for “parts per thousand.” For people working with the hydrologic cycle, this would be the abbreviation for “precipitation.” When you do use an abbreviation, it should be explained in the metadata.

1.5. When you use acronyms and initialisms, it shall be written in all capital letters. As per Standard 1.4, it shall be explained in the metadata.

1.6. Use specific names. If a name is too vague, users must rely upon supplemental documentation for definitions.

1.7. Dates shall be written as YYYYMMDD.

### 1.1. 1. Directory Names

1.8. Directory names shall not contain a dot.

### 1.1. 2. File Names

1.9. File names shall contain only a single dot, which is the character before the file extension.

### 1.1. 3. Feature Class Names

1.10. Feature class names shall be no longer than 30 characters. This is a limit imposed by Oracle, not ESRI.

1.11. Feature class names shall be of the form:
[ISOCode]_[Name]_ {Version}
where ISOCode is one of the ISO theme codes in Table 1, the name may include the program and/or the subject and should be as descriptive as possible, and version is optional

1.12. The ISO Code name shall be written as "ISOXXX", where XXX is the three digit number from Table 1.

### 1.1.4. Field Names

1.13. The suffix '_ID' shall be used for primary keys that are numeric. For example, fields named Site_ID, Plot_ID, or Station_ID. Use the same field name for foreign keys, i.e. Site_ID in one table may relate to Site_ID in another table.

1.14. The suffix "_Code" shall be used for primary keys that are alphanumeric. For example, a field containing three letter abbreviations of California counties would be County_Code, not County_ID.

1.15. Nouns shall be singular in field names. For example, use Life_Stage rather than Life_Stages.

1.16. Avoid a field name that is a word reserved for use by a database server or GIS software program, referenced in Appendix B. The list will differ depending on the software and version you are using. For example, a field should not be named "area" or "length." These are words used by ArcGIS.

## 1.2. Metadata

File and directory names are not explicitly documented in the metadata.

Acronyms and initialisms shall be defined in Section 5 of the metadata. Acronyms and initialisms used in table names and feature classes shall be described in Section 5.1.1. Acronyms and initialisms used in attributes or attribute values shall be defined in Section 5.1.2.

## 1.3. Relation to Other Standards

The naming conventions apply to field and table names, discussed in Chapter 5.

File names are used in version control and data maintenance, discussed in Chapter 15.

The GIS Data Subcommittee recommends that DWR develop a list of standard abbreviations.

# 2. File Organization

There is no one file organization scheme that is optimal for all possible cases. *General Framework for Managing Spatial Data at the California Department of Water Resources*, Appendix A shows the popularity of different file organizing schemes, from the surveys done by the GIS Data Subcommittee. The most popular schemes organize files by geography or project.

Another way to organize spatial data is by the category of data. FGDC and ISO spatial data themes are presented in Table 1. CERES uses the same list to organize data.

**Table 1. ISO Themes**

| Name | Code | Description |
|---|---|---|
| Farming | 001 | Rearing of animals and/or cultivation of plants Examples: agriculture, irrigation, aquaculture, plantations, herding, pests and diseases affecting crops and livestock |
| Biota | 002 | Flora and/or fauna in natural environment Examples: wildlife, vegetation, biological sciences, ecology, wilderness, sea life, wetlands, habitat, biological resources |
| Boundaries | 003 | Legal land descriptions Examples: political and administrative boundaries, governmental units, marine boundaries, voting districts, school districts, international boundaries |
| Climatology Meteorology Atmosphere | 004 | Processes and phenomena of the atmosphere Examples: cloud cover, weather, climate, atmospheric conditions, climate change, precipitation |
| Economy | 005 | Economic activities, conditions, and employment Examples: production, labor, revenue, business, commerce, industry, tourism and ecotourism, forestry, fisheries, commercial or subsistence hunting, exploration and exploitation of resources such as minerals, oil and gas |
| Elevation | 006 | Height above or below seal level Examples: altitude, bathymetry, digital elevation models, slope, derived products, digital elevation models or TINs |
| Environment | 007 | Environmental resources, protection and conservation Examples: environmental pollution, waste storage and treatment, environmental impact assessment, monitoring environmental risk, nature reserves, landscape, water quality, air quality, environmental modeling |
| Geoscientific Information | 008 | Information pertaining to earth sciences Examples: geophysical features and processes, geology, minerals, sciences dealing with the composition, structure and origin of the earth's rocks, risks of earthquakes, volcanic activity, |

| Name | Code | Description |
|---|---|---|
| | | landslides, gravity information, soils, permafrost, hydrogeology, groundwater, erosion |
| Health | 009 | Health, health services, human ecology, and safety Examples: disease and illness, factors affecting health, hygiene, substance abuse, mental and physical health, health services, health care providers, public health |
| Imagery Base Maps Earth Cover | 010 | Base maps Examples: land/earth cover, topographic maps, imagery, unclassified images, annotations, digital orthoimagery |
| Intelligence Military | 011 | Military bases, structures, activities Examples: barracks, training grounds, military transportation, information collection |
| Inland Waters | 012 | Inland water features, drainage systems and characteristics Examples: rivers and glaciers, salt lakes, water utilization plans, dams, currents, floods and flood hazards, water quality, hydrographic charts, watersheds, wetlands, hydrography |
| Location | 013 | Positional information and services Examples: addresses, geodetic networks, geodetic control points, postal zones and services, place names, geographic names |
| Oceans | 014 | Features and characteristics of salt water bodies (excluding inland waters) Examples: tides, tidal waves, coastal information, reefs, maritime, outer continental shelf submerged lands, shoreline |
| Planning Cadastre | 015 | Information used for appropriate actions for future use of the land Examples: land use maps, zoning maps, cadastral surveys, land ownership, parcels, easements, tax maps, federal land ownership status, public land conveyance records |
| Society | 016 | Characteristics of society and culture Examples: settlements, housing, anthropology, archaeology, education, traditional beliefs, manners and customs, demographic data, tourism, recreational areas and activities, parks, recreational trails, historical sites, cultural resources, social impact assessments, crime and justice, law enforcement, census information, immigration, ethnicity |
| Structure | 017 | Man-made construction Examples: buildings, museums, churches, factories, housing, monuments, shops, towers, building footprints, architectural and structural plans |
| Transportation | 018 | means and aids for conveying persons and/or goods Examples: roads, airports/airstrips, shipping routes, tunnels nautical charts, vehicle or vessel location, aeronautical charts, railways |

| Name | Code | Description |
|---|---|---|
| Utilities Communication | 019 | Energy, water and waste systems and communications infrastructure and services Examples: hydroelectricity, geothermal, solar and nuclear sources of energy, water purification and distribution, sewage collection and disposal, electricity and gas distribution, data communication, telecommunication, radio, communication networks |

Other ways of organizing spatial data are by access privileges or data base schema.

DWR should revisit this topic when ESRI releases ArcGIS 9.4. That version will allow geodatabases to have folders, which will help with organization of files. The current version of ArcGIS does not do this. This may also affect the naming standards.

## 2.1. Standards

2.1. DWR endorses directory names based on themes.

2.2. A data custodian shall place a feature data set, or feature class, into the appropriate theme.

2.3. If an individual project has multiple files, the data custodian may create a project folder (sub-directory) for the project.

## 2.2. Metadata

The full path to the file shall be specified in Section 6.4.2.2.1.1.1.1 of the metadata.

## 2.3. Relation to Other Standards

The GIS Data Subcommittee recommends that DWR develop an on-line, master catalog of enterprise spatial data sets that is searchable.

# 3. File Formats

File formats are important for

- ❖ Native format of the spatial data
- ❖ Products from spatial data

The native format of the spatial data must be one that can be used in a geodatabase or other spatial software. Knowledge of the file format is important when transferring spatial data from one person to another, and what, if any, format translations will be necessary.

The file format is also important for products from spatial data, such as maps in PDF files. People who want to use the products need to know what products they can choose from.

In both cases, technological changes over time will alter the file formats commonly used.

## 3.1. Standards

3.1. DWR endorses native file formats for spatial data that are compatible with ArcGIS version 9.3 (the current version of ArcGIS at the time the standards are being written). Files shall be in a format that can easily be imported or exported from ArcGIS.

3.2. DWR does not have any file format standards for products from spatial data.

## 3.2. Metadata

The metadata has two places to describe file formats.

Section 3.3.1 describes spatial data transfer format standards. Because these standards were developed in the 1990s and are outdated, DWR differs from the federal standard. DWR recommends that a data custodian complete this section, but file formats are not limited to those listed in the domain.

Section 6.4 describes standards for ordering spatial data from the organization which produced the data. In both DWR and federal standards, this information is conditional. The data custodian is not limited to the file formats listed in the domain for Section 6.4.2.1.1.

Popular products, including the file format, may be described in Section 1.2.3 for supplemental information.

## 3.3. Relation to Other Standards

File format relates to deliverable media standards, discussed in Chapter 18.

# 4. Database Design

Completeness is one of the qualities of good data, and addresses decisions about what is contained in the data set. Because completeness addresses intent and decisions, it is not a characteristic of quality that can be measured or checked against some ideal design.

The choices made with database design and modeling impact other characteristics of data quality, such as spatial consistency and horizontal accuracy.

## 4.1. Geodatabase Table Design

Good data modeling practices may often dictate that best database design be toward storing spatial data and attributes in separate tables. However, a downside to this approach is that in some cases it may needlessly complicate use of data. Consequently, there must be a conscious decision made about whether to embed attribute information into existing spatial feature class tables versus standalone attribute tables (to which data may be related, linked, joined, or queried through use of a common field). A person designing a geodatabase should be able to answer all of these questions:

- Which is the best way to model the data?
- Which is the most efficient way to maintain the data?
- Are the attributes literal and specific descriptors of the spatial objects?
- Do certain attributes pertain to only one feature class type or to many?
- Are separate editing processes/permissions needed for spatial objects and for attributes?
- How does tiling (if being used) affect the integrity of the relationship between spatial data and attribute data?

As DWR moves forward with an enterprise system, the answer to some of these questions may change. For instance, DWR may develop a standard list of counties. Any dataset using counties would then have to be modified to use the enterprise county list.

### 4.1.1 Data Design and Modeling with Respect to Spatial Consistency

Database design and modeling techniques directly affect spatial consistency. For example, if you desire to map a forest canopy, it is important to distinguish between mapping tree canopies and tree trunks, whether to map the canopies individually or map canopy overlaps, what minimum size constitutes an individual tree, and whether to map trees as polygons or as points, and whether to specify the elevation of the canopy as the average height (a single point), or a range (the minimum and maximum height of the canopy). The selection of a data model that is appropriate and feasible for the features to be created in the database is critical and will have a direct bearing on the spatial consistency.

### 4.1.2 Data Design and Modeling with Respect to Thematic and Attribute Consistency

Good database design and common database strategies should be employed wherever possible for the goal of enhanced thematic and attribute consistency.

## 4.2. Standards

**Mandatory Fields**
4.1. These six fields shall be added to all database tables if they do not already exist, and populated, as applicable.

1. A Unique Number To Identify The Record
2. Date Data Applies To
3. Source
4. Comments
5. Date Record Last Updated
6. Record Last Edited By

These fields will help everyone understand what is being recorded, when and by whom. They will also help track changes.

**Theme Names**
4.2. Fields that store values that have units shall be written as {name}_{units}.

**Feature Classes**
4.3. Feature classes shall be used instead of shape files.

**Spatial Consistency**
4.4. Data design and models shall not cause spatial inconsistency. Data shall be modeled in such a way that it can be digitized consistently throughout the entire coverage.

**Thematic and Attribute Consistency**
4.5. Make a clear distinction between user created fields and fields automatically maintained by the GIS software.

Whenever distinct, user-created fields for lengths or areas are included in a database, comparisons, explanations, or other explicit delineation shall be used to synchronize or otherwise identify differentiation between length/area field data automatically maintained by GIS software as compared to that developed by data creator/editor.

**Field Data Types**
5.1. Use the proper data type to store information. Dates shall be stored in date type fields, not text fields.

## 4.3. Metadata

Geodatabase design is not directly related to metadata.

## 4.4. Relation to Other Standards

Choices of database design and modeling directly affect spatial consistency, discussed in Chapter 11.

The choice of a projection is usually made during database design.

The GIS Data Subcommittee recommends that DWR develop standard data dictionaries (codesets) for spatial data, such as names and abbreviations of cities, counties and utilities.

# 5. Tables and Fields

Table and field names are important when developing a geodatabase. Good table names describe what information is stored in the table. Good field names are unambiguous and convey what information is stored in the field.

## 5.1. Standards

**Field Types**

5.1. Use the proper data type to store information. Dates shall be stored in date type fields, not text fields.

5.2. Store a single value in a field. For instance, do not store the entire address in a field. Instead, divide the address into its elemental parts: street address, city, state and zip code. Data validation and retrieval are more difficult when a single field contains compound values.

5.3. When calculating fields, use the field calculator or update queries to update calculated fields, rather than manual entering the data. The formula and the method used to update the calculated fields shall be documented in the metadata.

## 5.2. Metadata

Fields and table names are not directly related to metadata. These will be used when you design your tables and explain entities and attributes.

The domain values for fields, such as lists, abbreviations, lookup values from a list, reference to a data dictionary, or permissible ranges, shall be described in Section 5.1.2.4 of the metadata.

## 5.3. Relation to Other Standards

Table and field names use the naming conventions, discussed in Chapter 1.

# 6. Creation Methods

DWR generates its own spatial data, and acquires spatial data either from a contract or exchange with other organizations. Rarely are spatial data sets acquired and then edited.

## 6.1. Preparation

Here is a list of questions that should be considered before starting a new project. Reasoned and defensible answers to these questions will determine how various spatial data standards apply.

1. What is the purpose of the spatial data?
    a. An engineering product, such as a pipeline or a levee, or an elevation.
    b. A boundary, such as parcel data or survey quality data.
    c. An emergency response map, such as an area with landmark features.
    d. Other.
2. What will be the final product from this project?
    a. Hardcopy maps.
    b. Geodatabase.
        i. Enterprise geodatabase.
        ii. Personal geodatabase.
        iii. File geodatabase.
    c. Web services.
3. What projection will preserve the data?
    a. State Plane, used for parcel data.
    b. UTM, used for models.
    c. CA Teale Albers, used by emergency responders.
4. What is the type of data?
    a. Raster data used for images or other gridded data.
    b. Vector data used for points, lines, and polygons.
5. How will the data be managed?
    a. Enterprise data set, to which DWR spatial data standards apply.
    b. Program data set, to which DWR spatial data standards are only recommendations.
6. How will DWR spatial data standards apply? And, how will the creation method affect the ability of the dataset to meet those standards?
    a. Names
    b. Database Design
    c. Projection and Coordinate System

d. Positional Accuracy
e. Attribute Accuracy
f. Temporal Accuracy
g. Spatial Consistency
h. Thematic and Attribute Consistency
i. Logical Consistency
j. Accessibility
k. Data Maintenance
l. Edge matching
m. Holes in map or data
n. Data validation steps

7. There needs to be a QC plan and a QA plan
   Who will do the final review of the data?
   Who will complete the metadata?

Once the purpose of the spatial data is clear, then its accuracy can be known, and appropriate or inappropriate steps will be known for the creation method.

When creating a vector spatial data set, the first step in creating quality GIS databases is map preparation. Firmly locating the base map in the real world is critical for the accuracy of the data. Establishing coordinate control for the spatial data is the most important step in the data conversion process. Whether using benchmarks, corner tic marks or other surveyed locations, these must be visible and identifiable on the map source. Each control point shall be reviewed to make sure it has a known real world location.

## 6.2. Types of Data

There are two methods used to store spatial data: Raster and Vector.

**Raster Data**
Raster data stores imagery scanned maps or thematic gridded data. Raster data consists of a matrix or grid of cells, where each equally-sized cell stores a single value of information. The dimension of the matrix can be extended to store multiple bands of information (e.g. imagery), or may be a single band of information (thematic). The resolution of the raster data is specified by how large an area a single cell in the matrix or grid represents. The smaller the cell size, the finer the resolution.

Color imagery is comprised of 3 bands of information. “True color” imagery is produced if the information contained on the red, green, or blue bands represent amplitudes of electromagnetic energy from the respective visible-red, visible-green, and visible-blue wavelengths of the electromagnetic spectrum. “False color” imagery is produced if the information contained on the red, green, or blue bands represents any other

arrangement of the visible wavelengths, or if the information on any channel represents any other wavelength of the electromagnetic spectrum (e.g. ultraviolet, and infrared).

Thematic data is typically comprised of 1 band of information. Each cell in the grid represents a unique value pertaining to the theme of the data. A few examples of thematic raster-based data are digital elevation models (DEMs), temperature, vegetation type, land use, and precipitation.

**Vector Data**
Vector data stores points, lines or polygons. The topologies represent different geographic features.

Vector data is stored in a matrix, with x, y and sometimes z (elevation) linked to an attribute using various topologic rules.

Each of these methods has its own creation issues.

## 6.3. Raster Data Creation

Several methods exist with which to create raster data. A few methods by which raster data may be created are: remote sensing, analyzing imagery, approximation of mapped vector data, and derivation from other raster data.

### 6.3.1. Creation Methods with respect to Spatial Consistency

If possible, when creating raster data, a check should be done of registration marks. If there is a large root mean square error between the source data and the data being created, some corrective action needs to be taken before continuing.

The creator should also check the edges of the source data set and the data being created when applicable. The edges of the two data sets should coincide. If they do not, corrective action should be taken before continuing.

If spatial data is synthesized from multiple map sources, then there are bound to be conflicts between the original map data. These may include duplicated features, conflicting locations and/or attributes.

Raster data creation and editing methods affect spatial consistency. These include source constraints, logical constraints supporting spatial consistency, and edge-matching maximums and checks.

For enterprise data sets, aerial photography shall undergo orthocorrection.

Spatial data shall use a maximum error when edge-matching. Edge-matching errors should be minimized wherever possible. However, whatever the induced error, a maximum error tolerance threshold must be determined and recorded in the metadata.

Merging or mosaicking data from different data sources can be a significant and unique cause of spatial inconsistency. Cases may exist where a mosaic and/or merge may be employed on data which were created from source maps of different map scales or from different times. While this may be desirable from the standpoint of created so-called "seamless" data, it can compromise spatial consistency.

For example, if data from one county's road network is accurate to 1 meter, and from a second county's road network it is accurate to 5 meters, merging these data sources causes spatial inconsistency. Variable degrees of completeness can also affect spatial consistency. If data from one river basin risk of flood, but a second river basin's at-risk areas of lower accuracy are merged into the first, a dataset of low spatial consistency will result. Data from sources of different projections also needs to be handled with care for the same reason.

### 6.3.2. Creation Methods with respect to Thematic and Attribute Consistency

Data creation and/or editing shall use any available logical constraints. However, data shall only be created and/or edited only with logical constraints that apply equally throughout the entire coverage. While use of logical constraints can improve data quality and consistency, it can only achieve an improvement in consistency if the constraint itself is of a known, consistent quality.

## 6.4. Vector Data Creation

Vector data may be created by using a GPS (either for a single point or tracking a route), geocoding, digitizing from imagery, converting from other formats, or created from spatial analytical tools.

### 6.4.1. Creation Methods with respect to Spatial Consistency

Data shall be mapped at a scale appropriate to the source data. For example, if a map was created at a 1:24000 scale, on-screen digitizing shall use that same scale. If source orthophotography is created at a scale of 1:9600, features shall be digitized at that same scale.

Spatial data sets shall use appropriate vertex distance. The nominal vertex distance shall be determined prior to beginning of creation and/or editing. This distance shall be no smaller than that possible to create the smallest consistently discernable feature at mapping scale, and no larger than necessary to accurately capture accurate geometry at mapping scale.

Spatial data sets shall use a minimum mapping unit appropriate to the digitizing scale. The minimum size of a feature (minimum mapping unit) shall be related to the appropriate vertex interval in order to achieve accuracy and spatial distinction. For line feature type data, the minimum vertex interval and minimum mapping unit shall be equal. For polygon feature type data, the minimum mapping unit shall be no smaller than the smallest triangular area creatable by the minimum vertex interval.

Vertex, edge, and end snapping tolerances shall be set at all times while creating data. Tolerances shall be no less than the minimum vertex interval.

### 6.4.2. Creation Methods with respect to Thematic and Attribute Consistency

Spatial data sets shall use appropriate feature classes. Feature type (point, line, and polygon) shall be based on features only if that feature type can clearly be delineated as such throughout all of the data source (coverage) at mapping scale.

Data creation and/or editing shall use any available logical constraints. However, data shall be created and/or edited only with logical constraints that apply equally throughout the entire coverage. While use of logical constraints can improve data quality and consistency, it can only achieve a consistency improvement if the constraint itself is of a known, consistent quality itself. For example, if a rule is developed such as “levees shall not cross waterways” (or “new cable TV lines shall not cross gasoline pipelines”), it shall first be evaluated that waterway (or gasoline pipeline) data exists throughout the coverage, and that the constraint data are of a consistent-enough accuracy and completeness throughout the coverage to support use as a spatially consistent logical constraint.

## 6.5. Lineage

Lineage is important in understanding what you are looking at. Lineage refers to how the data was created, scrubbed and processed. To use and interpret the spatial data correct, people must know how the data was created, the accuracy and limitations of the instruments, all processing steps, and all QC procedures.

Some particular cases merit individual mention. These include:

- For a remotely sensed image, radiometric information is of utmost importance for correct utilization of the imagery.
- If data are collected from an aerial photograph, then a statement explaining the rectification process is highly recommended.
- If the raster has undergone multiple lossy compressions, then a report regarding the compression history is highly recommended.

If the spatial data set includes multiple layers or feature classes, then separate lineage documentation shall be included for each layer.

## 6.6. Standards

6.1. Spatial data creation and/or editing shall use any available logical constraints. However, data shall only be created and/or edited with logical constraints that apply equally throughout the entire coverage. For example, a logical constraint might be that a bridge completely crosses a river, and does not stop part of the way across the river.

6.2. When merging data, all of the possible factors affecting spatial consistency (including those mentioned here, or in the section on Spatial Consistency) should be considered and statistically evaluated. The data sets and statistical evaluation shall be described in the Lineage portion of the metadata.

6.3. When developing seamless datasets, use sources of comparable quality. Differences in the spatial variability between data sources shall be less than 10% of the map units. If the difference is greater than this, the spatial data shall be put in multiple data sets.

### 6.6.1. Raster Standards

6.4. Enterprise data created from imagery shall be mapped only from orthorectified imagery not raw photos, except for emergency response or legacy imagery.

6.5. Spatial data shall use a maximum error when edge-matching. This error shall be documented in the Attribute Accuracy section of the metadata.

### 6.6.2. Vector Standards

6.6. Spatial data shall be mapped at a scale appropriate to the source data.

6.7. Spatial data sets shall use feature types only if that type can be clearly delineated as such throughout the entire data source (coverage) at the mapping scale.

6.8. Spatial data sets determine the nominal vertex distance prior to beginning data creation or editing.

6.9. The nominal vertex distance shall be no smaller than that possible to create the smallest consistently discernable feature at mapping scale, and no larger than necessary to accurately capture geometry at mapping scale.

6.10. Spatial data creation and/or editing shall use vertex snapping at all times. Snapping tolerances shall be no less than the minimum vertex interval.

6.11. Spatial data sets shall use a minimum mapping unit appropriate to the digitizing scale. The minimum size of a feature (minimum mapping unit) shall be related to the appropriate vertex interval in order to achieve accuracy and spatial distinction.

## 6.7. Metadata

The type of spatial data created shall be described in Section 3 of the metadata.

Lineage shall be described in Section 2.5 of the metadata.

## 6.8. Relation to Other Standards

Raster and vector data have different completeness and consistency issues. See the spatial consistency, Chapter 11, and thematic and attribute consistency, Chapter 12.

# 7. Projection and Coordinate System

Will Patterson at the California Department of Fish and Game wrote a good explanation of different projection and coordinate systems used in California [Patterson, 2005]. The following section is taken from his discussion paper.

**B. Basic terminology**

A map projection transforms the three-dimensional shape of the earth onto a two-dimensional surface that can be printed on paper or viewed on a computer screen. There are many different kinds of map projections, each trying to preserve one or more real world properties such as area, shape, distance, and direction. No single projection preserves all these properties - some are focused on preserving particular properties while others may partially preserve multiple properties as a compromise projection.

A coordinate system provides a method of locating a position on the earth's surface using a particular unit of measure (which may be based on a projection). The terms coordinate system and projection are sometimes used interchangeably in GIS applications.

A horizontal datum is a set of parameters and control points used to define the shape of the earth. Datums provide a frame of reference for measuring locations, and may be determined for local, regional, or worldwide extents. There are also vertical datums that are used as references for elevation measurements. Within this document, the term datum refers to a horizontal datum.

**C. Datums commonly used in California**

The North American Datum of 1927 (NAD27) was defined through a series of ground control measurements with an origin point at Meades Ranch in Kansas. This datum has been historically used for many U.S. Geological Survey (USGS) maps. Since many GIS datasets have been digitized from USGS maps, NAD27 has remained a commonly used datum.

The North American Datum of 1983 (NAD83) was introduced as a replacement for NAD27 and has been officially adopted as the legal horizontal datum for the United States. It is an earth-centered datum based upon both ground control points and satellite observations. There are ongoing efforts to refine NAD83 for high-precision mapping and surveying purposes based on High Accuracy Reference Networks (HARNs - formerly called High Precision Geodetic Networks or HPGNs).

The World Geodetic System of 1984 (WGS84) is an earth-centered datum that was defined primarily for use with the Global Positioning System (GPS).

For general mapping purposes, WGS84 and NAD83 can be considered equivalent. For example, data collected in WGS84 can be treated as NAD83, unless you are trying to map locations more precisely than about 1 meter in accuracy.

The United States government has specified the North American Datum Conversion (NADCON) software as the Federal standard for converting between NAD27 and NAD83. This software is maintained by the National Geodetic Survey and is implemented in many GIS software programs.

**D. Projections and coordinate systems commonly used in California**

Geographic (Latitude/Longitude, Lat/Lon) is a worldwide coordinate system used on many maps and charts. It is technically not a projection, although it is often treated as one. Also referred to as "unprojected" or as the Global Reference System (GRS), this coordinate system is used in California by many organizations. Most GIS references to geographic coordinates assume the coordinate values (units of measure) are in decimal degrees, although other coordinate formats are also used. Longitude values may be indicated as negative since California resides in the Western Hemisphere (west of the Greenwich Prime Meridian) (Figure 1). Latitude values are positive as California is in the Northern Hemisphere (north of the Equator). It is important to remember that longitude is the X value and latitude is the Y value. Most GIS programs offer Geographic as a predefined option.

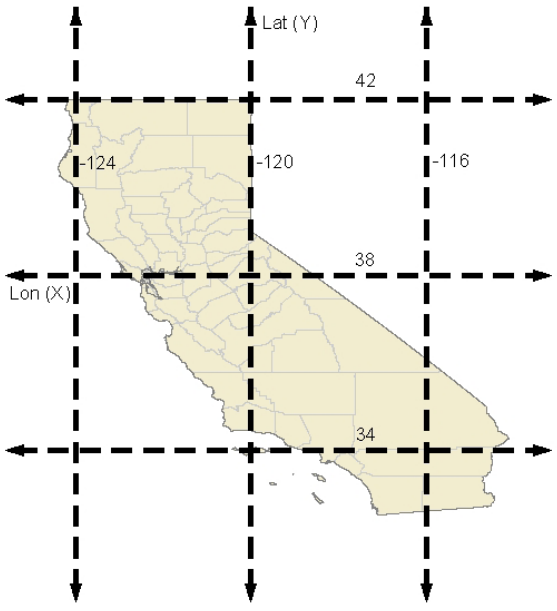


**Figure 1. Latitude and Longitude of California**

Geographic coordinates can be shown in several formats. Here are some examples:

| | |
|---|---|
| Decimal Degrees (DD) | -120.5 Longitude 38.7543 Latitude |
| Degrees Minutes Seconds (DMS) | -117 24 35 Longitude 33 45 53 Latitude |
| Degrees - Decimal Minutes | -123 50.459 Longitude 41 23.1 Latitude |
| Degrees - Minutes - Decimal Seconds | -118 10 40.35 Longitude 38 23 12.49 Latitude |

California Teale Albers (CTA) is an adaptation of the Albers Conical Equal Area projection as defined by the former State of California Teale Data Center GIS Solutions Group (Figure 2). It is a statewide projection that is optimized for area calculations, making it popular for organizations that map statewide resources. You may hear it referred to as “Teale Albers”, “California Albers”, or just “Albers” (be aware, however, that adaptations of the Albers projection exist for other areas). Coordinate values (units of measure) are in meters from the origin point of the projection (0,0) near the center of the state. The projection divides California into four quadrants.

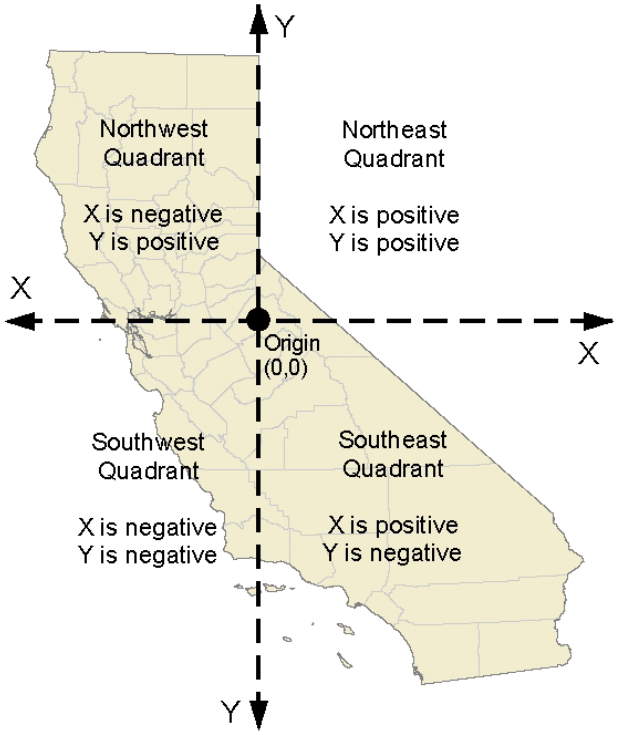


**Figure 2. California Teale Albers**

.

Here are the parameters:

| | |
|---|---|
| Projection | Albers |
| Units | Meters |
| 1st Standard Parallel | 34 |
| 2nd Standard Parallel | 40.5 |
| Longitude of Center of Projection (Central Meridian) | -120 |
| Latitude of Origin of Projection | 0 |
| False Easting | 0 |
| False Northing | -4000000 |
| X shift | 0 |
| Y shift | 0 |
| Spheroid / Datum | GRS80 / NAD83 or Clarke 1866 / NAD27 |

Because it is unique to California, some GIS software programs may not offer it as a predefined option.

