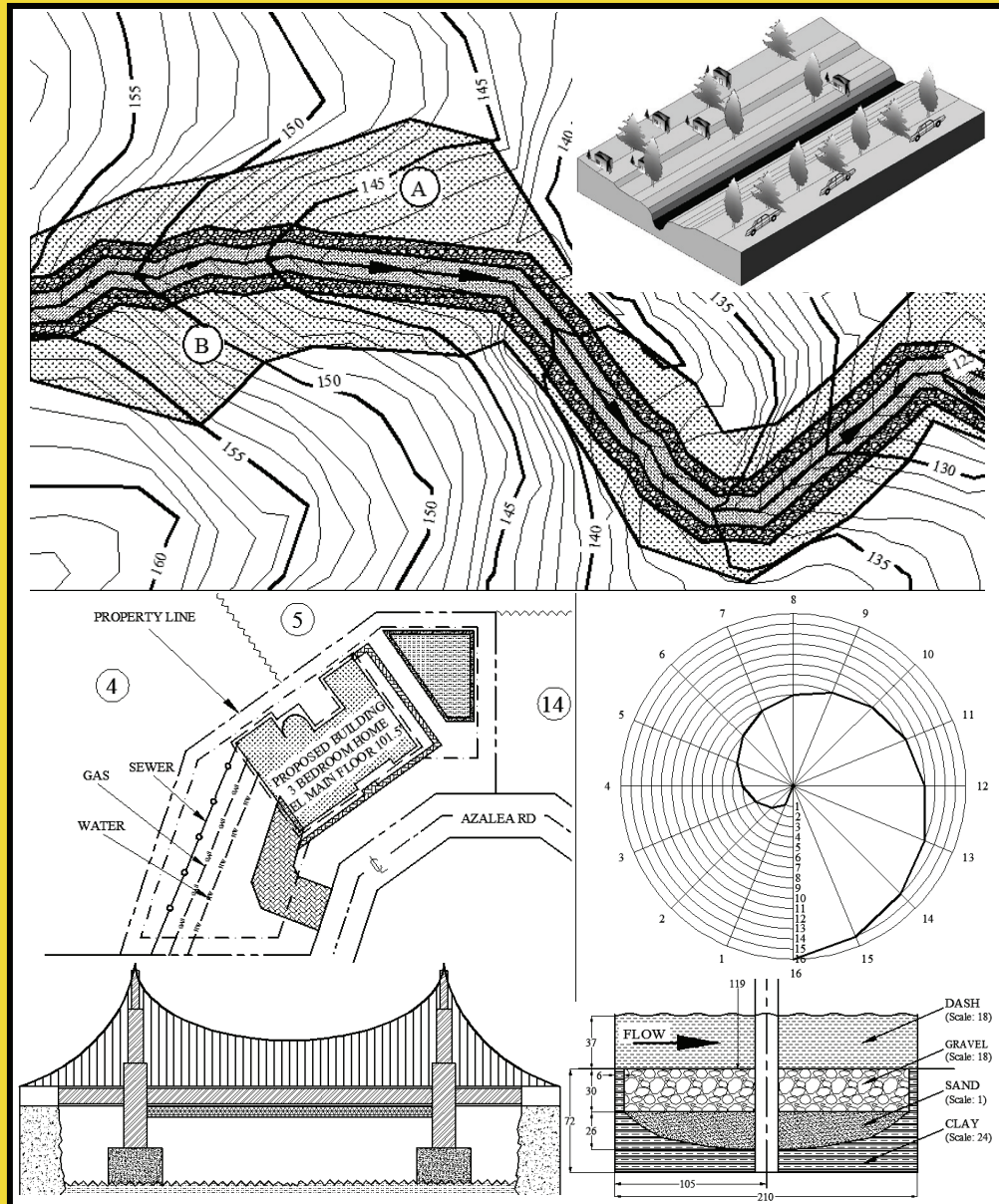# Introduction to AutoCAD 2012 for
Civil Engineering Applications

Learning to use AutoCAD for Civil Engineering Projects

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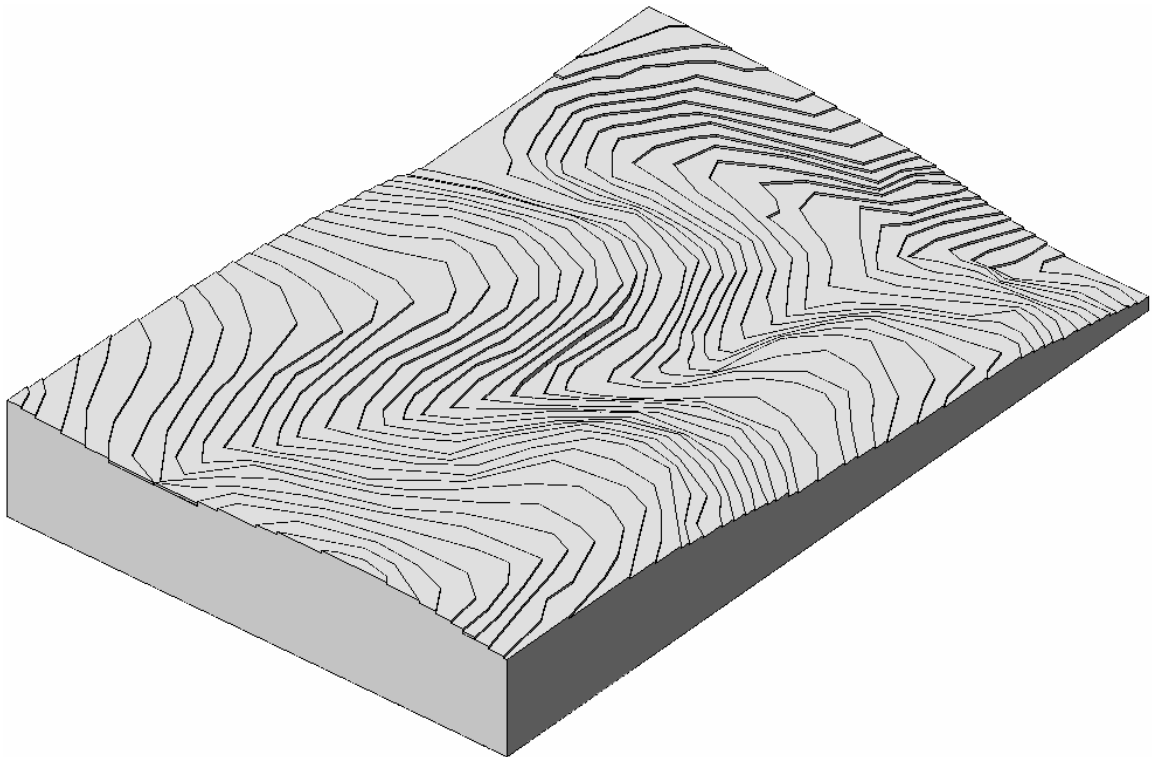# 11. Drainage Basin

11.1.   Objectives

- Understand water cycle
- Learn basics of drainage basin
- AutoCAD and drainage basin delineation

11.2.   Introduction

Hydrology is a Greek word, and it means the study of water. In the engineering community, hydrology is the scientific study of the movement, distribution, and quality of water throughout the earth. Hydrology addresses both the hydrologic cycle and water resources.

