



Shoreline Cleanup Assessment Technique (SCAT) Digital Data Management Standard

Version 1.0 - 5/2018

1. Purpose

This document describes standards for the storage and management of observational Shoreline Cleanup Assessment Technique (SCAT) data collected by field survey teams during oil spills and similar incidents to evaluate shoreline conditions and oiling, recommend and guide treatment, and document compliance with cleanup endpoints. The standard includes guidelines for

The volume of data collected and developed during oil spill response is growing at an ever increasing rate. This places a substantial burden on the response to be able to rapidly digest and interpret those data to inform operational decision making. This growth in the data management workload has been facilitated by the rapid evolution of electronic field data collection tools, data storage systems and common operational displays. Absent a common vision for how these systems will work together, these tools will be unable to provide a pathway to distill these data and translate them into operationally meaningful information.

This standard was developed by the National Oceanic and Atmospheric Administration (NOAA) Office of Response and Restoration (OR&R), Emergency Response Division (ERD). While there are a variety of SCAT or similar protocols and processes that exist ([CEDRE, 2006](#); [MCA, 2007](#); [Owens and Sergy, 2000](#); [Owens and Sergy 2004](#)), this standard is intended to support the storage and manipulation of data to support the SCAT process as described in the NOAA Shoreline Assessment Manual ([NOAA, 2013](#)). This standard is provided to the response community as a common point of reference in the development of electronic field data collection tools, databases and information products for SCAT activities. This is a voluntary standard that will be maintained and updated by NOAA based on input from the response community and the evolution of new technologies.

The data standard proposed here includes:

1. Recommended Quality Assurance/Quality Control (QAQC) and workflow terminology and steps
2. A conceptual data model, consisting of a set of proposed entities and relationships,
3. Required core tabular attributes describing these entities,
4. Rules for spatial representation of these entities, and required spatial relationships between entities,
5. Data interchange file formats and data structures, and
6. Minimum documentation requirements.

This proposed data standard does not include mandatory logical data model (a set of explicitly required normalized tables, attributes, and relationships) for use in Geographic Information (GIS) or Relational Database Management System (RDBMS) software, though it does suggest these via higher-level concepts. The spatial and attribute data required by the standard are not intended as the entirety of a fully articulated logical data model or database structure. It is expected that databases, applications, or other tools that are used to maintain data compliant with this standard will each have design requirements that require a specific logical model, or a more complex or normalized database structure. In short, the standard is a *standard for a data model*, not a database, database design, or a spatial data storage model.

The standard *does*, however, require the ability of any databases, applications, or other tools used to actively manage SCAT data to export the core tabular and spatial entities in one of a few specific formats using a fixed data structure.

In addition, the standard is intended to support data management for SCAT carried out for the simplest spill that would require management of digital SCAT data. Data managers may need to extend the standard (and associated logical schema or data model) to include additional conceptual entities (e.g. shoreline cleanup status categories), spatial features, tables, or attributes required for a more complex incident, or adapt to incident-specific requirements. Lastly this standard does not address all the tasks required as part of SCAT data management (see [Lamarche et al., 2007](#); [NOAA, 2013](#)). This standard only describes the required components for formal structured data that are collected by full SCAT teams. Data collected by pre-spill surveys, reconnaissance, field photography, special surveys, or to support administrative status tracking are all generally managed by SCAT data management teams, but these data can be highly spill-specific and are not within the scope of this standard.

2. Conceptual Data Model

The standard includes a few core conceptual entities, described below, including shorelines, segments, surveys, surface oil observations (SOO), subsurface oil observations (SSOO) and shoreline treatment recommendations (STRs) (Figure 1). These entities describe general classes of data collected and managed by SCAT.

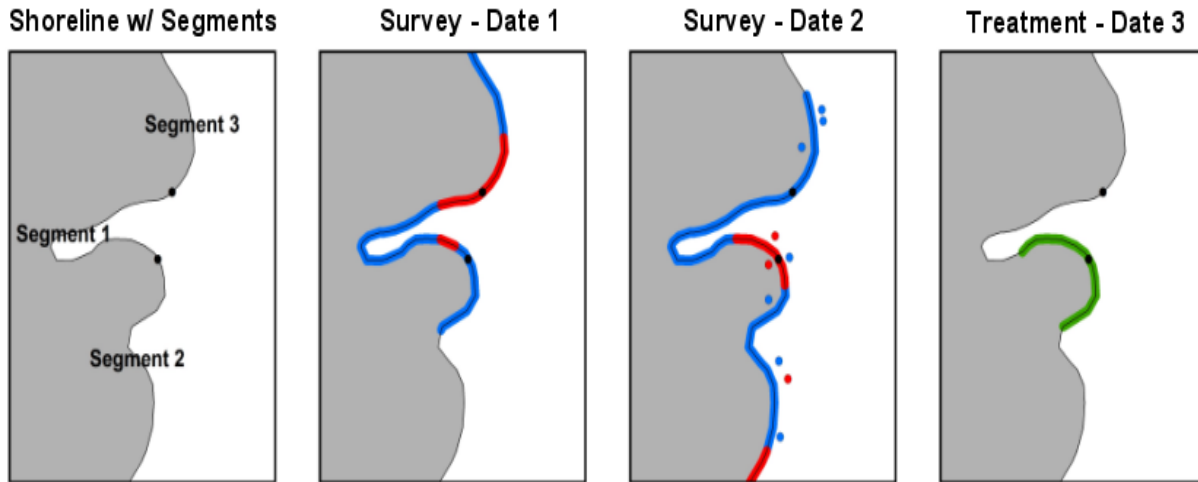


Figure 1. Schematic of spatial relationships among conceptual entities over time showing a shoreline partitioned into segments. SOOs from a survey on Dates 1 and 2 are depicted as blue and red lines coincident with the shoreline for No Oiling Observed and Oiled SOOs respectively. SSOOs from Date 2 are depicted as red and blue points in the vicinity of the shoreline for No Oiling Observed and Oiled SOOs respectively. The extent of an STR on Date 3 is depicted as a green line coincident with the shoreline.