Universal Transverse Mercator (UTM) is a worldwide coordinate system based on the Transverse Mercator projection. In this system, the globe (excluding polar regions) is divided into 60 zones with each zone covering six degrees of longitude. California is covered by UTM zones 10 and 11, with the boundary between the zones at -120 degrees longitude through the middle of the state (Figure 3). Coordinate values (units of measure) are in meters. For GIS projects, you can generally only work in one UTM zone at a time, making this coordinate system less favorable for California statewide data. Many GIS software programs offer UTM as a predefined option.


**Figure 3. UTM Zones of California**

A few organizations in California use the Transverse Mercator projection with custom parameters that do not follow the UTM convention (may be called “UTM Zone 10.5”). The Department of Water Resources and the Bureau of Land Management have both used this option, each implementing slightly different projection parameters.

State Plane Coordinate System (SPCS), also known as the California Coordinate System (CCS), is commonly used by surveying professionals and within local municipalities (cities, counties, regional governments). The California SPCS has 7 zones in NAD27 (Figure 4) and 6 zones in NAD83 (Figure 5), with Los Angeles County as the unique Zone 7 in NAD27. Coordinate values (units of measure) are U.S. Survey Feet in NAD27 and meters or U.S. Survey Feet in NAD83. For GIS projects, you can generally only work in one State Plane zone at a time, making this coordinate system less favorable for data covering large areas. Many GIS software programs offer State Plane as a predefined option.


**Figure 4. State Planes Zones in California in NAD27**


**Figure 5. State Planes Zones in California in NAD83**

## 7.1. Projection with respect to Spatial Consistency

The projection is typically selected during database design. The accuracy of the spatial features degrades if features are stored out of a projection's appropriate spatial extent. Also, if the areal extent of the dataset crosses projection boundaries, the horizontal accuracy will be variable. The projection shall be selected so that the spatial inconsistencies and horizontal inaccuracies are minimized.

## 7.2. Standards

**Projection**

7.1. DWR endorses six projection standards for vector and imagery data:

1. Latitude and Longitude (unprojected)
2. UTM 10
3. UTM 11
4. "UTM 10.5" or the "California UTM"
5. California Teale-Albers Equal-Area Projection
6. California State Plane in NAD83

Different professions use different projections. Land and Water Scientists and Environmental Scientists use UTM (all the variants listed). Engineers use the California State Plane projection in NAD83. It would be unreasonable to standardize on a single projection for every spatial data set in DWR.

**Datums**

7.2. DWR endorses NAD83 as the horizontal datum. California Public Resource Code, Section 8852, states

> 8852. The official geodetic datum to which horizontal positions and ellipsoid heights are referenced within the State of California shall be **NAD83**.

7.3. DWR endorses NAVD88 as the vertical datum. California Public Resource Code, Section 8853, states

> 8853. The official geodetic datum to which orthometric heights are referenced within the State of California shall be NAVD88.

7.4. Legacy data that does not use the appropriate projections and/or datum may be left in its original conditions. Spatial data that will continue to be used and updated, or will be extended, shall be converted to an appropriate projection and/or datum, as applicable.

## 7.3. Metadata

The bounding coordinates for the spatial data shall be described in Section 1.5 of the metadata.

The spatial reference information, including projections, datums, resolution and units, shall be described in Section 4 of the metadata.

## 7.4. Relation to Other Standards

The projection and coordinate is important when creating spatial data.

Legacy data is a special case. Static legacy data can remain as it is, using whatever coordinate system. Legacy data that continues to be updated and used will have to be converted to an enterprise standard.

# 8. Positional Accuracy

Accuracy is the degree to which information on a map or in a database matches actual, true or accepted values. The difference between the recorded and actual value is defined as the error.

For spatial data that has been created from digital imagery or scanned maps, the error for determining positional accuracy can be attributed to many sources. The total error can be thought of as:

Total Error = Error from flattening
+ Projection or datum error from accuracy of measurement on earth
+ Error from cartographic interpretation of physical features
+ Drafting error
+ Conversion error from analog to digital
+ Error of media stability
+ Digital processing error (accuracy of cursor placement)
+ Error from registration tic marks
+ Coordinate rounding error (machine precision)
+ Other errors (such as operator error)

When you calculate positional accuracy, you are calculating the total error for the spatial data.

DWR endorses positional accuracy standards and methods set by Federal Geographic Data Committee, the Subcommittee for Base Cartographic Data; and described in Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy (NSSDA) (FGDC-STD-007.3-1998).

There are two types of positional accuracy:
Horizontal
Vertical
One or both of these types of accuracy may apply to a data set.

The NSSDA standard is a 95% confidence level in the reported spatial information. So 95% of the positional information will have a ground position that is equal to or smaller than the reported accuracy. The reported accuracy is calculated using root mean-square error (RMSE) and an independent data set more accurate than the one being tested. The reported accuracy value reflects all uncertainties, including those introduced by geodetic control coordinates, compilation, and final computation of ground coordinate values in the product.

## 8.1. Testing for Positional Accuracy of a Single Data Set

This section is shamelessly taken from State of Minnesota's Planning and Land Management Information Center, Positional Accuracy Handbook (2000) based on the FGDC standard.

To comply with the NSSDA, a data custodian conducts a statistical test using the following steps:

1. Determine if the test involves horizontal accuracy, vertical accuracy or both.
2. Select a set of test points from the data set being evaluated.
3. Select an independent data set of higher accuracy that corresponds to the data being tested.
4. Collect measurements from identical points from each of those two sources.
5. Calculate a positional accuracy statistic using either the horizontal or vertical accuracy statistic worksheet.
6. Prepare an accuracy statement in a standardized report form.
7. Include that report in a comprehensive description of the data set metadata.

**1. Determining Which Test To Use.**

Identify the spatial characteristics of the data set being tested. Is the x,y accuracy being evaluated, or is the elevation (z component) accuracy also included? For each applicable spatial component, you will have to calculate an accuracy statistic.

**2. Selecting Test Points.**

A data set's positional accuracy is tested by comparing the coordinates of several points within the data set to the coordinates of the same points from an independent data set of greater accuracy. Points used for this comparison must be well-defined. They must be easy to find and measure in both the data set being tested and in the independent data set.

For data derived from maps at a scale of 1:5,000 or smaller, points found at right-angle intersections of linear features work well. These could be right-angle intersections of roads, railroads, canals, ditches, trails, fences and pipelines. For data derived from maps at scales larger than 1:5,000 — plats or property maps, for example — features like utility access covers, intersections of sidewalks, curbs or gutters make suitable test points. For survey data sets, survey monuments or other well-marked survey points provide excellent test points.

Twenty or more test points are required to conduct a statistically significant accuracy evaluation regardless of the size of the data set or area of coverage. Twenty points make a computation at the 95 percent confidence level reasonable. **The 95 percent confidence**

**level means that when *at least* 20 points are tested, it is acceptable that one point may exceed the computed accuracy** (emphasis added).

If fewer than 20 test points are available to be tested, the Federal Geographic Data Committee Spatial Data Transfer Standard is applicable. That standard can be found at
http://mcmcweb.er.usgs.gov/sdts/

### 3. Selecting an Independent Data Set.

The independent data set must be acquired separately from the data set being tested. It should be of the highest accuracy available. In general, the independent data set should be three times more accurate than the expected accuracy of the test data set. Unfortunately, this is not always possible or practical. If an independent data set that meets this criterion cannot be found, a data set of the highest accuracy feasible should be used. The accuracy of the independent data set should always be reported in the metadata.

The areal extent of the independent data set should approximate that of the original data set. When the tested data set covers a rectangular area and is believed to be uniformly accurate, an ideal distribution of test points allows for at least 20 percent to be located in each quadrant (see Figure 6). Test points should be spaced at intervals of at least 10 percent of the diagonal distance across the rectangular data set; the test points shown in Figure 7 comply with both these conditions.

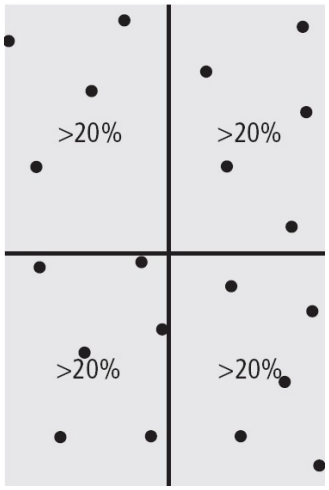


**Figure 6**

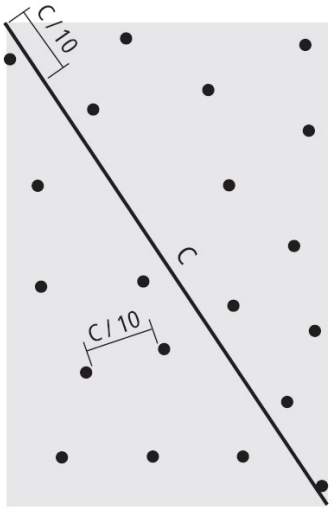


**Figure 7**

It is not always possible to find test points that are evenly distributed. When an independent data set covers only a portion of a tested data set, it can still be used to test the accuracy of the overlapping area. The goal in selecting an independent data set is to try to achieve a balance between one that is more accurate than the data set being tested and one which covers the same region.

Independent data sets can come from a variety of sources. It is most convenient to use a data set that already exists, however, an entirely new data set may have to be created to serve as control for the data set being tested. In all cases, the independent and test data sets must have common points. Always report the specific characteristics of the independent data set, including its origin, in the metadata.

**4. Recording Measurement Values.**

The next step is to collect test point coordinate values from both the test data set and the independent data set. When collecting these numbers, it is important to record them in an appropriate and similar numeric format. For example, if testing a digital database with an expected accuracy of about 10 meters, it would be overkill to record the coordinate values to the sixth decimal place; the nearest meter would be adequate. Use similar common sense when recording the computed accuracy statistic.

**5. Calculating the Accuracy Statistic.**

Once the coordinate values for each test point from the test data set and the independent data set have been determined, the positional accuracy statistic can be computed using the accuracy statistic worksheet in the DWR Spatial Accuracy Calculation workbook.

There are three possible cases:

Horizontal Accuracy. The Root Mean Square Error for x is approximately equal to the Root Mean Square Error for y. The accuracy is 1.7308 * combined Root Mean Square Error for x and y.

Horizontal Accuracy. The Root Mean Square Error for x is not equal to the Root Mean Square Error for y, and the ratio of the smallest value to the largest value is greater than 0.6. The accuracy is 1.22385 * ( Root Mean Square Error for x + Root Mean Square Error for y)

Vertical Accuracy. The accuracy is the 1.9600 * Root Mean Square Error for z.

The workbook will determine which formula is appropriate and calculate it. If the ratio of the smallest to largest root mean square error is less than 0.6, then the workbook will display an error message. In this case, the errors are not normally distributed, and none of the formulae are applicable.

The workbook will calculate both horizontal and vertical accuracies.

A sample calculation is presented in Appendix C.

**6. Preparing an Accuracy Statement.**

Once the positional accuracy of a test data set has been determined, it is important to report that value in a consistent and meaningful way. To do this one of two reporting statements can be used:

Tested _____ (meters, feet) (horizontal, vertical) accuracy at 95% confidence level

Compiled to meet _____ (meters, feet) (horizontal, vertical) accuracy at 95% confidence level

A data set's accuracy is reported with the tested statement when its accuracy was determined by comparison with an independent data set of greater accuracy as described in steps 2 through 5. For example, if after comparing horizontal test data points against those of an independent data set, the NSSDA statistic is calculated to be 34.8 feet, the proper form for the positional accuracy report is:

**Positional Accuracy: Tested 34.8 feet horizontal accuracy at 95% confidence level**

This means that a user of this data set can be confident that the horizontal position of a well-defined feature will be within 34.8 feet of its true location, as best as its true location has been determined, 95 percent of the time. When the method of compiling data has been thoroughly tested and that method produces a consistent accuracy statistic, the compiled to meet reporting statement can be used. Expanding on the same example, suppose the method of data collection consistently yields a positional accuracy statistic that was no worse — that is, no less accurate — than 34.8 feet for eight data sets tested. It would be appropriate to skip the testing process for data set nine, and assume that its accuracy is consistent with previously tested data. Report this condition using the following format:

**Positional Accuracy: Compiled to meet 34.8 feet horizontal accuracy at 95% confidence level**

To appropriately use the compiled to meet reporting statement, it is imperative that the data set compilation method consists of standard, well-documented, repeatable procedures. It is also important that several data sets be produced and tested. Finally, the NSSDA statistics computed in each test must be consistent. Once all these criteria are met, future data sets compiled by the same method do not have to be tested. The largest — or worst case — NSSDA statistic from all tests is always reported in the compiled to meet statement.

### 7. Including the Accuracy Report in Metadata.

The final step is to report the positional accuracy in a complete description of the data set. Often described as data about data, metadata lists the content, quality, condition, history and other characteristics of a data set.

To report the positional accuracy of a data set, complete the appropriate field in section 2 of the metadata guidelines (see figures 6 and 7). The horizontal and vertical positional accuracy reports are free text fields and can be filled out the same way. Write the entire

accuracy report statement followed by an explanation of how the accuracy value was determined and any useful characteristics of the independent data set.

Potential users of the data set might find this type of additional information useful.

### 8.1.1. Testing for Positional Accuracy for Multiple Data Sets

A dataset may contain themes or geographic areas that have different accuracies. The guidelines for reporting accuracy of a composite dataset are:

If data of varying accuracies can be identified separately in a dataset, compute and report separate accuracy values.

If data of varying accuracies are composited and cannot be separately identified AND the dataset is tested, report the accuracy value for the composited data.

If a composited dataset is not tested, report the accuracy value for the least accurate dataset component.

## 8.2. Standards

8.1. DWR endorses calculating the positional accuracy in compliance with the National Standard for Spatial Data Accuracy.

8.2. When creating a composite data set, calculate the positional accuracy for each source data set; and the composite data set.

## 8.3. Metadata

The NSSDA statistic should be placed in field 2.4.1.2.1 for horizontal accuracy and in field 2.4.2.2.1 for vertical accuracy. The text string “National Standard for Spatial Data Accuracy” should be entered in field 2.4.1.2.2 for horizontal accuracy and in field 2.4.2.2.2 for vertical explanations.

An explanation of how the accuracy value was determined can be included in the horizontal positional accuracy report fields: 2.4.1.1 for horizontal accuracy and 2.4.2.1 for vertical accuracy.

## 8.4. Relation to Other Standards

Positional accuracy is part of a larger metric for accuracy for spatial data. This metric includes attribute accuracy, Chapter 9, and temporal accuracy, Chapter 10.

# 9. Attribute Accuracy

Attribute accuracy is the agreement between the recorded and actual value. An error occurs because an object was misclassified. There are many ways to calculate accuracy, and no single way to quantify the accuracy for all attributes in all cases.

The data custodian will have to select a reasonable measure to quantify the attribute accuracy based on the type of data collected (raster vs. vector), reference information for comparison, if any, and how the data is entered into the geodatabase.

Methods to quantify the attribute accuracy include, but are not limited to:

1. Error table. An error table is a matrix showing all possible true values and all actual database values in rows and columns, and the frequency of each combination in each cell. A sample error matrix is presented in Table 2.

**Table 2. Sample Error Table**

| **Actual Class** | **Assigned Class** | | | | |
|---|---|---|---|---|---|
| | Cherry | Oak | Redwood | Willow | Total |
| Cherry | 85 | 10 | 3 | 2 | 100 |
| Oak | 4 | 985 | 2 | 9 | 1,000 |
| Redwood | 3 | 0 | 2 | 0 | 5 |
| Willow | 2 | 4 | 0 | 44 | 50 |
| Total | 94 | 999 | 7 | 55 | 1,155 |

The attribute accuracy is the portion of objects that were correctly assigned. The objects correctly classified is the sum of the diagonal cells is (85 + 985 + 2+ 44) = 1,116. The total number of objects is 1,155. The proportion of objects that were correctly classified is (1,116/1,155), or 96.6%.

2. Simple statistical values, including standard deviation, mean error (or total error), skewness or root mean square error.

3. Advanced statistical values, such as maximum likelihood estimator, Cohen's kappa coefficient, kriging, multi-Gaussian modeling, or simulated annealing.

In addition, the statistical values above can be supplemented with confidence intervals (ranges), percentile or proportions. These are not, in and of themselves, sufficient statistical measures of attribute accuracy for the metadata.

## 9.1. Standards

9.1. All attributes in all tables (except definition tables) shall be tested for accuracy using ANSI standards for testing, provided in Appendix F.

9.2. The attribute accuracy shall be quantified for all attributes.

9.3. The method used to quantify the accuracy shall be documented in the metadata.

## 9.2. Metadata

The attribute accuracy shall be described in Section 5.1.2.7 of the metadata.

The quantified accuracy value shall be reported in Section 5.1.2.7.1 of the metadata.

An explanation of the method used to quantify the accuracy, and any supplemental information, shall be reported in Section 5.1.2.7.2 of the metadata.

## 9.3. Relation to Other Standards

Attribute accuracy is part of a larger metric for accuracy, for spatial data. This group includes positional accuracy, Chapter 8, and temporal accuracy, Chapter 10.

# 10. Temporal Accuracy

Temporal accuracy defined by DWR is the same as currentness. Currentness is the time and/or date to which the data applies, and is just as important to potential users as positional accuracy or thematic accuracy. For this reason, DWR requires the field "Date Data Applies To" to be added and populated to geodatabases for spatial data.

Temporary accuracy is defined by some as the agreement between the recorded and 'actual' time; and not as currentness. Conceptually this is great, but there is no metric for measuring this difference between the "real" time of the event and the time recorded.

## 10.1. Standards

10.1. Currentness shall be described for the appropriate records in the appropriate tables, using the field: "Date Data Applies To."

## 10.2. Metadata

The temporal accuracy (currentness) shall be described in Section 1.3.1 of the metadata.

## 10.3. Relation to Other Standards

Temporal accuracy is part of a larger metric for accuracy, for spatial data. This group includes positional accuracy, Chapter 8, and attribute accuracy, Chapter 9.

# 11. Spatial Consistency

Consistency is another measure of the quality of data. Spatial consistency refers to how similar the data absolute and relative accuracies are for all spatial features in the database throughout a coverage, to what degree data models real world features are similar, and to how well it complies with topological rules. Consistency is also a measure of the internal validity of a database. If a database has similar spatial qualities throughout a coverage, it can be said to have spatial consistency.

Spatial consistency can suffer due to various causes. Poor or inconsistent quality of source/input data (such as data from multiple sources), inconsistent map scales, or data derived from where geodetic control quality that is not equivalent throughout a coverage results in inconsistency. Selection of the wrong data creation/editing methodology (e.g. inappropriate scale for a specified minimum mapping unit, incorrect snapping rules, wrong topological rules) can cause inconsistency. Edge-matching errors lead to variable accuracy throughout a coverage where the areal extent is larger than individual source tiles. The data model itself can lead to spatial inconsistency if the designed data model is itself inappropriate for the features to be mapped. And, of course, even without the causes just listed, inconsistent creation/editing technique (due to human error, different analysts doing it their own way, eyestrain due to fatigue, etc.) results in spatial inconsistency.

## 11.1. Relation to Other Processes

Consistency is an issue that is affected by many processes, including data design, projection, and creation methods. Methods to characterize and improve the spatial consistency are described in the remainder of this section. When consistency issues are found, evaluations described in the related sections shall be performed; and the evaluation and results shall be described in the metadata.

### 11.1.1. Relationship to Data Design and Modeling

Database design as related to spatial consistency is discussed in Chapter 4.1.1. Data shall be modeled in such a way that it can be digitized consistently throughout the entire coverage.

### 11.1.2. Relationship to Projection

Projection as related to spatial consistency is discussed in Chapter 7.1. The projection shall be selected so that the spatial inconsistencies and horizontal accuracies are minimized.

### 11.1.3. Relationship to Creation Methods

Data creation and editing methods affect spatial consistency. These include source constraints, use of appropriate scale, minimum mapping units, creation and editing rules, logical constraints supporting spatial consistency, edge-matching maximums and checks, and topology. All except topology are discussed in Chapter 6. Topology is discussed later in this section.

### 11.1.4. Relationship to Mosaicking

Merging or mosaicking data from different data sources can be a significant, unique cause of spatial inconsistency. Cases may exist where mosaic/merge may be employed on data which were created from source maps of different map scales or from different times. While this may be desirable from the standpoint of created so-called "seamless" data, it can compromise spatial consistency. This is discussed in Chapter 6.

## 11.2. Topology

You do not have to use topology, but if you do you should use it consistently.

Topology rules define the permissible spatial relationships (typically concerning adjacency, connectivity, area definition, and structure) between different features in the data set. Topology defines how point, line, and polygon features share coincident geometry (for example, street centerlines and census blocks share common geometry, and adjacent soil polygons share their common boundaries); defines and enforces data integrity rules (for example, there should be no gaps between polygons); supports spatial relationship queries and navigation (for example, navigating to adjacent or connecting features), and supports spatial editing tools. The rules you define for a topology control the relationships between features within a feature class, between features in different feature classes, or between subtypes of features.

The general topology rules for polygons, lines and points are defined in Appendix D. Appendix D has 10 rules for polygons, 13 rules for lines, and 4 rules for points.

You should think carefully when selecting which topological rules to follow. Not all topological rules may apply to an individual data set. For example, whereas in a parcel database the advantages of adjacent polygons having shared boundaries may be clear, in a database of trees in a forest, where adjacent trees may have overlapping canopies, adjacency rules could actually decrease the accuracy and spatial consistency of a database. Use Checklist in Appendix E to document the topology rules for an individual data set, conformance with each rule, and that the dataset meets acceptable spatial consistency standards pertaining to topology.

To test each applicable rule, use the sampling process described in Appendix F (based on ANSI/ASQC Standard Z1.4 for Sampling Plans). Each rule and the results of testing should be documented.

**Merging and Mosaicking**
For example, if data from one county's road network is accurate to 1 meter, and from a second county's road network it is accurate to 5 meters, merging these data sources causes spatial inconsistency. Variable degrees of completeness can also impact spatial consistency. If data from one river basin risk of flood, but a second river basin's at-risk areas of lower accuracy are merged into the first, a dataset of low spatial consistency will result.

Data from sources of different projections may also cause spatial inconsistency, and need to be handled with care for the same reason.

## 11.3. Standards

**Spatial Consistency with respect to Data Design**
4.4 Data design and models shall not cause spatial inconsistency. Data shall be modeled in such a way that it can be digitized consistently throughout the entire coverage

**Spatial Consistency with respect to Creation Methods**
6.1. Spatial data shall be mapped at a scale appropriate to the source data.

6.2. Enterprise data created from imagery shall be mapped only from orthorectified imagery.

6.3. Spatial data sets shall use feature types only if that type can be clearly delineated as such throughout the entire data source (coverage) at the mapping scale.

6.4. Spatial data sets determine the nominal vertex distance prior to beginning data creation or editing.

6.5. The nominal vertex distance prior shall be no smaller than that possible to create the smallest consistently discernable feature at mapping scale, and no larger than necessary to accurately capture accurate geometry at mapping scale.

6.6. Spatial data sets shall use a minimum mapping unit appropriate to the digitizing scale. The minimum size of a feature (minimum mapping unit) shall be related to the appropriate vertex interval in order to achieve accuracy and spatial distinction.

6.7. Spatial data creation and/or editing shall use vertex snapping at all times. Snapping tolerances shall be no less than the minimum vertex interval.

6.8. Spatial data creation and/or editing shall use any available logical constraints. However, data shall be created and/or edited only with logical constraints that apply equally throughout the entire coverage.

6.9. Spatial data shall use a maximum error when edge-matching. This error shall be documented in the Attribute Accuracy section of the metadata.

6.10. When merging data, all of the possible factors affecting spatial consistency (including those mentioned here, or in the chapter on Creation Methods), should be considered and statistically evaluated. The data sets and statistical evaluation shall be described in the Lineage portion of the metadata.

6.11. When developing seamless datasets, use sources of comparable quality. Differences in the spatial variability between data sources shall be less than 10%. If the difference is greater than this, the spatial data shall be put in multiple data sets.

**Spatial Consistency with respect to Projection**

7.5 The projection shall be selected so that the spatial inconsistencies and horizontal accuracies are minimized.

**Topology**

11.1. Spatial consistency can only be ensured if topology tools are used in a consistent manner. Whenever possible and appropriate, data shall be created/edited using topological tools to define topological relationships to other features within the subject feature dataset or to other feature classes.

11.2. DWR endorses the standard that each topology rule that is applicable to the spatial data set shall be 99% consistent. Use the checklist in Appendix E to document the topology rules for an individual data set, conformance with each rule, and that the dataset meets acceptable spatial consistency standards pertaining to topology. Use the process in Appendix F to determine the number of samples appropriate for the population, test the conformance to an individual rule with an acceptable quality limit of 99%.

## 11.4. Metadata

Section 3.3 of the metadata is optional. However, to successfully complete stratified random sampling of the topological rules, you will need to know the number of point and vector objects in your spatial data set.

Results of the quality assurance and quality control for spatial consistency, including the Checklist for Spatial Consistency, Appendix E, shall be discussed in the metadata. It is considered good practice to make qualitative notes if spatial consistency in the

database suffers in any way, and to explain potential causes, and to discuss any known impacts of poor spatial consistency on uses of the data.

Spatial consistency may be reported in one of two places:

- Section 2.2 (Logical Consistency) of the Metadata
- Section 2.3, the Completeness Report

## 11.5. Relation to Other Standards

Spatial consistency is supported by good database design, selection of an appropriate creation method, adherence to the techniques defined by the creation method, and to projections and coordinate system.

Spatial consistency is part of a larger metric of consistency for spatial data. This group includes thematic and attribute consistency, Chapter 12, and logical consistency, Chapter 13.

Spatial consistency is related to the positional accuracy of the dataset.

# 12. Thematic and Attribute Consistency

Thematic and attribute consistency refers to the degree to which the data represents the data theme in a constant manner, and that there is a lack of contradictions in redundant thematic attributes. Thematic and attribute consistency refers to how consistently theme features represent real-world features, among attribute values within a given specific field, or for how consistently data are represented from among different fields. For example, thematic attribute consistency considers how often oaks get classified as oaks compared to how consistently bulrushes get classified as bulrushes. Or, if attribute values for population, area, and population density are stored, then the stored values must agree with the calculated value. DWR Spatial Data Standards for thematic and attribute consistency will not refer to consistency of feature representation between data from different themes (sometimes called “cross-theme consistency”).

Data consistency can be related to accuracy, but it is not the same concept, and therefore has its own distinct set of applicable standards. Thematic and attribute consistency is not necessarily about whether or not the data are accurate. Instead, it is more about the degree to which errors are consistent. Moreover, consistency embodies the quality to which the database itself possesses internal validity. It is therefore best thought of as an internal quality, as a comparative measure among values within a database.

There are several causes of thematic and attribute inconsistency which are important to understand in order to best understand the spatial data standard and for how to comply with it. Some of them are the same causes to problems of accuracy or spatial consistency. Differential positional error or differing scale in source data can lead to thematic inconsistency. Variation in source data creation methods or database schema may cause thematic or attribute inconsistency. Combination effects by using data that may seem identical but where in fact the data dictionaries vary in different spatial coverages can be a major cause of inconsistency. A classic example of combination effects is NRCS soils data. NRCS SSURGO data are coded with an ID value (“MUID”) on a county-by-county basis, and a multitude of related tables use this county-conditional MUID for all of the database values to relate to. So, the MUID value “1045” may mean a certain type of sandy soil in one county, but MUID “1045” could refer to gravel in the adjacent county. Combining inappropriate datasets together where the data may seem to represent something identical but where in fact they are not is a common cause of thematic or attribute inconsistency. Data that are created from imagery where cloud or forest cover varies affects the ability to use the source imagery in a consistent manner for classification purposes. And, as always, human error can contribute to inconsistency.

Consistency is an issue that is affected by many processes, including data design, projection, and creation methods. Methods and standards to reduce thematic and attribute inconsistency are described in the remainder of this section. When

consistency issues are found, evaluations described the related sections shall be performed; and the evaluation and results shall be described in the metadata.

## 12.1. Standards

12.1. DWR endorses thematic and attribute consistency, and requires that all contradictions be removed before a spatial data set is promoted to enterprise status.

**Source Data Management**
A critical component of the thematic and attribute data standards is how source data are used when generating new data or in merging data together to form new data. To avoid consistency issues, then, the following standards shall apply:

12.2. **Imagery Cloud Cover**. Excepting imagery in support of emergency response or climate modeling purposes, derivative vector datasets shall use imagery with cloud cover not in excess of 5%.

12.3. **Visual Obstructions.** Where mapping of features directly on the Earth's surface with the intent to be free of overhead visual obstruction (such as forest canopy, bridges, etc.), the total coverage of obstructed surface area shall not exceed 10%.

This standard does not apply when mapping forests, urban areas, or features not directly on the ground.

12.4. **Nadir.** The angle that imagery is captured shall be specified in the metadata. If the data is orthorectified, that process shall be included as one of the process steps of the lineage in the metadata.

12.5. **Imagery Acquisition Dates.** Where mapping from imagery, and where multiple imagery datasets serve as sources, all source imagery shall absolutely be from within same decade. It is strongly recommended to be from the same year, and ideally will be from within the same season.

12.6. **Source Positional Accuracy**. Where mapping with data from multiple sources, accuracy is encouraged, but not required, to be within 20% of highest quality input (as determined by horizontal root mean square-error for positional accuracy) for all input datasets. Product data accuracy shall be cited as poorest accuracy of source input datasets, or as determined by QA/QC, whichever is worse.

**Database Design**
5.1. Use the proper data type to store information. Dates shall be stored in date type fields, not text fields.

13.8 **Use of Domains**. 12.7. Wherever possible, attributes values are defined in the appropriate definition (look-up) table, inclusive of their logical range or described in the appropriate data dictionary (codesets).

12.8. **Area and Length Consistency**. Whenever distinct, user-created fields for lengths or areas are included in a database, comparisons, explanations, or other explicit delineation shall be used to synchronize or otherwise identify differentiation between length/area field data automatically maintained by GIS software as compared to that developed by data creator/editor.

**Data Creation and Editing Practices**

12.9. **Use of Software Tools to Minimize Human Error**. Automated tools to populate databases shall be used whenever possible. For example, if a subset of records is to have a common value applied, the ESRI Field Calculator shall be used to create and/or update the subset of records, rather than manual line-by-line data entry.

12.10. **Spatial Joins Consistency**. When conducting spatial joins, each set of record updates or additions shall be reviewed for spatial accuracy.

