

Name: David Tarboton

CEE 6930 GIS in Water Resources Midterm Quiz

Fall 2000

There are 5 questions on this exam. Please do all 5. They are of equal credit.
[20 points were awarded for each]

1. The ArcView Geographic Information System can display different types of data. Briefly **define** each data type and give **an example** of a data theme that would be presented in this way.

Feature Data

Discrete objects with precise shapes that can be in the form of points, lines and polygons. Examples include roads, rivers, point locations of sampling sites and raingages. [3 points]

Image Data

Data that is in an image or picture format encoded as a value representing a color or intensity over the domain. Examples include aerial photographs, surface temperature images, satellite images. [2 points]

Grid Data

This is similar to image. This is data that is represented by a value for each grid cell in a grid over the domain. Examples include grid digital elevation model data and information derived from these, such as flow directions and contributing area's. [3 points]

TIN Data

A Triangular Irregular Network data structure defines geographic space as a set of contiguous non overlapping triangles. The nodes are at irregularly spaced points. The triangulation represents values at each point in the domain through interpolation within the triangles. An example is digital elevation data from irregularly sampled points. [2 points]

Tabular Data

This is attribute data descriptive of geographic objects. The objects may be any of the data forms above and the table gives information about the data items. Generally each row in the table refers to a single item and columns or fields in the table represent different data object descriptors. An example might be a table associated with point raingages where fields contain the annual and monthly rainfall values. [2 points]

(b) Standardized data sources can be used as the basis of constructing a water resources base map for an area. Briefly describe the following data sources

Hydrologic Unit Code Watersheds

These are polygons representing watersheds delineated by the USGS. A hierarchical system is used whereby subwatersheds within a larger watershed have the same initial (prefix) unit code and differ in the right hand digits. [3 points]

EPA River Reaches

These are river reaches digitized off topographic maps and supplied by the EPA as part of the BASINS software. Reaches are encoded as shape files that in addition to the polyline representation of river paths also include considerable attribute information and reach connectivity information. [2 points]

How can these two data sources be combined to form the base map of a river basin?

The data sources can be imported into ArcView, added as themes to a View. Projection may be necessary to reconcile coordinate systems. HUC Watershed polygons can be used to select and clip the reach files to only those reaches within the watersheds of interest. The view can then be added to a layout with scale and other annotation to produce a base map. [3 points]

2. (a) A GIS analysis of a region of the United States involves a set of point data that have been supplied using latitude and longitude coordinate information as follows. The analyst studies the “Latitude” and “Longitude” fields and realizes that the values given are a combination of degrees minutes and seconds, DDMSS. For example, 352628 is actually 35° 26’ 28’’. Convert these points into the corresponding values in decimal degrees (LongDD, LatDD) to four decimal places.

Point	Longitude	Latitude	LongDD	LatDD
1	910011	352628	91.0031	35.4411
2	912020	354040	91.3389	35.6778
3	910804	352338	91.1344	35.3939
4	910940	352810	91.1611	35.4694
5	903204	361719	90.5344	36.2886

[9 points]

Method $\text{Decimal Degrees} = \text{Degrees} + \frac{\text{Minutes}}{60} + \frac{\text{Seconds}}{60 * 60}$

e.g. $91^{\circ}09'40'' = 91 + \frac{9}{60} + \frac{40}{60 * 60} = 91.1611$

(b) The analyst obtains a River Reach file whose projection coordinates are as follows:

```
Projection      ALBERS
Zunits          NO
Units           METERS
Spheroid        CLARKE1866
Xshift          0.0000000000
Yshift          0.0000000000
Parameters
  29 30 0.000 /* 1st standard parallel
  45 30 0.000 /* 2nd standard parallel
-96  0 0.000 /* central meridian
  23  0 0.000 /* latitude of projection's origin
0.00000 /* false easting (meters)
0.00000 /* false northing (meters)
```

What **map projection** and **earth datum** has been used for the River Reach data?

The map projection is an Albers projection. The earth datum is the Clarke 1866 Spheroid. This is also called the North American Datum 1927, or NAD27 datum.
[4 points]

What is the **latitude** and **longitude** of the origin of the coordinate system of these data?

Latitude: 23 °N

Longitude -96 ° or 96 °W

[2 points]

(c) Briefly explain how the two data sets (a) and (b) can be transformed into the same coordinate system so that they can be overlaid correctly.

