HYDROLOGY SURFACE WATER EQUATION LIST

(1) CONTINUITY EQUATION FOR RIVER DISCHARGE

$$Q = AV = wdV = wd\frac{L}{t} = \frac{Vol}{t}$$

where Q = DISCHARGE (L^3/t)
A = Channel cross-sectional AREA (L^2)
V = VELOCITY (L/t)
w = CHANNEL WIDTH (L)
d = CHANNEL DEPTH (d)
Vol = VOLUME (L^3)
t = time (time units)

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(2) WATERSHED DRAINAGE DENSITY

$$D_d = \frac{\Sigma L}{A_d}$$

where ΣL = SUM OF TOTAL STREAM LENGTHS (L)
A_d = drainage Area (L^2)
D_d = DRAINAGE DENSITY $(L/L^2 = m/km^2)$

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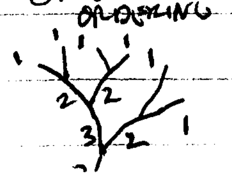
(3) SHREVE MAGNITUDE FOR WATERSHEDS

STREAM ORDERING



$M = \Sigma$ FREQUENCY OF FIRST ORDER STREAMS

(4) RATIONAL RUNOFF METHOD (for WATERSHEDS)

$$Q_p = CIA \quad \text{where}$$

Q_p = PEAK RUNOFF DISCHARGE (L^3/t)
C = RATIONAL RUNOFF COEFFICIENT (dimensionless)
I = RAINFALL INTENSITY (L/t)
A_d = DRAINAGE AREA (L^2)

VALUES OF "C"

PAVEMENT C = 0.70 – 0.95
SANDY SOILS C = 0.20 – 0.40
CLAYEY SOILS/COLLUVIUM C = 0.40 – 0.50

NOTE: WHERE SOILS ARE 100% SATURATED, $C \rightarrow 1.0$,
SO IN THIS CASE $Q_p = IA$

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(5) FLOOD RECURRENCE INTERVAL

$$R.I. = \frac{n+1}{m}$$

where n = TOTAL NO. OF EVENTS OR YEARS
M = RANK OF EVENT, WITH #1 = LARGEST

$$P = \frac{1}{R.I.}$$

P = PROBABILITY OF GIVEN MAGNITUDE OF FLOOD

(6) PEAK DISCHARGE

Q_p = MAXIMUM DISCHARGE ON RECORD (L^3/t)

Q_p DAILY = MAX. DAILY DISCHARGE

Q_p ANNUAL = MAX YEARLY Q

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(7) EMPIRICAL HYDROLOGIC RELATIONS FOR SELECT REGIONAL WATERSHEDS

(A) $Q_{max} = 38 M^{0.89} D^{-0.50}$ FOR APPALACHIAN PLATEAU REGION

where Q_{max} = maximum DISCHARGE (L^3/t)
M = STREAM MAGNITUDE (DIMENSIONLESS)
D = DRAINAGE DENSITY (L/L^2)

(B) $Q_{2.33} = 34.5 A^{0.93}$ (VERMONT WATERSHED)

$Q_{2.33}$ = DISCHARGE WITH A 2.33 yr RECURRENCE INTERVAL

A = DRAINAGE AREA

(C) GENERALIZED RELATIONSHIP

$Q_x = a A^b$ b range: 0.5 – 0.9

where x = RECURRENCE INTERVAL, Q = DISCHARGE, A = DRAINAGE AREA, a = Coefficient, b = exponent.

