FIGURE 5–3
Intensity-duration recurrence interval curves for Seattle, Washington, and Miami, Florida. The family of curves for each station shows the recurrence intervals for intensities of various duration. (From Dunne and Leopold, 1978)

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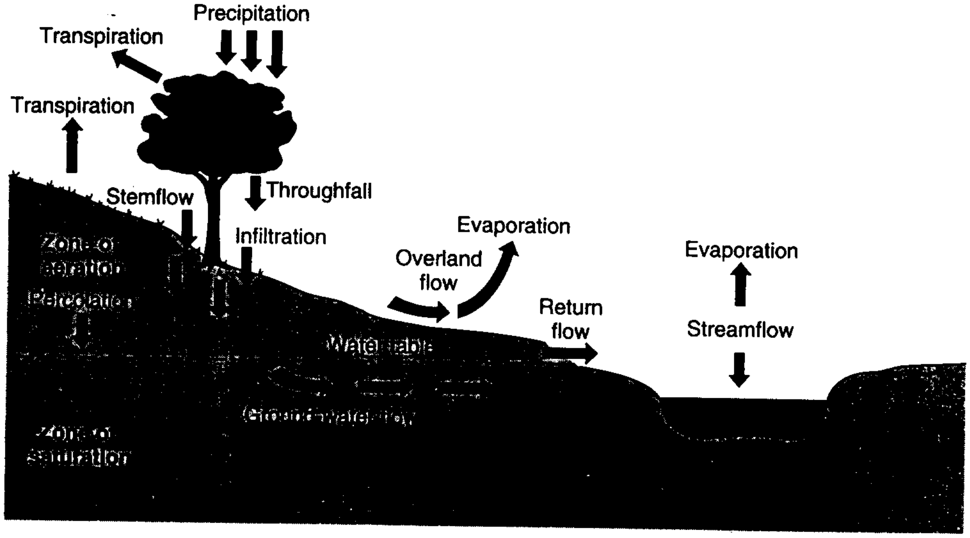

FIGURE 5–4
Components of a water budget derived from precipitation. (From Petts and Foster, 1985)

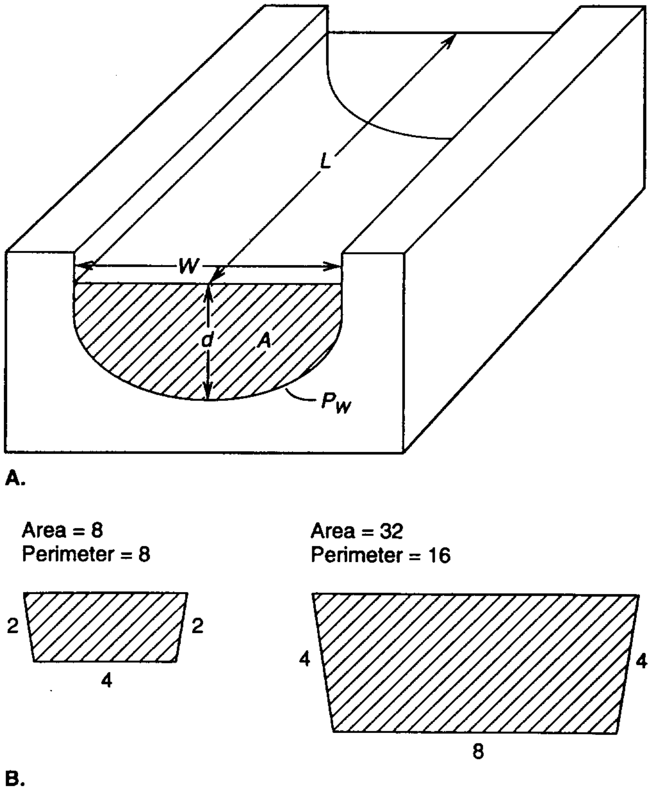

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FIGURE 5–6
(A) Typical stream channel. *W* is channel width; *d* is depth; *L* is length of a channel segment; P_w is wetted perimeter (portion of the channel in contact with water); *A* is cross-sectional area; and *R* is the hydraulic radius, A/P_w. (B) Change in ratio of channel cross-sectional area to wetted perimeter with increase in discharge.

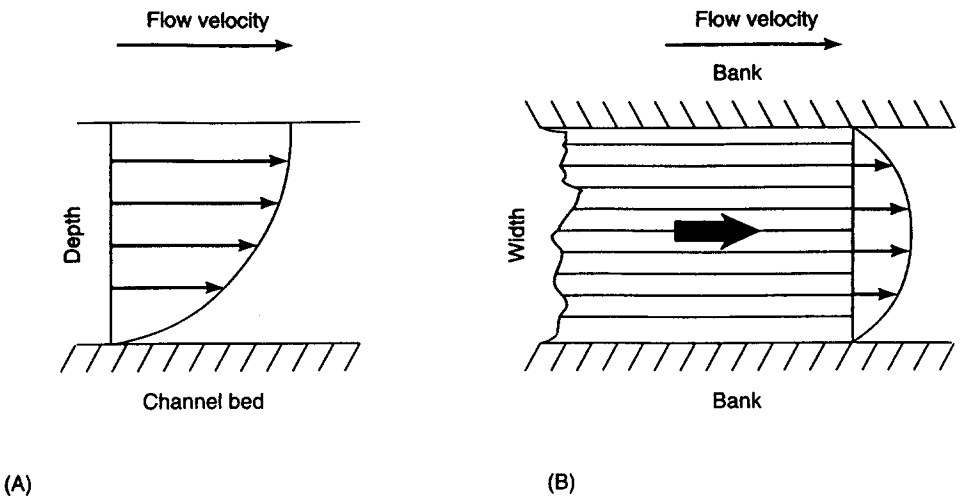

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FIGURE 6.1

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.

