

# Minnesota LiDAR Research and Education Subcommittee<sup>1</sup>

## Glossary of LiDAR-related Terms

Last revised 02/26/2014

This glossary is intended as a reference for Minnesotans working with LiDAR data.

For additional definitions visit:

<http://www.dnr.state.mn.us/water/hydroterms.html>

<http://water.usgs.gov/wsc/glossary.html>

<http://lidar.cr.usgs.gov/>

<http://www.worldatlas.com/mapterms.htm>

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### Accuracy

The closeness of an estimated value (e.g., measured or computed) to a standard or accepted (true) value of a particular quantity. Note: With the exception of GPS Continuously Operating Reference Stations (CORS), assumed to be known with zero errors relative to established datums, the true locations of 3-D spatial coordinates or other points are not known, but only estimated. Therefore, the accuracy of other coordinate information is unknown and can only be estimated.

[http://www.nap.edu/openbook.php?record\\_id=11829&page=135](http://www.nap.edu/openbook.php?record_id=11829&page=135)

### ArcHydro

Arc Hydro is a geospatial and temporal data model for water resources designed to operate within ArcGIS (Maidment, 2003). As a data structure, the ArcHydro model links hydrologic data to water resource modeling and decision-making methods. Designed with the National Hydrography Dataset (NHD) in-mind, ArcHydro standardizes water data structures so that data can be used consistently and efficiently to solve water resource problems. As a toolset, ArcHydro works within ArcGIS Desktop to build and process ArcHydro-compliant datasets. Some key toolset features allow users to perform upstream/downstream tracing, watershed delineation, and development of hydrologically-conditioned DEMs.

ESRI. 2011. "ArcHydro: GIS for Water Resources." <http://www.esri.com/library/fliers/pdfs/archydro.pdf>  
Maidment, D. R., ed., 2003. *Arc Hydro: GIS for Water Resources*, ESRI Press, Redlands, Ca.

### Aspect

Identifies the downslope direction of the maximum rate of change in value from each cell to its neighbors. Aspect can be thought of as the slope direction.

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<sup>1</sup> [http://www.mngeo.state.mn.us/committee/elevation/research\\_education/index.html](http://www.mngeo.state.mn.us/committee/elevation/research_education/index.html)

<http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/009z000000vp000000.htm>

### **Bare Earth**

Digital elevation data of the terrain, free from vegetation, buildings, and other man-made structures.

*Digital Elevation Model Technologies and Applications: The DEM Users Manual (Appendix A and B), by the American Society for Photogrammetry and Remote Sensing, Bethesda, MD, 2001.*

### **Breakline**

A linear feature demarking a change in the smoothness or continuity of a surface such as abrupt elevation changes or a stream line. The two most common forms of breaklines are as follows:

#### **Soft Breakline**

Ensures that known elevations, or z-values, along a linear feature are maintained (e.g., elevations along a pipeline, road centerline or drainage ditch), and ensures the boundary of natural and man-made features on the Earth's surface are appropriately represented in the digital terrain data by use of linear features and polygon edges. They are generally synonymous with 3-D breaklines because they are depicted with series of x/y/z coordinates.

<http://www.ndep.gov/glossary.html>

#### **Hard Breakline**

Defines interruptions in surface smoothness, e.g., to define streams, shorelines, dams, ridges, building footprints, and other locations with abrupt surface changes. Although some hard breaklines are three dimensional (3-D) breaklines, they are often depicted as two dimensional (2-D) breaklines because features such as shorelines and building footprints are normally depicted with a series of horizontal coordinates only which are often digitized from digital orthophotographs that include no elevation data.

<http://www.ndep.gov/glossary.html>

### **Compound Topographic Index (CTI) (also called Topographic Wetness Index (TWI))**

One method of modeling hydrology or catchment to represent soil water content (Moore et al 1991:11). CTI focuses on the relationship of slope and runoff. A CTI value is a secondary topographic attribute, or compound index calculated using a complex of primary topographic attributes (e.g. slope and aspect).

$$CTI = \ln ( A_s / \tan\beta)$$

Where **A** is the specific catchment area and  $\beta$  is the slope in degrees.

