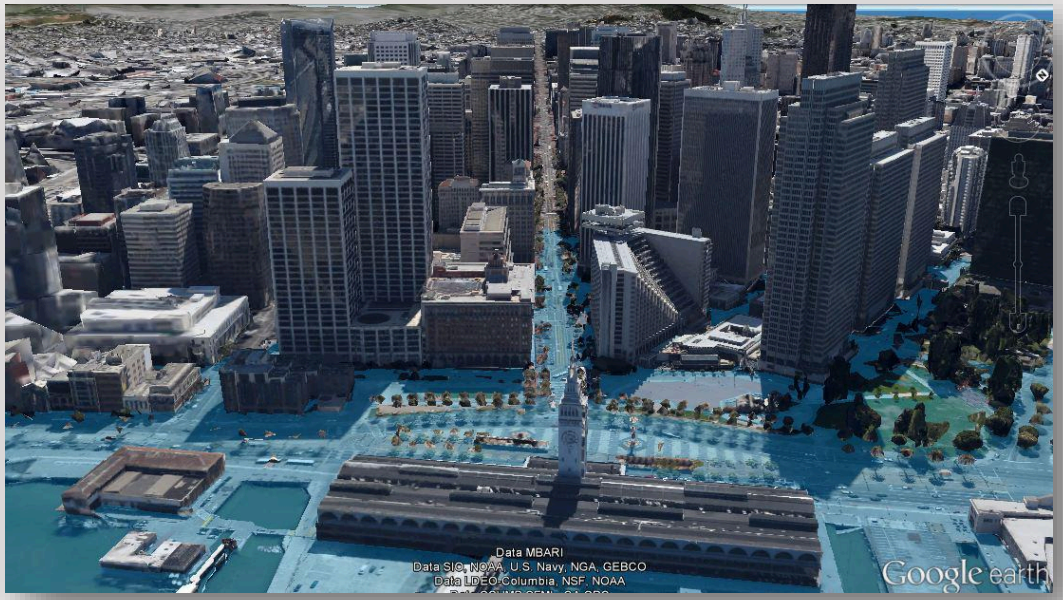
CLEMSON
CENTER FOR GEOSPATIAL TECHNOLOGIES
Introduction to GIS
For Civil Engineering
November 2, 1pm-4pm
406 Cooper
bit.ly/gisclemson

Agenda

- Introduction to GIS (1:00 – 1:30 pm)
- Managing your GIS Data: ArcCatalog (1:30 – 1:45 pm)
- Site Suitability Analysis: ArcMap (1:45 – 3:30 pm)
- Future steps: Creating your own data. Spatial and Statistical Analysis. (3:30 – 3:45 pm)
- Resources (3:45 – 4 pm)



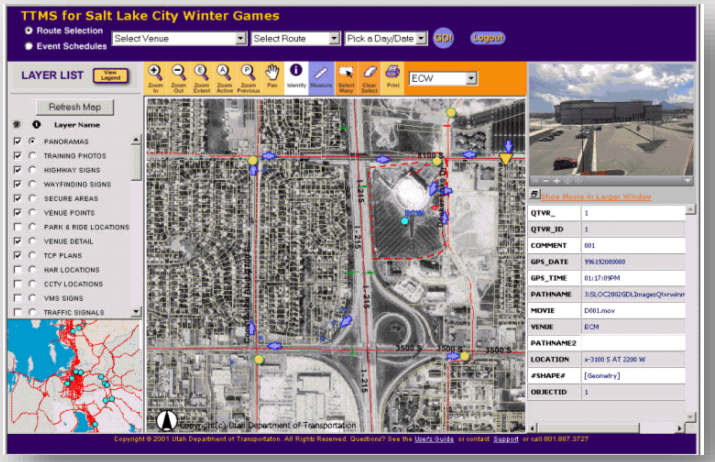
Clemson Center for Geospatial Technologies

MISSION: Support all faculty, students, and staff in their GIS-related activities.

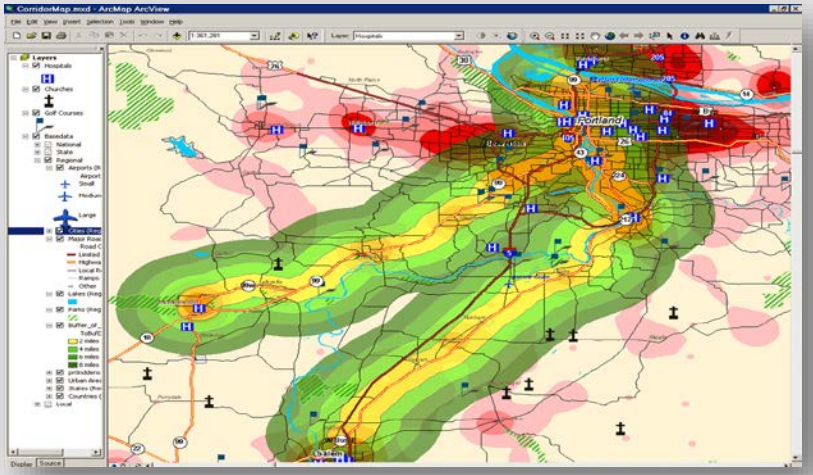
SERVICES

- Consultations
  - Data gathering
  - Advanced spatial analysis
  - Effective cartographic display
- Instruction
  - Class lectures
  - Customized workshops
- Troubleshooting & licensing
- GIS facility for project development: **Cooper Library!!**

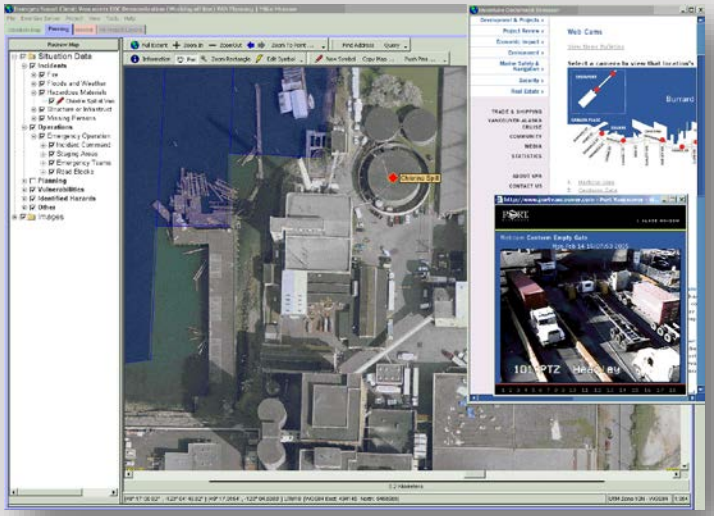
Geographic Information Systems for Civil Engineering



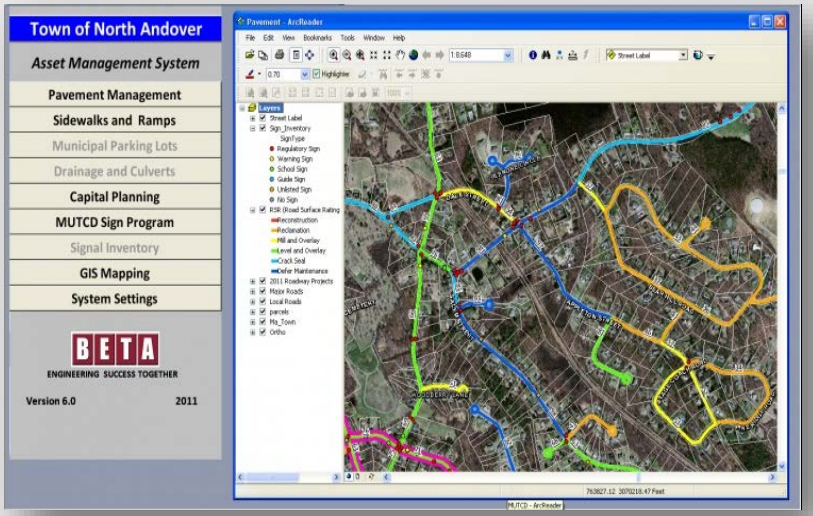
Infrastructure Management



Site Analysis



Critical Infrastructure Protection

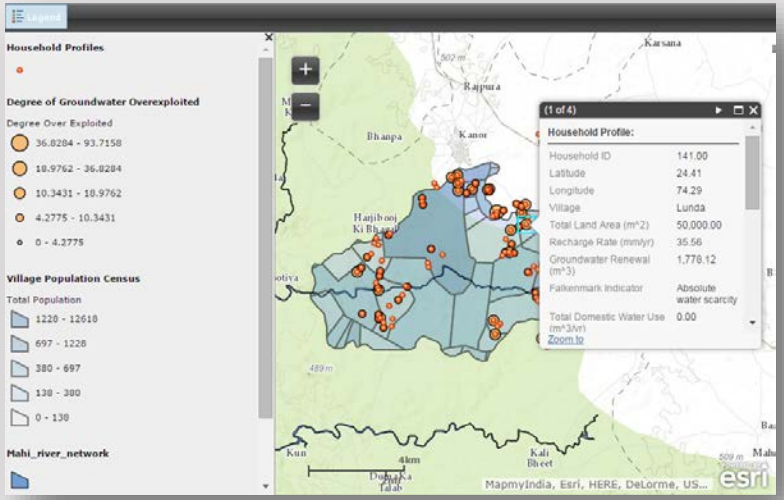


CAD Integration

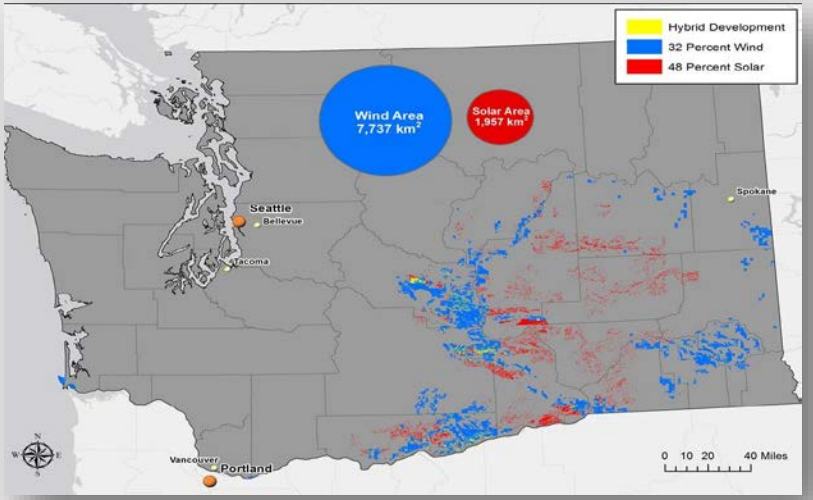
Applications of GIS in Civil Engineering