Shoreline Representation

Shorelines are intertidal, fluvial, or lacustrine environments where the land-water interface often changes in position and extent over both long and short time-scales. In order to accurately compare SCAT field data from multiple surveys at a single location it is necessary to reference these observations using a single digital shoreline representation. Shorelines representations are fixed extents of shoreline habitat that are largely spatially unchanging over the timeframe of an incident. These may be derived from existing spatial data before a spill occurs or it may be necessary to generate the Shoreline Representation after an incident has occurred. Shorelines are typically represented as a one-dimensional digital vector line, but may be represented as polygons (complex wetlands or floodplains) or, rarely, points. If a spill event persists for long enough, shoreline representations may move or change in morphology over that time span.

Segments

Shoreline segments are relatively fixed, spatially unchanging subsets of a shoreline representation that are used operationally during a spill response to reference specific portions of a shoreline. These may be predefined before surveys take place, or even before a spill occurs; however, they can also be determined in the field by SCAT teams as they conduct initial surveys. Optimally, segments have consistent geomorphic, physical, and administrative characteristics and are fixed in space. If a spill event persists for long enough, segments may move or change in morphology either as a function of change in their parent shoreline representation or within/along an unchanged parent shoreline representation for operational or administrative reasons. Segments are unique and non-

overlapping in space at a given point in time. A segment must be a child element of a shoreline representation.

Surveys

A survey is a time-specific assessment of the oiling conditions along some subset of a shoreline representation. Surveys may or may not cover the entire length of one or more specific segments. Surveys may describe shoreline surveyed by SCAT teams on foot or observed remotely from vessels or aircraft, and do not necessarily represent areas physically occupied by SCAT teams. Surface and subsurface oiling observations made by field teams on a specific survey are child elements of that survey. A survey has no spatial extent beyond those child elements and is thus defined by the aggregate of the spatial extents of those child elements. Surveys may overlap in space and time. Surveys are associated with structured data such as the date, time and location of the survey as well as a list of the SCAT team members and a formalized generic description of the survey area (see Table 2 below and sections 1-5 of the Shoreline Oil Summary form in [Appendix A](#)).

Surface Oiling Observation (SOO)

SOOs (commonly termed oiling zones, where no observed oil [NOO] is a type of oiling zone) are survey and time-specific representations of consistent observed surface oiling and other shoreline characteristics. SOOs are commonly referenced by start and end points (collected as GPS way points) of the oiling zone along with a description of the oiling characteristics using the SCAT methodology. These start-stop points are matched to the Shoreline Representation discussed above to comply with the topological requirements described in the following sections. This feature matching may be done at the time of data collection or via post-processing. Structured data associated with SOOs contain an across-shore width scalar value and a tidal elevation, but all SOOs that overlap along-shore are typically referenced as separate linear features that are all coincident with the shoreline. In some circumstances it may be necessary to represent SOOs as polygonal features (e.g. complex wetlands or floodplains) or points. Unless this is required to support unique operational considerations, however, it is recommended that SOOs be represented as linear features along a linear shoreline representation. SOOs may potentially overlap in space (different tidal zones along the same shoreline) and time. See Table 3 below and sections 6 of the Shoreline Oil Summary form in [Appendix A](#) for structured data associated with SOOs.

Subsurface Oiling Observation (SSOO)

SSOOs are survey and time-specific representations of observed subsurface oiling and other shoreline characteristics. SSOOs are generally explicitly referenced with a single zero-dimensional point together with one or more scalar depth values where oiling was investigated in the field by excavation of a pit, trench, or core. As with SOOs, SSOOs may occasionally be referenced as polygons or lines but this is not done in practice unless dictated by operational requirements. SSOOs may potentially overlap in space and time – though generally this will not occur if represented by zero-dimensional points. All SSOOs must be a child element of a survey. See Table 4 below and sections 7 of the Shoreline Oil Summary form in [Appendix A](#) for structured data associated with SSOOs.

Shoreline Treatment Recommendations (STR)

STRs are time-period-specific recommended cleanup actions prescribed/permitted for a given location. This location can either be defined by a spatial entity (e.g., a linear or polygonal feature) specific to the STR, or by referencing the spatial geometry of other entities. For example, the location of an STR could be the extent of a specific SSO or set of SSOs from a specific survey, or the entirety of a certain segment or segments.

3. Recommended QAQC and Workflow Terminology

It is helpful to have a common framework for describing the typical workflow, processing steps, and Quality Assurance/Quality Control (QAQC) procedures that commonly take place during the active collection and management of SCAT data. As such, the standard introduces a common set of terminology and best practices for field data collection.

The standard identifies the first phase of workflow as the field survey component. During this phase, field staff are in the field collecting data electronically or via analog methods, or reviewing the collected data internally prior to submitting the survey data. During this phase, the survey data are considered to have a QAQC status of *incomplete*. After the field personnel have reviewed the data they have collected in the field, electronic or analog, and submitted to data management staff, then the survey data are considered to have a QAQC status of *provisional*, and the survey data ingestion phase of the data management workflow begins. Note that if data are being collected via any electronic data collection system, the data may be actually housed in a centralized location on a commercial cloud, or response specific server during or immediately after collection, but are not considered as complete provisional data until review by field staff. Information products generated as part of this workflow phase vary by response, but include only items related to field survey effort and status such as the number of teams in the field and/or reported back, and general survey areas.

During the survey data ingestion phase of workflow, data are initially entered into a digital data management system if collected via analog methods. If entered digitally, an optional transcription verification QAQC check may take place during this phase of the workflow. Survey data are then reviewed by a SCAT data manager for survey consistency, wherein survey data are checked for completeness and logical consistency. Logical consistency refers to contradictions between individual data elements within survey data. For example, a zone wherein the categorical descriptor of the dominant oil character was recorded as “no oil” but where oil distribution was recorded as a non-zero value. After this QAQC check, the data are checked for accuracy by the SCAT Coordinator. Generally this check involves reviewing the collected survey data to ensure standardized descriptive terms are being used, correct methodology is being employed, observations of quantitative elements are calibrated among teams, etc. After these checks, then the field survey data are considered to have a QAQC status of *approved* and are made available to other users within the response, and enter the post-processing phase of the workflow. Prior to approval of field survey data, information products generated as part of this workflow phase are typically only metrics related to QAQC status of data in the data ingestion pipeline.

After field survey data are approved, then the approved field data themselves are the primary information product.

