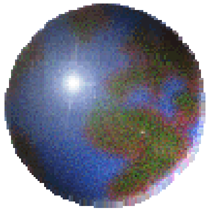


8. Geographic Data Modeling

Geographic Information Systems and Science

SECOND EDITION

Paul A. Longley, Michael F. Goodchild, David J. Maguire, David W. Rhind

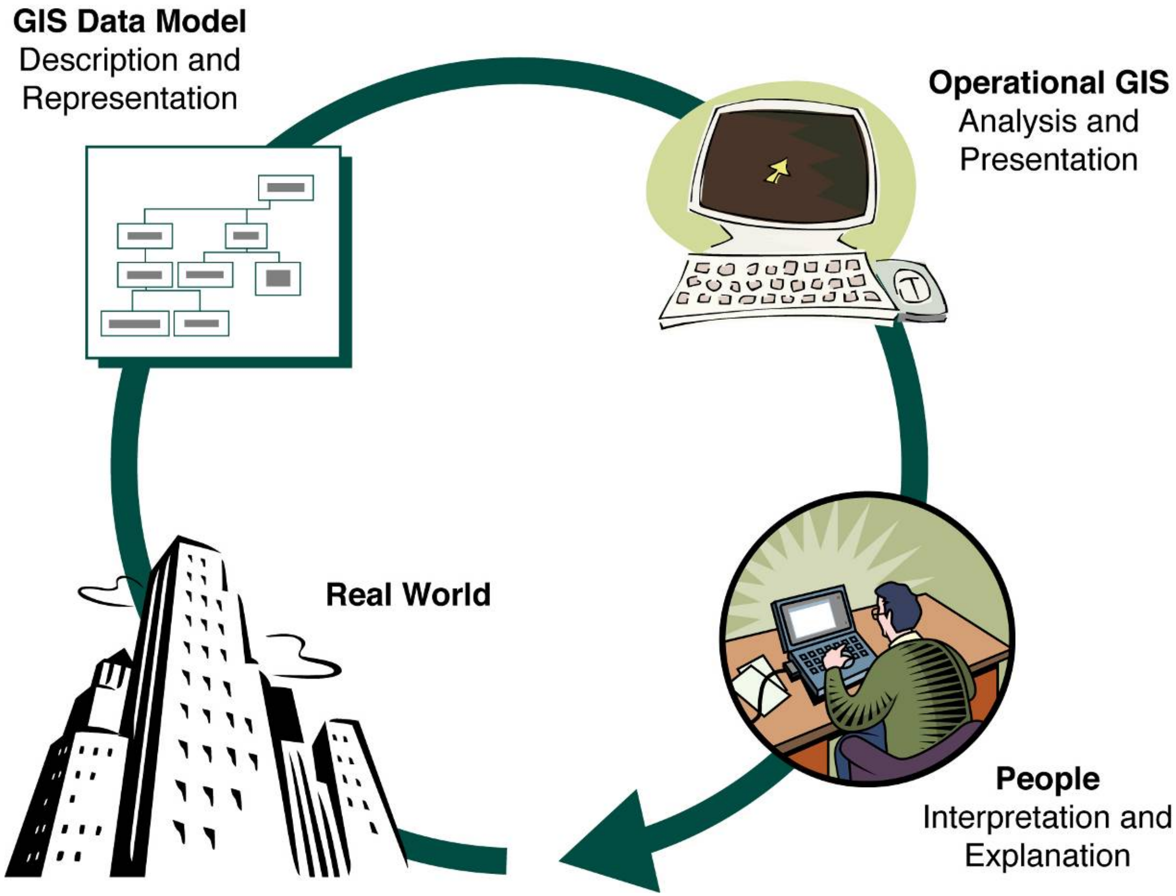
Outline

- Definitions
- Data models / modeling
- GIS data models
  - Topology
- Example
  - Water facilities

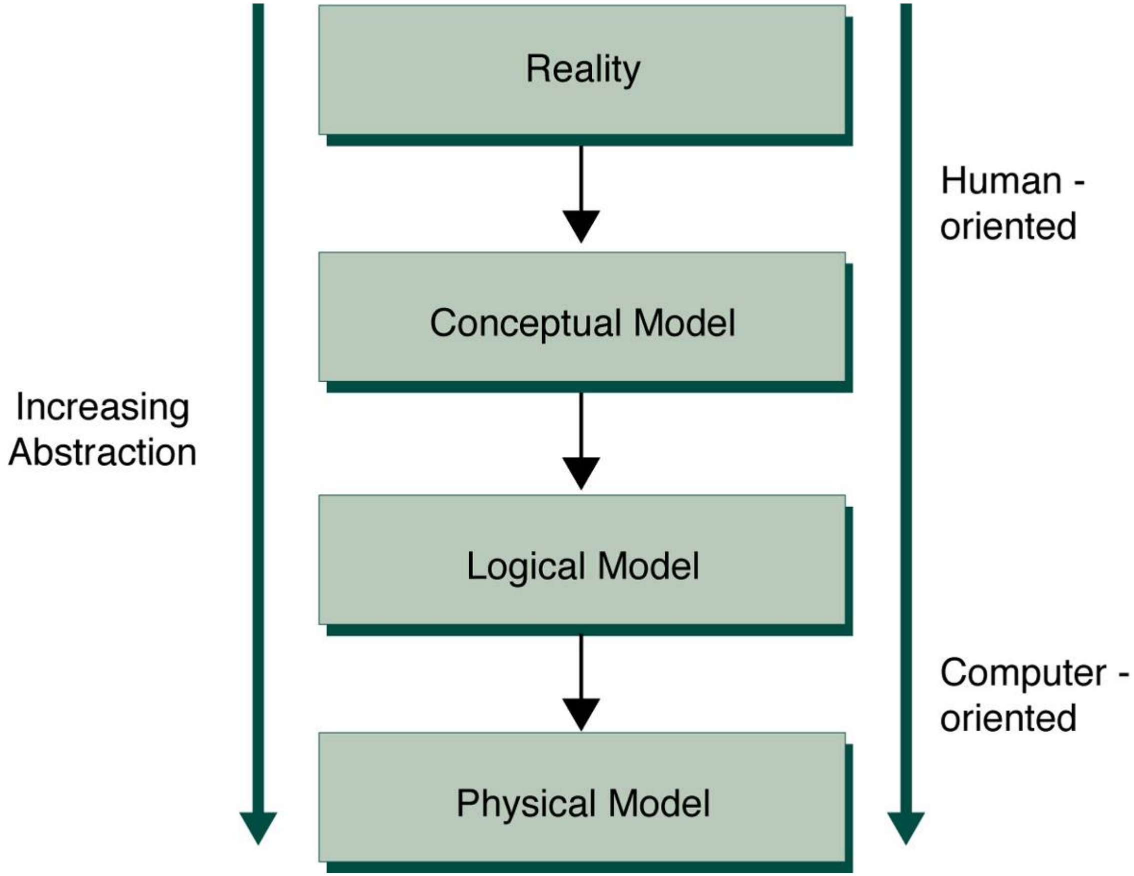
Definitions

- Data model
  - set of constructs for representing objects and processes in the digital environment
- Representation
  - Focus on conceptual and scientific issues

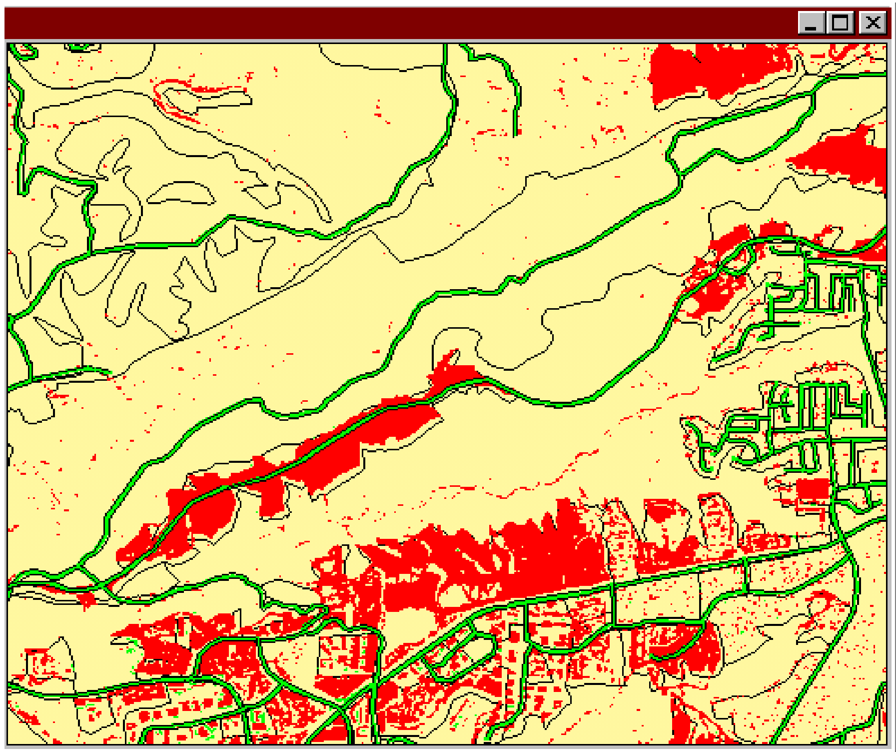
Role of a Data Model



Levels of Data Model Abstraction



Two representations of San Diego, California: (A) panchromatic SPOT raster satellite image collected in 1990 at 10 m resolution; (B) vector objects digitized from the image.