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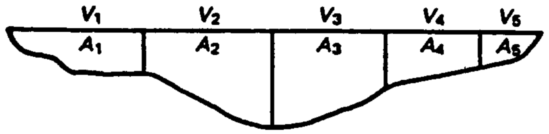

subareas of velocity domains.

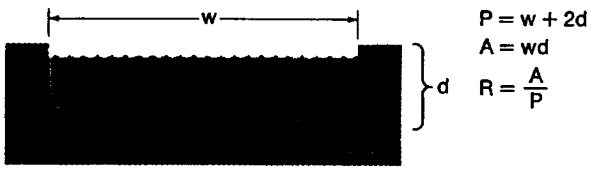

FIGURE 6.2

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

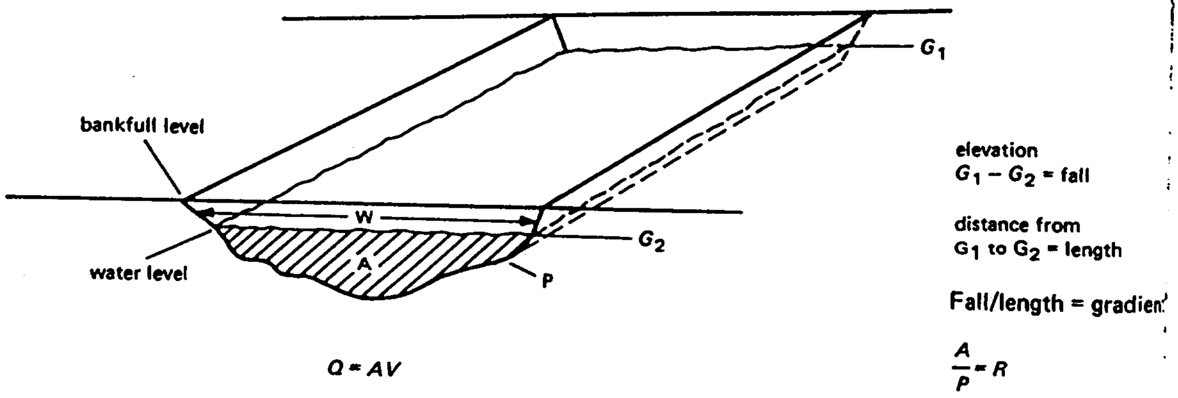

Figure 9.2. Nomenclature of channel morphology.

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FLUVIAL FIELD TRIP
EQUATION LIST

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$F < 1$ = 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

$$\tau_c = \gamma R S$$ = critical stream force for erosion

γ = specific wt. of H$_2$O = 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$_2$O = 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

[redacted]

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)

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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.

Geomorphology Summary Sheet p. 58-59 NOTES

WATER BUDGET

$$P = R + I + S$$

P = TOTAL PRECIPITATION

R = SURFACE RUNOFF

I = ~~Soil~~ [illegible] INTERCEPTION

S = SOIL / GROUNDWATER STORAGE

RECURRENCE INTERVAL

$$R_I = \frac{\text{TOTAL No. OF YEARS RECORD}}{\text{No. OBSERVATIONS ON TIME FRAME}}$$

FLUID MECHANICS

FORCE OF WATER

$$F_p = F_g(\sin\theta)$$

F_p = force parallel to channel

F_g = force of gravity

θ = angle of channel slope

MOMENTUM

$$m = (\text{mass})(\text{velocity})$$

FROUDE No.

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

u = velocity m/s g = force of gravity m^2/s^2

d = depth of flow m

REYNOLDS No.

$$Re = \frac{\rho d u}{v}$$

ρ = fluid density

v = viscosity

d = depth

u = velocity

Re = Reynolds No.

POROSITY & PERMEABILITY

$$P\% = \frac{V_T - V_S}{V_T} \times 100\%$$

V_T = TOTAL VOL.

V_S = VOL. SOLID

DARCY'S LAW

$$Q = \frac{KA(P_2 - P_1)}{\mu L}$$

Q = Discharge (L^3/T)

K = Permeability

A = x-sectional area

L = length

$P_2 - P_1$ = Head

μ = viscosity

RIVER MORPHOMETRY

- SINUOSITY

$$S = \frac{\text{Stream length}}{\text{valley length}}$$

- STRAHLER STREAM ORDERS
- DRAINAGE FREQUENCY $f = \frac{No.}{A}$
- BIFURCATION RATIO

$$R_b = \frac{N_o}{N_{o+1}}$$

- LENGTH RATIO

$$R_L = \frac{L_{AVG\,o}}{L_{AVG\,o+1}}$$

- DRAINAGE DENSITY

$$D = \frac{L_{TOTAL}}{A}$$

- TEXTURE RATIO

$$T = N/P$$

STREAM FLOW

CONTINUITY EQUATION

$$Q = VA = Vwd$$

Q = Discharge (L^3/T)

V = Velocity (L/T)

A = x sectional area

w = channel width

d = channel depth

$$P = 2d + w$$

P = wetted perimeter

Hydraulic Radius

$$R = A/P = m^2/m$$

MANNING EQUATION
METRIC UNITS

$$V = \frac{R^{0.66} S^{0}}{n}$$

V = mean velocity m/s

n = coefficient of roughness —

R = hydraulic radius m

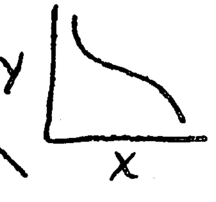
S = slope (gradient)