In many cases, provisional field survey data are used during the data ingestion workflow phase to begin Shoreline Treatment Recommendation (STR) development workflow phase. This phase may take place in parallel, or partially overlapping the data ingestion phase subject to the requirements of the response, and the prevailing operational tempo. Typically, STR preparation begins immediately after field survey data are complete and still provisional with close consultation between field staff and SCAT coordinator. However, STR preparation and approval within the wider response often takes some time, and will not be completed after field survey data are approved. The primary information products of this workflow phase is the STR itself.

The post-processing phase of the workflow involves the additional processing of approved SCAT field survey data for a variety of response-specific data management needs and tasks. Often, this will involve linear referencing (or, “snapping”) of field collected spatial data to a common reference shoreline, or other data manipulation and analysis tasks. Primary information products generated during this workflow phase vary by response, but typically include maximum precedent or current oiling spatial data, map, or tabular summary products. Typically, SCAT field staff, data managers and coordinators jointly conduct report QAQC checks during this phase to ensure that information products accurately reflect actual field conditions as described by the approved survey data.

A schematic of these recommended SCAT data collection workflow phases and associated QAQC statuses, checkpoints, and information products is included in Figure 2. Note that during a response with a typical operational tempo, SCAT field survey data collected on different days, as well as STRs, will be in all of these workflow phases simultaneously.

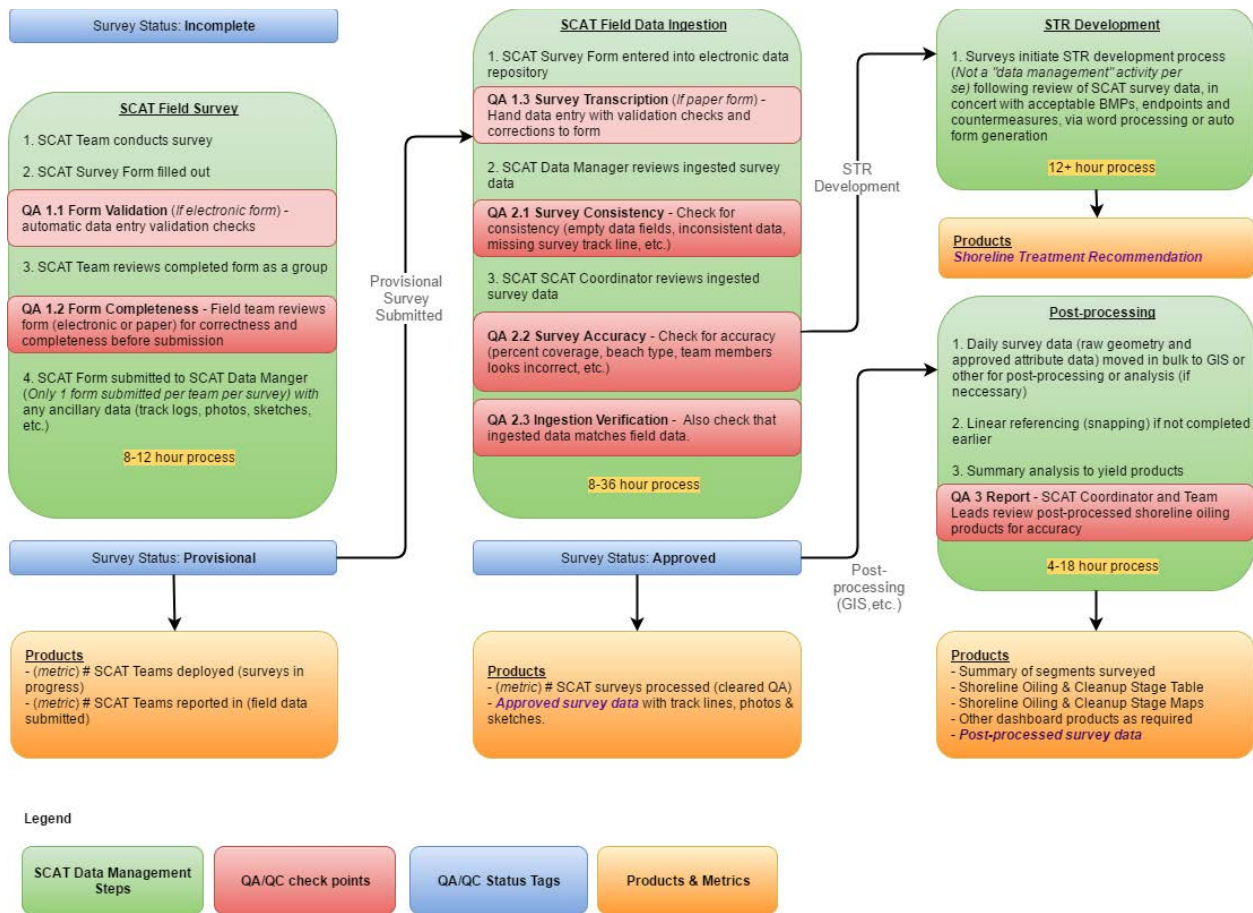


Figure 2. Schematic of recommended SCAT data collection workflow phases and associated QA/QC statuses, checkpoints, and information products.

4. Required Spatial Data and Relationships

Required Spatial Entities

Specific conceptual entities must have explicit and unique spatial representation as independent vector geometry for use and analysis in GIS software or web mapping applications. At minimum, these include:

- Shoreline Representation
- Segments
- Surface Oiling Observations (SOOs or oiling zones)
- Subsurface Oiling Observations (SSOOs or pits)

Other conceptual entities are also required to have spatial representations, but these do not necessarily have to be stored explicitly as independent vector geometry. Instead, they may be stored as lists or lookup tables into other entities that do have explicit geometry. These entities include:

- Surveys

- Shoreline Treatment Recommendations

Figure 3 is a schematic of entities and their required spatial relationships over time. Surveys are required to have spatial extents consisting only of their children surface and subsurface shoreline observations. STRs may have spatial extents defined by one or more SOOs or SSOOs, one or more segments, or some other portion of a shoreline representation, or some other spatial extent. If an STR may be uniquely defined by reference to other entities, then it can be spatially represented by a non-spatial list of these other features. If an STR has a spatial extent that cannot be uniquely defined by one or more SOOs, SSOOs, or segments, then it must be represented by explicit vector geometry.