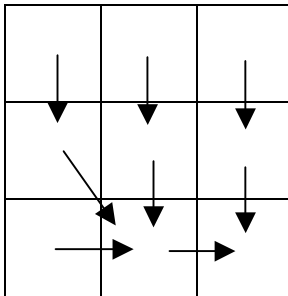
ArcView can most easily convert from geographic (latitude and longitude) coordinates to projected coordinates, so the approach would be to project dataset (a) into the projection of dataset (b). Add the data in dataset (a) as a theme into a new ArcView View. Then set the projection parameters (a view property) to the above. Then select the dataset and 'save' it via a command like 'convert to shapefile'. This will save the dataset in the projected units which can then be displayed together with dataset (b). For this to work correctly the dataset (a) needs to also be relative to the same earth datum. If dataset (a) is relative to a different datum (e.g. GRS80 rather than Clarke 1866) then a datum conversion would need to be performed. The Projection Utility can be used to perform datum conversions, or convert dataset (b) back to geographic coordinates (relative to a specific earth datum). This is much more tedious because the projection utility takes very long to start up.

[5 points]

3. Given the following grid of elevations

30	29	28
27	26	25
26	23	22

Determine the **flow direction grid** using the 8-direction pour point method. Indicate the flow direction by using an arrow in each cell.



Notes: To correctly assign edge flow directions one should really have information about elevations out of this domain. I constrained flows to within this domain except for the lowest point at the bottom right. Note also that flow is in the direction of steepest slope, which does not always correspond to the lowest elevation neighbor. For example for the top left cell

$$(30-26)/(100 \sqrt{2}) = 0.028$$

$$(30-27)/100 = 0.3$$

The steepest is to the cell with elevation 27 [7 points].

Determine the corresponding **flow accumulation grid**. Label each cell with the number of upstream cells draining into it.

0	0	0
1	1	1
0	5	8

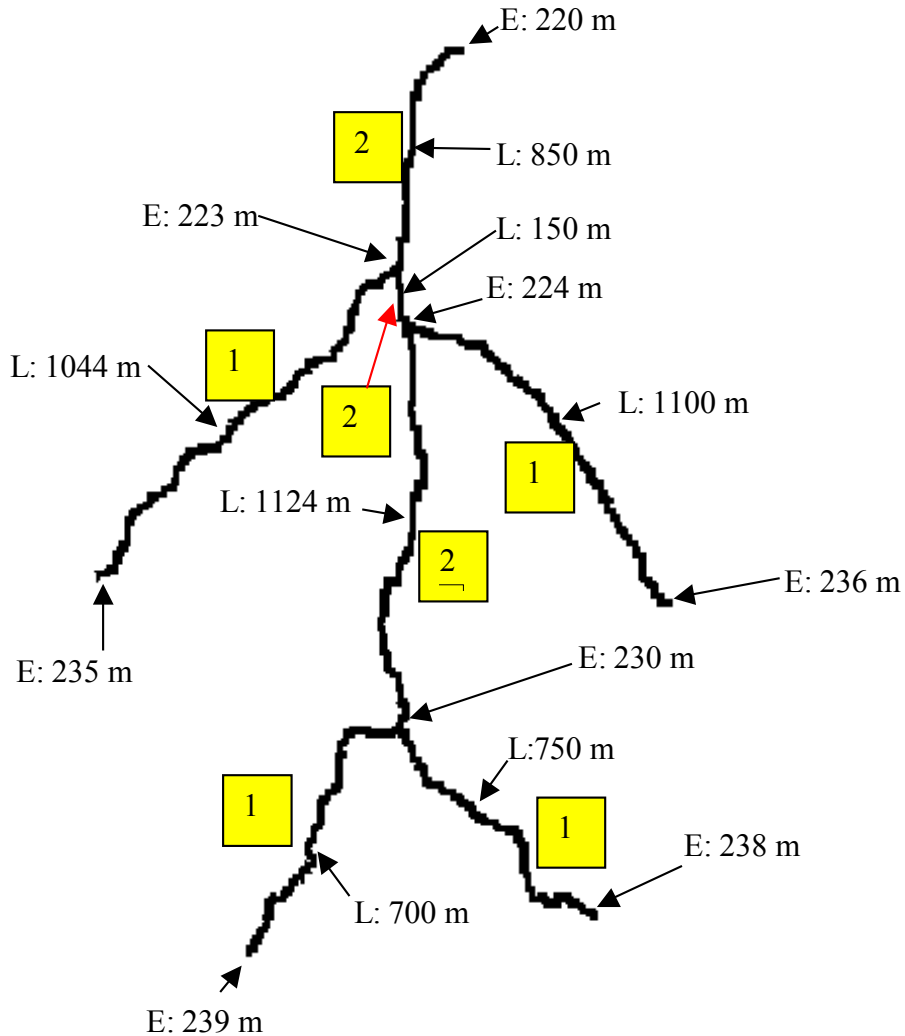
Note that here I have used the ESRI convention where the contributing area of the cell is not counted. This is the flow "into" the cell as the question asked. I prefer however the convention that represents flow accumulation including each cell itself. [6 points]

