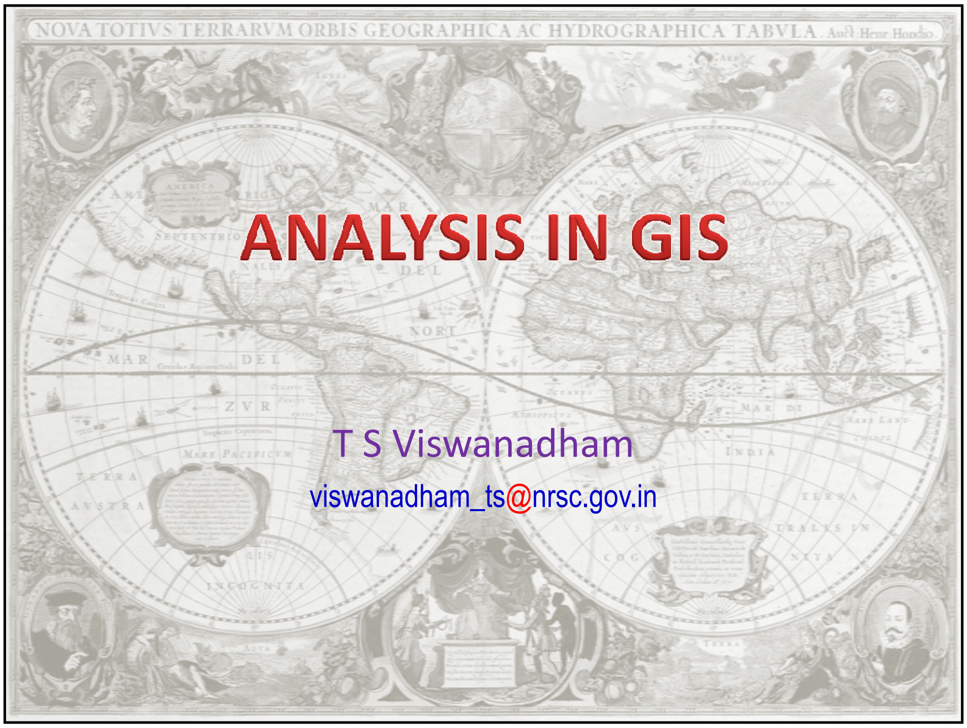

ANALYSIS IN GIS

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What is GIS?

"*Geographic Information System*"

- A new technological tool

- A Geospatial information handling strategy

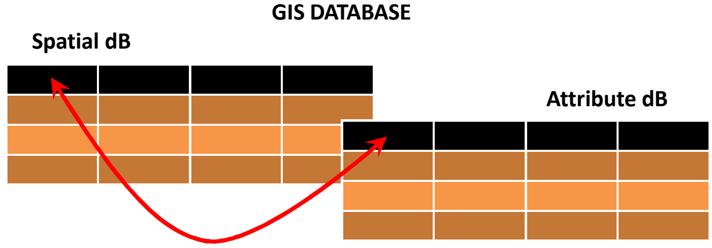
The objective is

"to improve overall decision making".

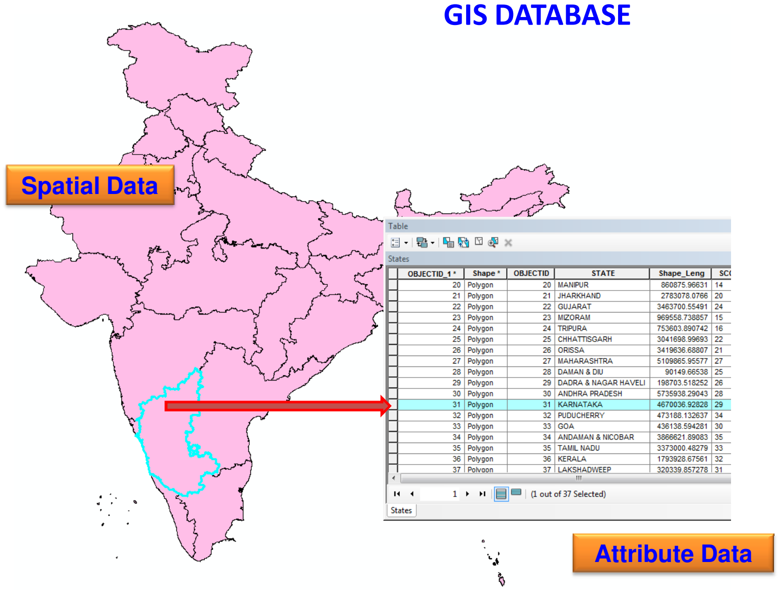
What is GIS?

A GIS does not hold maps or pictures.

It holds a database from which the data can be displayed in a variety of views.