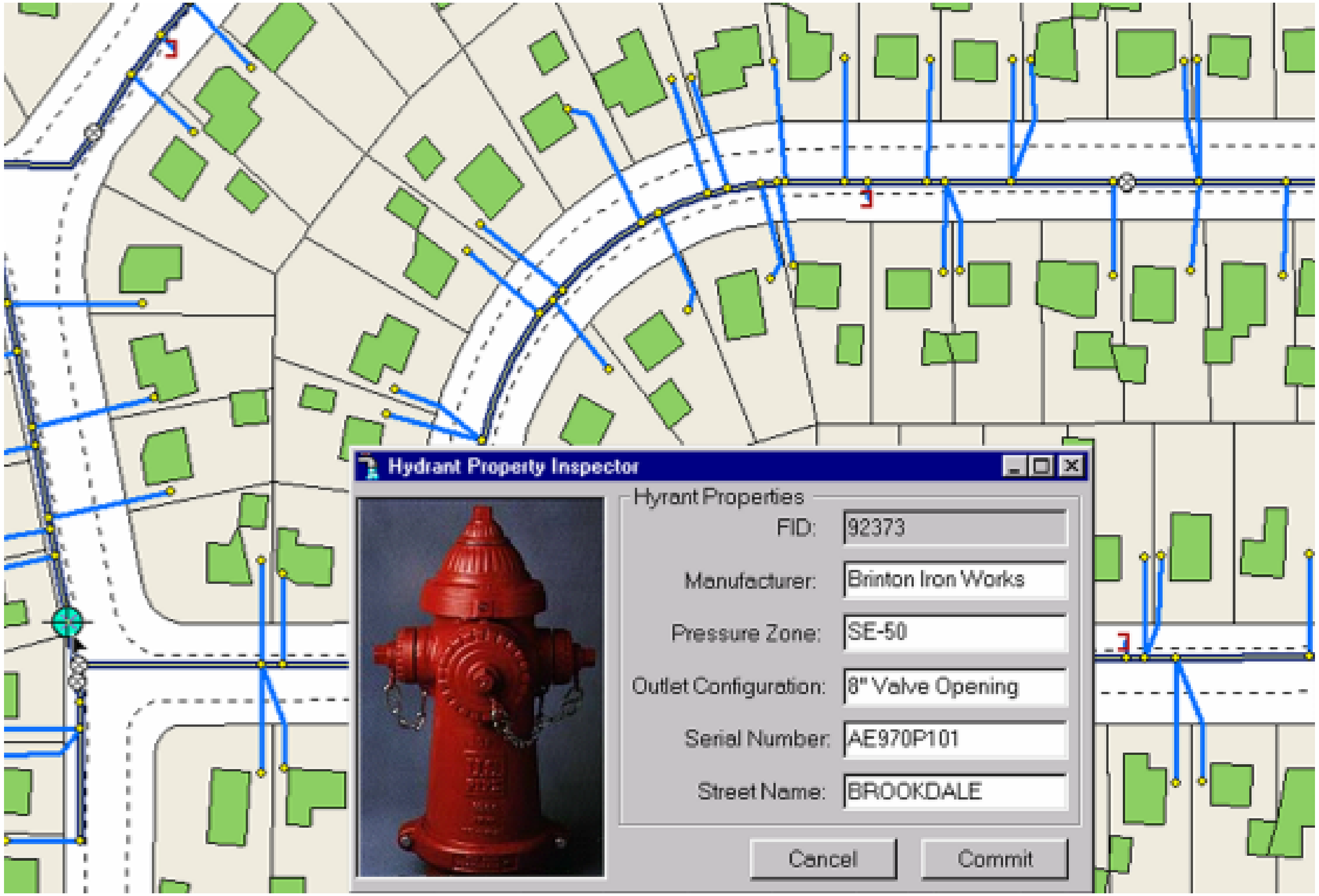
GIS Data Models & Applications

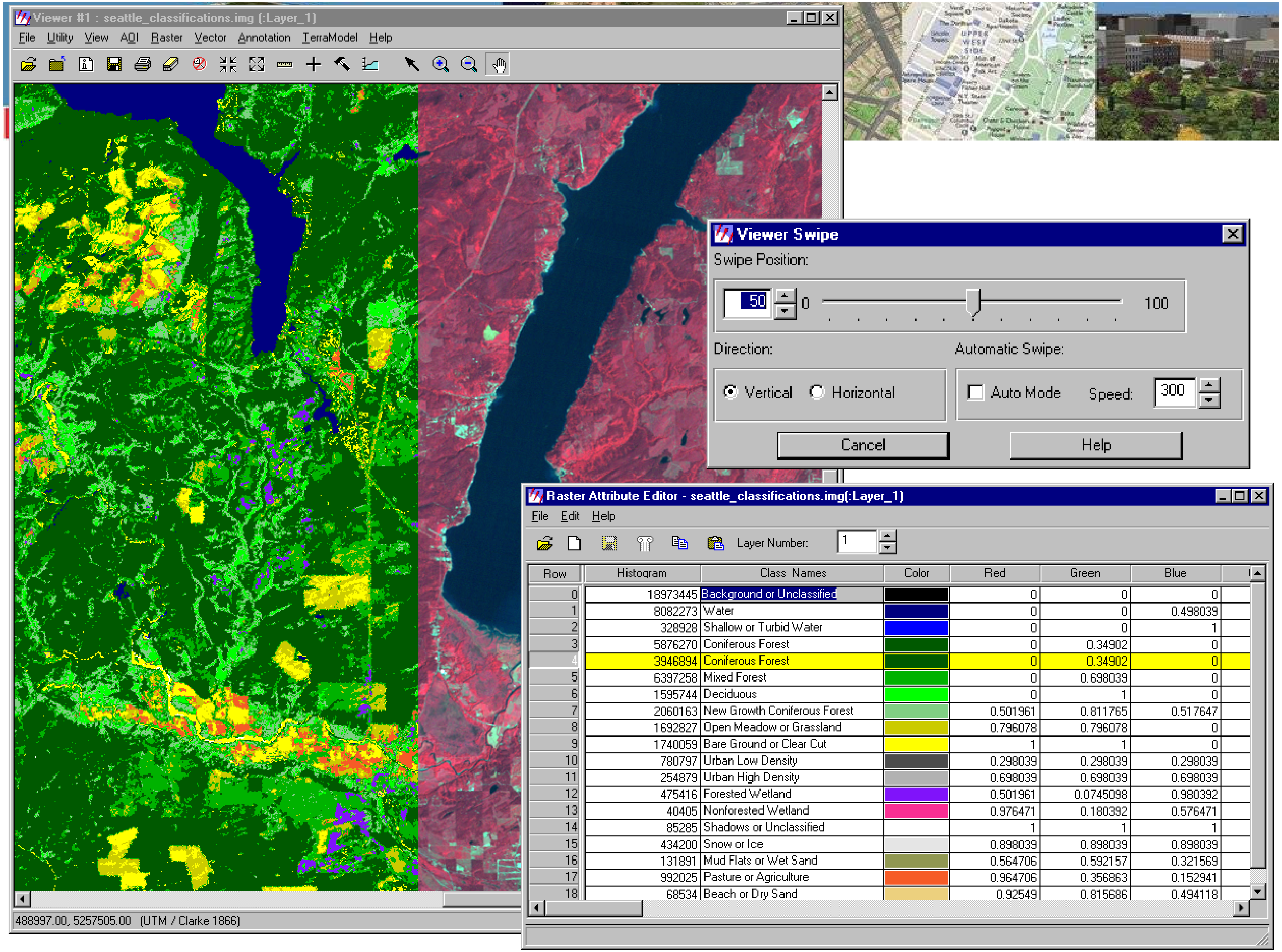
CAD	Engineering design
Graphical	Simple mapping
Image	Image processing and analysis
Raster/Grid	Spatial analysis / modeling
Network	Network analysis
Geo-relational	Geoprocessing geometric features
TIN	Surface /terrain analysis / modeling
Object	Features with behavior

Raster and Vector Models

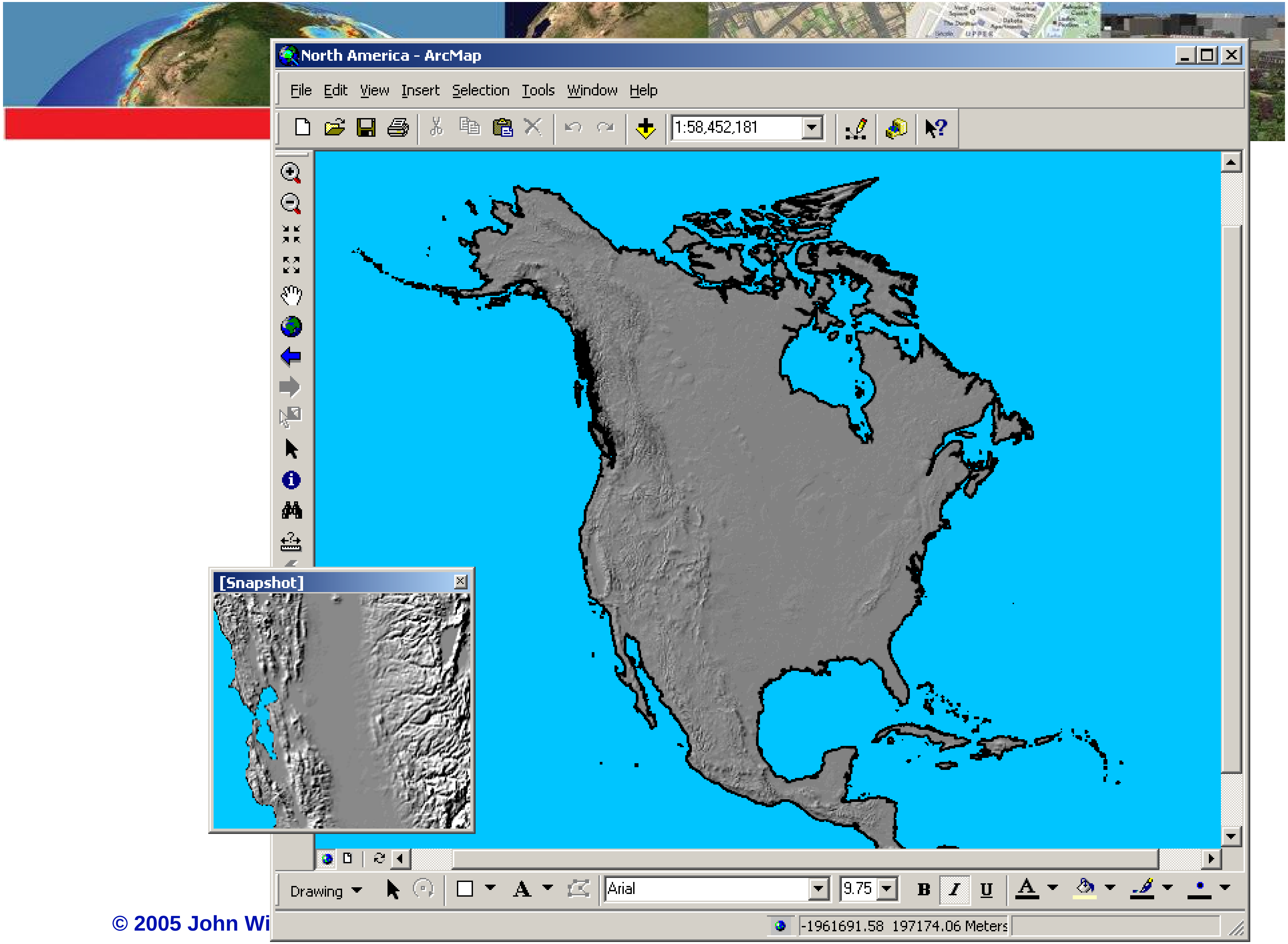
- Raster – implementation of field conceptual model
  - Array of cells used to represent objects
  - Useful as background maps and for spatial analysis
- Vector – implementation of discrete object conceptual model
  - Point, line and polygon representations
  - Widely used in cartography, and network analysis