11.3.   Hydrologic cycle

The hydrologic cycle, also known as the water cycle, is the continuous movement of the water above, on, and below the earth's surface. Hence, there is no beginning or ending point to this cycle. In the various stages of this cycle, water is available in one of the three different possible states: liquid, vapor, and ice. The most simplified representation of the hydrologic cycle is as follows. The major driving force of the hydrologic cycle is the sun. It heats the water in the oceans, lakes, rivers, streams, etc. and causes some of it to evaporate. The vapor rises into the air where cooler temperatures cause it to condense into clouds. These clouds drift over the land and the vapors fall as precipitation (rain, hail, snow, fog, etc.). The rainwater flows into lakes, rivers, or aquifers. The water in lakes, rivers, and aquifers then either evaporates back to the atmosphere or eventually flows back to the ocean, completing the cycle. Figure 11-1 shows a water cycle.
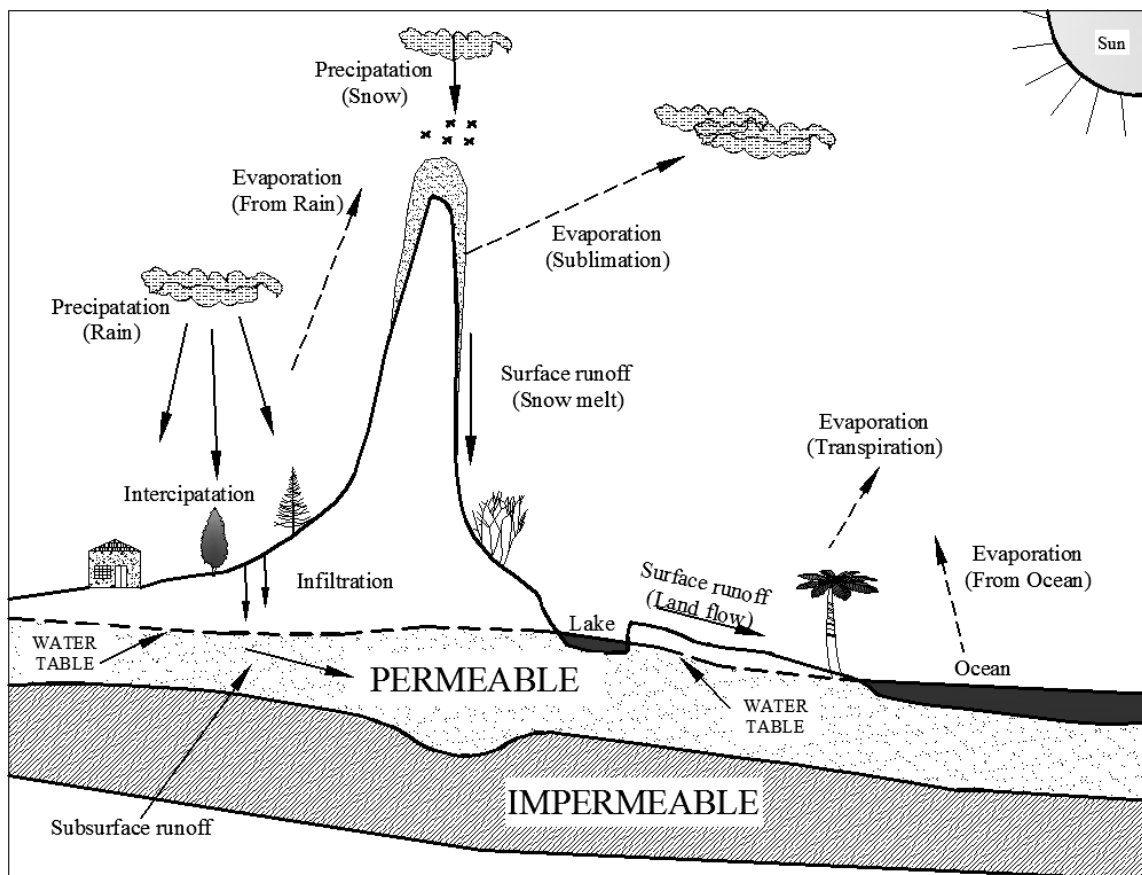

Figure 11-1

The hydrological cycle can be affected by the environmental effect and by humans. The following list shows some of the human factors affecting the water cycle.

- Agriculture
- Alteration of the chemical composition of the atmosphere
- Construction of dams
- Deforestation and afforestation
- Removal of groundwater from wells
- Water abstraction from rivers
- Urbanization

11.4.   Terminology

Refer to the Figure 11-1 for the terms discussed in this section.

- Condensation: Condensation is the transformation of water vapor to liquid water (as seen with the droplets in the air that produce clouds and fog).
- Precipitation: Precipitation is the process of condense water vapor falling to the earth's surface. Generally, precipitation occurs as rain. It also occurs as snow, hail, fog drip, and sleet.
- Interception: Interception is the precipitation that is interrupted by building, plant foliage, etc. Part of the intercepted precipitation will reach the ground surface and the remaining part will evaporate back to the atmosphere.
- Runoff: Runoff is the method by which water moves across the land. This includes both surface runoff and channel runoff. As water flows, it may infiltrate into the ground, evaporate into the air, become stored in lakes or reservoirs, or be extracted for agricultural or other human uses.
- Snowmelt: Snowmelt is the runoff produced by the melting snow.
- Groundwater: Groundwater is the water found below the ground surface. It may be available as soil moisture, liquid form, or frozen form.
- Infiltration: Infiltration is the percolation of the water from the ground surface into the ground. Once infiltrated, the water becomes soil moisture or groundwater.
- Subsurface flow: Subsurface flow is the underground flow of water. It may return to the surface as a spring or by the extraction using pumps.
- Advection: Advection is the movement of water (in solid, liquid, or vapor states) through the atmosphere. Without advection, water that evaporated over the oceans could not precipitate over the land.
- Evaporation: Evaporation is the transformation of water from a liquid to a gaseous state.
- Transpiration: Transpiration is the evaporation of water from the plants.
- Evapotranspiration: Evaporation and transpiration are collectively known as evapotranspiration.
- Sublimation: Sublimation is the transformation of water from a solid (ice) to gaseous (vapor) state.
- Water table: Water table is the underground water level at which the ground water pressure is equal to the atmospheric pressure.

