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SESSION 8: GEOGRAPHIC INFORMATION SYSTEMS AND MAP PROJECTIONS

KEY CONCEPTS:

In this session we will look at:

- Geographic information systems and Map projections.
- Content that needs to be covered for examination purposes and possible exam type questions.

X-PLANATION

Learner Notes:

- We will not be using computers during examinations so spending a lot of money and time doing advanced courses in GIS for the purpose of doing well in exams may not be necessary. The excuse that we can't do GIS because we don't have any computers is not relevant.
- Most of the questions will be based on maps, photos and diagrams.
- We need to note that the topographic map and orthophoto you receive during the exams are similar to GIS in that different types of relevant information are put together to make them.
- Topographic maps are representations of reality that shows us how things relate to each other in space. Maps represent different types of natural and manmade features/information, e.g. roads and cultivated land in the form of symbols.
- Orthophoto maps are accurate aerial photographs which contain information such as contour lines, spot heights, names of places etc. They are large scale aerial photographs that show great detail.

WHAT IS GIS?

- **Geographic** – place on Earth, Spatial – Where something is on earth?
- **Information** – data (facts) put together (layering) to make sense e.g. the number of people using a road. Data used in GIS can be the following: Maps, Remote sensing, Spatial resolution, Spectral resolution
- **System** – interrelated information – Using the data to make it mean something.

Definition: GIS is an organized collection of computer hardware, software, geographic data and personnel designed to capture, store, update, manipulate, analyze and display geographically referenced data.

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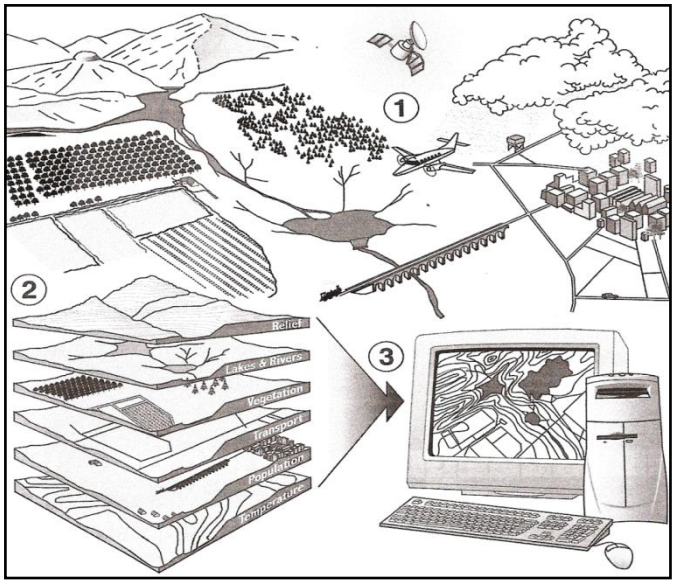

THE FIVE COMPONENTS OF A GIS:

Hardware, Software, Data, people and organizations, processes.
GIS has the same components as other information systems. It allows us to collect, store and process data to produce maps and answer on spatial queries. Let us compare GIS with the components of a vehicle.

THE BODY (HARDWARE)	THE FUEL (DATA/PROCESSING)
Computer hardware ○ Central processing unit ○ Monitor ○ Key board and drivers ○ Scanners and digitisers	Spatial data or geographical data. All data in the GIS can be linked to a point, line or area on the ground of which the geographical location is known.
THE ENGINE (SOFTWARE/PROCESSING)	**DRIVER (PEOPLE AND ORGANISATIONS/PROCESSING)**
Computer Programme specially to design to control the input of data into a system where they stored, updated, retrieved and processed.	This is the person or actually the team of people who link the hardware, software and data together to perform various functions. This includes data collection, analysis, and presentation. and management.

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CONCEPTS RELATED TO GIS:

Remote sensing - getting data about the earth's surface from a distance e.g. satellite images

Resolution - The detail and clarity of images in satellite and aerial photographs.

Clarity is better:

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Clarity is poor:

Spatial Resolution - The detail with which a map shows the location and shape of geographic features

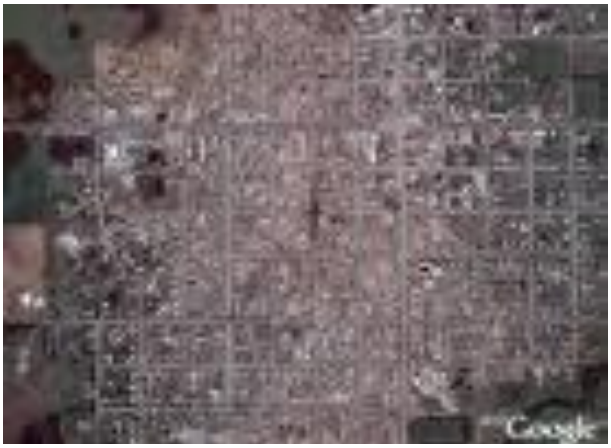
Spectral Resolution - Refers to the different kinds of information that can be collected

A database is a storage system with linked tables

Data is facts about reality that has been observed or measured. When data is stringed together it forms information.