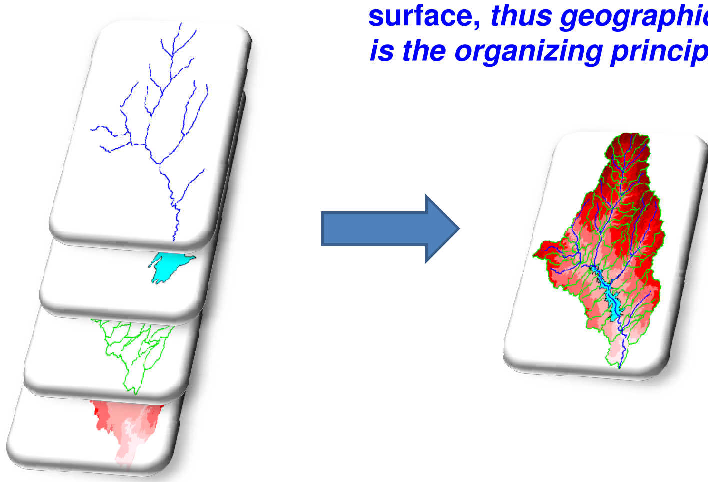
GIS DATABASE



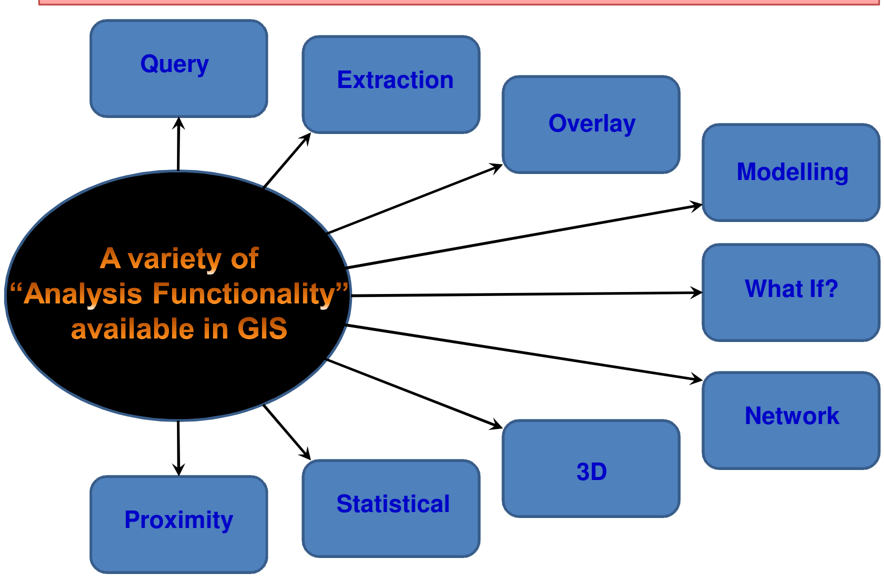
OBJECTID_1 *	Shape *	OBJECTID	STATE	Shape_Leng	SC
20	Polygon	20	MANIPUR	860875.96631	14
21	Polygon	21	JHARKHAND	2783078.0766	20
22	Polygon	22	GUJARAT	3463700.55491	24
23	Polygon	23	MIZORAM	969558.738857	15
24	Polygon	24	TRIPURA	753603.890742	16
25	Polygon	25	CHHATTISGARH	3041698.99693	22
26	Polygon	26	ORISSA	3419636.68807	21
27	Polygon	27	MAHARASHTRA	5109865.95577	27
28	Polygon	28	DAMAN & DIU	90149.66538	25
29	Polygon	29	DADRA & NAGAR HAVELI	198703.518252	26
30	Polygon	30	ANDHRA PRADESH	5735938.29043	28
31	Polygon	31	KARNATAKA	4670036.92828	29
32	Polygon	32	PUDUCHERRY	473188.132637	34
33	Polygon	33	GOA	436138.594281	30
34	Polygon	34	ANDAMAN & NICOBAR	3866621.89083	35
35	Polygon	35	TAMIL NADU	3373000.48279	33
36	Polygon	36	KERALA	1793928.67561	32
37	Polygon	37	LAKSHADWEEP	320339.857278	31

AN INTEGRATED VIEW

Layers are integrated using explicit location on the earth's surface, *thus geographic location is the organizing principal*.



Why GIS is a powerful tool?



GIS became a powerful technological tool because of its analysis techniques. A variety of tools are available for analysis in GIS. However, the techniques are different for different spatial models.

Raster analysis tools are different from Vector analysis tools.

The appropriate analysis tool(s) should be used depending on the spatial data model.

"Geoprocessing" is a GIS operation used to manipulate spatial data.

The whole set of **Vector Analysis Tools** are categorised into following groups.

- **Query Techniques**
- **Extraction Techniques**
- **Proximity Techniques**
- **Overlay Techniques**
- **Statistical Techniques**

Query Techniques

Attribute Query

Popular in DBMS, **Structured Query Language (SQL)** is a powerful language used to define one or more criteria that can consist of attributes, operators, and calculations for **selecting features and attribute records** from GIS database.

General syntax of a SQL statement is

SELECT <attribute name(s)> FROM <table> WHERE <condition statement>

Attribute Query

SQL Operators : Used to frame out conditional statement in SQL.

Arithmetic operators

Addition (+)
Subtraction (-)
Multiplication (*)
Division (/)
Modulus (%)

Logical operators

AND
"AREA" > 1500 AND "Type" = 'Residential'

OR
"AREA" > 1500 OR "Type" = 'Residential'

XOR
"AREA" > 1500 XOR "Type" = 'Residential'

NOT
NOT "STATE_NAME" = 'Goa'

Relational / Comparison operators

Equal (=)
Not equal (!= or <>)
Greater than (>)
Greater than or equal (>=)
Less than (<)
Less than or equal (<=)

[NOT] EXISTS
EXISTS (SELECT * FROM roads WHERE "Type" = 'NH')

[NOT] IN

"STATE_NAME" IN ('Bihar', 'Goa', 'Odisha', 'Asom')

"STATE_NAME" IN (SELECT "STATE_NAME" FROM states WHERE "POP" > 5000000)