[http://www.personal.psu.edu/mxb74/blogs/margarets\\_blog/2010/11/learning-about-compound-topographic-index-cti.html](http://www.personal.psu.edu/mxb74/blogs/margarets_blog/2010/11/learning-about-compound-topographic-index-cti.html)

### **Contours**

Lines of equal elevation on a surface. An imaginary line on the ground, all points of which are at the same elevation above or below a specified reference surface.

[http://resources.esri.com/help/9.3/arcgisdesktop/com/gp\\_toolref/geoprocessing/surface\\_creation\\_and\\_analysis.htm](http://resources.esri.com/help/9.3/arcgisdesktop/com/gp_toolref/geoprocessing/surface_creation_and_analysis.htm)

### **Datum**

In surveying or geomatics, this is a set of spatial coordinates that are used as a reference for measuring other locations. The state standard for Minnesota for the horizontal datum (i.e., coordinate system in which horizontal control points are located) is the North American Datum of 1983 (NAD 83) and the vertical datum (i.e., set of constants defining a height system) is the North American Vertical Datum of 1988 (NAVD 88).

<http://www.ngs.noaa.gov/faq.shtm>

### **DEM (Digital Elevation Model)**

An elevation model of the bare earth surface created for use in computer software having regularly spaced horizontal grid cells (x and y) and an associated vertical (z) value representing elevation for each cell.

[http://en.wikipedia.org/wiki/Digital\\_elevation\\_model](http://en.wikipedia.org/wiki/Digital_elevation_model)

### **DSM (Digital Surface Model)**

An elevation model created for use in computer software that is similar to DEMs or DTMs, except that DSMs depict the elevations of the top surfaces of buildings, trees, towers, and other features elevated above the bare earth.

[http://en.wikipedia.org/wiki/Digital\\_elevation\\_model](http://en.wikipedia.org/wiki/Digital_elevation_model)

### **DTM (Digital Terrain Model)**

An elevation model created for use in computer software utilizing bare-earth mass points and breaklines. DTMs are technically superior to a gridded DEM for many applications because a) distinctive terrain features are more clearly defined and well as

precisely located, and b) contours generated from DTMs more closely approximate the real shape of the terrain.

[http://en.wikipedia.org/wiki/Digital\\_elevation\\_model](http://en.wikipedia.org/wiki/Digital_elevation_model)

### **DFIRM (Digital Flood Insurance Rate Map)**

The newest rendition of FIRM map (see FIRM, below) that depicts flood risk information and supporting data used to develop the risk data.

<http://www.fema.gov/hazard/map/firm.shtm>

### **ESRI Terrain**

A dataset format to efficiently organize, catalog, edit, and generate high accuracy 3-D spatial data products.

<http://support.esri.com/en/knowledgebase/Gisdictionary/term/terrain>

### **Fill**

In the GIS field, referring to a procedure where the elevation of depressions in a digital elevation model are raised to an elevation equal to the lowest surrounding elevation, such that flow routing for these depressions becomes connected to the rest of the digital elevation model.

<http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=Fill>

### **Filter**

A process that moves a “window” across an entire raster, comparing cells to other cells. Filters can enhance edges, thereby isolating features, or diminish edges, thus smoothing them.

<http://webhelp.esri.com/arcgisdesktop/9.2/body.cfm?tocVisible=1&ID=5875&TopicName=Using%20the%20convolution%20filter%20process>

### **FIRM (Flood Insurance Rate Map)**

An official map of a community on which FEMA has delineated the flood hazard areas and the risk premium zones.

<http://www.fema.gov/hazard/map/firm.shtm>

### **Flow Accumulation (catchment area, upslope contributing area)**

Summing the flow from the number of cells from which water flows to a single cell.

<http://md.water.usgs.gov/posters/flowGIS/index.html>

### **Flow Direction**

The direction a fluid will move between raster cells.

[http://resources.esri.com/help/9.3/arcgisdesktop/com/gp\\_toolref/geoprocessing/surface\\_creation\\_and\\_analysis.htm](http://resources.esri.com/help/9.3/arcgisdesktop/com/gp_toolref/geoprocessing/surface_creation_and_analysis.htm)

### **Flow Routing**

In hydrology, a procedure to determine the time and magnitude of flow at a point on a watercourse from known or assumed hydrographs at one or more points upstream. In the GIS field, this more commonly refers to the procedure used to determine the flow direction for each grid cell based on the slope of a digital elevation model.

