How to Design a GeoDB

GEOG 419/519: Advanced GIS

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Key is asking the right questions:

- How can GIS technology be implemented to streamline existing functions or change the way we achieve a goal
- What data will benefit the organization the most?
- What data can be stored?
- Who is responsible for maintaining the database?

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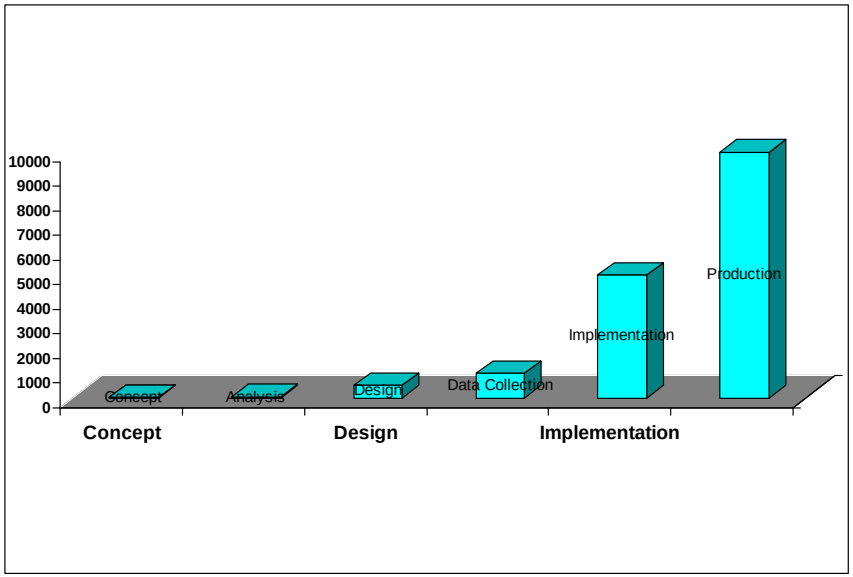
Truths about Design

- Time-consuming
- No end-use applications
- If not done:
  - Database may not meet requirements
  - Can end up with duplicate, missing, or unnecessary data
  - Lack of necessary management techniques



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Objectives of Design

- Design should define goals, identify, analyze, and evaluate design alternatives, and create implementation plan
- Investment of time and money up front saves even more time and money later
- A functional, well-organized database:
  - Satisfies organizational objectives
  - Contains all necessary data
  - Accommodates different views of the data
  - Distinguishes maintenance apps from user apps
  - Organizes data so that different users access the same data

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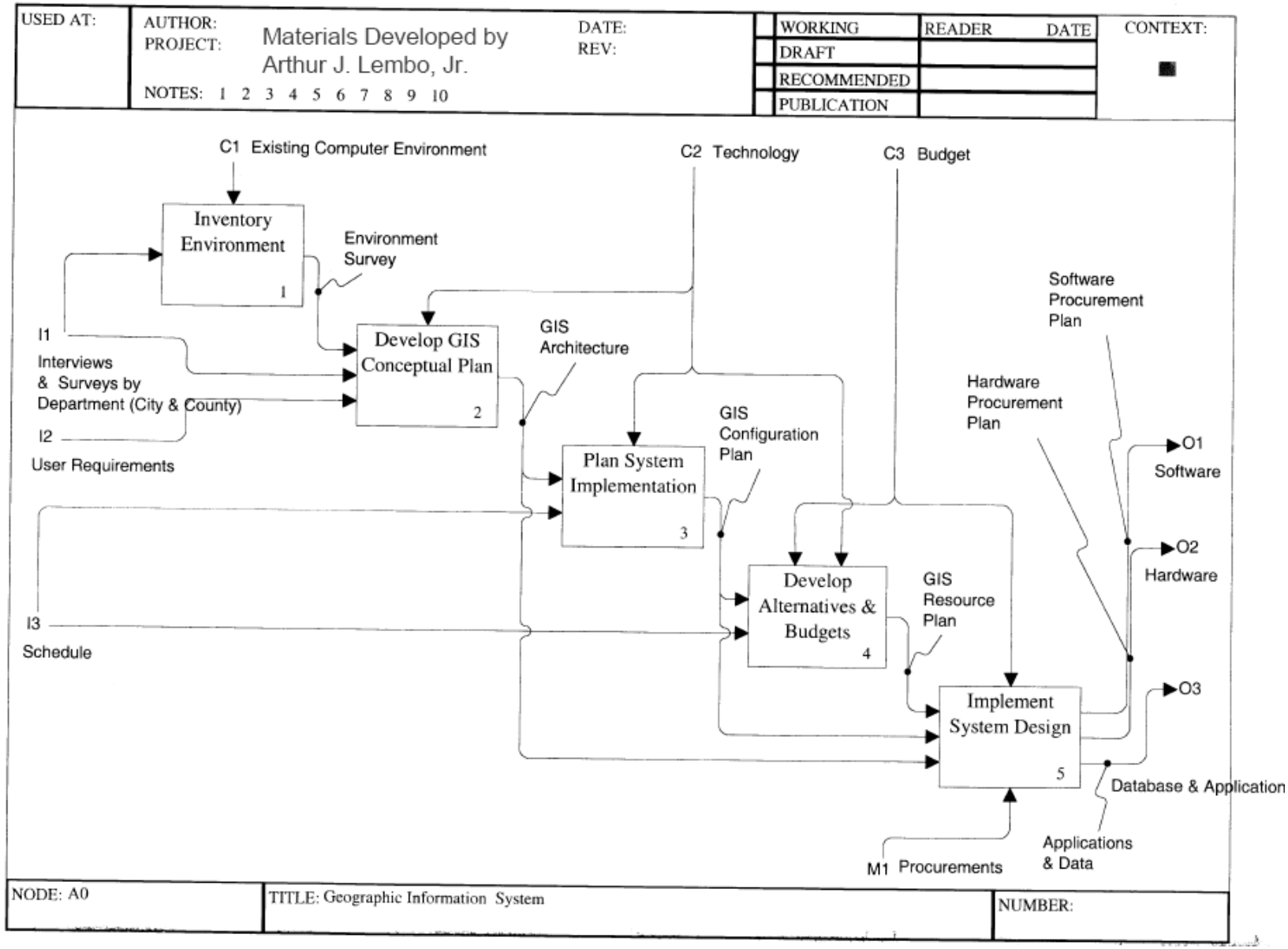