The quality control review of the spatial join process shall include at least a unique spatial consistency assessment and an individual classification error analysis for the data in each spatially-joined field to be performed subsequent to the spatial join.

If consistency errors occur, the error analysis may be used to assess consistency of subsets of the data, by applying the test to subsets of the data according to issue. For example, if data of different sources are used, apply the test to each of the input areas/domains.

12.11. **Merge/Mosaic Consistency**. Prior to merging/mosaicking data for composite spatial coverage, review of techniques, attribute values and data dictionaries shall be undertaken and evaluated to potential problems with attribute consistency of the composite data set.

Results of this evaluation shall be included in metadata, even if no potential problems are identified. If the evaluation suggests potential attribute consistency issues with the composite data set, then a tabular crosswalk table shall be developed by creator/editor and also included with metadata.

When two or more data sets are combined, then the attribute values have to be combined into a single, consistent set of values. This may require adding a field to each data set to preserve the original value, and record a new, consistent attribute value.

When two or more tables are joined, the thematic and attribute consistency for the composite data set shall be checked, and the metadata updated.

**Quality Control Processes**

12.12. **Symbolization Test.** All attributes shall be tested through a qualitative visual inspection that at least includes symbolizing each field according to either a, classified, or graduated symbologies. Gridding the data according to each field should also be used, as appropriate, to easily identify whether inconsistencies exist.

12.13. **Unique Values Check.** Tests shall be run to indicate each field's unique values; specifically whether values are out of range, simple data entry errors exist, entries are misspelled, and whether codesets are satisfactorily represented by the documented data dictionary.

12.14. **Statistical Checks.** Statistical checks that affect consistency should include at least standard deviation and geographic skew of database values for all fields related to geometry.

The mean is defined as

$$\mu = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{1}$$

The standard deviation is defined as

$$\sigma = \sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(x_i - \mu)^2} \tag{2}$$

The skew is defined as

$$\gamma = \frac{\sqrt{n(n-1)}}{(n-2)} \frac{\frac{1}{n}\sum(x_i - \mu)^3}{\left(\frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)^2\right)^{3/2}} \tag{3}$$

When calculated for geometry fields in a spatial data set, this is referred to as the geographic skew.

**Documentation**

12.15. Any known consistency issue shall be documented in the metadata. Results or statistical assessments should be included. A statement about overall and field-specific attribute consistency should be included as part of the overall documentation, along with any known usage restrictions a consistency issue could present.

## 12.2. Metadata

Thematic and entity accuracy are documented in Section 2.1 (Attribute Accuracy), Section 2.2 (Logical Consistency), Section 2.3 (Completeness), and Section 2.5 (Lineage) of the metadata. The Checklist for Thematic and Attribute Accuracy, Appendix G, shall be included in Section 2.1.1 of the metadata.

## 12.3. Relation to Other Standards

The GIS Data Subcommittee recommends that DWR develop standard data dictionaries.

Thematic and attribute consistency is part of a larger metric of consistency for spatial data. This group includes spatial consistency, Chapter 11, and logical consistency, Chapter 13.

# 13. Logical Consistency

Logical consistency describes the validity ranges of values occurring in the data set and can occur in spatial, thematic, and temporal parameters.

## 13.1. Standards

13.1. DWR endorses logical consistency, and requires that contradictions be removed before a spatial data set is promoted to enterprise status. All appropriate tables shall be checked for logical consistency.

13.2. All folder names, table names, field names, and field values shall be checked for spelling. This can be done loading tables into Excel, replacing underscores with spaces, and checking the spelling.

**General Consistency**

13.3. All composite data shall be compared to the source data for obvious omissions.

13.4. All table joins shall be checked that the relationship can be properly used.

13.5. All tables shall be checked to ensure there are no duplicate records.

13.6. All hyperlinks shall be root-relative paths or absolute paths, not relative paths using a dot notation.

13.7. All file system links shall use universal naming convention(UNC), not mapped lettered drives.

13.8. IDs and codes shall be used properly.

13.9. Wherever possible, attribute values are defined in the appropriate definition (look-up) table, inclusive of their logical range or described in the appropriate data dictionary (codesets).

13.10. Units of measure shall be included where appropriate.

13.11. Units of measure shall be metric, except as appropriate due to widely-used professional practice.

13.12. Physical values shall be greater than or equal to zero, when appropriate. For example, mass and precipitation should not be less than zero.

13.13. If applicable, stored results of calculations shall be consistent with calculated values.

No more than 1% of the records shall have differences between the calculated and stored values.

Relative differences between stored and calculated values shall be minimized.

13.14. Significant figures shall be properly applied to stored calculations.

**Date and Time Consistency**

13.15. Dates shall be in date format (ISO Standard 8601) and not text format, unless an explanation is provided in the metadata.

13.16. Minutes and seconds shall be greater than or equal to zero, and less than or equal to sixty.

13.17. Hours shall be greater than or equal to zero, and less than or equal to twenty-four.

13.18. Days shall be greater than or equal to one.

13.19. Days for January, March, May, July, August, October and December shall be less than or equal to 31.

13.20. Days for April, June, September and November shall be less than or equal to 30.

13.21. Days for February shall be

less than or equal to 29 when (the year is evenly divisible by 4 and not evenly divisible by 100) or (the year is evenly divisible by 400)

less than or equal to 28 in all other cases.

13.22. Months shall be greater than or equal to 1, and less than or equal to 12.

**Completeness**

13.23. A completeness table shall be created for each attribute field in each table in the data model, excluding definition tables. This table shall list the distinct, permissible values used for an attribute, and a count of the number of times the value appears.

**Documentation**

13.24. The checklist for logical consistency, Appendix H, shall be part of documentation maintained with the metadata for the spatial data set.

13.25. When records are added or edited, logical consistency shall be re-checked; and the metadata updated if appropriate.

## 13.2. Metadata

Logical consistency is reported in Section 2.2 of the metadata, including the Checklist for Logical Consistency, Appendix H.

## 13.3. Relation to Other Standards

Logical consistency is part of a larger metric of consistency for spatial data. This group includes spatial consistency, and thematic and attribute consistency.

This group includes thematic and attribute consistency, Chapter 12, and logical consistency, Chapter 13.

# 14. Accessibility Standards

The data custodian, with the assistance of the Department's Public Records Coordinator, will assign an accessibility level for the spatial data set and the metadata. Each accessibility level has two parts: access restriction and a reason for the restriction (if applicable). Table 3 presents the types of access restrictions, and whether a reason is required.

**Table 3. Access Restrictions for Spatial Data**

| Access Restriction | Reason Required |
|---|---|
| Not restricted (Public Domain) | |
| Restricted with Creative Commons license | Cite Creative Commons license |
| Proprietary: Restricted to DWR only | Cite reason from Public Records Act |
| Restricted to anyone in DWR and consultants working with DWR | Cite reason from Public Records Act |
| Available to an individual assigned a specific role within DWR. | Cite reason from Public Records Act |
| Available only to a specific individual | Cite terms of confidentiality |
| Available with appropriate permission | Cite terms of confidentiality |
| Proprietary (commercial license) – according to the license agreement | Cite terms of license |

The Public Records Act of the State of California (Government Code 6250 et seq) provides certain instances when access to public information may be restricted. Access may also be restricted because it is confidential under other parts of California law.

## 14.1. Standards

14.1. DWR requires an accessibility level for all enterprise spatial data.

14.2. DWR requires an accessibility level for the metadata of an enterprise data set.

14.3. The accessibility level for the metadata shall never be "less than" the accessibility level for the spatial data.

## 14.2. Metadata

The security level information for the spatial data may be described in Section 1.12 of the metadata.

The security level information for the metadata shall be described in Section 7.10 of the metadata.

## 14.3. Relation to Other Standards

None.

# 15. Data Maintenance

Data maintenance addresses issues of integrity over time. Data is rarely static.

Each data set has an update frequency and a maximum re-visitation interval. The update frequency is the estimated period of time people can expect changes to the data base. The maximum re-visitation interval is the period of time after which the data will not be changed, and will be archived.

The date also provides a system of version control. Any time significant changes are made to a data set, new metadata shall be created, checked and published. If the data set already complies with Department standards, then only the changes have to be checked. The entire data set does not have to be re-checked.

## 15.1. Standards

15.1. The update frequency, or maintenance interval, shall be stated for an enterprise data set.

15.2. DWR endorses a maximum re-visitation interval of five years for an enterprise data set, unless a justification is provided. Spatial data that is not reviewed in the maximum re-visitation interval shall become legacy data (See Chapter 17).

## 15.2. Metadata

The update frequency of the spatial data set shall be described in Section 1.4.2 of the metadata.

The maximum re-visitation interval is not explicitly described in the metadata.

## 15.3. Relation to Other Standards

None.

# 16. Quality Assurance and Quality Control

The terms quality assurance and quality control are often used interchangeably to refer to ways of ensuring the quality of geospatial data; however, they have distinctly different meanings. The following definitions are taken from DWR's QA/QC Manual for Bryte Laboratory

> **Quality Control:** The routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process.
>
> **Quality Assurance:** The total integrated program for assuring the reliability of monitoring and measurement data. QA is a system for integrating the quality planning, quality assessment, and quality improvement efforts to meet user requirements.

## Quality Control

Quality control is a process used when collecting and/or creating spatial data. Quality control procedures shall be developed by people who collect and create spatial data, and will vary from program to program. This could be Departmental staff or contractors hired by DWR.

The procedures shall ensure Department spatial data standards are met as defined in this document. The procedures shall use the worksheets defined in the following appendices:

Appendix E. Checklist for Spatial Consistency
Appendix G. Checklist for Thematic and Attribute Consistency
Appendix H. Checklist for Logical Consistency

These worksheets are an integral part of documenting each process.

If the Data Subcommittee reviews a data set and then decides not to approve a request for its elevation to enterprise status, the Data Subcommittee will provide a list of deficiencies to the Enterprise GIS Committee and Data Steward, with the understanding that if all the deficiencies are corrected, then the spatial data set will be eligible for enterprise status.

## Quality Assurance

Quality assurance is an independent check of the spatial data and the metadata that has been produced. This check provides future users of the data the assurance that:

- The data set adheres to all of DWR standards.

- If applicable, the data set uses terms from Departmental data dictionaries and Departmental abbreviations, not from program defined ones.
- Quality control processes were correctly applied and used.
- The metadata is complete.
- Any recommended improvement or necessary changes in DWR spatial data standards or the quality control procedures are noted and discussed with DWR's GIS governing body.
- The spatial data set is consistent with other Departmental enterprise spatial data sets.

Quality assurance shall not be done by the person producing the spatial data. One of the important characteristics of quality assurance is that a "different set of eyes" reviews the data. Quality assurance is an independent check of the spatial data.

Quality assurance of the spatial data should include a review by a subject matter expert. The subject matter expert can help check for consistency, both spatial consistency, and thematic and attribute consistency, by reviewing maps created from the data set. The expert should not have to be geospatial technology expert.

The last check, consistency with other Departmental enterprise spatial data sets, is important. A data creator or data custodian is focused on the quality of an individual data set. Somewhere in the process, there needs to be a check of how well one spatial data set fits with all the enterprise spatial data set. The process can use the Checklist for Enterprise Consistency (Appendix I). Without this check, the process of creating high quality data is wasted, because the spatial data sets will not fit together.

## 16.4. Metadata

The quality control process shall be reported as parts of the appropriate sections of the metadata.

The quality assurance process shall be reported in Section 2.5.2 of the metadata (processing step of lineage).

## 16.5. Relation to Other Standards

Quality control ensures adherence to DWR standards, and the production of high quality spatial data. These include:

Chapter 1. Names. Processes to ensure naming conventions are used.
Chapter 2. File Organization. Processes to ensure file organization conventions are used.
Chapter 4. Database Design. Processes to ensure database design decisions.

Chapter 5. Tables and Fields. Processes to ensure table and name conventions are used.
Chapter 6. Creation Methods. Processes to ensure creation methods minimize inaccuracies.
Chapter 7. Projection and Coordinate System. Processes to ensure standard coordinate systems are used.
Chapter 8. Positional Accuracy. Processes to ensure greatest positional accuracy possible.
Chapter 9. Attribute Accuracy. Processes to ensure greatest attribute accuracy possible.
Chapter 10. Temporal Accuracy. Processes to document the dates data was collected and analyzed.
Chapter 11. Spatial Consistency. Processes to ensure greatest spatial consistency possible.
Chapter 12. Thematic and Attribute Consistency. Processes to ensure greatest thematic and attribute consistency possible.
Chapter 13. Logical Consistency. Processes to ensure logical consistency.
Chapter 14. Accessibility Standards. Processes to ensure proper accessibility standards as assigned.
Chapter 15. Data Maintenance. Processes to ensure data is properly maintained.

Quality assurance is an evaluation of the "big picture." It includes a review of the quality control process and the relationship of a single spatial data set to items (including standards) beyond these standards.

# 17. Legacy Data

DWR has various paper maps, PLATT maps, imagery and vector data that have been collected over the years. This legacy spatial data in all likelihood does not have metadata. If there is metadata, it does not meet DWR's standards.

A survey of DWR in 2009 found that it has 280 archived boxes, 81 file map drawers, 543 linear feet of binders, 10,000 sheets of microfiche, and more than 4.6 GB of spatial data. The same survey found that about 20% of the spatial data in DWR had metadata. (See *General Framework for Managing Spatial Data at the California Department of Water Resources*, Appendix A.)

## 17. 1. Standards

Legacy spatial data that will remain as it is and be promoted to enterprise status is a special case. Metadata shall be completed for this legacy spatial data as much as possible, and the metadata will be what it is. Standard 6.3, 11.2, 12.2, 12.3, and 12.6 with specific numeric standards, shall not apply. It is acceptable to use "unknown" where appropriate when completing the metadata for a legacy dataset.

The GIS governing body shall assign data custodians for legacy data sets.

If the metadata is created for legacy data that meets DWR's current standards, then the legacy data shall be promoted to enterprise status. In this case, the spatial data set would be moved into the enterprise geodatabase.

Legacy spatial data that continues to be updated, or will be extended in the future, shall be required to meet DWR's requirements for spatial data, including developing complete metadata.

DWR endorses the policy that legacy data be maintained in a separate geodatabase from the enterprise spatial data. This geodatabase would be available to DWR and the public to use at their own risk.

## 17.2. Metadata

The data custodian will complete metadata for the legacy data. The metadata shall be as defined in Chapters 1 – 16 of this document, and be as complete as possible.

Legacy spatial data that continues to be updated, or will be extended in the future, shall meet DWR's requirements for spatial data, including developing complete metadata.

# 18. Deliverable Media Standards

DWR receives much of its spatial data from contractors or consultants. There are three options for delivering spatial data to DWR:

1. CD-ROM/DVD
2. External hard disk
3. FTP site

## 18.1. Standards

In all cases, documentation describing the files and metadata shall accompany the spatial data.

All spatial data shall be in an ArcSDE Geodatabase (what DWR would call an enterprise geodatabase), not a file or personal geodatabase.

For files in georeferenced aerial photography and imagery formats, check the information and completeness of the following files:

MrSID - Images must be Version MG2
Image Catalogs – Submitted as .DBF or as an Embedded Raster Catalog
JPEG – Must be accompanied by World File (JFW)
TIFF 4.0 – Must be accompanied by World File (TFW)

For digital elevation models (DEM) or digital terrain models (DTM), e00, GRID, or TIN must be accompanied by all ASCII source files. All elevation points submitted shall be delivered in a single, comma delimited ASCII file.

### 18.1.1 CD-ROM/DVD

If spatial data is delivered to DWR on CD-ROM/DVD, each CD-ROM /DVD shall include on its cover:

Program Name
Document Name
Description of Contents
Date
Disk Serial Number in the form of
"Disk X of XX"

### 18.1.2. External Hard Disk

If spatial data is delivered to DWR on an external hard disk, each external hard disk shall have a label tapped to it indicating:

Program Name
Document Name
Description of Contents
Date
Disk Serial Number in the form of
"Disk X of XX"

### 18.1.3. FTP Site

If spatial data is delivered to DWR from an ftp site, then DWR shall have access to the site, and the site shall be maintained for one year from the time final data is available.

## 18.2. Metadata

In all cases, documentation describing the files and metadata shall accompany the spatial data.

## 18.3. Relation to Other Standards

In all cases, DWR's current spatial data standards apply.

# 19. Metadata

Table 4 presents the metadata requirements as defined by the Federal Geographic Data Committee (FGDC). The first column of the table presents the level, or section, of the item. The second column presents the field name, in English. Each field has a field name as defined by the FGDC. This is repeated in the Field Name, Description and Constraint column. The third column presents the data type of the field. A compound data type is composed of multiple fields, some of which themselves may be compound data types. The fourth and fifth columns present the field requirements for DWR and FGDC, respectively. There are three possibilities:

Mandatory. These sections of the metadata are required.
Conditional. These sections of the metadata are required if the section if applicable to the spatial data set.
Optional. These sections of the metadata are optional.

There are 30 differences between DWR and the FGDC standards. These differences are high-lighted in red in the column for DWR's metadata requirements (including three times when the domain is not restricted to the FGDC standard). In most cases, DWR standards are the same as the FGDC standards. Where there are differences, the DWR standard is usually more strict than the FGDC standard (for example, mandatory rather than conditional). The one place DWR is less strict than the FGDC standards is with respect to file transfer types (Section 3.3.1).

The last column presents the field name (again), a description of the field, and any constraint on the field values.

**Table 4. Comparison of DWR and FGDC Metadata Standards**

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
|---|---|---|---|---|---|
| 1 | Identification Information | Compound | Mandatory. | Mandatory. | Identification Information. (FDGC field name = idinfo) Identification information. |
| 1.1 | Citation | Compound | Mandatory.<br><br>Contains Element 8. | Mandatory.<br><br>Contains Element 8. | Citation. (FDGC field name = citation) Information to be used to reference the data set. |
| 1.2 | Description | Compound | Mandatory. | Mandatory. | Description. (FDGC field name = descript) A characterization of the data set, including its intended use and limitations. |
| 1.2.1 | Abstract | Free Text | Mandatory. | Mandatory. | Abstract. (FDGC field name = abstract) A brief narrative summary of the data set. |
| 1.2.2 | Purpose | Free Text | Mandatory. | Mandatory. | Purpose. (FDGC field name = purpose) A summary of the intentions with which the data set was developed. |
| 1.2.3 | Supplemental Information | Free Text | Optional. | Optional. | Supplemental Information. (FDGC field name = supplinf) Other descriptive information about the data set. |
| 1.3 | Time Period of Content | Compound | Mandatory.<br><br>Contains Element 9. | Mandatory.<br><br>Contains Element 9. | Time Period of Content. (FDGC field name = timeperd) Time period(s) for which the data set corresponds to the currentness reference. |
| 1.3.1 | Currentness Reference | Text | Mandatory. | Mandatory. | Currentness Reference. (FDGC field name = current) The basis on which the time period of content information is determined. Domain: Ground condition "publication date" free text |
| 1.4 | Status | Compound | Mandatory.<br><br>Contains Elements 1.4.1 and 1.4.2 | Mandatory.<br><br>Contains Elements 1.4.1 and 1.4.2 | Status. (FDGC field name = status) The state of and maintenance information for the data set. |
| 1.4.1 | Progress | Text | Mandatory. | Mandatory. | Progress. (FDGC field name = progress) The state of the data set. Domain: complete, in work, planned |
| 1.4.2 | Maintenance and Update Frequency | Text | Mandatory. | Mandatory. | Maintenance and Update Frequency. (FDGC field name = update) The frequency with which changes and additions are made to the data set after the initial data set is completed. Domain: Continually "Daily" "Weekly" "Monthly" "Annually" "Unknown" "As needed" "Irregular" "None planned" free text |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
|---|---|---|---|---|---|
| 1.5 | Spatial Domain | Compound | Mandatory.<br><br>Contains Element1.5.1 and Element1 1.5.2. | Mandatory.<br><br>Contains Element1.5.1 and Element1 1.5.2. | Spatial Domain. (FDGC field name = spdom) The geographic areal domain of the data set. |
| 1.5.1 | Bounding Coordinates | Compound | Mandatory.<br><br>Contains Elements 1.5.1.1 – 1.5.1.4. | Mandatory.<br><br>Contains Elements 1.5.1.1 – 1.5.1.4. | Bounding Coordinates. (FDGC field name = bounding) The limits of coverage of a data set expressed by latitude and longitude values in the order western-most, eastern-most, northern-most, and southern-most. For data sets that include a complete band of latitude around the earth, the West Bounding Coordinate shall be assigned the value _180.0, and the East Bounding Coordinate shall be assigned the value 180.0. |
| 1.5.1.1 | West Bounding Coordinate | Real | Mandatory. | Mandatory. | West Bounding Coordinate. (FDGC field name = westbc) Western-most coordinate of the limit of coverage expressed in longitude. Domain: _180 <= West Bounding Coordinate < 180 |
| 1.5.1.2 | East Bounding Coordinate | Real | Mandatory. | Mandatory. | East Bounding Coordinate. (FDGC field name = eastbc) Eastern-most coordinate of the limit of coverage expressed in longitude. Domain: _180.0 <= East Bounding Coordinate <= 180.0 |
| 1.5.1.3 | North Bounding Coordinate | Real | Mandatory. | Mandatory. | North Bounding Coordinate. (FDGC field name = northbc) Northern-most coordinate of the limit of coverage expressed in latitude. Domain: _90.0 <= North Bounding Coordinate <= 90.0 |
| 1.5.1.4 | South Bounding Coordinate | Real | Mandatory. | Mandatory. | South Bounding Coordinate. (FDGC field name = southbc) Southern-most coordinate of the limit of coverage expressed in latitude. Domain: _90.0 <= South Bounding Coordinate <= 90.0 |
| 1.5.2 | Data Set G-Polygon | Compound | Optional.<br><br>Contains Element 1.5.2.1 and Element 1.5.2.2.<br><br>May be repeated many times. | Optional.<br><br>Contains Element 1.5.2.1 and Element 1.5.2.2.<br><br>May be repeated many times. | Data Set G-Polygon. (FDGC field name = dsgpoly) Coordinates defining the outline of an area covered by a data set. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
|---|---|---|---|---|---|
| 1.5.2.1 | Data Set G-Polygon Outer G-Ring | Compound | If Element 1.5.2 is included, Mandatory.<br><br>Contains one of Element 1.5.2.1.1 or Element 1.5.2.1.2 | If Element 1.5.2 is included, Mandatory.<br><br>Contains one of Element 1.5.2.1.1 or Element 1.5.2.1.2 | Data Set G-Polygon Outer G-Ring. (FDGC field name = dsgpolyo) The closed nonintersecting boundary of an interior area. |
| 1.5.2.1.1 | G-Ring Point | Compound | If selected from Element 1.5.2.1, Mandatory.<br><br>Contains Element 1.5.2.1.1.1 and Element 1.5.2.1.1.2.<br><br>Repeat 4 to an unlimited number of times. | If selected from Element 1.5.2.1, Mandatory.<br><br>Contains Element 1.5.2.1.1.1 and Element 1.5.2.1.1.2.<br><br>Repeat 4 to an unlimited number of times. | G-Ring Point. (FDGC field name = grngpoin) A single geographic location. |
| 1.5.2.1.1.1 | G-Ring Latitude | Real | If Element 1.5.2.1.1 is included, Mandatory. | If Element 1.5.2.1.1 is included, Mandatory. | G-Ring Latitude. (FDGC field name = gringlat) The latitude of a point of the g-ring. Domain: _90.0 <= G-Ring Latitude <= 90.0 |
| 1.5.2.1.1.2 | G-Ring Longitude | Real | If Element 1.5.2.1.1 is included, Mandatory. | If Element 1.5.2.1.1 is included, Mandatory. | G-Ring Longitude. (FDGC field name = gringlon) The longitude of a point of the g-ring. Domain: _180.0 <= G-Ring Longitude < 180.0 |
| 1.5.2.1.2 | G-Ring | Text | If selected from Element 1.5.2.1, Mandatory. | If selected from Element 1.5.2.1, Mandatory. | G-Ring. (FDGC field name = gring) A set of ordered pairs of floating-point numbers, separated by commas, in which the first number in each pair is the longitude of a point and the second is the latitude of the point. Longitude and latitude are specified in decimal degrees with north latitudes positive and south negative, east longitude positive and west negative. Domain: _90<= Latitude-elements <= 90, _180 <= Longitude-Elements = 180 |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 1.5.2.2 | Data Set G-Polygon Exclusion G-Ring | Compound | If Element 1.5.2 is included, Conditional.<br><br>Contains a choice of either Element 1.5.2.1.1 or Element 1.5.2.1.2.<br><br>Repeat an unlimited number of times. | If Element 1.5.2 is included, Conditional.<br><br>Contains a choice of either Element 1.5.2.1.1 or Element 1.5.2.1.2.<br><br>Repeat an unlimited number of times. | Data Set G-Polygon Exclusion G-Ring. (FDGC field name = dsgpolyx) The closed nonintersecting boundary of a void area (or "hole" in an interior area). |
| 1.6 | Keywords | Compound | Mandatory<br><br>Includes Elements 1.6.1 – 1.6.4. | Mandatory<br><br>Includes Elements 1.6.1 – 1.6.4. | Keywords. (FDGC field name = keywords) Words or phrases summarizing an aspect of the data set. |
| 1.6.1 | Theme | Compound | Mandatory<br><br>Contains Element 1.6.1.1 and Element 1.6.1.2,<br><br>Repeat unlimited number of times. | Mandatory<br><br>Contains Element 1.6.1.1 and Element 1.6.1.2,<br><br>Repeat unlimited number of times. | Theme. (FDGC field name = theme) Subjects covered by the data set (for a list of some commonly-used thesauri, see Part IV: Subject/index term sources in Network Development and MARC Standards Office, 1988, USMARC code list for relators, sources, and description conventions: Washington, Library of Congress) . |
| 1.6.1.1 | Theme Keyword Thesaurus | Text | Mandatory. | Mandatory. | Theme Keyword Thesaurus. (FDGC field name = themekt) Reference to a formally registered thesaurus or a similar authoritative source of theme keywords. |
| 1.6.1.2 | Theme Keyword | Text | Mandatory. | Mandatory. | Theme Keyword. (FDGC field name = themekey) Common-use word or phrase used to describe the subject of the data set. Domain: None free text |
| 1.6.2 | Place | Compound | Mandatory.<br><br>Contains Element 1.6.2.1 and Element 1.6.2.2,<br><br>Repeat unlimited number of times. | Conditional.<br><br>Contains Element 1.6.2.1 and Element 1.6.2.2,<br><br>Repeat unlimited number of times. | Place. (FDGC field name = place) Geographic locations characterized by the data set. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 1.6.2.1 | Place Keyword Thesaurus | Text | If Element 1.6.2 is included, Mandatory. | If Element 1.6.2 is included, Mandatory. | Place Keyword Thesaurus. (FDGC field name = placekt) Reference to a formally registered thesaurus or a similar authoritative source of place keywords. Domain: "None" "Geographic Names Information System" free text |
| 1.6.2.2 | Place Keyword | Free Text | If Element 1.6.2 is included, Mandatory. | If Element 1.6.2 is included, Mandatory. | Place Keyword. (FDGC field name = placekey) The geographic name of a location covered by a data set. |
| 1.6.3 | Stratum | Compound | Conditional.<br><br>Contains Element 1.6.3.1 and Element 1.6.3.2,<br><br>Repeat unlimited number of times. | Conditional.<br><br>Contains Element 1.6.3.1 and Element 1.6.3.2,<br><br>Repeat unlimited number of times. | Stratum. (FDGC field name = stratum) Layered, vertical locations characterized by the data set. |
| 1.6.3.1 | Stratrum Keyword Thesaurus | Text | If Element 1.6.3 is included, Mandatory. | If Element 1.6.3 is included, Mandatory. | Stratrum Keyword Thesaurus. (FDGC field name = stratkt) Reference to a formally registered thesaurus or a similar authoritative source of stratum keywords. Domain: None free text |
| 1.6.3.2 | Stratrum Keyword | Free Text | If Element 1.6.3 is included, Mandatory. | If Element 1.6.3 is included, Mandatory. | Stratrum Keyword. (FDGC field name = stratkey) The name of a vertical location used to describe the locations. |
| 1.6.4 | Temporal | Compound | Mandatory.<br><br>Contains Element 1.6.4.1 and Element 1.6.4.2,<br><br>Repeat unlimited number of times. | Conditional.<br><br>Contains Element 1.6.4.1 and Element 1.6.4.2,<br><br>Repeat unlimited number of times. | Temporal. (FDGC field name = temporal) time period(s) characterized by the data set. |
| 1.6.4.1 | Temporal Keyword Thesaurus | Text | If Element 1.6.4 is included, Mandatory. | If Element 1.6.4 is included, Mandatory. | Temporal Keyword Thesaurus. (FDGC field name = tempkt) Reference to a formally registered thesaurus or a similar authoritative source of temporal keywords. Domain: None free text |
| 1.6.4.2 | Temporal Keyword | Text | If Element 1.6.4 is included, Mandatory. | If Element 1.6.4 is included, Mandatory. | Temporal Keyword. (FDGC field name = tempkey) The name of a time period covered by a data set. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 1.7 | Access Constraints | Text | Mandatory. | Mandatory. | Access Constraints. (FDGC field name = accconst) Restrictions and legal prerequisites for accessing the data set. These include any access constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations on obtaining the data set. Domain: None free text |
| 1.8 | Use Constraints | Text | Mandatory. | Mandatory. | Use Constraints. (FDGC field name = useconst) Domain: None free text |
| 1.9 | Point of Contact | Compound | Mandatory.<br><br>Contains Section 10. | Optional.<br><br>Contains Section 10. | Point of Contact. (FDGC field name = ptcontac) Contact information for an individual or organization that is knowledgeable about the data set. |
| 1.10 | Browse Graphic | Compound | Mandatory.<br><br>Contains Elements1.10.1 – 1.10.3.<br><br>Repeated an unlimited number of times. | Optional.<br><br>Contains Elements1.10.1 – 1.10.3.<br><br>Repeated an unlimited number of times. | Browse Graphic. (FDGC field name = browse) A graphic that provides an illustration of the data set. The graphic should include a legend for interpreting the graphic. |
| 1.10.1 | Browse Graphic File Name | Text | Mandatory. | If Element 1.10 is included, Mandatory. | Browse Graphic File Name. (FDGC field name = browsen) Name of a related graphic file that provides an illustration of the data set. |
| 1.10.2 | Browse Graphic File Description | Free Text | Mandatory. | If Element 1.10 is included, Mandatory. | Browse Graphic File Description. (FDGC field name = browsed) A text description of the illustration<br><br>The graphic shall display enough of information that a person can identify the area covered by the data set. |
| 1.10.3 | Browse Graphic File Type | Text | Mandatory. | If Element 1.10 is included, Mandatory. | Browse Graphic File Type. (FDGC field name = browset) Graphic file type of a related graphic file. Domain: "CGM" Computer Graphics Metafile ; "EPS" Encapsulated Postscript format ; "EMF" Enhanced Metafile ; "GIF" Graphic Interchange Format ; "JPEG" Joint Photographic Experts Group format ; "PBM" Portable Bit Map format ; "PS" Postscript format ; "TIFF" Tagged Image File Format ; "WMF" Windows metafile ; "XWD" X-Windows Dump |