<http://water.usgs.gov/wsc/glossary.html>

### **GIS (Geographic Information System)**

Integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.

<http://www.gis.com/content/what-gis>

### **GPS (Global Positioning System)**

Technology that computes time and a three-dimensional position in space, for example the LIDAR sensor, using satellites.

*Digital Elevation Model Technologies and Applications: The DEM Users Manual (Appendix A and B), by the American Society for Photogrammetry and Remote Sensing, Bethesda, MD, 2001.*

### **Grid**

One of many data structures commonly used to represent geographic entities. A raster based data structure composed of square cells of equal size arranged in columns and rows.

<http://www.gis.unbc.ca/help/glossary.php>

## Hydro-flattening

The process of defining water bodies (most often using breaklines) and reclassifying all cells within their boundaries, as a single elevation.

[https://lidarbb.cr.usgs.gov/USGS-NGP%20Lidar%20Guidelines%20and%20Base%20Specification%20v13\(ILMF\).pdf](https://lidarbb.cr.usgs.gov/USGS-NGP%20Lidar%20Guidelines%20and%20Base%20Specification%20v13(ILMF).pdf)

## Hydrologic Conditioning

The process of modifying the elevation values in a DEM through raster processing and or interpolation to make the DEM more suitable for most hydrologic analyses. The modification process typically involves breaching digital dams (lowering the outlet) and elevating user-defined sinks to ensure that water flow paths are accurately represented in the conditioned DEM. Hydrologic conditioning is sometimes referred to as hydrologic correction and DEM drainage enforcement. However, the MN LiDAR Research and Education Subcommittee of the Minnesota Digital Elevation Committee has indicated that “hydrologic conditioning” is the preferred term for this type of DEM modification.

[Minnesota LiDAR Research and Elevation Subcommittee, 2012](#)

## Hydrologic Enforcement

Processing of mapped water bodies so that lakes and reservoirs are level and so that streams flow downhill. For example, a DEM, TIN or topographic contour dataset with elevations removed from the tops of selected drainage structures (bridges and culverts) so as to depict the terrain under those structures. Hydro-enforcement enables hydrologic and hydraulic models to depict water flowing under these structures, rather than appearing in the computer model to be dammed by them because of road deck elevations higher than the water levels.

<http://lidar.cr.usgs.gov/USGS-NGP%20Lidar%20Guidelines%20and%20Base%20Specification%20v13%28ILMF%29.pdf>

## Hydraulic

Of, involving, moved by, or operated by a fluid, especially water, under pressure.

[http://www.cawater-info.net/bk/glossary/water\\_management/en/h.htm](http://www.cawater-info.net/bk/glossary/water_management/en/h.htm)

## H&H (Hydrologic and Hydraulic)

The modeling of rainfall runoff (hydrology), providing peak discharges, and the resulting flow within a channel (hydraulics), which provides a profile of water surface elevations. Digital elevation data are used for H&H analyses.

*Digital Elevation Model Technologies and Applications: The DEM Users Manual (Appendix A and B), by the American Society for Photogrammetry and Remote Sensing, Bethesda, MD, 2001.*

### **Hillshade/Shaded Relief**

A function used to create an illuminated representation of a DEM surface, using a hypothetical light source, to enhance visualization effects.

*Digital Elevation Model Technologies and Applications: The DEM Users Manual (Appendix A and B), by the American Society for Photogrammetry and Remote Sensing, Bethesda, MD, 2001.*

### **IMU (Inertial Measurement Unit)**

Technology that computes the roll, pitch, and heading of a moving object, for example a LIDAR sensor.

*Digital Elevation Model Technologies and Applications: The DEM Users Manual (Appendix A and B), by the American Society for Photogrammetry and Remote Sensing, Bethesda, MD, 2001*

### **Intensity Image**

Intensity values of are a measure of the laser return signal strength. They are relative rather than absolute and vary with altitude, atmospheric conditions, directional reflectance properties, and the reflectivity of the target. Because of this, the process of creating images from LiDAR intensity data requires the exercise of judgment.

LiDAR intensity data can be particularly effective for impervious surface mapping.