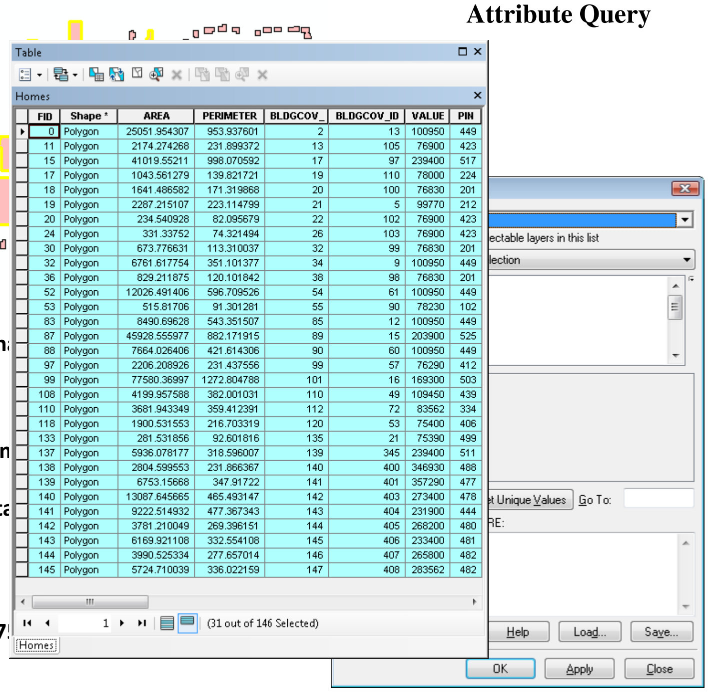
IS [NOT] NULL

Attribute Query

Find out all houses th
Rs.74999/-

SELECT <attribute nan
FROM <table>
WHERE <condition sta

SELECT *
FROM Homes
WHERE "VALUE" >= 7



FID	Shape *	AREA	PERIMETER	BLDGCOV_	BLDGCOV_ID	VALUE	PIN
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11	Polygon	2174.274268	231.899372	13	105	76900	423
15	Polygon	41019.55211	998.070592	17	97	239400	517
17	Polygon	1043.561279	139.821721	19	110	78000	224
18	Polygon	1641.486582	171.319868	20	100	76830	201
19	Polygon	2287.215107	223.114799	21	5	99770	212
20	Polygon	234.540928	82.095679	22	102	76900	423
24	Polygon	331.33752	74.321494	26	103	76900	423
30	Polygon	673.776631	113.310037	32	99	76830	201
32	Polygon	6761.617754	351.101377	34	9	100950	449
36	Polygon	829.211875	120.101842	38	98	76830	201
52	Polygon	12026.491406	596.709526	54	61	100950	449
53	Polygon	515.81706	91.301281	55	90	78230	102
83	Polygon	8490.69628	543.351507	85	12	100950	449
87	Polygon	45928.555977	882.171915	89	15	203900	525
88	Polygon	7664.026406	421.614306	90	60	100950	449
97	Polygon	2206.208926	231.437556	99	57	76290	412
99	Polygon	77580.36997	1272.804788	101	16	169300	503
108	Polygon	4199.957588	382.001031	110	49	109450	439
110	Polygon	3681.943349	359.412391	112	72	83562	334
118	Polygon	1900.531553	216.703319	120	53	75400	406
133	Polygon	281.531856	92.601816	135	21	75390	499
137	Polygon	5936.078177	318.596007	139	345	239400	511
138	Polygon	2804.599553	231.866367	140	400	346930	488
139	Polygon	6753.15668	347.91722	141	401	357290	477
140	Polygon	13087.645665	465.493147	142	403	273400	478
141	Polygon	9222.514932	477.367343	143	404	231900	444
142	Polygon	3781.210049	269.396151	144	405	268200	480
143	Polygon	6169.921108	332.554108	145	406	233400	481
144	Polygon	3990.525334	277.657014	146	407	265800	482
145	Polygon	5724.710039	336.022159	147	408	283562	482

Query Techniques

Spatial Query

A **spatial query** is a special type of database query supported by spatial databases. This type of query lets you

select features from one layer based on their location relative to features in the other layer.

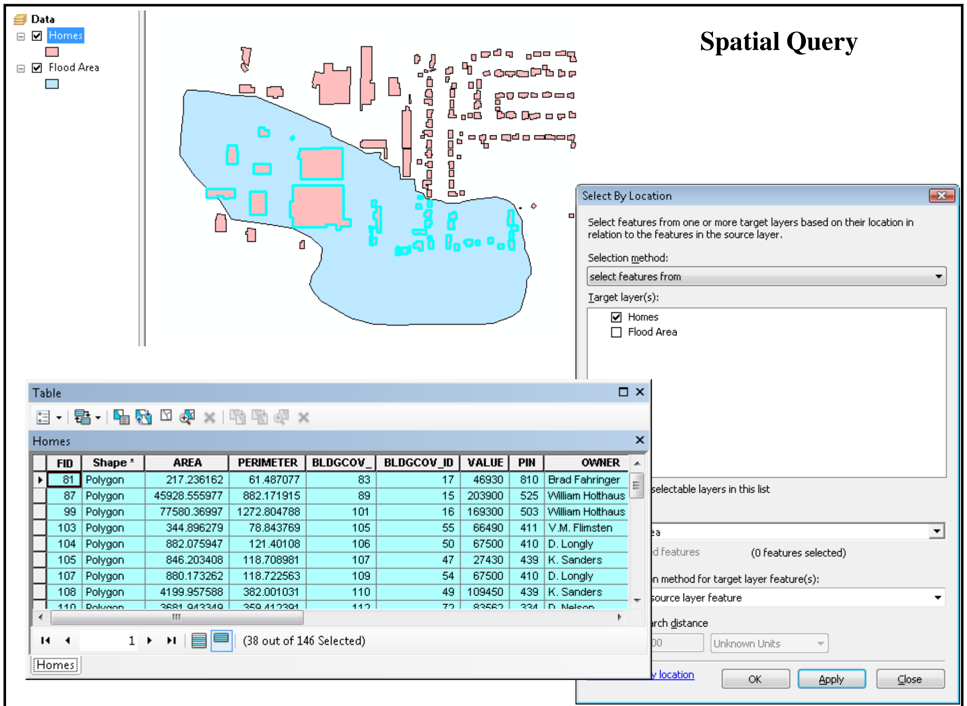
They allow for the use of geometry data types such as points, lines and polygons and that these queries consider the spatial relationship between these geometries.

For instance, if you want to know how many homes were affected by a recent flood and you mapped the flood area, you could select all the homes that are within the flooded area.

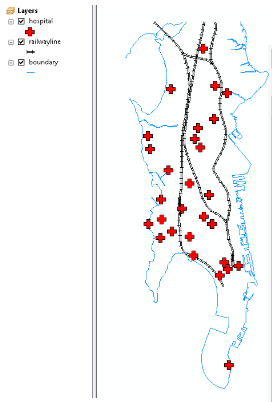
Target layer : The layer in which features will be selected. (**Homes** layer)

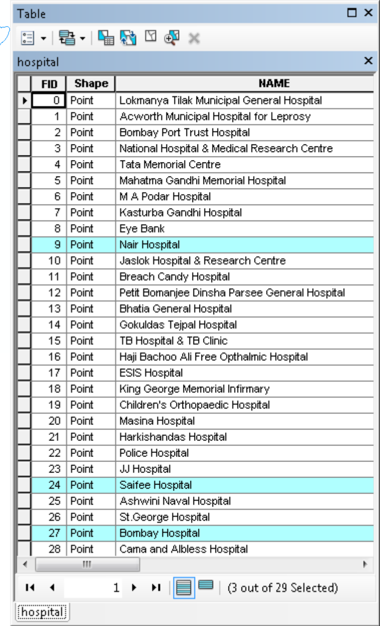
Source / Selector layer : The layer that is used to determine the selection based on its topological relationship to the target layer (**Flood Area** layer).

