GIS TOOLS

presented by:
Tim Haithcoat
University of Missouri
Columbia

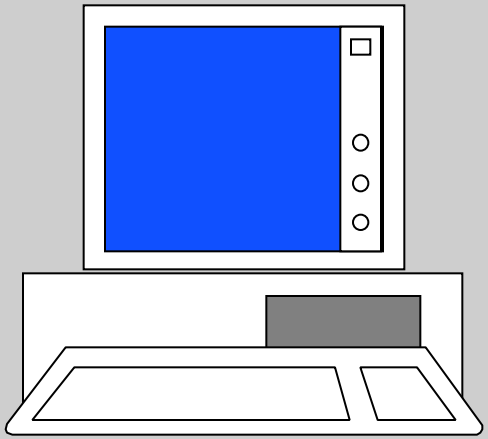
GIS Application Software Components

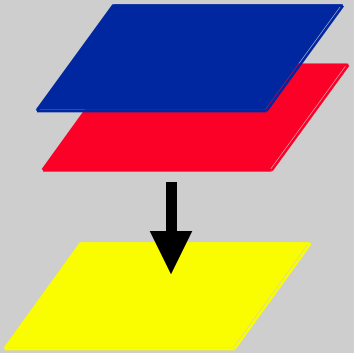
Graphics Processing →	Map entry, update, editing, display, and hard copy production
Database Management →	Attribute data entry, update, editing, query and reporting
Basic Cartographic Functions →	Area-distance calculation, geographic queries, thematic mapping, overlay, buffer analysis
Special applications →	Network analysis, terrain analysis, neighborhood analysis (districting)
Application Development →	Programming tools for customizing applications

Major GIS Application Categories

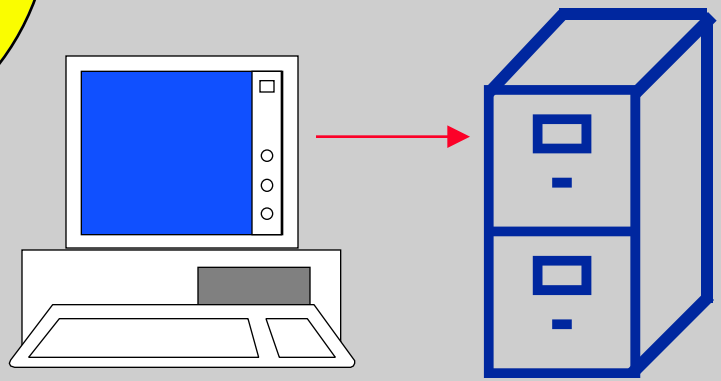
Standard Map Update Production

Data Query and Visualization





Spatial Analysis



Geographic Index to Detailed Records

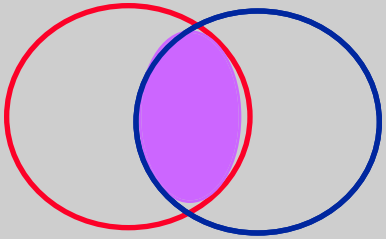
Geographic Query/Reporting

Use of database query and tabular report generation tools to perform special geographic queries and generate hard copy reports, displays, or maps.

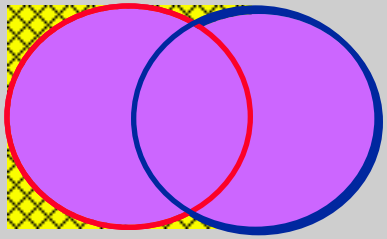
Examples:

- ✓ Display and produce tabular summary of all water quality permit sites exceeding discharge standards
- ✓ Identify and display all water lines of a specified age and diameter

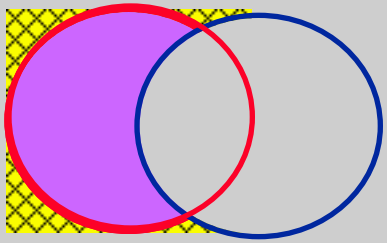
Boolean Operators



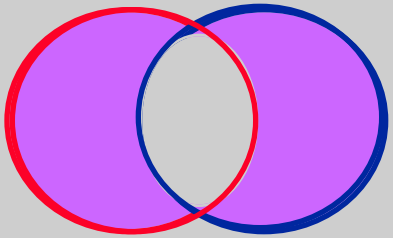
A AND B



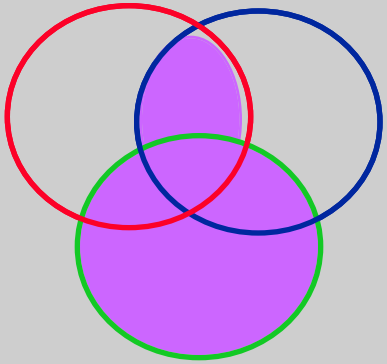
A OR B



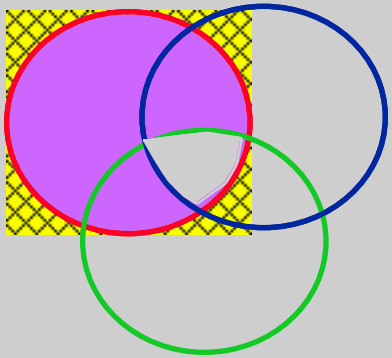
A NOT B



A XOR B

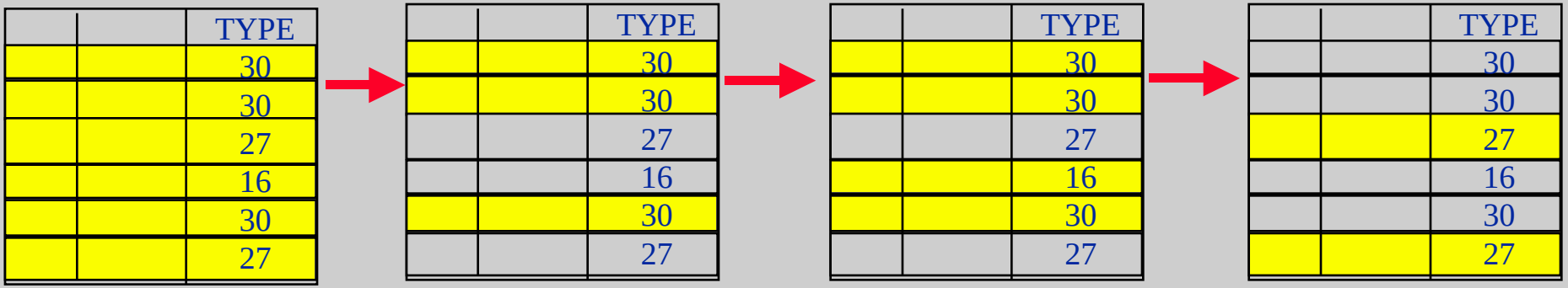


(A AND B) OR C



A AND (B OR C)

Selecting Records



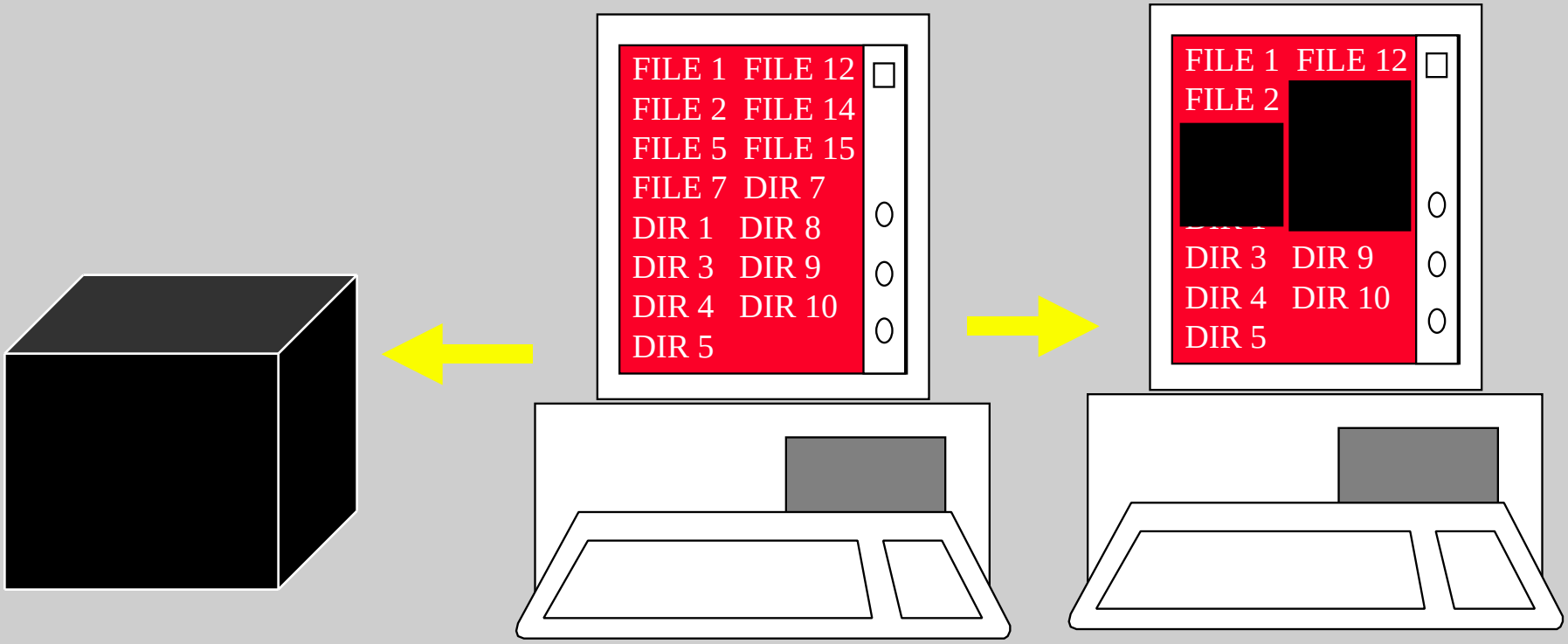
RESELECT
Reselect Type = 30
3 records selected

ASELECT
Aselect Type = 16
4 records selected
or
ASELECT
6 records selected

NSELECT

2 records selected

GIS Functions - Data Management



ARCHIVED DATA

ON-LINE STORAGE

DELETED FROM SYSTEM

Thematic Mapping

Production of maps in which a shading pattern is used to differentiate between categories of a geographic “theme” for a defined map or feature.