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| 1.11 | Data Set Credit | Free Text | Optional. | Optional. | Data Set Credit. (FDGC field name = datacred) Recognition of those who contributed to the data set. |
| 1.12 | Security Information | Compound | Mandatory.<br><br>Contains Elements 1.12.1 – 1.12.3.<br><br>Repeated an unlimited number of times. | Optional.<br><br>Contains Elements 1.12.1 – 1.12.3.<br><br>Repeated an unlimited number of times. | Security Information. (FDGC field name = secinfo) Handling restrictions imposed on the data set because of national security, privacy, or other concerns. |
| 1.12.1 | Security Classification System | Free Text | Mandatory. | If Element 1.12 is included, Mandatory. | Security Classification System. (FDGC field name = secsys) Name of the classification system. |
| 1.12.2 | Security Classification | Free Text | Mandatory. | If Element 1.12 is included, Mandatory. | Security Classification. (FDGC field name = secclass) Name of the handling restrictions on the data set. Domain: Top secret "Secret" "Confidential" "Restricted" "Unclassified" "Sensitive" |
| 1.12.3 | Security Handling Description | Free Text | Mandatory | If Element 1.12 is included, Mandatory. | Security Handling Description. (FDGC field name = sechandl) Additional information about the restrictions on handling the data set. |
| 1.13 | Native Data Set Environment | Free Text | Optional. | Optional. | Native Data Set Environment. (FDGC field name = native) A description of the data set in the producer's processing environment, including items such as the name of the software (including version), the computer operating system, file name (including host_, path_, and filenames), and the data set size . |
| 1.14 | Cross Reference | Compound | Optional. | Optional.<br><br>Contains Element 8. | Cross Reference. (FDGC field name = crossref) Information about other, related data sets that are likely to be of interest. |
| | | | | | |
| 2 | Data Quality Information | Compound | Mandatory.<br><br>Contains Elements 2.1 – 2.6. | Conditional.<br><br>Contains Elements 2.1 – 2.6. | Data Quality Information. (FDGC field name = dataqual) A general assessment of the quality of the data set. (Recommendations on information to be reported and tests to be performed are found in "Spatial Data Quality," which is chapter 3 of part 1 in Department of Commerce, 1992, Spatial Data Transfer Standard (SDTS) (federal Information Processing Standard 173): Washington, Department of Commerce, National Institute of Standards and Technology. |

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| 2.1 | Attribute Accuracy | Compound | Conditional.<br><br>Contains Element 2.1.1 and Element 2.1.2. | Conditional.<br><br>Contains Element 2.1.1 and Element 2.1.2. | Attribute Accuracy. (FDGC field name = attracc) An assessment of the accuracy of the identification of entities and assignment of attribute values in the data set. |
| 2.1.1 | Attribute Accuracy Report | Free Text | Mandatory. | Mandatory. | Attribute Accuracy Report. (FDGC field name = attraccr) An explanation of the accuracy of the identification of the entities and assignments of values in the data set and a description of the tests used. |
| 2.1.2 | Quantitative Attribute Accuracy Assessment | Compound | Optional.<br><br>Contains Element 2.1.2.1 and 2.1.2.2. | Optional.<br><br>Contains Element 2.1.2.1 and 2.1.2.2. | Quantitative Attribute Accuracy Assessment. (FDGC field name = qattracc) A value assigned to summarize the accuracy of the identification of the entities and assignments of values in the data set and the identification of the test that yielded the value. |
| 2.1.2.1 | Attribute Accuracy Value | Text | If Element 2.1.2 is included, Mandatory. | If Element 2.1.2 is included, Mandatory. | Attribute Accuracy Value. (FDGC field name = attraccv) An estimate of the accuracy of the identification of the entities and assignments of attribute values in the data set. Domain: Unknown free text |
| 2.1.2.2 | Attribute Accuracy Explanation | Free Text | If Element 2.1.2 is included, Mandatory. | If Element 2.1.2 is included, Mandatory. | Attribute Accuracy Explanation. (FDGC field name = attracce) The identification of the test that yielded the Attribute Accuracy Value. |
| 2.2 | Logical Consistency Report | Free Text | Mandatory. | Mandatory. | Logical Consistency Report. (FDGC field name = logic) An explanation of the fidelity of relationships in the data set and tests used. |
| 2.3 | Completeness Report | Free Text | Mandatory. | Mandatory. | Completeness Report. (FDGC field name = complete) Information about omissions, selection criteria, generalization, definitions used, and other rules used to derive the data set. |
| 2.4 | Positional Accuracy | Compound | Mandatory.<br><br>Contains Element 2.4.1 and Element 2.4.2. | Conditional.<br><br>Contains Element 2.4.1 and Element 2.4.2. | Positional Accuracy. (FDGC field name = posacc) An assessment of the accuracy of the positions of spatial objects. |
| 2.4.1 | Horizontal Positional Accuracy | Compound | Mandatory.<br><br>Contains Element 2.4.1.1 and Element 2.4.1.2. | Conditional.<br><br>Contains Element 2.4.1.1 and Element 2.4.1.2. | Horizontal Positional Accuracy. (FDGC field name = horizpa) An estimate of accuracy of the horizontal positions of the spatial objects. |

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| 2.4.1.1 | Horizontal Positional Accuracy Report | Free Text | Mandatory. | Mandatory. | Horizontal Positional Accuracy Report. (FDGC field name = horizpar) An explanation of the accuracy of the horizontal coordinate measurements and a description of the tests used. |
| 2.4.1.2 | Quantitative Horizontal Positional Accuracy Assessment | Compound | Mandatory.<br><br>Contains Element 2.4.1.2.1 and Element 2.4.1.2.2. | Optional.<br><br>Contains Element 2.4.1.2.1 and Element 2.4.1.2.2. | Quantitative Horizontal Positional Accuracy Assessment. (FDGC field name = qhorizpa) Numeric value assigned to summarize the accuracy of the horizontal coordinate measurements and the identification of the test that yielded the value. |
| 2.4.1.2.1 | Horizontal Positional Accuracy Value | Real | Mandatory. | If Element 2.4.1.2 is included, Mandatory | Horizontal Positional Accuracy Value. (FDGC field name = horizpav) An estimate of the accuracy of the horizontal coordinate measurements in the data set expressed in (ground). |
| 2.4.1.2.2 | Horizontal Positional Accuracy Explanation | Free Text | Mandatory. | If Element 2.4.1.2 is included, Mandatory | Horizontal Positional Accuracy Explanation. (FDGC field name = horizpae) The identification of the test that yielded the Horizontal Positional Accuracy Value. |
| 2.4.2 | Vertical Positional Accuracy | Compound | Conditional.<br><br>Contains Element 2.4.2.1 and Element 2.4.2.2. | Conditional.<br><br>Contains Element 2.4.2.1 and Element 2.4.2.2. | Vertical Positional Accuracy. (FDGC field name = vertacc) An estimate of accuracy of the vertical positions in the data set. |
| 2.4.2.1 | Vertical Positional Accuracy Report | Free Text | Mandatory | Mandatory | Vertical Positional Accuracy Report. (FDGC field name = vertaccr) An explanation of the accuracy of the vertical coordinate measurements and a description of the tests used. |
| 2.4.2.2 | Quantitative Vertical Positional Accuracy Assessment | Compound | Conditional.<br><br>Contains Element 2.4.2.2.1 and Element 2.4.2.2.2. | Optional.<br><br>Contains Element 2.4.2.2.1 and Element 2.4.2.2.2. | Quantitative Vertical Positional Accuracy Assessment. (FDGC field name = qvertpa) Numeric value assigned to summarize the accuracy of vertical coordinate measurements and the identification of the test that yielded the value. |
| 2.4.2.2.1 | Vertical Positional Accuracy Value | Real | If Element 2.4.2.2 is included, Mandatory | If Element 2.4.2.2 is included, Mandatory | Vertical Positional Accuracy Value. (FDGC field name = vertaccv) An estimate of the accuracy of the vertical coordinate measurements in the data set expressed in (ground) meters. |
| 2.4.2.2.2 | Vertical Positional Accuracy Explanation | Free Text | If Element 2.4.2.2 is included, Mandatory | If Element 2.4.2.2 is included, Mandatory | Vertical Positional Accuracy Explanation. (FDGC field name = vertacce) The identification of the test that yielded the Vertical Positional Accuracy Value. |

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| 2.5 | Lineage | Compound | Mandatory.<br><br>Contains Element 2.5.1 and Element 2.5.2. | Mandatory.<br><br>Contains Element 2.5.1 and Element 2.5.2. | Lineage. (FDGC field name = lineage) Information about the events, parameters, and source data which constructed the data set, and information about the responsible parties. |
| 2.5.1 | Source Information | Compound | Conditional.<br><br>Contains Elements 2.5.1.1 – 2.5.1.6. | Conditional.<br><br>Contains Elements 2.5.1.1 – 2.5.1.6. | Source Information. (FDGC field name = srcinfo) List of sources and a short discussion of the information contributed by each . |
| 2.5.1.1 | Source Citation | Compound | Mandatory<br><br>Contains Element 8. | Mandatory.<br><br>Contains Element 8. | Source Citation. (FDGC field name = srccite) Reference for a source data set. |
| 2.5.1.2 | Source Scale Denominator | Integer | Conditional. | Conditional. | Source Scale Denominator. (FDGC field name = srcscale) the denominator of the representative fraction on a map (for example, on a 1:24,000_scale map, the Source Scale Denominator is 24000) . Domain: Source Scale Denominator > 1 |
| 2.5.1.3 | Type of Source Media | Free Text | Mandatory. | Mandatory. | Type of Source Media. (FDGC field name = typesrc) The medium of the source data set . Domain: "paper" "stable-base material" "microfiche" "microfilm" "audiocassette" "chart" "filmstrip" "transparency" "videocassette" "videodisc" "videotape" "physical model" "computer program" "disc" "cartridge tape" "magnetic tape" "online" "CD_ROM" "electronic bulletin board" "electronic mail system" free text |
| 2.5.1.4 | Source Time Period of Content | Compound | Mandatory,<br><br>Contains Element 2.5.1.4.1 and Element 9. | Mandatory,<br><br>Contains Element 2.5.1.4.1 and Element 9. | Source Time Period of Content. (FDGC field name = srctime) Time period(s) for which the source data set corresponds to the ground . |
| 2.5.1.4.1 | Source Currentness Reference | Text | Mandatory. | Mandatory. | Source Currentness Reference. (FDGC field name = srccurr) The basis on which the source time period of content information of the source data set is determined . Domain: ground condition "publication date" free text |
| 2.5.1.5 | Source Citation Abbreviation | Free Text | Mandatory. | Mandatory. | Source Citation Abbreviation. (FDGC field name = srccitea) Short-form alias for the source citation. |
| 2.5.1.6 | Source Contribution | Free Text | Mandatory. | Mandatory. | Source Contribution. (FDGC field name = srccontr) Brief statement identifying the information contributed by the source to the data set. |

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| 2.5.2 | Process Step | Compound | Mandatory.<br><br>Contains Elements 2.5.2.1 – 2.5.2.6. | Mandatory.<br><br>Contains Elements 2.5.2.1 – 2.5.2.6. | Process Step. (FDGC field name = procstep) Information about a single event. |
| 2.5.2.1 | Process Description | Free Text | Mandatory | Mandatory | Process Description. (FDGC field name = procdesc) An explanation of the event and related parameters or tolerances . |
| 2.5.2.2 | Source Used Citation Abbreviation | Text | Conditional.<br><br>Repeated unlimited times. | Conditional.<br><br>Repeated unlimited times. | Source Used Citation Abbreviation. (FDGC field name = srcused) The Source Citation Abbreviation of a data set used in the processing step . Domain: Source Citation Abbreviations from the Source Information entries for the data set |
| 2.5.2.3 | Process Date | Date | Mandatory. | Mandatory. | Process Date. (FDGC field name = procdate) The date when the event was completed . Domain: Unknown "Not complete" free date |
| 2.5.2.4 | Process Time | Time | Optional. | Optional. | Process Time. (FDGC field name = proctime) The time when the event was completed. |
| 2.5.2.5 | Source Produced Citation Abbreviation | Text | Conditional.<br><br>Repeated unlimited times. | Conditional.<br><br>Repeated unlimited times. | Source Produced Citation Abbreviation. (FDGC field name = srcprod) The Source Citation Abbreviation of an intermediate data set that (1) is significant in the opinion of the data producer, (2) is generated in the processing step, and (3) is used in later processing steps . Domain: Source Citation Abbreviations from the Source Information entries |
| 2.5.2.6 | Process Contact | Compound | Mandatory. | Mandatory. | Process Contact. (FDGC field name = proccont) The party responsible for the processing step information . |
| 2.6 | Cloud Cover | Integer` | Mandatory. | Optional. | Cloud Cover. (FDGC field name = cloud) Area of a data set obstructed by clouds, expressed as a percentage of the spatial extent . Domain: 0 <= Cloud Cover <= 100 "Unknown" |
| | | | | | |
| 3 | Spatial Data Organization Information | Compound | Mandatory.<br><br>Contains Element 3.1 and Element 3.2, and one of (Element 3.3 or Element 3.4). | Conditional.<br><br>Contains Element 3.1 and Element 3.2, and one of (Element 3.3 or Element 3.4). | Spatial Data Organization Information. (FDGC field name = spdoinfo) The mechanism used to represent spatial information in the data set . |
| 3.1 | Indirect Spatial Reference | Free Text | Conditional. | Conditional. | Indirect Spatial Reference. (FDGC field name = indspref) Name of types of geographic features, addressing schemes, or other means through which locations are referenced in the data set. |

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| 3.2 | Direct Spatial Reference Method | Text | Conditional.<br><br>@@ | Conditional. | Direct Spatial Reference Method. (FDGC field name = direct) The system of objects used to represent space in the data set. Domain: Point "Vector" "Raster" |
| 3.3 | Point and Vector Object Information | Text | If selected from Element 3, Mandatory.<br><br>Contains one from Element 3.3.1 or Element 3.3.2. | If selected from Element 3, Mandatory.<br><br>Contains one from Element 3.3.1 or Element 3.3.2. | Point and Vector Object Information. (FDGC field name = ptvctinf) The types and numbers of vector or non-gridded point spatial objects in the data set. |
| 3.3.1 | SDTS Terms Description | Compound | If this element is selected from Element 3.3, Optional.<br><br>Contains Element 3.3.1.1 and Element 3.3.1.2.<br><br>Can be repeated unlimited times. | If this element is selected from Element 3.3, Mandatory.<br><br>Contains Element 3.3.1.1 and Element 3.3.1.2.<br><br>Can be repeated unlimited times. | SDTS Terms Description. (FDGC field name = sdtsterm) Point and vector object information using the terminology and concepts from "Spatial Data Concepts," which is Chapter 2 of Part 1 in Department of Commerce, 1992, Spatial Data Transfer Standard (SDTS) (Federal Information Processing Standard 173): Washington, Department of Commerce, National Institute of Standards and Technology. (Note that this reference to the SDTS is used ONLY to provide a set of terminology for the point and vector objects.) . |
| 3.3.1.1 | SDTS Point and Vector Object Type | Text | If Element 3.3.1 is selected from Element 3.3, Mandatory<br><br>If this element is used, DWR does not restrict the user to the domain values listed. | If Element 3.3.1 is selected from Element 3.3, Mandatory | SDTS Point and Vector Object Type. (FDGC field name = sdtstype) Name of point and vector spatial objects used to locate zero-, one-, and two-dimensional spatial locations in the data set. Domain: (The domain is from "Spatial Data Concepts," which is Chapter 2 of Part 1 in Department of Commerce, 1992, Spatial Data Transfer Standard (SDTS) (Federal Information Processing Standard 173): Washington, Department of Commerce, National Institute of Standards and Technology): "Point" "Entity point" "Label point" "Area point" "Node, planar graph" "Node, network" "String" "Link" "Complete chain" "Area chain" "Network chain, planar graph" "Network chain, non-planar graph" "Circular arc, three point center" "Elliptical arc" "Uniform B-spline" "Piecewise Bezier" "Ring with mixed composition" "Ring composed of strings" "Ring composed of chains" "Ring composed of arcs" "G-polygon" "GT-polygon composed of rings" "GT-polygon composed of chains" "Universe polygon composed of rings" "Universe polygon |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| | | | | | composed of chains" "Void polygon composed of rings" "Void polygon composed of chains" |
| 3.3.1.2 | Point and Vector Object Count | Integer | If Element 3.3.1 is selected from Element 3.3, Optional. | If Element 3.3.1 is selected from Element 3.3, Optional. | Point and Vector Object Count. (FDGC field name = ptvctcnt) The total number of the point or vector object type occurring in the data set. Domain: Point and Vector Object Count > 0 |
| 3.3.2 | VPF Terms Description | Compound | If this element is selected from Element 3.3, Mandatory.<br><br>Contains Elements 3.3.2.1 – 3.3.2.3. | If this element is selected from Element 3.3, Mandatory.<br><br>Contains Elements 3.3.2.1 – 3.3.2.3. | VPF Terms Description. (FDGC field name = vpfterm) Point and vector object information using the terminology and concepts from Department of Defense, 1992, Vector Product Format (MIL_STD_600006): Philadelphia, Department of Defense, Defense Printing Service Detachment Office. (Note that this reference to the VPF is used ONLY to provide a set of terminology for the point and vector objects. |
| 3.3.2.1 | VPF Topology Level | Integer | If Element 3.3.2 is selected from Element 3.3, Mandatory. | If Element 3.3.2 is selected from Element 3.3, Mandatory. | VPF Topology Level. (FDGC field name = vpflevel) The completeness of the topology carried by the data set. The levels of completeness are defined in Department of Defense, 1992, Vector Product Format (MIL_STD_600006): Philadelphia, Department of Defense, Defense Printing Service Detachment Office. Domain: 0 <= VPF Topology Level <= 3 |
| 3.3.2.2 | VPF Point and Vector Object Information | Compound | If Element 3.3.2 is selected from Element 3.3, Mandatory.<br><br>Can be repeated unlimited times. | If Element 3.3.2 is selected from Element 3.3, Mandatory.<br><br>Can be repeated unlimited times. | VPF Point and Vector Object Information. (FDGC field name = vpfinfo) Information about VPF point and vector objects . |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 3.3.2.2.1 | VPF Point and Vector Object Type | Text | If Element 3.3.2 is selected from Element 3.3, Optional.<br><br>If this element is used, DWR does not restrict the user to the domain values listed. | If Element 3.3.2 is selected from Element 3.3, Optional.<br><br>Can be repeated unlimited times. | VPF Point and Vector Object Type. (FDGC field name = vpftype) Name of point and vector spatial objects used to locate zero-, one-, and two-dimensional spatial locations in the data set. Domain: (The domain is from Department of Defense, 1992, Vector Product Format (MIL_STD_600006): Philadelphia, Department of Defense, Defense Printing Service Detachment Office): "Node" "Edge" "Face" "Text" |
| 3.3.2.2.2 | VPF Point and Vector Object Count | Integer | If Element 3.3.2 is selected from Element 3.3, Optional. | If Element 3.3.2 is selected from Element 3.3, Optional. | VPF Point and Vector Object Count. (FDGC field name = ptvctcnt) Must be greater than zero. |
| 3.4 | Raster Object Information | Compound | If this element is selected from Element 3, Mandatory.<br><br>Contains Element 3.4.1 and Element 3.4.2. | If this element is selected from Element 3, Mandatory.<br><br>Contains Element 3.4.1 and Element 3.4.2. | Raster Object Information. (FDGC field name = rastinfo) The types and numbers of raster spatial objects in the data set. |
| 3.4.1 | Raster Object Type | Text | If Element 3.4 is selected from Element 3, Mandatory. | If Element 3.4 is selected from Element 3, Mandatory. | Raster Object Type. (FDGC field name = rasttype) Raster spatial objects used to locate zero-, two-, or three-dimensional locations in the data set. Domain: (With the exception of "voxel", the domain is from "Spatial Data Concepts," which is chapter 2 of part 1 in Department of Commerce, 1992, Spatial Data Transfer Standard (SDTS) (Federal Information Processing Standard 173): Washington, Department of Commerce, National Institute of Standards and Technology): "Point" "Pixel" "Grid Cell" "Voxel" |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 3.4.2 | Row Count | Integer | If the metadata includes Element 3.4.2, it must also include Element 3.4.3 (mandatory) and Element 3.4.4 (conditional).<br><br>The specification is inconsistent here. | If the metadata includes Element 3.4.2, it must also include Element 3.4.3 (mandatory) and Element 3.4.4 (conditional).<br><br>The specification is inconsistent here. | Row Count. (FDGC field name = rowcount) The maximum number of raster objects along the ordinate (y) axis. For use with rectangular raster objects. Domain: Row Count > 0 |
| 3.4.3 | Column Count | Integer | If the metadata includes Element 3.4.3, it must also include Element 3.4.2 (mandatory) and Element 3.4.4 (conditional).<br><br>The specification is inconsistent here. | If the metadata includes Element 3.4.3, it must also include Element 3.4.2 (mandatory) and Element 3.4.4 (conditional).<br><br>The specification is inconsistent here. | Column Count. (FDGC field name = colcount) The maximum number of raster objects along the abscissa (x) axis. For use with rectangular raster objects. Domain: Column Count > 0 |
| 3.4.4 | Vertical Count | Integer | If the metadata includes Element 3.4.4, it must also include Element 3.4.2 (mandatory) and Element 3.4.3 (mandatory).<br><br>The specification is inconsistent here. | If the metadata includes Element 3.4.4, it must also include Element 3.4.2 (mandatory) and Element 3.4.3 (mandatory).<br><br>The specification is inconsistent here. | Vertical Count. (FDGC field name = vrtcount) The maximum number of raster objects along the vertical (z) axis. For use with rectangular volumetric raster objects (voxels). Domain: Depth Count > 0 |
| | | | | | |
| 4 | Spatial Reference Information | Compound | Mandatory.<br><br>Contains Element 4.1 and Element 4.2. | Conditional.<br><br>Contains Element 4.1 and Element 4.2. | Spatial Reference Information. (FDGC field name = spref) The description of the reference frame for, and the means to encode, coordinates in the data set . |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 4.1 | Horizontal Coordinate System Definition | Compound | Conditional.<br><br>Contains one from (Element 4.1.1, Element 4.1.2 or Element 4.1.3), and Element 4.1.4. | Conditional.<br><br>Contains one from (Element 4.1.1, Element 4.1.2 or Element 4.1.3), and Element 4.1.4. | Horizontal Coordinate System Definition. (FDGC field name = horizsys) The reference frame or system from which linear or angular quantities are measured and assigned to the position that a point occupies. |
| 4.1.1 | Geographic | Compound | If this element is selected from Element 4.1, Mandatory.<br><br>Contains Elements 4.1.1.1 – 4.1.1.3. | If this element is selected from Element 4.1, Mandatory.<br><br>Contains Elements 4.1.1.1 – 4.1.1.3. | Geographic. (FDGC field name = geograph) The quantities of latitude and longitude which define the position of a point on the Earth's surface with respect to a reference spheroid. |
| 4.1.1.1 | Latitude Resolution | Real | If Element 4.1.1 is selected from Element 4.1, Mandatory. | If Element 4.1.1 is selected from Element 4.1, Mandatory. | Latitude Resolution. (FDGC field name = latres) The minimum difference between two adjacent latitude values expressed in Geographic Coordinate Units of measure. Domain: Latitude Resolution > 0.0 |
| 4.1.1.2 | Longitude Resolution | Real | If Element 4.1.1 is selected from Element 4.1, Mandatory. | If Element 4.1.1 is selected from Element 4.1, Mandatory. | Longitude Resolution. (FDGC field name = longres) The minimum difference between two adjacent longitude values expressed in Geographic Coordinate Units of measure. Domain: Longitude Resolution > 0.0 |
| 4.1.1.3 | Geographic Coordinate Units | Text | If Element 4.1.1 is selected from Element 4.1, Mandatory. | If Element 4.1.1 is selected from Element 4.1, Mandatory. | Geographic Coordinate Units. (FDGC field name = geogunit) Units of measure used for the latitude and longitude values. Domain: "Decimal degrees" "Decimal minutes" "Decimal seconds" "Degrees and decimal minutes" "Degrees, minutes, and decimal seconds" "Radians" "Grads" |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 4.1.2 | Planar | Text | If this element is selected from Element 4.1, Mandatory.<br><br>Contains one from (Element 4.1.2.1, Element 4.1.2.2 or Element 4.1.2.3) and Element 4.1.2.4.<br><br>Repeated unlimited times. | If this element is selected from Element 4.1, Mandatory.<br><br>Contains one from (Element 4.1.2.1, Element 4.1.2.2 or Element 4.1.2.3) and Element 4.1.2.4.<br><br>Repeated unlimited times. | Planar. (FDGC field name = planar) The quantities of distances, or distances and angles, which define the position of a Federal Geographic Data Committee FGDC_STD_001_1998 Content Standard for Digital Geospatial Metadata 25 point on a reference plane to which the surface of the Earth has been projected. |
| 4.1.2.1 | Map Projection | Compound | If this element is selected from Element 4.1.2 Mandatory.<br><br>Contains Element 4.1.2.1.1 and one from (Element 4.1.2.1.2 – Element 4.1.2.1.23).<br><br>For DWR created spatial data, only Element 4.1.2.1.2 (California Teale-Albers) is acceptable. Other elements are acceptable for spatial data created outside of DWR. | If this element is selected from Element 4.1.2 Mandatory.<br><br>Contains Element 4.1.2.1.1 and one from (Element 4.1.2.1.2 – Element 4.1.2.1.23). | Map Projection. (FDGC field name = mapproj) The systematic representation of all or part of the surface of the Earth on a plane or developable surface. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 4.1.2.1.1 | Map Projection Name | Text | If Element 4.1.2.1 is selected from Element 4.1.2, Mandatory. | If Element 4.1.2.1 is selected from Element 4.1.2, Mandatory. | Map Projection Name. (FDGC field name = mapprojn) Name of the map projection. Domain: "Albers Conical Equal Area" "Azimuthal Equidistant" "Equidistant Conic" "Equirectangular" "General Vertical Near-sided Projection" "Gnomonic" "Lambert Azimuthal Equal Area" "Lambert Conformal Conic" "Mercator" "Modified Stereographic for Alaska" "Miller Cylindrical" "Oblique Mercator" "Orthographic" "Polar Stereographic" "Polyconic" "Robinson" "Sinusoidal" "Space Oblique Mercator" "Stereographic" "Transverse Mercator" "van der Grinten" |
| 4.1.2.1.2 | Albers Conical Equal Area | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Albers Conical Equal Area. (FDGC field name = albers) Contains parameters for the Albers Conical Equal Area projection . |
| 4.1.2.1.3 | Azimuthal Equidistant | Compound | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.5 is selected from element 4.1.2.2, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.5 is selected from element 4.1.2.2, Mandatory. | Azimuthal Equidistant. (FDGC field name = azimequi) Contains parameters for the Azimuthal Equidistant projection . |
| 4.1.2.1.4 | Equidistant Conic | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Equidistant Conic. (FDGC field name = equircon) Contains parameters for the Equidistant Conic projection . |
| 4.1.2.1.5 | Equirectangular | Compound | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.5 is selected from element 4.1.2.2, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.5 is selected from element 4.1.2.2, Mandatory. | Equirectangular. (FDGC field name = equirect) Contains parameters for the Equirectangular projection . |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 4.1.2.1.6 | General Vertical Near-Sided Perspective | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | General Vertical Near-Sided Perspective. (FDGC field name = gvnsp) Contains parameters for the General . |
| 4.1.2.1.7 | Gnomonic | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Gnomonic. (FDGC field name = gnomonic) Contains parameters for the Gnomonic projection . |
| 4.1.2.1.8 | Lambert Azimuthal Equal Area | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Lambert Azimuthal Equal Area. (FDGC field name = lamberta) Contains parameters for the Lambert Azimuthal Equal Area projection . |
| 4.1.2.1.9 | Lambert Conformal Conic | Compound | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.4 is selected from element 4.1.2.2, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.4 is selected from element 4.1.2.2, Mandatory. | Lambert Conformal Conic. (FDGC field name = lambertc) Contains parameters for the Lambert Conformal . |
| 4.1.2.1.10 | Mercator | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Mercator. (FDGC field name = mercator) Contains parameters for the Mercator projection . |
| 4.1.2.1.11 | Modified Stereographic for Alaska | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Modified Stereographic for Alaska. (FDGC field name = modsak) Contains parameters for the Modified Stereographic for Alaska projection . |
| 4.1.2.1.12 | Miller Cylindrical | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Miller Cylindrical. (FDGC field name = miller) Contains parameters for the Miller Cylindrical projection . |

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| 4.1.2.1.13 | Oblique Mercator | Compound | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.4 is selected from element 4.1.2.2, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.4 is selected from element 4.1.2.2, Mandatory. | Oblique Mercator. (FDGC field name = obgmerc) Contains parameters for the Oblique Mercator projection . |
| 4.1.2.1.14 | Orthographic | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Orthographic. (FDGC field name = orthogr) Contains parameters for the Orthographic projection . |
| 4.1.2.1.15 | Polar Stereographic | Compound | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.3 is selected from element 4.1.2.2, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.3 is selected from element 4.1.2.2, Mandatory. | Polar Stereographic. (FDGC field name = polarst) Contains parameters for the Polar Stereographic projection . |
| 4.1.2.1.16 | Polyconic | Compound | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.4 is selected from element 4.1.2.2, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.4 is selected from element 4.1.2.2, Mandatory. | Polyconic. (FDGC field name = polycon) Contains parameters for the Polyconic projection. |
| 4.1.2.1.17 | Robinson | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Robinson. (FDGC field name = robinson) Contains parameters for the Robinson projection . |