Transportation

Land Development



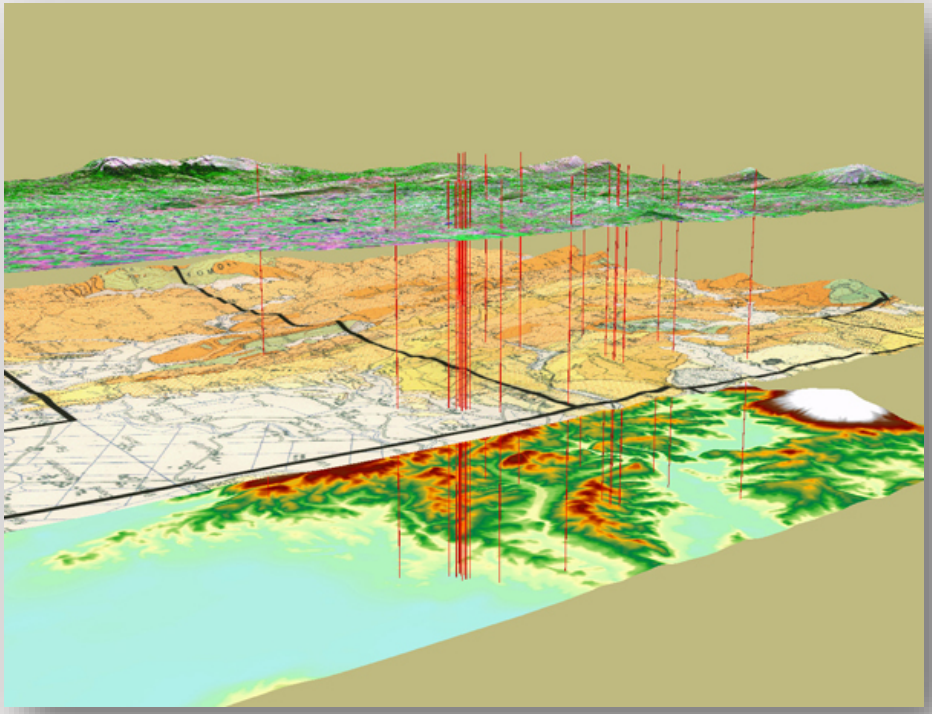
Water Resources

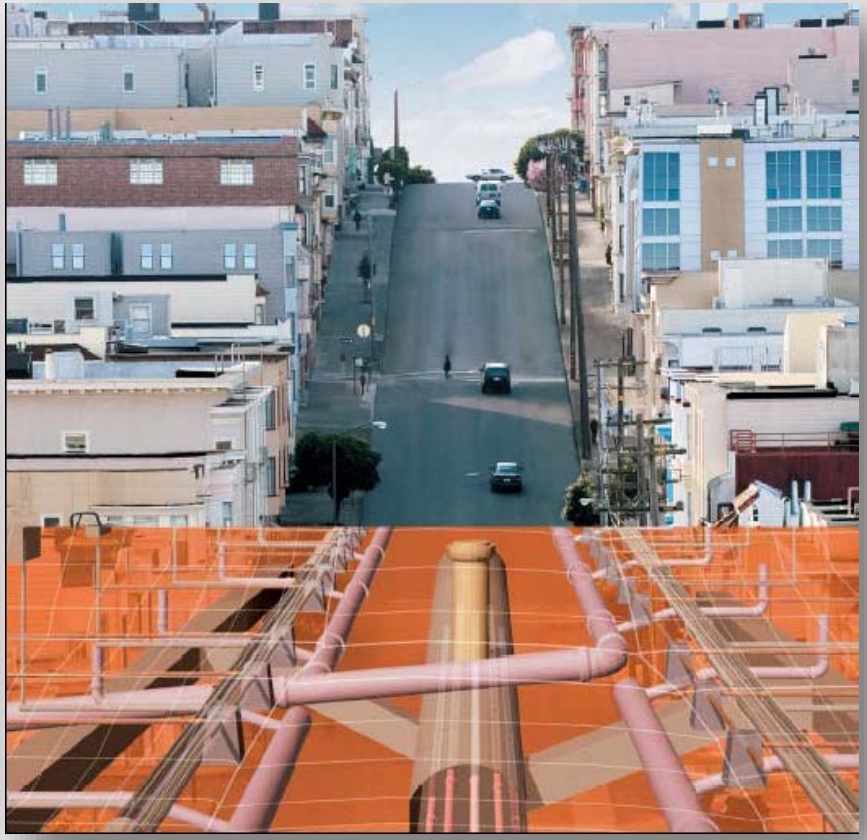


Energy

What is GIS?

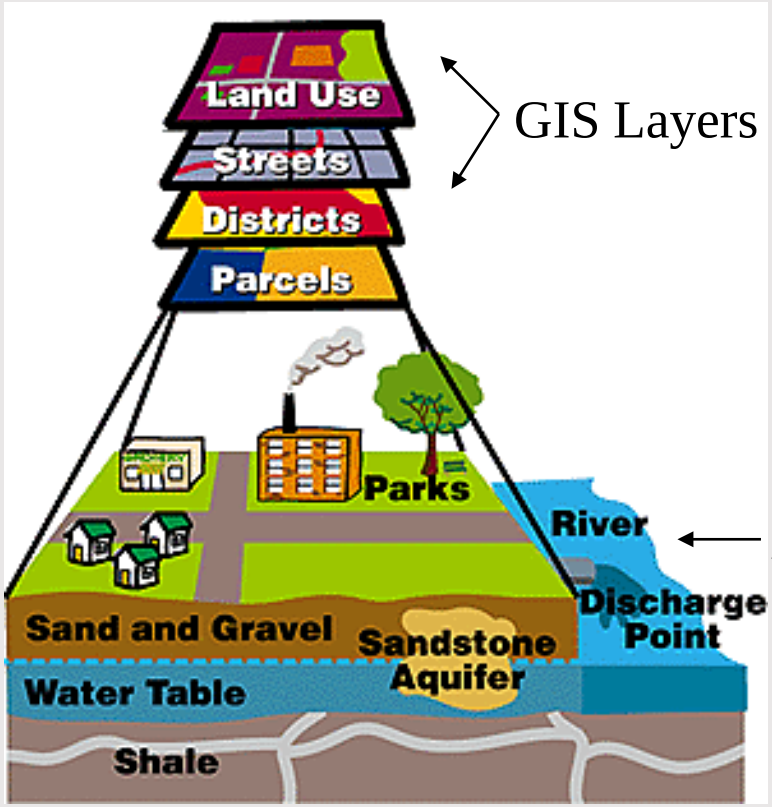
A geographic information system (**GIS**) is a computer-based tool that **links geographic information** (where things are) with **descriptive information** (what things are).



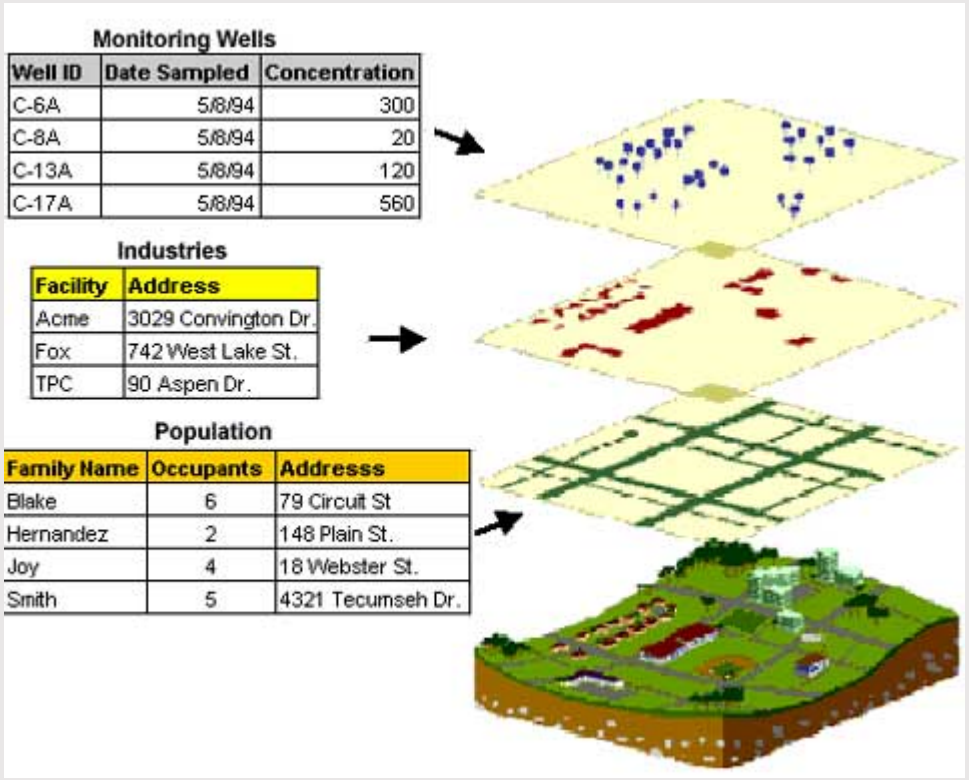


What is GIS?

A GIS is: "***A system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data which are spatially referenced to the Earth*** (Chorley, 1987)."



Real World



Monitoring Wells

Well ID	Date Sampled	Concentration
C-6A	5/8/94	300
C-8A	5/8/94	20
C-13A	5/8/94	120
C-17A	5/8/94	560

Industries

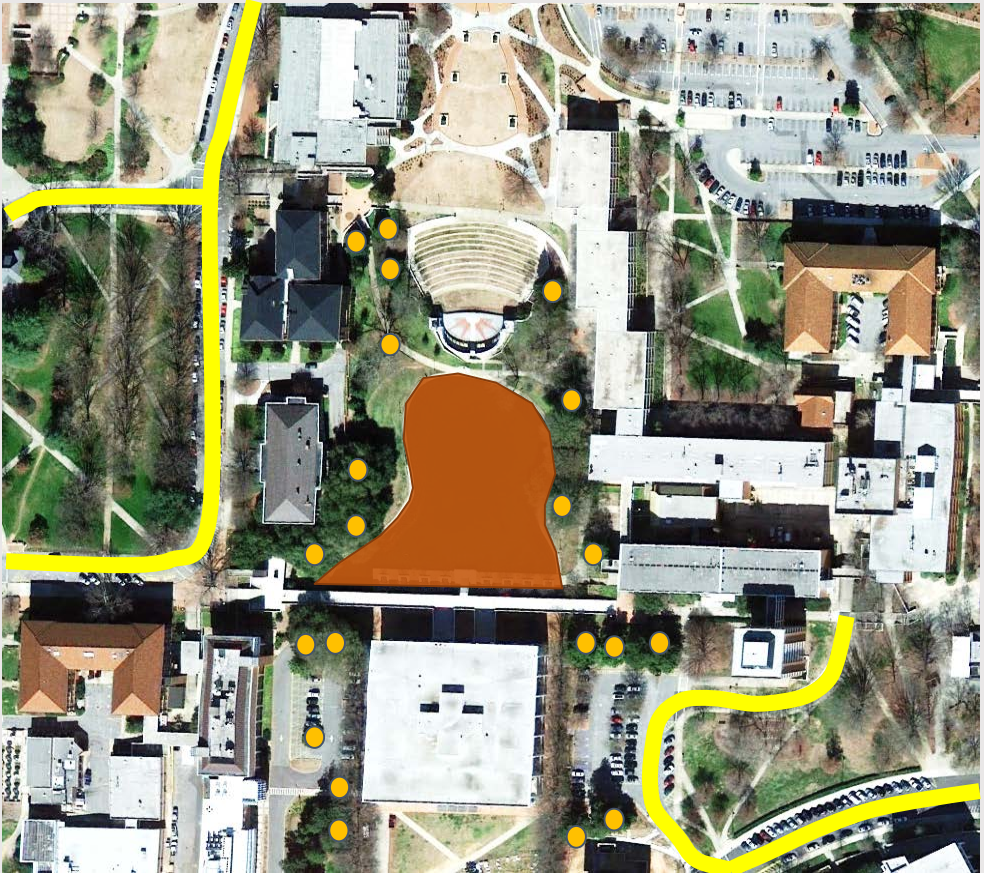
Facility	Address
Acme	3029 Convington Dr.
Fox	742 West Lake St.
TPC	90 Aspen Dr.

Population

Family Name	Occupants	Addresss
Blake	6	79 Circuit St
Hernandez	2	148 Plain St.
Joy	4	18 Webster St.
Smith	5	4321 Tecumseh Dr.