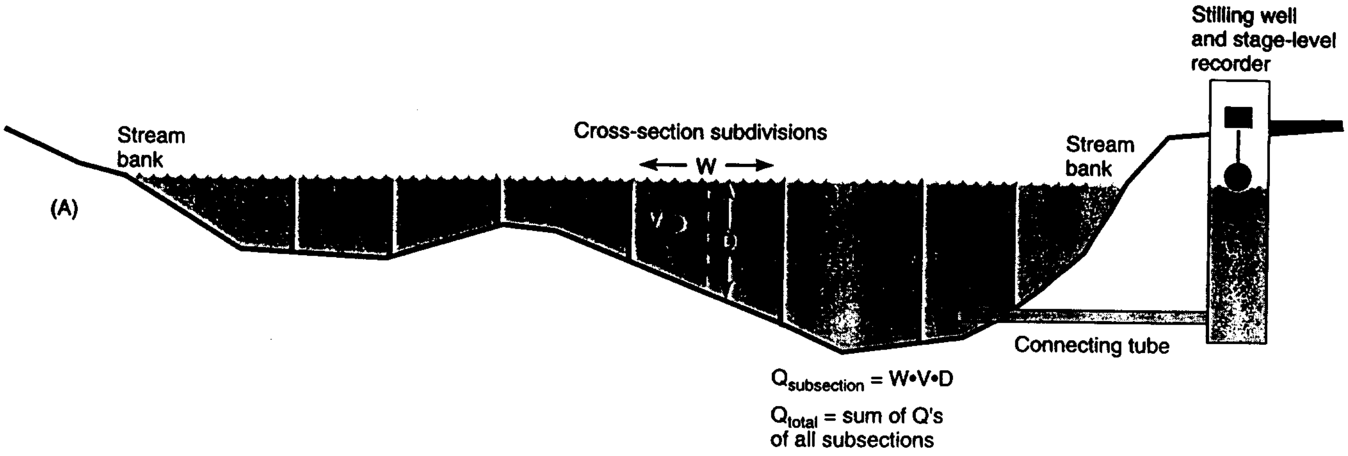
HYPSOMETRIC ANALYSIS

$$X = a/A = \frac{\text{area above datum}}{\text{TOTAL BASIN AREA}}$$

$$Y = \frac{h}{H} = \frac{\text{Ht. above datum}}{\text{TOTAL BASIN RELIEF}}$$

Hypsometric Curve





(D)

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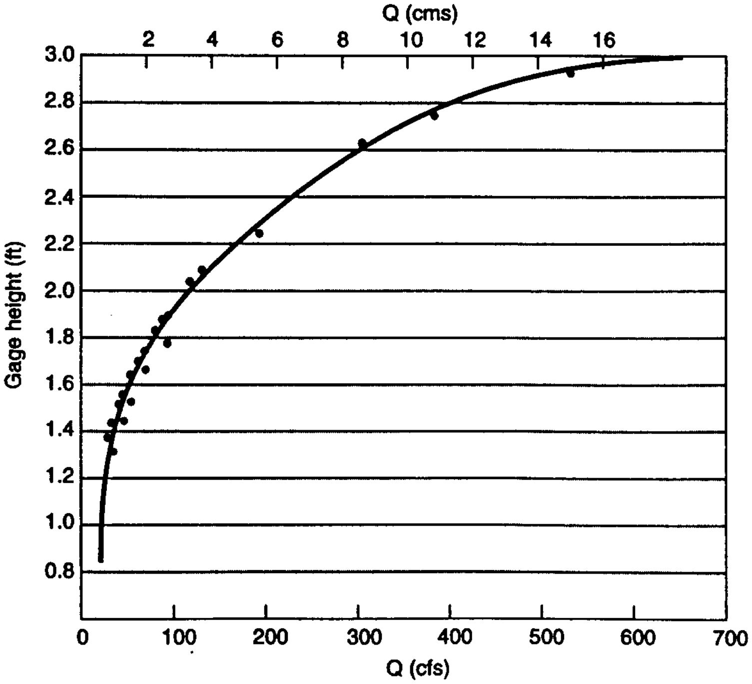
FIGURE 5.33

Rating curve for low flow. Rock Creek near Red Lodge, Mont.