Spatial Query



SPATIAL QUERY





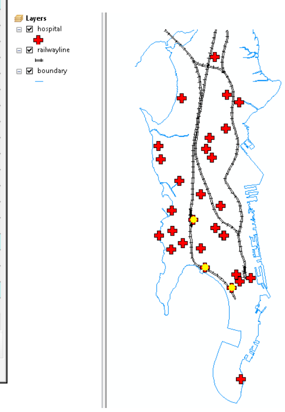
Table

hospital

FID	Shape	NAME
0	Point	Lokmanya Tilak Municipal General Hospital
1	Point	Acworth Municipal Hospital for Leprosy
2	Point	Bombay Port Trust Hospital
3	Point	National Hospital & Medical Research Centre
4	Point	Tata Memorial Centre
5	Point	Mahatma Gandhi Memorial Hospital
6	Point	M A Podar Hospital
7	Point	Kasturba Gandhi Hospital
8	Point	Eye Bank
9	Point	Nair Hospital
10	Point	Jaslok Hospital & Research Centre
11	Point	Breach Candy Hospital
12	Point	Petit Bomanjee Dinsha Parsee General Hospital
13	Point	Bhatia General Hospital
14	Point	Gokuldas Tejpal Hospital
15	Point	TB Hospital & TB Clinic
16	Point	Haji Bachoo Ali Free Opthalmic Hospital
17	Point	ESIS Hospital
18	Point	King George Memorial Infirmary
19	Point	Children's Orthopaedic Hospital
20	Point	Masina Hospital
21	Point	Harkishandas Hospital
22	Point	Police Hospital
23	Point	JJ Hospital
24	Point	Saifee Hospital
25	Point	Ashwini Naval Hospital
26	Point	St.George Hospital
27	Point	Bombay Hospital
28	Point	Cama and Albless Hospital

1 (3 out of 29 Selected)

hospital



SPATIAL SELECTION METHODS

Spatial Selection Method	Meaning
Intersect	Select any feature in the target layer that geometrically shares a common part with the source feature(s)
Are within a distance of	First creates a buffer(s) with a size equal to the distance specified around the source feature(s), then selects all the features intersecting the buffer
Contain	The geometry of the source feature must fall inside the geometry of the target feature including its boundaries.
Completely Contain	Source feature must fall inside the geometry of the target feature, excluding the target's boundaries (the boundaries cannot touch).
Are within	The geometry of the target feature must fall inside the geometry of the source feature including its boundaries.
Are completely within	The target feature must fall within the geometry of the source feature excluding the source's boundaries (the boundaries cannot touch). This is the reverse operator from Completely contain.
Have their centroid in	A target feature will be selected by this operator if the centroid of its geometry falls into the geometry of the source feature or on its boundaries.
Share a line segment with	Target layer features share a line segment with the Source layer feature.
Touch the boundary of	Target layer features touch the boundary of the Source layer feature.
Are identical to	Target layer features are identical to the Source layer feature. Two features are considered identical if their geometries are strictly equal.
Are crossed by the outline of	Target layer features are crossed by the outline of the Source layer feature.

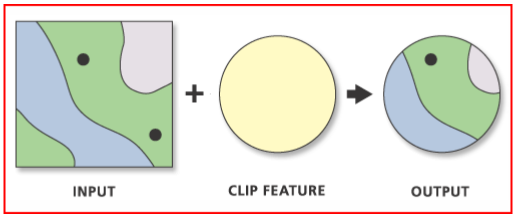
Feature Extraction Techniques

Extraction tools are used to create
a subset of spatial database

- CLIP
- ERASE
- SPLIT
- SELECT
- TABLE SELECT

- CLIP
- ERASE
- SPLIT
- SELECT
- TABLE SELECT

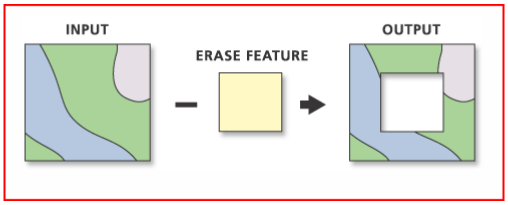
Clip is used to cut out a portion of a layer using one or more of the features in another feature class as a "**cookie cutter**". This is useful for creating a new geographic **subset** out of larger feature class.



INPUT FEATURES	CLIP FEATURES	OUTPUT FEATURES
Polygons	Polygons	Polygons
Lines	Lines / Polygons	(Coincident) Lines
Points	Points / Lines / Polygons	(Coincident) Points

- CLIP
- **ERASE**
- SPLIT
- SELECT
- TABLE SELECT

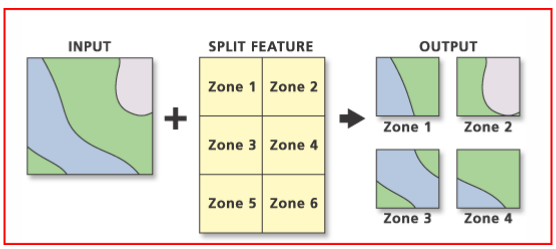
Only those portions of the Input Features **falling outside the Erase Features outside boundaries are copied** to the Output Feature Class.



A **polygon erase** feature can be used **to erase polygons, lines, or points** from the input features
A **line erase** feature can be used **to erase lines or points** from the input features
A **point erase** feature can be used **to erase points** from the input features.

- CLIP
- ERASE
- **SPLIT**
- SELECT
- TABLE SELECT

The spatial extraction of features by clipping portions of the input feature class into **multiple feature classes**.

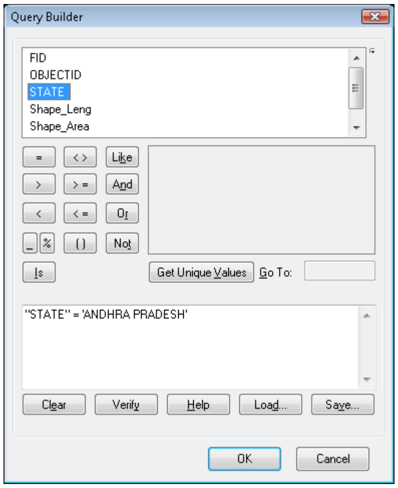


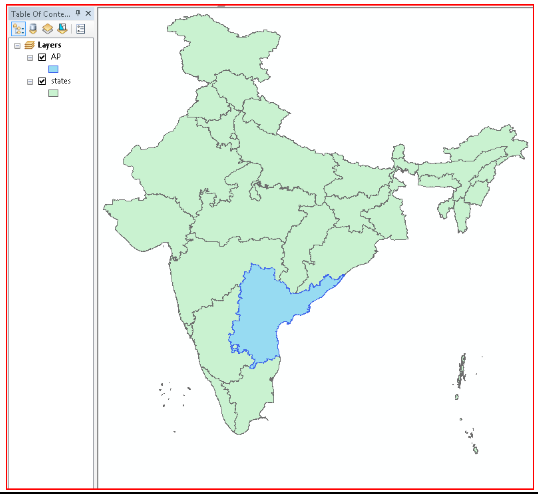
The INPUT features are split into four OUTPUT feature classes based on four of six overlaying SPLIT FEATUREs. These six split features correspond to six unique split field (character data type) values.

The character field used to split the input features. This field's values identify the split features used to create each output feature class. The split field's unique values provide the output feature classes' names.

- CLIP
- ERASE
- SPLIT
- **SELECT**
- TABLE SELECT

Extracts features from an input feature class or input feature layer, using a **SQL expression** through **Query Builder** and stores them in an output feature class.