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| 4.1.2.1.18 | Sinusoidal | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Sinusoidal. (FDGC field name = sinusoidel) Contains parameters for the Sinusoidal projection . |
| 4.1.2.1.19 | Space Oblique Mercator (Landsat) | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Space Oblique Mercator (Landsat). (FDGC field name = spaceobq) Contains parameters for the Space Oblique Mercator (Landsat) projection . |
| 4.1.2.1.20 | Stereographic | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Stereographic. (FDGC field name = stereo) Contains parameters for the Stereographic projection . |
| 4.1.2.1.21 | Transverse Mercator | Compound | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.2 is selected from element 4.1.2.2, Mandatory.<br><br>If Element 4.1.2.2.4 is selected from element 4.1.2.2, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>If Element 4.1.2.2.2 is selected from element 4.1.2.2, Mandatory.<br><br>If Element 4.1.2.2.4 is selected from element 4.1.2.2, Mandatory. | Transverse Mercator. (FDGC field name = transmer) Contains parameters for the Transverse Mercator projection . |
| 4.1.2.1.22 | van der Grinten | Compound | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | van der Grinten. (FDGC field name = vdgrin) Contains parameters for the van der Grinten projection . |
| 4.1.2.1.23 | Map Projection Parameters | Compound | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>Contains Element 4.1.2.1.23.1 - 4.1.2.1.23.18. | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>Contains Element 4.1.2.1.23.1 - 4.1.2.1.23.18. | Map Projection Parameters. (FDGC field name = mapprojp) A complete parameter set of the projection that was used for the data set. The information provided shall include the names of the parameters and values used for the data set that describe the mathematical relationship between the Earth and the plane or developable surface for the projection. |

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| 4.1.2.1.23.1 | Standard Parallel | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Standard Parallel. (FDGC field name = stdparll) Line of constant latitude at which the surface of the Earth and the plane or developable surface intersect . Domain: _90.0 <= Standard Parallel <= 90.0 |
| 4.1.2.1.23.2 | Longitude of Central Meridian | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Longitude of Central Meridian. (FDGC field name = longcm) the line of longitude at the center of a map projection generally used as the basis for constructing the projection . Domain: _180.0 <= Longitude of Central Meridian < 180.0 |
| 4.1.2.1.23.3 | Latitude of Projection Origin | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Latitude of Projection Origin. (FDGC field name = latprio) Latitude chosen as the origin of rectangular coordinates for a map projection. Domain: _90.0 <= Latitude of Projection Origin <= 90.0 |
| 4.1.2.1.23.4 | False Easting | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | False Easting. (FDGC field name = feast) The value added to all "x" values in the rectangular coordinates for a map projection. This value frequently is assigned to eliminate negative numbers. Expressed in the unit of measure identified in Planar Coordinate Units. |
| 4.1.2.1.23.5 | False Northing | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | False Northing. (FDGC field name = fnorth) The value added to all "y" values in the rectangular coordinates for a map projection. This value frequently is assigned to eliminate negative numbers. Expressed in the unit of measure identified in Planar Coordinate Units . |
| 4.1.2.1.23.6 | Scale Factor at Equator | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Scale Factor at Equator. (FDGC field name = sfequat) A multiplier for reducing a distance obtained from a map by computation or scaling to the actual distance along the equator. Domain: Scale Factor at Equator > 0.0 |
| 4.1.2.1.23.7 | Height of Perspective Point Above Surface | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Height of Perspective Point Above Surface. (FDGC field name = heightpt) height of viewpoint above the Earth, expressed in meters. Domain: of Perspective Point Above Surface > 0.0 |
| 4.1.2.1.23.8 | Longitude of Projection Center | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Longitude of Projection Center. (FDGC field name = longpc) Longitude of the point of projection for azimuthal projections . Domain: _180.0 <= Longitude of Projection Center < 180.0 |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 4.1.2.1.23.9 | Latitude of Projection Center | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Latitude of Projection Center. (FDGC field name = latpric) Latitude of the point of projection for azimuthal projections. Domain: Latitude of Projection Center <= 90.0 |
| 4.1.2.1.23.10 | Scale Factor at Center Line | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Scale Factor at Center Line. (FDGC field name = sfctrlin) A multiplier for reducing a distance obtained from a map by computation or scaling to the actual distance along the center line . Domain: Scale Factor at Center Line > 0.0 |
| 4.1.2.1.23.11 | Oblique Line Azimuth | Real | If this element is selected from Element 4.1.2.1.23, Conditional.<br><br>Contains Element 4.1.2.1.23.11.1 and Element 4.1.2.1.23.11.2. | If this element is selected from Element 4.1.2.1.23, Conditional.<br><br>Contains Element 4.1.2.1.23.11.1 and Element 4.1.2.1.23.11.2. | Oblique Line Azimuth. (FDGC field name = obglazim) Method used to describe the line along which an oblique mercator map projection is centered using the map projection origin and an azimuth . |
| 4.1.2.1.23.11.1 | Azimuthal Angle | Real | If this Element 4.1.2.1.23.11 is selected from Element 4.1.2.1.23, Mandatory | If this Element 4.1.2.1.23.11 is selected from Element 4.1.2.1.23, Mandatory | Azimuthal Angle. (FDGC field name = azimangl) Angle measured clockwise from north, and expressed in degrees. Domain: 0.0 <= Azimuthal Angle < 360.0 |
| 4.1.2.1.23.11.2 | Azimuth Measure Point Longitude | Real | If this Element 4.1.2.1.23.11 is selected from Element 4.1.2.1.23, Mandatory | If this Element 4.1.2.1.23.11 is selected from Element 4.1.2.1.23, Mandatory | Azimuth Measure Point Longitude. (FDGC field name = azimptl) Longitude of the map projection origin . Domain: _180.0 <= Azimuth Measure Point Longitude <180.0 |
| 4.1.2.1.23.12 | Oblique Line Point | Compound | If this element is selected from Element 4.1.2.1.23, Conditional.<br><br>Contains Element 4.1.2.1.23.12.1 – 4.1.2.1.23.12.4. | If this element is selected from Element 4.1.2.1.23, Conditional.<br><br>Contains Element 4.1.2.1.23.12.1 – 4.1.2.1.23.12.4. | Oblique Line Point. (FDGC field name = obqlpt) Method used to describe the line along which an oblique mercator map projection is centered using two points near the limits of the mapped region that define the center line. . |

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| 4.1.2.1.23.12.1 | Oblique Line Latitude | Real | If this Element 4.1.2.1.23.12 is selected from Element 4.1.2.1.23, Mandatory | If this Element 4.1.2.1.23.12 is selected from Element 4.1.2.1.23, Mandatory | Oblique Line Latitude. (FDGC field name = obqllat) Latitude of a point defining the oblique line . Domain: _90.0 <= Oblique Line Latitude <= 90.0 |
| 4.1.2.1.23.12.2 | Oblique Line Longitude | Real | If this Element 4.1.2.1.23.12 is selected from Element 4.1.2.1.23, Mandatory | If this Element 4.1.2.1.23.12 is selected from Element 4.1.2.1.23, Mandatory | Oblique Line Longitude. (FDGC field name = obqllong) longitude of a point defining the oblique line . Domain: _180.0 <= Oblique Line Longitude < 180.0 |
| 4.1.2.1.23.13 | Straight Vertical Longitude from Pole | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Straight Vertical Longitude from Pole. (FDGC field name = svlong) Longitude to be oriented straight up from the North or South Pole . Domain: _180.0 <= Straight Vertical Longitude from Pole < 180.0 |
| 4.1.2.1.23.14 | Scale Factor at Projection Origin | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Scale Factor at Projection Origin. (FDGC field name = sfprjorg) A multiplier for reducing a distance obtained from a map by computation or scaling to the actual distance at the projection origin . Domain: Scale Factor at Projection Origin > 0.0 |
| 4.1.2.1.23.15 | Landsat Number | Integer | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Landsat Number. (FDGC field name = landsat) Number of the Landsat satellite. (Note: This data element exists solely to provide a parameter needed to define the space oblique mercator projection. It is not used to identify data originating from a remote sensing vehicle.) . |
| 4.1.2.1.23.16 | Path Number | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Path Number. (FDGC field name = pathnum) Number of the orbit of the Landsat satellite. (Note: This data element exists solely to provide a parameter needed to define the space oblique mercator projection. It is not used to identify data originating from a remote sensing vehicle.) . Domain: 0 < Path Number < 251 for Landsats 1, 2, or 3 0 < Path Number < 233 for Landsats 4 or 5, free integer |
| 4.1.2.1.23.17 | Scale Factor at Central Meridian | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Scale Factor at Central Meridian. (FDGC field name = sfctrmer) A multiplier for reducing a distance obtained from a map by computation or scaling to the actual distance along the central meridian. Domain: Scale Factor at Central Meridian > 0.0 |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 4.1.2.1.23.18 | Other Projection's Definition | Real | If this element is selected from Element 4.1.2.1.23, Conditional. | If this element is selected from Element 4.1.2.1.23, Conditional. | Other Projection's Definition. (FDGC field name = oprojdef) A description of a projection, not defined elsewhere in the standard, that was used for the data set. The information provided shall include the name of the projection, names of parameters and values used for the data set, and the citation of the specification for the algorithms that describe the mathematical relationship between Earth and plane or developable surface for the projection. |
| 4.1.2.2 | Grid Coordinate System | Compound | If this element is selected from Element 4.1.2 Mandatory.<br><br>Contains Element 4.1.2.2.1, and one of (Element 4.1.2.2.2 - Element 4.1.2.2.6) | If this element is selected from Element 4.1.2 Mandatory.<br><br>Contains Element 4.1.2.2.1, and one of (Element 4.1.2.2.2 - Element 4.1.2.2.6) | Grid Coordinate System. (FDGC field name = gridsys) A plane-rectangular coordinate system usually based on, and mathematically adjusted to, a map projection so that geographic positions can be readily transformed to and from plane coordinates. |
| 4.1.2.2.1 | Grid Coordinate System Name | Text | If Element 4.1.2.2 is selected from Element 4.1.2, Mandatory. | If Element 4.1.2.2 is selected from Element 4.1.2, Mandatory. | Grid Coordinate System Name. (FDGC field name = gridsysn) Name of the grid coordinate system . Domain: "Universal Transverse Mercator" "Universal Polar Stereographic" "State Plane Coordinate System 1927" "State Plane Coordinate System 1983" "ARC Coordinate System" "other grid system" |
| 4.1.2.2.2 | Universal Transverse Mercator (UTM) | Compound | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>Contains Element 4.1.2.2.2.1 and Element 4.1.2.21. | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>Contains Element 4.1.2.2.2.1 and Element 4.1.2.21. | Universal Transverse Mercator (UTM). (FDGC field name = utm) A grid system based on the transverse mercator projection, applied between latitudes 84 degrees north and 80 degrees south on the Earth's surface. |
| 4.1.2.2.2.1 | UTM Zone Number | Integer | If Element 4.1.2.2.2 is selected from 4.1.2.1, Mandatory | If Element 4.1.2.2.2 is selected from 4.1.2.1, Mandatory | UTM Zone Number. (FDGC field name = utmzone) Identifier for the UTM zone . Domain: 1 <= UTM Zone Number <= 60 for the northern hemisphere; _60 <= UTM Zone Number <= _1 for the southern hemisphere |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 4.1.2.2.3 | Universal Polar Stereographic (UPS) | Compound | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>Contains Element 4.1.2.2.3.1 and Element 4.1.2.15. | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>Contains Element 4.1.2.2.3.1 and Element 4.1.2.15. | Universal Polar Stereographic (UPS). (FDGC field name = ups) A grid system based on the polar stereographic projection, applied to the Earth's polar regions north of 84 degrees north and south of 80 degrees south . |
| 4.1.2.2.3.1 | UPS Zone Identifier | Text | If Element 4.1.2.2.3 is selected from 4.1.2.1, Mandatory | If Element 4.1.2.2.3 is selected from 4.1.2.1, Mandatory | UPS Zone Identifier. (FDGC field name = upszone) Identifier for the UPS zone . Domain: "A" "B" "Y" "Z" |
| 4.1.2.2.4 | State Plane Coordinate System (SPCS) | Compound | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>Contains Element 4.1.2.2.4.1 and one from (Element 4.1.2.1.9, Element 4.1.2.1.21, Element 4.1.2.1.13, or Element 4.1.2.1.16) | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>Contains Element 4.1.2.2.4.1 and one from (Element 4.1.2.1.9, Element 4.1.2.1.21, Element 4.1.2.1.13, or Element 4.1.2.1.16) | State Plane Coordinate System (SPCS). (FDGC field name = spcs) A plane-rectangular coordinate system established for each state in the United States by the National Geodetic Survey . |
| 4.1.2.2.4.1 | SPCS Zone Identifier | Text | If Element 4.1.2.2.4 is selected from 4.1.2.1, Mandatory | If Element 4.1.2.2.4 is selected from 4.1.2.1, Mandatory | SPCS Zone Identifier. (FDGC field name = spcszone) Identifier for the SPCS zone . Domain: Four-digit numeric codes for the State Plane Coordinate Systems based on the North American Datum of 1927 are found in Department of Commerce, 1986, Representation of geographic point locations for information interchange (Federal Information Processing Standard 70_1): Washington: Department of Commerce, National Institute of Standards and Technology. Codes for the State Plane Coordinate Systems based on the North American Datum of 1983 are found in Department of Commerce, 1989 (January), State Plane Coordinate System of 1983 (National Oceanic and Atmospheric Administration Manual NOS NGS 5): Silver Spring, Maryland, National Oceanic and Atmospheric Administration, National Ocean Service, Coast and Geodetic Survey. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 4.1.2.2.5 | ARC Coordinate System | Compound | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>Contains Element 4.1.2.2.1.1 and one from (Element 4.1.2.1.5, or Element 4.1.2.1.3) | If this element is selected from Element 4.1.2.1, Mandatory.<br><br>Contains Element 4.1.2.2.1.1 and one from (Element 4.1.2.1.5, or Element 4.1.2.1.3) | ARC Coordinate System. (FDGC field name = arcsys) The Equal Arc-second Coordinate System, a plane-rectangular coordinate system established in Department of Defense, 1990, Military specification ARC Digitized Raster Graphics (ADRG) (MIL_A_89007): Philadelphia, Department of Defense, Defense Printing Service Detachment Office . |
| 4.1.2.2.5.1 | ARC System Zone Identifier | Integer | If Element 4.1.2.2.5 is selected from 4.1.2.1, Mandatory | If Element 4.1.2.2.5 is selected from 4.1.2.1, Mandatory | ARC System Zone Identifier. (FDGC field name = arczone) Identifier for the ARC Coordinate System Zone. Domain: 1 <= ARC System Zone Identifier <= 18 |
| 4.1.2.2.6 | Other Grid System's Definition | Free Text | If this element is selected from Element 4.1.2.1, Mandatory. | If this element is selected from Element 4.1.2.1, Mandatory. | Other Grid System's Definition. (FDGC field name = othergrd) A complete description of a grid system, not defined elsewhere in this standard, that was used for the data set. The information provided shall include the name of the grid system, the names of the parameters and values used for the data set, and the citation of the specification for the algorithms that describe the mathematical relationship between the Earth and the coordinates of the grid system . |
| 4.1.2.3 | Local Planar | Compound | If this element is selected from Element 4.1.2 Mandatory.<br><br>Contains Element 4.1.2.3.1 and Element 4.1.2.3.2 | If this element is selected from Element 4.1.2 Mandatory.<br><br>Contains Element 4.1.2.3.1 and Element 4.1.2.3.2 | Local Planar. (FDGC field name = localp) Any right-handed planar coordinate system of which the z-axis coincides with a plumb line through the origin that locally is aligned with the surface of the Earth . |
| 4.1.2.3.1 | Local Planar Description | Free Text | If Element 4.1.2.3 is selected from 4.1.2, Mandatory. | If Element 4.1.2.3 is selected from 4.1.2, Mandatory. | Local Planar Description. (FDGC field name = localpd) A description of the local planar system. |
| 4.1.2.3.2 | Local Planar Georeference Information | Free Text | If Element 4.1.2.3 is selected from 4.1.2, Mandatory. | If Element 4.1.2.3 is selected from 4.1.2, Mandatory. | Local Planar Georeference Information. (FDGC field name = localpgi) A description of the information provided to register the local planar system to the Earth (e.g. control points, satellite ephemeral data, inertial navigation data) . |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 4.1.2.4 | Planar Coordinate Information | Compound | Mandatory<br><br>Contains Element 4.1.2.1.1 and one from (Element 4.1.2.4.2 - 4.1.2.4.4) | Mandatory<br><br>Contains Element 4.1.2.1.1 and one from (Element 4.1.2.4.2 - 4.1.2.4.4) | Planar Coordinate Information. (FDGC field name = planci) Information about the coordinate system developed on the planar surface. |
| 4.1.2.4.1 | Planar Coordinate Encoding Method | Text | Mandatory. | Mandatory. | Planar Coordinate Encoding Method. (FDGC field name = plance) The means used to represent horizontal positions . Domain: "coordinate pair" "distance and bearing" "row and column" |
| 4.1.2.4.2 | Coordinate Representation | Compound | If this element is selected from Element 4.1.2.4 Mandatory.<br><br>Contains Element 4.1.2.4.2.1 and Element 4.1.2.4.2.2 | If this element is selected from Element 4.1.2.4 Mandatory.<br><br>Contains Element 4.1.2.4.2.1 and Element 4.1.2.4.2.2 | Coordinate Representation. (FDGC field name = coordrep) The method of encoding the position of a point by measuring its distance from perpendicular reference axes (the "coordinate pair" and "row and column" methods). . |
| 4.1.2.4.2.1 | Abscissa Resolution | Real | If Element 4.1.2.4.2 is selected from 4.1.2.4, Mandatory. | If Element 4.1.2.4.2 is selected from 4.1.2.4, Mandatory. | Abscissa Resolution. (FDGC field name = absres) The (nominal) minimum distance between the "x" or column values of two adjacent points, expressed in Planar Distance Units of measure . Domain: Abscissa Resolution > 0.0 |
| 4.1.2.4.2.2 | Ordinate Resolution | Real | If Element 4.1.2.4.2 is selected from 4.1.2.4, Mandatory. | If Element 4.1.2.4.2 is selected from 4.1.2.4, Mandatory. | Ordinate Resolution. (FDGC field name = ordres) The (nominal) minimum distance between the "y" or row values of two adjacent points, expressed in Planar Distance Units of measure. Domain: Ordinate Resolution > 0.0 |
| 4.1.2.4.3 | Distance and Bearing Representation | Compound | If this element is selected from Element 4.1.2.4 Mandatory.<br><br>Contains Elements 4.1.2.4.3.1 and 4.1.2.4.3.5 | If this element is selected from Element 4.1.2.4 Mandatory.<br><br>Contains Elements 4.1.2.4.3.1 and 4.1.2.4.3.5 | Distance and Bearing Representation. (FDGC field name = distbrep) A method of encoding the position of a point by measuring its distance and direction (azimuth angle) from another point . |
| 4.1.2.4.3.1 | Distance Resolution | Real | If Element 4.1.2.4.3 is selected from 4.1.2.4, Mandatory. | If Element 4.1.2.4.3 is selected from 4.1.2.4, Mandatory. | Distance Resolution. (FDGC field name = distres) The minimum distance measurable between two points, expressed Planar Distance Units of measure. Domain: Distance Resolution > 0.0 |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 4.1.2.4.3.2 | Bearing Resolution | Real | If Element 4.1.2.4.3 is selected from 4.1.2.4, Mandatory | If Element 4.1.2.4.3 is selected from 4.1.2.4, Mandatory | Bearing Resolution. (FDGC field name = bearres) The minimum angle measurable between two points, expressed in Bearing Units of measure. Domain: Bearing Resolution > 0.0 |
| 4.1.2.4.3.3 | Bearing Units | Text | If Element 4.1.2.4.3 is selected from 4.1.2.4, Mandatory. | If Element 4.1.2.4.3 is selected from 4.1.2.4, Mandatory. | Bearing Units. (FDGC field name = bearunit) Units of measure used for angles. Domain: "Decimal degrees" "Decimal minutes" "Decimal seconds" "Degrees and decimal minutes" "Degrees, minutes, and decimal seconds" "Radians" "Grads" |
| 4.1.2.4.3.4 | Bearing Reference Direction | Text | If Element 4.1.2.4.3 is selected from 4.1.2.4, Mandatory. | If Element 4.1.2.4.3 is selected from 4.1.2.4, Mandatory. | Bearing Reference Direction. (FDGC field name = bearrefd) Direction from which the bearing is measured . Domain: "North" "South" |
| 4.1.2.4.3.5 | Bearing Reference Meridian | Text | If Element 4.1.2.4.3 is selected from 4.1.2.4, Mandatory. | If Element 4.1.2.4.3 is selected from 4.1.2.4, Mandatory. | Bearing Reference Meridian. (FDGC field name = bearrefm) Axis from which the bearing is measured . Domain: "Assumed" "Grid" "Magnetic" "Astronomic" "Geodetic" |
| 4.1.2.4.4 | Planar Distance Units | Compound | If this element is selected from Element 4.1.2.4 Mandatory. | If this element is selected from Element 4.1.2.4 Mandatory. | Planar Distance Units. (FDGC field name = plandu) Units of measure used for distances. Domain: meters "international feet" "survey feet" free text |
| 4.1.3 | Local | Compound | If this element is selected from Element 4.1, Mandatory.<br><br>Contains Elements 4.1.1.1, 4.1.1.2 and 4.1.1.3; and Elements 4.1.3.1 and 4.1.3.2. | If this element is selected from Element 4.1, Mandatory.<br><br>Contains Element 4.1.1.1, Element 4.1.1.2 and Element 4.1.1.3. | Local. (FDGC field name = local) A description of any coordinate system that is not aligned with the surface of the Earth. |
| 4.1.3.1 | Local Description | Free Text | If Element 4.1.3 is selected from 4.1, Mandatory. | If Element 4.1.3 is selected from 4.1, Mandatory. | Local Description. (FDGC field name = localdes) A description of any coordinate system that is not aligned with the surface of the Earth . |
| 4.1.3.2 | Local Georeference Information | Free Text | If Element 4.1.3 is selected from 4.1, Mandatory. | If Element 4.1.3 is selected from 4.1, Mandatory. | Local Georeference Information. (FDGC field name = localgeo) A description of the information provided to register the local system to the Earth (e.g. control points, satellite ephemeral data, inertial navigation data). |
| 4.1.4 | Geodetic Model | Compound | Conditional.<br><br>Contains Elements 4.1.4.1 – 4.1.4.4 | Conditional.<br><br>Contains Elements 4.1.4.1 – 4.1.4.4 | Geodetic Model. (FDGC field name = geodetic) Parameters for the shape of the earth. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 4.1.4.1 | Horizontal Datum Name | Text | Conditional. | Conditional. | Horizontal Datum Name. (FDGC field name = horizdn) The identification given to the reference system used for defining the coordinates of points. Domain: "North American Datum of 1927" "North American Datum of 1983" |
| 4.1.4.2 | Ellipsoid Name | Text | Mandatory. | Mandatory. | Ellipsoid Name. (FDGC field name = ellips) Identification given to established representations of the Earth's shape. Domain: "Clarke 1866" "Geodetic Reference System 80" free text |
| 4.1.4.3 | Semi-Major Axis | Real | Mandatory. | Mandatory. | Semi-Major Axis. (FDGC field name = semiaxis) Radius of the equatorial axis of the ellipsoid . Domain: Semi-major Axis > 0.0 |
| 4.1.4.4 | Denominator of Flattening Ratio | Real | Conditional. | Conditional. | Denominator of Flattening Ratio. (FDGC field name = denflat) The denominator of the ratio of the difference between the equatorial and polar radii of the ellipsoid when the numerator is set to 1 . Domain: Denominator of Flattening > 0.0 |
| 4.2 | Vertical Coordinate System Definition | Compound | Conditional.<br><br>Contains Element 4.2.1 and Element 4.2.2. | Conditional.<br><br>Contains Element 4.2.1 and Element 4.2.2. | Vertical Coordinate System Definition. (FDGC field name = vertdef) The reference frame or system from which vertical distances (altitudes or depths) are measured. |
| 4.2.1 | Altitude System Definition | Compound | Conditional.<br><br>Contains Elements 4.2.1.1 - 4.2.1.4. | Conditional.<br><br>Contains Elements 4.2.1.1 - 4.2.1.4. | Altitude System Definition. (FDGC field name = altsys) The reference frame or system from which altitudes (elevations) are measured. The term "altitude"' is used instead of the common term "elevation" to conform to the terminology in Federal Information Processing Standards 70_1 and 173. |
| 4.2.1.1 | Altitude Datum Name | Text | Mandatory. | Mandatory. | Altitude Datum Name. (FDGC field name = altdatum) The identification given to the surface taken as the surface of reference from which altitudes are measured. Domain: "National Geodetic Vertical Datum of 1929" "North American Vertical Datum of 1988" free text |
| 4.2.1.2 | Altitude Resolution | Real | Mandatory. | Mandatory. | Altitude Resolution. (FDGC field name = altres) The minimum distance possible between two adjacent altitude values, expressed in Altitude Distance Units of measure. Domain: Altitude Resolution > 0.0 |
| 4.2.1.3 | Altitude Distance Units | Text | Mandatory. | Mandatory. | Altitude Distance Units. (FDGC field name = altunits) Units in which altitudes are recorded. Domain: meters "feet" free text |
| 4.2.1.4 | Altitude Encoding Method | Text | Mandatory. | Mandatory. | Altitude Encoding Method. (FDGC field name = altenc) The means used to encode the altitudes. Domain: "Explicit elevation coordinate included with horizontal coordinates" "Implicit coordinate" "Attribute values" |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 4.2.2 | Depth System Definition | Compound | Conditional.<br><br>Contains Elements 4.2.2.1 - 4.2.2.4. | Conditional.<br><br>Contains Elements 4.2.2.1 - 4.2.2.4. | Depth System Definition. (FDGC field name = depthsys) The reference frame or system from which depths are measured. |
| 4.2.2.1 | Depth Datum Name | Text | Mandatory. | Mandatory. | Depth Datum Name. (FDGC field name = depthdn) The identification given to surface of reference from which depths are measured. Domain: "Local surface" "Chart datum; datum for sounding reduction" "Lowest astronomical tide" "Highest astronomical tide" "Mean low water" "Mean high water" "Mean sea level" "Land survey datum" "Mean low water springs" "Mean high water springs" "Mean low water neap" "Mean high water neap" "Mean lower low water" "Mean lower low water springs" "Mean higher high water" "Mean higher low water" "Mean lower high water" "Spring tide" "Tropic lower low water" "Neap tide" "High water" "Higher high water" "Low water" "Low-water datum" "Lowest low water" "Lower low water" "Lowest normal low water" "Mean tide level" "Indian spring low water" "High-water full and charge" "Low-water full and charge" "Columbia River datum" "Gulf Coast low water datum" "Equatorial springs low water" "Approximate lowest astronomical tide" "No correction" free text |
| 4.2.2.2 | Depth Resolution | Real | Mandatory.<br><br>Can be repeated unlimited times | Mandatory.<br><br>Can be repeated unlimited times | Depth Resolution. (FDGC field name = depthres) the minimum distance possible between two adjacent depth values, expressed in Depth Distance Units of measure. Domain: Depth Resolution > 0.0 |
| 4.2.2.3 | Depth Distance Units | Text | Mandatory. | Mandatory. | Depth Distance Units. (FDGC field name = depthdu) Units in which depths are recorded. Domain: meters "feet" free text |
| 4.2.2.4 | Depth Encoding Method | Text | Mandatory. | Mandatory. | Depth Encoding Method. (FDGC field name = depthem) The means used to encode depths. Domain: "Explicit depth coordinate included with horizontal coordinates" "Implicit coordinate" "Attribute values" |
| | | | | | |
| 5 | Entity and Attribute Information | Compound | Mandatory.<br><br>Contains Element 5.1. May also contain Element 5.2. | Conditional.<br><br>Contains one or both from (Element 5.1 or Element 5.2) | Entity and Attribute Information. (FDGC field name = eainfo) Details about the information content of the data set, including the entity types, their attributes, and the domains from which attribute values may be assigned. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 5.1 | Detailed Description | Compound | If this element is selected from Element 5, Mandatory.<br><br>Contains Element 5.1.1 and Element 5.1.2.<br><br>Can be repeated unlimited times | If this element is selected from Element 5, Mandatory.<br><br>Contains Element 5.1.1 and Element 5.1.2.<br><br>Can be repeated unlimited times | Detailed Description. (FDGC field name = detailed) Description of the entities, attributes, attribute values, and related characteristics encoded in the data set. |
| 5.1.1 | Entity Type | Compound | If Element 5.1 is selected from Element 5, Mandatory.<br><br>Contains Element 5.1.1.1 – 5.1.1.3. | If Element 5.1 is selected from Element 5, Mandatory.<br><br>Contains Element 5.1.1.1 – 5.1.1.3. | Entity Type. (FDGC field name = enttype) The definition and description of a set into which similar entity instances are classified. |
| 5.1.1.1 | Entity Type Label | Text | If Element 5.1 is selected from Element 5, Mandatory. | If Element 5.1 is selected from Element 5, Mandatory. | Entity Type Label. (FDGC field name = enttypl) The name of the entity type. |
| 5.1.1.2 | Entity Type Definition | Free Text | If Element 5.1 is selected from Element 5, Mandatory. | If Element 5.1 is selected from Element 5, Mandatory. | Entity Type Definition. (FDGC field name = enttypd) The description of the entity type. |
| 5.1.1.3 | Entity Type Definition Source | Free Text | If Element 5.1 is selected from Element 5, Mandatory. | If Element 5.1 is selected from Element 5, Mandatory. | Entity Type Definition Source. (FDGC field name = enttypds) The authority of the definition. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 5.1.2 | Attribute | Compound | If Element 5.1 is selected from Element 5, Mandatory.<br><br>If Element 5.1.2.4.1 is selected from Element 5.1.2.4, Mandatory<br><br>If Element 5.1.2.4.2 is selected from Element 5.1.2.4, Mandatory<br><br>Contains Elements 5.1.2.1 – 5.1.2.8.<br><br>Can be repeated unlimited times. | If Element 5.1 is selected from Element 5, Mandatory.<br><br>If Element 5.1.2.4.1 is selected from Element 5.1.2.4, Mandatory<br><br>If Element 5.1.2.4.2 is selected from Element 5.1.2.4, Mandatory<br><br>Contains Elements 5.1.2.1 – 5.1.2.8.<br><br>Can be repeated unlimited times. | Attribute. (FDGC field name = attr) A defined characteristic of an entity. |
| 5.1.2.1 | Attribute Label | Text | If Element 5.1 is selected from Element 5, Mandatory. | If Element 5.1 is selected from Element 5, Mandatory. | Attribute Label. (FDGC field name = attrlabl) The name of the attribute. |
| 5.1.2.2 | Attribute Definition | Free Text | If Element 5.1 is selected from Element 5, Mandatory. | If Element 5.1 is selected from Element 5, Mandatory. | Attribute Definition. (FDGC field name = attrdef) The description of the attribute. |
| 5.1.2.3 | Attribute Definition Source | Free Text | If Element 5.1 is selected from Element 5, Mandatory | If Element 5.1 is selected from Element 5, Mandatory | Attribute Definition Source. (FDGC field name = attrdefs) The authority of the definition. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 5.1.2.4 | Attribute Domain Values | Compound | If Element 5.1 is selected from Element 5, Mandatory.<br><br>Contains one from (Element 5.1.2.4.1, Element 5.1.2.4.2, Element 5.1.2.4.3, Element 5.1.2.4.4)<br><br>Can be repeated unlimited times. | If Element 5.1 is selected from Element 5, Mandatory.<br><br>Contains one from (Element 5.1.2.4.1, Element 5.1.2.4.2, Element 5.1.2.4.3, Element 5.1.2.4.4)<br><br>Can be repeated unlimited times. | Attribute Domain Values. (FDGC field name = attrdomv) The valid values that can be assigned for an attribute. |
| 5.1.2.4.1 | Enumerated Domain | Compound | If this element is selected from Element 5.1.2.4, Mandatory.<br><br>Contains Elements 5.1.2.4.1.1 – 5.1.2.4.1.3, and Element 5.1.2 | If this element is selected from Element 5.1.2.4, Mandatory.<br><br>Contains Elements 5.1.2.4.1.1 – 5.1.2.4.1.3, and Element 5.1.2 | Enumerated Domain. (FDGC field name = edom) The members of an established set of valid values. |
| 5.1.2.4.1.1 | Enumerated Domain Value | Text | If Element 5.1.2.4.1 is selected from Element 5.1.2.4, Mandatory. | If Element 5.1.2.4.1 is selected from Element 5.1.2.4, Mandatory. | Enumerated Domain Value. (FDGC field name = edomv) The name or label of a member of the set. |
| 5.1.2.4.1.2 | Enumerated Domain Value Definition | Free Text | If Element 5.1.2.4.1 is selected from Element 5.1.2.4, Mandatory. | If Element 5.1.2.4.1 is selected from Element 5.1.2.4, Mandatory. | Enumerated Domain Value Definition. (FDGC field name = edomvd) The description of the value. |
| 5.1.2.4.1.3 | Enumerated Domain Value Definition Source | Free Text | If Element 5.1.2.4.1 is selected from Element 5.1.2.4, Mandatory | If Element 5.1.2.4.1 is selected from Element 5.1.2.4, Mandatory | Enumerated Domain Value Definition Source. (FDGC field name = edomvds) the authority of the definition. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 5.1.2.4.2 | Range Domain | Compound | If this element is selected from Element 5.1.2.4, Mandatory.<br><br>Contains Elements 5.1.2.4.2.1 – 5.1.2.4.2.3, and Element 5.1.2 | If this element is selected from Element 5.1.2.4, Mandatory.<br><br>Contains Elements 5.1.2.4.2.1 – 5.1.2.4.2.3, and Element 5.1.2 | Range Domain. (FDGC field name = rdom) The minimum and maximum values of a continuum of valid values. |
| 5.1.2.4.2.1 | Range Domain Minimum | Text | If Element 5.1.2.4.2 is selected from Element 5.1.2.4, Mandatory. | If Element 5.1.2.4.2 is selected from Element 5.1.2.4, Mandatory. | Range Domain Minimum. (FDGC field name = rdommin) The least value that the attribute can be assigned. |
| 5.1.2.4.2.2 | Range Domain Maximum | Text | If Element 5.1.2.4.2 is selected from Element 5.1.2.4, Mandatory. | If Element 5.1.2.4.2 is selected from Element 5.1.2.4, Mandatory. | Range Domain Maximum. (FDGC field name = rdommax) The greatest value that the attribute can be assigned. |
| 5.1.2.4.2.3 | Attribute Units of Measure | Text | If Element 5.1.2.4.2 is selected from Element 5.1.2.4, Conditional. | If Element 5.1.2.4.2 is selected from Element 5.1.2.4, Conditional. | Attribute Units of Measure. (FDGC field name = attrunit) The standard of measurement for an attribute value. |
| 5.1.2.4.2.4 | Attribute Measurement Resolution | Real | If Element 5.1.2.4.2 is selected from Element 5.1.2.4, Optional. | If Element 5.1.2.4.2 is selected from Element 5.1.2.4, Optional. | Attribute Measurement Resolution. (FDGC field name = attrmres) The smallest unit increment to which an attribute value is measured. Domain: Attribute Measurement Resolution > 0.0 |
| 5.1.2.4.3 | Codeset Domain | Compound | If this element is selected from Element 5.1.2.4, Mandatory.<br><br>Contains Elements 5.1.2.4.3.1 – 5.1.2.4.3.2 | If this element is selected from Element 5.1.2.4, Mandatory.<br><br>Contains Elements 5.1.2.4.3.1 – 5.1.2.4.3.2 | Codeset Domain. (FDGC field name = codesetd) Reference to a standard or list which contains the members of an established set of valid values. |
| 5.1.2.4.3.1 | Codeset Name | Free Text | If Element 5.1.2.4.3 is selected from Element 5.1.2.4, Conditional | If Element 5.1.2.4.3 is selected from Element 5.1.2.4, Conditional | Codeset Name. (FDGC field name = codesetn) The title of the codeset. |