Examples:

- Shaded land use maps
- Population density maps

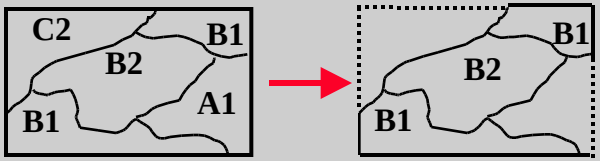
Spatial Aggregation

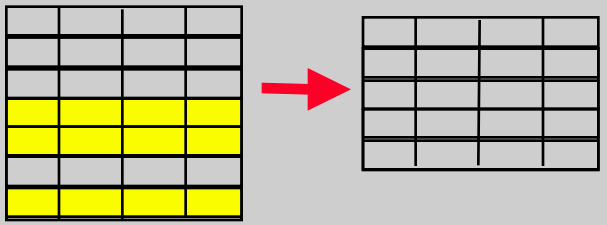
The retrieval and tabulation of map features or occurrences that are encompassed by a user-defined area.

Examples:

- ✓ Summary of crime incidents by police reporting district
- ✓ Calculation of newly paved road mileage within a state highway maintenance district

Logical Operators Spatial Results Tabular Results



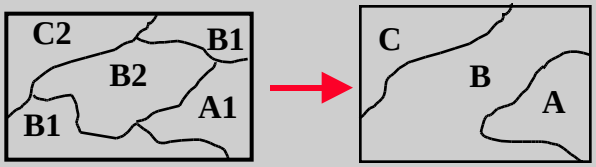


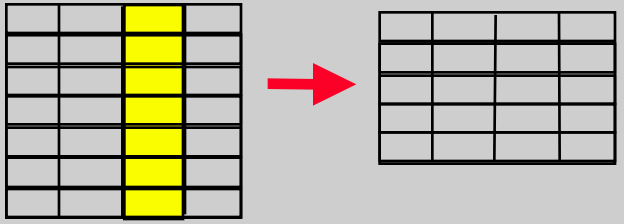
RESLECT

Selection by logical expressions

Subset of existing features (same features, but fewer of them)

Subset of records (same items & same values, but fewer records)





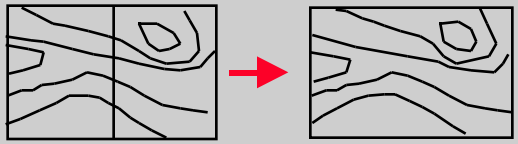
DISSOLVE (one item)

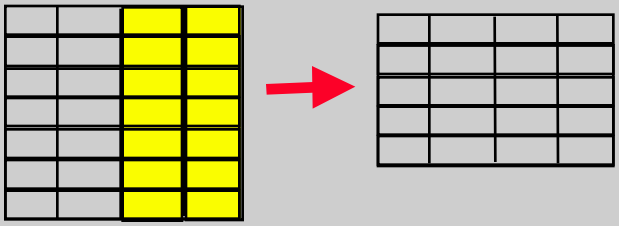
Selection by item

Polygons with same values merge (fewer polygons)

Item Reduction (less items, fewer records,new User-IDs & adjusted areas)

Logical Operators	Spatial Results	Tabular Results



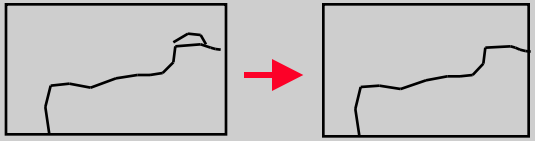


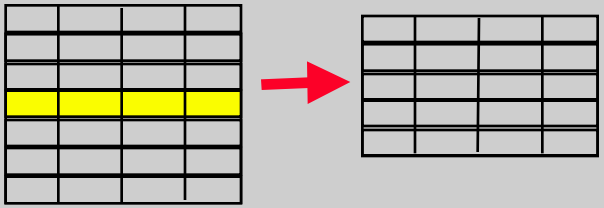
DISSOLVE (all items)

Selection by #ALL option

Polygons with same values merge (fewer polygons)

Item Reduction (same items, fewer records, areas adjusted & feature IDs can be maintained or offset.)





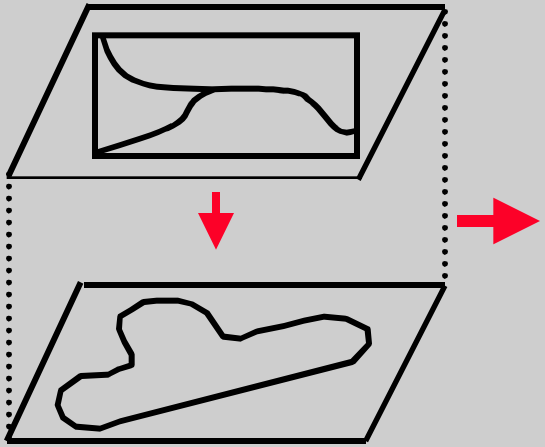
ELIMINATE

Selection by logical expressions

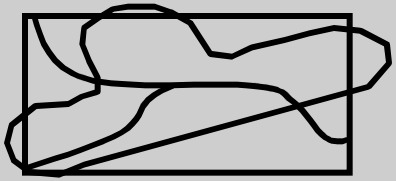
Polygons merged to neighbor by removing longest shared border (fewer polygons)

Record Reduction (same items, fewer records, (areas adjusted & User-IDs of eliminated polygons are deleted)

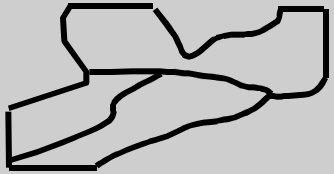
Input Coverages



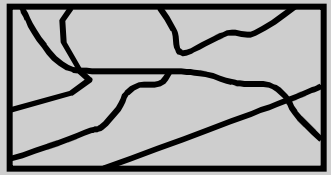
UNION



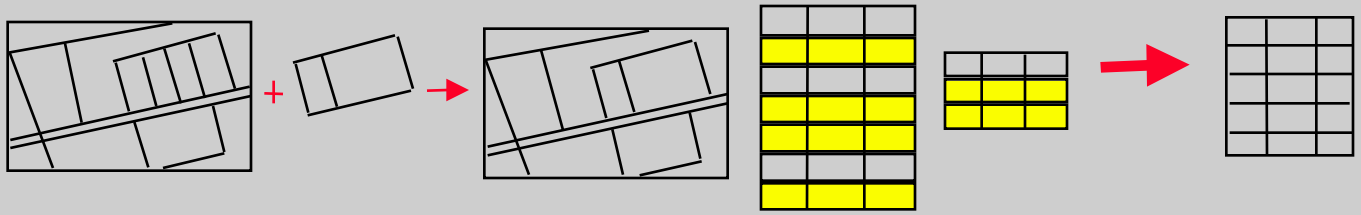
INTERSECT



IDENTITY



Boundary Operations **Spatial Results** **Tabular Results**



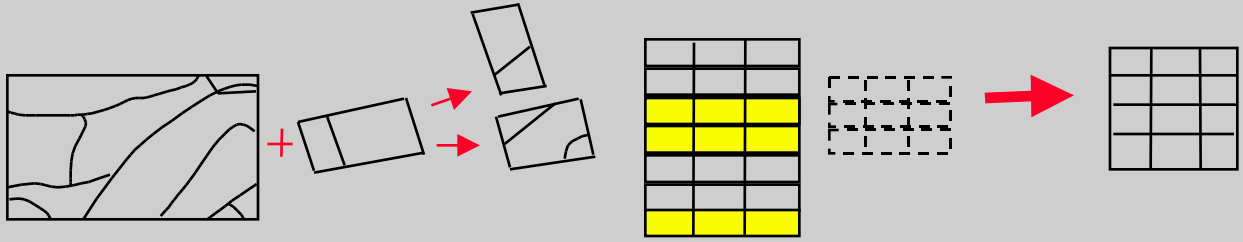
UPDATE
POLY
NET

Replace existing polygons

~ external polygon boundary is used to 'cut & paste" new features
~ updating uses topological

Replaces old records

~ attributes in [update_cover] must match [in_cover]
~ User-IDs are renumbered (unique values)



SPLIT
POLY
LINE
POINT
NET
LINK

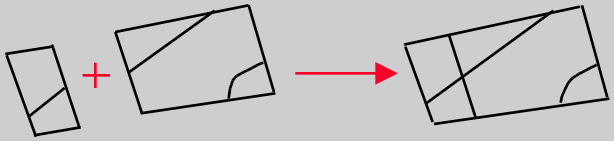
Subset of existing features

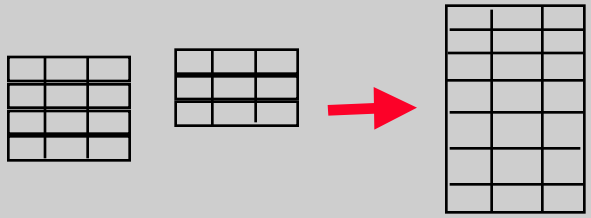
~ retains features inside internal polygon boundaries
~ splitting uses topological overlay

Subset of records

~ same attributes as [in_cover] but fewer records, areas adjusted & User-IDs are renumbered (unique values)

Boundary Operations	Spatial Results	Tabular Results





MAPJOIN

POLY
NET

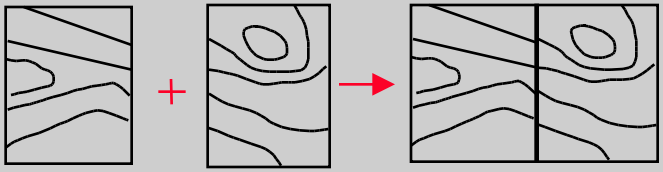
Merge Adjacent polygons

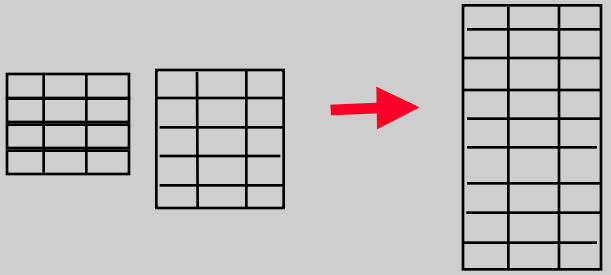
~polygons from many coverages are combined, including their borders