Design Guidelines

- Involve users
- Take it one step at a time
- Build a team
- Be creative
- Create deliverables
- Keep organizational goals and objectives in focus
- Do not add detail prematurely
- Document carefully
- Be flexible
- Plan from you model

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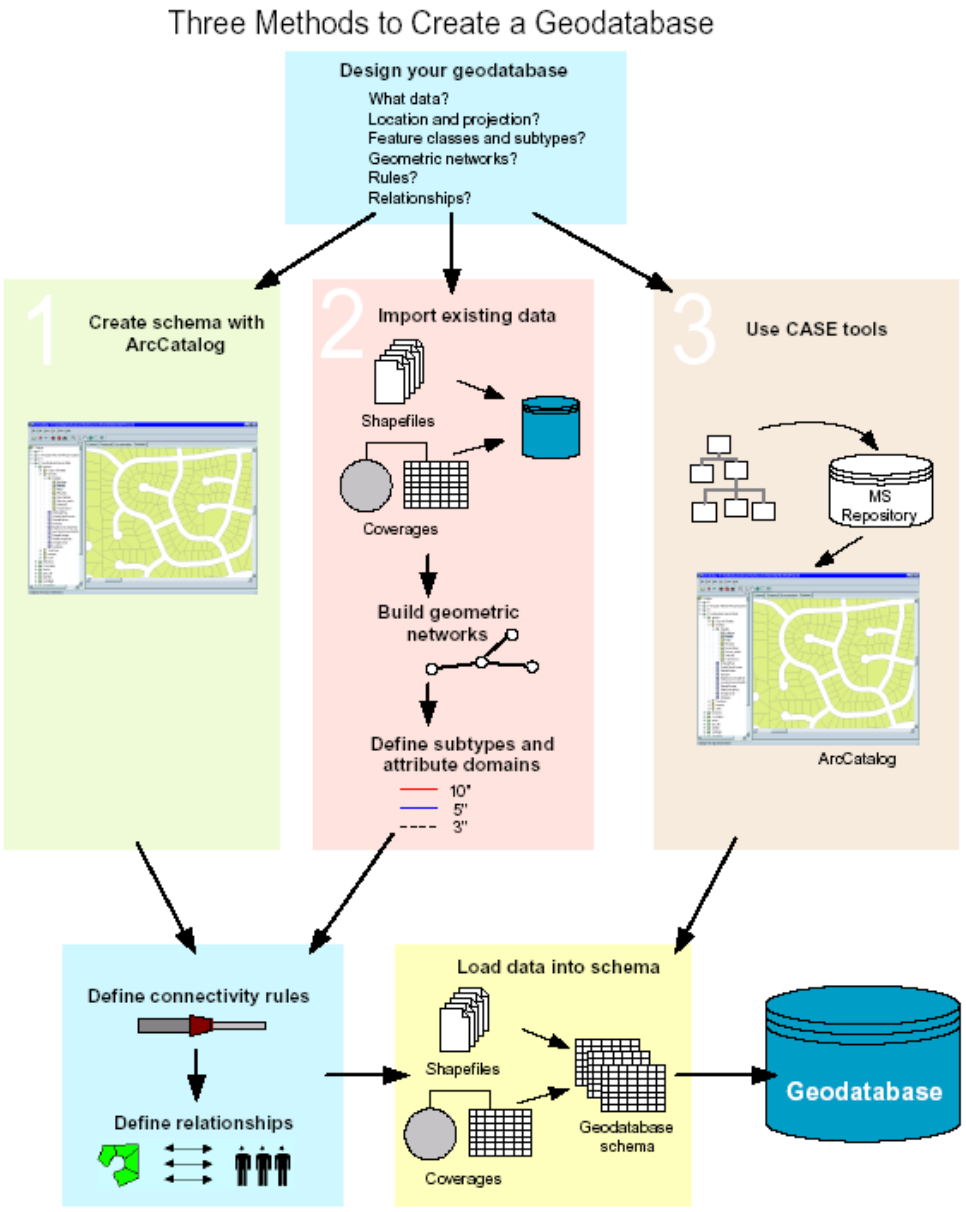
- **Create from scratch**: create schema for features datasets, classes, and attribute tables.
- **Import Existing Data**: a schema is created, and existing data in imported in.
- **Use CASE tools**: computer aided software engineering principles and GUIs can be used to create a geodatabase
- THIS IS HOW TO BUILD A COMPUTER DATABASE, BUT DOESN'T MEAN ITS OF ANY USE – for this you need good database design



