Conventional Paradigms of Hydrology

Watershed & Catchment Delineation

Contact information:
Jack Hermance
Environmental Geophysics/Conventional Paradigms of Hydrology
Department of Geological Sciences
Brown University, Providence, RI
02913-1846
Tel: 401-863-3830
e-mail: John.Hermance@Brown.Edu
© John F. Hermance
September 5, 2009

Selected Watersheds of the World
(From McKnight & Hess, 2008)

Topics for Watershed Delineation

What is a watershed?
How are they delineated?
Catchments and Reaches in GIS.
(An aside on creating DEMs.)

© John F. Hermance
September 5, 2009
Watershed: The area delivering water to a collection (outflow) point.

Delineating a Watershed (The “Paradigm”)

Guiding concept: Consider the surface of the watershed as an impermeable membrane draped over the earth’s surface.

A drop of water falling on any point within the watershed will flow downhill, perpendicular to local contours, along the local topographic gradient, eventually reaching the outflow point or basin outlet.
Plane view (2D) contoured map with colored “image” map.

The “drop” rolls down gradient.

Leaving the watershed.

Method for Type 1 (A Discrete Outflow “Point”):

Begin with topographic control (but expect local hydrogeologic controls).

Start at the outflow point of a given stream.

Draw the topographic divide at right angles to the stream, then at right angles to topographic contours.

Continue the trace until a point is reached above the headwaters of the stream network at an extremity from the beginning outflow point.
Trace the boundary up-gradient.

Hopefully, the two traces meet.

The watershed.

The "Clove" Watershed

Delineating a watershed or catchment area.
Watersheds
What are they?

Definition: Type 1. An area topographically (or hydrogeologically) defined that contributes all the water flowing through a “point” (or cross-section) of a particular stream.

Definition: Type 2. An area topographically (or hydrogeologically) defined that contributes all the water flowing to a particular locally-defined, closed area (such as a pond, reservoir, lake, valley, stream reach, etc.).

Synonyms:
- Watershed
- Drainage basin
- River basin
- Catchment

Method for Type 2 Watersheds (Distributed Collectors):
Begin with topographic control (but expect local hydrogeologic controls).
Start at a reference point on the distributed “collector” (such as a point on the shore of a lake).
Draw the topographic divide uphill at right angles to the shore, and to right angles to topographic contours.
Continue the trace “up-gradient” as far as you can to the point where topography inflects and goes “down-hill”.
Stop at this highest point. [The topographic gradient along this trace from the lake shore to this highest point should be everywhere positive (uphill) or zero. Else, … you’ve gone too far!]
Return to the lake shore and repeat the process for a point adjacent to the last one.
Continue this procedure along the distributed collector; then connect the extreme points of each trace to define the “watershed”.

Topographic "Divide"
(Catchments are usually defined by topographic “divides”.)

Application: Extent of recharge zone of a local reservoir.

Watershed: The area that delivers water to a distributed collection zone.
Continental Divide

Elevation from NA Hydro1k Gtopo30 DEM.


Regional Watersheds

Landcover classes (from remote sensing data)

The Continental Divide in terms of several principal basins.

Colorado R.
Mississippi R.
Río Grande R.
What comprises a watershed?
- Surface drainage area
- Associated soils
- Plants & animals
- Geologic formations
- Storage elements (specific and generic “reservoirs”)
- Lakes, ponds, aquifers, impounded reservoirs
- Outflow zone(s)
- Streams
- Subsurface flow (groundwater)
- Evaporation from the ground, plant or water surfaces
- Transpiration from plants
  - as well as
  - Cultural usage patterns: present, future, historic & prehistoric.

Creating Watershed Models
Digital Elevation Models (DEM’s): Produced by USGS from digitized topographic maps.

Example of a DEM data set (Thames River Basin)

<table>
<thead>
<tr>
<th>Actual Data</th>
<th>Format of X,Y,Z Triplets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Long</td>
</tr>
<tr>
<td>72.4955,41.3046,42</td>
<td>-72.4955</td>
</tr>
<tr>
<td>72.4874,41.3046,50</td>
<td>-72.4874</td>
</tr>
<tr>
<td>72.479,41.3046,37</td>
<td>-72.479</td>
</tr>
<tr>
<td>72.4584,41.3046,30</td>
<td>-72.4584</td>
</tr>
<tr>
<td>72.386,41.3046,37</td>
<td>-72.386</td>
</tr>
<tr>
<td>72.3402,41.3046,27</td>
<td>-72.3402</td>
</tr>
<tr>
<td>72.3269,41.3046,27</td>
<td>-72.3269</td>
</tr>
<tr>
<td>72.3164,41.3046,17</td>
<td>-72.3164</td>
</tr>
<tr>
<td>72.3053,41.3046,9</td>
<td>-72.3053</td>
</tr>
<tr>
<td>72.2446,41.3046,5</td>
<td>-72.2446</td>
</tr>
<tr>
<td>72.3382,41.3046,10</td>
<td>-72.3382</td>
</tr>
<tr>
<td>72.3278,41.3046,16</td>
<td>-72.3278</td>
</tr>
<tr>
<td>72.3131,41.3046,25</td>
<td>-72.3131</td>
</tr>
</tbody>
</table>

© John F. Hermance
September 5, 2009
Exercise: Trace the watershed.

The geologic watershed may differ from the topographic watershed.

And what do you do about "pods", "dimples" or depressions?

Important terms

*Divide:* The surface trace of the boundary that delimits a watershed.

Topographic divides versus Groundwater divides

*Drainage area:* The projection to a horizontal plane of the watershed, or subwatershed. (Not necessarily the “true” surface area of a watershed.)
Watersheds: The fundamental unit of Conventional Paradigms of Hydrology

Analogous to basic physics and chemistry, where the fundamental unit is the atom, in Conventional Paradigms of Hydrology the fundamental unit is the watershed.

Just as atoms are comprised of electrons, protons and neutrons, so are watersheds comprised of landforms, biota, streams, lakes and aquifers.

However, unlike atoms, where electrons, protons and neutrons can be pulled off and take on an activity of their own, in watersheds, a stream or an aquifer cannot be isolated from the other components.
Interpolation to a grid:
Begin with data.

Interpolation to a grid:
An example point.

Interpolation to a grid:
Triangular interpolation.

Discussion of pixelation.
30 meter raster.
Discussion of pixelation.
250 meter raster.

Discussion of pixelation.
One (1) km raster.