Records are Combined

~ attributes in all coverages being combined must match

~ User-IDs can be offset or remain the same (Duplicate values possible)





APPEND

POLY
LINE
POINT
NET
LINK

Merge similar features adjacent or coincident

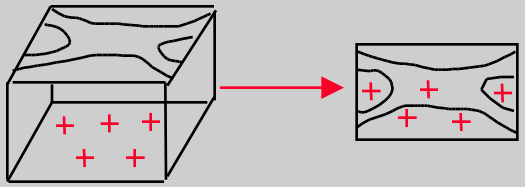
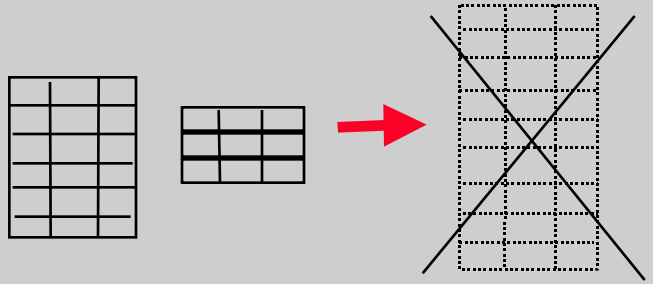
~ features from several coverages are combined

~topology must be reestablished with CLEAN or BUILD

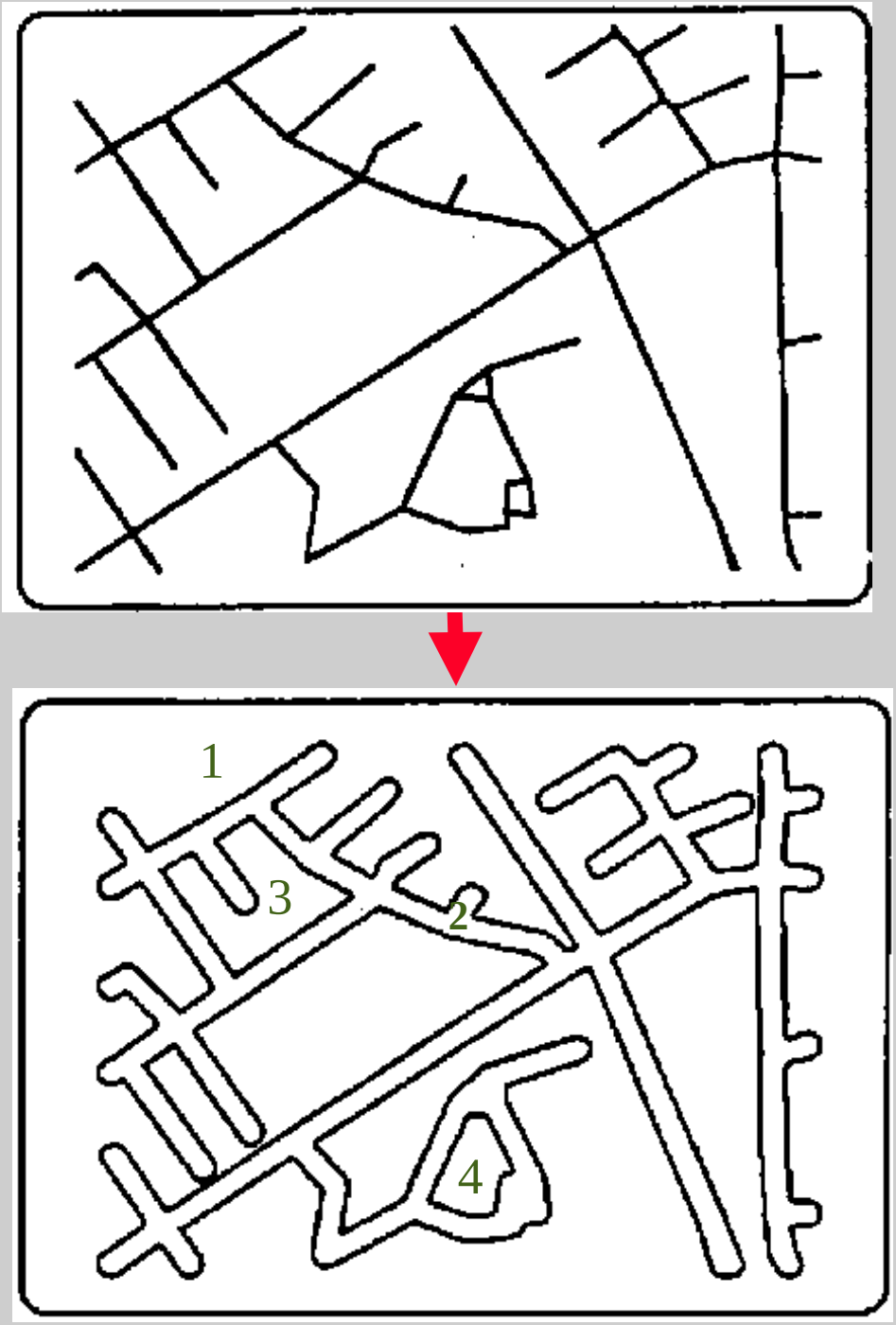
Records are Combined

~ attributes in all coverages being combined must match

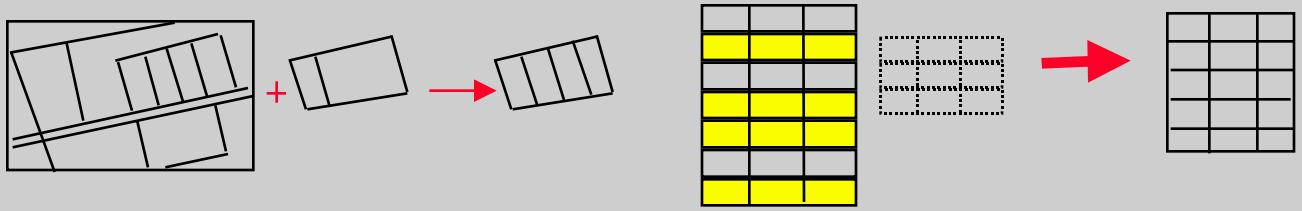
~ User-IDs can be offset or remain the same (Duplicate values possible)

Boundary Operations	Spatial Results	Tabular Results
APPEND (all types) NO TEST option	 Merge different features - adjacent or coincident ~features from several coverages are combined ~ topology must be reestablished with CLEAN or BUILD	 Feature attributes are lost ~ attributes do not matter because they are not appended

Buffer



Boundary Operations	Spatial Results	Tabular Results



CLIP

POLY
LINE
POINT
NET
LINK

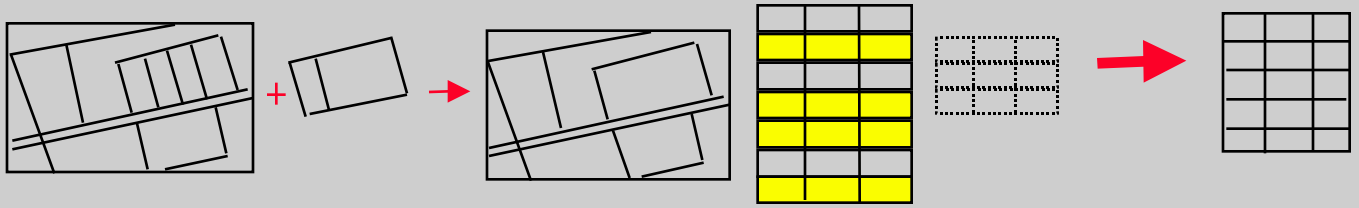
Subset of existing features

~ retains features inside the external polygon boundary

~ clipping uses topological overlay

Subset of records

~ same attributes as [in_cover] but fewer records, areas adjusted & User-IDs are renumbered (unique values)



ERASECOV

POLY
LINE
POINT
NET
LINK

Subset of existing features

~ erases features inside the external polygon boundaries

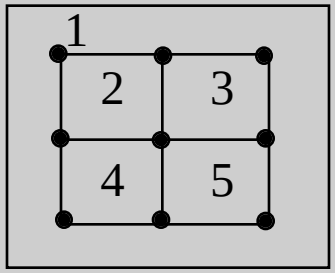
~ erasing uses topological overlay

Subset of records

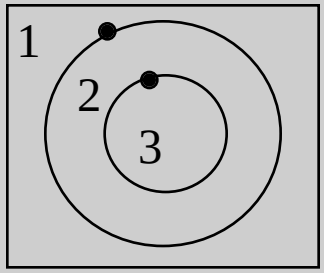
~ same attributes as [in_cover] but fewer records, areas adjusted & User-IDs are renumbered (unique values)

Union

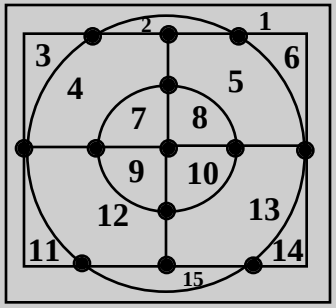
Input Coverage



Union Coverage



Output Coverage



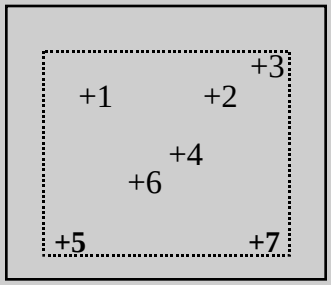
INPUT COVERAGE	
#	Attribute
1	
2	A
3	B
4	C
5	D

UNION COVERAGE	
#	Attribute
1	
2	102
3	103

OUTPUT COVERAGE	INPUT COVERAGE		UNION COVERAGE	
#	#	Attribute	#	Attribute
1	1		1	
2	1		2	102
3	2	A	1	
4	2	A	2	102
5	3	B	2	102
6	3	B	1	
7	2	A	3	103
8	3	B	3	103
9	4	C	3	103
10	5	D	3	103
11	4	C	1	
12	4	C	2	102
13	5	D	2	102
14	5	D	1	
15	1		2	102