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| 5.1.2.4.3.2 | Codeset Source | Text | If Element 5.1.2.4.3 is selected from Element 5.1.2.4, Conditional. | If Element 5.1.2.4.3 is selected from Element 5.1.2.4, Conditional. | Codeset Source. (FDGC field name = codesets) The authority for the codeset. |
| 5.1.2.4.4 | Unrepresentable Domain | Text | If this element is selected from Element 5.1.2.4, Mandatory. | If this element is selected from Element 5.1.2.4, Mandatory. | Unrepresentable Domain. (FDGC field name = udom) Description of the values and reasons why they cannot be represented. |
| 5.1.2.5 | Beginning Date of Attribute Values | Date | If Element 5.1 is selected from Element 5, Optional.<br><br>If this element is included the metadata, Element 5.1.2.6 must also be included. | If Element 5.1 is selected from Element 5, Optional.<br><br>If this element is included the metadata, Element 5.1.2.6 must also be included. | Beginning Date of Attribute Values. (FDGC field name = begdatea) Earliest or only date for which the attribute values are current. In cases when a range of dates are provided, this is the earliest date for which the information is valid. |
| 5.1.2.6 | Ending Date of Attribute Values | Date | If Element 5.1 is selected from Element 5, Optional.<br><br>If this element is included the metadata, Element 5.1.2.5 must also be included. | If Element 5.1 is selected from Element 5, Optional.<br><br>If this element is included the metadata, Element 5.1.2.5 must also be included. | Ending Date of Attribute Values. (FDGC field name = enddatea) latest date for which the information is current. Used in cases when a range of dates are provided . |
| 5.1.2.7 | Attribute Value Accuracy Information | Compound | If Element 5.1 is selected from Element 5, Mandatory.<br><br>Contains Element 5.1.2.7.1 and Element 5.1.2.7.2. | If Element 5.1 is selected from Element 5, Optional.<br><br>Contains Element 5.1.2.7.1 and Element 5.1.2.7.2. | Attribute Value Accuracy Information. (FDGC field name = attrvai) An assessment of the accuracy of the assignment of attribute values. |

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| 5.1.2.7.1 | Attribute Value Accuracy | Real | If this element is included the metadata, Element 5.1.2.7.2 must also be included. | If this element is included the metadata, Element 5.1.2.7.2 must also be included. | Attribute Value Accuracy. (FDGC field name = attrva) An estimate of the accuracy of the assignment of attribute values. |
| 5.1.2.7.2 | Attribute Value Accuracy Explanation | Text | If this element is included the metadata, Element 5.1.2.7.1 must also be included. | If this element is included the metadata, Element 5.1.2.7.1 must also be included. | Attribute Value Accuracy Explanation. (FDGC field name = attrvae) The definition of the Attribute Value Accuracy measure and units, and a description of how the estimate was derived. |
| 5.1.2.8 | Attribute Measurement Frequency | Text | If Element 5.1 is selected from Element 5, Optional. | If Element 5.1 is selected from Element 5, Optional. | Attribute Measurement Frequency. (FDGC field name = attrmfrq) The frequency with which attribute values are added. Domain: Unknown "As needed" "Irregular" "None planned" free text |
| 5.2 | Overview Description | Compound | If this element is selected from Element 5, Mandatory.<br><br>Contains Element 5.2.1 and Element 5.2.2.<br><br>Can be repeated unlimited times. | If this element is selected from Element 5, Mandatory.<br><br>Contains Element 5.2.1 and Element 5.2.2.<br><br>Can be repeated unlimited times. | Overview Description. (FDGC field name = overview) Summary of, and citation to detailed description of, the information content of the data set. |
| 5.2.1 | Entity and Attribute Overview | Text | If Element 5.2 is selected from Element 5, Mandatory. | If Element 5.2 is selected from Element 5, Mandatory. | Entity and Attribute Overview. (FDGC field name = eaover) Detailed summary of the information contained in a data set. |
| 5.2.2 | Entity and Attribute Detail Citation | Text | If Element 5.2 is selected from Element 5, Mandatory. | If Element 5.2 is selected from Element 5, Mandatory. | Entity and Attribute Detail Citation. (FDGC field name = eadetcit) Reference to the complete description of the entity types, attributes, and attribute values for the data set. |

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| 6 | Distribution Information | Compound | Mandatory,<br><br>Contains Elements 6.1 – 6.7.<br><br>Can be repeated unlimited times. | Conditional,<br><br>Contains Elements 6.1 – 6.7.<br><br>Can be repeated unlimited times. | Distribution Information. (FDGC field name = distinfo) Information about the distributor of and options for obtaining the data set. |
| 6.1 | Distributor | Compound | Mandatory. | Mandatory. | Distributor. (FDGC field name = distrib) The party from whom the data set may be obtained. |
| 6.2 | Resource Description | Text | Conditional. | Conditional. | Resource Description. (FDGC field name = resdesc) The identifier by which the distributor knows the data set. |
| 6.3 | Distribution Liability | Text | Mandatory. | Mandatory. | Distribution Liability. (FDGC field name = distliab) Statement of the liability assumed by the distributor. |
| 6.4 | Standard Order Process | Compound | Conditional.<br><br>Contains one from (Element 6.4.1 and Element 6.4.2) and Elements 6.4.3 – 6.4.5. | Conditional.<br><br>Contains one from (Element 6.4.1 and Element 6.4.2) and Elements 6.4.3 – 6.4.5. | Standard Order Process. (FDGC field name = stdorder) The common ways in which the data set may be obtained or received, and related instructions and fee information. |
| 6.4.1 | Non-Digital Form | Text | If this element selected from Element 6.4, Mandatory. | If this element selected from Element 6.4, Mandatory. | Non-Digital Form. (FDGC field name = nondig) The description of options for obtaining the data set on non-computer compatible media. |
| 6.4.2 | Digital Form | Compound | If this element selected from Element 6.4, Mandatory.<br><br>Contains Element 6.4.2.1 and Element 6.4.2.2.<br><br>Can be repeated unlimited times. | If this element selected from Element 6.4, Mandatory.<br><br>Contains Element 6.4.2.1 and Element 6.4.2.2.<br><br>Can be repeated unlimited times. | Digital Form. (FDGC field name = digform) The description of options for obtaining the data set on computer-compatible media. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 6.4.2.1 | Digital Transfer Information | Compound | If Element 6.4.2 selected from Element 6.4, Mandatory.<br><br>Contains Elements 6.4.2.1.1 - 6.4.2.7.<br><br>Can be repeated unlimited times. | If Element 6.4.2 selected from Element 6.4, Mandatory.<br><br>Contains Elements 6.4.2.1.1 - 6.4.2.7.<br><br>Can be repeated unlimited times. | Digital Transfer Information. (FDGC field name = digtinfo) Description of the form of the data to be distributed. |
| 6.4.2.1.1 | Format Name | Text | If Element 6.4.2 selected from Element 6.4, Mandatory.<br><br>If this element is used, DWR does not restrict the user to the domain values listed. | If Element 6.4.2 selected from Element 6.4, Mandatory. | Format Name. (FDGC field name = formname) The name of the data transfer format. Domain: "ARCE" ARC/INFO Export format "ARCG" ARC/INFO Generate format "ASCII" ASCII file, formatted for text attributes, declared format "BIL" Imagery, band interleaved by line "BIP" Imagery, band interleaved by pixel "BSQ" Imagery, band interleaved sequential "CDF" Common Data Format "CFF" Cartographic Feature File (U.S. Forest Service) "COORD" User-created coordinate file, declared format "DEM" Digital Elevation Model format (U.S. Geological Survey) "DFAD" Digital Feature Analysis Data (National Imagery and Mapping Agency) "DGN" Microstation format (Intergraph Corporation) "DIGEST" Digital Geographic Information Exchange Standard "DLG" Digital Line Graph (U.S. Geological Survey) "DTED" Digital Terrain Elevation Data (MIL-D-89020) "DWG" AutoCAD Drawing format "DX90" Data Exchange '90 "DXF" AutoCAD Drawing Exchange Format "ERDAS" ERDAS image files (ERDAS Corporation) "GRASS" Geographic Resources Analysis Support System "HDF" Hierarchical Data Format "IGDS" Interactive Graphic Design System format (Intergraph Corporation) "IGES" Initial Graphics Exchange Standard "MOSS" Multiple Overlay Statistical System export file "netCDF" network Common Data Format "NITF" National Imagery Transfer Format "RPF" Raster Product Format Federal Geographic Data Committee FGDC-STD-001-1998 Content Standard for Digital Geospatial Metadata 45 (National Imagery and Mapping Agency) "RVC" Raster Vector Converted format (MicroImages) "RVF" Raster Vector Format (MicroImages) "SDTS" Spatial Data Transfer Standard (Federal |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| | | | | | Information Processing Standard 173) "SIF" Standard Interchange Format (DOD Project 2851) "SLF" Standard Linear Format (National Imagery and Mapping Agency) "TIFF" Tagged Image File Format "TGRLN" Topologically Integrated Geographic Encoding and Referencing (TIGER) Line format (Bureau of the Census) "VPF" Vector Product Format (National Imagery and Mapping Agency) |
| 6.4.2.1.2 | Format Version Number | Text | If Element 6.4.2 selected from Element 6.4, Mandatory.<br><br>If the metadata contains this element, it must also contain Element 6.4.2.1.3, and may contain Element 6.4.2.1.4. | If Element 6.4.2 selected from Element 6.4, Mandatory.<br><br>If the metadata contains this element, it must also contain Element 6.4.2.1.3, and may contain Element 6.4.2.1.4. | Format Version Number. (FDGC field name = formvern) Version number of the format. |
| 6.4.2.1.3 | Format Version Date | Date | If Element 6.4.2 selected from Element 6.4, Mandatory.<br><br>If the metadata contains this element, it must also contain Element 6.4.2.1.2, and may contain Element 6.4.2.1.4. | If Element 6.4.2 selected from Element 6.4, Mandatory.<br><br>If the metadata contains this element, it must also contain Element 6.4.2.1.2, and may contain Element 6.4.2.1.4. | Format Version Date. (FDGC field name = formverd) Date of the version of the format. |
| 6.4.2.1.4 | Format Specification | Text | If Element 6.4.2 selected from Element 6.4, Optional. | If Element 6.4.2 selected from Element 6.4, Optional. | Format Specification. (FDGC field name = formspec) Name of a subset, profile, or product specification of the format. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 6.4.2.1.5 | Format Information Content | Text | If Element 6.4.2 selected from Element 6.4, Optional. | If Element 6.4.2 selected from Element 6.4, Optional. | Format Information Content. (FDGC field name = formcont) Description of the content of the data encoded in a format. |
| 6.4.2.1.6 | File Decompression Technique | Text | If Element 6.4.2 selected from Element 6.4, Conditional. | If Element 6.4.2 selected from Element 6.4, Conditional. | File Decompression Technique. (FDGC field name = filedec) Recommendations of algorithms or processes (including means of obtaining these algorithms or processes) that can be applied to read or expand data sets to which data compression techniques have been applied. Domain: No compression applied, free text |
| 6.4.2.1.7 | Transfer Size | Real | If Element 6.4.2 selected from Element 6.4, Optional. | If Element 6.4.2 selected from Element 6.4, Optional. | Transfer Size. (FDGC field name = transize) The size, or estimated size, of the transferred data set in megabytes. Domain: Transfer Size > 0.0 |
| 6.4.2.2 | Digital Transfer Option | Compound | If Element 6.4.2 selected from Element 6.4, Mandatory.<br><br>Contains one from (Element 6.2.4.2.2.1 and Element 6.2.4.2.2) | If Element 6.4.2 selected from Element 6.4, Mandatory.<br><br>Contains one from (Element 6.2.4.2.2.1 and Element 6.2.4.2.2) | Digital Transfer Option. (FDGC field name = digtopt) The means and media by which a data set is obtained from the distributor. |
| 6.4.2.2.1 | Online Option | Compound | If this element is selected from Element 6.4.2.2, Mandatory.<br><br>Contains Elements 6.2.4.2.2.1.1 - 6.2.4.2.2.1.3. | If this element is selected from Element 6.4.2.2, Mandatory.<br><br>Contains Elements 6.2.4.2.2.1.1 - 6.2.4.2.2.1.3. | Online Option. (FDGC field name = onlinopt) Information required to directly obtain the data set electronically. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 6.4.2.2.1.1 | Computer Contact Information | Compound | If Element 6.4.2.2.1 is selected from Element 6.4.2.2, Mandatory.<br><br>Contains one from (Element 6.2.4.2.2.1.1.1 or Element 6.2.4.2.2.1.1.2).<br><br>Can be repeated unlimited times. | If Element 6.4.2.2.1 is selected from Element 6.4.2.2, Mandatory.<br><br>Contains one from (Element 6.2.4.2.2.1.1.1 or Element 6.2.4.2.2.1.1.2).<br><br>Can be repeated unlimited times. | Computer Contact Information. (FDGC field name = computer) Instructions for establishing communications with the distribution computer. |
| 6.4.2.2.1.1.1 | Network Address | Compound | If this element is selected from Element 6.4.2.2.1.1, Mandatory.<br><br>Contains Element 6.4.2.2.1.1.1.1. | If this element is selected from Element 6.4.2.2.1.1, Mandatory.<br><br>Contains Element 6.4.2.2.1.1.1.1. | Network Address. (FDGC field name = networka) The electronic address from which the data set can be obtained from the distribution computer. |
| 6.4.2.2.1.1.1.1 | Network Resource Name | Free Text | If Element 6.4.2.2.1.1.1 is selected from Element 6.4.2.2.1.1, Mandatory. | If Element 6.4.2.2.1.1.1 is selected from Element 6.4.2.2.1.1, Mandatory. | Network Resource Name. (FDGC field name = networkr) The name of the file or service from which the data set can be obtained. |
| 6.4.2.2.1.1.2 | Dialup Instructions | Compound | If this element is selected from Element 6.4.2.2.1.1, Mandatory.<br><br>Contains Elements 6.4.2.2.1.1.2.1 - 6.4.2.2.1.1.2.8. | If this element is selected from Element 6.4.2.2.1.1, Mandatory.<br><br>Contains Elements 6.4.2.2.1.1.2.1 - 6.4.2.2.1.1.2.8. | Dialup Instructions. (FDGC field name = dialinst) Information required to access the distribution computer remotely through telephone lines. |
| 6.4.2.2.1.1.2.1 | Lowest BPS | Integer | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Mandatory. | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Mandatory. | Lowest BPS. (FDGC field name = lowbps) Lowest or only speed for the connection's communication, expressed in bits per second. Domain: Lowest BPS >= 110 |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 6.4.2.2.1.1.2.2 | Highest BPS | Integer | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Conditional. | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Conditional. | Highest BPS. (FDGC field name = highbps) Highest speed for the connection's communication, expressed in bits per second. Used in cases when a range of rates are provided. Domain: Highest BPS > Lowest BPS |
| 6.4.2.2.1.1.2.3 | Number Data Bits | Integer | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Mandatory. | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Mandatory. | Number DataBits. (FDGC field name = numdata) Number of data bits in each character exchanged in the communication. Domain: 7 <= Number DataBits <= 8 |
| 6.4.2.2.1.1.2.4 | Number Stop Bits | Integer | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Mandatory. | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Mandatory. | Number StopBits. (FDGC field name = numstop) Number of stop bits in each character exchanged in the communication. Domain: 1 <= Number StopBits <= 2 |
| 6.4.2.2.1.1.2.5 | Parity | Text | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Mandatory. | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Mandatory. | Parity. (FDGC field name = parity) Parity error checking used in each character exchanged in the communication. Domain: "None" "Odd" "Even" "Mark" "Space" |
| 6.4.2.2.1.1.2.6 | Compression Support | Text | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Conditional. | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Conditional. | Compression Support. (FDGC field name = compress) Data compression available through the modem service to speed data transfer . Domain: "V.32" "V.32bis" "V.42" "V.42bis" |
| 6.4.2.2.1.1.2.7 | Dialup Telephone | Text | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Mandatory. | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Mandatory. | Dialup Telephone. (FDGC field name = dialtel) The telephone number of the distribution computer. |
| 6.4.2.2.1.1.2.8 | Dialup File Name | Free Text | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Mandatory. | If Element 6.4.2.2.1.1.1.2 is selected from Element 6.4.2.2.1.1, Mandatory. | Dialup File Name. (FDGC field name = dialfile) The name of a file containing the data set on the distribution computer. |

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| 6.4.2.2.1.2 | Access Instructions" | Free Text | If Element 6.4.2.2.1 is selected from Element 6.4.2.2, Optional. | If Element 6.4.2.2.1 is selected from Element 6.4.2.2, Optional. | Access Instructions". (FDGC field name = accinst) Instructions on the steps required to access the data set. |
| 6.4.2.2.1.3 | Online Computer and Operating System | Free Text | If Element 6.4.2.2.1 is selected from Element 6.4.2.2, Optional. | If Element 6.4.2.2.1 is selected from Element 6.4.2.2, Optional. | Online Computer and Operating System. (FDGC field name = oncomp) The brand of distribution computer and its operating system. |
| 6.4.2.2.2 | Offline Option | Compound | If this element is selected from Element 6.4.2.2, Mandatory.<br><br>Contains Elements 6.2.4.2.2.2.1 - 6.2.4.2.2.2.4. | If this element is selected from Element 6.4.2.2, Mandatory.<br><br>Contains Elements 6.2.4.2.2.2.1 - 6.2.4.2.2.2.4. | Offline Option. (FDGC field name = offoptn) Information about media-specific options for receiving the data set . |
| 6.4.2.2.2.1 | Offline Media | Text | If Element 6.4.2.2 is selected from Element 6.4.2.1, Conditional.<br><br>Contains Element 6.4.2.2.2.2.1 and Element 6.4.2.2.2.2.2. | If Element 6.4.2.2 is selected from Element 6.4.2.1, Conditional.<br><br>Contains Element 6.4.2.2.2.2.1 and Element 6.4.2.2.2.2.2. | Offline Media. (FDGC field name = offmedia) Name of the media on which the data set can be received. Domain: "CD-ROM" "3-1/2 inch floppy disk" "5-1/4 inch floppy disk" "9-track tape" "4 mm cartridge tape" "8 mm cartridge tape" "1/4-inch cartridge tape" free text |
| 6.4.2.2.2.2 | Recording Capacity | Compound | If Element 6.4.2.2.2 is selected from Element 6.4.2.2, Conditional.<br><br>Contains Element 6.4.2.2.2.2.1 and Element 6.4.2.2.2.2.2. | If Element 6.4.2.2.2 is selected from Element 6.4.2.2, Conditional.<br><br>Contains Element 6.4.2.2.2.2.1 and Element 6.4.2.2.2.2.2. | Recording Capacity. (FDGC field name = reccap) The density of information to which data are written. Used in cases where different recording capacities are possible. . |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
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| 6.4.2.2.2.2.1 | Recording Density | Real | If Element 6.4.2.2.2 is selected from Element 6.4.2.2, Mandatory.<br><br>Can be repeated unlimited times. | If Element 6.4.2.2.2 is selected from Element 6.4.2.2, Mandatory.<br><br>Can be repeated unlimited times. | Recording Density. (FDGC field name = recden) The density in which the data set can be recorded. |
| 6.4.2.2.2.2.2 | Recording Density Units | Free Text | If Element 6.4.2.2.2 is selected from Element 6.4.2.2, Mandatory. | If Element 6.4.2.2.2 is selected from Element 6.4.2.2, Mandatory. | Recording Density Units. (FDGC field name = recdenu) The units of measure for the recording density. |
| 6.4.2.2.2.3 | Recording Format | Text | If Element 6.4.2.2.2 is selected from Element 6.4.2.2, Mandatory.<br><br>Can be repeated unlimited times. | If Element 6.4.2.2.2 is selected from Element 6.4.2.2, Mandatory.<br><br>Can be repeated unlimited times. | Recording Format. (FDGC field name = recfmt) The options available or method used to write the data set to the medium. Domain: "cpio" "tar" "High Sierra" "ISO 9660" "ISO 9660 with Rock Ridge extensions" "ISO 9660 with Apple HFS extensions" free text |
| 6.4.2.2.2.4 | Compatibility Information | Free Text | If Element 6.4.2.2.2 is selected from Element 6.4.2.2, Conditional. | If Element 6.4.2.2.2 is selected from Element 6.4.2.2, Conditional. | Compatibility Information. (FDGC field name = compat) Description of other limitations or requirements for using the medium. |
| 6.4.3 | Fees | Free Text | Mandatory. | Mandatory. | Fees. (FDGC field name = fees) The fees and terms for retrieving the data set. |
| 6.4.4 | Ordering Instructions | Free Text | Optional. | Optional. | Ordering Instructions. (FDGC field name = ordering) General instructions and advice about, and special terms and services provided for, the data set by the distributor. |
| 6.4.5 | Turnaround | Text | Optional. | Optional. | Turnaround. (FDGC field name = turnarnd) Typical turnaround time for the filling of an order. |
| 6.5 | Custom Order Process | Text | Conditional. | Conditional. | Custom Order Process. (FDGC field name = custom) Description of custom distribution services available, and the terms and conditions for obtaining these services. |
| 6.6 | Technical Prerequisites | Text | Optional. | Optional. | Technical Prerequisites. (FDGC field name = techpreq) Description of any technical capabilities that the consumer must have to use the data set in the form(s) provided by the distributor. |
| 6.7 | Available Time Period | Compound | Optional. | Optional. | Available Time Period. (FDGC field name = availabl) The time period when the data set will be available from the distributor. |