(8) TIME FOR HYDRAULIC CONCENTRATION OF DRAINAGE BASIN

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DEFINED: TIME REQUIRED DURING A STORM, FOR OVERLAND AND CHANNEL FLOW TO TRAVEL FROM THE MOST DISTANT DRAINAGE DIVIDE TO THE OUTLET OF THE BASIN

$$t_c = \frac{L^{1.15}}{7700\,H^{0.38}}$$ (EMPIRICAL EQUATION)

t_c = time of concentration (hours)

L = LENGTH FROM DIVIDE TO BASIN OUTLET (ft)

H = BASIN RELIEF BETWEEN DIVIDE AND OUTLET (ft)

FLOOD FREQUENCY ANALYSIS

HOW-TO: Steps in plotting a Gumbel flood-frequency curve:

1. Count or calculate the length of record (n, in years).

2. Determine the rank (r) for each flood of record. Rank in order from greatest flood (r = 1) to least flood (r = n).

3. Determine the recurrence interval for all floods with the equation (n + 1)/r.

4. Select a vertical axis for plotting discharge on the Gumbel curve. This takes experience and intuition, as the vertical axis must allow for the greatest flood of record AND 200 YEAR RECURRENCE FLOODS, which are usually greater than any flood of record. As a general rule, a vertical axis in which the greatest flood of record is 1/2 to 2/3 of the maximum value on the vertical axis will be adequate.

5. Plot the individual flood events on the curve.

6. Fit the curve with a straight line, or 2 or 3 straight line segments. Line segments should be defined by more than 2 data.

FLUVIAL FIELD TRIP
EQUATION LIST

F < 1 = TRANQUIL FLOW
F = 1 = CRITICAL FLOW
F > 1 = SUPER CRITICAL FLOW

FROUDE NO. – DESCRIBES FLOW TYPE

$$Fr = \frac{V}{\sqrt{dg}}$$

V = velocity m/sec
d = depth m
g = gravity acc. = 9.8 m/sec^2

MANNING'S EQUATION – TO CALCULATE STREAM VELOCITY

$$V = \frac{R^{2/3} S^{1/2}}{n}$$

V = VELOCITY m/sec
R = HYDRAULIC RADIUS = $\frac{A}{P}$ — A = CHANNEL AREA m^2; P = WETTED PERIMETER m
S = SLOPE
n = ROUGHNESS

$$T_c = \gamma R S$$ = CRITICAL STREAM FORCE FOR EROSION

γ = SPECIFIC WT. OF H_2O = 9800 N/m^3
R = HYDRAULIC RADIUS = $\frac{A}{P}$
S = SLOPE

STREAM POWER = KINETIC ENERGY AVAILABLE FOR WORK

TOTAL POWER $\Omega = \gamma Q S$ (WATTS)

UNIT POWER $\omega = \frac{\gamma Q S}{w}$ (WATTS/m)

γ = SP. WT. H_2O = 9800 N/m^3
Q = DISCHARGE = m^3/sec
S = SLOPE
w = width m

CONTINUITY EQUATION

$$Q = VA$$

Q = DISCHARGE m^3/sec
V = VELOCITY m/sec
A = AREA OF CHANNEL m^2

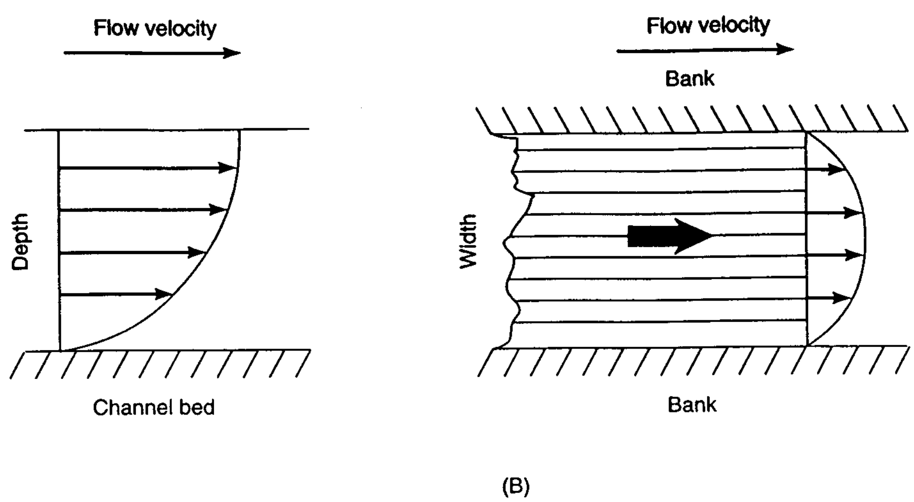
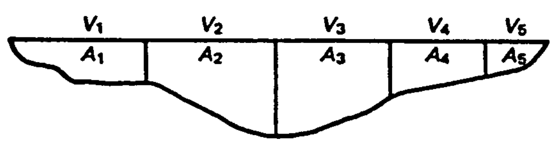


FIGURE 6.1
Diagram showing the changes in flow velocity with (A) flow depth and (B) flow width. Resistance to flow along the bed and banks allows the greatest velocities to occur toward the center of the channel near the water surface.



subareas of velocity domains.