11.5. Watershed or Drainage basin

A watershed is the area of land that drains into a stream at a given location; that is, it is an area of land bounded by a hydrologic system. Generally, a watershed is defined in terms of a point or outlet and all the land area that sheds (pours) water to the outlet during a rainstorm. Using the concept that "water runs downhill," a watershed is defined by all points enclosed within an area from which the rain falling at these points will contribute water to the outlet. Figure 11-2 represents the delineation of a watershed boundary. Watersheds come in all shapes and sizes and cross county, state, and national boundaries.
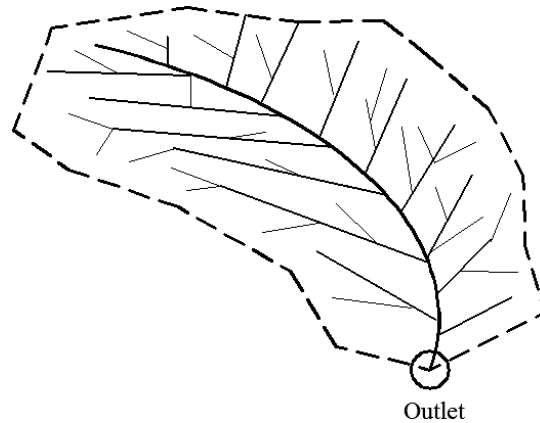

Outlet

Figure 11-2

A drainage basin is a region of land where the precipitation's water flows downhill into a river, lake, dam, or ocean. The drainage basin includes both the channels and the land from which water drains into those channels. Each drainage basin is separated topographically from adjacent basins by a ridge, hill, or mountain, which is known as a water divide. The dashed line is the main water divide of the hydrographic basin as shown in Figure 11-2. In North America, watershed refers to the drainage basin itself. The terms catchments, catchment area, catchment basin, drainage area, river basin, and water basin are also used to represent the same concept.

The majority of water that discharges from the basin outlet originated as the precipitation falling on the basin. In hydrology, the drainage basin is a logical unit of focus for studying the movement of water within the hydrological cycle. A portion of the water that enters the groundwater system beneath the drainage basin may flow towards the outlet of another drainage basin because groundwater flow directions do not always match those of their overlying drainage network. Measurement of the discharge of water from a basin may be made by a stream gauge located at the basin's outlet.

11.6. Watershed characteristics

11.6.1. Drainage area

The drainage area (A) is probably the single most important watershed characteristic for a hydrologic design. It reflects the volume of water that can be generated from rainfall. The

drainage area is used to indicate the potential for rainfall to provide a volume of water. It is common in hydrologic design to assume a constant depth of rainfall occurring uniformly over the watershed. Under this assumption, the volume of the water available for the runoff would be the product of rainfall depth and the drainage area. Thus the drainage area is required as input to models ranging from simple linear prediction equations to complex computer models.

11.6.2. Watershed length

The length (L) of a watershed is the second greatest characteristic of interest. While the length increases as the drainage increases, the length of a watershed is important in hydrologic computations. Watershed length is usually defined as the distance measured along the main channel from the watershed outlet to the basin divide. Since the channel does not extend to the basin divide, it is necessary to extend a line from the end of the channel to the basin divide following a path where the greatest volume of water would travel. The straight-line distance from the outlet point on the watershed divide is not usually used to compute L because the travel distance of floodwaters is conceptually the length of interest. Thus, the length is measured along the principal flow path. Since it will be used for hydrologic calculations, this length is more appropriately labeled the hydrologic length. The length is usually used in computing as a time parameter, which is a measure of the travel time of water through the watershed.

11.6.3. Watershed slope

Flood magnitudes reflect the momentum of the runoff. Slope is an important factor in the momentum. Both watershed and channel slope may be of interest. Watershed slope reflects the rate of change of elevation with respect to distance along the principal flow path. Typically, the principal flow path is delineated, and the watershed slope (S) is computed as the difference in elevation (ΔE) between the end points of the principal flow path divided by the hydrologic length of the flow path (L).

The elevation difference, ΔE, may not necessarily be the maximum elevation difference within the watershed since the point of highest elevation may occur along a side boundary of the watershed rather than at the end of the principal flow path.

11.6.4. Miscellaneous

Some of the other important watershed factors are listed here.
- Land cover and use
- Surface roughness
- Soil characteristics
  - Texture
  - Soil structure
  - Soil moisture
  - Hydrologic soil groups

11.7.   Major steps in a watershed delineation

The major steps in watershed delineation process are listed below.

Step 1: Mark the centerline of a channel by joining the Vs. For a channel, the tip of the V is upstream.
Step 2: Show the direction of flow. A channel flows from a higher elevation (upstream) to the lower elevation (downstream).
Step 3: Delineate the watershed boundary by connecting the ridge lines in the elevation contour lines map. For a ridge, the tip of the V or U is downstream.
Step 4: Choose and label the point of the watershed outlet. The outlet is usually a monitoring location or hydraulic structure.

11.8.   Watershed delineation using AutoCAD

In AutoCAD the watershed delineation can be performed using the following steps.