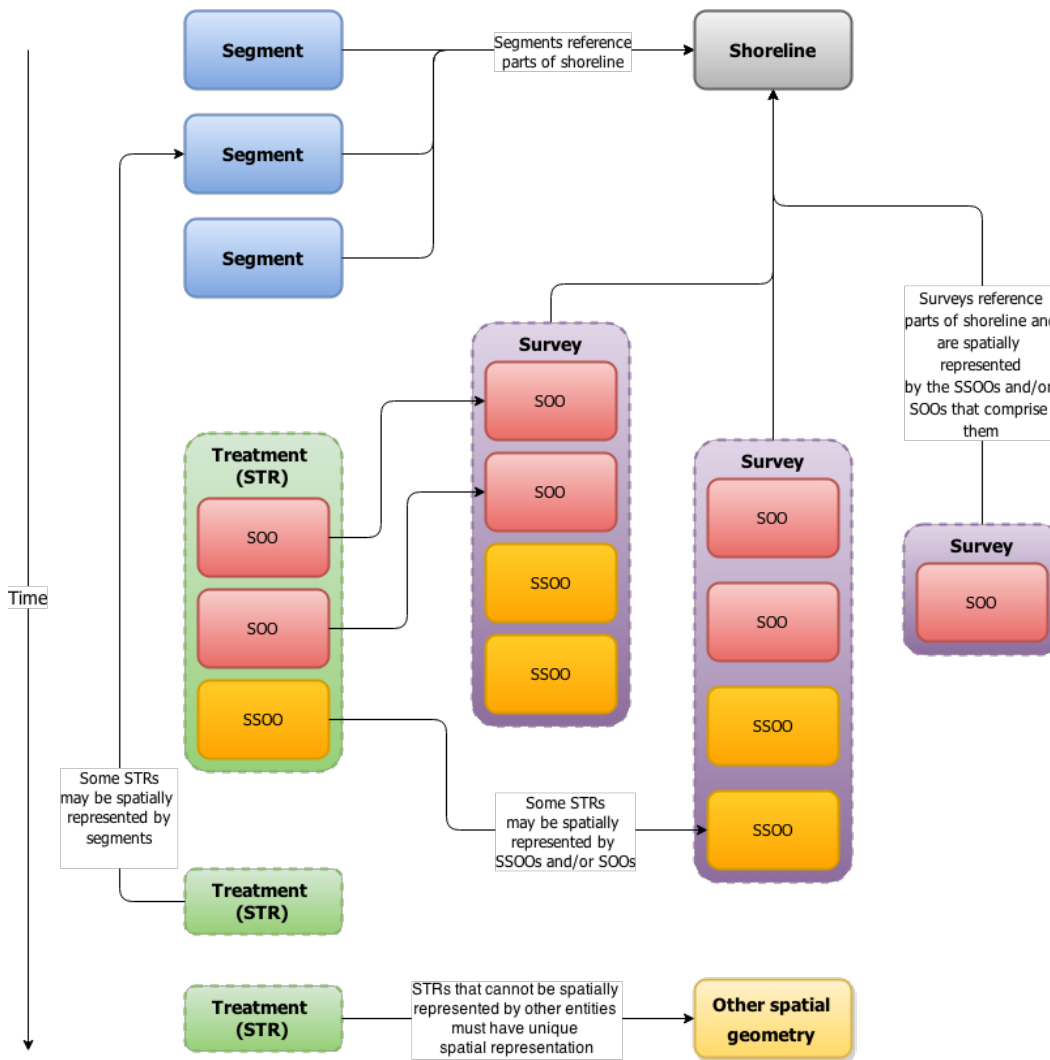


Figure 3. Schematic of logical relationships among conceptual entities over time. Entities with solid outlines are have unique individual spatial representations. Entities with dashed outlines have spatial extents defined by the spatial representations of other entities.

Required Spatial Topology

In addition to logical relationships between entities described above, the standard also includes rules describing required relationships between spatial features. These are made explicit using the concept of topology. Topology, defined here as the properties of geometric features in two dimensions, is a way to define and explicitly test for properties like adjacency, connectivity, proximity, and coincidence. Certain topological relationships are required by the standard for features with polygonal and linear spatial representations. These relationships are referenced in the descriptions of conceptual entities above. Most importantly, it is required that all linear surface oiling representations (zones) must be coincident with the linear shoreline representation. If any other entities such as subsurface oiling representations, shoreline treatment recommendations, or other entities are represented as linear features, these must also be coincident with the linear shoreline representation. This standard makes reference to spatial relationships described in the DE-9IM model (Clementini et al., 1993; Egenhoffer and Franzosa, 1991) which is implemented in standard GIS software and spatial databases.

The standard requires that these topological relationships exist, but does not have any requirements for how or when these relationships are enforced. For example, raw spatial data (e.g. field collected coordinates) or interim analysis products stored within a GIS or RDBMS software system are not required to comply with these topological rules. However, the standard does require that topologically compliant data is either: 1.) automatically or regularly generated as part of such software systems and associated data management processes, or 2.) is readily and simply generated when generating data for export or interchange. For example, a survey team might record the location of a linear SOO (zone) using a GPS device that records points that are not coincident with the shoreline representation. Storage of these raw coordinate data is acceptable and encouraged. To generate data compliant with this standard, however, these raw coordinates must be made topologically correct by "snapping" these coordinates to the shoreline representation and generating linear features that comply with the rules below.

The standard requires the following topological relationships:

- All linear features must not self-cross or self-overlap (e.g. must be simple and not complex).
- All linear features must overlap with a linear shoreline if the relevant shoreline is represented linearly and not as a polygon.
- Linear features must not cross other linear features of the same type but may overlap other linear features of the same type.
- Linear and polygonal features with multiple parts (e.g. multipart features or collections of features with the same geometry type) are permitted but not required.
- All spatial features must be covered by a polygonal shoreline, intertidal zone, or potentially oiled area if such a feature exists (features may lie exactly on the boundary of a polygonal shoreline, but may not extend beyond)

- Polygonal features may have interior holes, but multipart polygonal features may not have parts contained in interior holes in that feature. These "islands" must be represented as separate spatial features.

See figures 4-7 below for illustrative examples.