<http://www.esri.com/news/arcuser/0103/lidar.html>

<http://www.cnrhome.uidaho.edu/default.aspx?pid=90302>

### **Landform Classification**

Topographic Positional Index (TPI) values calculated from several neighborhood sizes provide more information about the general shape of the landscape than TPI values from a single neighborhood . . . more complex landscape features can be identified by combining TPI grids generated at different scales.

<http://scialert.net/fulltext/?doi=jas.2008.910.921>

### **LAS**

A public file format for the interchange of LIDAR data. Las is a binary file format that maintains information specific to the LIDAR nature of the data while not being overly complex or large.

[http://www.asprs.org/a/society/committees/standards/lidar\\_exchange\\_format.html](http://www.asprs.org/a/society/committees/standards/lidar_exchange_format.html)

## **LAZ**

A compressed LAS file. LAZ files can be 80% smaller filesize than the original LAS, making them ideal for data transfer and download. LAZ files are easily uncompressed using the Lastools – laszip utility.

[http://www.asprs.org/a/society/committees/standards/lidar\\_exchange\\_format.html](http://www.asprs.org/a/society/committees/standards/lidar_exchange_format.html)

## **LIDAR (Light Detection and Ranging)**

A system for measuring the location of a reflecting object by emitting timed pulses of laser light and measuring the time between emission and reception of reflected pulses. The measured time interval is converted to distance. LiDAR systems commonly incorporate GPS and IMU components, so that the location of these reflecting objects can be calculated from the known location of the LiDAR unit and the distance measured from the laser pulse.

*Digital Elevation Model Technologies and Applications: The DEM Users Manual (Appendix A and B), by the American Society for Photogrammetry and Remote Sensing, Bethesda, MD, 2001.*

## **LiDAR Intensity**

The energy amplitude pertaining to each return. Surfaces of like types reflect like intensities. Contrast is typically more pronounced in LiDAR intensity data than in others types of imagery, making it useful for automating land cover mapping and identifying impervious surfaces.

<http://www.ndep.gov/glossary.html>

## **LiDAR Returns**

Reflected energy recorded at precisely referenced points in time. Also called “points”.

<http://www.ndep.gov/glossary.html>

## **LiDAR Preliminary Processing**

Steps taken to prepare LiDAR data for visualization, analysis, modeling, and cartographic representation. Steps include: filtering for noise, corrected through the global positioning system survey, and converting to local referenced coordinate system.

<http://gis.mapsofworld.com/lidar/lidar-data-processing.html>

## **LiDAR Post-Processing**

Steps taken to derive final products like DEM (Digital Elevation Model), DTM (Digital Terrain Model), TIN (Triangulated Irregular Network), breaklines, and contours. Post-

processing steps include tiling data, classification, filtering (bare earth, buildings, vegetation), and pyramiding.

<http://gis.mapsofworld.com/lidar/lidar-data-processing.html>

### Mass Points

A dataset of irregularly spaced points, each with x (latitude), y (longitude), and z (elevation) values typically used to form a TIN.

[Minnesota LiDAR Research and Education Subcommittee, 2012](#)

### Peak

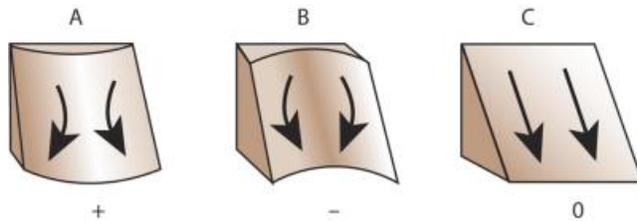
1. [geography] The highest point of a mountain or hill.
2. [modeling] In modeling, a point on a surface around which slopes are negative.



<http://support.esri.com/en/knowledgebase/GISDictionary/search>

### Plan Curvature

Planform curvature (commonly called plan curvature) is measured perpendicular to the direction of the maximum slope. A positive value indicates the surface is sidewardly convex at that cell. A negative plan indicates the surface is sidewardly concave at that cell. A value of zero indicates the surface is linear



ESRI. 2010. "Understanding Curvature Rasters"

<http://blogs.esri.com/esri/arcgis/2010/10/27/understanding-curvature-rasters/>

### Point Cloud

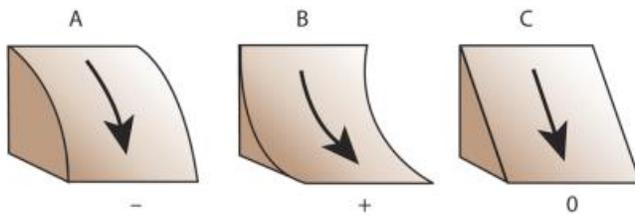
A Raw LiDAR Dataset comprised of the x, y, and z coordinates from all first, intermediate, and last returns from each laser pulse.