Paper Maps:

Satellite Data / Aerial Photos:



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Digital Maps:

Tabular Data:

Table 1: Operational crime successes for the Johannesburg ACCU

2006	Arrests	Vehicle seizures	Firearm seizures	Ammun-ition seizures	Stations assisted[4]
28 June – 4 July	26	5	5	38	6
5 July – 11 July	10	2	4	107	18
12 July – 18 July	2	3	0	0	14
19 July – 25 July	4	5	2	55	11
26 July – 1 Aug	20	4	1	10	16
2 Aug – 8 Aug	7	0	0	58	4
9 Aug – 15 Aug	3	2	1	1	3
16 Aug – 22 Aug	No stats	No stats	No stats	No stats	No stats
23 Aug – 29 Aug	2	5	0	20	7
30 Aug – 5 Sept	12	3	1	1	9
6 Sept – 12 Sept	6	7	3	5	5
12 Sept – 19 Sept	9	5	2	15	5
20 Sept – 26 Sept	11	7	4	33	8
27 Sept – 3 Oct	No stats	No stats	No stats	No stats	No stats
4 Oct – 10 Oct	10	8	1	0	No stats

Source: Johannesburg Crime Combating Unit

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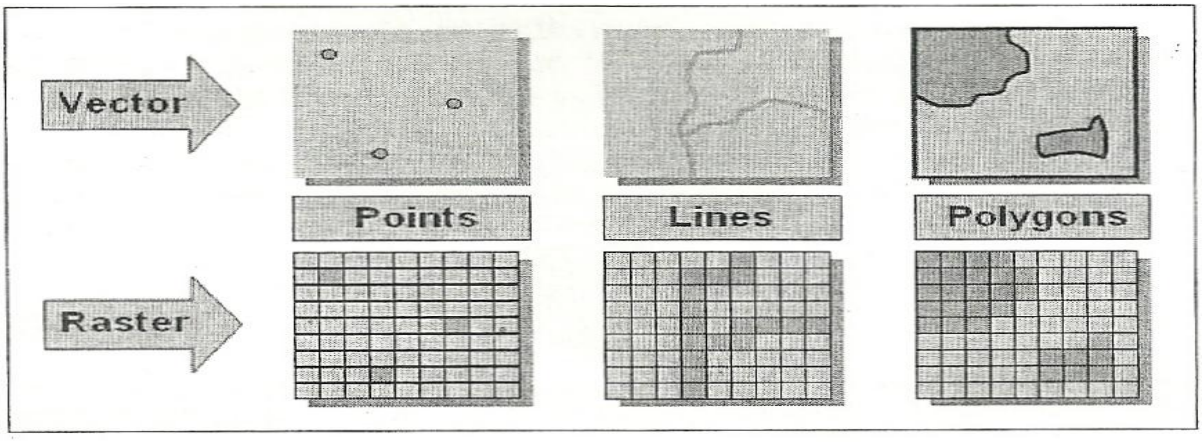
GPS Data:

(Global Positioning System)

Spatial Data - The *location and shapes* of geographic features and the relationships between them. E.g. Coordinates.

Attribute Data - Information about the *location or area* of geographic features and the relationships between them. E.g. Temperatures



Raster Data:

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ORTHOPHOTO MAP

- Raster data

TOPOGRAPHIC MAP

- Vector data

Vector Data - Representation of an area using point, lines and polygons

Raster Data - Representation of an area using rectangular grid cells also referred to as pixels or picture elements

Data Manipulation - When data is processed and converted into useful information .e.g. correcting distortions and sharpening definitions

Clarity is better:

Clarity is poor:

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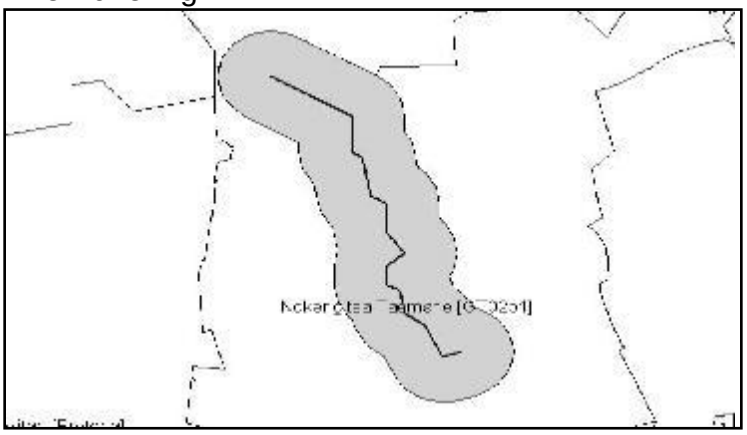
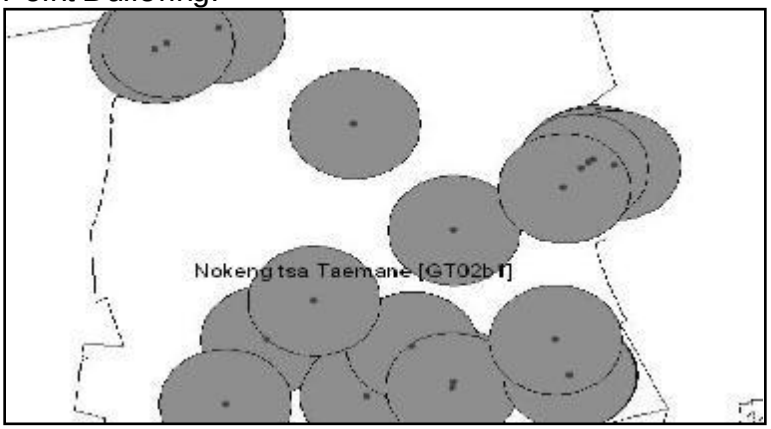
Buffering - A zone drawn around a mapped feature measured in units of distance or time.