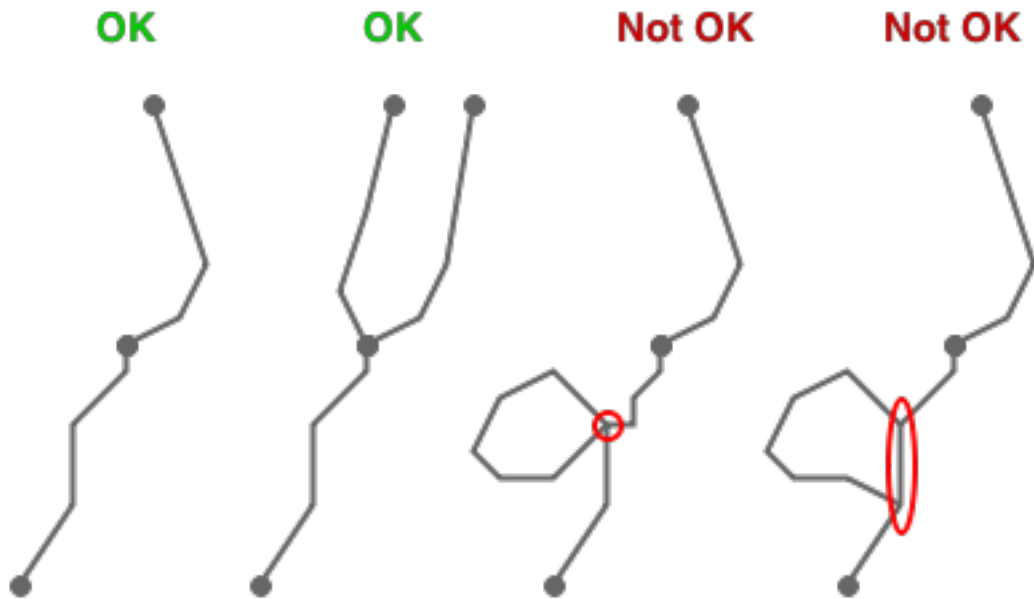


Figure 4. Linear features may intersect other linear features at endpoints but may not self-cross, or self-overlap. Linear feature endpoints depicted as dots, whereas feature vertices are not depicted.



Figure 5. All non-shoreline linear features must overlap linear shoreline features

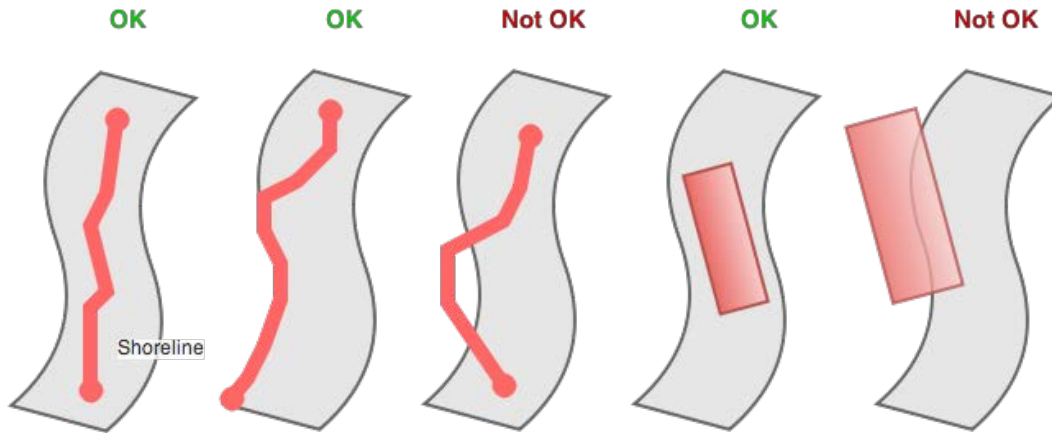


Figure 6. All non-shoreline spatial features must be covered by polygonal shoreline features (lie in the interior or along the boundary of the polygonal shoreline feature) if such features exist.

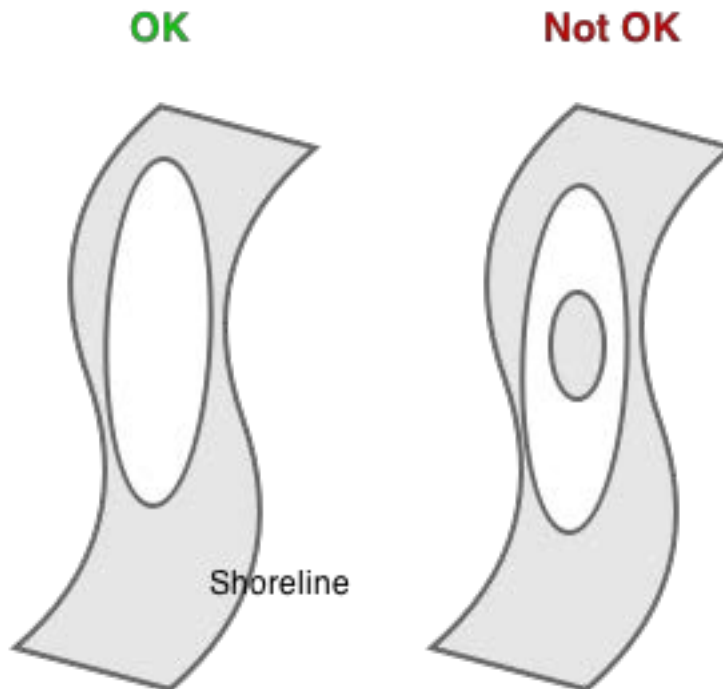


Figure 7. All polygonal shoreline features may have interior holes, but multipart polygonal features may not have parts contained within interior holes (i.e., cannot have an "island" within a hole).

All of these relationships are enforceable and testable in most commercial or open-source vector-based GIS, spatially enabled database software packages, or topology libraries including ArcGIS, Quantum GIS, Oracle Spatial, PostGIS, Java Topology Suite (JTS), and others.

5. Required Tabular Attributes and Logical Relationships

This standard includes a set of core attributes for each conceptual entity represented in a data table. These are listed in the tables below. For entities that require explicit spatial representation, these may be stored in a format that combines spatial and attribute information, or in data tables that are separate from spatial information. NOAA recognizes that each incident presents unique challenges and requirements, so it is anticipated and desirable that this standard may be extended. Data managers and spill response personnel are free to add additional fields to store additional or more specific information, though the field specified in the tables below are mandatory. Additional codes may be added to the codesets specified below where required to record different or event-specific conditions. This standard requires only that any such changes be included in accompanying documentation or metadata (see the Metadata section below). Different GIS and database software packages may have different requirements and conventions regarding field naming. As such, the field names included below are intended as suggested field names only. Data managers are free to adopt field names suitable for use in the specific software packages in use during a response. Field names should be fully annotated in accompanying metadata, and compliant with the following criteria:

- Should begin with alphabetical characters.
- Should not include spaces, dashes, or special characters other than underscores.
- Should avoid unmodified words commonly reserved by GIS or RDMS software systems or programming constructs, such as "date", "order", "file", "range", "loop", "by" etc. For example, "date" is unacceptable as a field name, but "obs_date" is acceptable.
- Should be limited to 10 characters where possible to meet limitations of the ESRI shapefile format.
- Should be human-readable where possible.