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| 7 | Metadata Reference Information | Compound | Mandatory.<br><br>Contains Elements 7.1 – 7.11. | Mandatory.<br><br>Contains Elements 7.1 – 7.11. | Metadata Reference Information. (FDGC field name = metainfo) Information on the currentness of the metadata information, and the responsible party. |
| 7.1 | Metadata Date | Date | Mandatory. | Mandatory. | Metadata Date. (FDGC field name = metd) The date that the metadata were created or last updated. |
| 7.2 | Metadata Review Date | Date | Optional. | Optional. | Metadata Review Date. (FDGC field name = metrd) The date of the latest review of the metadata entry. Domain: Metadata Review Date later than Metadata Date |
| 7.3 | Metadata Future Review Date | Date | Optional. | Optional. | Metadata Future Review Date. (FDGC field name = metfrd) The date by which the metadata entry should be reviewed. Domain: Metadata Future Review Date later than Metadata Review Date |
| 7.4 | Metadata Contact | Compound | Mandatory.<br><br>Contains Element 10. | Mandatory.<br><br>Contains Element 10. | Metadata Contact. (FDGC field name = metc) The party responsible for the metadata information. |
| 7.5 | Metadata Standard Name | Text | Mandatory. | Mandatory. | Metadata Standard Name. (FDGC field name = metstdn) The name of the metadata standard used to document the data set. Domain: FGDC Content Standard for Digital Geospatial Metadata free text |
| 7.6 | Metadata Standard Version | Text | Mandatory. | Mandatory. | Metadata Standard Version. (FDGC field name = metstdv) Identification of the version of the metadata standard used to document the data set. |
| 7.7 | Metadata Time Convention | Text | Conditional. | Conditional. | Metadata Time Convention. (FDGC field name = mettc) Form used to convey time of day information in the metadata entry. Used if time of day information is included in the metadata for a data set. Domain: local time "local time with time differential factor" "universal time" |
| 7.8 | Metadata Access Constraints | Text | Conditional. | Optional. | Metadata Access Constraints. (FDGC field name = metac) Restrictions and legal prerequisites for accessing the metadata. These include any access constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations on obtaining the metadata. . |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
|---|---|---|---|---|---|
| 7.9 | Metadata Use Constraints | Text | Conditional. | Optional. | Metadata Use Constraints. (FDGC field name = metuc) Restrictions and legal prerequisites for using the metadata after access is granted. These include any metadata use constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations on using the metadata. . |
| 7.10 | Metadata Security Information | Compound | Conditional.<br><br>Contains Elements 7.10.1 – 7.10.3. | Optional.<br><br>Contains Elements 7.10.1 – 7.10.3. | Metadata Security Information. (FDGC field name = metsi) Handling restrictions imposed on the metadata because of national security, privacy, or other concerns. |
| 7.10.1 | Metadata Security Classification System | Text | If Element 7.10 is included in the metadata, Mandatory. | If Element 7.10 is included in the metadata, Mandatory. | Metadata Security Classification System. (FDGC field name = metscs) Name of the classification system for the metadata. |
| 7.10.2 | Metadata Security Classification | Text | If Element 7.10 is included in the metadata, Mandatory. | If Element 7.10 is included in the metadata, Mandatory. | Metadata Security Classification. (FDGC field name = metsc) Name of the handling restrictions on the metadata. Domain: Top secret "Secret" "Confidential" "Restricted" "Unclassified" "Sensitive" |
| 7.10.3 | Metadata Security Handling Description | Text | If Element 7.10 is included in the metadata, Mandatory. | If Element 7.10 is included in the metadata, Mandatory. | Metadata Security Handling Description. (FDGC field name = metshd) Additional information about the restrictions on handling the metadata. |
| 7.11 | Metadata Extensions | Compound | Conditional.<br><br>Contains Elements 7.11.1 – 7.11.2. | Conditional.<br><br>Contains Elements 7.11.1 – 7.11.2. | Metadata Extensions. (FDGC field name = metextns) A reference to extended elements to the standard which may be defined by a metadata producer or a user community. Extended elements are elements outside the Standard, but needed by the metadata producer. If extended elements are created, they must follow the guidelines in Appendix D, Guidelines for Creating Extended Elements to the Content Standard for Digital Geospatial Metadata. |
| 7.11.1 | Online Linkage | Text | If Element 7.11 is included in the metadata, Conditional.<br><br>Can be repeated unlimited times. | If Element 7.11 is included in the metadata, Conditional.<br><br>Can be repeated unlimited times. | Online Linkage. (FDGC field name = onllink) The name of an online computer resource that contains the metadata extension information for the data set. Entries should follow the Uniform Resource Locator convention of the Internet. . |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
|---|---|---|---|---|---|
| 7.11.2 | Profile Name | Text | If Element 7.11 is included in the metadata, Conditional. | If Element 7.11 is included in the metadata, Conditional. | Profile Name. (FDGC field name = metprof) The name given to a document that describes the application of the Standard to a specific user community. |
| | | | | | |
| 8 | Citation Information | Compound | Mandatory.<br><br>Contains Elements 8.1 – 8.11 | Mandatory.<br><br>Contains Elements 8.1 – 8.11 | Citation Information. (FDGC field name = citeinfo) |
| 8.1 | Originator | Free Text | Mandatory. | Mandatory. | Originator. (FDGC field name = origin) The name of an organization or individual that developed the data set. If the name of editors or compilers are provided, the name must be followed by "(ed.)" or "(comp.)" respectively. Domain: "Unknown" |
| 8.2 | Publication Date | Date | Mandatory. | Mandatory. | Publication Date. (FDGC field name = pubdate) The date when the data set is published or otherwise made available for release. Domain: "Unknown" "Unpublished material" free date |
| 8.3 | Publication Time | Time | Optional. | Optional. | Publication Time. (FDGC field name = pubtime) The time of day when the data set is published or otherwise made available for release. Domain: "Unknown" free time |
| 8.4 | Title | Free Text | Mandatory. | Mandatory. | Title. (FDGC field name = title) The name by which the data set is known. Federal Geographic Data Committee FGDC_STD_001_1998 Content Standard for Digital Geospatial Metadata 54 . |
| 8.5 | Edition | Text | Mandatory. | Conditional. | Edition. (FDGC field name = edition) The version of the title . |
| 8.6 | Geospatial Data Presentation Form | Text | Conditional. | Conditional. | Geospatial Data Presentation Form. (FDGC field name = geoform) The mode in which the geospatial data are represented . Domain: (the listed domain is partially from pp. 88-91 in Anglo-American Committee on Cataloguing of Cartographic Materials, 1982, Cartographic materials: A manual of interpretation for AACR2: Chicago, American Library Association): "atlas" “audio” "diagram" “document” "globe" "map" "model" “multimedia presentation” "profile" “raster digital data” "remote-sensing image" "section" “spreadsheet” “tabular digital data” “vector digital data” “video” "view" free text |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
|---|---|---|---|---|---|
| 8.7 | Series Information | Compound | Conditional.<br><br>Contains Element 8.7.1 and Element 8.7.2. | Conditional.<br><br>Contains Element 8.7.1 and Element 8.7.2. | Series Information. (FDGC field name = serinfo) The identification of the series publication of which the data set is a part. |
| 8.7.1 | Series Name | Free Text | Mandatory. | Mandatory. | Series Name. (FDGC field name = sername) The name of the series publication of which the data set is a part . |
| 8.7.2 | Issue Identification | Free Text | Mandatory. | Mandatory. | Issue Identification. (FDGC field name = issue) Information identifying the issue of the series publication of which the data set is a part. |
| 8.8 | Publication Information | Compound | Conditional.<br><br>Contains Element 8.8.1 and Element 8.8.2. | Conditional.<br><br>Contains Element 8.8.1 and Element 8.8.2. | Publication Information. (FDGC field name = pubinfo) Publication details for published data sets. |
| 8.8.1 | Publication Place | Free Text | Mandatory. | Mandatory. | Publication Place. (FDGC field name = pubplace) The name of the city (and state or province, and country, if needed to identify the city) where the data set was published or released. . |
| 8.8.2 | Publisher | Free Text | Mandatory. | Mandatory. | Publisher. (FDGC field name = publish) The name of the individual or organization that published the data set . |
| 8.9 | Other Citation Details | Free Text | Conditional. | Conditional. | Other Citation Details. (FDGC field name = othercit) Other information required to complete the citation. |
| 8.10 | Online Linkage | Free Text | Optional. | Optional. | Online Linkage. (FDGC field name = onlink) The name of an online computer resource that contains the data set. Entries should follow the Uniform Resource Locator convention of the Internet. |
| 8.11 | Larger Work Citation | Compound | Conditional.<br><br>Contains Element 8. | Conditional.<br><br>Contains Element 8. | Larger Work Citation. (FDGC field name = lworkcit) The information identifying a larger work in which the data set is included. |
| | | | | | |
| 9 | Time Period Information | Compound | Mandatory.<br><br>Contains one of (Element 9.1, Element 9.2 or 9.3) | Mandatory.<br><br>Contains one of (Element 9.1, Element 9.2 or 9.3) | Time Period Information. (FDGC field name = timeinfo) Information about the date and time of an event. (Note: this section provides a means of stating temporal information, and is used by other sections of the metadata standard. This section is never used alone.) . |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
|---|---|---|---|---|---|
| 9.1 | Single Date/Time | Compound | If this element is selected from Element 9, Mandatory.<br><br>Contains Element 9.1.1 and Element 9.1.2. | If this element is selected from Element 9, Mandatory.<br><br>Contains Element 9.1.1 and Element 9.1.2. | Single Date/Time. (FDGC field name = sngdate) Means of encoding a single date and time . |
| 9.1.1 | Calendar Date | Date | If Element 9.1 is selected from Element 9, Mandatory. | If Element 9.1 is selected from Element 9, Mandatory. | Calendar Date. (FDGC field name = caldate) The year (and optionally month, or month and day). Domain: "Unknown" free date |
| 9.1.2 | Time of Day | Time | If Element 9.1 is selected from Element 9, Mandatory. | If Element 9.1 is selected from Element 9, Mandatory. | Time of Day. (FDGC field name = time) The hour (and optionally minute, or minute and second) of the day . Domain: "Unknown" free time |
| 9.2 | Multiple Dates/Times | Compound | If this element is selected from Element 9, Mandatory.<br><br>Contains Element 9.1.<br><br>Repeated two or more times. | If this element is selected from Element 9, Mandatory.<br><br>Contains Element 9.1.<br><br>Repeated two or more times. | Multiple Dates/Times. (FDGC field name = ndattim) Means of encoding multiple individual dates and times . |
| 9.3 | Range of Dates/Times | Compound | If this element is selected from Element 9, Mandatory.<br><br>Contains Elements 9.3.1 – 9.3.4. | If this element is selected from Element 9, Mandatory.<br><br>Contains Elements 9.3.1 – 9.3.4. | Range of Dates/Times. (FDGC field name = rngdates) Means of encoding a range of dates and times . |
| 9.3.1 | Beginning Date | Date | If Element 9.3 is selected from Element 9, Mandatory. | If Element 9.3 is selected from Element 9, Mandatory. | Beginning Date. (FDGC field name = begdate) The first year (and optionally month, or month and day) of the event. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
|---|---|---|---|---|---|
| 9.3.2 | Beginning Time | Time | If Element 9.3 is selected from Element 9, Optional. | If Element 9.3 is selected from Element 9, Optional. | Beginning Time. (FDGC field name = begtime) The first hour (and optionally minute, or minute and second) of the day . |
| 9.3.3 | Ending Date | Date | If Element 9.3 is selected from Element 9, Mandatory. | If Element 9.3 is selected from Element 9, Mandatory. | Ending Date. (FDGC field name = enddate) The last year (and optionally month, or month and day) for the event. |
| 9.3.4 | Ending Time | Time | If Element 9.3 is selected from Element 9, Optional. | If Element 9.3 is selected from Element 9, Optional. | Ending Time. (FDGC field name = endtime) The last hour (and optionally minute, or minute and second) of the day for . |
| | | | | | |
| 10 | Contact Information | Compound | Mandatory.<br><br>Contains one of (Element 10.1 or Element 10.2) and Elements 10.3 – 10.10. | Mandatory.<br><br>Contains one of (Element 10.1 or Element 10.2) and Elements 10.3 – 10.10. | Contact Information. (FDGC field name = cntinfo) Identity of, and means to communicate with, person(s) and organization(s) associated with the data set. (Note: this section provides a means of identifying individuals and organizations, and is used by other sections of the metadata standard. This section is never used alone.) . |
| 10.1 | Contact Person Primary | Compound | If this element is selected from Element 10, Mandatory.<br><br>Contains Element 10.1.1 and Element 10.1.2. | If this element is selected from Element 10, Mandatory.<br><br>Contains Element 10.1.1 and Element 10.1.2. | Contact Person Primary. (FDGC field name = cntperp) The person, and the affiliation of the person, associated with the data set. Used in cases where the association of the person to the data set is more significant than the association of the organization to the data set. . |
| 10.1.1 | Contact Person | Free Text | If Element 10.1 is selected from Element 10, Mandatory.<br><br>If Element 10.2 is selected from Element 10, Optional. | If Element 10.1 is selected from Element 10, Mandatory.<br><br>If Element 10.2 is selected from Element 10, Optional. | Contact Person. (FDGC field name = cntperson) The person, and the affiliation of the person, associated with the data set. Used in cases where the association of the person to the data set is more significant than the association of the organization to the data set. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
|---|---|---|---|---|---|
| 10.1.2 | Contact Organization | Free Text | If Element 10.1 is selected from Element 10, Optional.<br><br>If Element 10.2 is selected from Element 10, Mandatory. | If Element 10.1 is selected from Element 10, Optional.<br><br>If Element 10.2 is selected from Element 10, Mandatory. | Contact Organization. (FDGC field name = cntorganization) The name of the organization to which the contact type applies. |
| 10.2 | Contact Organization Primary | Compound | If this element is selected from Element 10, Mandatory.<br><br>Contains Element 10.1.1 and Element 10.1.2. | If this element is selected from Element 10, Mandatory.<br><br>Contains Element 10.1.1 and Element 10.1.2. | Contact Organization Primary. (FDGC field name = cntorgp) The organization, and the member of the organization, associated with the data set. Used in cases where the association of the organization to the data set is more significant than the association of the person to the data set . |
| 10.3 | Contact Position | Free Text | Conditional. | Optional. | Contact Position. (FDGC field name = cntposition) The title of individual . |
| 10.4 | Contact Address | Compound | Mandatory.<br><br>Contains Elements 10.4.1 – 10.4.6.<br><br>Can be repeated unlimited times. | Mandatory.<br><br>Contains Elements 10.4.1 – 10.4.6.<br><br>Can be repeated unlimited times. | Contact Address. (FDGC field name = cntaddr) The address for the organization or individual. |
| 10.4.1 | Address Type | Text | Mandatory. | Mandatory. | Address Type. (FDGC field name = addrtype) The information provided by the address. Domain: "mailing" "physical" "mailing and physical", free text |
| 10.4.2 | Address | Free Text | Mandatory. | Conditional. | Address. (FDGC field name = address) An address line for the address . |
| 10.4.3 | City | Free Text | Mandatory. | Mandatory. | City. (FDGC field name = city) The city of the address . |
| 10.4.4 | State or Province | Text | Mandatory. | Mandatory. | State or Province. (FDGC field name = state) The state or province of the address. |
| 10.4.5 | Postal Code | Text | Mandatory. | Mandatory. | Postal Code. (FDGC field name = postal) The ZIP or other postal code of the address. |

| Level | Formatted Field Name | Data Type | DWR's Standard | FGDC's Standard | Field Name, Description and Constraint |
|---|---|---|---|---|---|
| 10.4.6 | Country | Free Text | Optional. | Mandatory. | Country. (FDGC field name = country) The country of the address . |
| 10.5 | Contact Voice Telephone | Free Text | Mandatory.<br><br>Can be repeated unlimited times. | Mandatory.<br><br>Can be repeated unlimited times. | Contact Voice Telephone. (FDGC field name = cntvoice) The telephone number by which individuals can speak to the organization or individual. |
| 10.6 | Contact TDD/TTY Telephone | Free Text | Optional.<br><br>Can be repeated unlimited times. | Optional.<br><br>Can be repeated unlimited times. | Contact TDD/TTY Telephone. (FDGC field name = cnttdd) The telephone number by which hearing-impaired individuals can contact the organization or individual. |
| 10.7 | Contact Facsimile Telephone | Free Text | Optional.<br><br>Can be repeated unlimited times. | Optional.<br><br>Can be repeated unlimited times. | Contact Facsimile Telephone. (FDGC field name = cntfax) The telephone number of a facsimile machine of the organization or individual. |
| 10.8 | Contact Electronic Mail Address | Free Text | Mandatory.<br><br>Can be repeated unlimited times. | Optional.<br><br>Can be repeated unlimited times. | Contact Electronic Mail Address. (FDGC field name = cntemail) The address of the electronic mailbox of the organization or individual. |
| 10.9 | Hours of Service | Free Text | Optional.<br><br>Can be repeated unlimited times. | Optional.<br><br>Can be repeated unlimited times. | Hours of Service. (FDGC field name = hours) Time period when individuals can speak to the organization or individual. |
| 10.10 | Contact Instructions | Free Text | Optional.<br><br>Can be repeated unlimited times. | Optional.<br><br>Can be repeated unlimited times. | Contact Instructions. (FDGC field name = cntinst) Supplemental instructions on how or when to contact the individual or organization. |

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# Appendix A. Common Data Sources

## Census Data

Census data is used to identify large or small scale areas and the demographics of that specific area. To accommodate the various scales the data is not projected. For Census 2000 data:

Geographic Coordinate System (GCS)
NAD 83
No measurement system

## Models

Digital Elevation Models (DEM) – or Digital Terrain Model (DTM) are a bare earth raster data sets used for elevation, modeling studies, and base maps. The USGS does not leave data unprojected to prevent coordinate alignment issues

Universal Transverse Mercator (UTM)
Scale: 1:24,000
Meters

## California Emergency Services Agency

The California Emergency Services Agency (CalEMA) has established standards to preserve the area and boundaries. The CalEMA and other agencies most often use:

California Teale Albers
NAD 83
Meters

## Topographic Maps

U.S. Geological Survey (USGS) 7.5 minute maps are digital raster graphics (DRG). The graphic map was scanned at 250 dots per inch. The USGS does not leave data unprojected because of coordinate alignment issues. For that reason, USGS uses:

Universal Transverse Mercator (UTM)
Scale 1:24,000
Meters

## DWR Engineering Modeling

The Department Water Resources uses data for modeling or to answer engineering specific questions. To maintain data accuracy (elevation, distance) and include the whole state the projection used is:

Universal Transverse Mercator Zone 10.5 (combining Zone 10 and Zone 11)
NAD 83
Meters

## Surveying

Cadastral data is used for land records, parcel boundaries, or legal descriptions. The perimeter, area, metes (bearings and distance) and bounds (physical monuments or geodetic control) define the dataset.

State Plane Coordinate System (SPCS)
NAD 83
U. S. Survey Feet

## Global Positioning System

Most Global default to the World Geodetic System 1984 (WGS 84). This is a single point on the earth in relationship to the Greenwich, UK. The WGS 84 should be plotted using the datum NAD 83 and units of meters.

# Appendix B. Reserved Words

Reserved words are ones that the database or the system does not allow you to use. In this, we have both a database (Oracle) and a geodatabase (ArcGIS) with reserve words.

The link,

http://download.oracle.com/docs/cd/B19306_01/em.102/b40103/app_oracle_reserved_words.htm

lists the reserved words for Oracle.

The Command, SE_connection_get_keyword_info() on an ArcSDE server will list the reserved words for ArcGIS.

http://forums.esri.com/Thread.asp?c=158&f=2284&t=239197

A compilation of reserved words is not useful, because the words change from one application to another, and from version to version of an application.

# Appendix C. Horizontal Accuracy Calculations

This example is taken from the Federal Geographic Data Committee, Subcommittee for Base Cartographic Data. Chapter 3. National Standard for Spatial Data Accuracy (NSSDA) (FGDC-STD-007.3-1998), Appendix 3-B.

The data for horizontal accuracy computations come from the draft National Mapping Program (NMP) Technical Instructions, Procedure Manual for Map Accuracy Testing (National Mapping Division, 1987). Positions on the Crider, Kentucky 1:24,000-scale USGS topographic quadrangle were tested against a triangulated solution of positions independent of the control solution used to produce the map. The photography used to collect the independent source was different from that used for the map compilation, and a different control configuration was utilized.

Coordinates are on the State Plane Coordinate System (south zone), based on NAD 27. Units are
in feet.
x (computed) and y (computed) are coordinate values from the triangulated solution.
x (map) and y (map) are coordinate values for map positions.

Table C.1 assumes that RMSEx = RMSEy (13.26 and 15.04, respectively). The positional accuracy is

Positional Accuracy = 1.7308 * 20.07 feet
= 34.7 feet

Therefore, the accuracy value according to the NSSDA, at 95% confidence. The accuracy value according to the NSSDA is 35 feet. Of twenty-five points tested, only point # 10360 has a positional error that exceeds 35 feet.

Alternatively, we could calculate the positional accuracy assuming RMSE for x was not equal to the RMSE for y.

Positional Accuracy = 2.4477 * (13.28 + 15.04) feet / 2
= 34.7 feet

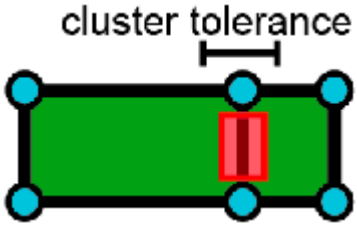
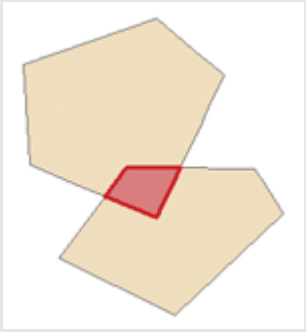
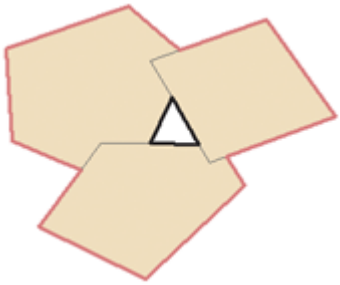
## Table C.1 Sample Positional Accuracy Calculations

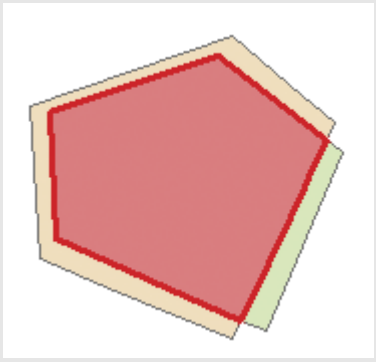
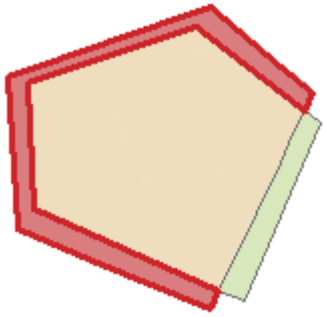
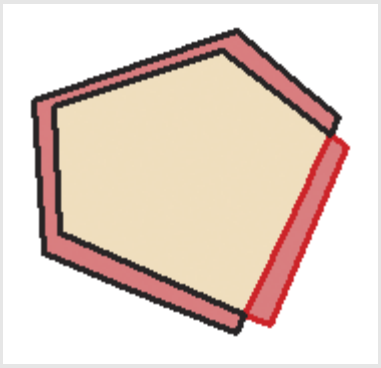
| Point Number | Point Description | Computed X Value | Independent X Value | Difference of X Values | Squared Difference of X Values | Computed Y Value | Independent Y Value | Difference of Y Values | Squared Difference of Y Values | Sum of Squared Differences |
|---|---|---|---|---|---|---|---|---|---|---|
| 10351 | T-RD-W | 1373883 | 1373894 | -11 | 121 | 298298 | 298297 | 1 | 1 | 122 |
| 10352 | T-RD-E | 1370503 | 1370486 | 17 | 289 | 303727 | 303747 | -20 | 400 | 689 |
| 10353 | RD AT RR | 1361523 | 1361537 | -14 | 196 | 302705 | 302705 | 0 | 0 | 196 |
| 10354 | T-RD-SW | 1357653 | 1357667 | -14 | 196 | 298726 | 298746 | -20 | 400 | 596 |
| 10355 | T-RD-SE | 1348121 | 1348128 | -7 | 49 | 299725 | 299755 | -30 | 900 | 949 |
| 10356 | RD AT RR | 1345601 | 1345625 | -24 | 576 | 309911 | 309910 | 1 | 1 | 577 |
| 10357 | T-RD-E | 1350505 | 1350507 | -2 | 4 | 318478 | 318477 | 1 | 1 | 5 |
| 10358 | X-RD | 1351781 | 1351792 | -11 | 121 | 307697 | 307698 | -1 | 1 | 122 |
| 10359 | T-RD-E | 1352361 | 1352379 | -18 | 324 | 311109 | 311099 | 10 | 100 | 424 |
| 10360 | X-RD | 1360657 | 1360645 | 12 | 144 | 316720 | 316761 | -41 | 1681 | 1825 |
| 10361 | Y-RD-SW | 1368215 | 1368202 | 13 | 169 | 309842 | 309869 | -27 | 729 | 898 |
| 10362 | T-RD-W | 1370299 | 1370282 | 17 | 289 | 316832 | 316849 | -17 | 289 | 578 |
| 10363 | T-RD-S | 1373855 | 1373839 | 16 | 256 | 319893 | 319886 | 7 | 49 | 305 |
| 10364 | Y-RD-W | 1379981 | 1379962 | 19 | 361 | 311641 | 311633 | 8 | 64 | 425 |
| 10365 | T-RD-E | 1378625 | 1378628 | -3 | 9 | 334995 | 335010 | -15 | 225 | 234 |
| 10366 | T-RD-SE | 1374735 | 1374742 | -7 | 49 | 333909 | 333922 | -13 | 169 | 218 |
| 10367 | T-RD-NW | 1370581 | 1370576 | 5 | 25 | 324098 | 324095 | 3 | 9 | 34 |
| 10368 | Y-RD-SE | 1359379 | 1359387 | -8 | 64 | 328690 | 328691 | -1 | 1 | 65 |
| 10369 | T-RD-S | 1346459 | 1346479 | -20 | 400 | 330816 | 330812 | 4 | 16 | 416 |
| 10370 | T-RD-E | 1347101 | 1347109 | -8 | 64 | 335869 | 335850 | 19 | 361 | 425 |
| 10371 | T-RD-SE | 1350733 | 1350748 | -15 | 225 | 332715 | 332725 | -10 | 100 | 325 |
| 10372 | T-RD-N | 1354395 | 1354411 | -16 | 256 | 335337 | 335345 | -8 | 64 | 320 |
| 10373 | T-RD-S | 1358563 | 1358570 | -7 | 49 | 335398 | 335406 | -8 | 64 | 113 |
| 10374 | X-RD | 1365561 | 1365574 | -13 | 169 | 333873 | 333877 | -4 | 16 | 185 |
| 10375 | X-RD | 1373645 | 1373643 | 2 | 4 | 339613 | 339609 | 4 | 16 | 20 |
| | | | | | | | | | | |
| **Sum** | | | | | 4409 | | | | 5657 | 10066 |
| **Average** | | | | | 176.36 | | | | 226.28 | 402.64 |
| **Root Mean Square Error** | | | | | 13.28 | | | | 15.04 | 20.07 |

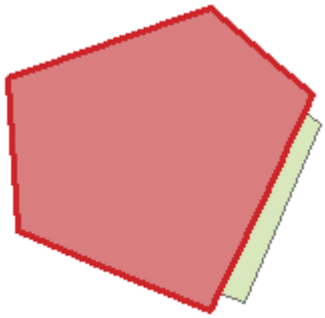
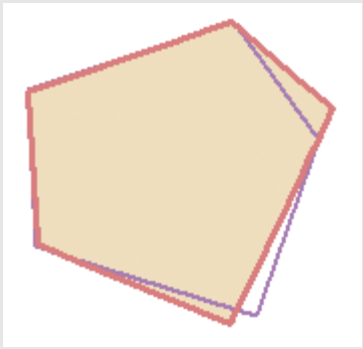
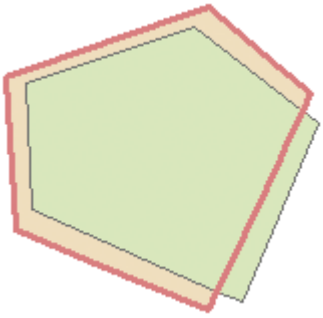
# Appendix D. Topology Rules for Polygons, Lines and Points

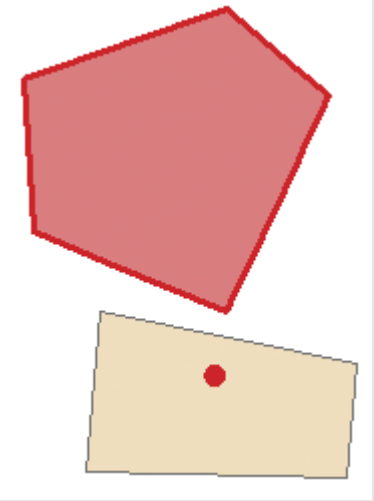
These rules are taken from
http://webhelp.esri.com/arcgisserver/9.3.1/dotNet/index.htm#geodatabases/topology_in_arcgis.htm

## Polygon rules

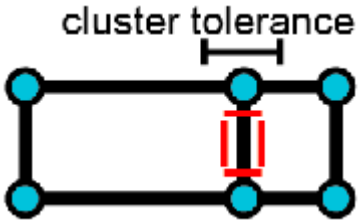
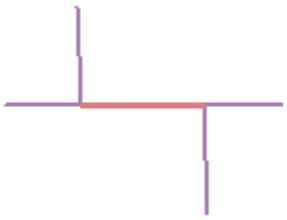
| Topology Rule | Rule description | Potential fixes | Examples |
|---|---|---|---|
| **Must Be Larger Than Cluster Tolerance** | Requires that a feature does not collapse during a validate process. This rule is mandatory for a topology, and applies to all line and polygon feature classes. In instances where this rule is violated, the original geometry is left unchanged. | Delete |  Any polygon feature, such as the one in red that would collapse when validating the topology is an error. |
| **Must Not Overlap** | Requires that the interior of polygons in the feature class not overlap. The polygons can share edges or vertices. This rule is used when an area cannot belong to two or more polygons. It is useful for modeling administrative boundaries, such as ZIP Codes or voting districts, and mutually exclusive area classifications, such as land cover or landform type. | Subtract, Merge, Create Feature |  |
| **Must Not Have Gaps** | This rule requires that there are no voids within a single polygon or between adjacent polygons. All polygons must form a continuous surface. An error will always exist on the perimeter of the surface. You can either ignore this error or mark it as an exception. Use this rule on data that must completely cover an area. For example, soil polygons cannot include gaps or form voids—they must cover an entire area. | Create Feature |  You can use Create Feature to create a new polygon in the void in the center. You can also use Create Feature or mark the error on the outside boundary as an exception. |

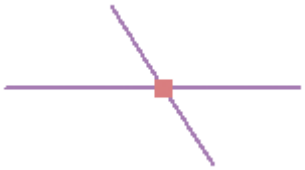
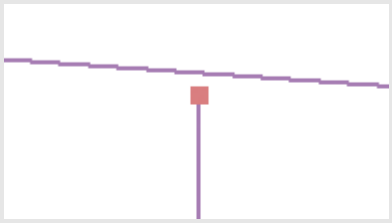
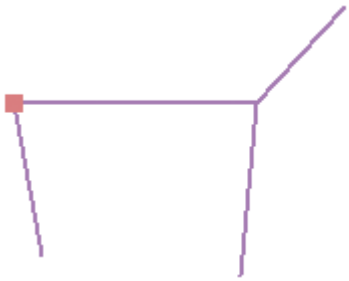
| | | | |
|---|---|---|---|
| **Must Not Overlap With** | Requires that the interior of polygons in one feature class must not overlap with the interior of polygons in another feature class. Polygons of the two feature classes can share edges or vertices or be completely disjointed. This rule is used when an area cannot belong to two separate feature classes. It is useful for combining two mutually exclusive systems of area classification, such as zoning and water body type, where areas defined within the zoning class cannot also be defined in the water body class and vice versa. | Subtract, Merge |  |
| **Must Be Covered By Feature Class Of** | Requires that a polygon in one feature class must share all of its area with polygons in another feature class. An area in the first feature class that is not covered by polygons from the other feature class is an error. This rule is used when an area of one type, such as a state, should be completely covered by areas of another type, such as counties. | Subtract, Create Feature |  |
| **Must Cover Each Other** | Requires that the polygons of one feature class must share all of their area with the polygons of another feature class. Polygons may share edges or vertices. Any area defined in either feature class that is not shared with the other is an error. This rule is used when two systems of classification are used for the same geographic area, and any given point defined in one system must also be defined in the other. One such case occurs with nested hierarchical datasets, such as census blocks and block groups or small watersheds and large drainage basins. The rule can also be applied to non-hierarchically related polygon feature classes, such as soil type and slope class. | Subtract, Create Feature |  |

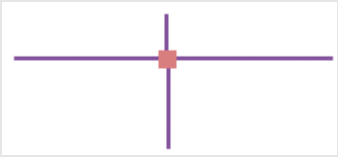
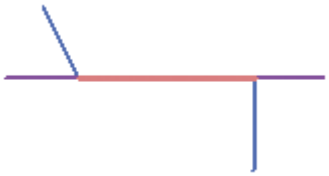
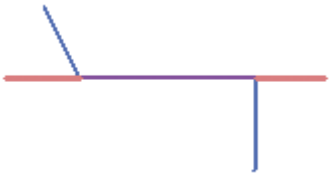
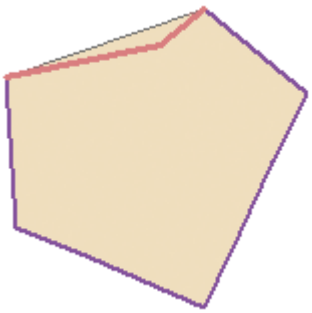
| | | | |
|---|---|---|---|
| **Must Be Covered By** | Requires that polygons of one feature class must be contained within polygons of another feature class. Polygons may share edges or vertices. Any area defined in the contained feature class must be covered by an area in the covering feature class. This rule is used when area features of a given type must be located within features of another type. This rule is useful when modeling areas that are subsets of a larger surrounding area, such as management units within forests or blocks within block groups. | Create Feature |  |
| **Boundary Must Be Covered By** | Requires that boundaries of polygon features must be covered by lines in another feature class. This rule is used when area features need to have line features that mark the boundaries of the areas. This is usually when the areas have one set of attributes and their boundaries have other attributes. For example, parcels might be stored in the geodatabase along with their boundaries. Each parcel might be defined by one or more line features that store information about their length or the date surveyed, and every parcel should exactly match its boundaries. | Create Feature |  |
| **Area Boundary Must Be Covered By Boundary Of** | Requires that boundaries of polygon features in one feature class be covered by boundaries of polygon features in another feature class. This is useful when polygon features in one feature class, such as subdivisions, are composed of multiple polygons in another class, such as parcels, and the shared boundaries must be aligned. | None |  |