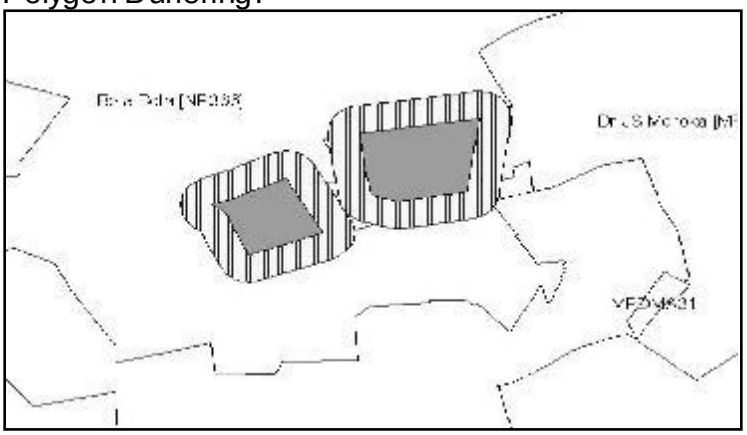
Line Buffering:



Point Buffering:



Polygon Buffering:



Statistical Analysis - Interpreting the various forms of statistics in relation to a query

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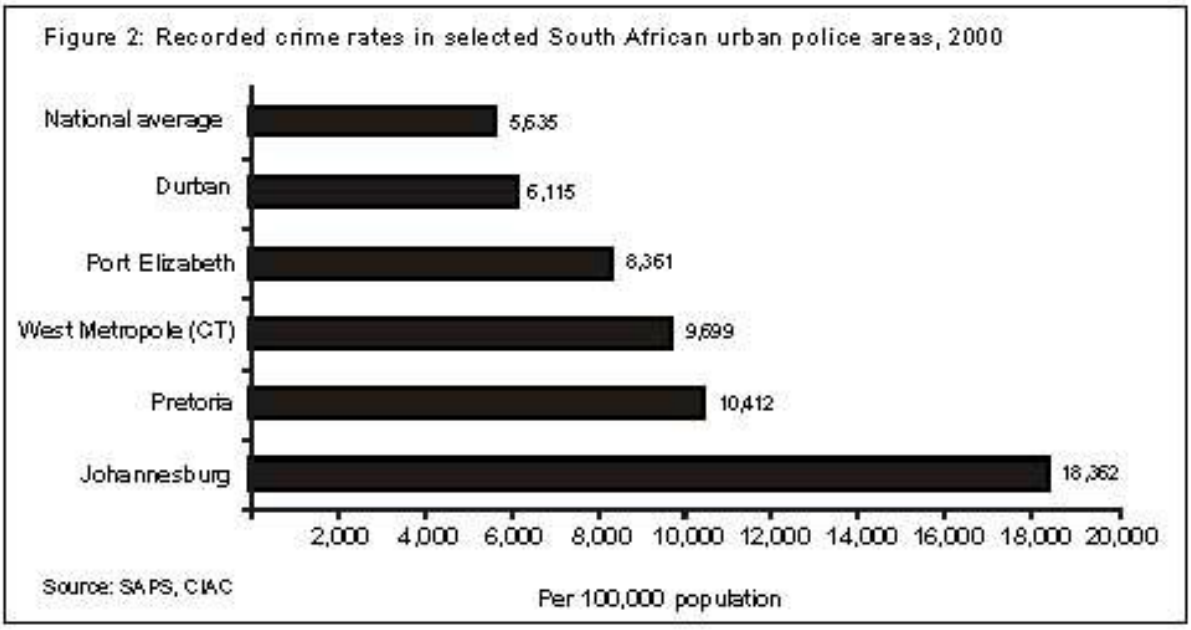

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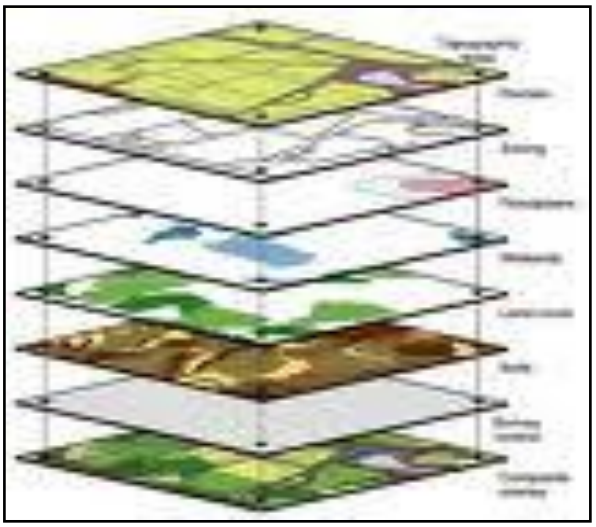
Crime per 100,000 people in the RSA for the period January to December 1994-1998						
Crime category	1994	1995	1996	1997	1998	Ave. annual growth
Murder	69.28	67.19	63.53	59.18	58.47	-4%
Attempted murder	70.49	66.88	70.26	67.75	69.15	0%
Robbery with aggravated circumstances	219.22	201.98	165.70	167.73	207.61	-1%
Common robbery	83.72	103.12	126.91	126.79	146.01	15%
Public violence	3.16	2.60	2.23	2.51	2.57	-5%
Illegal strikes	0.90	0.99	0.28	0.12	0.15	-36%
Rape and attempted rape	109.55	119.83	124.39	125.54	115.84	1%
Intercourse with a girl under the prescribed age and/or female imbecile	2.03	1.68	1.43	1.29	1.11	-14%
Indecent assault	10.00	12.29	12.86	12.16	11.40	3%
Cruelty and ill-treatment of children (excluding sexual offences, assault and murder)	7.03	7.33	5.70	5.70	4.90	-9%
Kidnapping	10.29	10.51	10.24	9.71	9.86	-1%
Abduction	7.25	5.80	4.97	6.51	7.26	0%
Assault with the intend to inflict grievous bodily harm	542.87	557.44	567.78	564.53	550.20	0%
Common assault	500.31	517.36	505.95	485.65	468.53	-2%
Burglary - business premises (including attempts)	229.95	217.89	216.50	213.27	221.21	-1%
Burglary - residential premises (including attempts)	588.76	615.64	607.24	600.20	627.21	2%
Stock-theft	116.55	112.57	103.04	103.27	95.18	-5%
Shoplifting	173.15	159.01	153.26	153.54	148.10	-4%
Theft of motor vehicles and motorcycles	269.31	254.91	238.31	242.21	252.73	-2%
Theft out of or from motor vehicles and motorcycles	471.54	478.79	444.09	424.21	442.97	-2%
Theft not mentioned elsewhere	987.39	979.35	936.82	933.45	1004.07	0%
Arson	29.32	24.62	24.80	23.66	23.81	-5%
Malicious damage to property	316.55	323.87	321.10	305.67	299.93	-1%
malappropriations, embezzlements, etc.	161.59	153.91	153.23	153.15	145.95	-3%
Drug related crime	122.19	102.87	96.69	103.02	93.63	-6%
Driving under the influence of alcohol or drugs	69.12	58.46	59.09	66.92	60.19	-3%
Illegal possession of firearms and ammunition	28.75	29.98	31.75	30.99	34.00	4%
Explosives act	1.47	0.85	0.91	0.49	0.31	-32%
Total	**5201.75**	**5187.60**	**5049.09**	**4989.43**	**5102.37**	0%
Carjacking*			31.69	31.32	35.52	6%
Hijacking of trucks*			9.10	10.34	13.57	22%
Robbery of cash in transit*			1.01	0.55	0.50	-29%
Bank robbery*			1.58	1.20	1.12	-16%
POPULATION	**38,729,085**	**39,643,934**	**40,583,573**	**41,548,719**	**42,540,106**	2%
* These crimes have already been accounted for under robbery with aggravating circumstances						