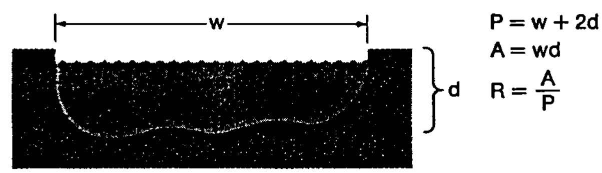


FIGURE 6.2
Cross-sectional measurements of a stream channel: w = width, d = depth, A = area, R = hydraulic radius, P = distance along wetted perimeter.

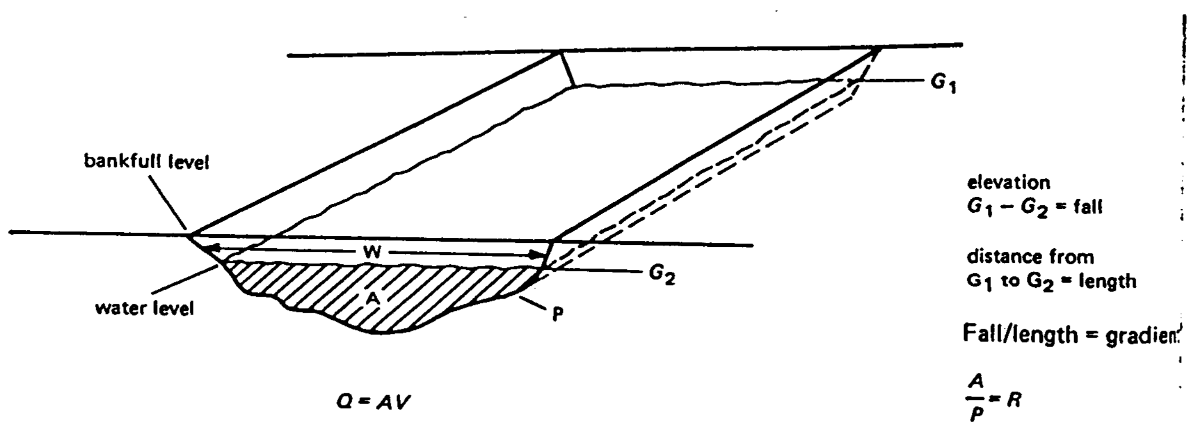


Figure 9.2. Nomenclature of channel morphology.

TABLE 1 — ROUGHNESS

A. [redacted] Values of Roughness, n

River Description	*Roughness, n*
Ordinary rivers:	
clean, straight channel, no riffles or pools	0.030
straight, weedy, boulders	0.035
clean winding channel, pools and riffles	0.040
weedy, winding, deep pools	0.070
Alluvial channels:	
vegetated, no brush, grassy	0.030–.035
vegetated, brushy	0.050–.10
no vegetation	
ripples, dunes	0.017–.035
plane bed	0.011–.015
antidunes	0.012–.020
Mountain streams: rocky beds	
no vegetation, steep banks	
bed of gravel, cobbles,	0.040
bed of cobbles and boulders	0.050

Compiled and adapted from Chow (1959 and 1964)

B.

[redacted] Manning roughness coefficients (*n*) for different boundary types.