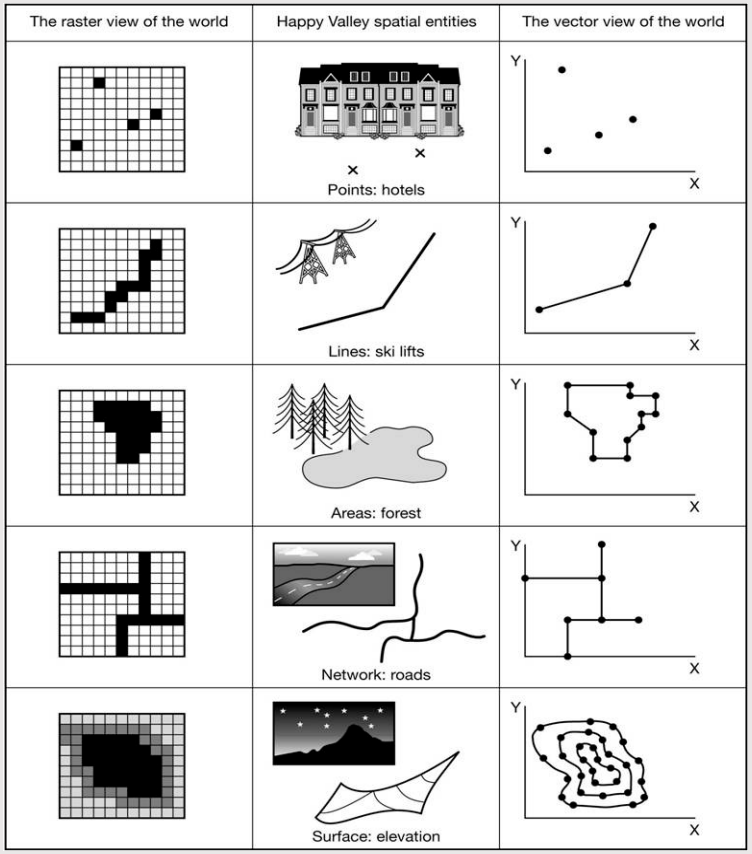
How GIS Works

A GIS stores information about the world as a collection of **thematic layers** that can be linked together by geography



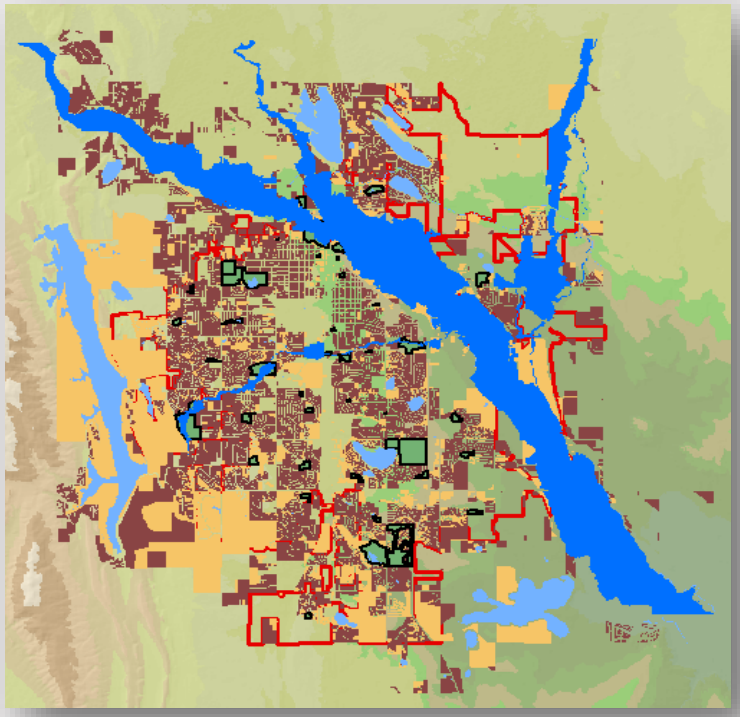
There are 2 basic spatial data types representing the real world:

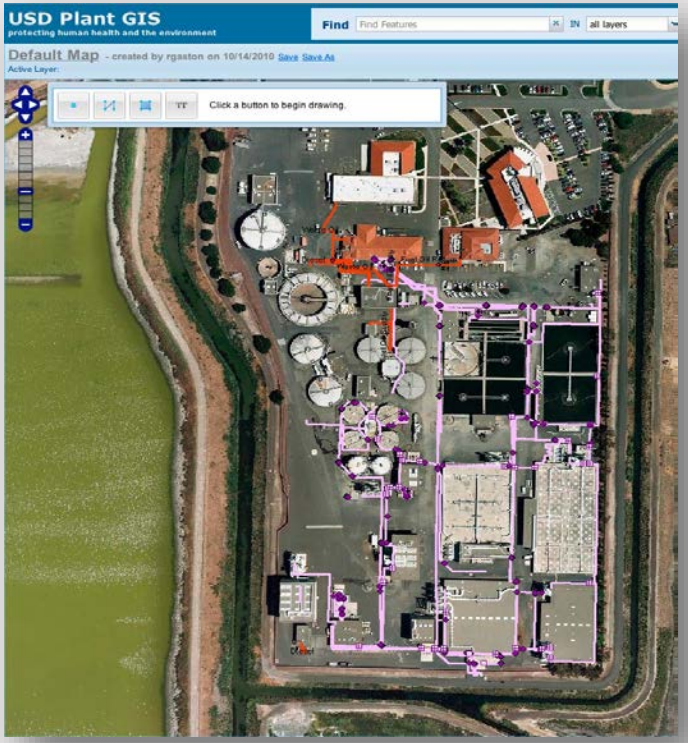
Raster **Vector**



Site Analysis: Best sites for wastewater treatment plant

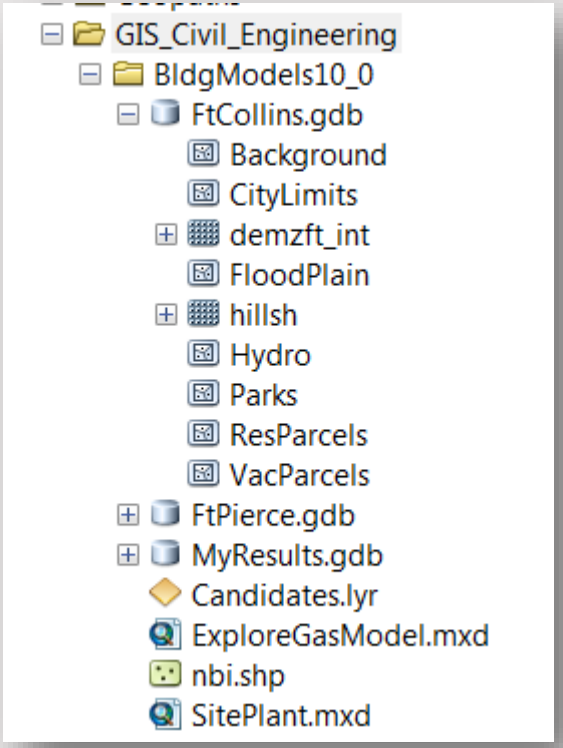
- Criteria:
  - Must be within 3,000 feet of the river
  - Must be within 1 mile of the city limits
  - Must be at least 300 feet from residential parcels and parks
  - Must lie outside the flood plain
  - Must be on vacant parcels that are 50,000 square feet or greater





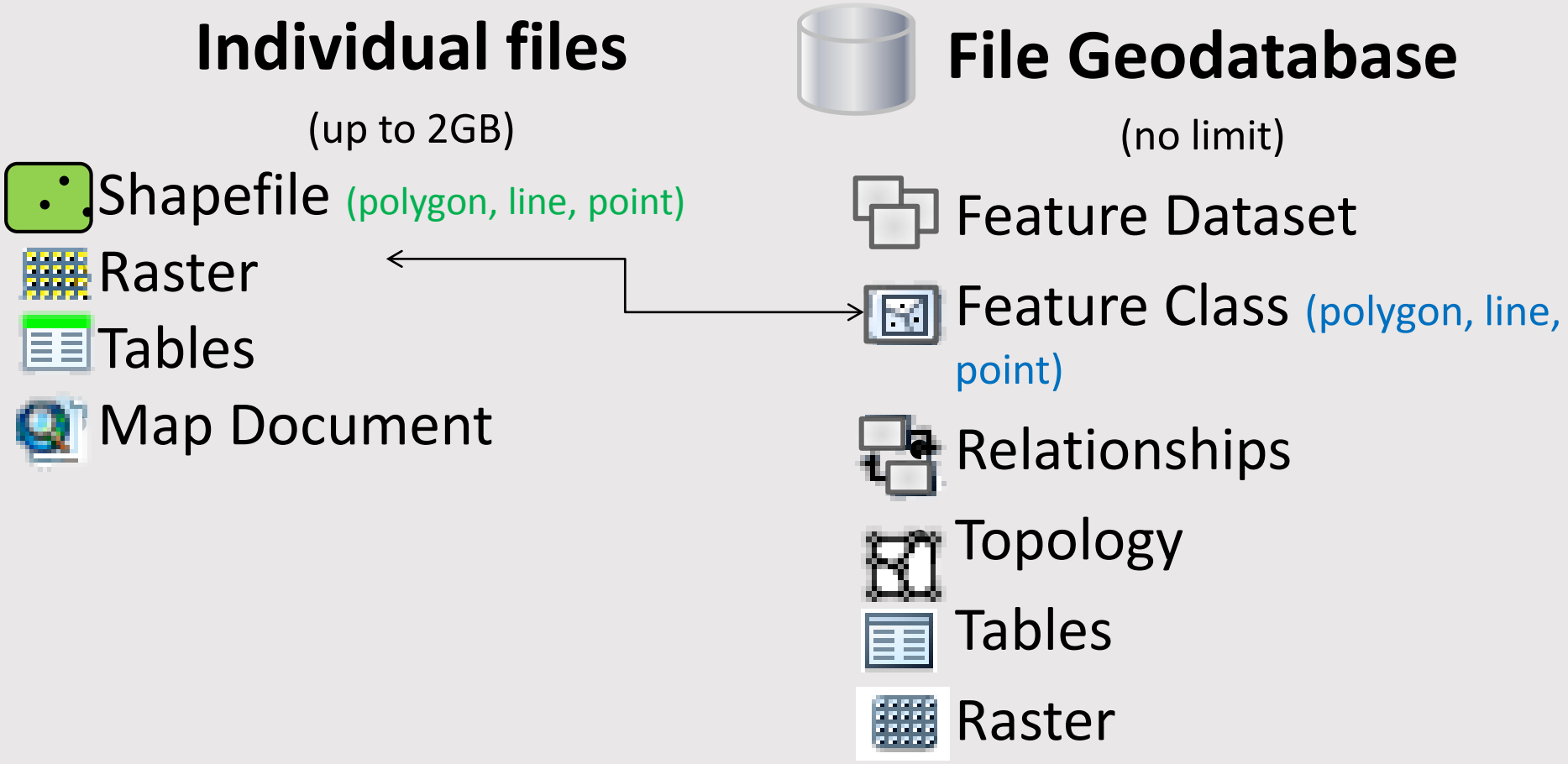
Learning ArcGIS (Part I): ArcCatalog

- Explore GIS data through Windows Explorer
  - Go to Start -- Computer
  - Navigate to your Workshop Data folder



- Explore GIS data through ArcCatalog
  - ArcCatalog works just like Windows Explorer
  - Ideal for:
    - Copying, pasting, deleting and renaming data
    - Previewing data
  - Always try to work on the left tree

Vector and Raster Data Models



Shapefile Vs. Geodatabase

Shapefile	Geodatabase
Attribute table < 2GB	No limit
Geometry < 2GB	No limit
Max number of fields: 255	No limit
Field names < 10 characters	Field names > 10 characters
No update on area, perimeter	Automatic updates
No x,y tolerance	x,y tolerance
3-5 times bigger	3-5 times less space
Spatial Index inefficient	Faster query performance
No date and time in a field, no null values, no raster values	Date and time, null values, raster values

When to use Shapefiles?