8 ~~85~~ 746

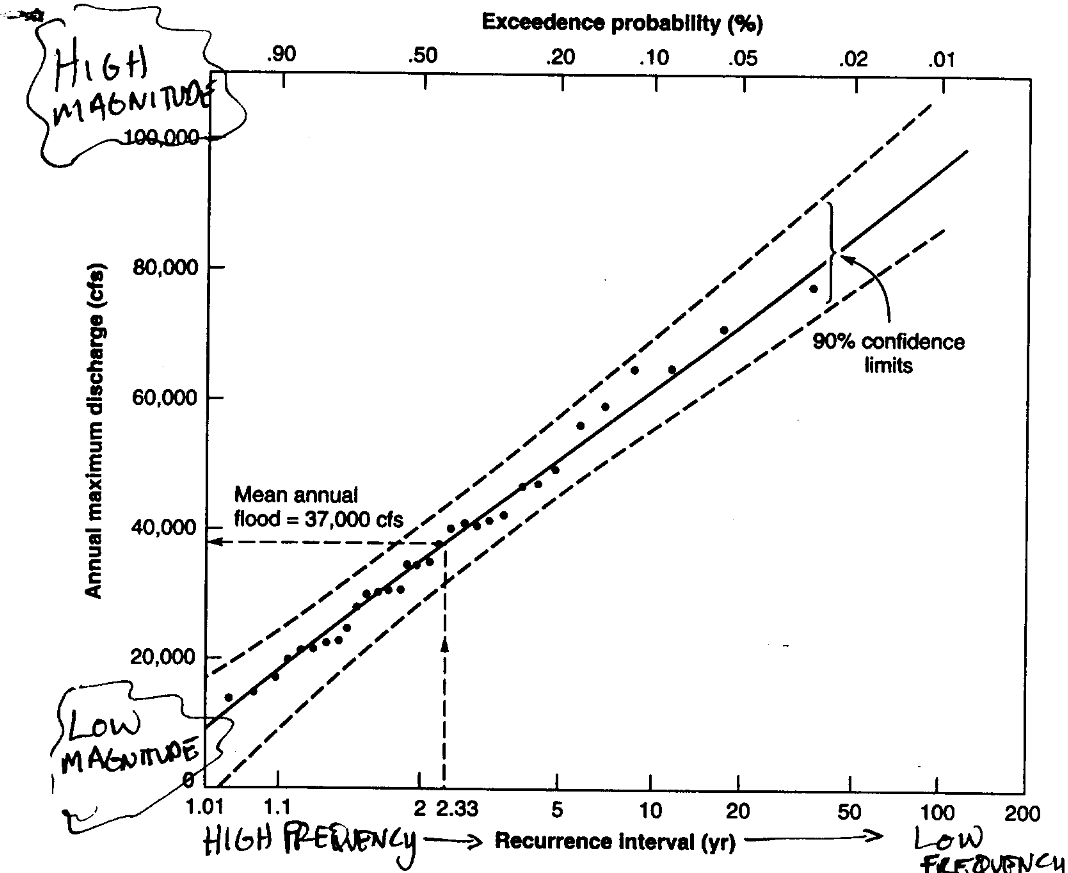


FIGURE 5-8
Flood frequency curve for annual floods on the Skykomish River, Washington. Dashed lines are 90-percent confidence limits. (Data from U.S. Geological Survey; plot from Dunne and Leopold, 1978)

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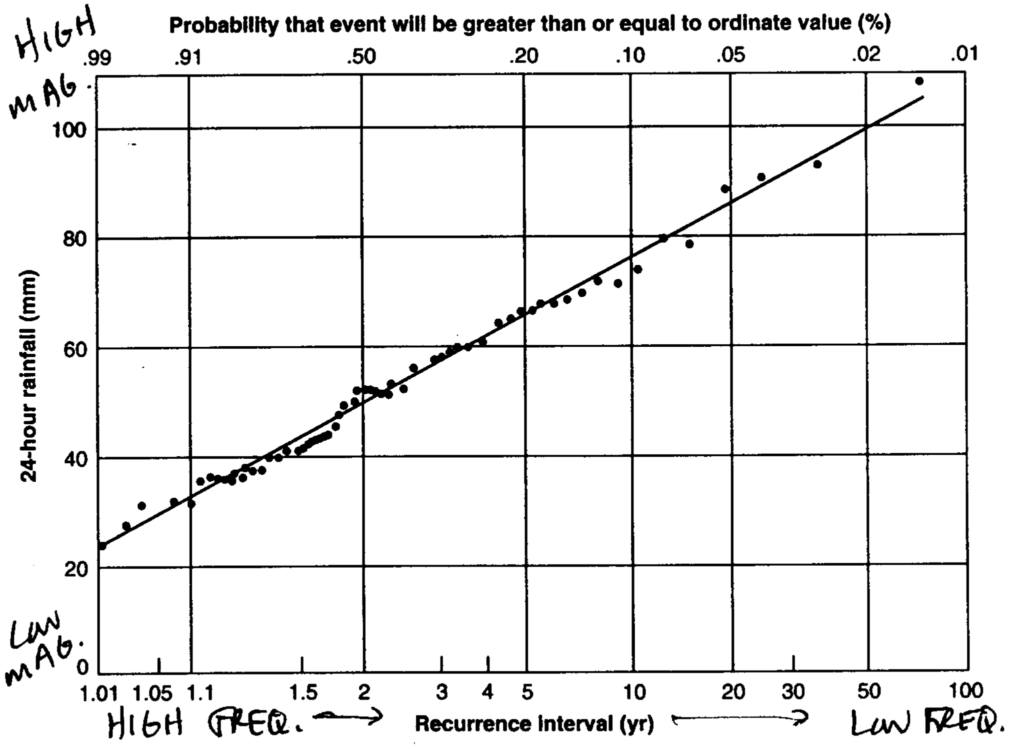

FIGURE 5-1
Recurrence interval of 24-hour precipitation, Buffalo, New York, 1891–1961. (From Dunne and Leopold, 1978)