Required Tabular Attributes

Note that certain attributes of surveys, Surface Oiling Observations (SSOs) or oiling zones, and Subsurface Oiling Observations (SSOOs) are always required to be collected in the field at the time of survey, while other attributes may be assigned after the fact, or programmatically by data collection or storage software. These attributes are indicated in a separate column for the relevant conceptual entities in the tables below. Raw or field collected data consisting of hardcopy or scanned forms or electronically collected SCAT field data in any format must include this subset of tabular attributes for these conceptual entities to be compliant with this standard.

Table 1. Required tabular attributes for segments. No segment related data is required to be collected in the field, though this is possible and permitted.

Attribute	Description	Suggested Field Name	Type	Codeset or valid values
Segment ID	Unique identifier	SEG_ID	Text	Alphanumeric text string containing identifier sufficient to uniquely identify segment
Start date	Beginning date of applicability of shoreline segment	START_DATE	Date	Valid date in local time zone
End date	Ending date of applicability of shoreline segment	STOP_DATE	Date	Valid date in local time zone
Start Latitude	Latitude of beginning of linear segment	START_LAT	Numeric	Floating point values in decimal degrees in WGS84 datum.
Start Longitude	Longitude of beginning of linear segment	START_LON	Numeric	Floating point values in decimal degrees in WGS84 datum.
End Latitude	Latitude of end of linear segment	END_LAT	Numeric	Floating point values in decimal degrees in WGS84 datum. Null values permitted only for segments represented as a single point.
End Longitude	Longitude of end of linear segment	END_LON	Numeric	Floating point values in decimal degrees in WGS84 datum. Null values permitted only for segments represented as a single point.
Shoreline type	Shoreline type	SEG_STYPE	Text - Codeset	Estuarine, Riverine, or Lacustrine Environmental Sensitivity Index (ESI) shoreline classification. See NOAA, 2002; 2013 . Other codesets acceptable with documentation.

Table 2. Required tabular attributes for Surveys. Attributes required to be collected in the field via form or electronic data collection indicated (“Field Req.”).

Attribute	Field Req.	Description	Suggested Field Name	Type	Codeset or valid values
Survey ID	No	Unique identifier	SURV_ID	Text	Alphanumeric text string containing identifier sufficient to uniquely identify survey within and across dates
Survey Date	Yes	Date of survey	SURV_DATE	Date	Valid date in local time zone
Survey Start Time	Yes	Time of survey start	START_TIME	Time	Valid time in local time zone
Survey Stop Time	Yes	Time of survey end	STOP_TIME	Time	Valid time in local time zone
Survey By	Yes	Personnel conducting survey	SURV_PER1	Text	Name and organization of first team member conducting survey. Though not required by standard, this may be pulled from lookup table. Multiple fields required to hold unknown count of multiple values.
Survey By	Yes		SURV_PER2	Text	See above.
Survey By	Yes		SURV_PER3	Text	See above.
Survey By	Yes		SURV_PER4	Text	See above.
Survey By	Yes		SURV_PER5	Text	See above.
Survey By	Yes		SURV_PER6	Text	See above.
Segments	No	Segment(s) surveyed	SEGMENTS	Text or Lookup Table	
Survey Method	Yes	Method used to conduct survey	SURV_TYPE	Text - Codeset	Codes: Foot; ATV; Airboat; Boat; Helicopter/Aircraft; Overlook; UAS; Dog

Table 3. Required tabular attributes for Surface Oiling Observations (SSOs) or oiling zones. Attributes required to be collected in the field via form or electronic data collection indicated (“Field Req.”).

Attribute	Field Req.	Description	Suggested Field Name	Type	Codeset or valid values
Zone ID	No	Unique identifier	ZONE_ID	Text	Alphanumeric text string containing identifier sufficient to uniquely identify oiled zone within survey
Elevation	Yes	Categorical descriptor for average/dominant elevation relative to tidal or other water level datum	ZONE_ELEV	Text - Codeset	Codeset for tidal environments: LI: Lower intertidal; MI: Middle intertidal; UI: Upper intertidal; SU: Supratidal; LI/MI Lower- to middle intertidal; MI/UI: Middle- to upper intertidal; UI/SU Upper intertidal to supratidal; LI/MI/UI Lower- to upper intertidal; MI/UI/SI: Middle intertidal to supratidal; LI/MI/UI/SU: Lower intertidal to supratidal Other codesets acceptable with documentation.
Start Latitude	Yes	Latitude of beginning of linear zone	START_LAT	Numeric	Floating point values in decimal degrees in WGS84 datum.
Start Longitude	Yes	Longitude of beginning of linear zone	START_LON	Numeric	Floating point values in decimal degrees in WGS84 datum.
End Latitude	Yes	Latitude of end of linear zone	END_LAT	Numeric	Floating point values in decimal degrees in WGS84 datum. Null values permitted only for observations represented as a single point.
End Longitude	Yes	Longitude of end of linear zone	END_LON	Numeric	Floating point values in decimal degrees in WGS84 datum. Null values permitted only for observations represented as a single point.
Width	Yes	Average across-shore width of oiled zone in meters	WIDTH	Numeric	Floating point values in meters. Zero values permitted only for NO observations.