1. Launch AutoCAD 2012.
2. Contour map
   - Open the contour map.
   - Create a layer for the contour labels and make it the current layer.
   - Label the index contour using the *Text*, *Background Mask*, and the *Rotate* commands, Figure 11-3.
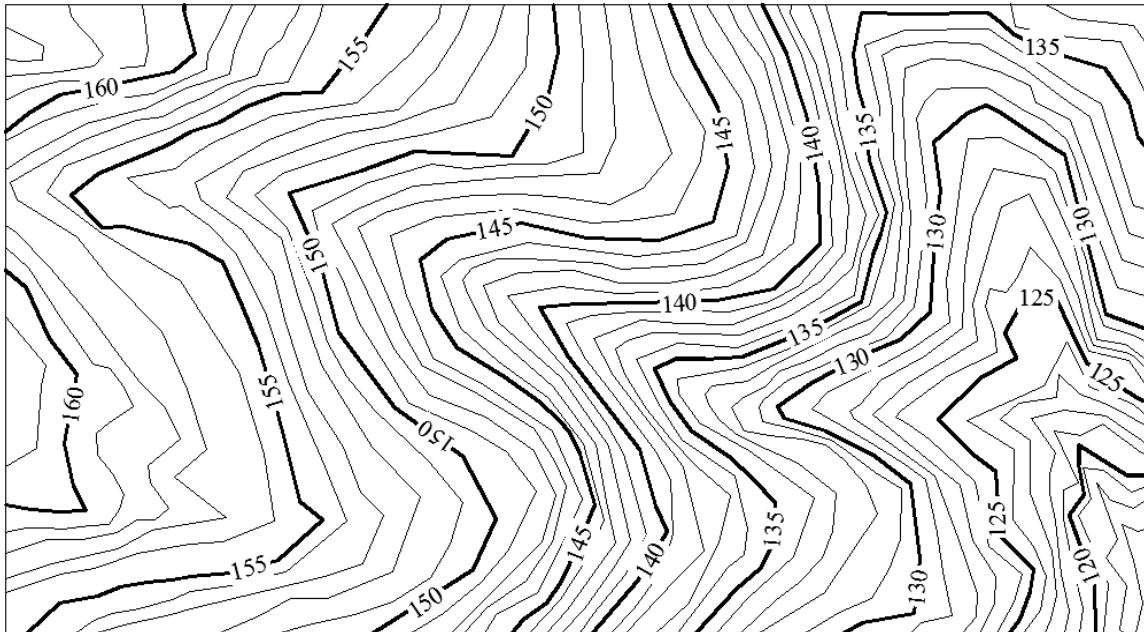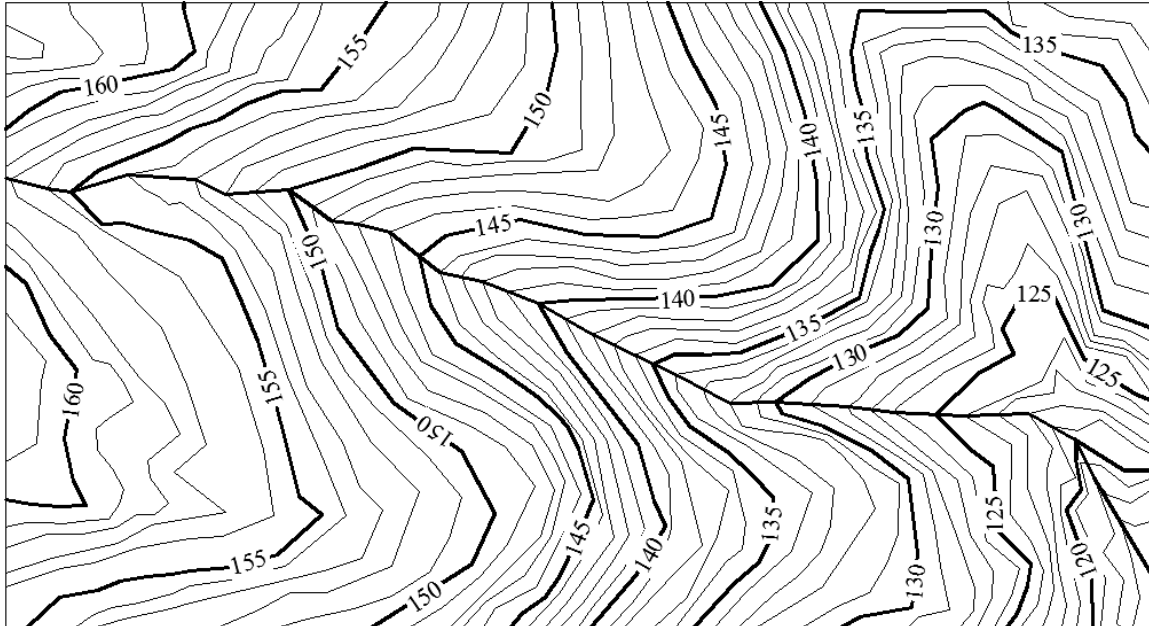

Figure 11-3

3. Center line
   - Create a layer for the center line of the channel. Change its color, linetype, and lineweight. Make it the current layer.
   - A channel flows from the higher elevation to the lower elevation. As mention earlier, the contour lines cross the streambed upstream by creating V with the bottom of the V's pointing upstream.
   - Draw the centerlines for the channel, Figure 11-4.
     o Activate the *Polyline* command.
     o Draw a polyline through the bottom of Vs as shown in Figure 11-4.

Figure 11-4

4. Direction of the flow
   - Create a layer for the direction of flow in the channel. Change its color and lineweight. Make it the current layer
   - Show the direction of the flow for the channels using the quick leader. Use first part of the *qleader* command to draw arrows.
   - Label the channel as shown in Figure 11-5.