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Steps in Building a GeoDB

- Model the user's view of data
- Define objects and relationships
- Select geographic representation
- Match to geodatabase elements
- Organize geodatabase structure

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Designing GIS Databases

- Model the users' view
- Define entities and their relationships
- Identify representation of entities
- Match to GIS data model
- Organize into geographic data sets

The first three steps develop the conceptual model, classifying features based on an understanding of the data required to support the organization's functions, and deciding their spatial representation.

The last two steps develop the logical model, matching the conceptual models to ArcGIS geographic data sets

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The Data Model

- **Data Model** is a formal definition of the data required in a GIS. Types include:
  - Structured List
  - Entity Relationship Diagram
- Purpose of the data model is to ensure that the data is identified and described in a *completely rigorous and unambiguous fashion*

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Example Structured List

Design your geodatabase

- What data?
- Location and projection?
- Feature classes and subtypes?
- Geometric networks?
- Rules?
- Relationships?

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Feature	Layer	Type	Prim. Attr.	Owner
Landuse	LU	Poly	LUID	Planning
Soils	Soil	Poly	SoilID	na
Elevation	DEM	Raster	na	na
Hydrography	Hydro	Line	ID	DEC
Roads	CL	Line	ID	Eng.
Buildings	Bldg	Poly	ID	Eng.
Parcels	Parcel	Poly	SBL	Assessor

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Model the User's View

- Identify the functions that support the organization's goals and objectives
- Identify the data required to support the functions
- Organize the data into logical sets of features
- Define an initial implementation plan
- Identify organizational functions

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1 Model the user's view of data

Identify organizational functions

The geodatabase design will be influenced by the structure of your organization. Distinct departments may have responsibility for different segments of the geographic data.

At a basic level, you begin by identifying the providers and consumers of geographic information. The key data flows are modeled. This is the starting point for identifying logical groupings of data.

Determine data needed to support functions

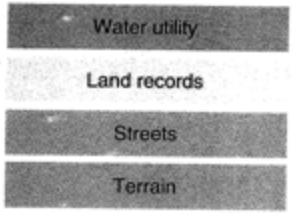
For each function, identify all of the types of data that are necessary to fulfill this group's requirement to deliver information.

Land records

Types of data	Data source
Parcel	Subdivision plats
Easement	Engineering records
Parcel description	Land title
Parcel photograph	Historic archive
Owner	Land assessment
Address	Phone database

For each data type, identify the likely source of data. A part of the project plan must include an estimate for cost of data capture, processing, and validation.

Organize data into logical groupings



From an inventory of all the types of geographic data that an organization maintains, identify a modest set of groupings that comprise all of your geographic data systems.

Define Entities and Relationships

- Identify and describe entities
- Identify and describe the relationships among these entities
- Document the entities and relationship with UML diagrams
- Create statements about how the system works then evaluate those statements in terms of entities and relationships

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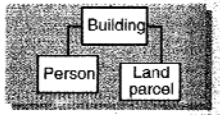


Define objects and relationships

identify entities and their relationships

entity	related to
Water Utility	
Pump	–
Meter	–
Meter box	Meter
Valve	–
Water main	–
Treatment plant	–
Land records	
Parcel	–
Easement	–
Parcel description	Parcel
Parcel photograph	–
Owner	Parcel
Address	–
Streets	
Street	–
Bridge	–
Name	Street
Traffic light	–
Bus route	–
Bus stop	–
Environment	
Historic monument	–
Fence	–
Vegetation cover	–
Place names	–
River valley	–
Satellite image	–

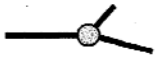
Identify and describe objects

Form sentences that state the entities and their behavior. The nouns are entities and the verbs are relationships.

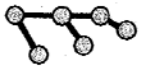
This step can be done by writing a progressive series of statements starting with "a water system is composed of devices and water lines." Each statement should be simple and accurate.

A valve controls the flow of water.

A water device connects to one or more water mains.



A water system is composed of devices and water lines.

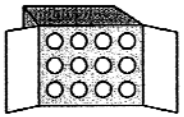


A water main is a type of water line.

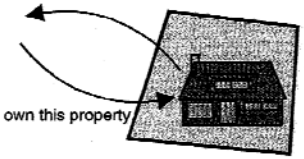
Specify relationships between objects

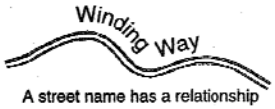
Many entities have close relationships with other entities. Relationships guide your geodatabase design.

A meter box is composed of meters.



The land title lists me as owner.



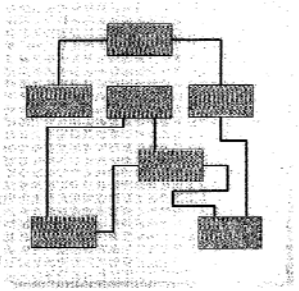


A street name has a relationship with a street feature.