- Exporting to other software
- Emailing, sharing
- Simple geometry files

Learning ArcGIS (Part II): ArcMap

- **ArcCatalog** previews, storages and manages data

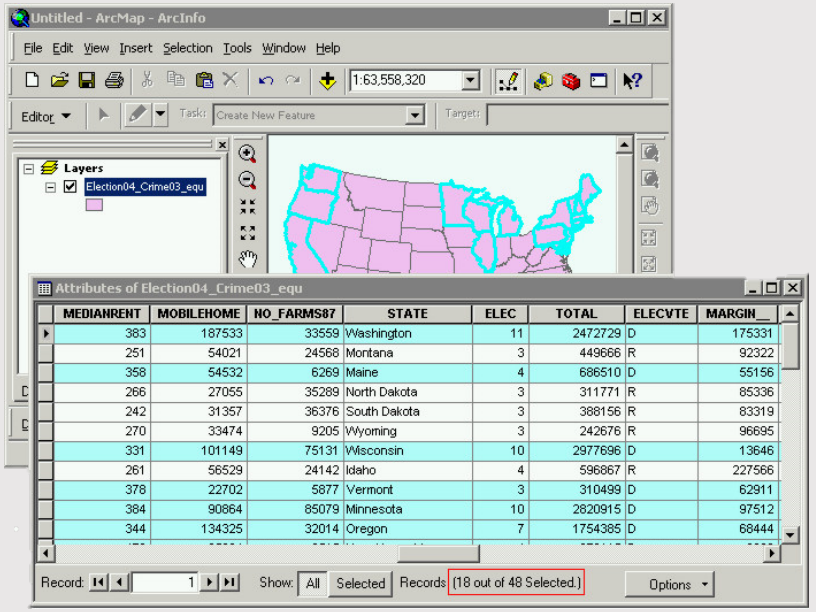
- **ArcMap** works with the data (canvas), manipulates, creates, and analyzes geographic data

Querying Tables

- Queries are the most common operations in a spatial database
  - used to **find features** that meet certain criteria
  - used to explore **patterns** or **spatial relationships**
  - used to **isolate features** for future analysis (subset or filter data)
  - can be performed based on geometry (**spatial**) or attributes (**tabular**)
- Structured Query Language (**SQL**)
  - standard language for retrieving and updating information in a database
- Most common operation is the **SELECT**
  - SELECT * FROM "*Table*" WHERE "*Field = Value*"
  - returns a subset of records, e.g. restricts records based on some condition
- Can be simple or complex
  - simple: "area" > 20
  - complex: ("area" > 20) AND ("area" < 50)

SQL

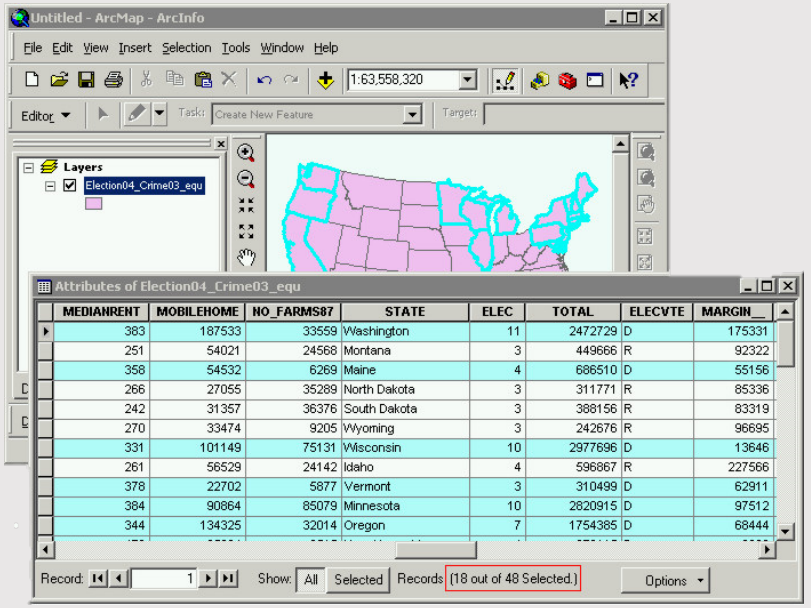
- **Set Algebra**
  - basis for simple query expressions
    - = (equal)



ELECVTE = “D”

SQL

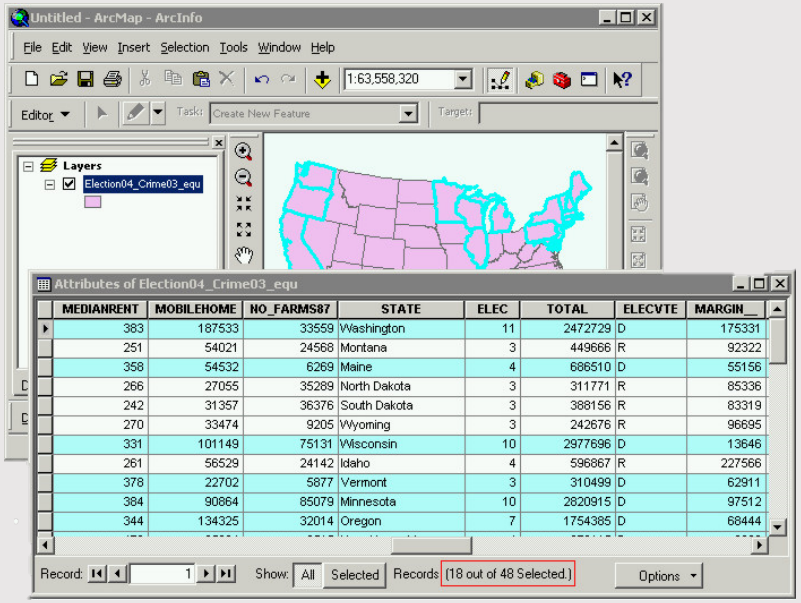
- **Set Algebra**
  - basis for simple query expressions
    - **=** (equal)
    - **>** (greater than)
    - **<** (less than)
    - **<>** (not equal to)
  - can be used on both strings and numbers



MARGIN > 100000

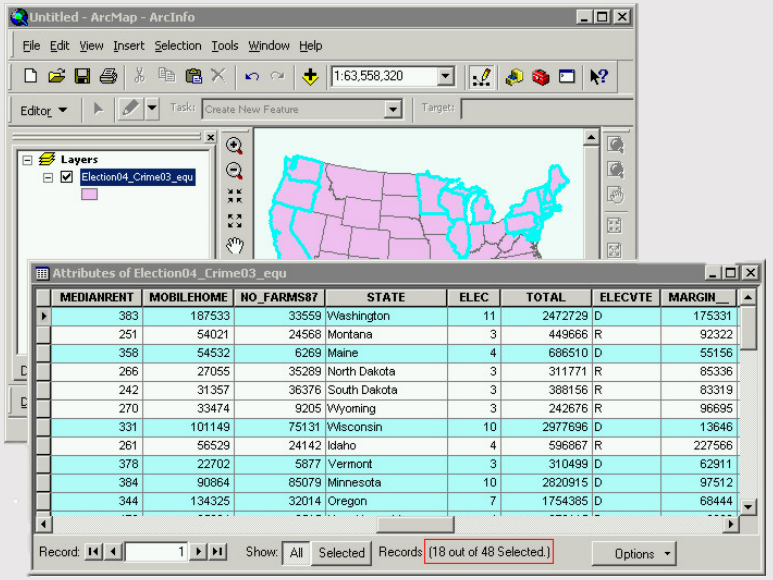
SQL

- **Set Algebra**
  - basis for simple query expressions
    - **=** (equal)
    - **>** (greater than)
    - **<** (less than)
    - **<>** (not equal to)
  - can be used on both strings and numbers
- **Boolean Algebra**
  - basis for complex query expressions
    - **NOT**: accepts value of one input and outputs opposite value



STATE **NOT** South Carolina

SQL

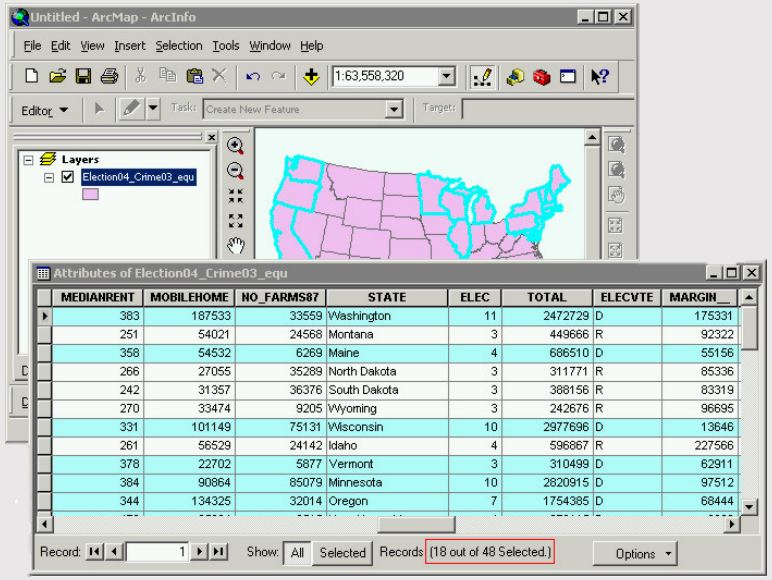


- **Set Algebra**
  - basis for simple query expressions
    - **=** (equal)
    - **>** (greater than)
    - **<** (less than)
    - **<>** (not equal to)
  - can be used on both strings and numbers
- **Boolean Algebra**
  - basis for complex query expressions
    - **NOT**: accepts value of one input and outputs opposite value
    - **AND**: accepts two values as input and outputs the intersection of both

MARGIN > 100000 **AND**
MARGIN < 150000

SQL

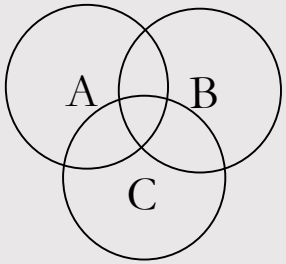
- **Set Algebra**
  - basis for simple query expressions
    - **=** (equal)
    - **>** (greater than)
    - **<** (less than)
    - **<>** (not equal to)
  - can be used on both strings and numbers
- **Boolean Algebra**
  - basis for complex query expressions
    - **NOT**: accepts value of one input and outputs opposite value
    - **AND**: accepts two values as input and outputs the intersection of both
    - **OR**: accepts two values as input and outputs the sum of both
  - parentheses may be required and the order of precedence is important



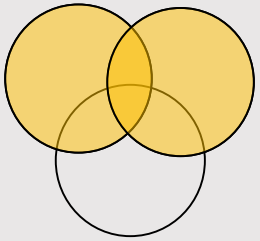
MARGIN < 50000 **OR**
MARGIN > 250000

Boolean Algebra

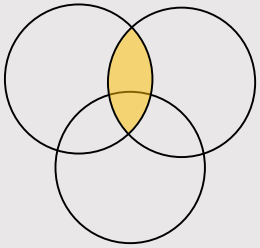
Regions



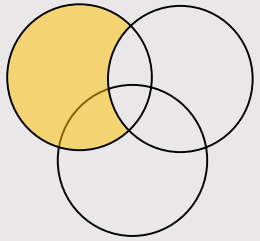
A *OR* B



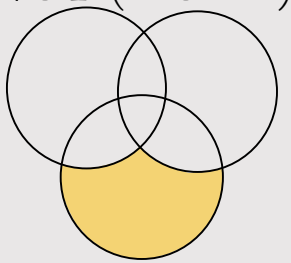
A *AND* B



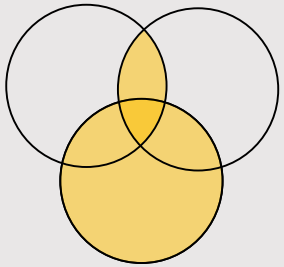
A *NOT* B



NOT (A *OR* B)



A *AND* B *OR* C



Simple Queries

ID	Area	Landuse	Municipality
1	10.5	Urban	City
2	330.3	Farm	County
3	2.4	Suburban	Township
4	96.0	Suburban	County
5	22.1	Urban	City
6	30.2	Farm	Township
7	4.4	Urban	County

Find all records with ***Area*** greater than 20.0 ⟵ Area > 20.0

Find all ***Urban Landuse*** ⟵ Landuse = Urban

Find all records with ***Area*** less than or equal to 55.0 ⟵ Area <= 55.0

Find all ***Non-Urban Landuse*** ⟵ Landuse <> Urban

Compound Queries

Find all the municipalities that are not urban cities

NOT [(Landuse = Urban) AND (Municipality = City)]

- Landuse = Urban
- Municipality = City
- Set1 ***AND*** Set2
- ***NOT*** (Set3)

ID	Area	Landuse	Municipality
1	10.5	Urban	City
2	330.3	Farm	County
3	2.4	Suburban	Township
4	96.0	Suburban	County
5	22.1	Urban	City
6	30.2	Farm	Township
7	4.4	Urban	County

The Spatial Analysis Workflow

Scope

Who is your client?