5. Outlet point
   - Create a layer for the outlet. Change its color and lineweight. Make it the current layer.
   - In Figure 11-6, point *A*, the intersection of the channel and the edge of the contour map is selected as the outlet point for the watershed.
   - Draw a point at the outlet and label it.
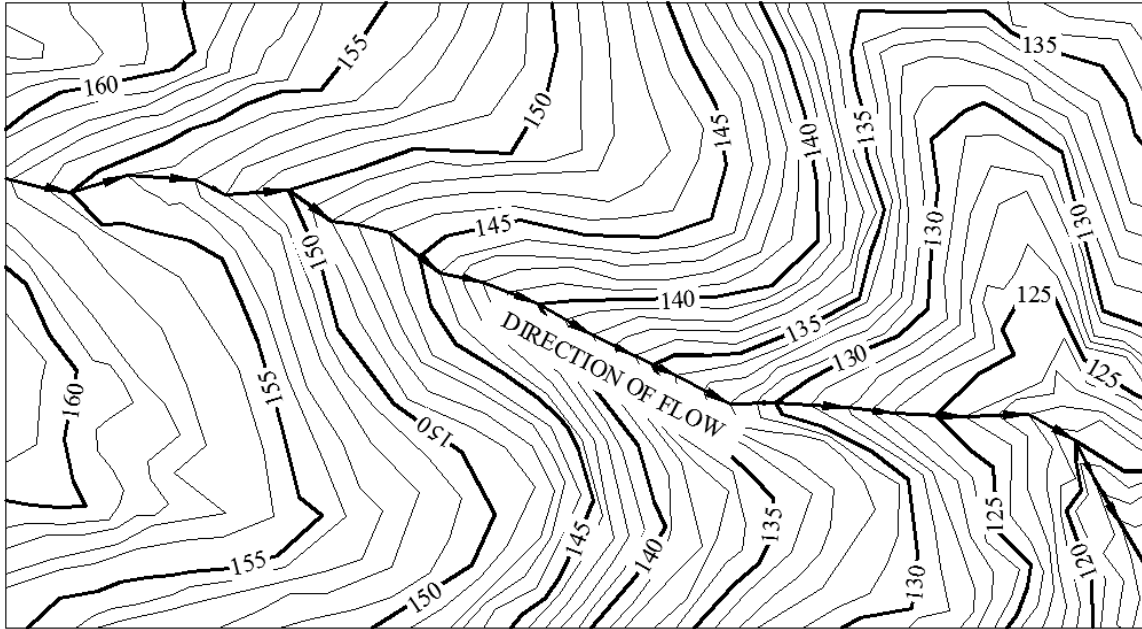
Figure 11-5
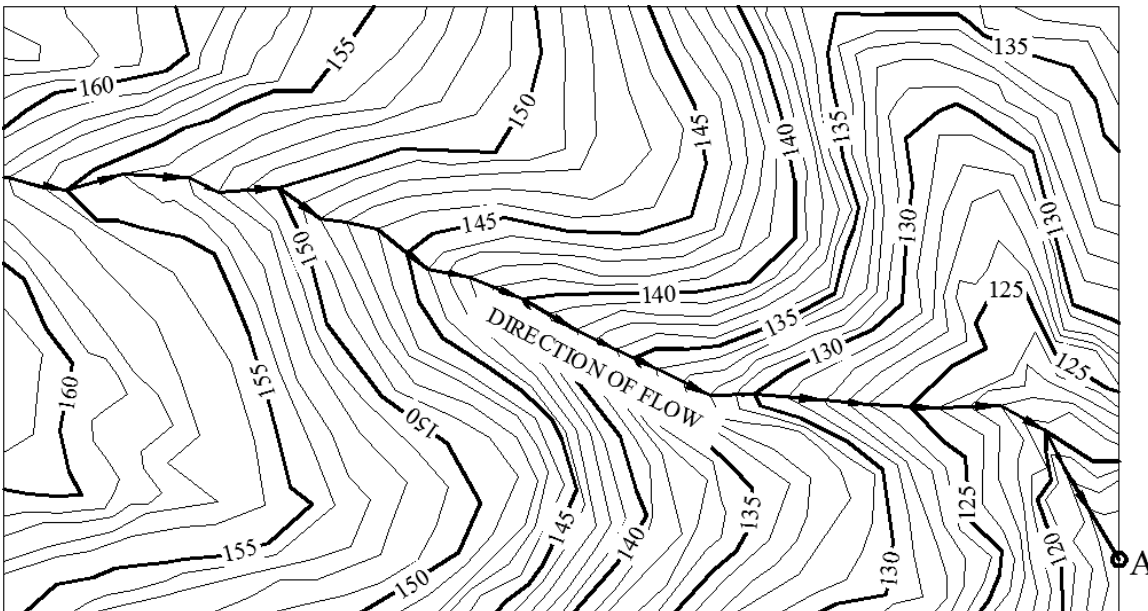
Figure 11-6

6. Delineate the watershed
   - Create a layer for the watershed boundary. Change its color and lineweight. Make it the current layer.
   - The contour lines cross the ridge downstream by creating V's or U's pointing downstream.
   - Draw the boundary lines for the channel.
   o Activate the *Polyline* command.

○   Draw a polyline through the bottom of Us as shown in Figure 11-7.
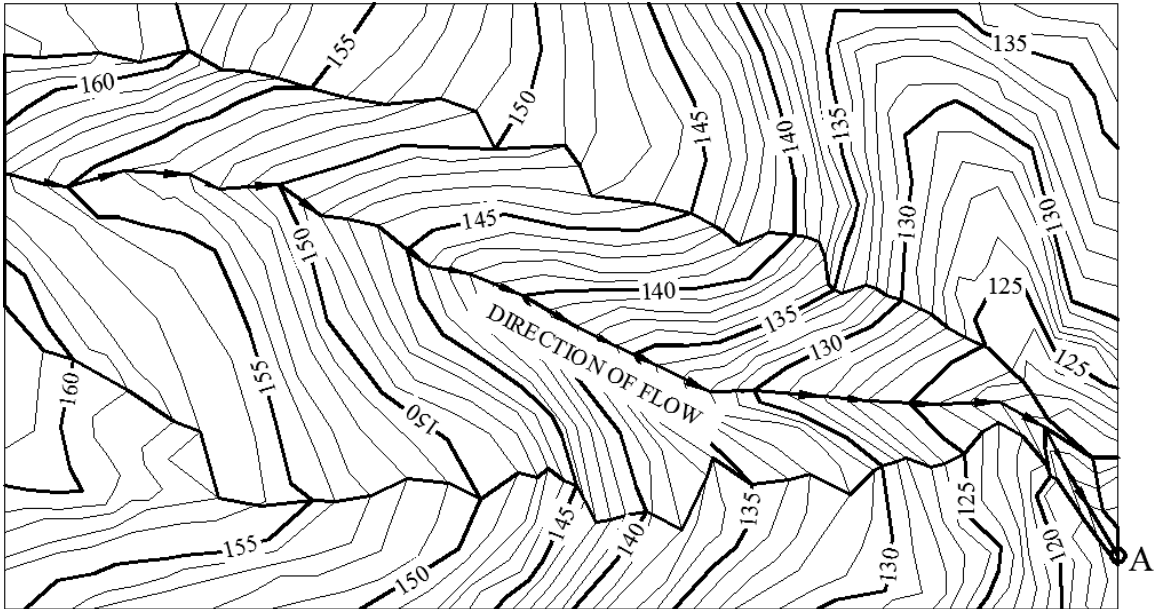
Figure 11-7