SECOND EDITION

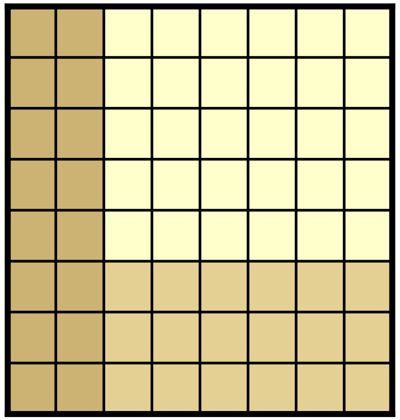

Hydrant Property Inspector
Hyrant Properties
FID: 92373
Manufacturer: Brinton Iron Works
Pressure Zone: SE-50
Outlet Configuration: 8" Valve Opening
Serial Number: AE970P101
Street Name: BROOKDALE
Cancel
Commit

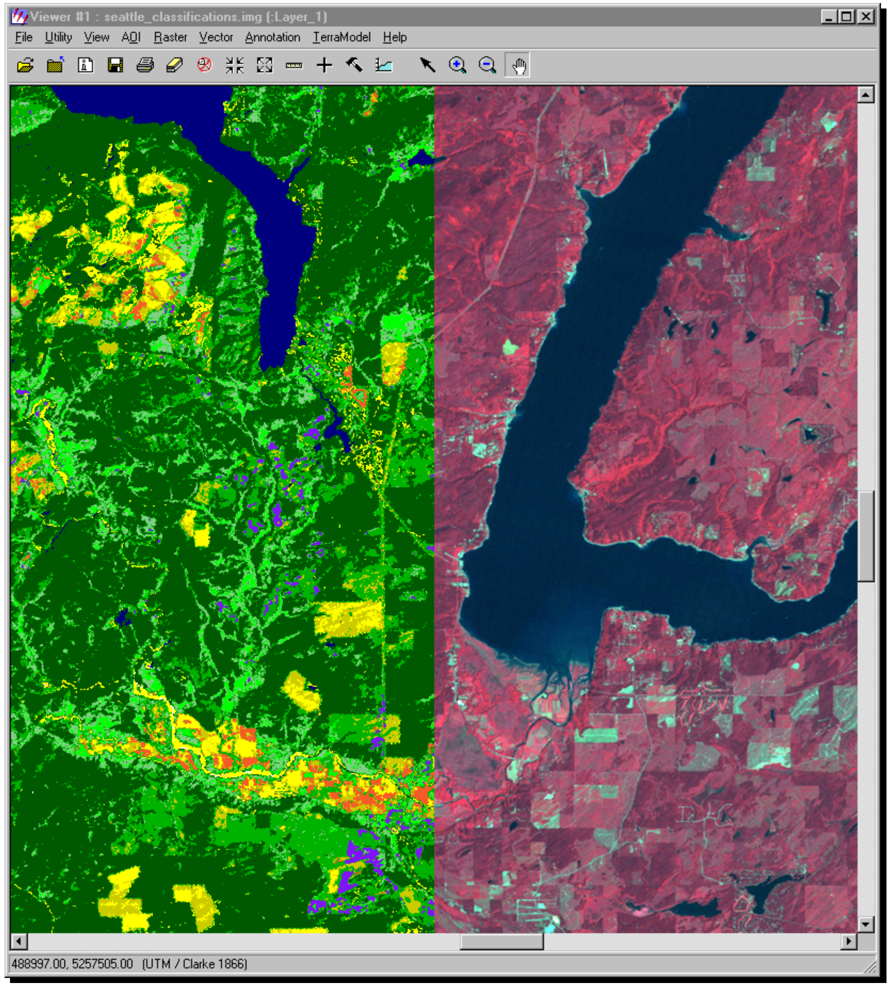


Viewer #1 : seattle_classifications.img (:Layer_1)
File Utility View AOI Raster Vector Annotation TerraModel Help
488997.00, 5257505.00 (UTM / Clarke 1866)
Viewer Swipe
Swipe Position:
50
0
100
Direction:
Vertical
Horizontal
Automatic Swipe:
Auto Mode
Speed:
300
Cancel
Help
Raster Attribute Editor - seattle_classifications.img(:Layer_1)
File Edit Help
Layer Number:
1
Row Histogram Class Names Color Red Green Blue
0 18973445 Background or Unclassified 0 0 0
1 8082273 Water 0 0 0.498039
2 328928 Shallow or Turbid Water 0 0 1
3 5876270 Coniferous Forest 0 0.34902 0
4 3946894 Coniferous Forest 0 0.34902 0
5 6397258 Mixed Forest 0 0.698039 0
6 1595744 Deciduous 0 1 0
7 2060163 New Growth Coniferous Forest 0.501961 0.811765 0.517647
8 1692827 Open Meadow or Grassland 0.796078 0.796078 0
9 1740059 Bare Ground or Clear Cut 1 1 0
10 780797 Urban Low Density 0.298039 0.298039 0.298039
11 254879 Urban High Density 0.698039 0.698039 0.698039
12 475416 Forested Wetland 0.501961 0.0745098 0.980392
13 40405 Nonforested Wetland 0.976471 0.180392 0.576471
14 85285 Shadows or Unclassified 1 1 1
15 434200 Snow or Ice 0.898039 0.898039 0.898039
16 131891 Mud Flats or Wet Sand 0.564706 0.592157 0.321569
17 992025 Pasture or Agriculture 0.964706 0.356863 0.152941
18 68534 Beach or Dry Sand 0.92549 0.815686 0.494118


North America - ArcMap
File Edit View Insert Selection Tools Window Help
1:58,452,181
[Snapshot]
Drawing
Arial
9.75
-1961691.58 197174.06 Meters

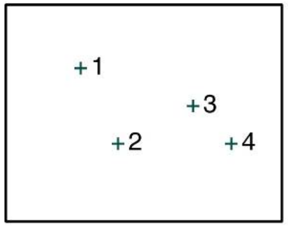
Raster – Satellite Imagery





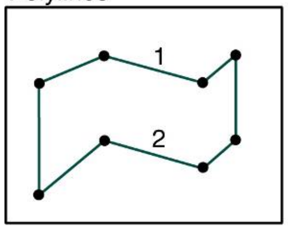
Vector Data Model

Points



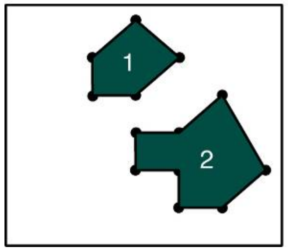
Point number	(x,y) coordinates
1	(2,4)
2	(3,2)
3	(5,3)
4	(6,2)

Polylines



Polyline number	(x,y) coordinates
1	(1,5) (3,6) (6,5) (7,6)
2	(1,1) (3,3) (6,2) (7,3)

Polygons

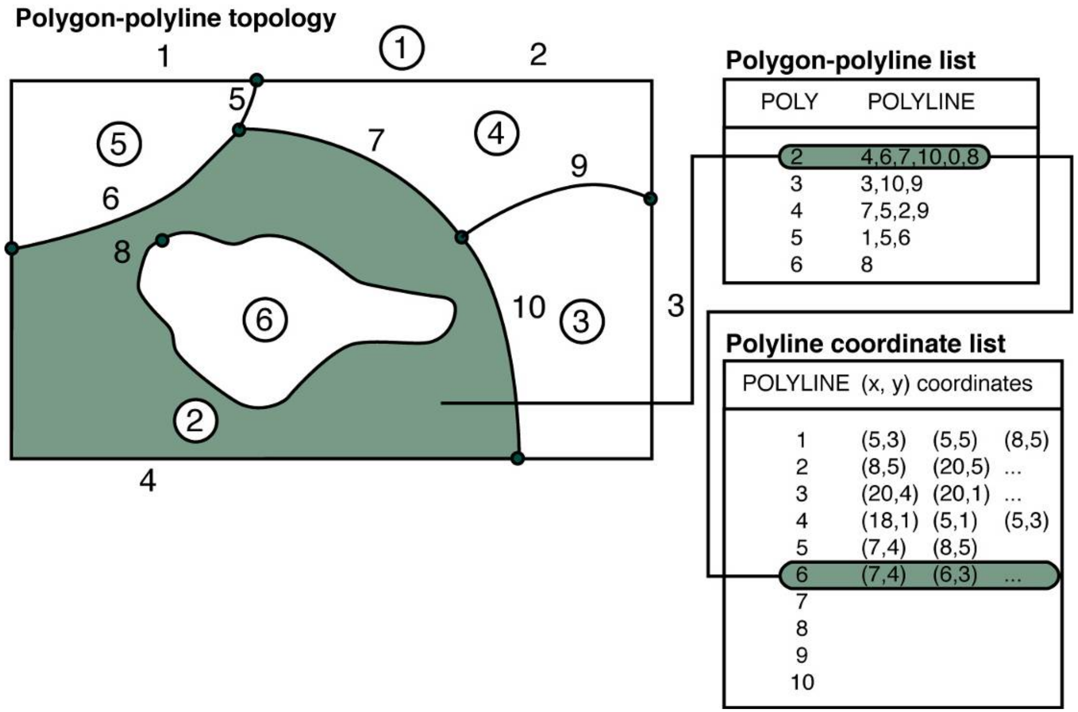


Polygon number	(x,y) coordinates
1	(2,4) (2,5) (3,6) (4,5) (3,4) (2,4)
2	(3,2) (3,3) (4,3) (5,4) (6,2) (5,1) (4,1) (4,2) (3,2)