Break it down

Representation

Distribution

Accuracy

Scale:

- Temporal

- Spatial

Format

Review question

Common approaches

Data suitable?

Share analysis

ArcToolbox

Automation:

Use model Builder

Or Python

Visually but … importantly,

Statistically;

INTERPRET your results

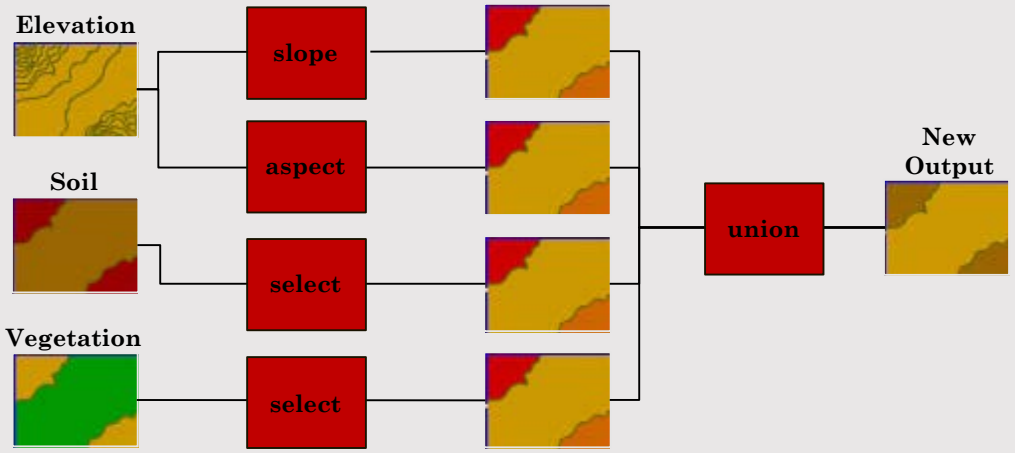
Spatial (geo)processing

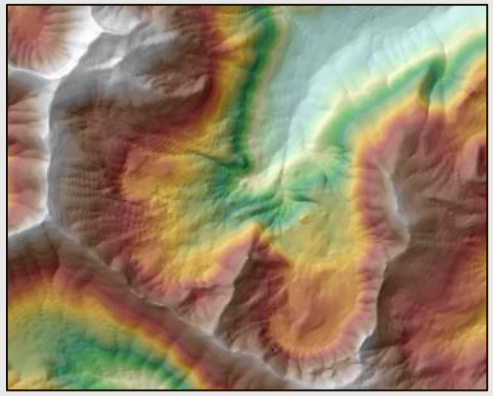
Application of GIS operations to spatial and related attribute data

- incorporates basic components of spatial data analysis and modeling
- operations use one or more datasets to create one or more outputs
- often connect several operations sequentially to solve a problem

Framework referred to as **geoprocessing**

- can be executed individually or combined into complex models
- the challenge is choosing the **operation** and the **order** by which to apply them



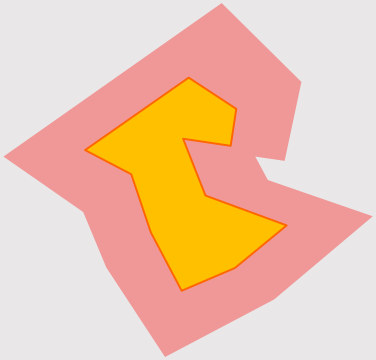


Proximity Analysis in Vector: Buffer

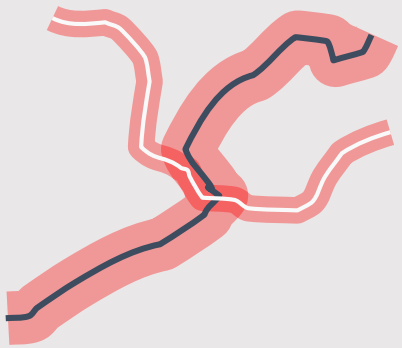
A region that is less than or equal to a set distance from one or more features

- can buffer points, lines, polygons
  - fixed distance: 500 m around a market
  - variable distance: 250 m for small roads, 500 m for major highways
  - nested (multi-ring): 500 m, 750 m, 1000 m around an endocrinologist

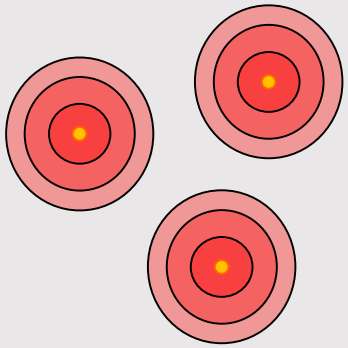
Fixed



Variable Distance



Nested (Multi-ring)

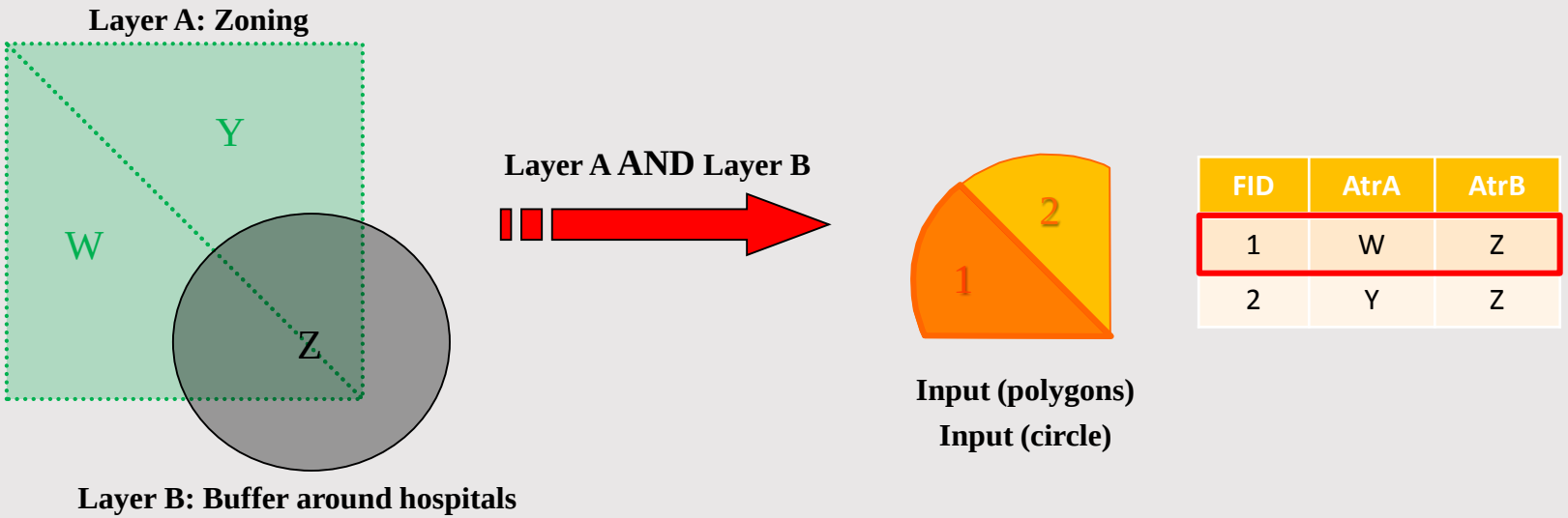


Intersect

Output includes only the geometry that is spatially coincident or ***common*** (intersect) in all inputs

- area occupied by both input features
- there is merging of both **geography** and the **attributes** of all layers
- input layers may be point, line, or polygon; **output lowest dimension**

Considered a spatial counterpart to the boolean operator ***AND***



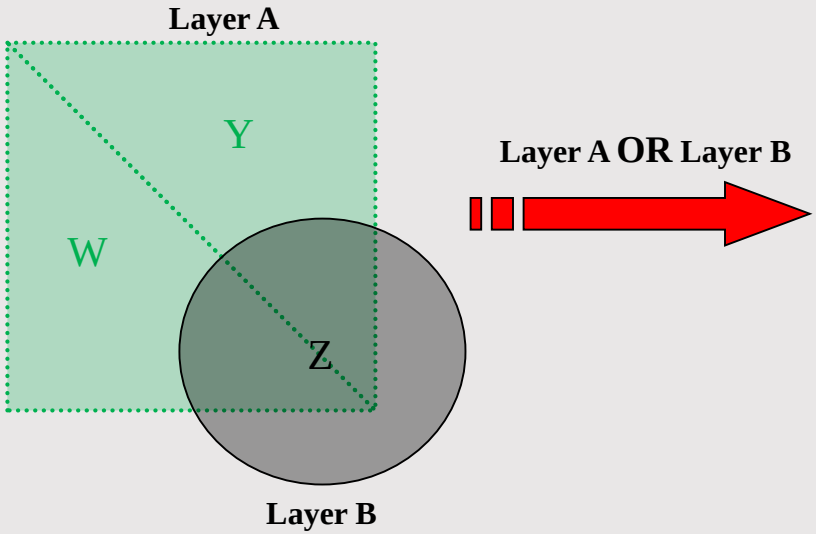
FID	AtrA	AtrB
1	W	Z
2	Y	Z

Union

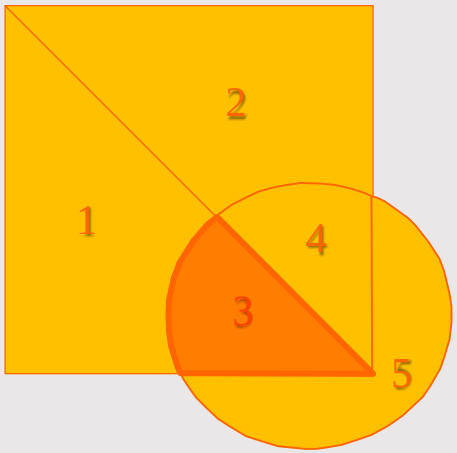
Output features include ***all*** those that are in either of **both** inputs

- area occupied by all inputs
- there is merging of **geography** and the **attributes** of all layers
- input layers only **polygons**

Considered a spatial counterpart to the boolean operator ***OR***



Layer A OR Layer B



Input (polygons)
Input (circle)