- CLIP
- ERASE
- SPLIT
- SELECT
- **TABLE SELECT**

Extracts **selected attributes** from an input table based on an attribute query and stores them in the **output table**. **Remember no spatial features will be extracted to output.**

Table

ap_towns

Rowid	FID	HQ	TOWN	STATE	DIST	TALUK
1	0	NARAYANKHER	NARAYANKHER	ANDHRA PRADES	MEDAK	NARAYANKHEI
2	0	ZAHIRABAD	ZAHIRABAD	ANDHRA PRADES	MEDAK	ZAHIRABAD
3	0	VIKARABAD	VIKARABAD	ANDHRA PRADES	RANGAREDDY	VIKARABAD
4	0	TANDUR	TANDUR	ANDHRA PRADES	RANGAREDDY	TANDUR
5	0	PARGI	PARGI	ANDHRA PRADES	RANGAREDDY	PARGI
6	0	KORANGAL	KORANGAL	ANDHRA PRADES	MAHBUBNAGAR	KORANGAL
7	0	MAHBUBNAGAR	MAHBUBNAGAR	ANDHRA PRADES	MAHBUBNAGAR	MAHBUBNAGA
8	0	MAKHTAL	MAKHTAL	ANDHRA PRADES	MAHBUBNAGAR	MAKHTAL
9	0	GADWAL	GADWAL	ANDHRA PRADES	MAHBUBNAGAR	GADWAL
10	0	ATAMKUR	ATAMKUR	ANDHRA PRADES	MAHBUBNAGAR	ATAMKUR
11	0	ADILABAD	ADILABAD	ANDHRA PRADES	ADILABAD	ADILABAD
12	0	UTNUR	UTNUR	ANDHRA PRADES	ADILABAD	UTNUR
13	0	BOATH	BOATH	ANDHRA PRADES	ADILABAD	BOATH
14	0	NIRMAL	NIRMAL	ANDHRA PRADES	ADILABAD	NIRMAL
15	0	KHANAPUR	KHANAPUR	ANDHRA PRADES	ADILABAD	KHANAPUR
16	0	METPALLI	METPALLI	ANDHRA PRADES	KARIMNAGAR	METPALLI
17	0	ARMUR	ARMUR	ANDHRA PRADES	NIZAMABAD	ARMUR
18	0	JAGTIAL	JAGTIAL	ANDHRA PRADES	KARIMNAGAR	JAGTIAL
19	0	NIZAMABAD	NIZAMABAD	ANDHRA PRADES	NIZAMABAD	NIZAMABAD

1 (0 out of 190 Selected)

ap_towns

Proximity Analysis Techniques

The Proximity techniques are used to determine the proximity (closeness or distance) of features within one or more feature classes or between two feature classes.

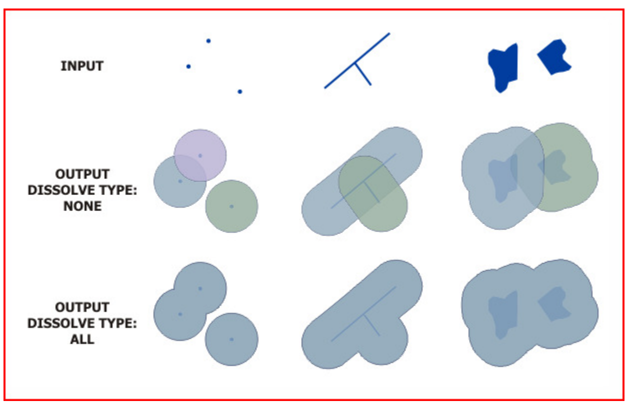
- ❖ BUFFER
- ❖ MULTIPLE BUFFERS

- ❖ BUFFER
- ❖ MULTIPLE BUFFERS

Creates buffer polygons around input features to a specified distance. The dissolve can be performed to remove overlapping buffers.

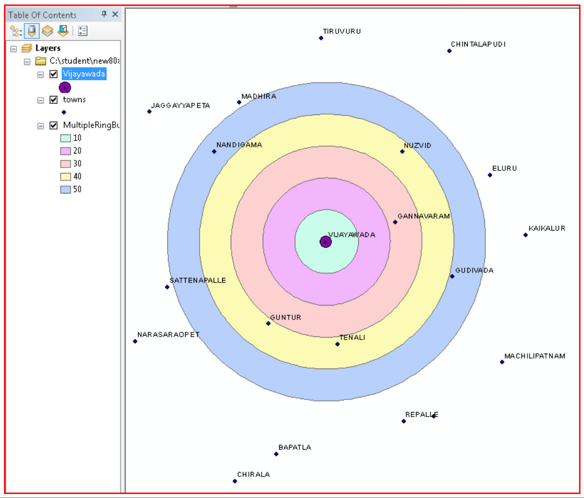
Negative buffer distance means inside the polygon.

Variable buffer distance can be specified as the name of one of the **attribute** in the table.



❖ BUFFER
❖ **MULTIPLE BUFFERS**

Creates **multiple buffers** at specified distances around the input features. These buffers can optionally be merged and dissolved using the buffer distance values to create non-overlapping buffers.



Overlay Analysis Techniques

The Overlay toolset contains tools to overlay multiple feature classes to combine, erase, modify, or update spatial features in a new feature class. New information is created when overlaying one set of features with another.

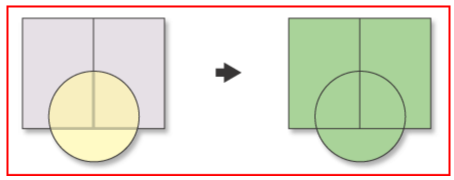
- ❖ **UNION**
- ❖ **INTERSECT**
- ❖ **IDENTITY**
- ❖ **SYMMETRICAL DIFFERENCE**
- ❖ **UPDATE**

- **UNION**
- INTERSECT
- IDENTITY
- SYMMETRICAL DIFFERENCE
- UPDATE

Computes a geometric intersection of the Input Features. All features will be written to the Output Feature Class with the attributes from the Input Features, which it overlaps.

All input 1 and input 2 (union layer) must have **polygon geometry**.

INPUT 1 OUTPUT



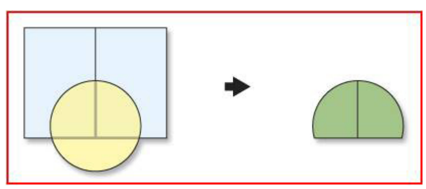
INPUT 2
(Union Layer)

- UNION
- **INTERSECT**
- IDENTITY
- SYMMETRICAL DIFFERENCE
- UPDATE

The Intersect tool calculates the geometric intersection of any number of feature classes and feature layers. The features or portion of features that are common to (intersect) all inputs will be written to the Output Feature Class.