7. <u>Hatch the watershed</u>
    • Create a layer for the watershed hatch. Change its color and lineweight. Make it the current layer.
        ○   Turnoff all the layers except the watershed and watershed hatch layers, Figure 11-8a.
        ○   Activate the *Hatch* command.
        ○   Hatch the watershed, using the pattern *GRASS* and the scale of 40, Figure 11-8b.
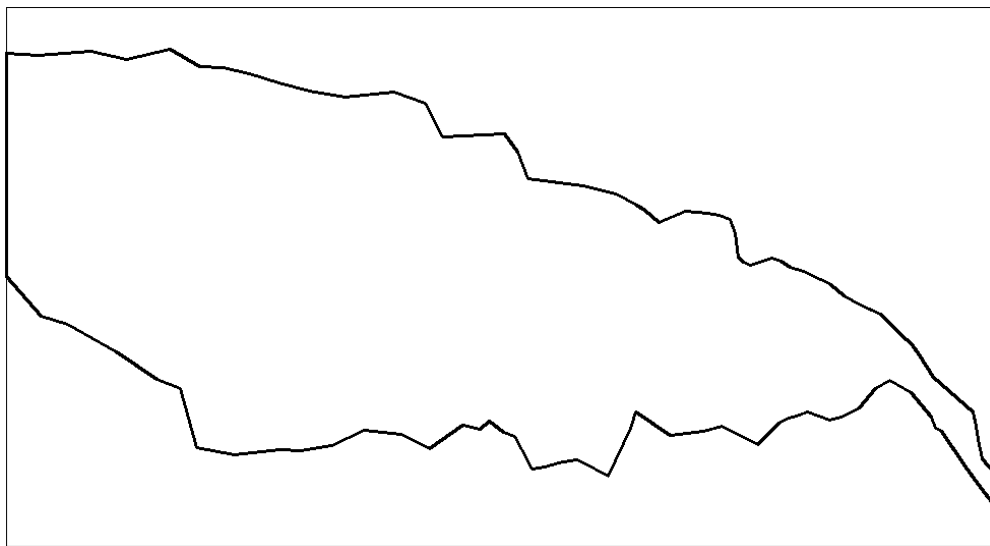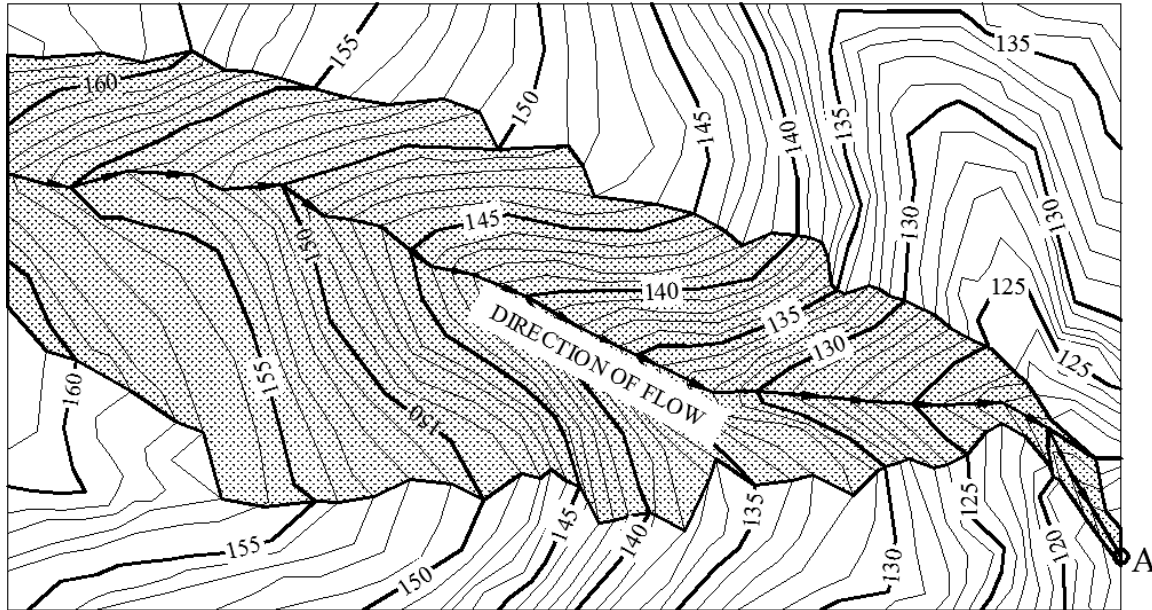

Figure 11-8a

Figure 11-8b

8. <u>Channel length</u>
    - Create a layer for the channel length and the watershed area. Change its color and lineweight. Make it the current layer.
    - Set the drawing units to be engineering as follow. (i) From the *Format* menu, select the *Units* option. This will open *Drawing Units* dialog box. (ii) In the *Drawing Units* dialog box, under the *Length* panel, select the *Engineering* units, Figure 11-9a.
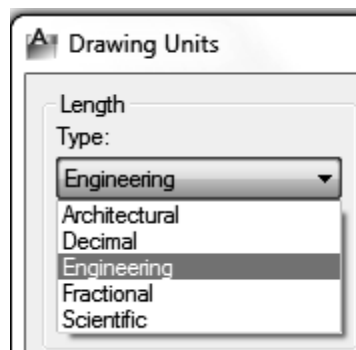

Figure 11-9a

    - Find the length of the channel in feet (length of the channel's center line). The easiest and the fastest method is the property sheet.
    - Select the centerline of the channel and open its property sheet, Figure 11-9b.
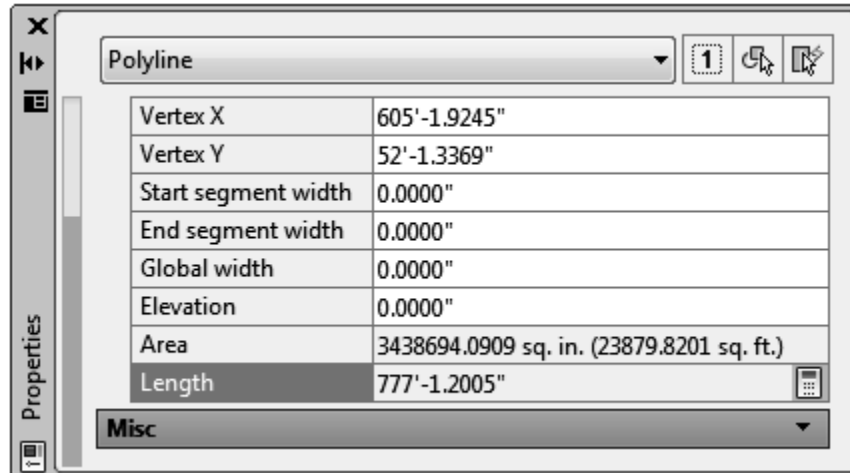   - The last entry in the *Geometry* panel is the length of the channel.

Figure 11-9b

9. Watershed area
   - The area of the watershed can be obtained using one of the two techniques.
     (a) Using the *Property* sheet
        - Select the boundary of the watershed.
        - Open its property sheet, Figure 11-10.
        - The second last entry in the *Geometry* panel is the area of the watershed.
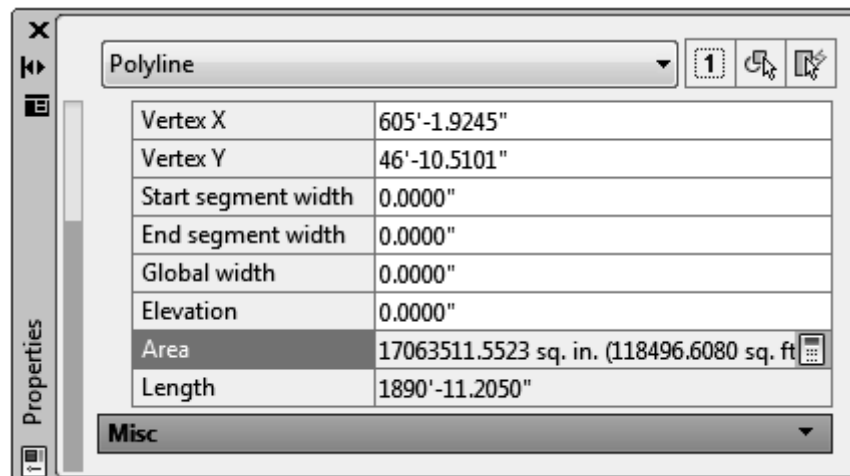   - The area is in square feet.