FID	AtrA	AtrB
1	W	
2	Y	
3	W	Z
4	Y	Z
5		Z

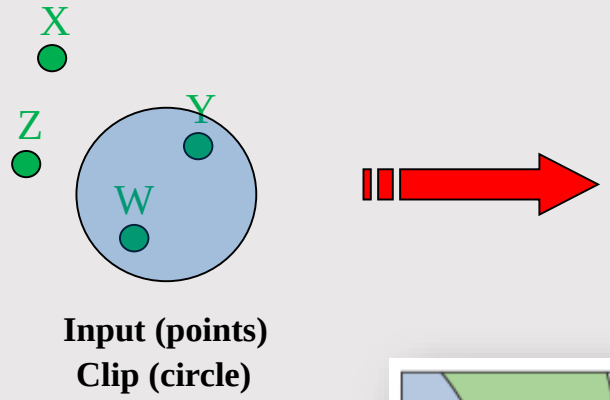
Clip

Use features of one dataset to "**cut out**" features from another

- "cookie cutter" overlay, retains area of overlap
- there is a change in **geography** and **only the input attributes remain**
- input layer can be point, line, or polygon; **clip layer must be polygon**

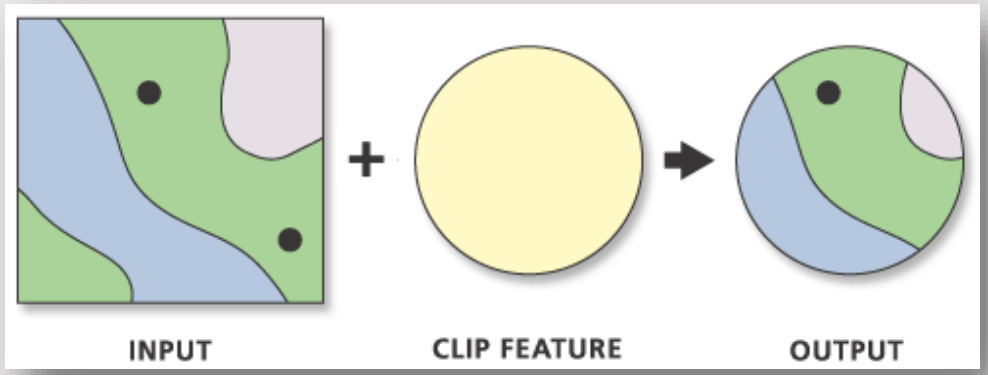
Commonly used to cut out data for a specific study area

- for example, clip various continental data layers to map smaller regions

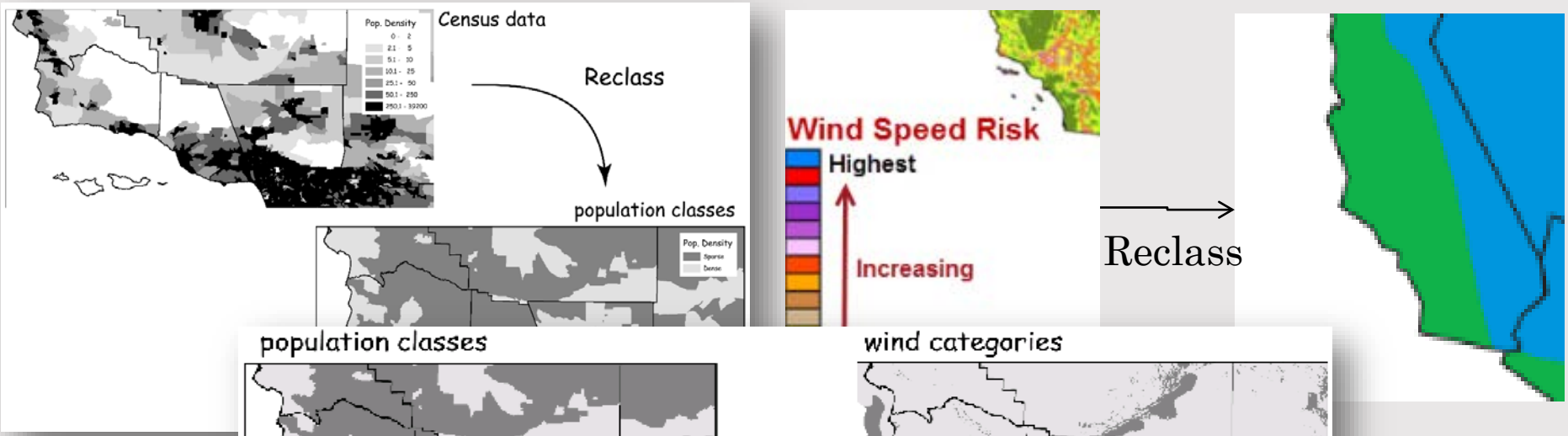


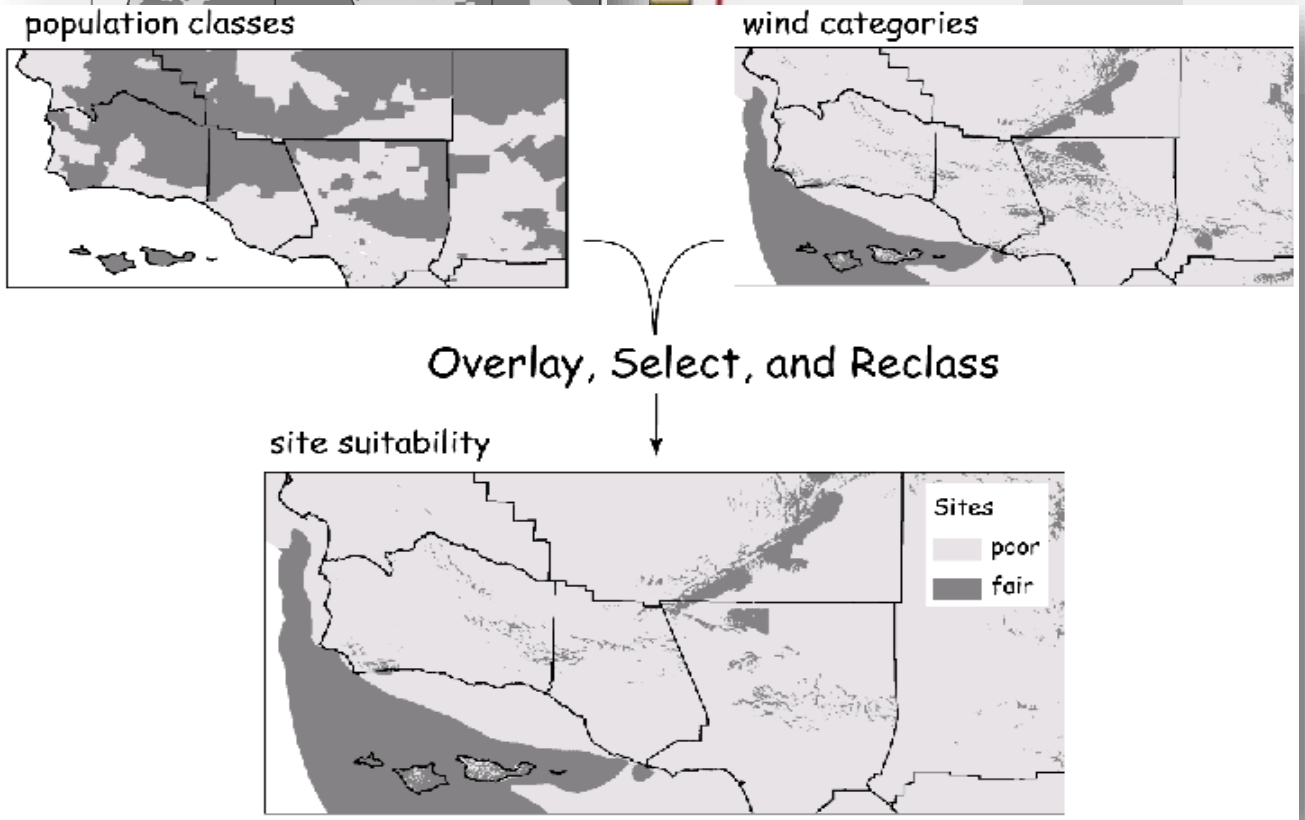
FID	Atr
1	W
2	Y

Input (points)
Clip (circle)



Example: Suitable areas for wind farms





Research Questions

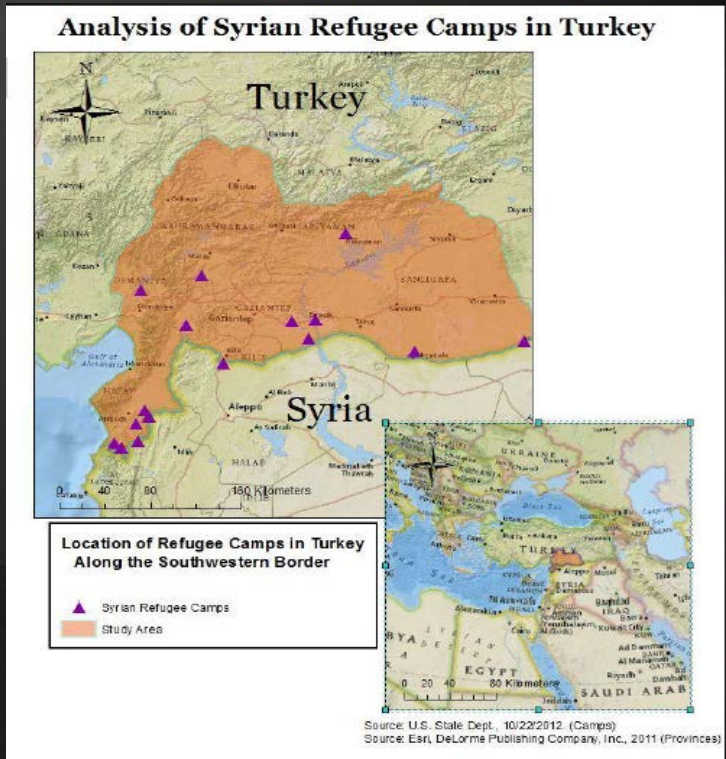
-How do various factors affect the suitability of Syrian refugee camps in Turkey?

-How can we use this analysis to inform the Turkish government as to which camps should receive more funding, resources, and attention?

-Where is the most suitable location for new refugee camps?