INPUT 1 OUTPUT

Input 1	Input 2	Output
Point	Polygon	Point
Arc	Polygon	Arc
Polygon	Polygon	Polygon



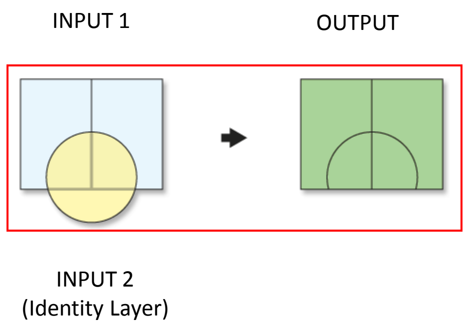
INPUT 2
(Intersect Layer)

- UNION
- INTERSECT
- **IDENTITY**
- SYMMETRICAL DIFFERENCE
- UPDATE

Computes a geometric intersection of the Input Features and Identity Features. The Input Features or portions thereof that overlap Identity Features will get the attributes of those Identity Features.

The Input Features must be point, multipoint, line, or polygon. The Identity Features must be polygons.

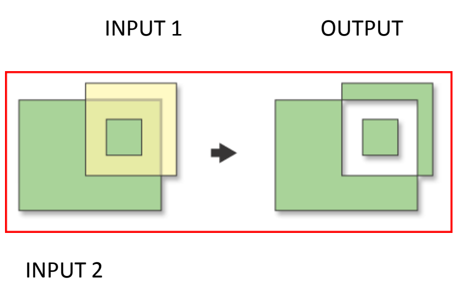
Input 1	Input 2	Output
Point	Polygon	Point
Arc	Polygon	Arc
Polygon	Polygon	Polygon



- UNION
- INTERSECT
- IDENTITY
- **SYMMETRICAL DIFFERENCE**
- UPDATE

Features or portions of features in the input and update **features which do not overlap** will be written to the Output Feature Class.

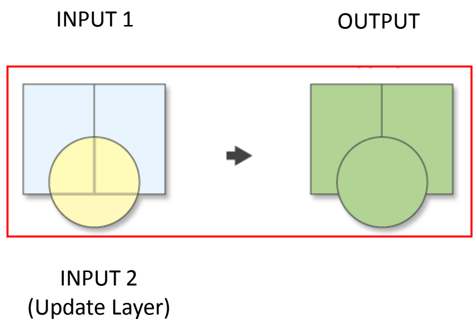
Both inputs must have **polygon** geometry.



- UNION
- INTERSECT
- IDENTITY
- SYMMETRICAL DIFFERENCE
- **UPDATE**

The attributes and geometry of the Input Features are updated by the Update Features or layer that they overlap.

Both inputs must have **polygon** geometry.



Statistical Analysis Techniques

Statistical analysis in GIS is of two types:

- **Non-spatial statistical analysis**
- **Spatial statistical analysis**

Non-spatial statistics are used to analyze attribute (numerical) data associated with features.

E.g., Understanding the distribution of values for a particular attribute by summarizing the data.

Charts and graphs, such as a histogram or Q-Q plots are also used for analyzing non-spatial data. In all cases, only the values are analyzed.

The locations of the features with which the values are associated and any spatial relationships between the features are not considered.

Spatial statistics, on the other hand, focus on the spatial relationships between features.

Spatial statistics are used for

- **Analyzing Patterns**
- **Mapping Clusters**
- **Measuring Geographic Distributions**
- **Modelling Spatial Relationships**

Statistical functions analyze the underlying data and give you a measure that can be used to confirm the existence and strength of the pattern.

Geostatistics

Geostatistics are a type of **spatial statistics**. Kriging, for example, is a very powerful geostatistical technique that goes beyond interpolation, looking not only at nearby features to predict values where you don't have sample data, but actually **utilizing spatial relationships** to give you stronger, more accurate predictions.

Geostatistics are ideal for analyzing and predicting the values associated with nearly any kind of spatially continuous phenomena.

The **semivariogram** is a statistical measure of the rate of change with distance, for attributes that vary in space.

The **semivariogram depicts the spatial autocorrelation** of the measured sample points. Once each pair of locations is plotted, a model is fit through them.

The Steps in a Geo-statistical Study

1) **Exploratory Spatial Data Analysis**
   (Spatial Data Variability, Spatial Data Dependence, Global Trends & Outliers)

2) **Structural data analysis**
   (Calculation and Modeling of Variograms)

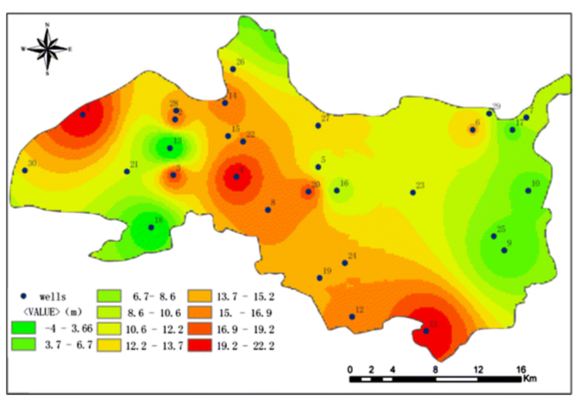
3) **Making predictions**
   (kriging or simulations)

4) **Analysis of Result**

"Based on the geo-statistical theory data of **30 groundwater level observation wells** were used to estimate the decline of groundwater level in study area (Beijing piedmont). Seven different interpolation methods **(inverse distance weighted interpolation, global polynomial interpolation, local polynomial interpolation, tension spline interpolation, ordinary Kriging interpolation, simple Kriging interpolation and universal Kriging interpolation)** were used for interpolating groundwater level between 2001 and 2013. Cross-validation, absolute error and coefficient of determination (R^2) was applied to evaluate the accuracy of different methods.

Groundwater level drawdown during 2001 and 2013.

"The result shows that simple Kriging method gave the best fit".

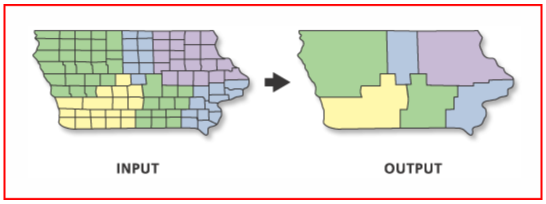


Tools for Generalization

Tools in the Generalization toolset can be used to aggregate or eliminate features.