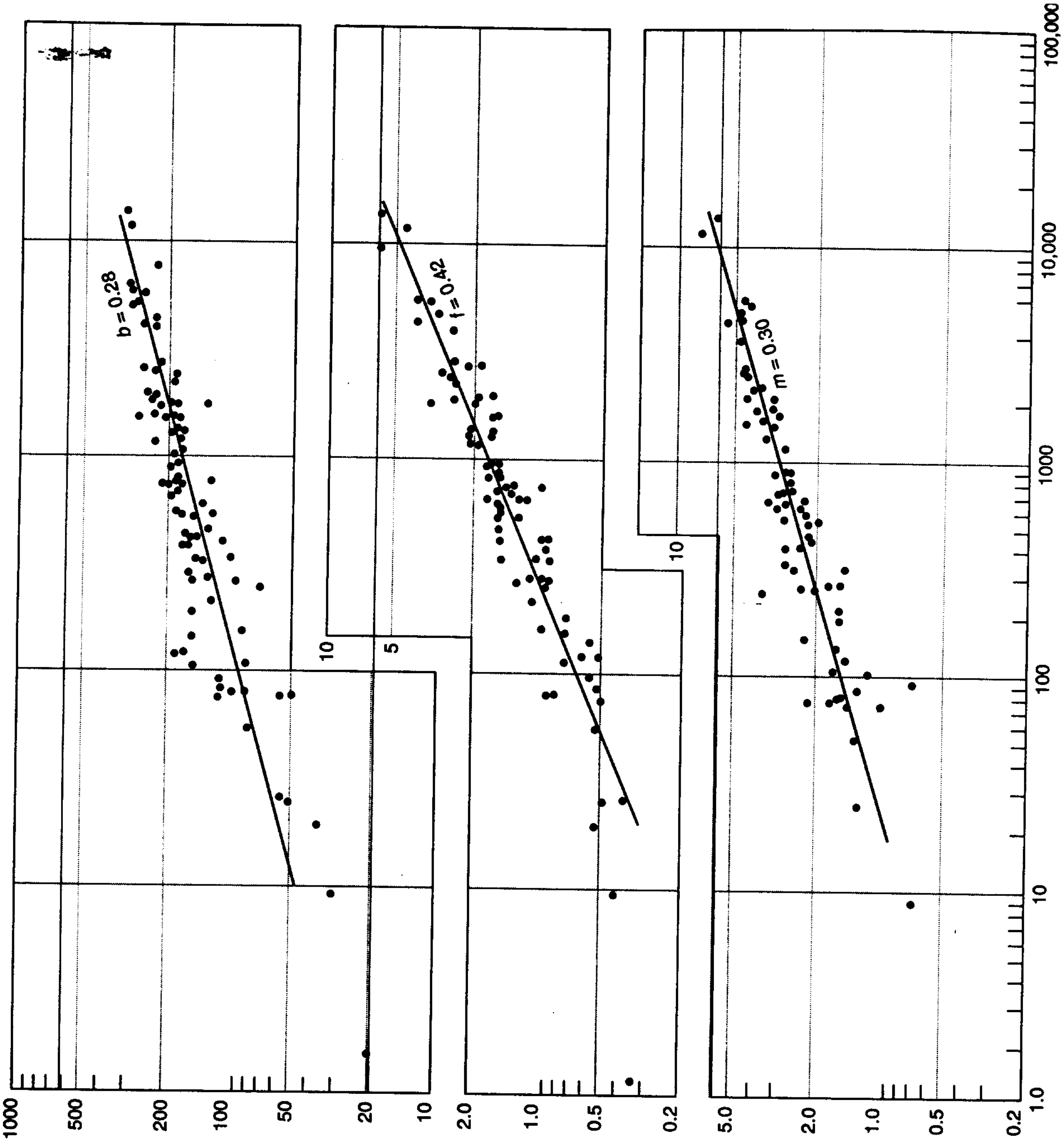

FIGURE 5-7
Relationship of discharge to width, depth, and velocity in a stream. (From Leopold and Maddock, 1953)

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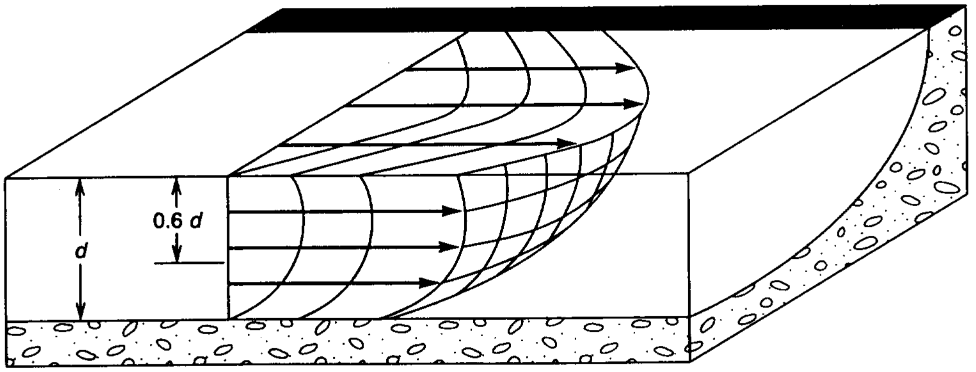

FIGURE 5-14
Three-dimensional, velocity-gradient curve for water flowing in a stream channel.