Database - A collection of data organized for use in computers



Thematic Layering/Data layering - Maps showing different types of information are projected onto one another/placed on top of one another

Data Integration - Putting together various sources of information

ECONOMIC ACTIVITY/PROBLEM	USE OF GIS
Agriculture	Rainfall patterns, predicting climate, soil type, suitability of crop
Crime prevention	Crime statistics in spatial patterns
Traffic congestion	Controlling traffic lights based on information collect
Financial	Banks monitoring customer patterns of behaviour
Mining	Exploring for mineral deposits.
Personal use	Finding out the shortest route to school. Buying a house which is the safest place etc

X-AMPLE QUESTIONS:

Question 1:

Data manipulation is used to control how features are represented on small and large-scale maps.

1.1 Explain the meaning of the term *data manipulation*.

(1 x 2) (2)

1.2 Explain why it is necessary to manipulate data on maps.

(1 x 2) (2)

Question 2:

Two learners from a school in Paarl have an assignment and have to take photographs of the Berg River. One has a 2.0 megapixel camera and the other has a 3.5 megapixel camera. The resolution of the photographs taken by the boys will differ.

2.1 Explain the meaning of the term resolution.

(1 x 2) (2)

2.2 Which one of the cameras will take better quality pictures? Explain your answer.

(2 x 2) (4)

2.3 Heavy rainfall sometimes results in flooding along the Berg River, as is evident in the image below. How could the local government use GIS to manage this disaster?

(2 x 2) (4)

Question 3:

3.1 Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A – E) next to the question number (3.1.1 – 3.1.3), for example 3.1.3 F.

	COLUMN A	COLUMN B
3.1.1	The raw facts that are collected about a feature	A raster data B vector data C remote sensing D data base E data
3.1.2	Gathering of data about the Earth from a distance, using satellites such as Landsat.	
3.1.3	Data represented by pixels in the form of grid cells or pixels	

(3 x 2) (6)

3.2 Name any TWO functional elements of GIS. (2 x 2) (4)

3.3 With reference to the term buffering:

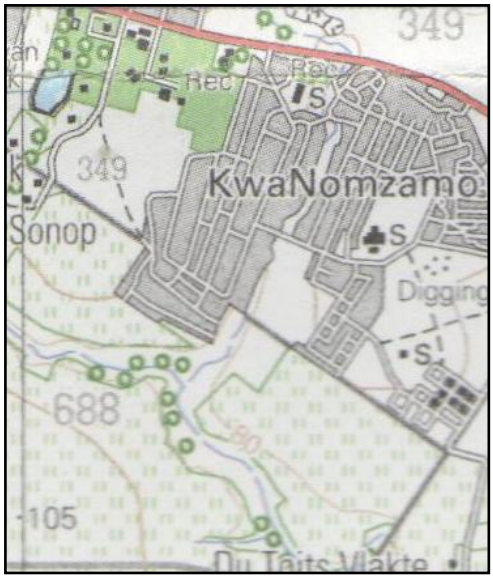
3.3.1 Define the term *buffering*. (1 x 2) (2)

3.3.2 Explain how buffering can be used to protect the coastal environments visible on the topographical map. (1 x 2) (2)

3.4 Which ONE, the topographical map or the orthophoto map, is an example of vector data? (1 x 2) (2)

Question 4:

4.1 Identify a polygon feature and a line feature in block C2.

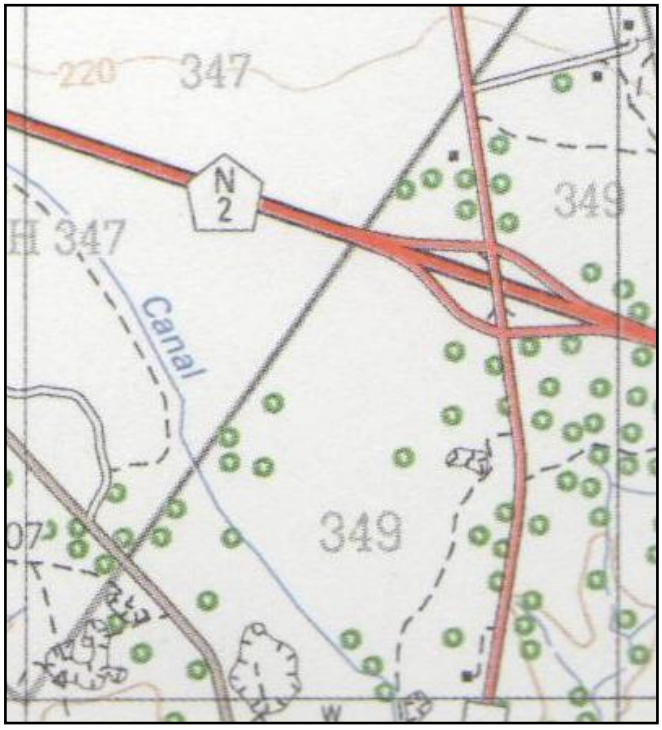


(2 x 2) (4)