Identity - Point Option

Input Coverage

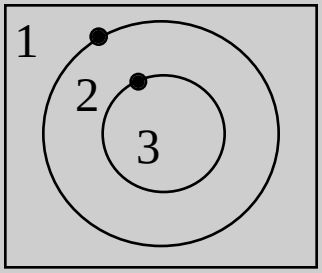


INPUT COVERAGE	
#	Attribute
1	A
2	B
3	C
4	D
5	E
6	F
7	G

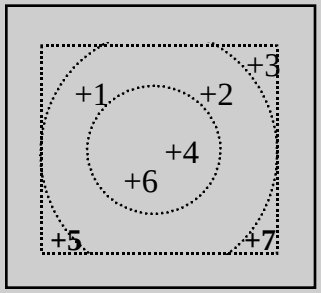
IDENTITY COVERAGE	
#	Attribute
1	
2	102
3	103

OUTPUT COVERAGE	INPUT COVERAGE		IDENTITY COVERAGE	
#	#	Attribute	#	Attribute
1	1	A	2	102
2	2	B	2	102
3	2	C	1	
4	3	D	3	103
5	3	E	1	
6	4	F	3	103
7	4	G	1	

Identity Coverage

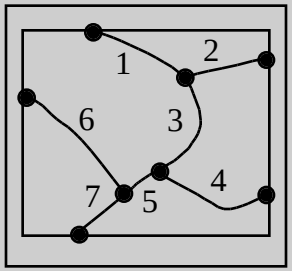


Output Coverage

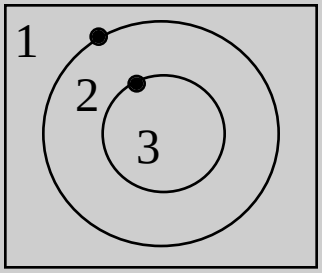


Identity - Line Option

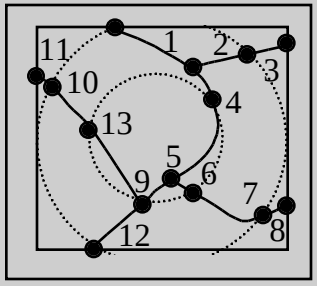
Input Coverage



Identity Coverage



Output Coverage



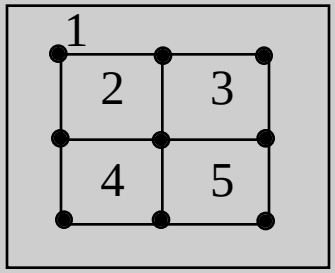
INPUT COVERAGE	
#	Attribute
1	A
2	B
3	A
4	C
5	A
6	D
7	A

UNION COVERAGE	
#	Attribute
1	
2	102
3	103

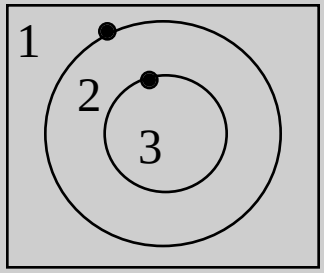
OUTPUT COVERAGE	INPUT COVERAGE		UNION COVERAGE	
#	#	Attribute	#	Attribute
1	1	A	2	102
2	2	B	2	102
3	2	B	1	
4	3	A	2	102
5	3	A	3	103
6	4	C	3	103
7	4	C	2	102
8	4	C	1	
9	5	A	3	103
10	6	D	2	102
11	6	D	1	
12	7	A	2	102
13	6	D	3	103

Identity - Poly Option

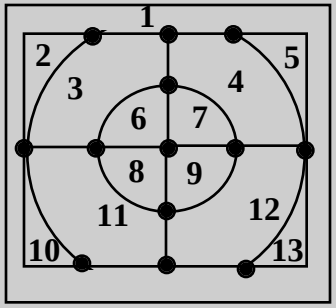
Input Coverage



Identity Coverage



Output Coverage



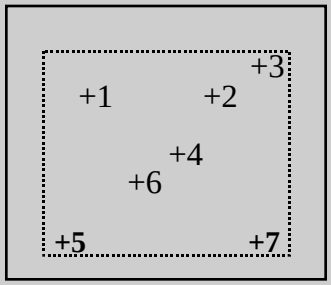
INPUT COVERAGE	
#	Attribute
1	
2	A
3	B
4	C
5	D

IDENTITY COVERAGE	
#	Attribute
1	
2	102
3	103

OUTPUT COVERAGE	INPUT COVERAGE		IDENTITY COVERAGE	
#	#	Attribute	#	Attribute
1	1		1	
2	2	A	1	
3	2	A	2	102
4	3	B	2	102
5	3	B	1	
6	2	A	3	103
7	3	B	3	103
8	4	C	3	103
9	5	D	3	103
10	4	C	1	
11	4	C	2	102
12	5	D	2	102
13	5	D	1	

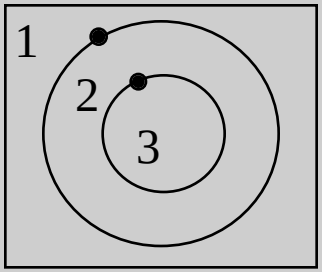
Intersect - Point Option

Input Coverage



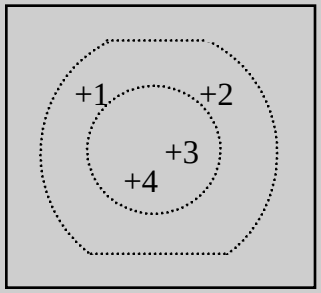
INPUT COVERAGE	
#	Attribute
1	A
2	B
3	C
4	D
5	E
6	F
7	G

Intersect Coverage



INTERSECT COVERAGE	
#	Attribute
1	
2	102
3	103

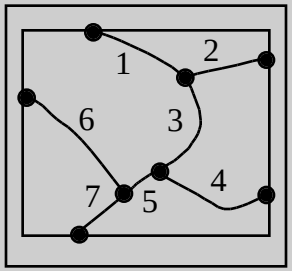
Output Coverage



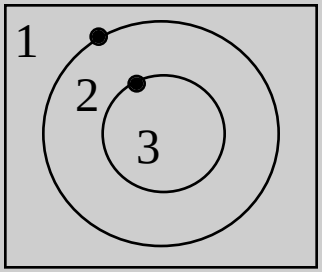
OUTPUT COVERAGE	INPUT COVERAGE		INTERSECT COVERAGE	
#	#	Attribute	#	Attribute
1	1	A	2	102
2	2	B	2	102
3	4	D	3	103
4	6	F	3	103

Intersect - Line Option

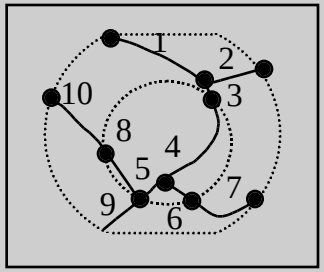
Input Coverage



Intersect Coverage



Output Coverage



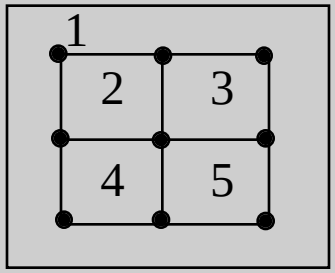
INPUT COVERAGE	
#	Attribute
1	A
2	B
3	A
4	C
5	A
6	D
7	A

INTERSECT COVERAGE	
#	Attribute
1	
2	102
3	103

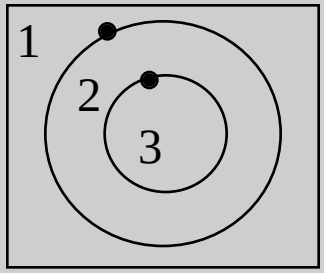
OUTPUT COVERAGE	INPUT COVERAGE		INTERSECT COVERAGE	
#	#	Attribute	#	Attribute
1	1	A	2	102
2	2	B	2	102
3	3	A	2	102
4	3	A	3	103
5	5	A	3	103
6	4	C	3	103
7	4	C	2	102
8	6	D	3	103
9	7	A	2	102
10	6	D	2	102

Intersect - Poly Option

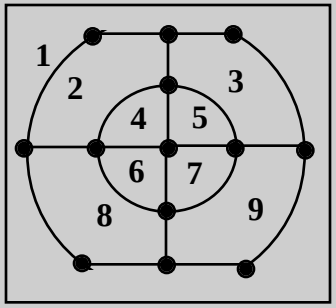
Input Coverage



Intersect Coverage



Output Coverage



INPUT COVERAGE	
#	Attribute
1	
2	A
3	B
4	C
5	D

INTERSECT COVERAGE	
#	Attribute
1	
2	102
3	103

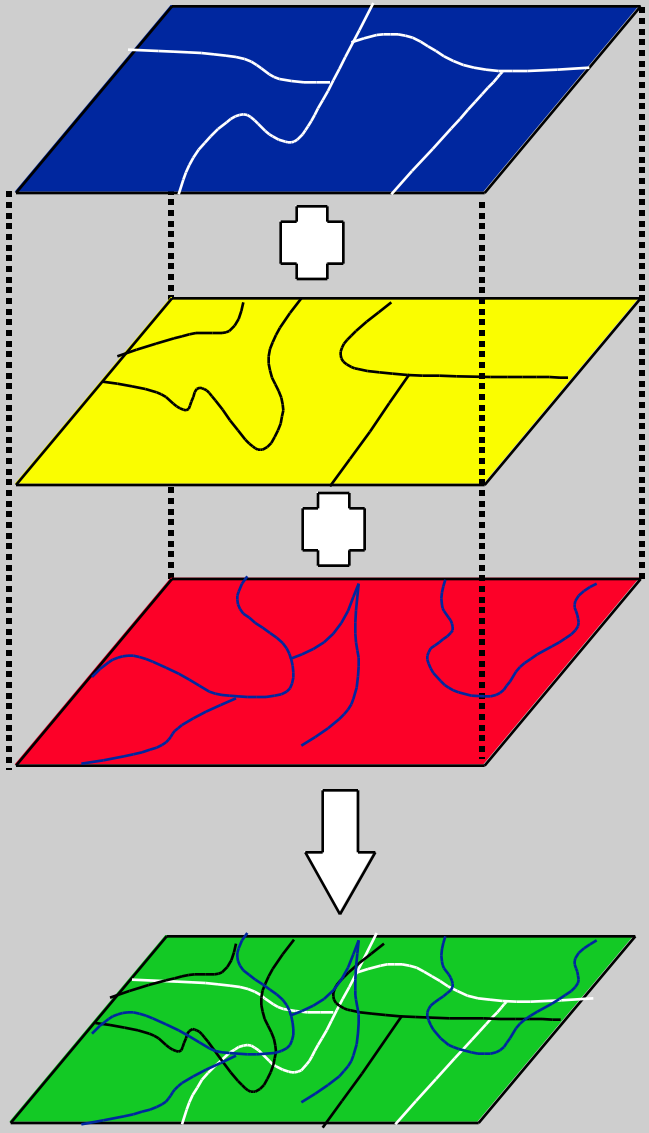
OUTPUT COVERAGE	INPUT COVERAGE		INTERSECT COVERAGE	
#	#	Attribute	#	Attribute
1	1		1	
2	2	A	2	102
3	3	B	2	102
4	2	A	3	103
5	3	B	3	103
6	4	C	3	103
7	5	D	3	103
8	4	C	2	102
9	5	D	2	102

Suitability Analysis Using Map Overlays

Governmental Administrative Units

Land Use

Soils



Suitability for Industrial Development

Analysis of these interrelated maps

Produces

Application (Result)

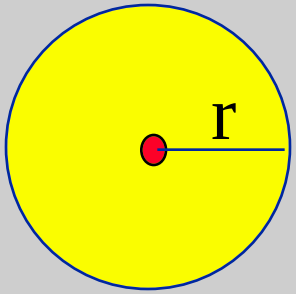
Polygon Overlay

The vertical overlay of multiple map layers to derive a resulting map layer based on some logical combination of attributes from the original layers.