Attribute	Field Req.	Description	Suggested Field Name	Type	Codeset or valid values
Distribution	Yes	Average areal distribution of surface oil as percentage or ratio of substrate of oiled zone or categorical descriptor of same	SO_DIST	Numeric <i>OR</i> Text - Codeset	Floating point values as percentage or ratio. Zero values permitted only for NOO observations. Null values permitted only for observations with discrete oiling counts, unit areas, and sizes. May only be null for NO observations or only for observations with discrete oiling counts, unit areas, and sizes. Codes (if codeset used): CN: Continuous ; BR: Broken; PT: Patchy; SP: Sporadic; TR: Trace
Thickness	Yes	Average thickness of surface oil in cm or categorical descriptor of same	SO_THICK	Numeric <i>OR</i> Text - Codeset	Floating point values in cm. Zero values permitted only for NO observations. Null or blank values permitted only for observations with discrete oiling counts, unit areas, and sizes. May only be null or blank for NO observations or only for observations with discrete oiling counts, unit areas, and sizes. Codes (if codeset used): TO: Thick oil; CV: Cover; CT: Coat; ST: Stain; FL: Film
Character	Yes	Categorical descriptor of dominant oil character within oiled zone	SO_CHAR	Text - Codeset	May only be null or blank only for observations with discrete oiling counts, unit areas, and sizes. Codes: FR: Fresh oil; MS: Mousse/emulsion; TB: Tarballs; PT: Patties; TC: Tarry coat; SR: Surface residue; AP: Asphalt pavement; NO: No oil observed

Attribute	Field Req.	Description	Suggested Field Name	Type	Codeset or valid values
Substrate	Yes	Categorical descriptor for location of surface oil (sediment/soil, vegetation canopy, or both)	SUBSTR	Text - Codeset	Null or blank values permitted only for NO observations. Codes: S: Sediment; V: Vegetation canopy; B: Both sediment and canopy
Discrete oiling count per unit area	Yes	Count per unit area of tarballs or residue balls in oiled zone	TB_CNT	Numeric	Integer values. Zero values permitted only for NO observations or observations with areal distribution and thickness as above.
Discrete oiling count unit area	Yes	Area of count of tarballs or residue balls in oiled zone	TB_AREA	Numeric	Floating point values. Zero, null or blank values permitted only for NO observations or observations with areal distribution and thickness as above.
Discrete oiling count unit area	Yes	Unit area or length of count of tarballs or residue balls in oiled zone	TB_ARUNIT	Text - Codeset	Null or blank values permitted only for NO observations or observations with areal distribution and thickness as above. Codes: M2: Per square meter; M100: Per 100 meter alongshore; M: Per meter alongshore; ZONE: Per area of zone
Discrete oiling avg. size	Yes	Average planimetric diameter in cm of tarballs or residue balls in oiled zone.	TB_AVSIZE	Numeric	Floating point values in centimeters. Zero, null or blank values permitted only for NO observations or observations with areal distribution and thickness as above.
Discrete oiling large size	Yes	Largest planimetric diameter in cm of tarballs or residue balls in oiled zone.	TB_LGSIZE	Numeric	Floating point values in centimeters. Zero, null or blank values permitted only for NO observations or observations with areal distribution and thickness as above.
Type of discrete oiling	Yes	Dominant categorical descriptor of tarballs, residue balls or other discrete oiling within oiled zone	TB_TYPE	Text - Codeset	Null or blank values permitted only for NO observations or observations with areal distribution and thickness as above.

Attribute	Field Req.	Description	Suggested Field Name	Type	Codeset or valid values
					Codes: F: Fresh oil; E: Emulsion; S: Sticky; W: Weathered; R: Residue; O: Other
Plant oiling bottom elevation	Yes	Average vertical elevation of lowest oiling on plant canopy in cm from sediment surface	P_OILBOT	Numeric	Floating point values in centimeters. Zero values only permitted for NO or non-plant oiling observations (Substrate <> P or B).
Plant oiling top elevation	Yes	Average vertical elevation of highest oiling on plant canopy in cm from sediment substrate	P_OILTOP	Numeric	Floating point values in centimeters. Zero values only permitted for NO or non-plant oiling observations (Substrate <> P or B).
Plant height	Yes	Average height of plant canopy in cm from sediment surface	P_HEIGHT	Numeric	Floating point values in centimeters. Zero values only permitted for NO or non-plant oiling observations (Substrate <> P or B).
Shoreline Type	Yes	Shoreline type	ZONE_STYPE	Text - Codeset	Estuarine, Riverine, or Lacustrine Environmental Sensitivity Index (ESI) shoreline classification. See NOAA, 2002; 2013 . Other codesets acceptable with documentation.
Category	No	Categorical descriptor of relative oiling intensity.	ZONE_CAT	Text - Codeset	Computed. See NOAA, 2013 .
Survey ID	No	Unique identifier	SURV_ID	Text	Alphanumeric text string containing identifier sufficient to uniquely identify survey within and across dates. See survey table.
Segment ID	No	Unique identifier	SEG_ID	Text	Alphanumeric text string containing identifier sufficient to uniquely identify segment. See segment table.

Table 4. Required tabular attributes for Subsurface Oiling Observations (SSOs). Attributes required to be collected in the field via form or electronic data collection indicated.

Attribute	Field Req'd	Description	Suggested Field Name	Type	Codeset or valid values
Pit ID	No	Unique identifier	PIT_ID	Text	Alphanumeric text string containing identifier sufficient to uniquely identify pit, trench, or core within survey
Pit Latitude	Yes	Latitude of pit	PIT_LAT	Numeric	Floating point values in decimal degrees.
Pit Longitude	Yes	Longitude of pit	PIT_LON	Numeric	Floating point values in decimal degrees.
Elevation	Yes	Categorical descriptor for average/dominant elevation relative to tidal or other water level datum	PIT_ELEV	Text - Codeset	Codeset for tidal environments: LI: Lower intertidal; MI: Middle intertidal; UI: Upper intertidal; SU: Supratidal Other codesets acceptable with documentation.
Pit depth	Yes	Maximum depth of subsurface pit, trench or core in cm below sediment surface.	DEPTH	Numeric	Floating point values in centimeters. No zero values permitted.
Oiling top depth	Yes	Average depth of the top of observed subsurface oiling in cm below sediment surface.	SSO_TOP	Numeric	Floating point values in centimeters. Null or blank values only permitted for NO observations.
Oiling bottom depth	Yes	Average depth of the bottom of observed subsurface oiling in cm below sediment surface.	SSO_BOT	Numeric	Floating point values in centimeters. Zero, null or blank values permitted only for NO observations.
Character	Yes	Categorical descriptor of dominant oil character within oiled pit	SSO_CHAR	Text - Codeset	Null or blank values not permitted. Codes: SR: Surface residue; SAP: Subsurface asphalt pavement; OP: Oil-filled pores; PP: Partially filled pores; OR: Oil residue; OF: Oil film; TR: Trace;