4.2 With reference to the concept of attribute data, answer the following questions.

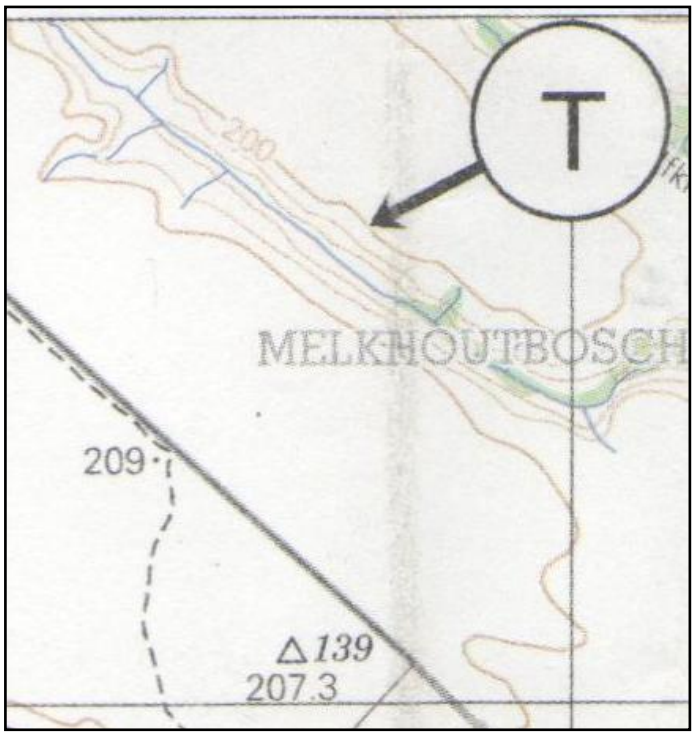
4.2.1 Define the term *attribute data*. (1 x 2) (2)

4.2.2 Name ONE attribute of the N2 in block A2.



(1 x 2) (2)

4.3 Data integration is combining different types of data for the purpose of decision-making. Discuss TWO types of data that a farmer in black A5 will consider before cultivation.



(2 x 2) (4)

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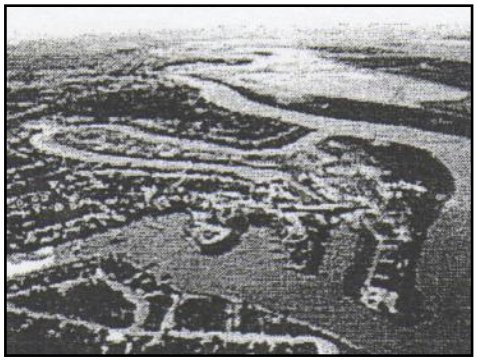
X-ERCISE QUESTIONS

Question 1:

Two learners from a school in Paarl have an assignment and have to take photographs of the Berg River. One has a 2.0 megapixel camera and the other has a 3.5 megapixel camera. The resolution of the photographs taken by the boys will differ.

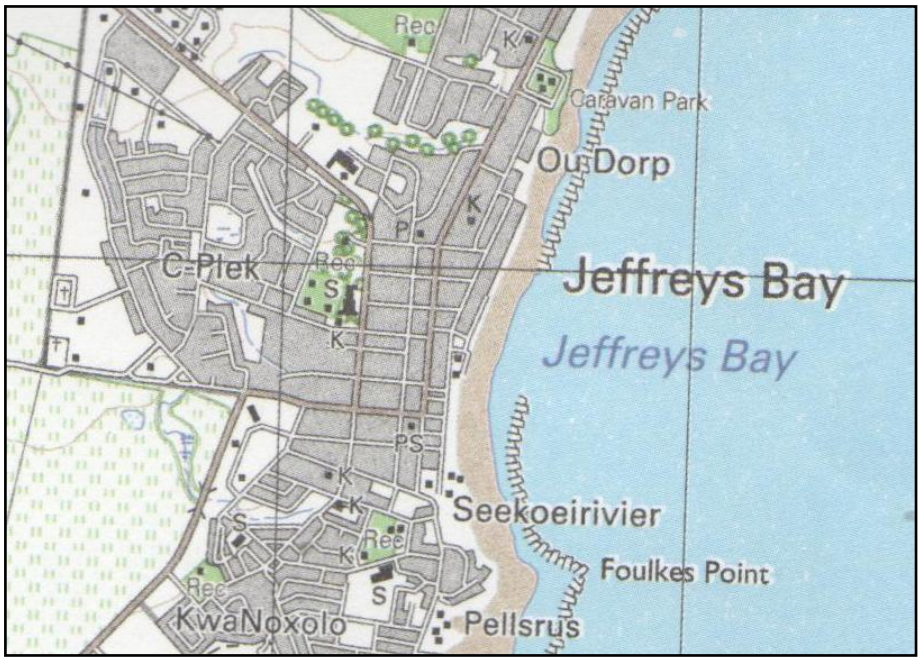


1.1 Urbanisation has a negative impact on rivers. How will buffering prevent the mismanagement of the Berg River? (2 x 2) (4)