Examples:

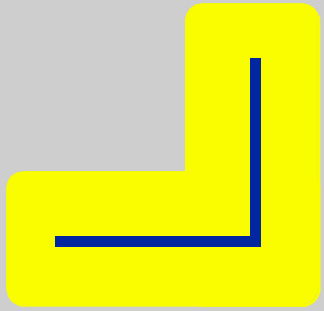
- Erosion analysis based on overlay of soil, slope, and land cover layer;
- Determine parcels that fall within flood prone areas
- Site suitability for industrial development

Buffering



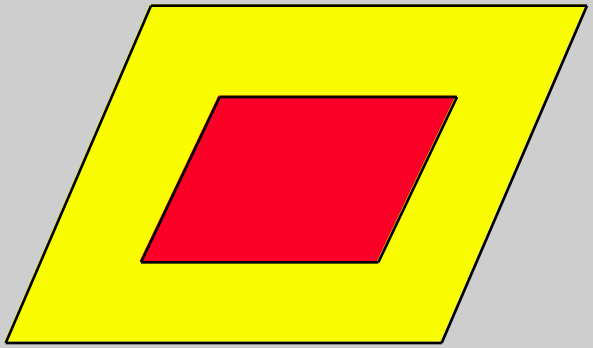
Buffering a Point

example: All area within one mile of the city.



Buffering a Line

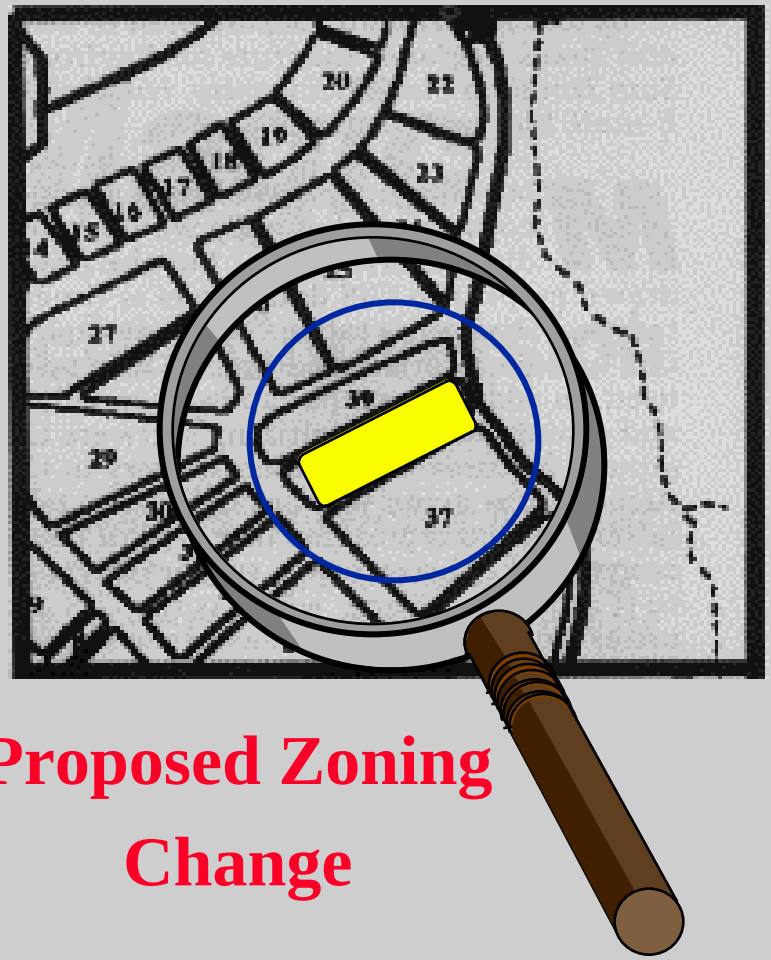
example: All areas within 1000 meters of a road.



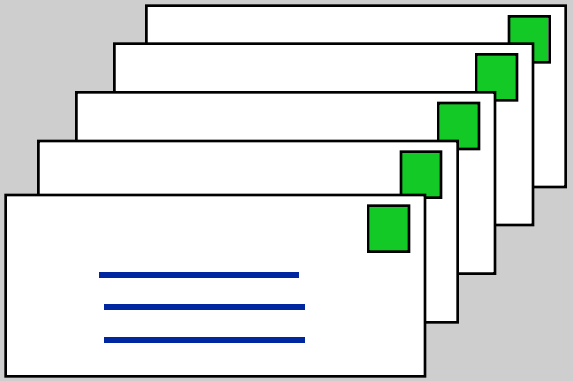
Buffering an Area

example: All areas within 500 meters of a wetlands area.

Using a GIS to Query a Geographic Database



Proposed Zoning Change



Neighbors must be notified

Proximity/Buffer Analysis

Generation and selection of map data within specified distance around a point, line, or polygon feature

Examples:

- Property search to find all parcels within a specified distance of a target parcel
- Environmental impact analysis requiring delineation of a buffer zone around a stream

Network Analysis

Analytical technique to evaluate flow or paths through a defined linear network.

Examples:

- Analysis of optimal routes through road network
- Analysis of flow in a water distribution system

Address Matching and Incident Mapping

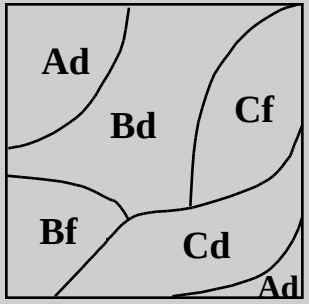
Generation of maps showing the point location of features or phenomena on a suitable base map. Incident locations may be defined by x, y coordinate, street address, or other locational identifier.

Examples:

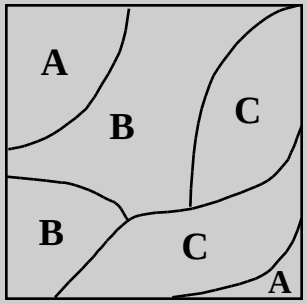
- Mapping of water sampling points
- Police incident mapping

Steps:

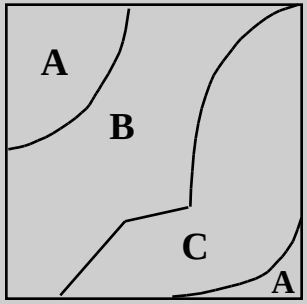
1. **Reclassify** soil areas by soil type only.
2. **Dissolve** boundaries between areas of same soil type.
3. **Merge** polygons into large objects.



Soil Types A, B and C with growth potentials d and f



Soil Types A, B and C



Soil Types A, B, and C

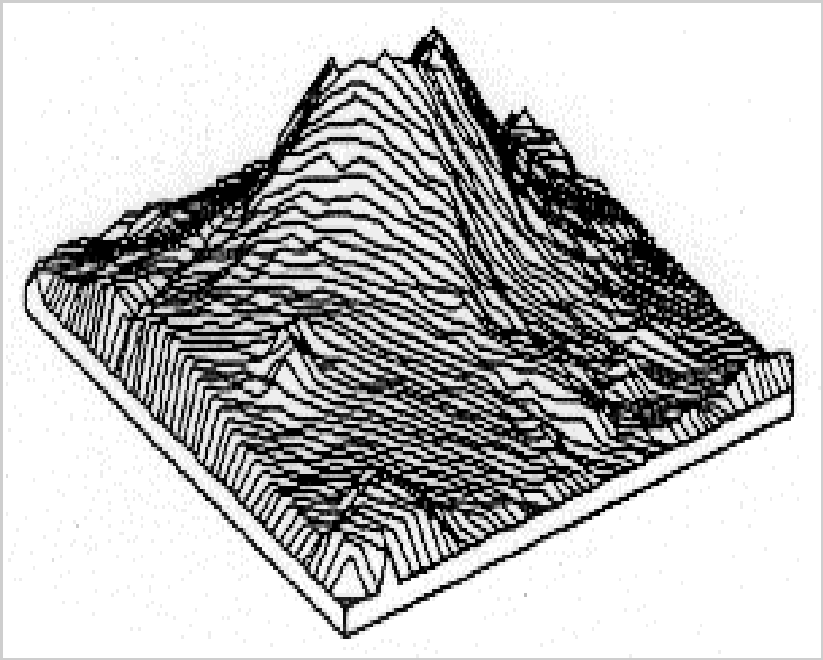
Terrain Analysis

Use of three-dimensional data to perform landscape or terrain evaluation.

Examples:

- ✓ Use of digital elevation models to generate contour maps and perform slope analysis
- ✓ Civil engineering calculations to determine cut-and-fill volumes and generate vertical profile drawings

What is a Surface?



- ✓ A surface is a continuous feature, without discrete intervals.
- ✓ There is no way to store all the information about a surface.
- ✓ We must **approximate** a surface with **samples**.

Surface Data

- ✓ A 3-D model of the surface is generated from a TIN, lattice, or vector contour file.
- ✓ Both models are based on point data which associates a z value item with an x,y location.
- ✓ The z value usually measures surface elevation and provides the surface model with its third dimension.
- ✓ These values can also be used to represent a wide variety of measurements. Common examples are:depth, temperature, rainfall, pollutants, barometric pressure and demographic distribution.
- ✓ Surfaces which are generated to represent these data points become the model upon which to perform surface analysis.