Topology

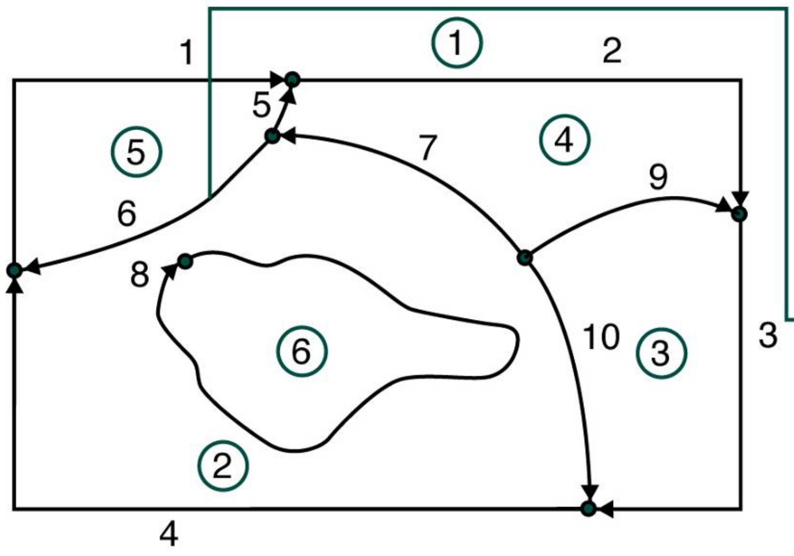
- Science and mathematics of geometric relationships
  - Simple features + topological rules
  - Connectivity
  - Adjacency
  - Shared nodes / edges
- Topology uses
  - Data validation
  - Spatial analysis (e.g. network tracing, polygon adjacency)

Topological Polygon Data Layer



Contiguity of Topological Polygons

Left-right topology



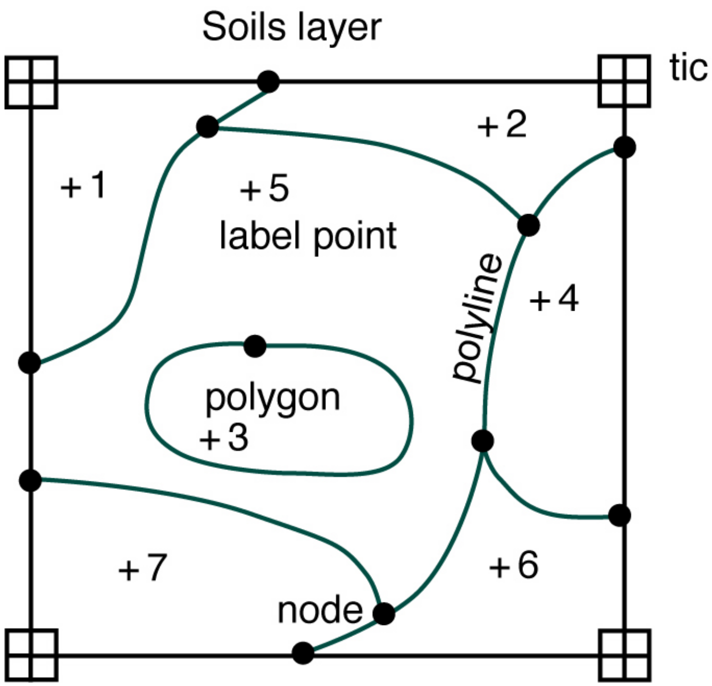
Left-right list

Polyline#	LPoly	RPoly
1	1	5
2	1	4
3	1	3
4	1	2
5	5	4
6	2	5
7	2	4
8	2	6
9	4	3
10	3	2

Polyline coordinate list

POLYLINE#	X, Y Pairs
1	5,3 5,5 8,5
2	8,5 20,5 ...
3	20,4 20,1 ...
4	18,1 5,1 5,3
5	7,4 8,5
6	7,4 6,3 ...
7	
8	
9	
10	