Document model in diagram

Once you have collected your list of entities and relationships, it is a good practice to create a data model diagram.

Using business graphics software, start by making boxes for entities and lines with arrows for relationships. This diagram will facilitate discussion with domain experts and advance the refinement of the model.



The Nature of Geographic Data

- Geographic data has been described as:
  - **Object** - a thing that can be seen or touched.
  - **Entity** - objects or things to be included in a database
  - **Feature** - the make, shape, form or appearance of a person or thing. Term that derives itself from cartography (*features on a map)*
  - **Attribute** - characteristics of the entities

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Identify the representation of entities

- Is the feature represented on a map?
- Is the shape of a feature important?
- Is the feature best accessed through its relationship with another feature?
- Will the feature have different representations at different scales?

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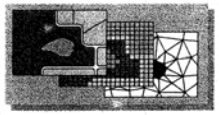
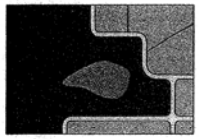


Select geographic representation

set spatial representation as vector, raster, and TIN

entity	related to	spatial type
Water utility		
Pump	–	point
Meter	–	point
Meter box	Meter	point
Valve	–	point
Water main	–	line
Treatment plant	–	point
Land records		
Parcel	–	area
Easement	–	line
Parcel description	Parcel	text
Parcel photograph	–	image
Owner	Parcel	object
Address	–	location
Streets		
Street	–	line
Bridge	–	point
Name	Street	text
Traffic light	–	point
Bus route	–	line
Bus stop	–	point
Environment		
Historic monument	–	point
Fence	–	line
Vegetation cover	–	area
Place names	–	text
River valley	–	surface
Satellite image	–	image

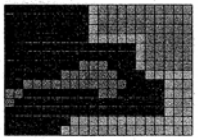
Represent discrete features with points, lines, areas



You can model the richest expression of features with the vector types. These entities are well defined on a map and are permanent.

point *an entity too small to map with a line or area*
line *a long entity too narrow to map with an area*
area *an entity with length and width at the map scale*
annotation *a descriptive label on an entity*
object *a nongeographic entity, such as an owner*

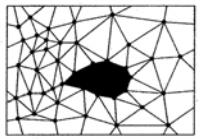
Characterize continuous phenomena with images



Images have versatile application in a GIS. You would specify images for aerial or satellite photographs, photographs of facilities, and any scanned documents.

image *a file that contains a continuous valued map, aerial photograph, copy of a plat, or picture of a building*

Model terrain with surfaces



When you model a continuous phenomenon that has a z value, specify surface. (Later, you will decide whether TIN or raster is better for the surface.)

surface *a system of points or locations with elevation values that form a mesh for a mathetical approximation of the shape of the earth*

Classical Entities and Spatial Component

Design your geodatabase

What data?
Location and projection?
Feature classes and subtypes?
Geometric networks?
Rules?
Relationships?

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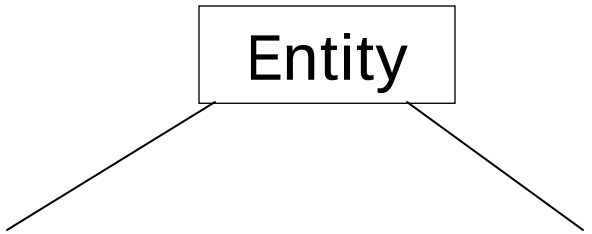

Entity Attributes

Street (name, number)

Soil Zone (name, perm.)

Well (type, date tested)

Spatial Component

line (coordinates, topology)

polygon (coordinates, topology)

point (coordinates)

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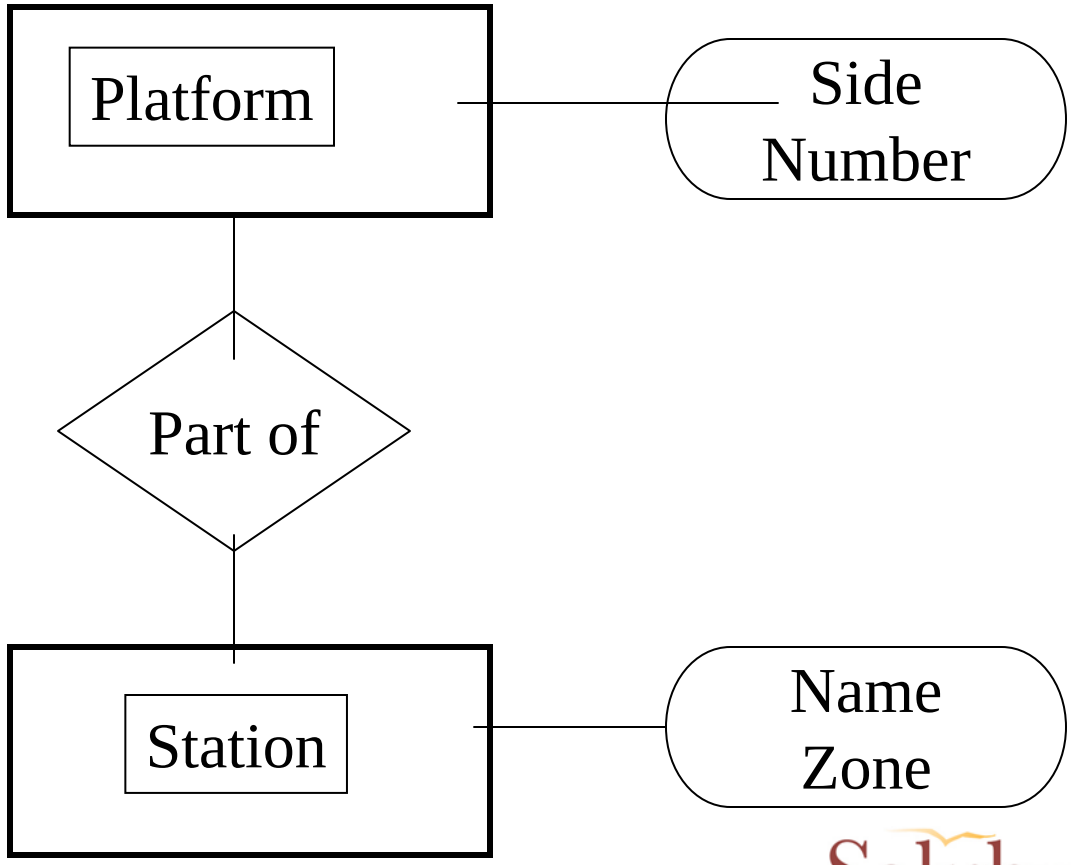
E-R Diagram