[Minnesota LiDAR Research and Education Subcommittee, 2012](#)

### Profile Curvature

Profile curvature is parallel to the direction of the maximum slope. A negative value indicates that the surface is upwardly convex at that cell. A positive profile indicates that

the surface is upwardly concave at that cell. A value of zero indicates that the surface is linear. Profile curvature affects the acceleration or deceleration of flow across the surface.



ESRI. 2010. "Understanding Curvature Rasters."

<http://blogs.esri.com/esri/arcgis/2010/10/27/understanding-curvature-rasters/>

### **Pour Point**

The boundary cell with the lowest elevation for the contributing area of a sink or a catchment. If the sink were filled with water, the Pour Point is where water would leave the sink.

<http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=Fill>

### **Pre-processing**

Steps to prepare a spatial dataset for processing, modeling, analysis, and cartographic representation. The need for preprocessing is based upon the quality of the initial DEM. Some amount of preprocessing is almost always required of DEMs before they are used in hydrologic and hydraulic modeling.

<http://gis.mapsofworld.com/lidar/lidar-data-processing.html>

### **Projection**

A method by which the curved surface of the earth is portrayed on a flat surface. This generally requires a systematic mathematical transformation of the earth's graticule of lines of longitude and latitude onto a plane. Some projections can be visualized as a transparent globe with a light bulb at its center (though not all projections emanate from the globe's center) casting lines of latitude and longitude onto a sheet of paper. Generally, the paper is either flat and placed tangent to the globe (a planar or azimuthal projection) or formed into a cone or cylinder and placed over the globe (cylindrical and conical projections). Every map projection distorts distance, area, shape, direction, or some combination thereof.

<http://support.esri.com/en/knowledgebase/Gisdictionary/term/projection>

### **Raster**

A spatial data model that defines space as an array of equally sized cells arranged in rows and columns, and composed of single or multiple bands. Each cell contains an attribute value and location coordinates. Unlike a vector structure, which stores coordinates explicitly, raster coordinates are contained in the ordering of the matrix. Groups of cells that share the same value represent the same type of geographic feature.

<http://support.esri.com/en/knowledgebase/Gisdictionary/term/raster>

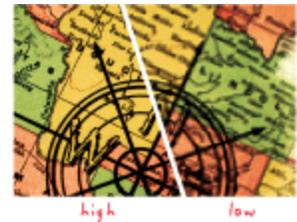
## Raw

Unfiltered, unprocessed LiDAR data containing x, y, z coordinates as well as other collection information.

[Minnesota LiDAR Research and Education Subcommittee, 2012](#)

## Resolution

1. [cartography] The detail with which a map depicts the location and shape of geographic features. The larger the map scale, the higher the possible resolution. As scale decreases, resolution diminishes and feature boundaries must be smoothed, simplified, or not shown at all; for example, small areas may have to be represented as points.
2. [graphics (computing)] The dimensions represented by each cell or pixel in a raster.
3. [graphics (computing)] The smallest spacing between two display elements, expressed as dots per inch, pixels per line, or lines per millimeter.



<http://support.esri.com/en/knowledgebase/GISDictionary/search>

## RMSE (Root Mean Square Error)

The square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points. A measure often used to determine the vertical accuracy of a LiDAR dataset.

*Digital Elevation Model Technologies and Applications: The DEM Users Manual (Appendix A and B), by the American Society for Photogrammetry and Remote Sensing, Bethesda, MD, 2001*

## Slope

Calculates the maximum rate of change in value from a cell to its neighbors. It hereby

identifies the steepest downhill descent from a cell to neighboring cells. Slope can be used to describe overland and subsurface flow velocity and runoff rate.