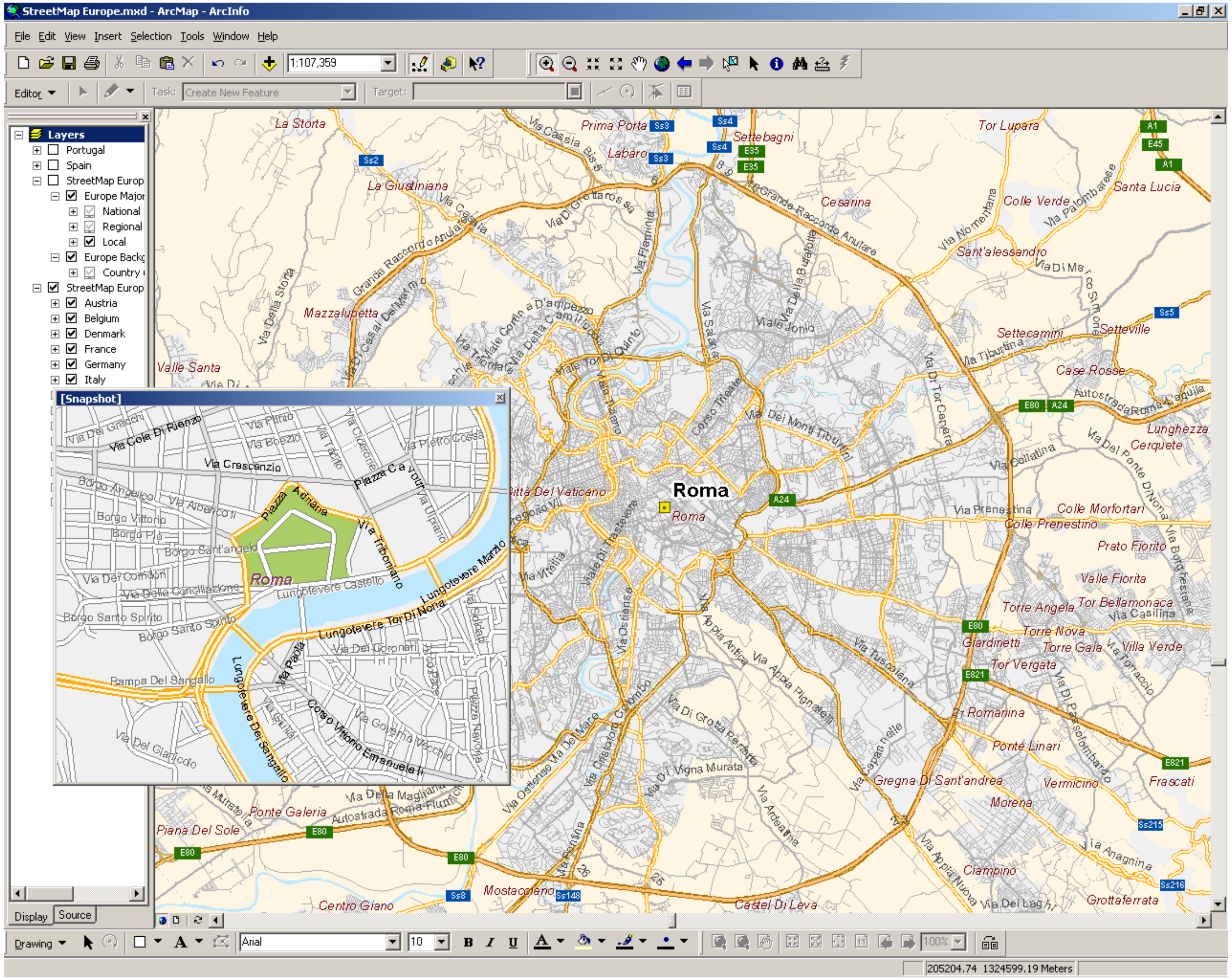
Geo-relational Polygon Dataset



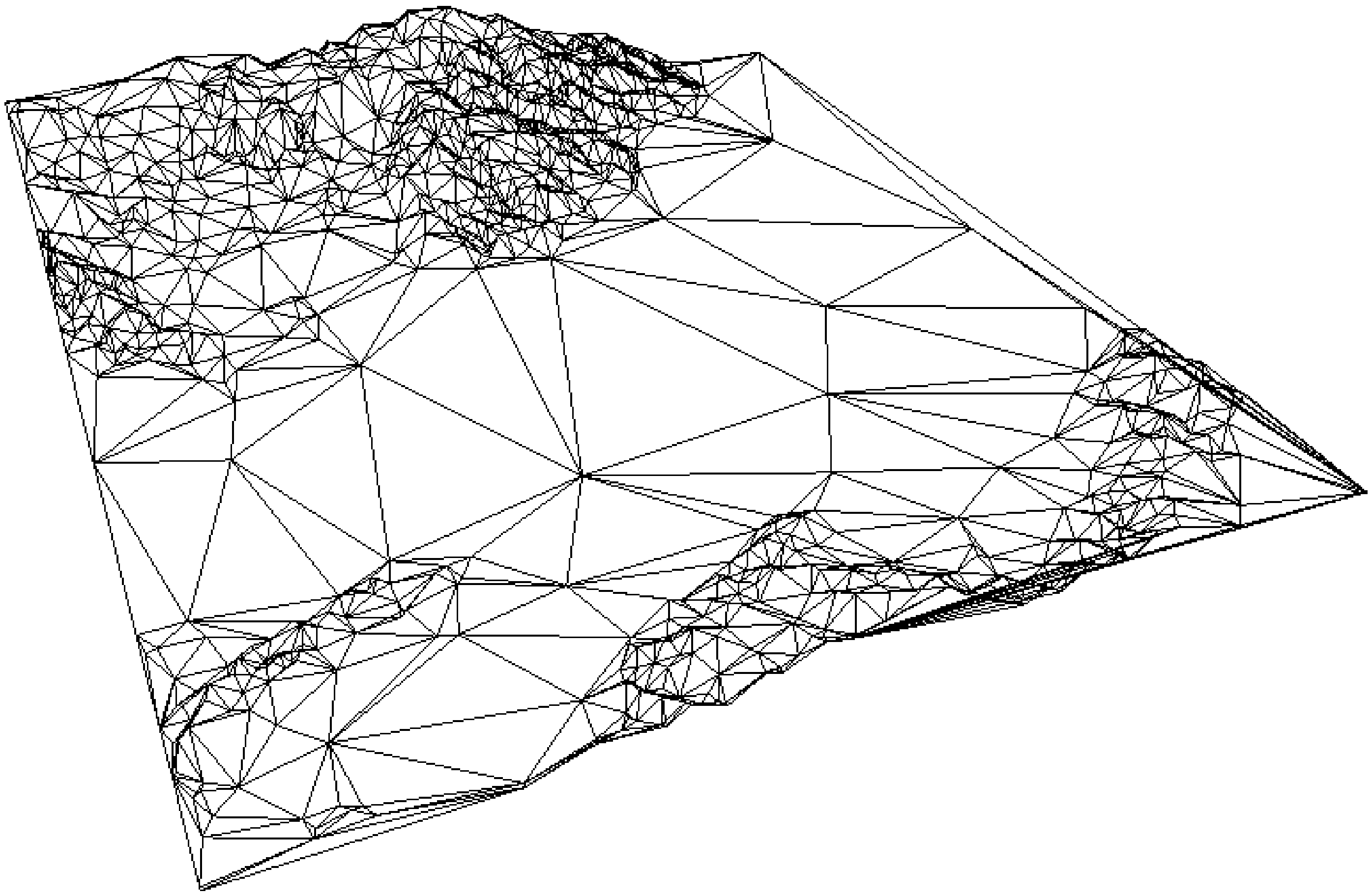
Soils attributes

ID	Soil	Class	Suitability
1	A3	113	HIGH
2	C6	95	LOW
3	B7	212	MODERATE
4	B13	201	MODERATE
5	Z22	86	LOW
6	A6	77	HIGH
7	A1	117	LOW