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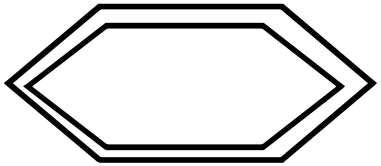
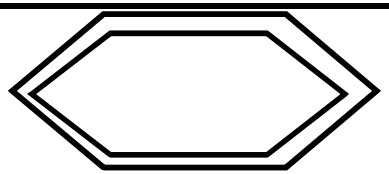
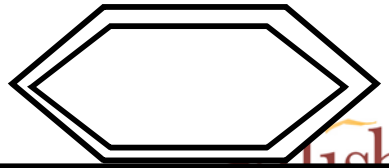
Spatial Relationships

Spatial Relationship	Verbs	Symbol
Connectivity	Connect, link	
Contiguity	Adjacent	
Containment	Contained	
Proximity	Nearest	
Coincidence	Coincident	

Considerations in Modeling Geography in an E-R Diagram

- Correct Identification and Definition of Entities
- Defining a Corresponding “Spatial” Entity for Each “Traditional” Entity
- Recognition of Multiple Instances of Geographic Entities
  - time and scale
  - Represented by: entity simple, entity spatial, entity time

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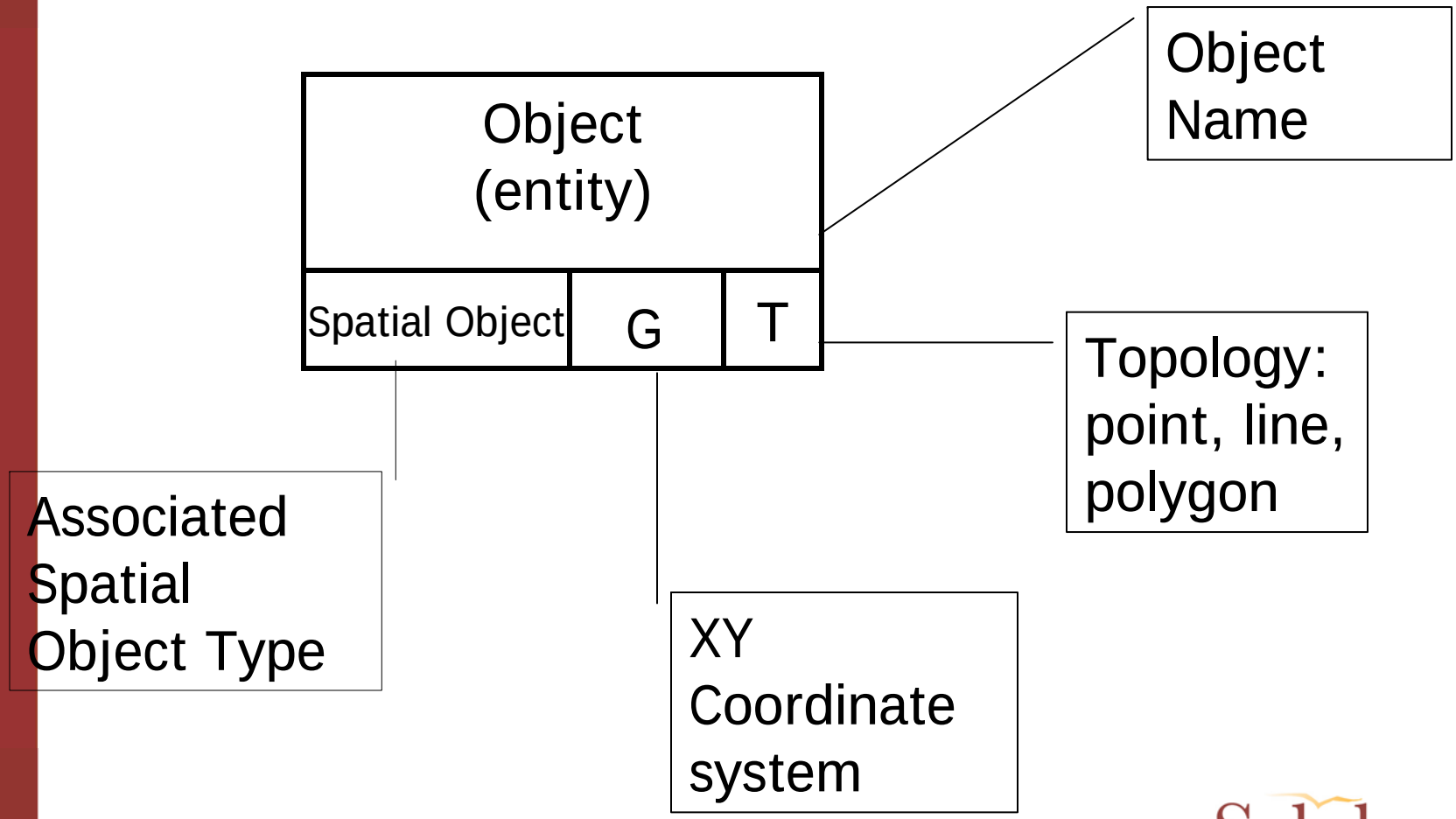
Representation of Spatial Objects