DISSOLVE

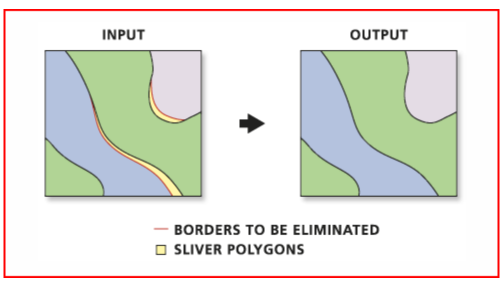
Aggregates features based on specified attributes.



Tools for Generalization

ELIMINATE

Eliminates polygons by merging them with neighboring polygons that have the largest area or the longest shared border. Eliminate is often **used to remove small sliver polygons** that are the result of overlay operations.

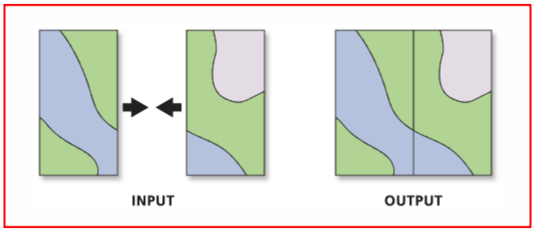


General Tools

MERGE

Combines multiple input datasets of the same data type into a **single, new output** dataset. This tool can combine point, line, or polygon feature classes or tables. (Input data sources need not be adjacent; overlap is allowed.)

All input datasets must be of the same type.

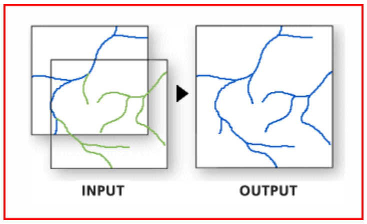


Edgematching is used to align features along the edges of adjacent layers.

General Tools

APPEND

Appends multiple input datasets **into an existing target dataset**. Input datasets can be point, line, or polygon feature classes, tables, rasters, annotation feature classes, or dimensions feature classes.



Raster Analysis Techniques

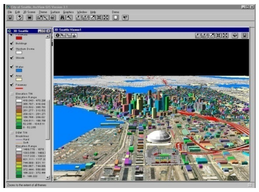
Raster vs. Vector Analysis Techniques

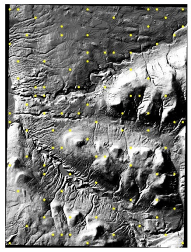
- **Analysis using vector model is different from that of raster**
  - some operations are more accurate
  - some operations are slower
  - some operations are faster
- **Vector GIS normally uses topological properties**
- **Raster GIS uses map algebra, pixel counts**, etc.

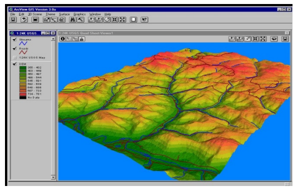
Why to use Raster GIS?

Raster GIS is often used because:

- Raster is better suited for **spatially continuous data** like elevations
- Raster is better for creating **visualizations and modeling** environmental phenomena
- Other continuous data may include: pH, air pressure, temperature, salinity, etc.
- Raster data is a simplified realization of the world, and allows for **fast and efficient processing**







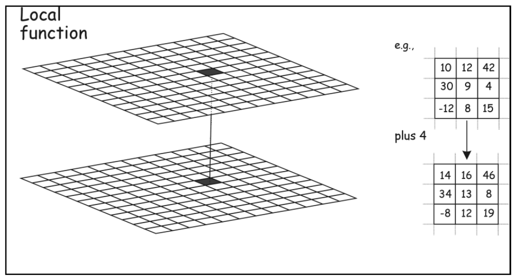
A raster GIS performs geoprocessing tasks on a grid based realization of the world

Operations on Raster Layers

- **Local Operations**(Cell by cell)
- **Focal Operations** (Neighborhood)
- **Zonal Operations** (Region-specific)
- **Global Operations** (Entire layer)

Local Operations

- New layer is a function of two or more input layers
- Output value for each cell is a function of the values of the corresponding cells in the input layers
- Neighboring or distant cells have no effect



Focal Operations

- Focal functions apply one calculation to all input grid cells within a "focus"

input grid

24	50	7	41	32
30	27	8	22	39
14	16	21	16	41
38	6	44	8	7
36	7	32	30	32
38	20	28	28	21
32	2	13	35	49

output grid

32.8	24.3	25.8	24.8	33.5
26.8	21.9	23.1	25.2	31.8
21.8	22.7	18.7	22.9	22.2
19.5	23.8	20.0	25.7	22.3
24.2	27.7	22.6	25.6	21.0
22.5	23.1	21.7	29.8	32.5
23.0	22.2	21.0	29.0	33.3

focal mean

(27 + 8 + 22 + 16 + 21 + 16 + 6 + 44 + 8) / 9 = 18.7

Zonal Operations

- Zonal functions apply one calculation to all input grid cells within each zone

input grid

53	57	33	10	14
78	31	12	22	55
32	9	9	85	26
6	54	33	85	94
75	25	76	49	27
48	16	67	23	89
36	46	82	97	74
45	86	44	42	35

zone grid

1	1	1	2	2
1	1	1	2	2
1	1	1	2	2
5	5	1	2	2
5	5	1	2	2
5	5	10	91	91
5	5	10	91	91
5	5	10	10	10

output (zonal sum) grid

423	423	423	467	467
423	423	423	467	467
423	423	423	467	467
437	437	423	467	467
437	437	423	467	467
437	437	270	283	283
437	437	270	283	283
437	437	270	270	270

zonal sum

(53 + 57 + 33 + 78 + 31 + 12 + 32 + 9 + 9 + 33 + 76) = 423

Global Operations

- Global functions apply a single calculation to all input grid cells

input grid

12	49	20	46	26
6	37	20	46	28
49	45	38	15	6
23	5	35	17	17
22	48	3	45	23
42	14	23	32	42
31	23	41	2	40

output grid

-0.537	-0.954	0.913	0.902	0.763
-0.279	-0.644	0.913	0.902	0.271
-0.954	0.851	0.296	0.65	-0.279
-0.846	-0.959	-0.428	-0.961	-0.961
-0.009	-0.768	0.141	0.851	-0.846
-0.917	0.991	-0.846	0.551	-0.917
-0.404	-0.846	-0.159	0.909	0.745

global sine

sin(12) = -0.537

Raster Overlay Operations

(MAP ALGEBRA)

Map algebra is a cell by cell combination of raster layers using mathematical operations