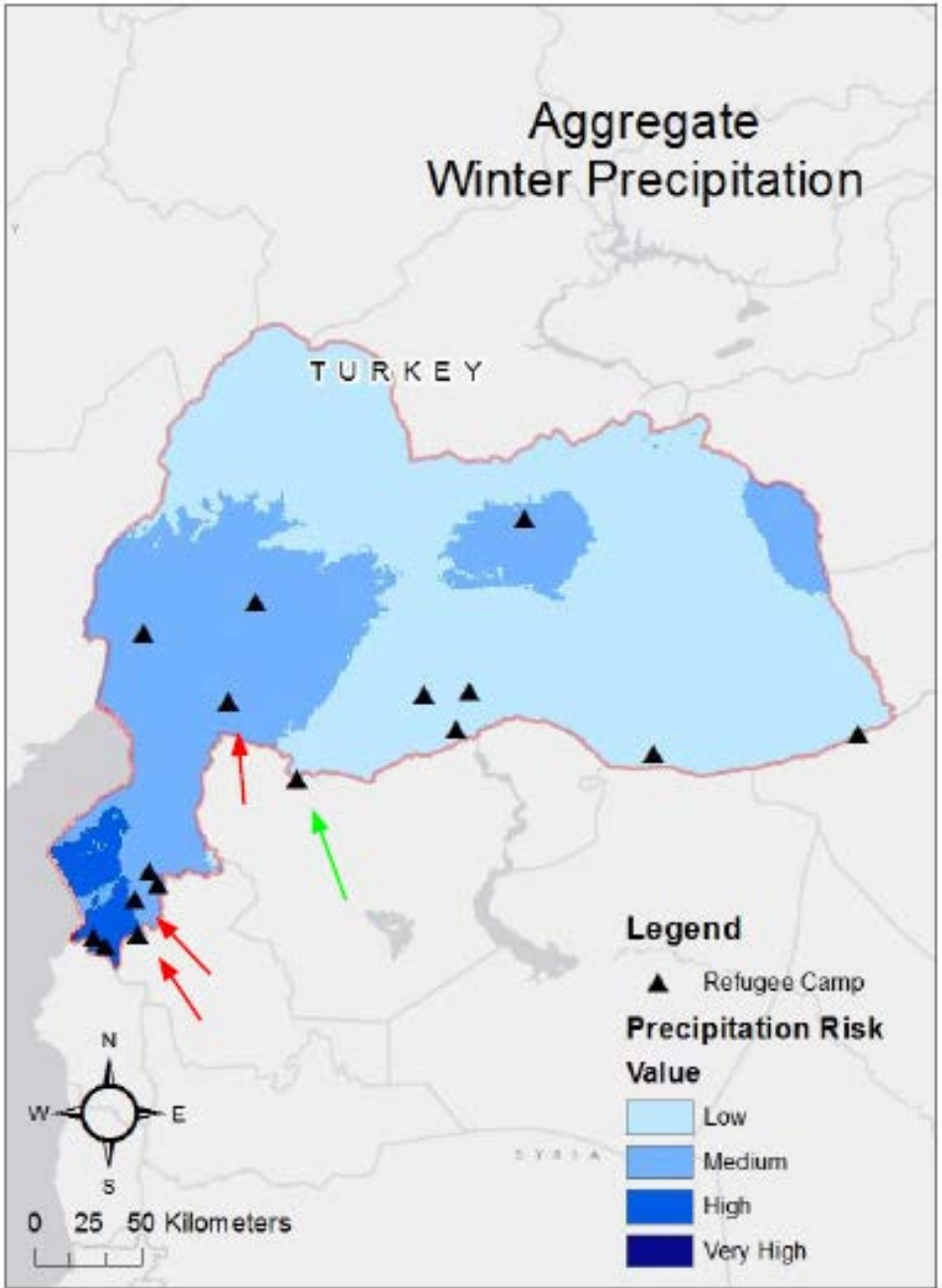
-Chosen factors used for analysis of the suitability of the 16 existing camps in Turkey:

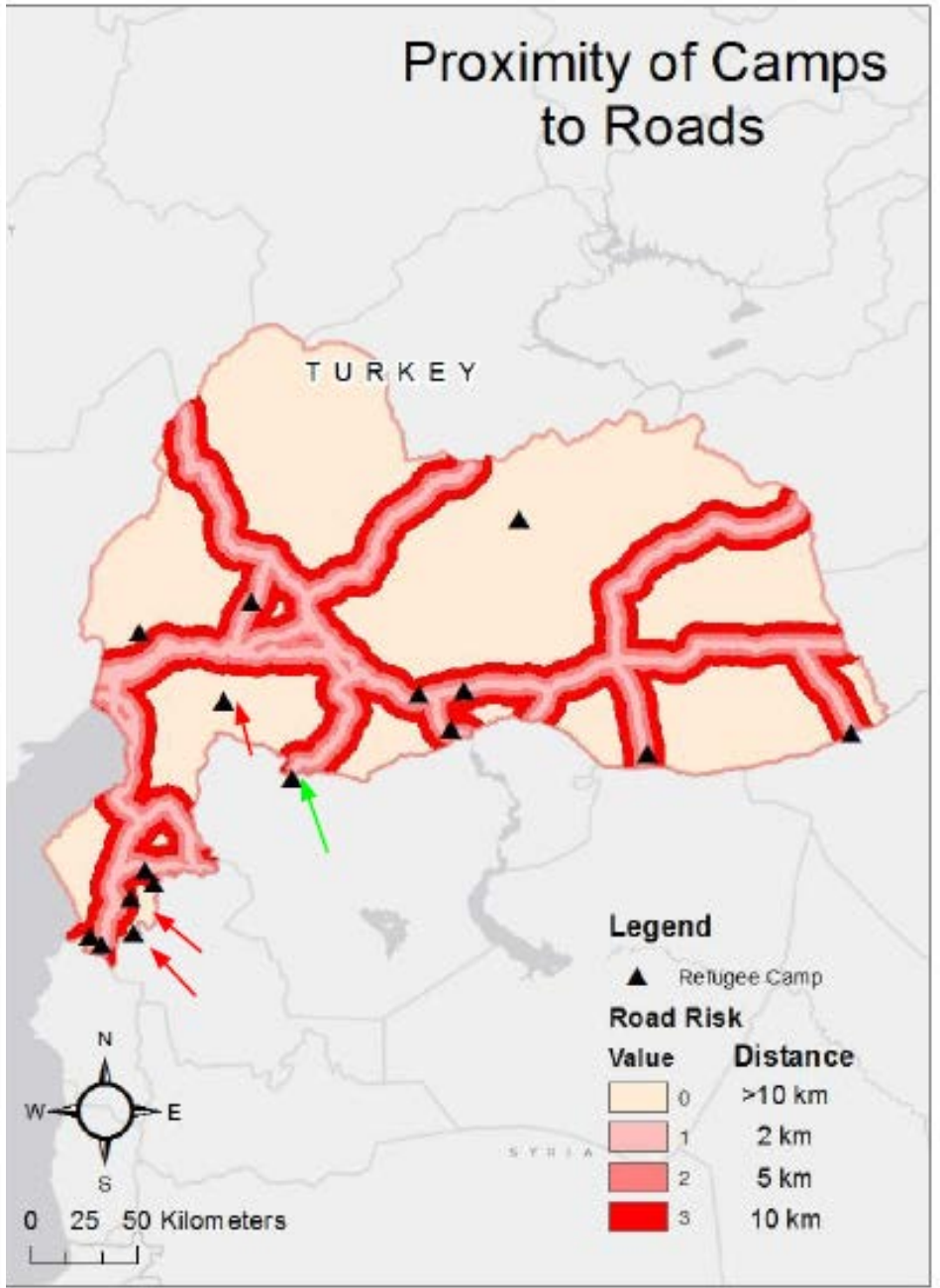
1) elevation
2) precipitation
3) slope
4) distance to roads
5) distance to cities
6) distance to rivers



Ranking Criteria

Factor	Classification	Ranking
1) Roads	0 km - 2km	1
	2 km - 5 km	3
	5 km - 10 km	10
2) Cities	0 km - 5 km	5
	>5km	0
3) Rivers	0 km - 5 km	5
	>5km	0
4) Precipitation (Nov-Feb) (mm*10)	0 - 285	1
	285 - 375	5
	375 - 539	7
	539 - 931	10
5) Elevation	0 m - 500 m	1
	500 m - 1000 m	2
	1000 m – 2000 m	8
	2000 m - 2500 m	8
	2500 m – 3000 m	10
	3000 m – 3083 m	15
6) Slope (percent_rise)	0 % - 5 %	3
	5% - 10%	0
	10% - 20%	7
	20% - 40%	10
	40% - 314.22%	15


Aggregate
Winter Precipitation
TURKEY
SYRIA
Legend
Refugee Camp
Precipitation Risk
Value
Low
Medium
High
Very High
N
W
E
S
0 25 50 Kilometers

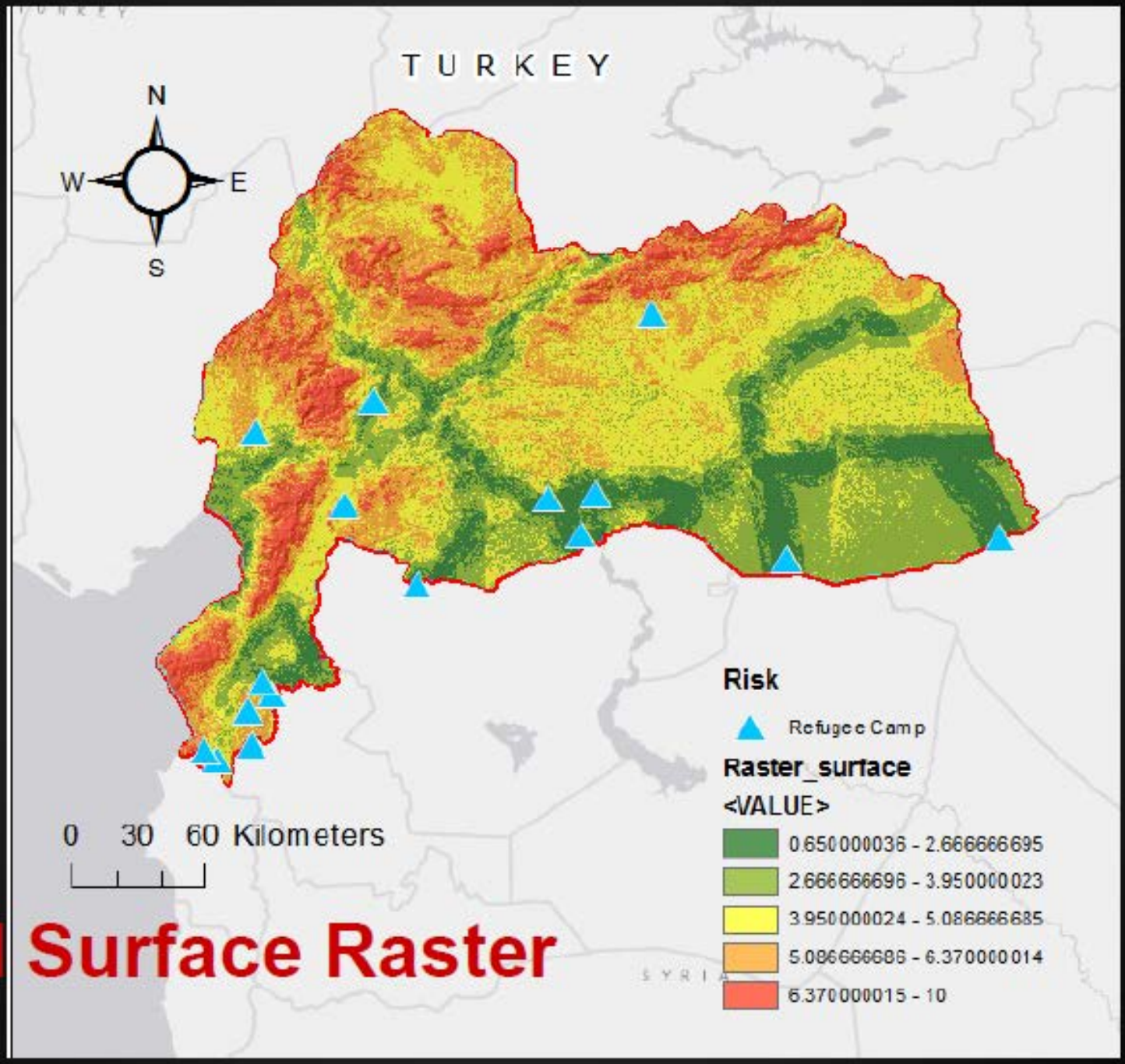

Proximity of Camps
to Roads
TURKEY
SYRIA
Legend
Refugee Camp
Road Risk
Value
Distance
0
>10 km
1
2 km
2
5 km
3
10 km
N
W
E
S
0 25 50 Kilometers

Risk Assessment

Risk Factors	Weights
Elevation	30 %
Precipitation	20%
Roads	15 %
Slope	15 %
Cities	10 %
Rivers	10 %

$$0.30_{(RISKRANK1)} + 0.20_{(RISKRANK2)} + .15_{(RISKRANK3)} + 0.15_{(RISKRANK4)} + 0.15_{(RISKRANK5)} + 0.10_{(RISKRANK6)} + 0.10_{(RISKRANK7)} = \underline{\text{WEIGHTED INDEX OF RISK}}$$