Question 2:

The police have not been able to track a car hijacking gang in the greater Jeffreys Bay area. How can they use GIS to narrow their search? (2 x 2) (4)

Question 3:



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3.4 GIS allows us to use thematic layers on maps. Refer to the topographical map and name TWO layers of information that were used in compiling the topographical map of Humansdorp. (2 x 2) (4)

3.5 The Hip Hop Joint company wants to open a new store in Jeffreys Bay. Suggest TWO ways in which GIS can be used to assist with the location of the store. (2 x 2) (4)

Question 4:

4.1 Explain the meaning of the following terms

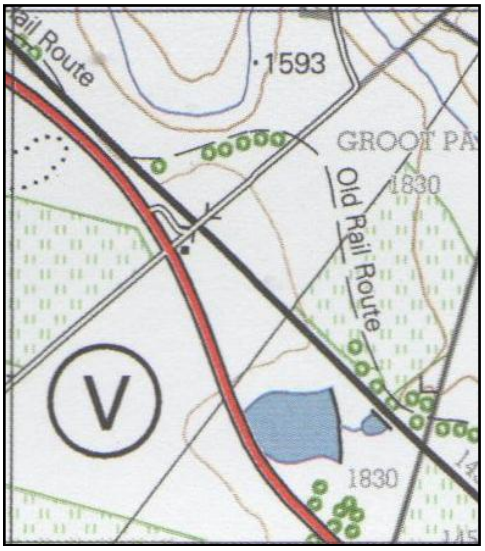
4.1.1 Remote sensing (1x2) (2)

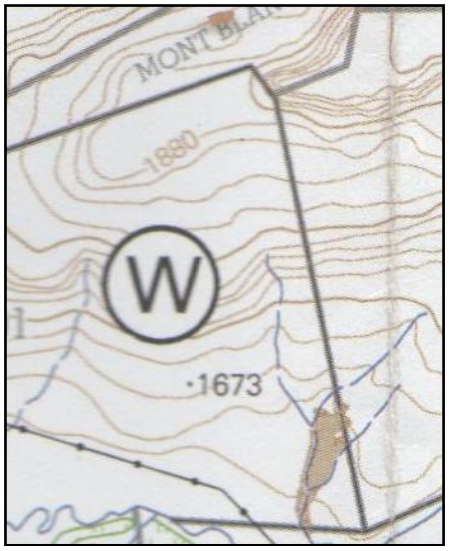
4.1.2 Spatial resolution (1x2) (2)

4.1.3 Data layering (1x2) (2)

4.2 Explain TWO uses of data layering in GIS. (2x2) (4)

4.3 You want to build a heavy industry and you are given a choice between area V in Block B3 and area W in Block F4. Which area would you choose. State two data layers you would use to make your decision. (3x2) (6)





4.4 Explain TWO ways why maps are important in any GIS (2x2) (4)

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SOLUTIONS TO X-ERCISE QUESTIONS

Question 1:

Indicates where no agriculture and industries can be located.
Prevent pollution from pesticides and industrial wastes being deposited.
Leaves areas clear for urban expansion.
Conserve natural areas / maintaining green belts.
[Any TWO of the above]

Question 2:

Check database to see if any clues left behind by the gang correspond with other crime scenes.
Check the crime scene and surroundings and see if there is a pattern.
Demarcate the areas within which the crime takes place.
Research the modus operandi of gangs that were involved in similar crimes
[Any TWO. Accept other reasonable answers.]

Question 3:

3.1
Infrastructure – rail links. Power lines.
Land use – industries, churches, hospitals, etc.
Relief Features – steepness of the land.
Vegetation – natural, cultivated.
Drainage – rivers, marches.
[Any TWO]

3.2
To determine the proximity of similar shops in the area.
Gives an idea of earning potential in the area.
Indicates population density of area.
Determine population demographics.
Indicates accessibility.
Can determine compatibility with other stores.
Determine crime levels.
Determine availability of open land.
[Any TWO. Accept any other reasonable answer]

Question 4:

4.1.1
Gathering information about the earth with any instrument used remotely from outer space.

4.1.2
Refers to the detail with which a map depicts the location.

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4.1.3
Putting information into layers.

4.2
Comparing information.
Analyzing sets of information.
Different sets of data can be compared.
Comparisons can assist with future developments.
(Any TWO – accept other suitable answers)

4.3
Area V.
Transport.
Water supply/dam.
Flat land.
(Any TWO data layers – accept other suitable answers)

4.4
Location is the common key that links all sets of data.
Every item of attribute data is linked to a map coordinate position.
(Any TWO – accept other suitable answers)

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TOPIC 1: MAP PROJECTIONS

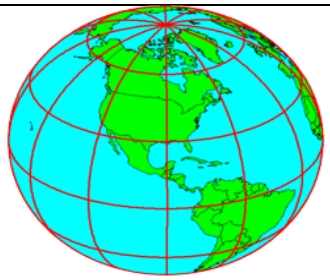
Learner Notes:

- Map projections can deal with a lot of complex detail and learners seem to find this very difficult and confusing.
- Learners need to know the basics of map projections. What is map projections, the convenience of using maps, the projection properties and distortions and the different projection classes and associated projections
- This section is hardly ever tested but it is the basis to understanding and appreciating the designing of maps.

X-PLANATION:

DEFINITION:
It is an attempt to portray the surface of the earth or a portion of the earth on a flat surface.

SHAPE OF THE EARTH:
We think of the earth as a sphere when it is actually an ellipsoid, slightly larger in radius at the equator than at the poles.