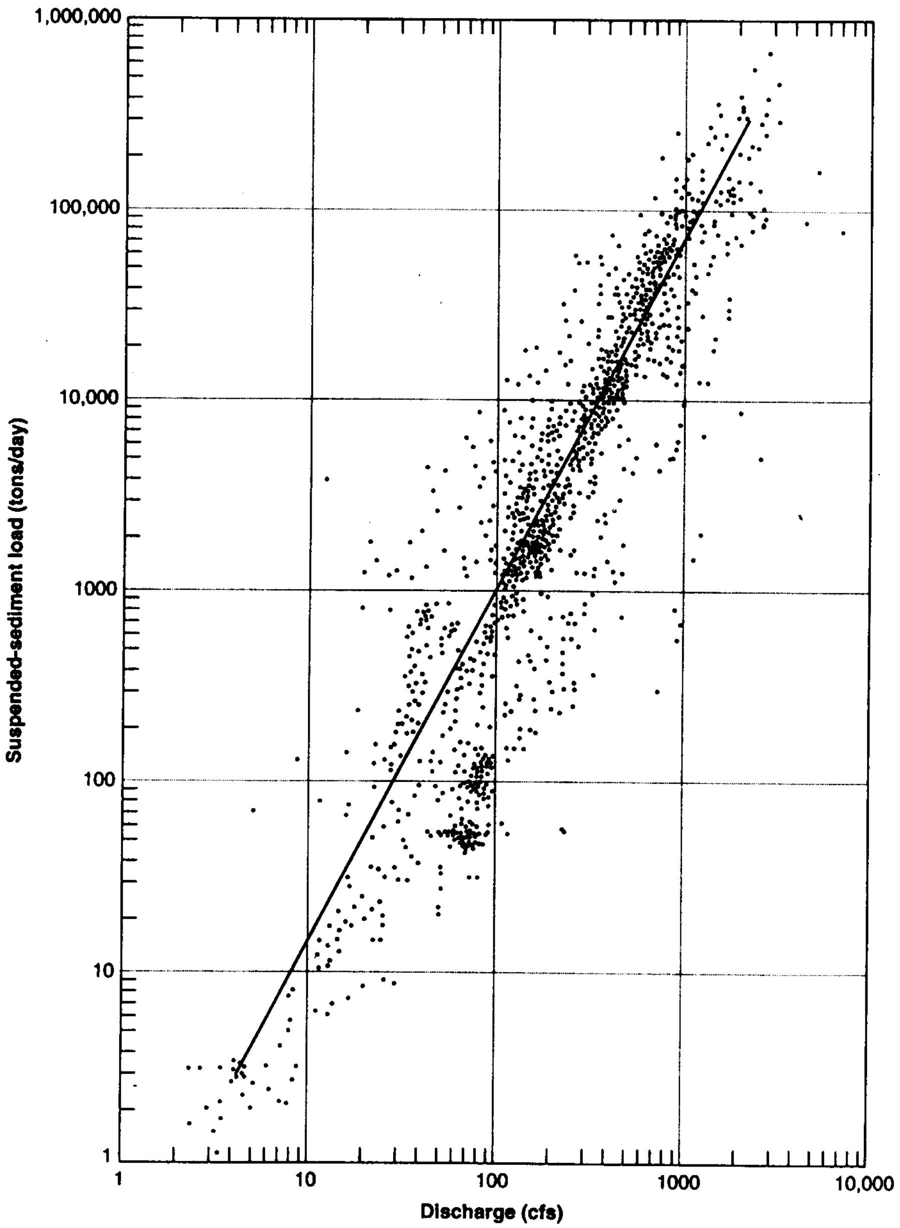

FIGURE 5–19
Increase in suspended load with discharge, Powder River at Arvada, Wyoming. (From Leopold and Maddock, 1953)

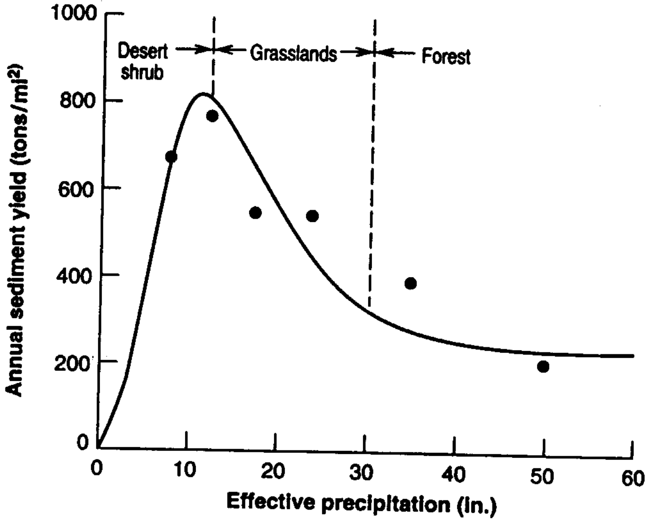

FIGURE 5–18
Relationship between sediment yield and climate/vegetation (From Langbein and Schumm, 1958).

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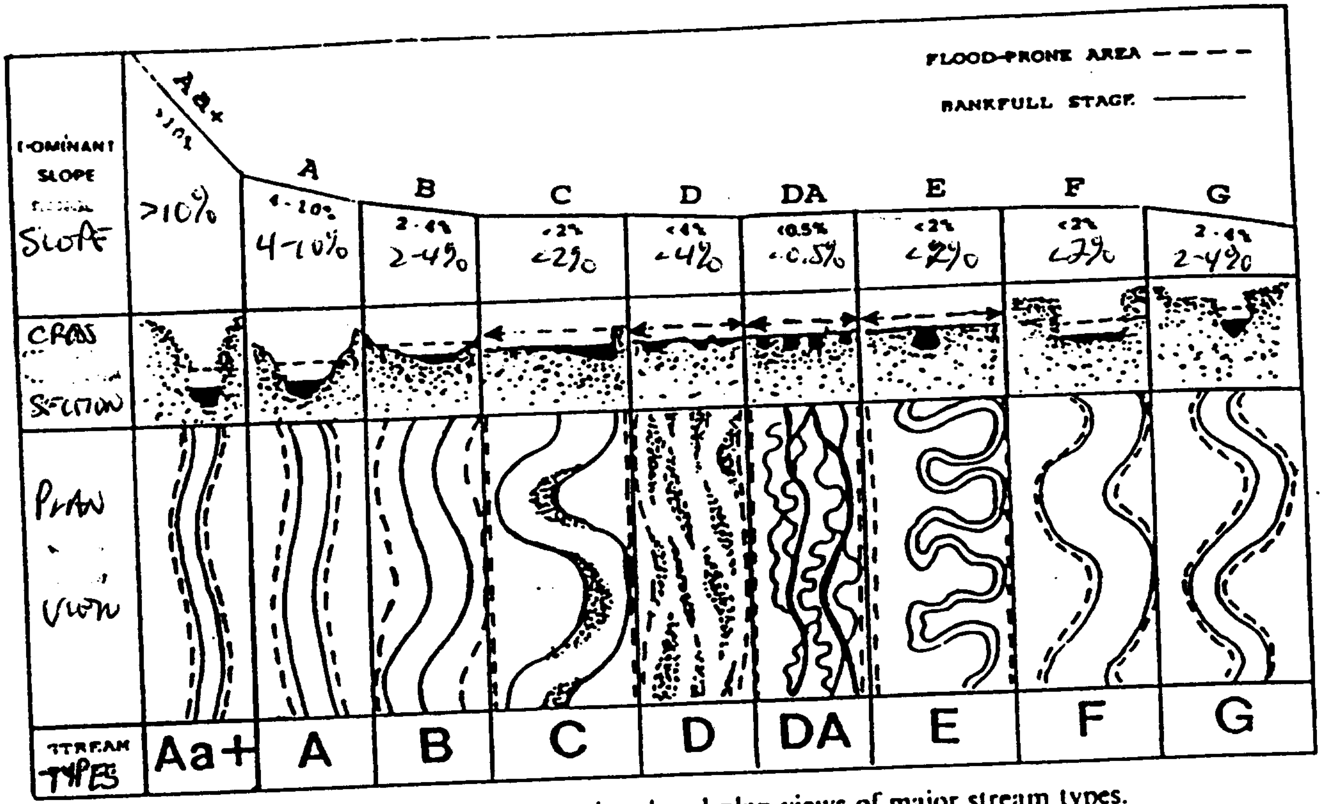

FIG. 2 ~~Fig. 1~~. Longitudinal, cross-sectional and plan views of major stream types.