Boundary	Manning *n* ($ft^{1/6}$)
Very smooth surfaces such as glass, plastic, or brass	0.010
Very smooth concrete and planed timber	0.011
Smooth concrete	0.012
Ordinary concrete lining	0.013
Good wood	0.014
Vitrified clay	0.015
Shot concrete, untroweled, and earth channels in best condition	0.017
Straight unlined earth canals in good condition	0.020
Rivers and earth canals in fair condition; some growth	0.025
Winding natural streams and canals in poor condition; considerable moss growth	0.035
Mountain streams with rocky beds and rivers with variable sections and some vegetation along banks	0.041–0.050

Source: *Handbook of Applied Hydrology*, ed. by Ven T. Chow, copyright 1964 McGraw-Hill Publishing Co., Inc.

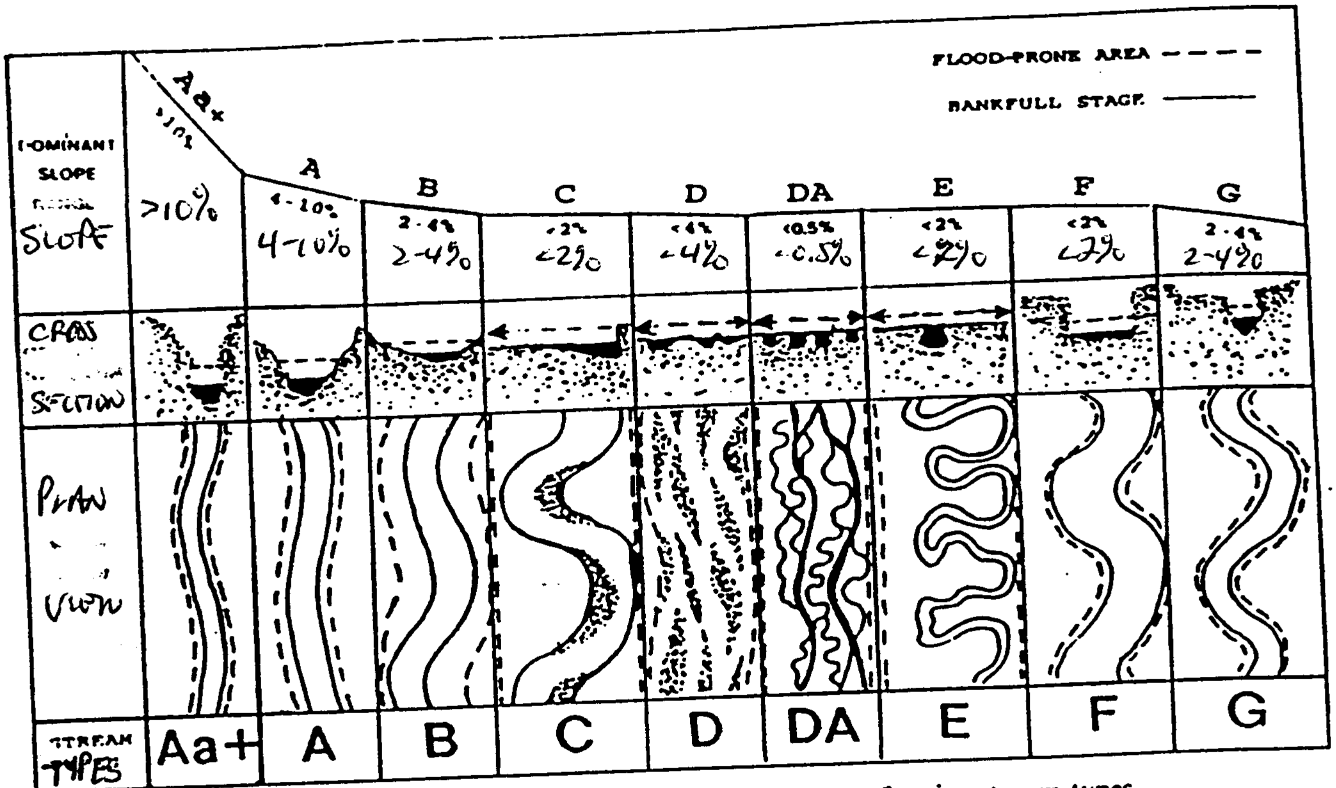


FIG. 2 ~~Fig. 1~~. Longitudinal, cross-sectional and plan views of major stream types.