If these are 100m cells, the mean annual rainfall over this area is 500mm, and 20% of the rainfall becomes runoff, determine the mean annual runoff from this nine-cell area in m³/year.

There are 9 cells total. The total area is therefore $9 * 100 * 100 = 90,000 \text{ m}^2$.

Annual runoff = $90,000 * 0.5 * 0.2 = 9\ 000 \text{ m}^3/\text{yr}$. [6 points]

4. Consider the river network with elevations at junctions (denoted E:) and segment lengths (denoted L:) (both in meters) shown



- a) Identify and label on the drawing which of the 7 streams are first order and which are second order. **Order shown in shaded (yellow) boxes next to each stream segment.** [5 points]

- b) Determine the average stream drop for first order streams and second order streams. 4 first order streams having drops (difference between start and end elevations of) 9, 8, 12, 12 m. The average of these is **10.25 m**

One second order stream having drop of **10 m** (The second order stream is the sequence of three second order segments shown). [5 points]

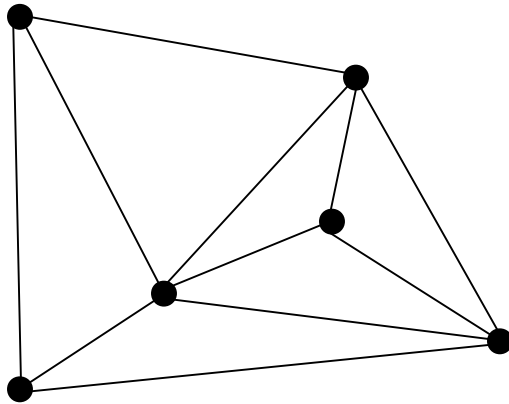
- c) Determine the drainage density. The total area drained by this watershed is 7.1 km^2 . The total length of the channel network shown is obtained by summing segment lengths as: $5718 \text{ m} = 5.718 \text{ km}$

Drainage Density = Length/Area = $5.718/7.1 = 0.805 \text{ km}^{-1}$ [5 points]

- d) Briefly explain the basis for deciding upon a support area threshold to define streams using the stream drop test.

Establish a support area threshold where stream drops of the first order streams are not significantly different, using a t test for the difference between means, from the stream drops of higher order streams. The smallest support area threshold that satisfies this will result in the highest resolution channel network consistent with this empirical geomorphological channel network property. [5 points]

5. A set of elevation points for an area has been obtained by aerial photogrammetry, as shown below. Construct a Delaunay triangulation of this area.



This is really tough to do in a test setting because drawing circumcircles is tedious and few carry around compasses these days. [5 points]

Briefly explain how to create a flood plain map using a Triangulated Irregular Network representation of the terrain surface and the HEC-RAS hydraulic model.

1. Delineate flow paths comprising river centerline, left and right banks and left and right flood plain paths. Digitize these as shapefiles in ArcView using the GEORAS extension
2. Digitize river cross section lines perpendicular to these flow paths.
3. Use GEORAS to export the elevation profiles based on the TIN elevations along these cross sections, and also along the flow lines to HEC RAS.
4. Use HEC HMS to model flood flows. For flood plain delineation the water surface profile is estimated assuming a number of preset flows at steady state.
5. Use HEC HMS inputs and run HEC RAS.
6. Export HEC RAS water surface elevations in GIS format and input to ArcView

7. Use the GEORAS extension to intersect the water surface elevation surface with the ground elevation surface to map the extent and depth of flooding. [5 points]

How can the discharge values be determined for the flood plain delineation?

Using HEC HMS [3 points]

If you wanted to describe quantitative information about the soils of a study area, what datasets could you draw on to obtain this information?

STATSGO, SSURGO or NATSGO [3 points]

Explain the relationship between a soil **map unit** and soil **components**.

A map unit is an area comprising one or more polygons. Soil components are the soil types within this area expressed as fractions or percentages. The spatial position of these soil components is not indicated. [4 points]