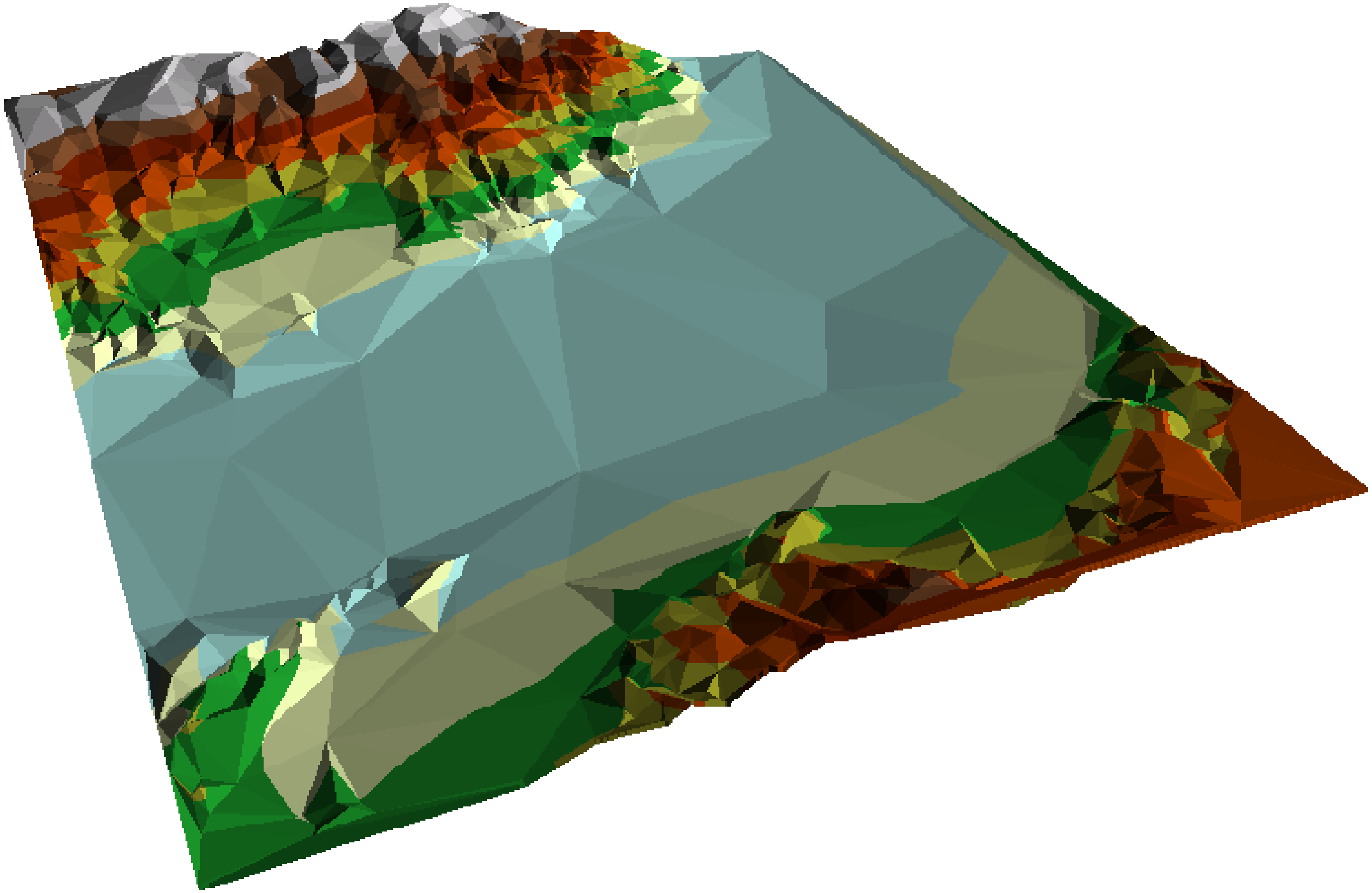
Figure 8.11 An example street network



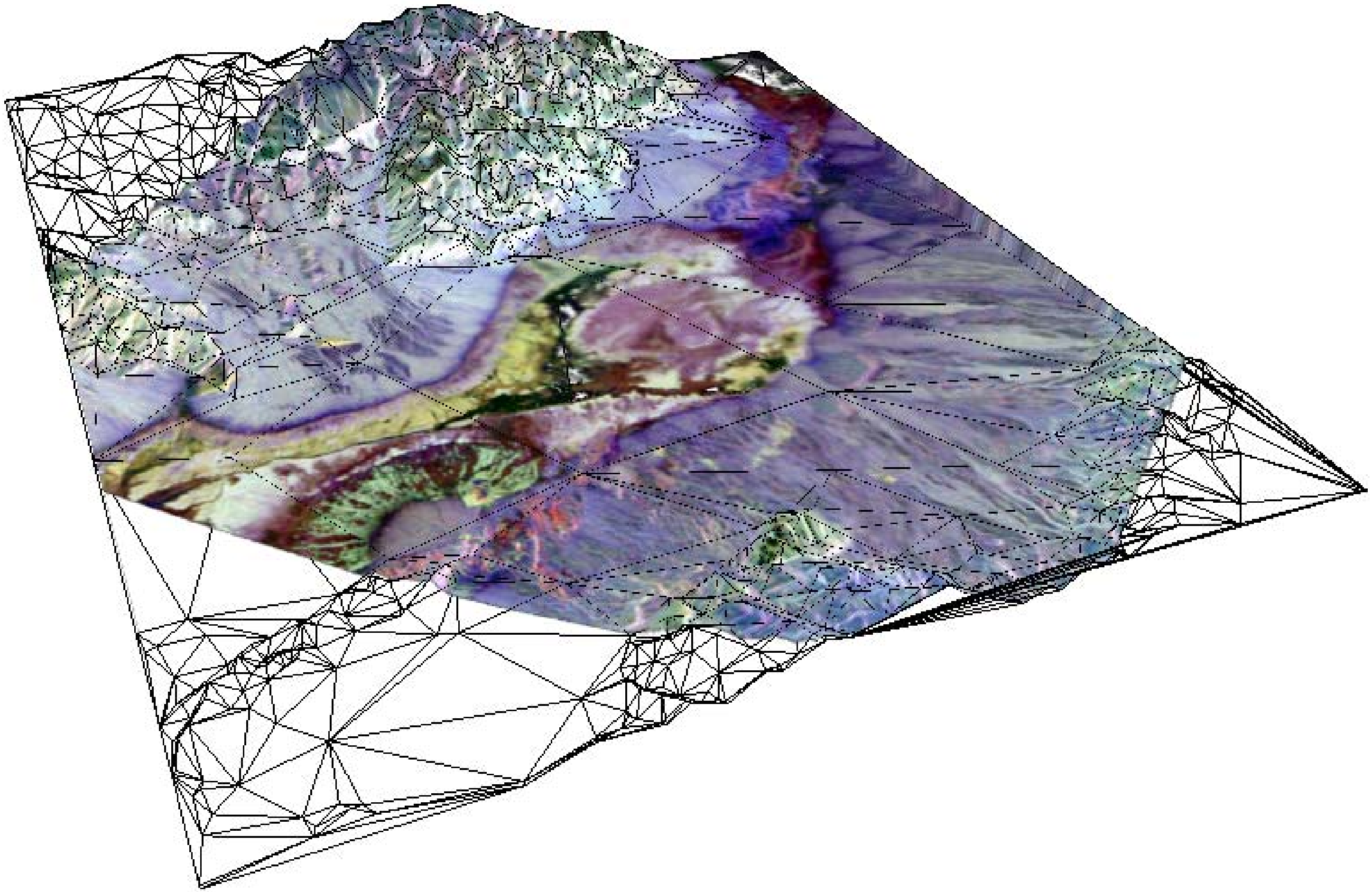
TIN Surface of Death Valley, California



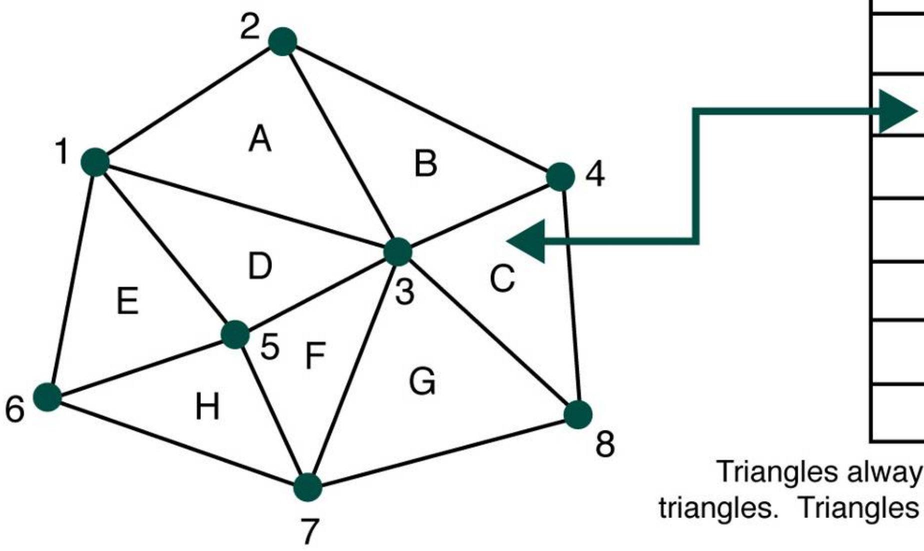
TIN Surface of Death Valley, California



TIN Surface of Death Valley, California

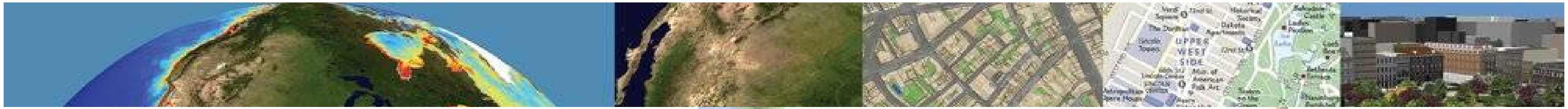


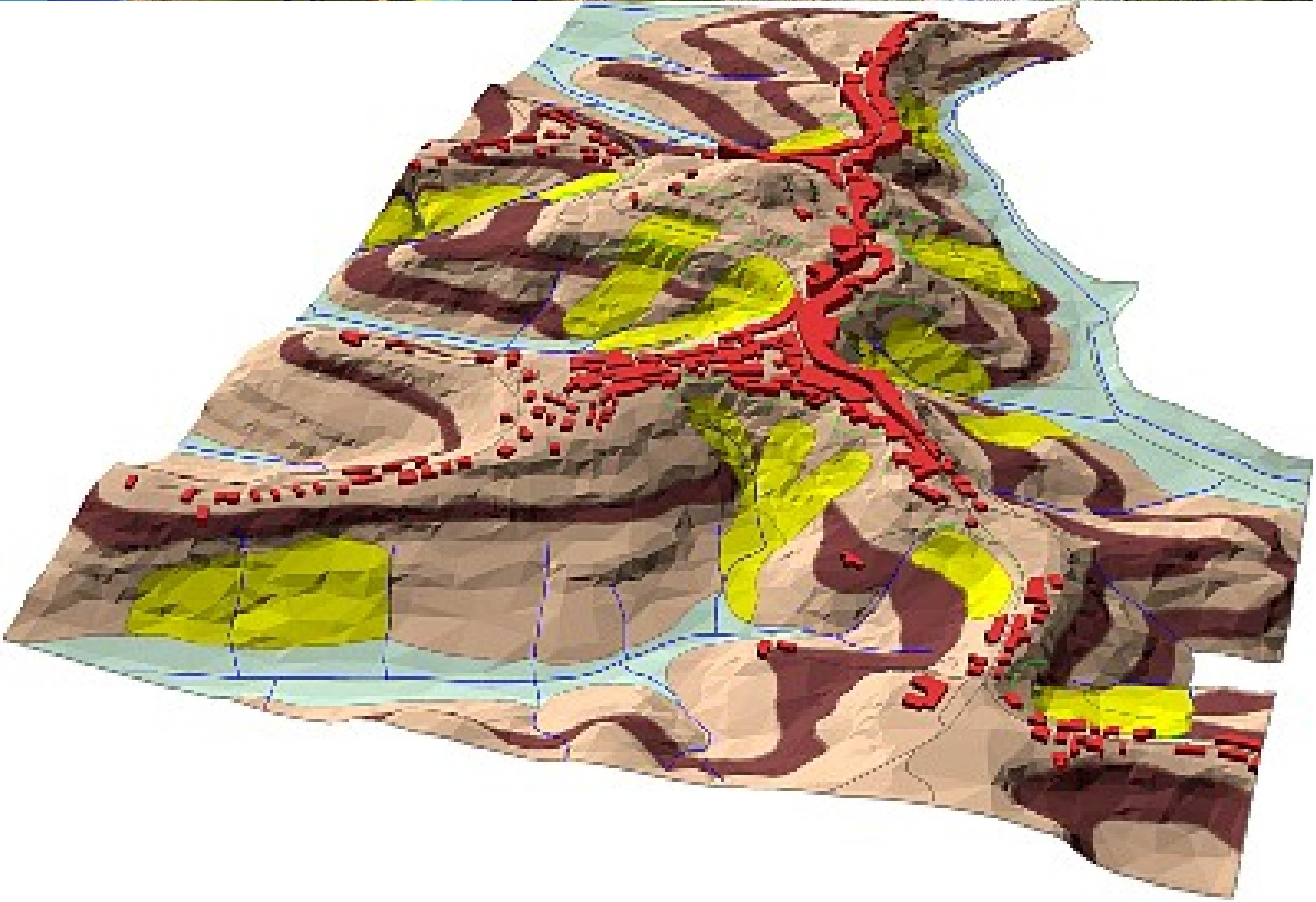
A TIN is a topologic data structure that manages information about the nodes that comprise each triangle and the neighbours to each triangle



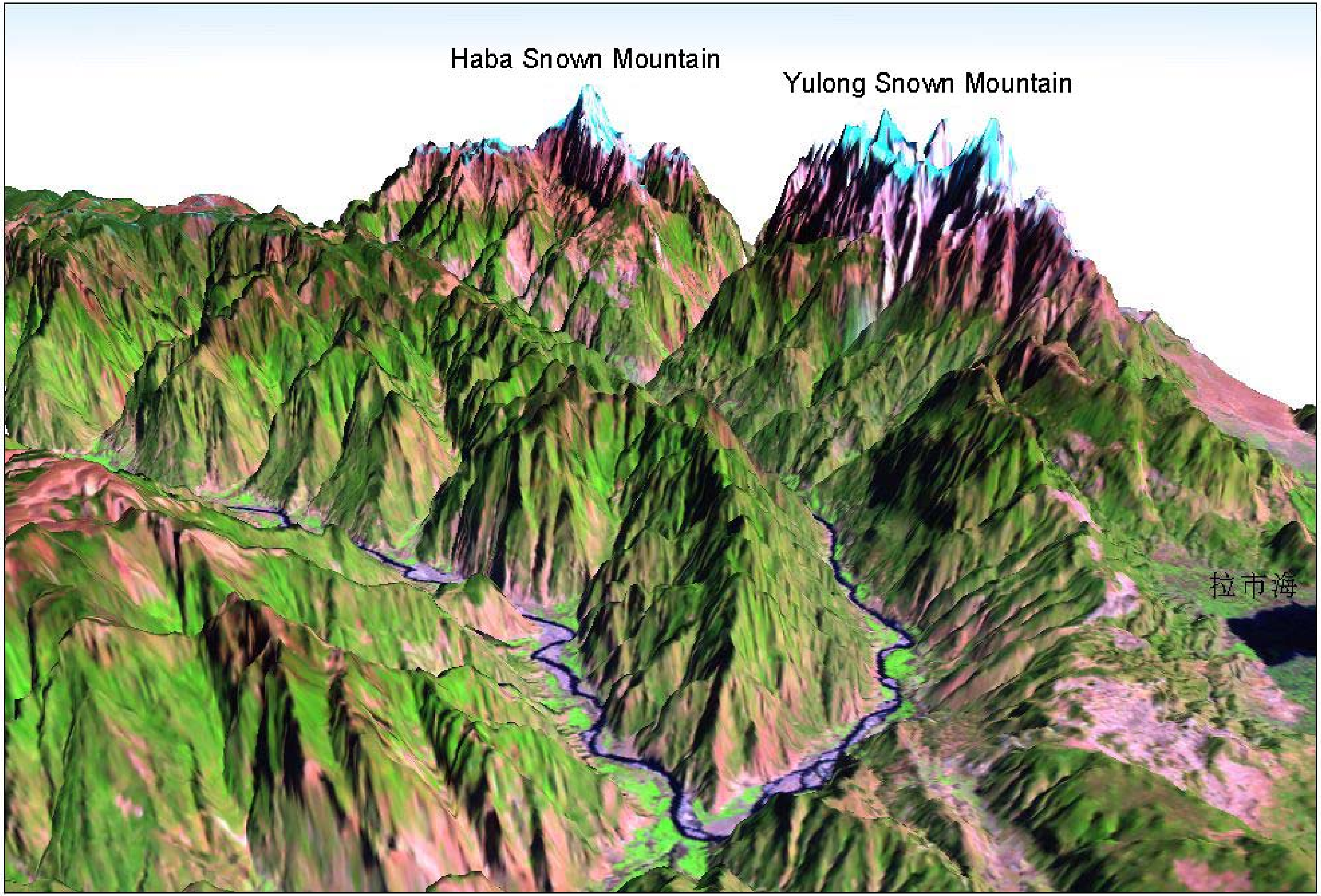
Triangle	Node list	Neighbours
A	1, 2, 3	-, B, D
B	2, 4, 3	-, C, A
C	4, 8, 3	-, G, B
D	1, 3, 5	A, F, E
E	1, 5, 6	D, H, -
F	3, 7, 5	G, H, D
G	3, 8, 7	C, -, F
H	5, 7, 6	F, -, E

Triangles always have three nodes and usually have three neighbouring triangles. Triangles on the periphery of the TIN can have one or two neighbours.