SPHERE	ELLIPSOID
	

Distance around equator = 40,075,452.7 m
Distance around pole to pole = 39,939,593.9 m

DIFFICULTIES ASSOCIATED WITH USING THE GLOBE TO DO MAPWORK:

- Globes are accurate but expensive
- Small scale and relatively little detail
- Bulky (transport and storage)
- Globe: perspective view
  (i.e. the view from a single point)
- Map: orthographic view
  (i.e. the view is directly overhead for all points)

PROJECTIONS PROPERTIES AND DISTORTIONS:

- Some distortions of **conformality, distance, direction, area** and **scale** always result from this process.

- Some projections minimize distortions in some of these properties at the expense of maximizing errors in others.
- Some projections are attempts to only moderately distort all of these properties.

PROJECTION PROPERTIES (1)
Conformality

- Shape is preserved locally on conformal maps.
- When the scale of a map at any point on the map is the same in any direction, the projection is conformal.
- Meridians (lines of longitude) and parallels (lines of latitude) intersect at right angles

PROJECTION PROPERTIES (2)
Equivalence

- Area is preserved.
- When a map portrays areas over the entire map so that all mapped areas have the same proportional relationship to the areas on the Earth that they represent, the map is an equal-area map.

PROJECTION PROPERTIES (3)
Equidistance

- A map is equidistant when it portrays distances from the center of the projection to any other place on the map.

Direction

- A map preserves direction when azimuths (angles from a point on a line to another point) are portrayed correctly in all directions.

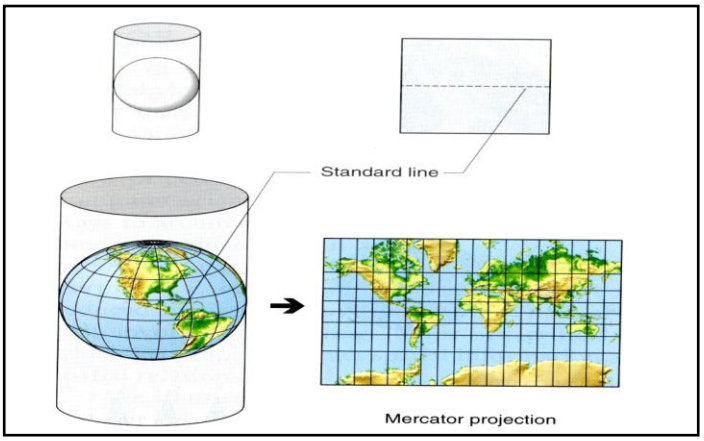
PROJECTION PROPERTIES (4)

- Most maps don't preserve ANY of the properties mentioned!
- This is because accuracy in one property causes distortion in the others
- Consequently, many maps are compromise projections, which don't preserve any of the properties but which don't make extreme distortion in any of the globe's properties either.

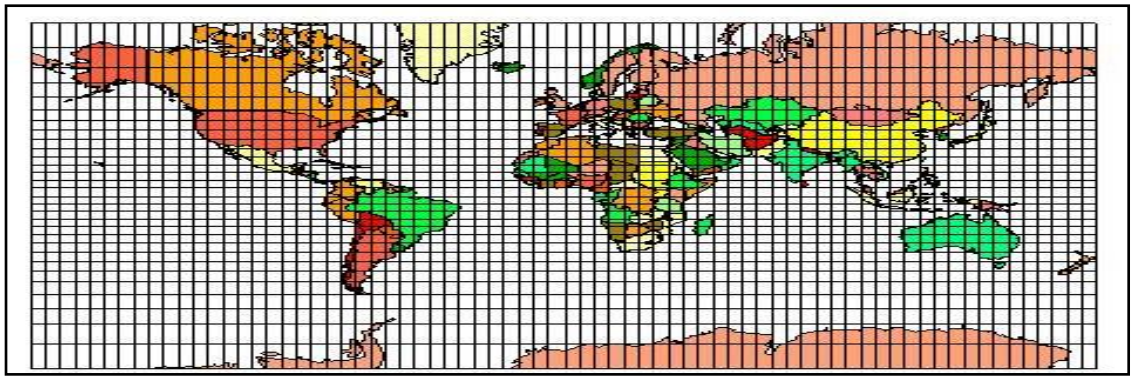
MAP PROJECTIONS CLASSES:
Refers to the different ways in which map projections are done

Cylindrical Projection:

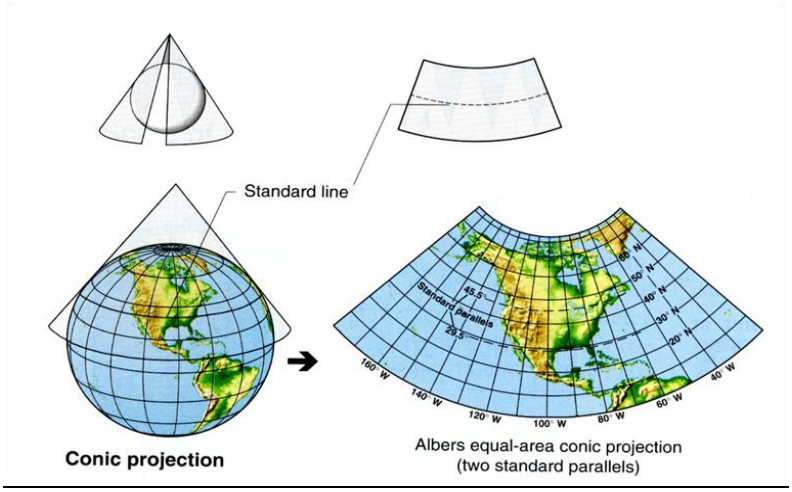
- Examples: Mercator Transverse Projection.
- Graticule: lines of latitude and longitude intersect at right angles



- Good for ***equatorial regions*** but greatly distorted at high latitudes.



Conic Projection:



- Example: Lambert Conformal Conic; Albers Equal Area Conic
- Lines of latitude arched; lines of longitude radiate outwards;
- Depicts shapes and areas well; good for East-West land areas.