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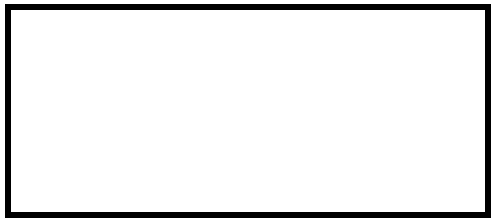
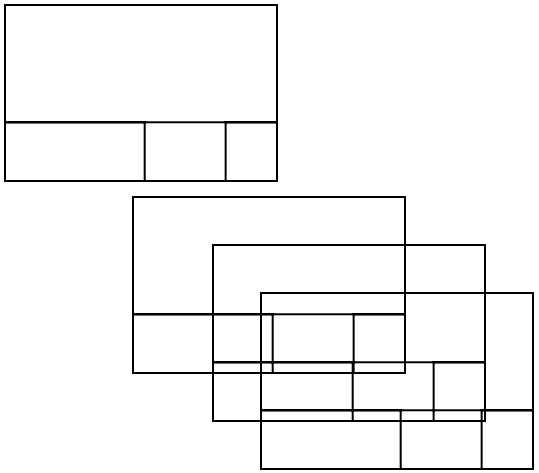
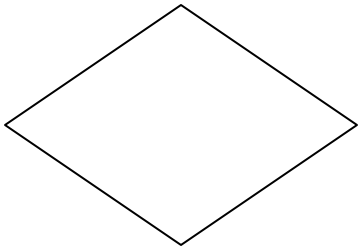
Modeling Spatial Relationships

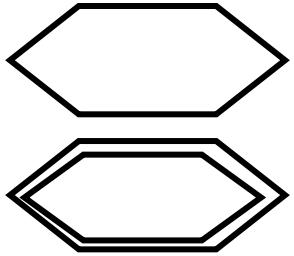


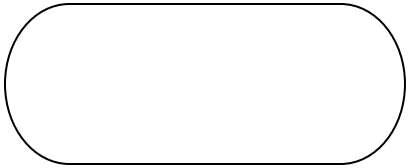
ENTITY





RELATIONSHIP





ATTRIBUTE

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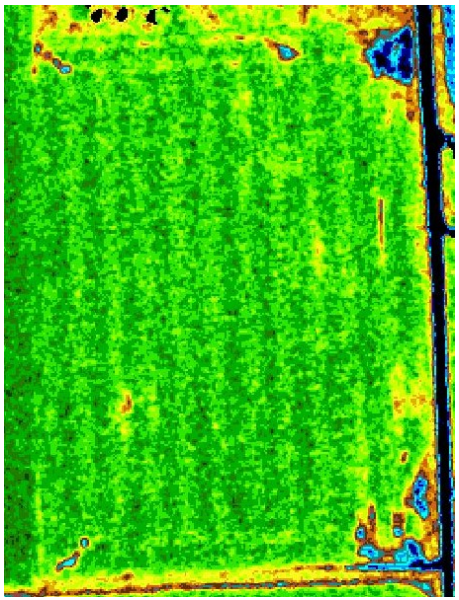
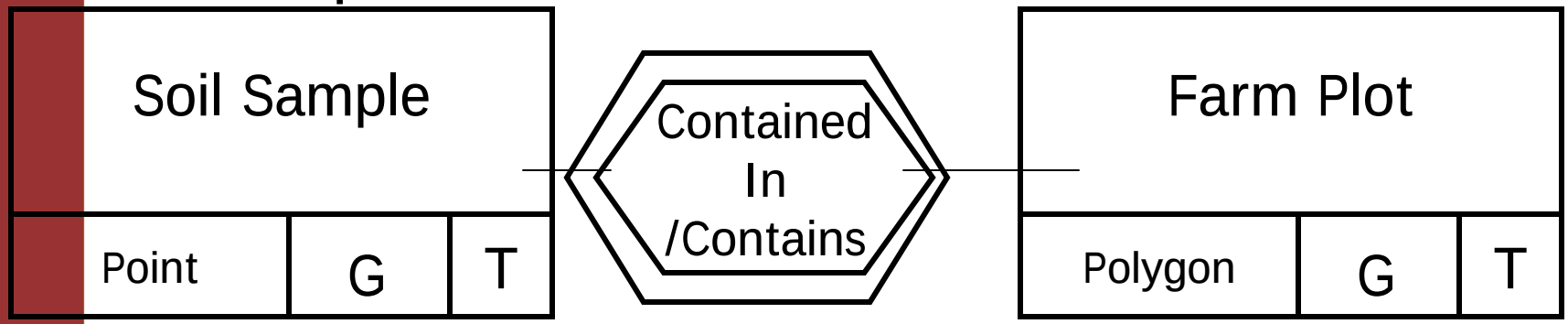
Developing a Spatial E-R Diagram