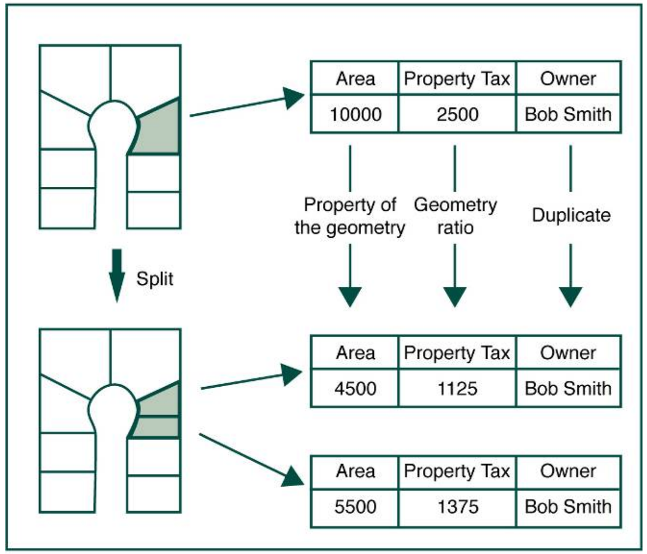
Three Dimension Landscape of First Turn on Yangtse River in CHINA



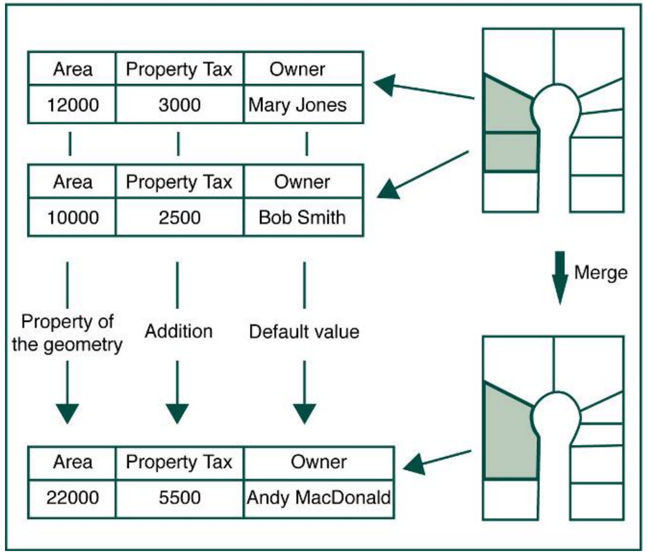
Human Settlements Research Center, Tsinghua University

Example of split and merge rules for parcel objects: (A) split; (B) merge

(A)



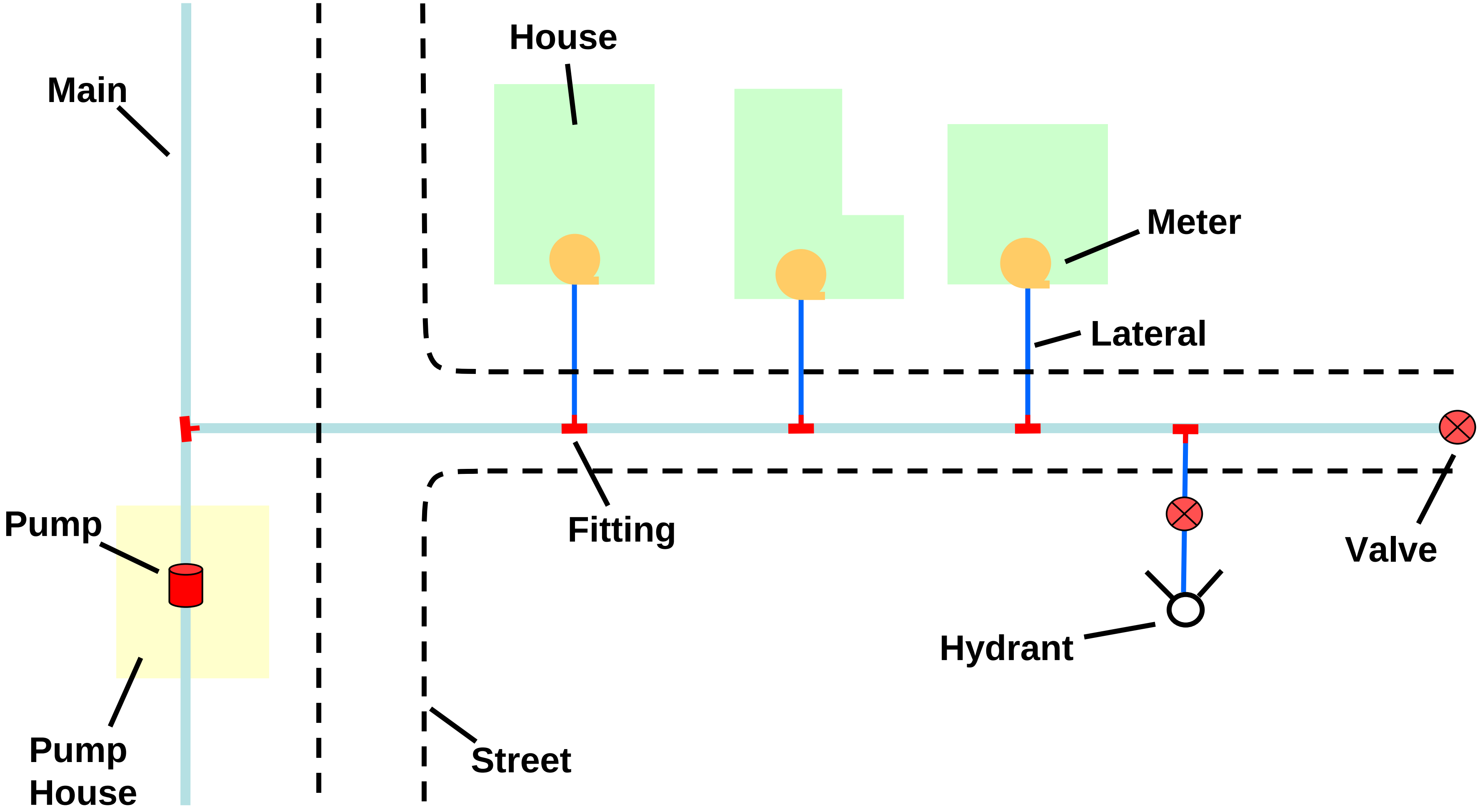
(B)