Surface Analysis

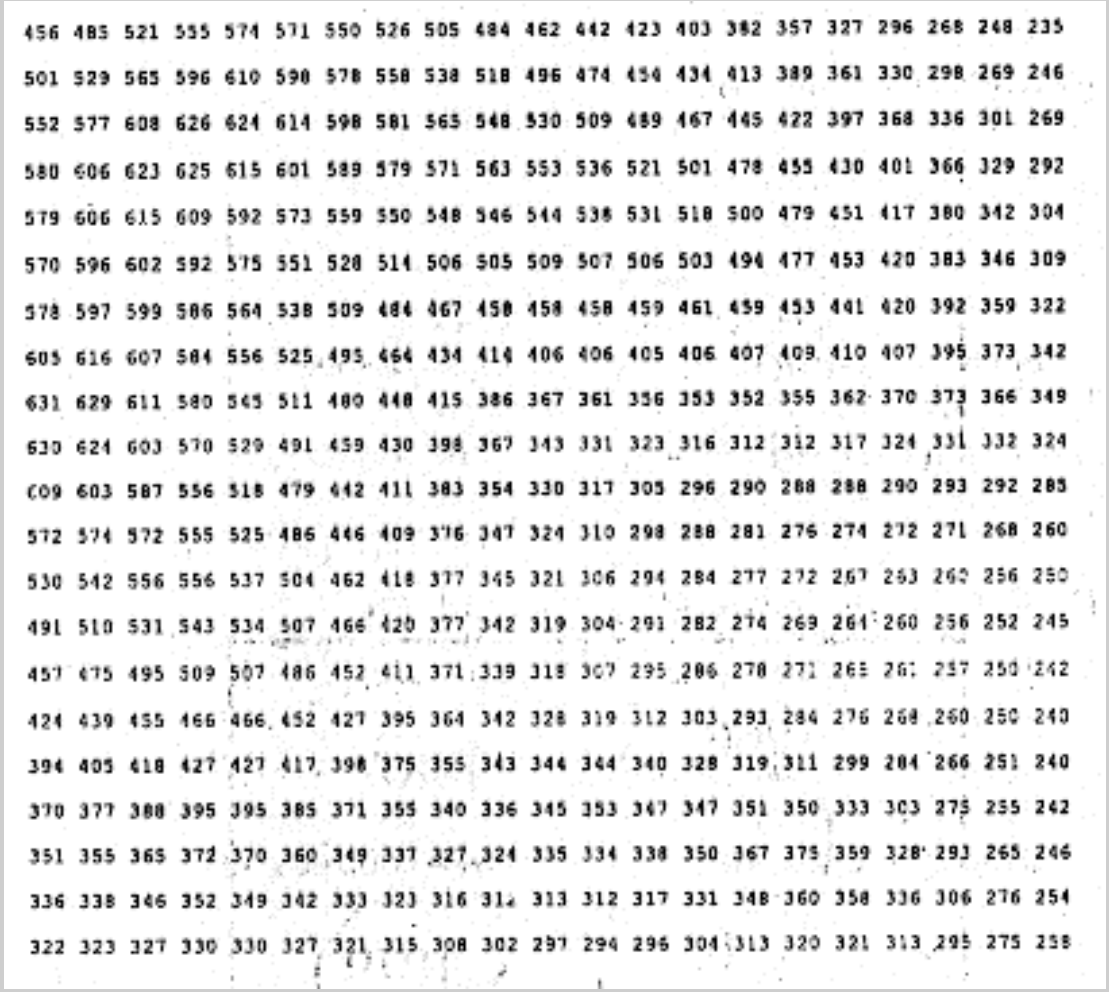
Can be performed to answer any of the following questions.

- What is the elevation of a selected point on the surface?
- Can specified points see each other?
- What are the real distances traveled along the surface?
- How much area does a region of the surface really cover?
- What is the area lying below a profile of the surface?
- How much space does the surface model occupy?
- How steep are different areas of the surface?
- Which direction does each area face?
- Which regions have a similar elevation?
- What climatic patterns can be generated?
- Where should the boundaries between centers be located?

Elevation Represented as Points

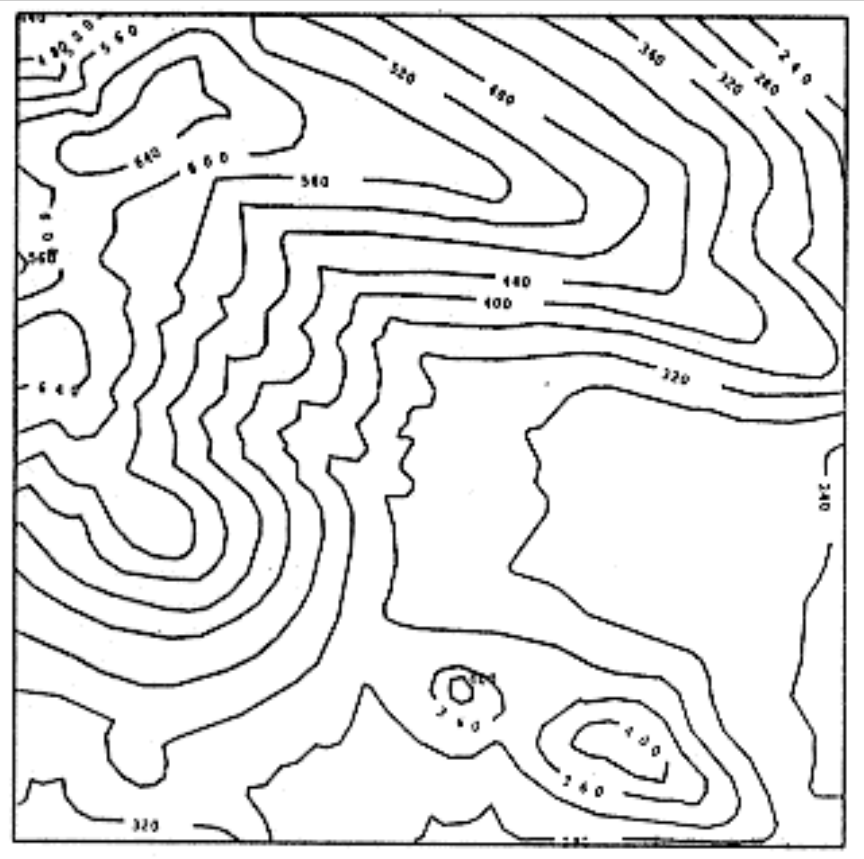
Tiefort Mountains, California

Lattice description for smlat22
Lattice size and origin
  Points X/Y = 21 21
  Origin (x,y) = 540000.00
3911940.000
Lattice distance between points:
  Distance in X = 30.000
  Distance in Y = 30.000
Surface value in range:
  Min z=235.000
  Max z=631.00
Lattice boundary:
  Xmin=540000.000
  Xmax= 540600.000
  Ymin= 3911940.000
  Ymax = 3912540.000