- Is Derived From Needs Assessment
- Relationships Determined from Application Descriptions



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Match to a GeoDB model

- Determine appropriate geodb representation for entities
  - Spatial type = point
    - Unconnected – point feature
    - Connected – simple junction
    - Connected with internal topology – complex junction
  - Spatial type = line
    - Stand-alone line = line feature
    - Line in a system = simple edge
    - Line with connected sections = complex edge
  - Areas = polygon feature (with potential planar topology)
  - Objects = objects

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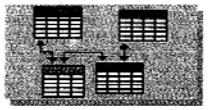


Match to geodatabase elements

apply feature geometry and topology

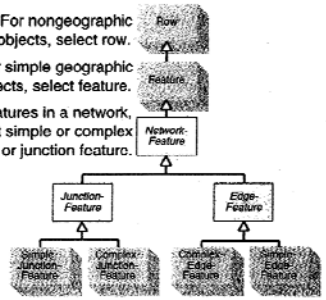
entity	related to	spatial type	ArcInfo type
Water utility			
Pump	–	point	object
Meter	–	point	point feature
Meter box	Meter	point	point feature
Valve	–	point	simple junction
Water main	–	line	complex edge
Treatment plant	–	point	complex junction
Land records			
Parcel	–	area	polygon feature
Easement	–	line	line feature
Parcel description	Parcel	text	annotation feature
Parcel photograph	–	image	raster
Owner	Parcel	object	object
Address	–	location	address
Streets			
Street	–	line	line feature
Bridge	–	point	point feature
Name	Street	text	annotation feature
Traffic light	–	point	point feature
Bus route	–	line	line feature
Bus stop	–	point	point feature
Environment			
Historic monument	–	point	point feature
Fence	–	line	line feature
Vegetation cover	–	area	polygon feature
Place names	–	text	annotation feature
River valley	–	surface	TIN
Satellite image	–	image	raster

Determine feature and geometry type

For nongeographic objects, select row.

For simple geographic objects, select feature.

For features in a network, select simple or complex edge or junction feature.



Specify topological graphs

For linear systems, such as transportation or utility, select geometric network.

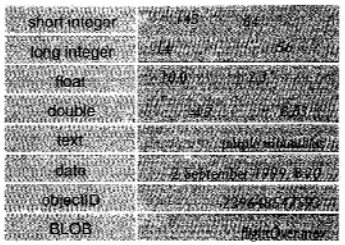
A geometric network has custom behavior built in to make the editing of networks easy.

For systems of land or jurisdictions, a planar topology manages the shared geometry of a set of features.

A planar topology enforces that no feature can cross another without an intersection.

Implement attribute types for objects

Each entity can have many attributes. These are the attribute types.



Physical Design

- Logical Design Performed Independent of Physical Design
- Must Now Move Logical Design to Physical Design
- Physical Design Example (ARC/INFO, geodatabase):