- **Unary** – one layer
- **Binary** – two layers

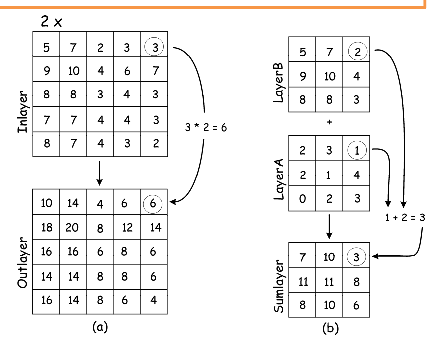
All basic mathematical operations can be used

- Addition
- Subtraction
- Multiplication
- Division
- Max
- Min
- ...

virtually any mathematical operation

Strong analytical functions

```
Outgrid = grid1 + grid2
Outgrid = grid1 * 2
Outgrid = sin(grid1)
Outgrid = costallocation(sourcegrid, costgrid, accumgrid, backgrid)
Outgrid = con(>5 (ingrid1),0,ingrid1)
Outgrid = select(grid1, 'VALUE = 10')
slp_dem = slp_grid * dem
```



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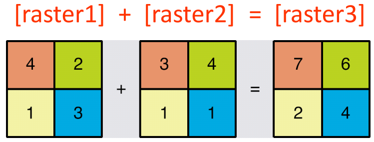
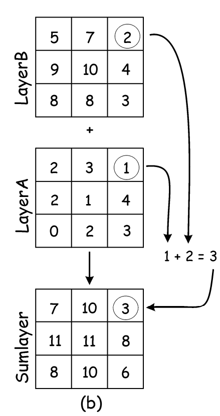
Raster Overlay Operations

(MAP ALGEBRA)

- Output cell value is the result of an arithmetic operation on the input layers
- e.g., if **a** and **b** are input layers and **c** is an output layer,
  c = a + b
  c = a * b
  …..
- Also, any kind of function such as Average, Sum, Min, Max, Standard Deviation, etc.

[raster1] + [raster2] = [raster3]





Raster Modelling

- Relating multiple rasters
- Processes may be:
  - Local: one cell only
  - Neighborhood: cells relating to each other in a defined manner
  - Zonal: cells in a given section
  - Global: all cells

- **Suitability modelling**

soil + slope + for sale = Site options

- **Diffusion Modelling**

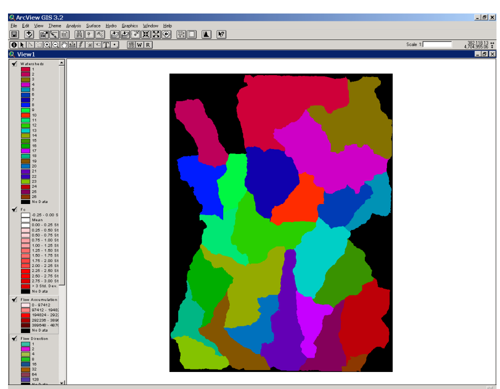
Incidence matrix × Probability mask = System at time t+1

- **Connectivity Modelling**

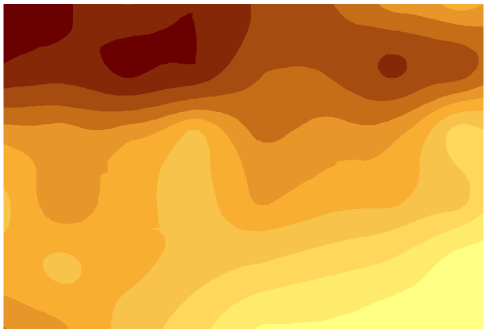
Initial State + Connectivity matrix = Resultant State

Watershed Delineation

- Fill Sinks in DEM
- Compute Flow Direction
- Compute Flow Accumulation
- Generate Watershed

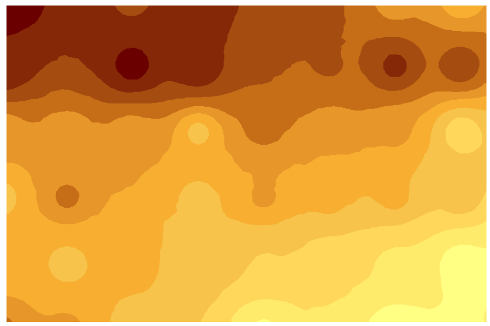


Kriging



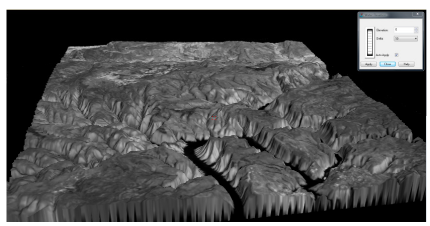
Surface Generation (interpolation)

IDW

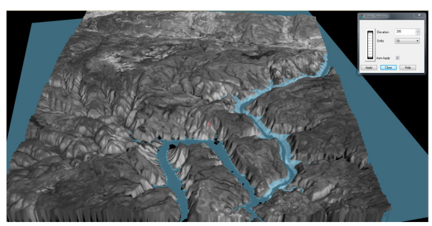


Flood Effect Simulation

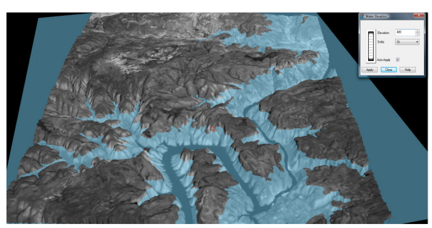
Water elevation : Normal



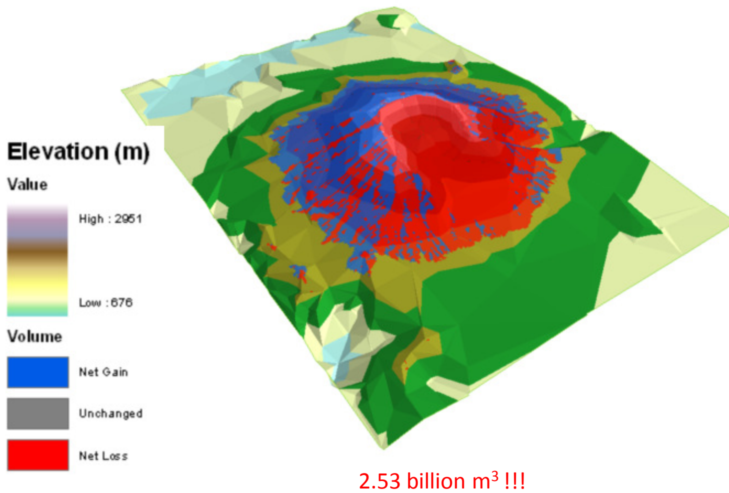
Water elevation : 200 m



Water elevation : 400 m



Volumetric Analysis



2.53 billion m^3 !!!

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