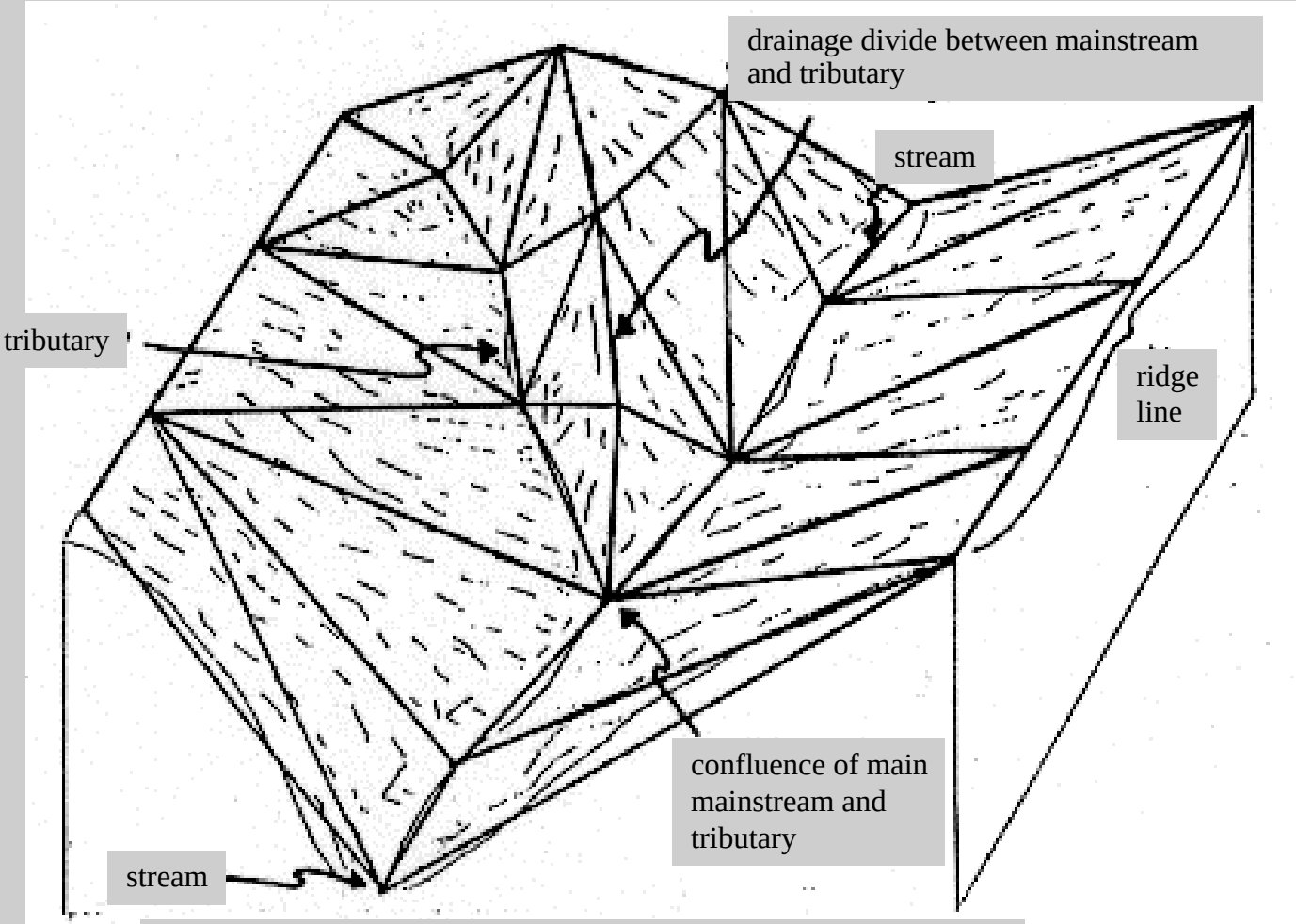
Elevation Represented as Lines

Tiefort Mountains, California



Triangulation of a Terrain Surface

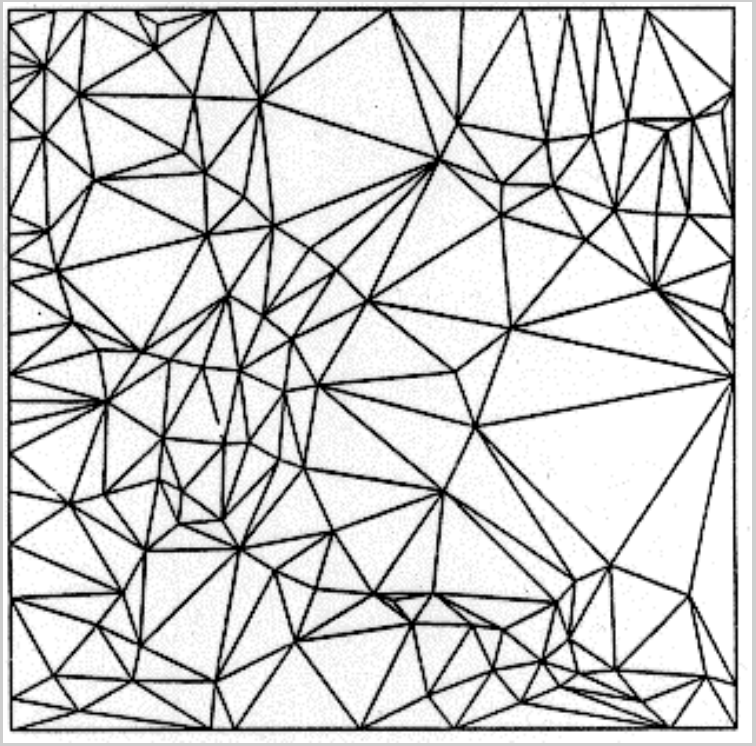
Source: Heil, R.J. and S.M. Brych, "An approach for consistent topographic representation of varying terrain", *Proceedings of the Digital Terrain Models (DTM) Symposium*, Falls Church, VA: ASP and ACSM, 1978, p. 408, Figure 4b.

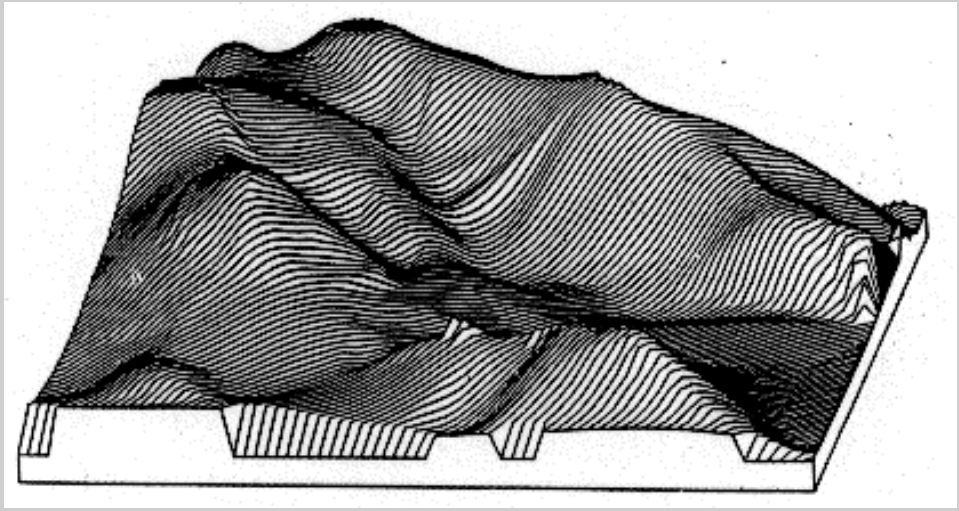


B. An example of triangulation representing terrain.

Elevation Represented as Areas

Tiefort Mountains, California

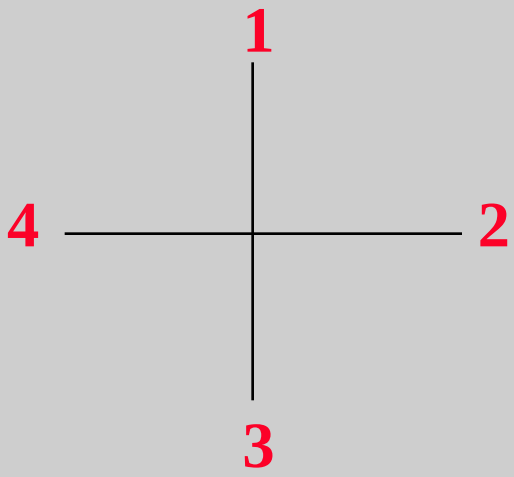




Flow Direction Example

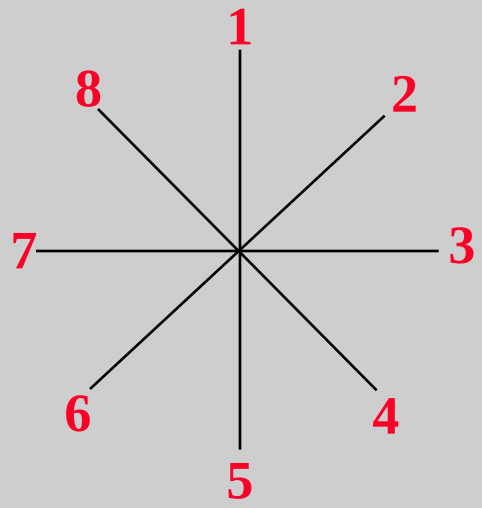
DEM:

10	9	11	12
8	7	6	7
5	4	3	4
5	0	1	5



4 moves

3	3	3	3
3	3	3	3
2	3	3	4
2	0	4	4

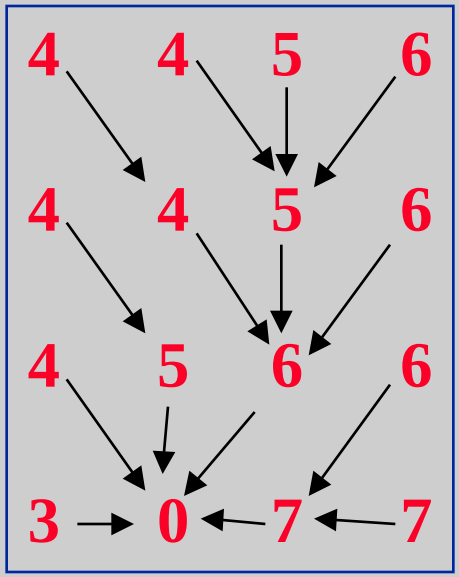


8 moves

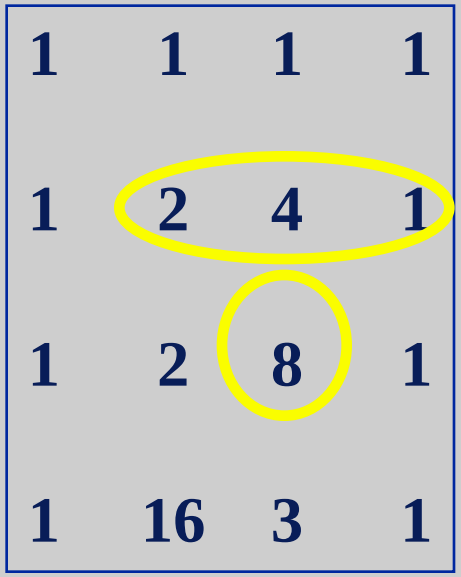
4	4	5	6
4	4	5	6
4	5	6	6
3	0	7	7

Determining the Network

Flow Directions



Accumulating Flow



Critical Flow Level 2

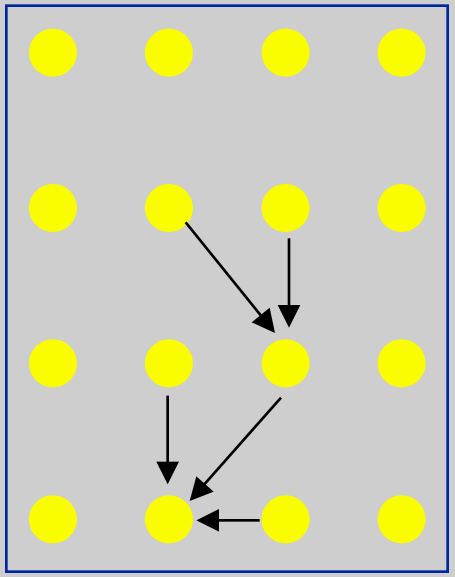
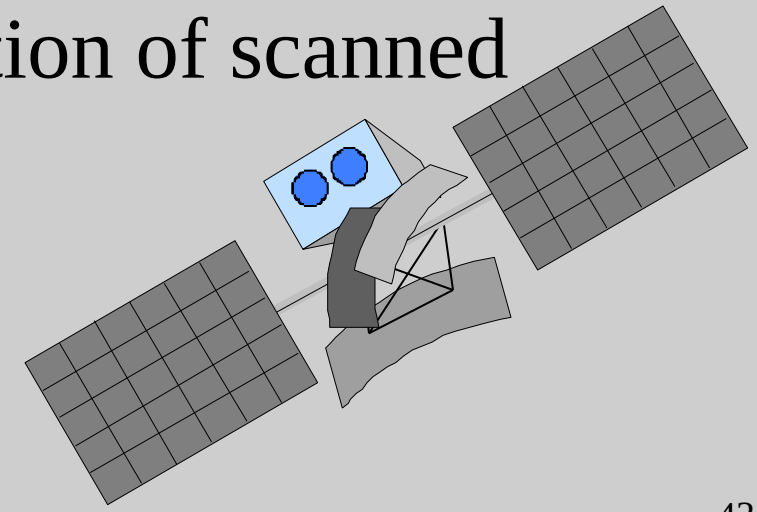


Image Processing

Analysis of raster images from scanners to interpret, display, and analyze map features.