<http://webhelp.esri.com/arcgisdesktop/9.2/body.cfm?tocVisible=0&ID=1&TopicName=How%20Slope%20works>

### **Slope Position Classification**

Topographic Positional Index (TPI) values can be used to classify the landscape into slope position classes based on how extreme the TPI values are and by the slope at each point. Logically, high TPI values are found near the tops of hills while low TPI values are found in valley bottoms. TPI values near 0 are found on either flat ground or somewhere mid-slope.

<http://scialert.net/fulltext/?doi=jas.2008.910.921>

### **Sink**

A cell or set of spatially connected cells whose flow direction cannot be assigned to a valid value in a flow direction raster. This can occur when all neighboring cells are higher than the processing cell or when two cells flow into each other, creating a two-cell loop. The identification and removal of sinks when creating a depressionless DEM is an iterative process. It is sometimes referred to as "Pit".

<http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//009z00000065000000.htm>

### **Smoothing**

A process of "smoothing" numerical data by considering the neighboring values. Normally this is done by averaging the neighboring cell values that surround a target cell. Smoothing is typically applied to elevation data to remove noise prior to contour creation.

[http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?id=4731&pid=4714&topicname=Generalizing\\_and\\_smoothing\\_features\\_and\\_edges](http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?id=4731&pid=4714&topicname=Generalizing_and_smoothing_features_and_edges)

### **Spatial Interpolation**

Used to estimate a value of a variable at an unsampled location from measurements made at other locations. Spatial interpolation is based on the notion that points which are close together in space tend to have similar value attributes, known as positive spatial autocorrelation.

<http://www.uiowa.edu/~geog/health/index9.html>

### **Specific Catchment Area**

The upslope area per unit width of contour,  $L$ , ( $a = A/L$ ) (Moore et al., 1991) is a distributed

quantity that has important hydrological, geomorphological and geological significance (Tarboton, 1997).

In terrain modeling the specific catchment area is typically taken as the number of upstream grid cells times the grid cell area and divided by the grid cell width. For calculation purposes, Specific Catchment Area would then be the flow accumulation multiplied by the grid cell size.

<http://env.uregina.ca/pesticide/PMM/Runoff.htm>

### Stream Burning

Use of an algorithm to ensure that flow is forced to those cells that correspond to the true locations of streams. “Burns” (excavates) new channels into the DEM to force alignment and improve hydrologic and hydraulic modeling.

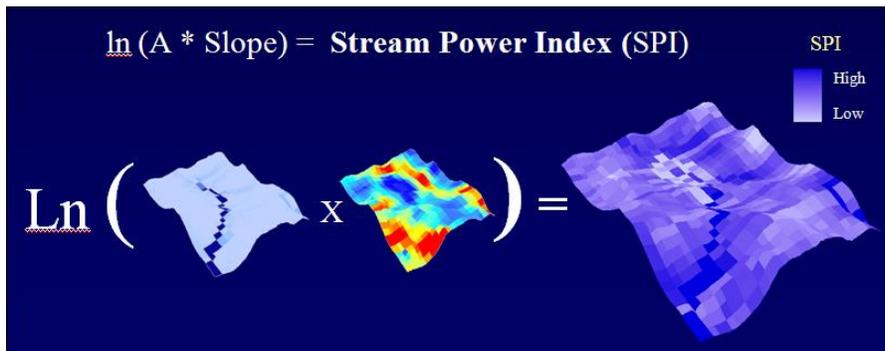
[www.ce.utexas.edu/prof/maidment/giswr2002/visual/DEM.ppt](http://www.ce.utexas.edu/prof/maidment/giswr2002/visual/DEM.ppt)

### Stream Power Index

Stream Power Index (SPI) is a secondary terrain attribute that measures the erosive power of flowing water. This measure is based on the assumption that discharge is proportional to specific catchment area. (Wilson and Gallant, 2000).

$$\text{SPI} = \ln ( A_s * \tan\beta )$$

Where  $A_s$  is the specific catchment area and  $\beta$  is the slope in degrees.



Galzki, J.C., A.S. Birr, and D.J. Mulla. 2011. Identifying critical agricultural areas with three-meter LiDAR elevation data for precision conservation. *Journal of Soil and Water Conservation* 66(6):423 - 430.

[http://www.gitta.info/TerrainAnalyi/en/html/HydroloAppls\\_learningObject4.html](http://www.gitta.info/TerrainAnalyi/en/html/HydroloAppls_learningObject4.html)

### Surface (also Terrain)

An area of land having a particular characteristic, such as sandy terrain or mountainous terrain.