Figure 11-10

     (b) Using the *Inquiry* command
        - Select the *Tools* dropdown menu, select the *Inquiry* option, and select the *Area* option, Figure 11-11a.
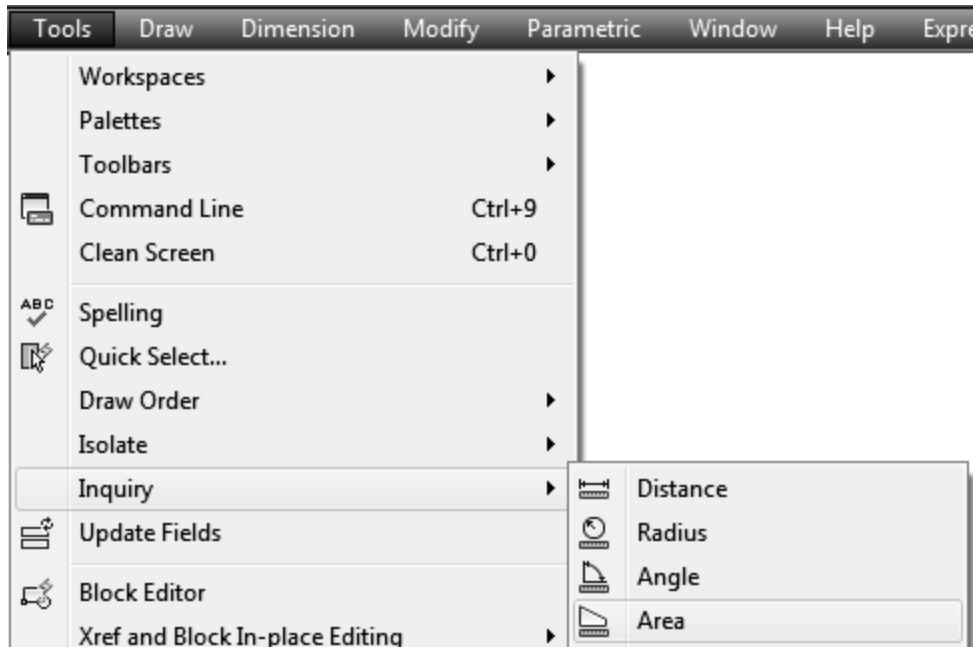   - The prompt shown in Figure 11-11b will appear.

Figure 11-11a

- o Use the down arrow and choose the *Object* option for the closed polyline.
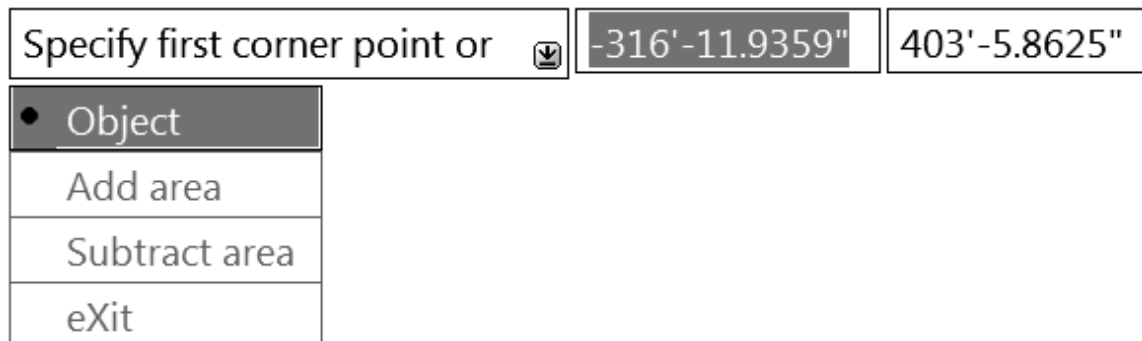

Figure 11-11b

- o Click on the watershed boundary (make sure the boundary is represented by a single closed polyline).
- o The area information will appear on the screen, Figure 11-11c.
- o Press the *Esc* key to exit the command.