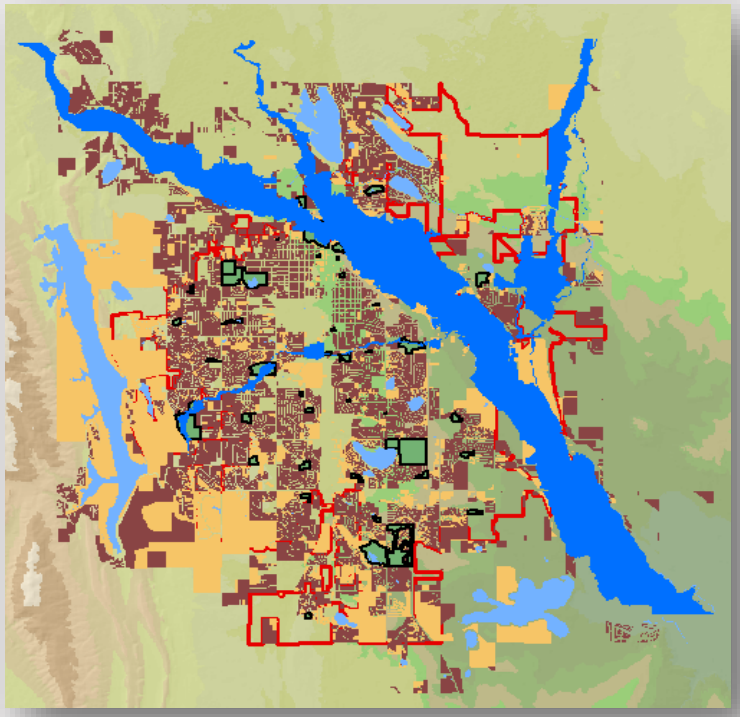
NAME	Elevation_Risk	Precipitation_Risk	Water_Risk	Cities_Risk	Roads_Risk	Slope_Risk	AggregateRisk
Öncüpinar	2	1	0	0	1	0	1
Apaydin	1	5	0	0	3	3	2
Akçakale	1	1	0	0	3	7	2
Akçakale	1	1	0	0	3	7	2
Ceylanpinar	1	1	0	5	1	3	2
Karkamis	1	1	0	0	3	7	2
Nizip	2	1	0	5	3	0	2
Birecik	1	1	0	5	1	7	2
Yibo	2	7	0	0	3	3	3
Türkoglu	2	5	0	5	1	7	3
Tekel	2	7	0	5	1	10	4
Boynuyogun	1	5	0	0	10	7	4
Osmaniye	1	5	0	0	15	0	4
Adiyaman	2	5	0	5	15	0	4
Kuyubasi	1	5	0	0	15	7	5
Tekel	1	5	0	5	10	10	5
Islâhiye	1	5	0	0	15	10	5

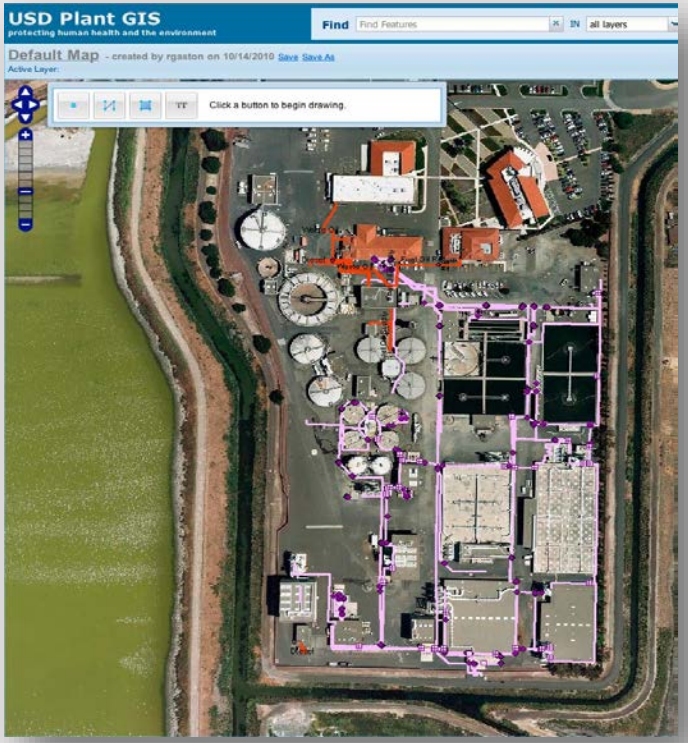


Final Surface Raster

Site Analysis: Best sites for wastewater treatment plant

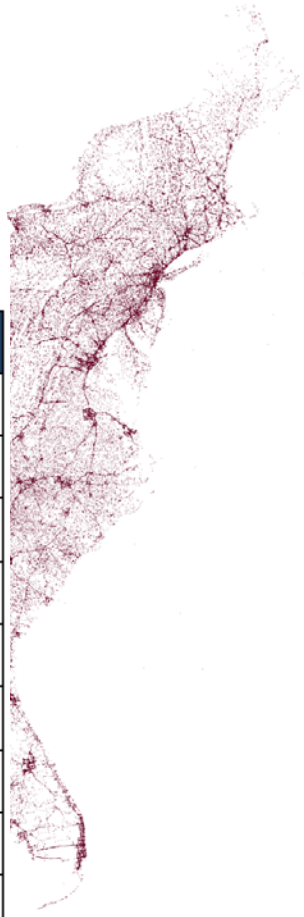
- Criteria:
  - Must be within 3,000 feet of the river
  - Must be within 1 mile of the city limits
  - Must be at least 300 feet from residential parcels and parks
  - Must lie outside the flood plain
  - Must be on vacant parcels that are 50,000 square feet or greater





Next Steps (I): Data Gathering

Every bridge in America



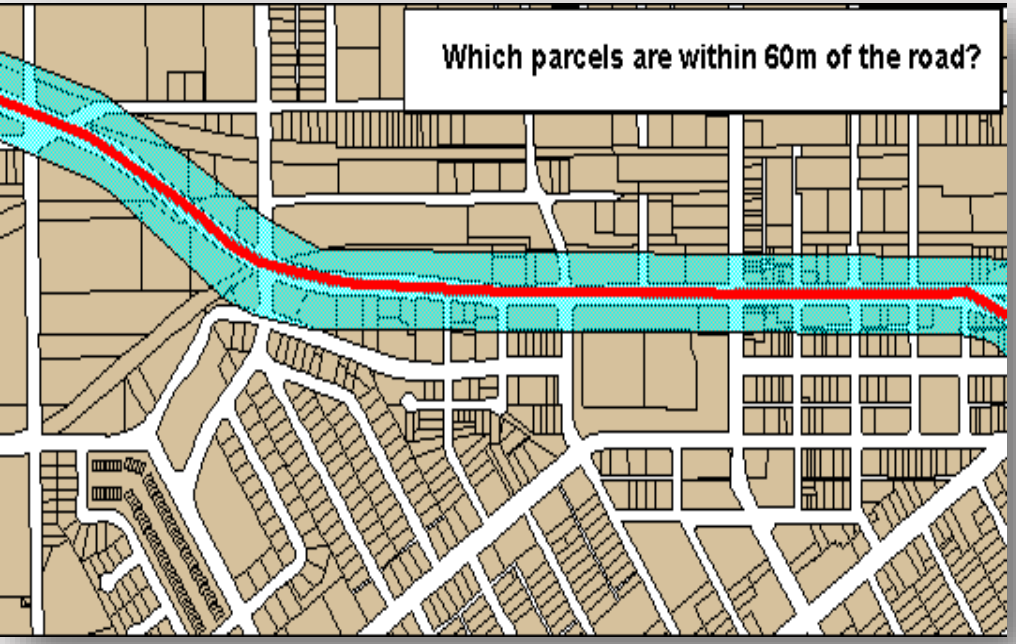
Top 10 Most Traveled Structurally Deficient Bridges in the State:

County	Year Built	Daily Crossings	Type of Bridge	Location
Caddo	1965	134,300	Urban Interstate	I-20 over St. Louis Southwestern Railroad
Orleans	1960	84,720	Urban Interstate	I-10 over city streets and railroad
Calcasieu	1952	70,100	Urban Interstate	I-10 over the Calcasieu River, Railroad and streets (Calcasieu River Bridge)
St. Martin	1970	63,700	Urban Interstate	LA-354 over I-10
Jefferson	1967	59,040	Urban Interstate	I-10 EB over the Veterans Memorial Highway
Jefferson	1967	59,040	Urban Interstate	I-10 WB over Veterans Memorial Highway
Jefferson	1987	53,820	Urban freeway/expressway	US-90B EB over the Harvey Canal, street and railroad
Jefferson	1987	53,820	Urban freeway/expressway	US-90B WB over the Harvey Canal, street and railroad
Bossier	1966	53,400	Urban Interstate	I-20 over the St. Louis Southwestern and Kansas City Southern Railroads and Westerfield
Bossier	1966	53,400	Urban Interstate	I-20 over US-71, the Kansas City Southern Railroad, and a SW ramp

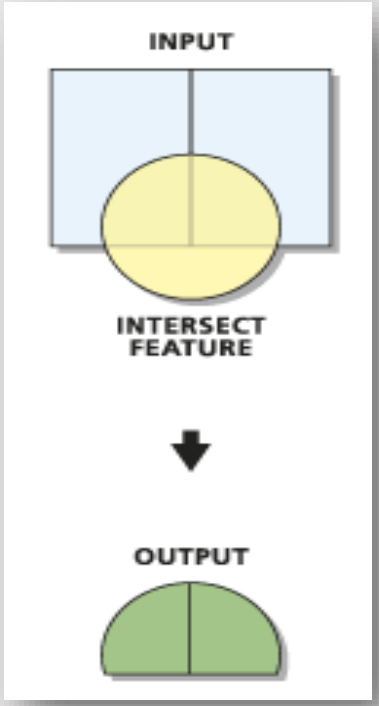
nway Administration

Next Steps (II): Spatial Analysis

Buffer Analysis

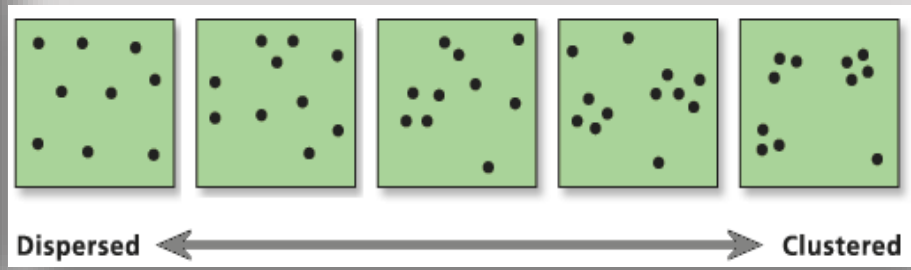


Intersection



Hot Spot Analysis

Average Nearest Neighbor



Your next Steps

Practice, practice, practice!

Your next workshop:
GIS Data Creation
and Management!

GIS Consultation Reference with CCGT

Resources

HAZUS MH
EARTHQUAKE • WIND • FLOOD

- Physical damage
- Economic loss
- Social impacts

CERTIFICATE OF ATTENDANCE
This Acknowledges That
[Recipient Name]
Has Successfully Completed 21 Hours of Training In
1. Introduction to GIS (101)
2. GIS Data Creation and Management (102)
3. Working with Tabular data (103)
4. Field Data Collection using GIS (104)
5. Introduction to Spatial Analysis (105)
6. Spatial statistics with GIS (106)
7. Introduction to ArcGIS Online and Story Maps (107)
SPATIAL TECHNOLOGIES
Patricia Carbajales-Dale, Co-Director, CCGT

clemsongis.org

Thank you!