<http://support.esri.com/en/knowledgebase/Gisdictionary/term/terrain>

### **Terrain (see also ESRI terrain)**

The characteristic features of a land surface: landforms, elevation, rocks, soils, and vegetation. Terrain defines a particular region or area. Terrain data can be represented by numerous LiDAR-derived products.

<http://support.esri.com/en/knowledgebase/Gisdictionary/term/terrain>

### **Terrain Analysis**

Use of remote sensing data for mapping, analyzing, and interpretation of geographic information on the natural and man-made features of the terrain often utilized in land use planning, forest site assessment, wildlife habitat, water quality and soil conservation management.

GIS software may be applied to derive primary and secondary terrain attributes to describe the morphology of the landscape and the influence of topography on environmental processes.

<http://www.ars.usda.gov/>

### **Terrain Attributes**

Primary terrain attributes such as slope, aspect and flow accumulation are calculated directly from elevation data. Secondary terrain attributes involve combinations of primary attributes and are indices that describe the spatial variability of specific process occurring in the landscape such as the potential for sheet erosion. Examples are the stream power index and the wetness index.

<http://www.ars.usda.gov/>

### **Topographic Position Index (TPI)**

Topographic Position Index is the difference between the elevation at a cell and the average elevation in a neighborhood surrounding that cell. Positive values indicate that the cell is higher than its neighbors while negative values indicate the cell is lower. TPI is a simplification of the Landscape Position Index described by Fels and Zobel (1995) and was developed in detail by Weiss (2001). TPI values provide a simple and powerful means to classify the landscape into morphological classes\* (Jenness, 2005).

\*Morphological classes include slope position i.e. ridge top, valley bottom, mid-slope; and landform category i.e. steep narrow canyons, gentle valleys, plains, open slopes, mesas, etc.).

<http://scialert.net/fulltext/?doi=jas.2008.910.921>

## Topography

The study of Earth's surface shape and features or the surface shape and features of other celestial bodies. It is also the description of such surface shapes and features (especially their depiction in maps).

<http://en.wikipedia.org/wiki/Topographical>

## Triangulated Irregular Network (TIN)

A set of adjacent, non-overlapping triangles computed from irregularly-spaced points with latitude, longitude, and elevation values. The TIN data structure is based on irregularly-spaced point, line, and polygon data interpreted as mass points and breaklines. It stores the topological relationship between triangles and their adjacent neighbors. A TIN may be preferable to a DEM when it is critical to preserve the precise location of narrow or small features, such as levees, ditch or stream centerlines, isolated peaks, or pits in the data model.

*Digital Elevation Model Technologies and Applications: The DEM Users Manual (Appendix A and B)*, by the American Society for Photogrammetry and Remote Sensing, Bethesda, MD, 2001

## Vector

Geographic representation of spatial features as points, lines, and polygons. Each geometry is linked to a row in a database that describes their attributes. Vector data can also be used to represent continuously varying phenomena. Contour lines and triangulated irregular networks (TIN) are used to represent elevation or other continuously changing values. TINs record values at point locations, which are connected by lines to form an irregular mesh of triangles. The face of the triangles represent the terrain surface.

<http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//003n00000005000000>

## Vegetation Removal

Correction of surface elevations so as to depict the elevation of the bare earth terrain beneath the vegetation and man-made structures.

*Digital Elevation Model Technologies and Applications: The DEM Users Manual (Appendix A and B)*, by the American Society for Photogrammetry and Remote Sensing, Bethesda, MD, 2001

## Voids

Portions of a digital elevation dataset where no elevation data are available.

*Digital Elevation Model Technologies and Applications: The DEM Users Manual (Appendix A and B)*, by the American Society for Photogrammetry and Remote Sensing, Bethesda, MD, 2001

**Water Surface Profile**

A measure of how the flow depth changes longitudinally.

<http://water.usgs.gov/wsc/glossary.html>

**Z-Values**

The elevations of the 3-D surface above the vertical datum at designated x/y locations.

[http://www.nap.edu/openbook.php?record\\_id=11829&page=135](http://www.nap.edu/openbook.php?record_id=11829&page=135)