- Convert the area into acres using the conversion factor of 1 Acres = 43560 sq. ft.
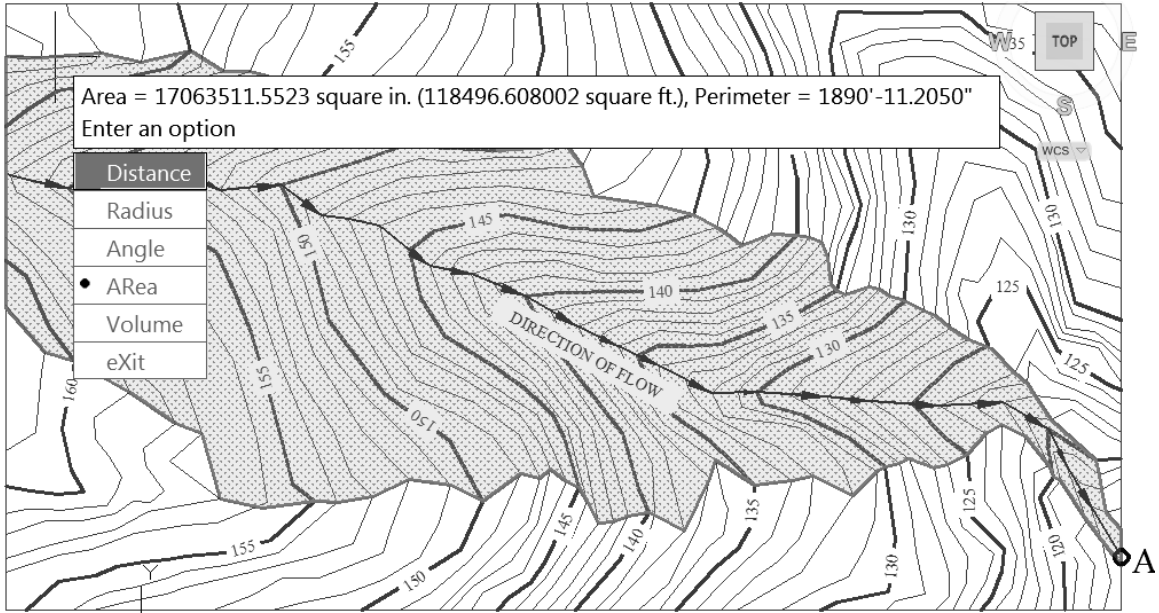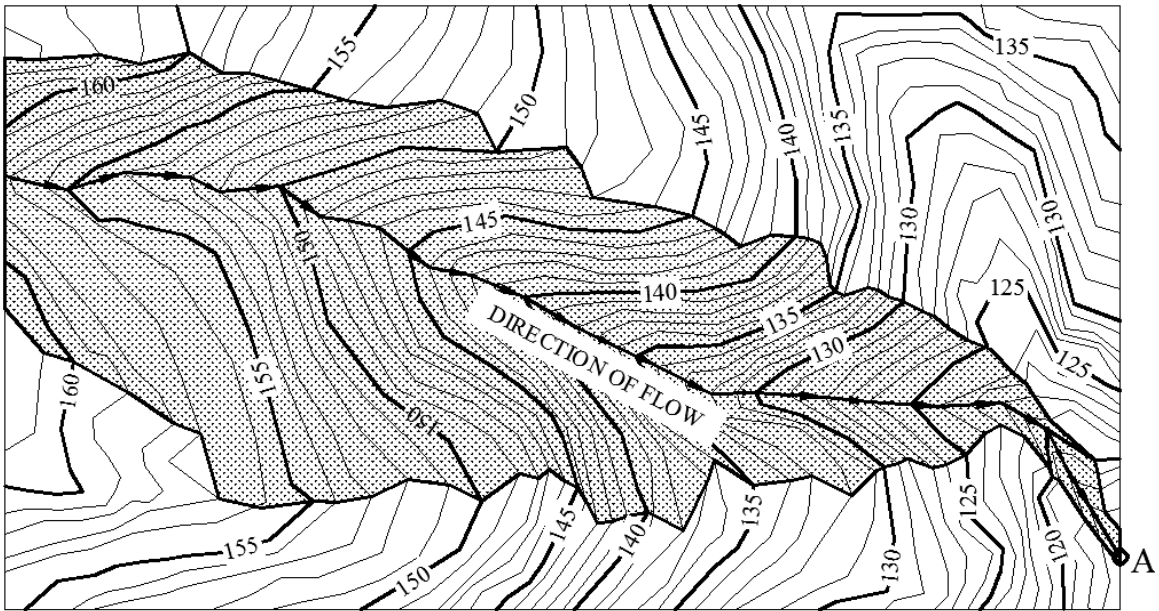
Figure 11-11c

10. <u>Display the length and area on the drawing</u>
    - Create either two multiline texts boxes or draw a table. For the demonstration purposes, Figure 11-12 shows both the text boxes and the table.
    - Show the length and the area as on the drawing.

LENGTH OF THE CHANNEL:777FT   AREA OF THE WATERSHED: 2.70378 ACRES

LENGTH (FEET)	AREA (ACRES)
777	2.7308

Figure 11-12

11. Insert Template file
- Finally, insert a layout from the template file labeled as "My_acad_Landscape_tmplt.dwt".
- Update the Title block.
- Set the viewport scale to 1:900.
- Lock the viewport
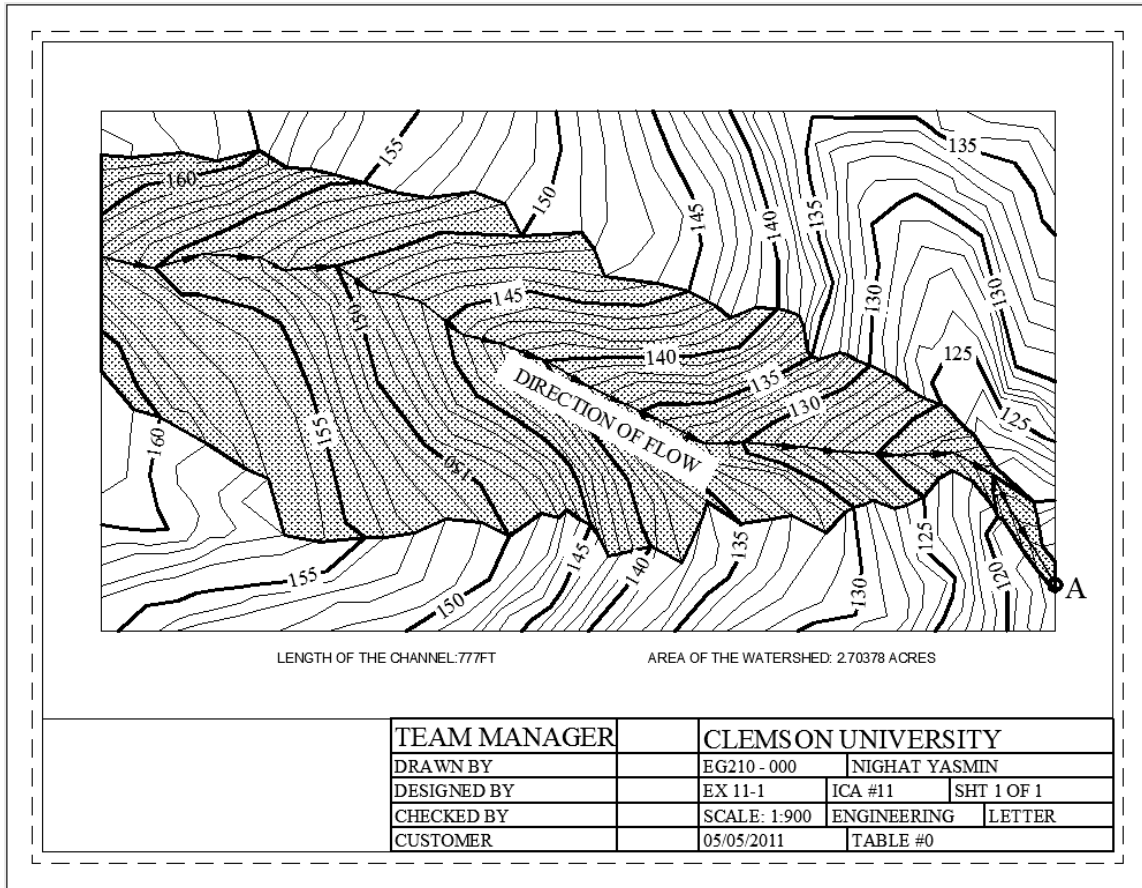- The resultant template file is shown in Figure 11-13.

Figure 11-13