Examples:

- Mapping of land cover using image data from the SPOT or Landsat satellite
- Display and manipulation of scanned facility drawings.

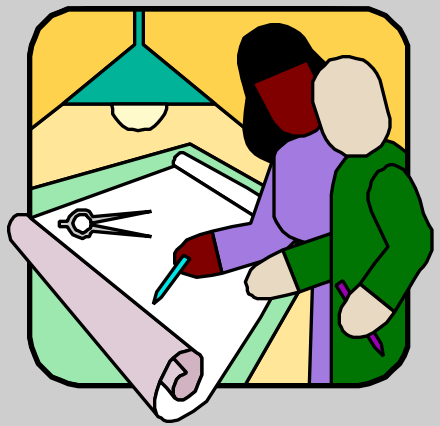


Document Management/Hypermedia

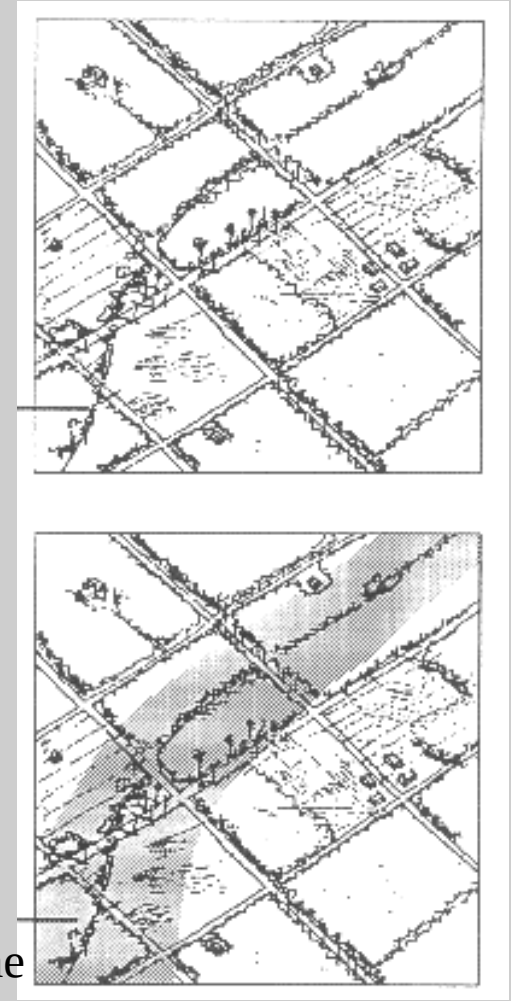
Storage and retrieval of geographically referenced documents (often optically scanned) in geographic query and analysis.

Examples:

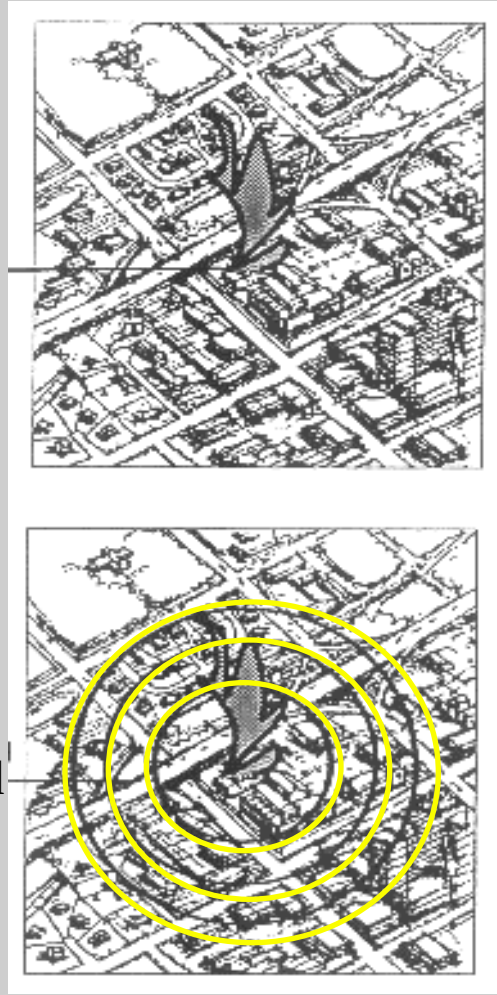
- Use of GIS as pointer to scanned engineering drawings, site photographs, building permit forms, or deeds



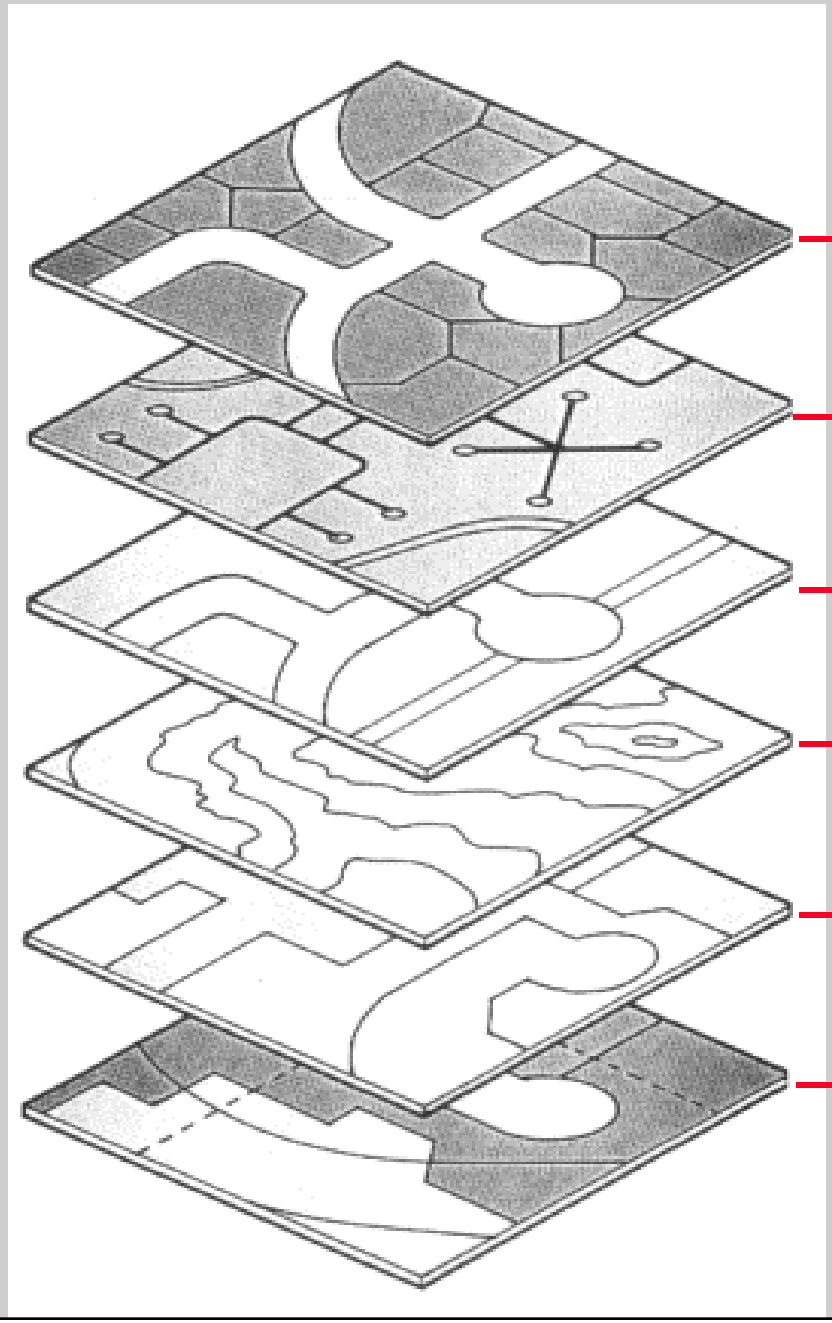
GIS Functions - Manipulation and Analysis



Parcels susceptible to flooding



Impact of Events



Layers of Information

Essential data provided by various department of government become layers of information in a GIS. Typical layers include:

Land Records - parcels, subdivisions, easements, right-of-way, ownership, valuation and assessment information.

Public Works and Utilities - sewers, storm drains, street lamps, trees, telecommunications systems and utilities.

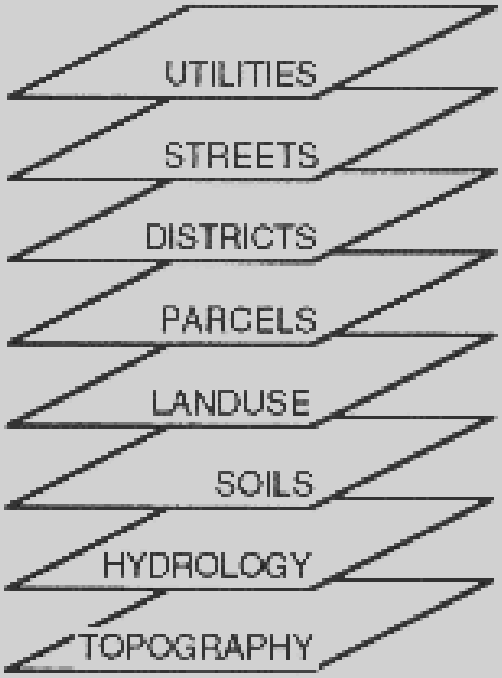
Roads - centerlines, intersections, street rights-of-way and emergency access routes.

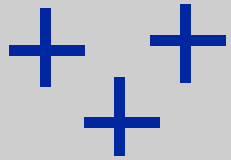
Environmental - geology, soil, vegetation, floodplains, wetlands, hazard areas and noise contours.

Planning - zoning, development proposals and land use plans.

Administrative - city limits, voting precincts, census tracts, fire and police areas, assessment districts and zip codes.

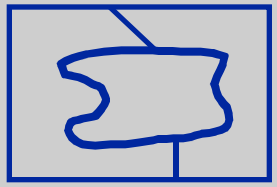
Representing Geographic Features





POINTS

ARCS



POLYGONS

GEOGRAPHIC DATA **PC ARC/INFO COVERAGES** **FEATURE TYPES**