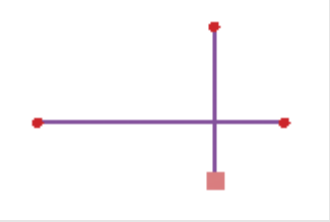
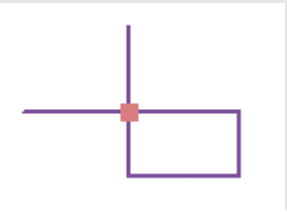
| | | | |
|---|---|---|---|
| **Contains Point** | Requires that a polygon in one feature class contain at least one point from another feature class. Points must be within the polygon, not on the boundary. This is useful when every polygon should have at least one associated point, such as when parcels must have an address point. | Create Feature |  The top polygon is an error because it does not contain a point. |

## Line rules

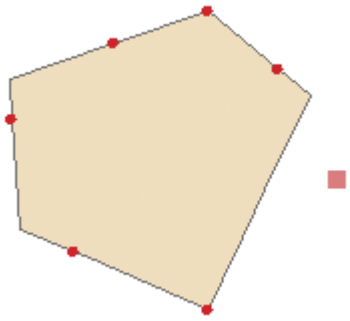
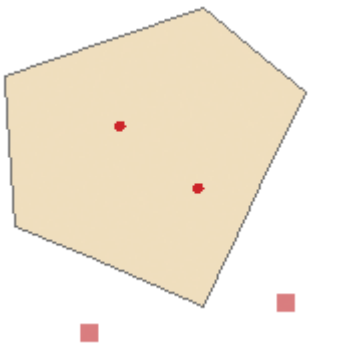
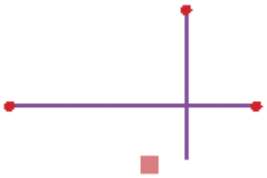
| Topology Rule | Rule description | Potential fixes | Examples |
|---|---|---|---|
| **Must Be Larger Than Cluster Tolerance** | Requires that a feature does not collapse during a validate process. This rule is mandatory for a topology, and applies to all line and polygon feature classes. In instances where this rule is violated, the original geometry is left unchanged. | Delete |   Any line feature, such as these lines in red that would collapse when validating the topology is an error. |
| **Must Not Overlap** | Requires that lines not overlap with lines in the same feature class. This rule is used where line segments should not be duplicated; for example, in a stream feature class. Lines can cross or intersect but cannot share segments. | Subtract |  |

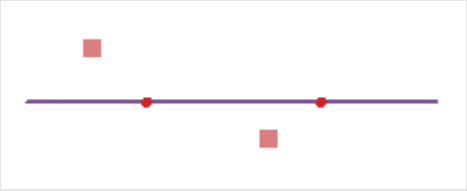
| | | | |
|---|---|---|---|
| **Must Not Intersect** | Requires that line features from the same feature class not cross or overlap each other. Lines can share endpoints. This rule is used for contour lines that should never cross each other or in cases where the intersection of lines should only occur at endpoints, such as street segments and intersections. | Split, Subtract |  |
| **Must Not Have Dangles** | Requires that a line feature must touch lines from the same feature class at both endpoints. An endpoint that is not connected to another line is called a dangle. This rule is used when line features must form closed loops, such as when they are defining the boundaries of polygon features. It may also be used in cases where lines typically connect to other lines, as with streets. In this case, exceptions can be used where the rule is occasionally violated, as with cul-de-sac or dead end street segments. | Extend, Trim, Snap |  |
| **Must Not Have Pseudonodes** | Requires that a line connect to at least two other lines at each endpoint. Lines that connect to one other line (or to themselves) are said to have pseudonodes. This rule is used where line features must form closed loops, such as when they define the boundaries of polygons or when line features logically must connect to two other line features at each end, as with segments in a stream network, with exceptions being marked for the originating ends of first-order streams. | Merge to Largest, Merge |  |

| | | | |
|---|---|---|---|
| **Must Not Intersect Or Touch Interior** | Requires that a line in one feature class must only touch other lines of the same feature class at endpoints. Any line segment in which features overlap or any intersection not at an endpoint is an error. This rule is useful where lines must only be connected at endpoints, such as in the case of lot lines, which must split (only connect to the endpoints of) back lot lines and which cannot overlap each other. | Subtract, Split |  |
| **Must Not Overlap With** | Requires that a line from one feature class not overlap with line features in another feature class. This rule is used when line features cannot share the same space. For example, roads must not overlap with railroads or depression subtypes of contour lines cannot overlap with other contour lines. | Subtract |  Where the purple lines overlap is an error. |
| **Must Be Covered By Feature Class Of** | Requires that lines from one feature class must be covered by the lines in another feature class. This is useful for modeling logically different but spatially coincident lines, such as routes and streets. A bus route feature class must not depart from the streets defined in the street feature class. | None |  Where the purple lines don't overlap is an error. |
| **Must Be Covered By Boundary Of** | Requires that lines be covered by the boundaries of area features. This is useful for modeling lines, such as lot lines, that must coincide with the edge of polygon features, such as lots. | Subtract |  |

| | | | |
|---|---|---|---|
| **Endpoint Must Be Covered By** | Requires that the endpoints of line features must be covered by point features in another feature class. This is useful for modeling cases where a fitting must connect two pipes, or a street intersection must be found at the junction of two streets. | Create Feature |  The square at the bottom indicates an error, because there is no point covering the endpoint of the line. |
| **Must Not Self Overlap** | Requires that line features not overlap themselves. They can cross or touch themselves, but must not have coincident segments. This rule is useful for features such as streets, where segments might touch in a loop, but where the same street should not follow the same course twice. | Simplify |  The individual line feature overlaps itself, with the error indicated by the coral line. |
| **Must Not Self Intersect** | Requires that line features not cross or overlap themselves. This rule is useful for lines, such as contour lines, that cannot cross themselves. | Simplify |  |
| **Must Be Single Part** | Requires that lines have only one part. This rule is useful where line features, such as highways, may not have multiple parts. | Explode |  Multipart lines are created from a single sketch. |

## Point rules

| Topology Rule | Rule description | Potential fixes | Examples |
|---|---|---|---|
| **Must Be Covered By Boundary Of** | Requires that points fall on the boundaries of area features. This is useful when the point features help support the boundary system, such as boundary markers, which must be found on the edges of certain areas. | None |  The square on the right indicates an error because it is a point that is not on the boundary of the polygon. |
| **Must Be Properly Inside Polygons** | Requires that points fall within area features. This is useful when the point features are related to polygons, such as wells and well pads or address points and parcels. | Delete |  The squares are errors where there are points that are not inside the polygon. |
| **Must Be Covered By Endpoint Of** | Requires that points in one feature class must be covered by the endpoints of lines in another feature class. This rule is similar to the line rule, "Endpoint Must Be Covered By", except that, in cases where the rule is violated, it is the point feature that is marked as an error, rather than the line. Boundary corner markers might be constrained to be covered by the endpoints of boundary lines. | Delete |  The square indicates an error where the point is not on an endpoint of a line. |

| | | | |
|---|---|---|---|
| **Must Be Covered By Line** | Requires that points in one feature class be covered by lines in another feature class. It does not constrain the covering portion of the line to be an endpoint. This rule is useful for points that fall along a set of lines, such as highway signs along highways. | None |  The squares are points that are not covered by the line. |

# Appendix E. Checklist for Spatial Consistency

| Topology Rule | Rule is Applicable | Population Size | Sample Size | Number of Errors | Checked By | Date |
|---|---|---|---|---|---|---|
| Polygon Must Be Larger Than Cluster Tolerance | | | | | | |
| Polygon Must Not Overlap | | | | | | |
| Polygon Must Not Have Gaps | | | | | | |
| Polygon Must Not Overlap With | | | | | | |
| Polygon Must Be Covered By Feature Class Of | | | | | | |
| Polygon Must Cover Each Other | | | | | | |
| Polygon Must Be Covered By | | | | | | |
| Polygon Boundary Must Be Covered By | | | | | | |
| Polygon Area Boundary Must Be Covered By Boundary Of | | | | | | |
| Polygon Contains Point | | | | | | |
| Line Must Be Larger Than Cluster Tolerance | | | | | | |
| | | | | | | |
| Line Must Not Overlap | | | | | | |
| Line Must Not Intersect | | | | | | |
| Line Must Not Have Dangles | | | | | | |
| Line Must Not Have Pseudonodes | | | | | | |
| Line Must Not Intersect Or Touch Interior | | | | | | |
| Line Must Not Overlap With | | | | | | |
| Line Must Be Covered By Feature Class Of | | | | | | |

| |
|---|
| Line Must Be Covered By Boundary Of |
| Line Endpoint Must Be Covered By |
| Line Must Not Self Overlap |
| Line Must Not Self Intersect |
| Line Must Be Single Part |
| |
| Point Must Be Covered By Boundary Of |
| Point Must Be Properly Inside Polygons |
| Point Must Be Covered By Endpoint Of |
| Point Must Be Covered By Line |

# Appendix F. ANSI/ASQC Z1.4. Sampling Plans

The ANSI Sampling Plans assume:

1. Sampling presumes that the population being sampled is homogeneous. That is, the items being sampled and tested are made up of similar items, and the items were created in similar ways.

2. Sample sizes must be large enough to provide a statistically valid evaluation, and vary with the population. The larger the population, the larger the sample size.

3. The sampling plan assumes that errors are normally distributed in the population.

## Inspection Procedures

This procedure is known as stratified, random sampling.

Separate the population of all items into categories that are homogenous. Each category must then be tested.

Determine the acceptable quality limit from the Standards.

Determine the number of items in the population to test.

Start with the normal inspection table, Table II-A. Select the row corresponding to the size of the category population. This will tell you the number of samples you need.

Select the column for the acceptable quality limit.

The cell (intersection of the row and column) will tell you the maximum allowable number of errors in your test. If you have this number or less, the test succeeds. If you have more than this number, the test fails.

If the test fails, you can re-test again, using Table II-C for tightened inspection. Follow the same process as with Table II-A. If this test also fails, then testing should be stopped, the process should be evaluated, and the process and the data should be corrected.

## Table II-A. Single Sample Plans for Normal Inspection

| Population Size | | Sample Size | Acceptable Quality Level | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min | Max | | 60.0 | 75.0 | 85.0 | 90.0 | 93.5 | 96.0 | 97.5 | 98.5 | 99.0 | 99.35 | 99.60 | 99.75 | 99.85 | 99.90 | 99.94 | 99.96 | 99.975 | 99.985 | 99.990 |
| 2 | 8 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 15 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 25 | 5 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 50 | 8 | 7 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 51 | 90 | 13 | 10 | 7 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 91 | 150 | 20 | 14 | 10 | 7 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 151 | 280 | 32 | 21 | 14 | 10 | 7 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 281 | 500 | 50 | 21 | 21 | 14 | 10 | 7 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 501 | 1,200 | 80 | 21 | 21 | 21 | 14 | 10 | 7 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1,201 | 3,200 | 125 | 21 | 21 | 21 | 21 | 14 | 10 | 7 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3,201 | 10,000 | 200 | 21 | 21 | 21 | 21 | 21 | 14 | 10 | 7 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10,001 | 35,000 | 315 | 21 | 21 | 21 | 21 | 21 | 21 | 14 | 10 | 7 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 35,001 | 150,000 | 500 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 14 | 10 | 7 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 150,001 | 500,000 | 800 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 14 | 10 | 7 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 |
| 500,001 | 6.022e23 | 1,250 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 14 | 10 | 7 | 5 | 3 | 2 | 1 | 0 | 0 | 0 |

## Table II-C. Single Sample Plans for Tightened Inspection

| Population Size | | Sample Size | Acceptable Quality Level | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min | Max | | 60.0 | 75.0 | 85.0 | 90.0 | 93.5 | 96.0 | 97.5 | 98.5 | 99.0 | 99.35 | 99.60 | 99.75 | 99.85 | 99.90 | 99.94 | 99.96 | 99.975 | 99.985 | 99.990 |
| 2 | 8 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 15 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 25 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 50 | 13 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 51 | 90 | 20 | 12 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 91 | 150 | 32 | 18 | 12 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 151 | 280 | 50 | 18 | 18 | 12 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 281 | 500 | 80 | 18 | 18 | 18 | 12 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| 501 | 1,200 | 125 | 18 | 18 | 18 | 18 | 12 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1,201 | 3,200 | 200 | 18 | 18 | 18 | 18 | 18 | 12 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3,201 | 10,000 | 315 | 18 | 18 | 18 | 18 | 18 | 18 | 12 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10,001 | 35,000 | 500 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 12 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 35,001 | 150,000 | 800 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 12 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 150,001 | 500,000 | 1,250 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 12 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 |
| 500,001 | 6.022e23 | 2,000 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 12 | 8 | 5 | 3 | 2 | 1 | 0 | 0 | 0 |

# Appendix G. Checklist for Thematic and Attribute Consistency

| Standard | Number of Errors | Checked By | Date |
|---|---|---|---|
| All entities are within the outside boundary identified with registration marks. | | | |
| Symbolizing the data against all fields to check the range of values. | | | |
| No extra entities have been digitized. | | | |
| Similar features use similar symbols. | | | |
| Linkage of features with attribute fields. | | | |
| One or no label for each feature. | | | |
| Attributes shall adhere to naming standards. | | | |
| Classification schemes are clearly defined and documented. | | | |
| Logical cartographic consistency. | | | |
| Data crossing projection and/or coordinate system boundaries. | | | |

# Appendix H. Checklist for Logical Consistency

Table Name: _____

| Standard | Number of Errors | Checked By | Date |
|---|---|---|---|
| Spelling has been checked. | | | |
| Comparison of the data set to the source data for obvious omissions. | | | |
| Checking that tables can be properly joined. | | | |
| No duplicate records. | | | |
| Hyperlinks are properly formed. | | | |
| File system links are properly formed. | | | |
| IDs and codes are properly used. | | | |
| Whenever possible, attribute values are defined in the appropriate definition (look-up) table, inclusive of their logical range or described in the appropriate data dictionary (codesets). | | | |
| Units of measure are included where appropriate. | | | |
| Units of measure are metric, except as appropriate due to widely-used professional practice. | | | |
| Physical values equal to or greater than zero, when appropriate. | | | |
| If applicable, stored results of calculations are consistent calculated values. Differences between stored and calculated values shall be no more than 2%. | | | |
| Date and Time Consistency. Use if appropriate. | | | |
| Dates are in date format (ISO Standard 8601) and not text format, unless an explanation is provided in the metadata. | | | |
| Minutes and seconds are greater than or equal to zero, and less than or equal to sixty. | | | |
| Hours are greater than or equal to zero, and less than or equal to twenty-four. | | | |

Days are appropriate for month and year.
- Days are greater than or equal to one.
- Days for January, March, May, July, August, October and December are less than or equal to 31.
- Days for April, June, September and November are less than or equal to 30.
- Days for February are
  - less than or equal to 29 when (the year is evenly divisible by 4 and not evenly divisible by 100) or (the year is evenly divisible by 400)
  - less than or equal to 28 in all other cases.

Months are greater than or equal to 1, and less than or equal to 12.

Attach completeness table, if applicable.

# Appendix I. Checklist for Enterprise Consistency

Spatial Data Set Name: _____

This spatial data set has been checked for consistency with the following enterprise spatial data sets:

| Enterprise Spatial Data Set | Not Applicable | Checked for Consistency By | Date |
|---|---|---|---|
| | | | |
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# Glossary

ESRI's GIS Dictionary is a good on-line GIS dictionary, and is available at:
http://support.esri.com/index.cfm?fa=knowledgebase.gisDictionary.gateway

The selected terms defined here are shamelessly taken from ESRI's GIS Dictionary.

FGDC Federal Geographic Data Committee also has a glossary, which is not as expansive, and is available at:
http://www.fgdc.gov/metadata/csdgm/glossary.html

**attribute**

[data models] Non-spatial information about a geographic feature in a GIS, usually stored in a table and linked to the feature by a unique identifier. For example, attributes of a river might include its name, length, and sediment load at a gauging station.
[data models] In raster datasets, information associated with each unique value of a raster cell.
[graphics (map display)] Information that specifies how features are displayed and labeled on a map; for example, the graphic attributes of a river might include line thickness, line length, color, and font for labeling.

**attribute domain**

[data structures] In a geodatabase, a mechanism for enforcing data integrity. Attribute domains define what values are allowed in a field in a feature class or non-spatial attribute table. If the features or non-spatial objects have been grouped into subtypes, different attribute domains can be assigned to each of the subtypes.

**attribute table**

[data structures] A database or tabular file containing information about a set of geographic features, usually arranged so that each row represents a feature and each column represents one feature attribute. In raster datasets, each row of an attribute table corresponds to a certain zone of cells having the same value. In a GIS, attribute tables are often joined or related to spatial data layers, and the attribute values they contain can be used to find, query, and symbolize features or raster cells.

**boundary effect**

[data quality] A problem created during spatial analysis, caused by arbitrary or discrete boundaries being imposed on spatial data representing non-discrete or unbounded spatial phenomena. Boundary problems include edge effects, in which patterns of interaction or interdependency across the borders of the bounded region are ignored or distorted, and shape effects, in which the shape imposed on the bounded area affects the perceived interactions between phenomena.

**clean data**

[data quality] Data that is free from error.

**cleaning**

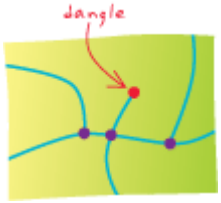
[data conversion] Improving the appearance of scanned or digitized data by correcting overshoots and undershoots, closing polygons, performing coordinate editing, and so on.


**coordinate system**

[coordinate systems] A reference framework consisting of a set of points, lines, and/or surfaces, and a set of rules, used to define the positions of points in space in either two or three dimensions. The Cartesian coordinate system and the geographic coordinate system used on the earth's surface are common examples of coordinate systems.


**dangle**

[data capture] The endpoint of a dangling arc.




**dangle tolerance**

[data capture] In ArcInfo coverages, the minimum length allowed for dangling arcs by the clean process, which removes dangling arcs shorter than the dangle tolerance.

**data capture**

[data capture] Any operation that converts GIS data into computer-readable form. Geographic data can be captured by being downloaded directly into a GIS from sources such as remote-sensing or GPS data, or it can be digitized, scanned, or keyed in manually from paper maps or photographs.

data model

[data models] In GIS, a mathematical construct for representing geographic objects or surfaces as data. For example, the vector data model represents geography as collections of points, lines, and polygons; the raster data model represents geography as cell matrixes that store numeric values; and the TIN data model represents geography as sets of contiguous, non-overlapping triangles.

[ESRI software] In ArcGIS, a set of database design specifications for objects in a GIS application. A data model describes the thematic layers used in the application (for example, hamburger stands, roads, and counties); their spatial representation (for example, point, line, or polygon); their attributes; their integrity rules and relationships (for example, counties must nest within states); their cartographic portrayal; and their metadata requirements.

[data models] In information theory, a description of the rules by which data is defined, organized, queried, and updated within an information system (usually a database management system).

**database generalization**

[database structures] The abstraction, reduction, and simplification of features and feature classes for deriving a simpler model of reality or decreasing stored data volumes.

**digitizing**

[data capture] The process of converting the geographic features on an analog map into digital format using a digitizing tablet, or digitizer, which is connected to a computer. Features on a paper map are traced with a digitizer puck, a device similar to a mouse, and the x,y coordinates of these features are automatically recorded and stored as spatial data.

**error table**

[ESRI software] A geodatabase table used by the GIS Data Reviewer to track error information through the quality control process. Defects are recorded, resolved and verified in the error table.

**feature class**

[ESRI software] In ArcGIS, a collection of geographic features with the same geometry type (such as point, line, or polygon), the same attributes, and the same spatial reference. Feature classes can be stored in geodatabases, shapefiles, coverages, or other data formats. Feature classes allow homogeneous features to be grouped into a single unit for data storage purposes. For example, highways, primary roads, and secondary roads can be grouped into a line feature class named "roads." In a geodatabase, feature classes can also store annotation and dimensions.


**geodatabase**

[ESRI software] A database or file structure used primarily to store, query, and manipulate spatial data. Geodatabases store geometry, a spatial reference

system, attributes, and behavioral rules for data. Various types of geographic datasets can be collected within a geodatabase, including feature classes, attribute tables, raster datasets, network datasets, topologies, and many others. Geodatabases can be stored in IBM DB2, IBM Informix, Oracle, Microsoft Access, Microsoft SQL Server, and PostgreSQL relational database management systems, or in a system of files, such as a file geodatabase.

**geodatabase data model**

[ESRI software] The schema for the various geographic datasets and tables in an instance of a geodatabase. The schema defines the GIS objects, rules, and relationships used to add GIS behavior and integrity to the datasets in a collection.

**GIS**

[GIS technology] Acronym for geographic information system. An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analyzed.

**HARN**

[geodesy] Acronym for High Accuracy Reference Network. A regional or statewide resurvey and readjustment of NAD 1983 control points using GPS techniques. The resurvey date is often included as part of the datum name: NAD 1983 (1991) or NAD91.

**heads-up digitizing**

[data capture] Manual digitization by tracing a mouse over features displayed on a computer monitor, used as a method of vectorizing raster data.

**image**

[data capture] A representation or description of a scene, typically produced by an optical or electronic device, such as a camera or a scanning radiometer. Common examples include remotely sensed data (for example, satellite data), scanned data, and photographs.

[ESRI software] In ArcGIS, a raster dataset.

**lossless compression**

[data transfer] Data compression that has the ability to store data without changing any of the values, but is only able to compress the data at a low ratio (typically 2:1 or 3:1). In GIS, lossless compression is often used to compress raster data when the pixel values of the raster will be used for analysis or deriving other data products.

**lossy compression**

[data transfer] Data compression that provides high compression ratios (for example 10:1 to 100:1), but does not retain all the information in the data. In GIS, lossy compression is used to compress raster datasets that will be used as background images, but is not suitable for raster datasets used for analysis or deriving other data products.

**metadata**

[data transfer] Information that describes the content, quality, condition, origin, and other characteristics of data or other pieces of information. Metadata for

spatial data may describe and document its subject matter; how, when, where, and by whom the data was collected; availability and distribution information; its projection, scale, resolution, and accuracy; and its reliability with regard to some standard. Metadata consists of properties and documentation. Properties are derived from the data source (for example, the coordinate system and projection of the data), while documentation is entered by a person (for example, keywords used to describe the data).

**normal distribution**

[statistics] A theoretical frequency distribution of a dataset in which the distribution of values can be graphically represented as a symmetrical bell curve. Normal distributions are typically characterized by a clustering of values near the mean, with few values departing radically from the mean. There are as many values on the left side of the curve as on the right, so the mean and median values for the distribution are the same. Sixty-eight percent of the values are plus or minus one standard deviation from the mean; 95 percent of the values are plus or minus two standard deviations; and 99 percent of the values are plus or minus three standard deviations.

**object**

[data models] In GIS, a digital representation of a spatial or non-spatial entity. Objects usually belong to a class of objects with common attribute values and behaviors.

[programming] In object-oriented programming, an instance of the data structure and behavior defined by a class.

[software] In computing, a piece of software that performs a specific task and is controlled by another piece of software, called a client. For example, an object is often the interface by which an application program accesses an operating system and other services.

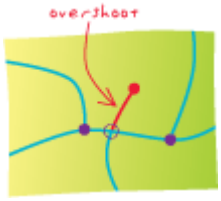
[ESRI software] In ArcMap, ArcScene, or ArcGlobe, the camera, view, table or layer to which an animation track is attached.

**orthorectification**

[satellite imaging] The process of correcting the geometry of an image so that it appears as though each pixel were acquired from directly overhead. Orthorectification uses elevation data to correct terrain distortion in aerial or satellite imagery.

**overshoot**

[data structures] The portion of an arc digitized past its intersection with another arc.



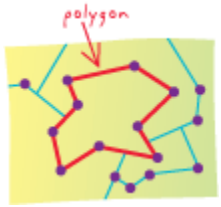

**pixel**

[data models] The smallest unit of information in an image or raster map, usually square or rectangular. Pixel is often used synonymously with cell.

[remote sensing] In remote sensing, the fundamental unit of data collection. A pixel is represented in a remotely sensed image as a cell in an array of data values.
[graphics (computing)] The smallest element of a display device, such as a video monitor, that can be independently assigned attributes, such as color and intensity. Pixel is an abbreviation for picture element.

**polygon**

[data models] On a map, a closed shape defined by a connected sequence of x,y coordinate pairs, where the first and last coordinate pair are the same and all other pairs are unique.



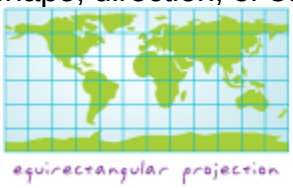

[ESRI software] In ArcGIS software, a shape defined by one or more rings, where a ring is a path that starts and ends at the same point. If a polygon has more than one ring, the rings may be separate from one another or they may nest inside one another, but they may not overlap.

**precision**

[data quality] The closeness of a repeated set of observations of the same quantity to one another. Precision is a measure of the control over random error. For example, assessment of the quality of a surveyor's work is based in part on the precision of their measured values.
[data quality] The number of significant digits used to store numbers, particularly coordinate values. Precision is important for accurate feature representation, analysis, and mapping.
[data quality] A statistical measure of repeatability, usually expressed as the variance of repeated measures about the mean.

**projection**

[map projections] A method by which the curved surface of the earth is portrayed on a flat surface. This generally requires a systematic mathematical transformation of the earth's graticule of lines of longitude and latitude onto a plane. Some projections can be visualized as a transparent globe with a light bulb at its center (though not all projections emanate from the globe's center) casting lines of latitude and longitude onto a sheet of paper. Generally, the paper is either flat and placed tangent to the globe (a planar or azimuthal projection) or formed into a cone or cylinder and placed over the globe (cylindrical and conical projections). Every map projection distorts distance, area, shape, direction, or some combination thereof.



**quality assurance**

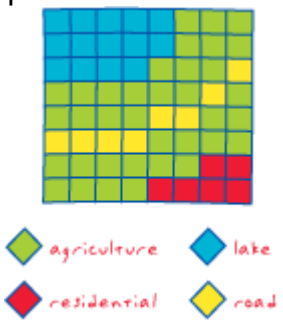
[quality assurance] A process used to verify the quality of a product after its production.

**quality control**

[quality control] A process used during production of a product to ensure its quality.

**raster**

A spatial data model that defines space as an array of equally sized cells arranged in rows and columns, and composed of single or multiple bands. Each cell contains an attribute value and location coordinates. Unlike a vector structure, which stores coordinates explicitly, raster coordinates are contained in the ordering of the matrix. Groups of cells that share the same value represent the same type of geographic feature.




**remote sensing**

[remote sensing] Collecting and interpreting information about the environment and the surface of the earth from a distance, primarily by sensing radiation that is naturally emitted or reflected by the earth's surface or from the atmosphere, or by sensing signals transmitted from a device and reflected back to it. Examples of remote-sensing methods include aerial photography, radar, and satellite imaging.

**remote-sensing imagery**

[remote sensing] Imagery acquired from satellites and aircraft, including panchromatic, radar, microwave, and multispectral satellite imagery.

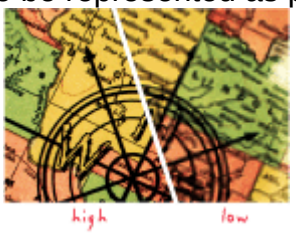

**rendering**

[graphics (computing)] The process of drawing to a display; the conversion of the geometry, coloring, texturing, lighting, and other characteristics of an object into a display image.

**resolution**

[cartography] The detail with which a map depicts the location and shape of geographic features. The larger the map scale, the higher the possible resolution. As scale decreases, resolution diminishes and feature boundaries

must be smoothed, simplified, or not shown at all; for example, small areas may have to be represented as points.




[graphics (computing)] The dimensions represented by each cell or pixel in a raster.
[graphics (computing)] The smallest spacing between two display elements, expressed as dots per inch, pixels per line, or lines per millimeter.
[ESRI software] In ArcGIS, the smallest allowable separation between two coordinate values in a feature class. A spatial reference can include x, y, z, and m resolution values. The inverse of a resolution value was called a precision or scale value prior to ArcGIS 9.2.

**RMS Error (RMSE)**

[spatial statistics (use for geostatistics)] Acronym for root mean square error. A measure of the difference between locations that are known and locations that have been interpolated or digitized. RMS error is derived by squaring the differences between known and unknown points, adding those together, dividing that by the number of test points, and then taking the square root of that result.

**scrubbing**

[quality control] Checking the accuracy of data before it is converted into a different format.
[quality control] Improving the appearance of data by closing open polygons, fixing overshoots and undershoots, refining thick lines, and so forth.

**spatial data**

[data structures] Information about the locations and shapes of geographic features and the relationships between them, usually stored as coordinates and topology.
[data models] Any data that can be mapped.

**symbolization**

[symbology] The process of devising a set of marks of appropriate size, color, shape, and pattern, and assigning them to map features to convey their characteristics at a given map scale.

**topology**

[ESRI software] In geodatabases, the arrangement that constrains how point, line, and polygon features share geometry. For example, street centerlines and census blocks share geometry, and adjacent soil polygons share geometry. Topology defines and enforces data integrity rules (for example, there should be no gaps between polygons). It supports topological relationship queries and navigation (for example, navigating feature adjacency or connectivity), supports sophisticated editing tools, and allows feature construction from unstructured geometry (for example, constructing polygons from lines).

[Euclidean geometry] The branch of geometry that deals with the properties of a figure that remain unchanged even when the figure is bent, stretched, or otherwise distorted.

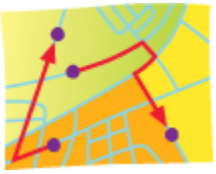
[ESRI software] In an ArcInfo coverage, the spatial relationships between connecting or adjacent features in a geographic data layer (for example, arcs, nodes, polygons, and points). Topological relationships are used for spatial modeling operations that do not require coordinate information.

**undershoot**

[data capture] A line that falls short of another line that it should intersect.


**vector**

[data models] A coordinate-based data model that represents geographic features as points, lines, and polygons. Each point feature is represented as a single coordinate pair, while line and polygon features are represented as ordered lists of vertices. Attributes are associated with each vector feature, as opposed to a raster data model, which associates attributes with grid cells.



**vectorization**

[data conversion] The conversion of raster data (an array of cell values) to vector data (a series of points, lines, and polygons).

**voxel**

[graphics (computing)] A three-dimensional pixel used to display and rotate three-dimensional images.