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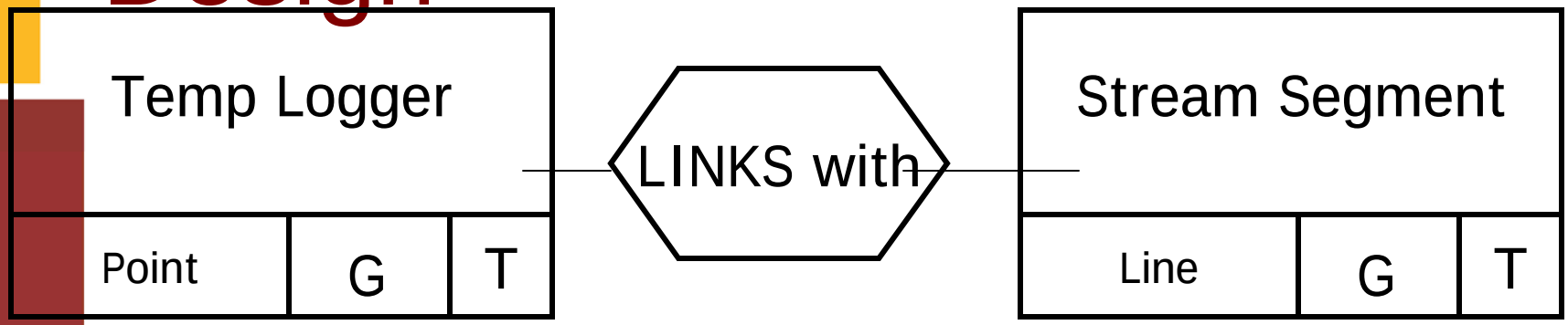
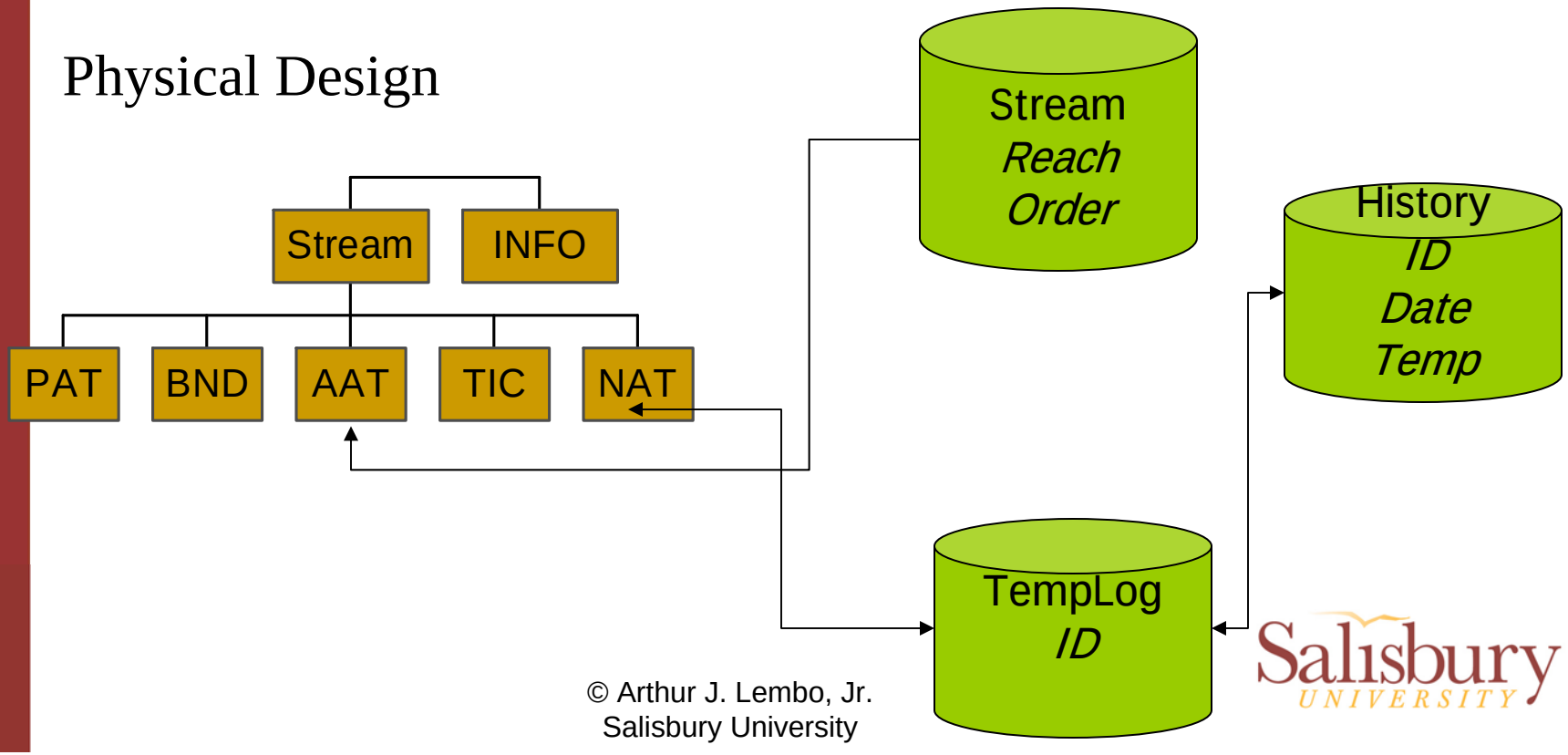
Conceptual vs. Physical Design



Physical Design



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Organize into Geographic Datasets

- Assign entities to feature classes and subtypes
  - Feature classes vs. subtypes
- Group related sets of features into geometric networks or planar topologies
  - Simple edges & junctions, complex edges & junctions – geometric network
  - Need space-filling and no overlapping – planar topology
- Organize feature classes and datasets into geodb's

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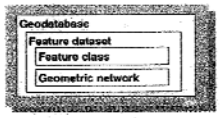

Organize geodatabase structure

entity	related to	spatial type	ArcInfo type
Water utility			
Pump	–	point	object
Meter	–	point	point feature
Meter box	Meter	point	point feature
Valve	–	point	simple junction
Water main	–	line	complex edge
Treatment plant	–	point	complex junction
Land records			
Parcel	–	area	polygon feature
Easement	–	line	line feature
Parcel description	Parcel	text	annotation feature
Parcel photograph	–	image	raster
Owner	Parcel	object	object
Address	–	location	address
Streets			
Street	–	line	polyline feature
Bridge	–	point	point feature
Name	Street	text	annotation feature
Traffic light	–	point	point feature
Bus route	–	line	line feature
Bus stop	–	point	point feature
Environment			
Historic monument	–	point	point feature
Fence	–	line	line feature
Vegetation cover	–	area	polygon feature
Place names	–	text	annotation feature
River valley	–	surface	TIN
Satellite image	–	image	raster