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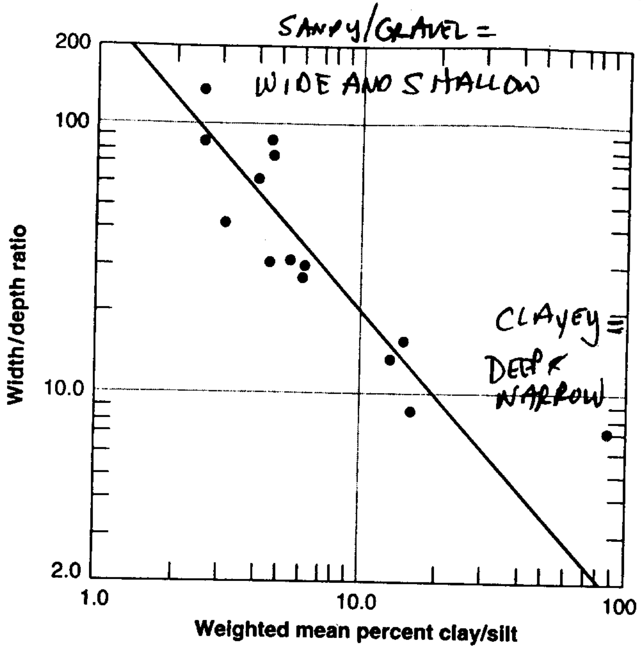

FIGURE 5-31
Relationship between silt/clay content of bank-forming material and width/depth of the channel. (From Schumm, 1960, 1977)

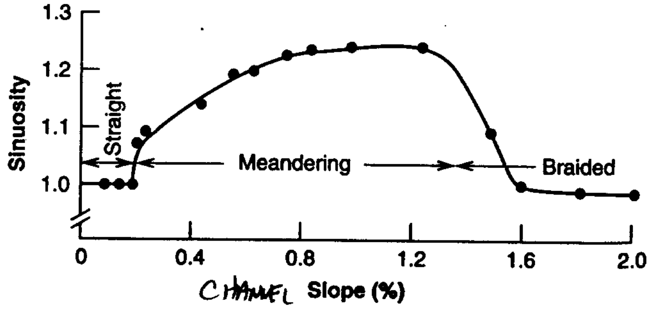

FIGURE 5-33
Stream gradients of meandering and braiding streams. (From Schumm and Khan, 1972)

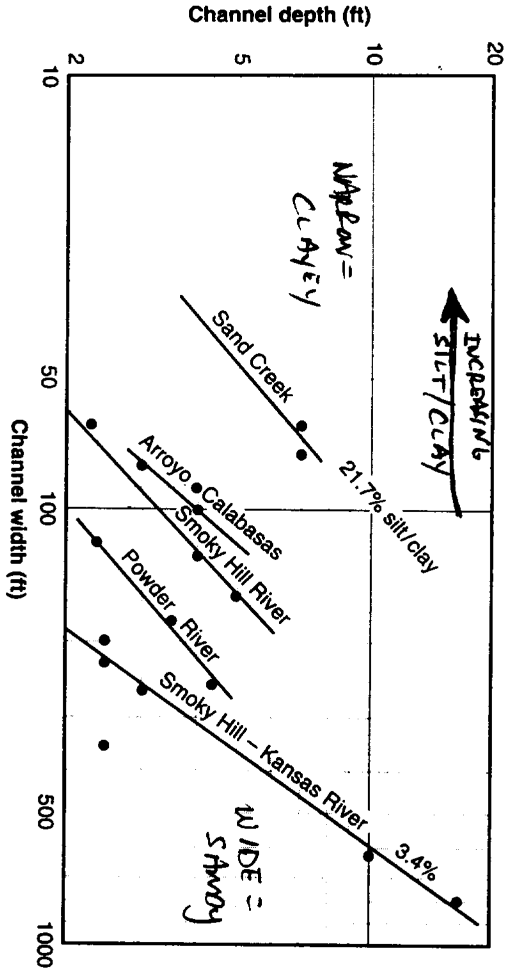

FIGURE 5-32
Relationship of width/depth ratios to silt/clay content in alluvial streams on the Great Plains. (From Schumm, 1960)

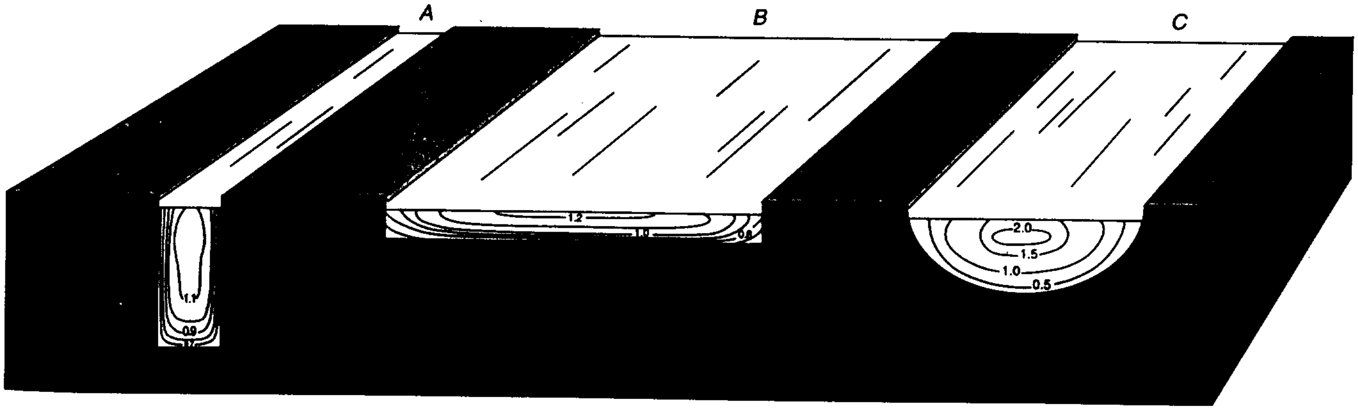

FIGURE 5-30
Variation of width/depth relationships in stream channels.