Attribute	Field Req'd	Description	Suggested Field Name	Type	Codeset or valid values
					NO: No oil observed
Distribution	Yes	Average areal distribution of subsurface oil within vertical oil interval as percentage or ratio of surface area in excavated pit, trench, or core or categorical descriptor of same.	SSO_DIST	Numeric <i>OR</i> Text - Codeset	Floating point values as percentage or ratio. Zero values permitted only for NOO observations. Codes (if codeset used): CN: Continuous; BR: Broken; PT: Patchy; SP: Sporadic; TR: Trace
Depth to Water Table	Yes	Average depth of the bottom of observed water level in cm below sediment surface	WATER_DEP	Numeric	Floating point values in centimeters.
Sheen Color	Yes	Categorical descriptor of sheen on water table in pit, trench, or core if present	SHEEN	Text - Codeset	Codes: B: Brown; R: Rainbow; S: Silver; N: No sheen observed
Clean Below	Yes	Boolean indicator of presence of clean sediment below oiled sediment	CLN_BELOW	Boolean	T/F
Category	No	Categorical descriptor of relative oiling intensity in pit	PIT_CAT	Text - Codeset	Computed. See NOAA, 2013 .
Survey ID	No	Unique identifier	SURV_ID	Text	Alphanumeric text string containing identifier sufficient to uniquely identify survey within and across dates. See survey table.
Segment ID	No	Unique identifier	SEG_ID	Text	Alphanumeric text string containing identifier sufficient to uniquely identify segment. See segment table.

Table 5. Required tabular attributes for Shoreline Treatment Recommendations (STRs).
No STR related data is required to be collected in the field, though this is possible and permitted.

Attribute	Description	Suggested Field Name	Type	Codeset or valid values
STR ID	Unique identifier	STR_ID	Text	Alphanumeric text string containing identifier sufficient to uniquely identify STR
STR Issue Date	Date STR was issued as permit	STR_ISSUE	Date	Valid date in local time zone
STR Completion Date	Date STR was completed	STR_COMPL	Date	Valid date in local time zone
STR Replaced By	Superseding STR	STR_REPL	Text or lookup table	Either text or lookup table containing or pointing to one or more STR IDs that replaced or superseded if present.

Logical Relationships

The standard includes requirements for logical relationships between records in data tables describing the entities involved and records in other data tables and spatial features. The standard has no requirements for how and when these logical relationships are enforced. Relationships may be enforced by rules declared as part of the logical schema of compliant databases, built into the applications that make use of these databases, or checked via Quality Assurance/Quality Control (QAQC) procedures. Briefly, this standard requires:

- All spatial features describing surface oiling representations (zones) or subsurface oiling representations (pits) should have one corresponding record in the data tables containing attributes for those features.
- All tabular records describing surface oiling representations (zones) or subsurface oiling representations (pits) should have one or more corresponding spatial features describing these entities.
- All tabular records describing surface oiling representations (zones) or subsurface oiling representations (pits) should have a parent record in the data table containing information about the survey in which the given observation was made.
- All tabular records describing surveys are required to have at least one child record in the data table containing information about surface oiling observations (zones) or subsurface oiling observations made in that survey.

6. Data Interchange File Formats and Naming Conventions

This standard requires that all compliant spatial and associated tabular data, regardless of file formats and structures used to store or manipulate his data, must be made available in a limited set of widespread and commonly used commercial, or open-source, cross-platform formats. Compliant data must be able to be readily and simply converted/exported to one of these compliant file format to facilitate interchange.

Standard compliant data should made available in one of three formats:

- 1.) As multiple ESRI shapefile (.shp) and comma-separated text (.csv) files. All spatial data should be included as features in shapefiles, as described in ESRI (1998). Tabular data should be should made available as CSV files, as described by Shafranovich (2005).
- 2.) As a single ESRI File Geodatabase (.gdb) as described by ESRI (2017) containing individual feature classes for spatial data, and data tables for tabular data.
- 3.) As multiple JavaScript Object Notation (JSON) or GeoJSON (.json/.geojson) files. Spatial data should be included as features in GeoJSON files, as described in Butler et al. (2016). Tabular data should be included as JSON files, as described in Bray (2014).

Each conceptual entity (e.g. segments, zones, etc.) should be stored in a unique shapefile, feature class, or GeoJSON file. If the same type of conceptual entity is represented by geometries of different dimensions (e.g. zones stored as both linear and polygonal features) then a separate unique shapefile or feature class for each geometry type should be included.

To preserve flexibility required for storing data in different formats and manipulating data in different software packages, this standard does not specify explicit file names. It is important however that file names follow a logical and documented naming convention. It is recommended that file names include an explicit date of generation. Further, file names should be compliant with the following criteria:

- Should begin with alphabetical characters.
- Should not include spaces, dashes, or special characters other than underscores.

File formats such as .ai, .eps, .ps, .pdf, or .psd created from graphics editing applications such as Adobe Illustrator, Adobe Photoshop, Adobe Acrobat or other image generating applications or drivers are not acceptable. Similarly, data in file formats such as .dxf or .dwg from Computer Aided Design (CAD) applications are also not compliant with this standard. Text should be encoded using the UTF-8 Unicode encoding standard if the internal Unicode encoding is not otherwise specified.

Note examples of standard-compliant data interchange files in ESRI shapefile (.shp), comma-separated text (.csv) files, ESRI File Geodatabase (.gdb), and JSON (.json) and GeoJSON (.geojson) format for each conceptual entity accompany this document.

7. Metadata

Documentation sufficient to allow users not participating in data collection or management during a spill event to understand and use SCAT data is a mandatory component of this standard. Metadata is structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource (NISO, 2004). Because SCAT data have a spatial component by definition, geospatial metadata standards are most appropriate, but any of the following standards is acceptable:

- ISO 19115 (ISO, 2014)
- Federal Geospatial Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (FGDC, 1998)
- Project Open Data Metadata Schema v1.1 (POD, 2015)

See references for internet resources specific to each of these standards. Tools enabling rapid and semi-automated creation of compliant metadata, either as stand-alone software or integrated with commercial and open source GIS and database software packages, are widely available. Compliance with a specific metadata standard is encouraged but not mandatory under the SCAT data standard. Regardless of the metadata standard applied, documentation sufficient for other users to understand the content, scope, structure, logical relationships, field names and contents, and other important details is required.

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