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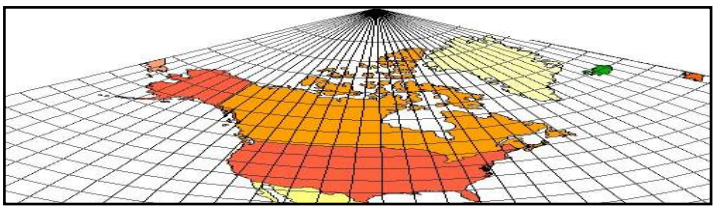
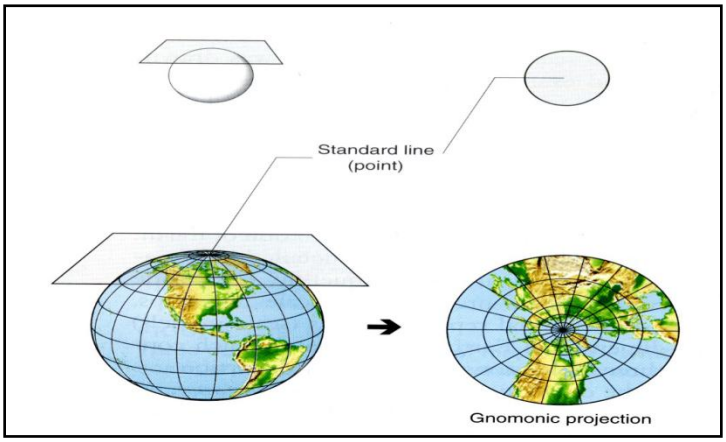
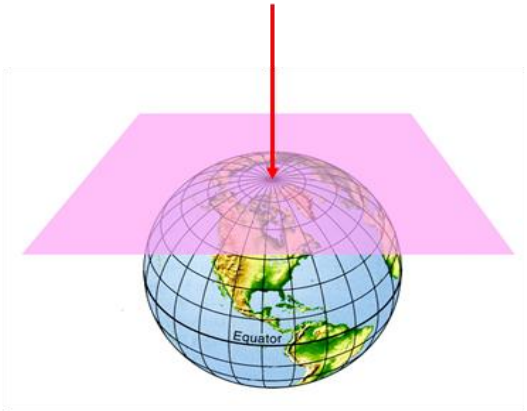


Azimuthal / Planer Projections:

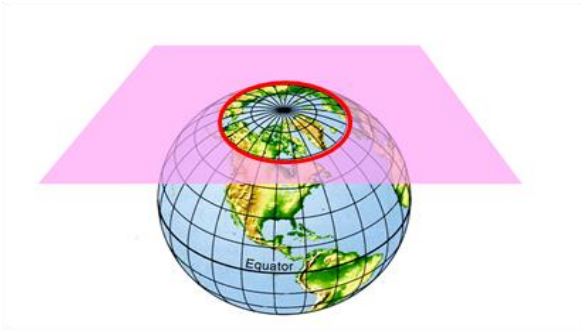


Tangent **Secant**

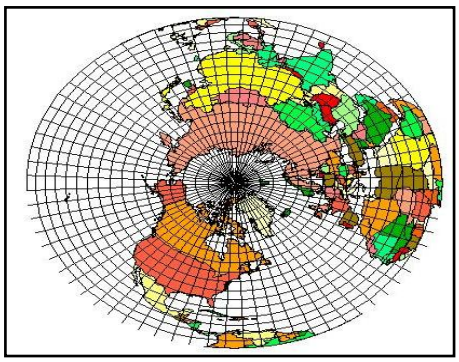
Standard point



Standard line (circle)



- Examples: Lambert's Equal Area Azimuthal
- Graticule: Lines of latitude circular; lines of longitude radiating out
- Good for ***polar regions***



Miscellaneous Projections:

Miscellaneous projections include unprojected ones such as rectangular latitude and longitude grids and other examples of that do not fall into the cylindrical, conic, or azimuthal categories.

X-AMPLE QUESTIONS:

Question 1:

Explain the term map projection.

Question 2:

State FOUR projection properties.

Question 3:

Explain the meaning of map projection classes.

Question 4:

Name THREE map projection classes and provide an example.

Question 5:

Refer to the figure below and answer the question that follows:

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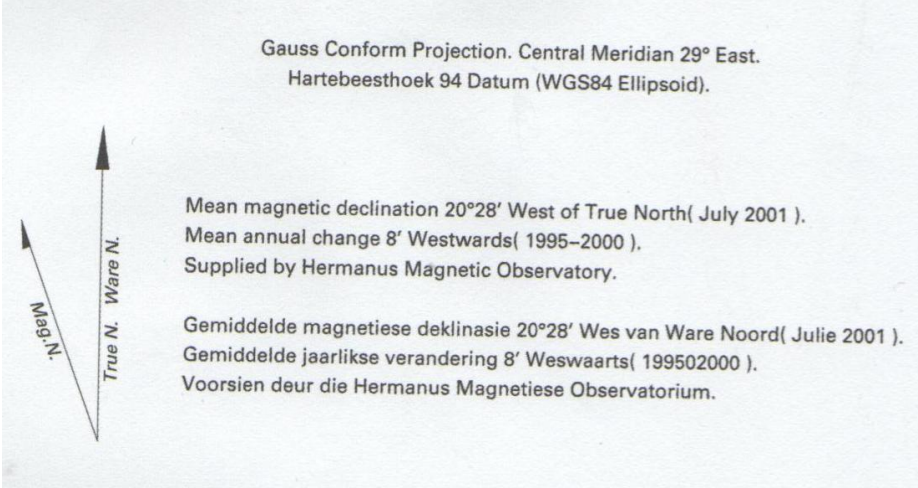

Name the projection that is used in South African topographic maps