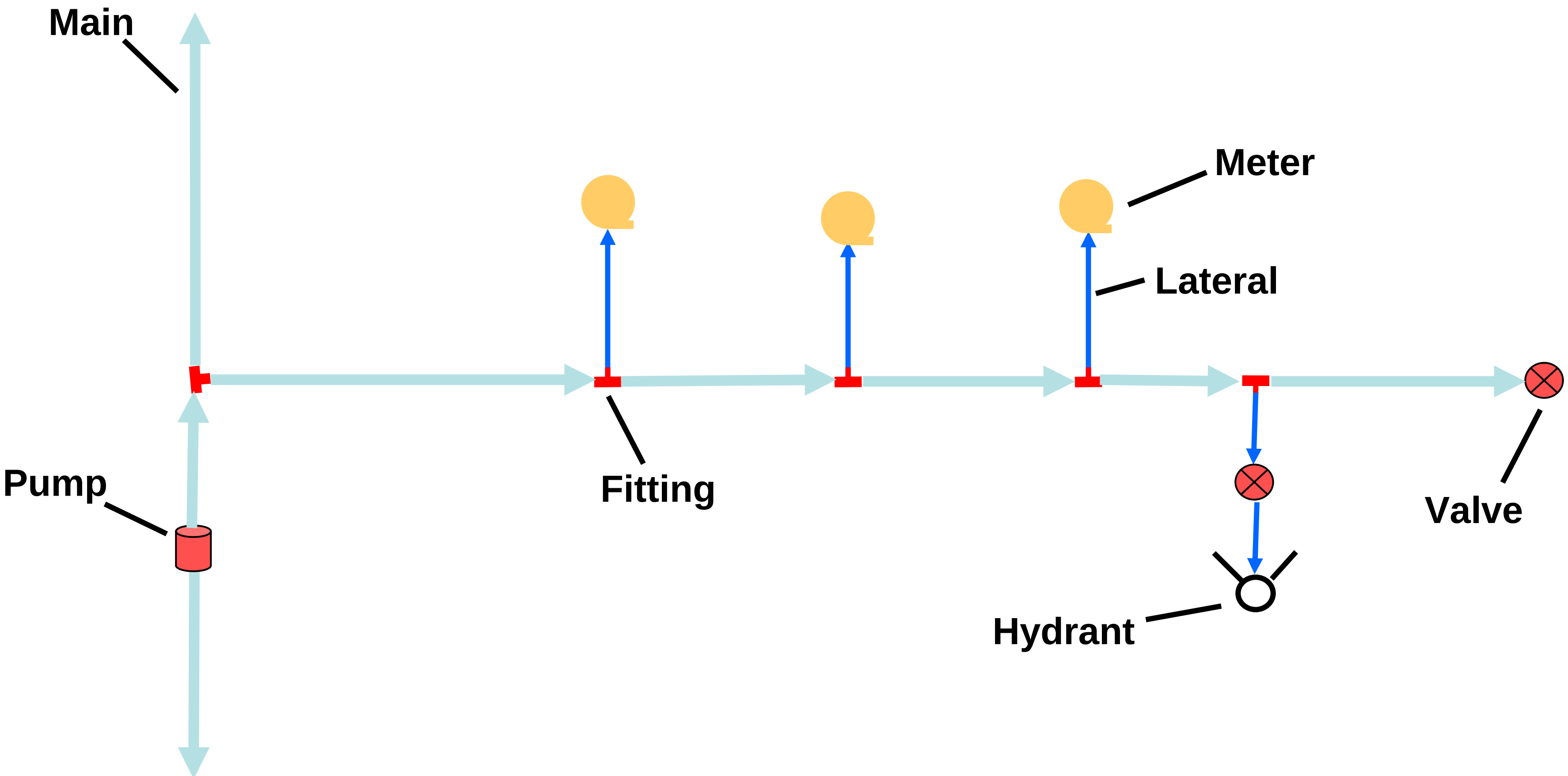
Example Water Facilities Data Model

- Start with objects and relationships
- Model as object types and relationships
  - Topological network
  - Hierarchical ‘type of’
  - Collection ‘composed of’
- Add related attribute tables

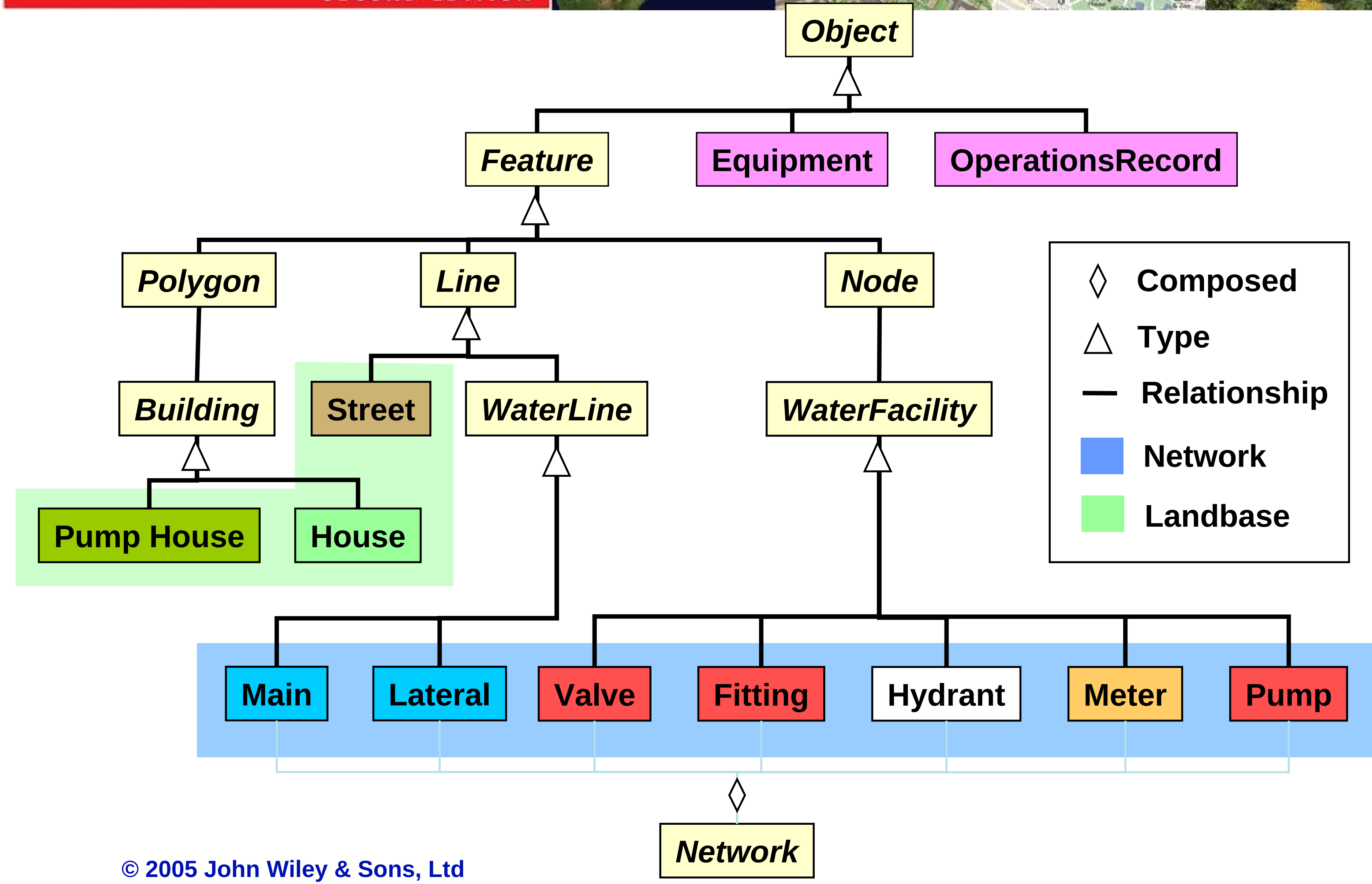
Water Distribution system



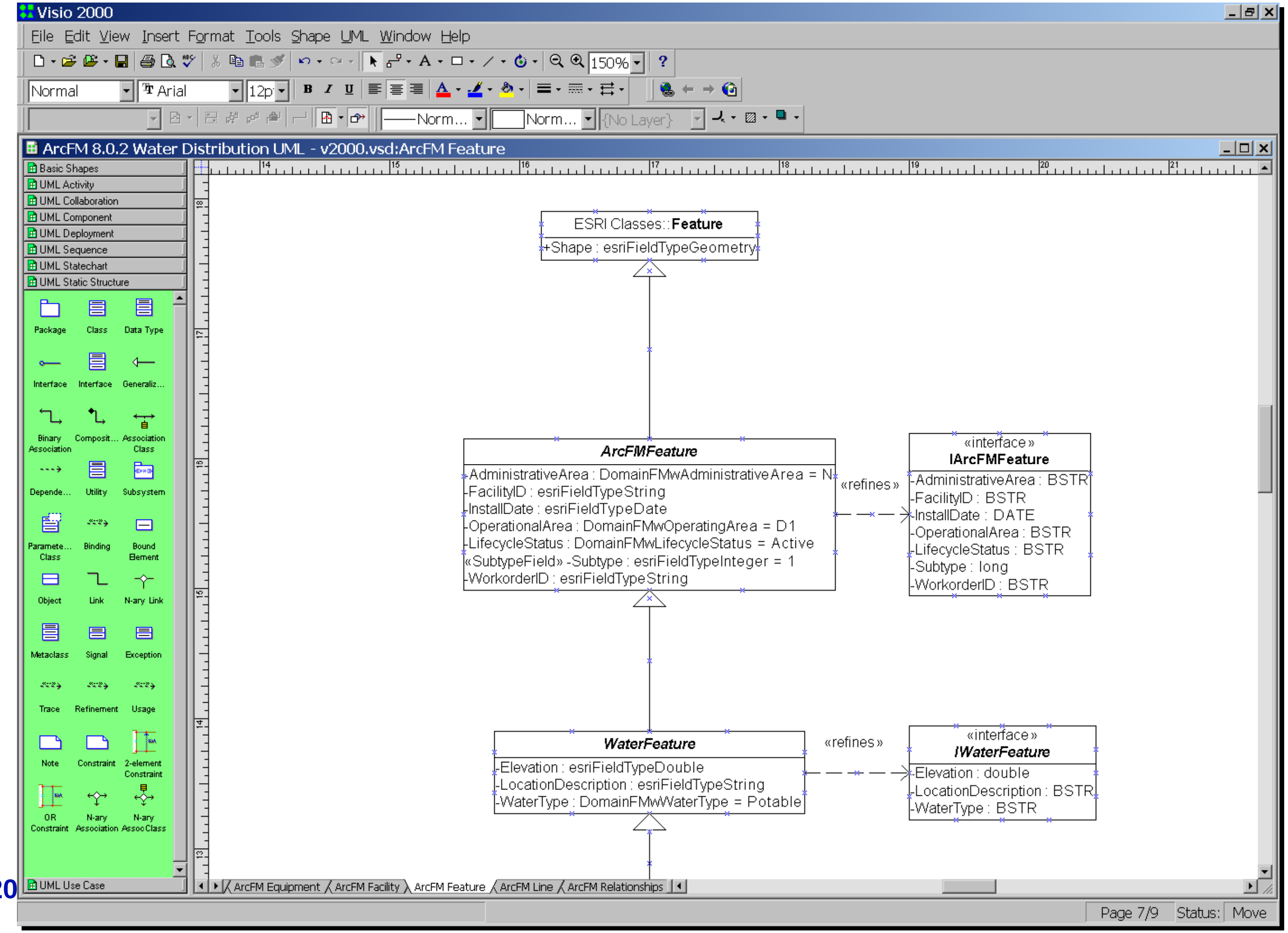
Water Distribution System




SECOND EDITION


Object
Feature
Equipment
OperationsRecord
Polygon
Line
Node
Building
Street
WaterLine
WaterFacility
Pump House
House
Main
Lateral
Valve
Fitting
Hydrant
Meter
Pump
Network
Composed
Type
Relationship
Network
Landbase

Visio CASE Tool (UML Representation)



Common Mistakes

- Design in abstract without reference to GIS software core data model
- Don't budget right amount of time
  - Too much, too little
- Try to be too wide ranging and generic instead of specific and practical
- Design for elegance instead of performance

Conclusions

- Data modeling is an art and a science
- Can't really understand it without practical experience
- Mature tools available to help
  - CASE, UML
- Never forget its GIS data modeling