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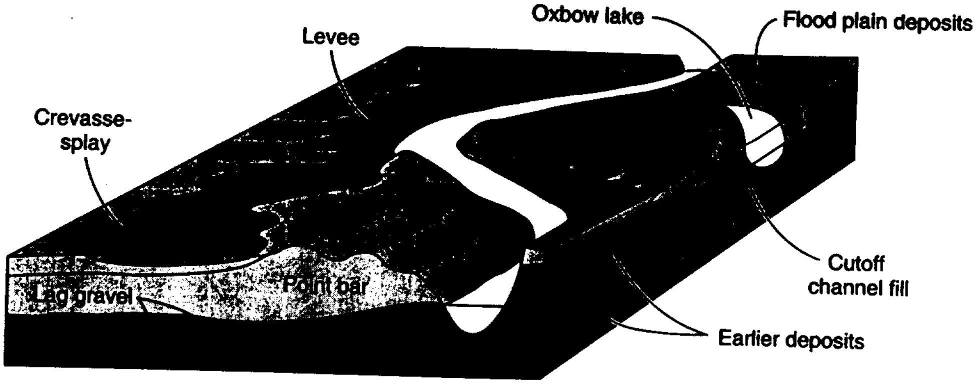

FIGURE 6–19
Typical flood-plain landforms. (Modified from Happ, 1971)

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FIGURE 6–20
Point-bar deposits on the inside of a meander, Sauk River, Washington.

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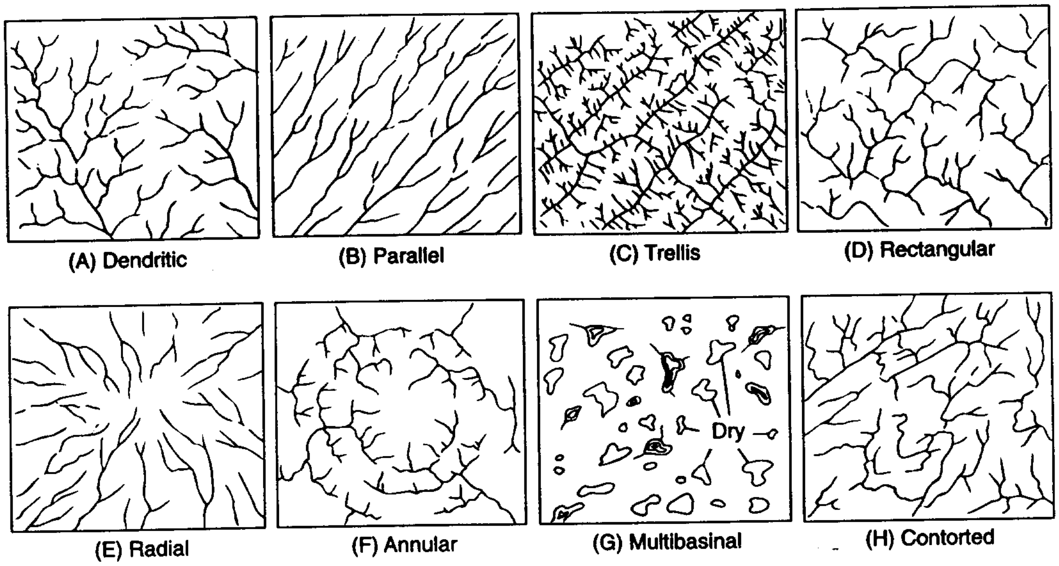

(A) Dendritic (B) Parallel (C) Trellis (D) Rectangular

(E) Radial (F) Annular (G) Multibasinal (H) Contorted

FIGURE 5.2
Basic drainage patterns. Descriptions are given in table 5.1.
(Howard 1967, reprinted by permission)

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TABLE 5.1 Descriptions and characteristics of basic drainage patterns illustrated in figure 5.2.

Pattern	Geological Significance
Dendritic	Horizontal sediments or beveled, uniformly resistant, crystalline rocks. Gentle regional slope at present or at time of drainage inception. Type pattern resembles spreading oak or chestnut tree.
Parallel	Generally indicates moderate to steep slopes but also found in areas of parallel, elongate landforms. All transitions possible between this pattern and dendritic and trellis patterns.
Trellis	Dipping or folded sedimentary, volcanic, or low-grade metasedimentary rocks; areas of parallel fractures; exposed lake or seafloors ribbed by beach ridges. All transitions to parallel pattern. Pattern is regarded here as one in which small tributaries are essentially same size on opposite sides of long parallel subsequent streams.
Rectangular	Joints and/or faults at right angles. Lacks orderly repetitive quality of trellis pattern; streams and divides lack regional continuity.
Radial	Volcanoes, domes, and erosion residuals. A complex of radial patterns in a volcanic field might be called multiradial.
Annular	Structural domes and basins, diatremes, and possibly stocks.
Multibasinal	Hummocky surficial deposits; differentially scoured or deflated bedrock; areas of recent volcanism, limestone solution, and permafrost. This descriptive term is suggested for all multiple-depression patterns whose exact origins are unknown.
Contorted	Contorted, coarsely layered metamorphic rocks. Dikes, veins, and migmatized bands provide the resistant layers in some areas. Pattern differs from recurved trellis in lack of regional orderliness, discontinuity of ridges and valleys, and generally smaller scale.

From Howard, 1967, reprinted by permission.

74c

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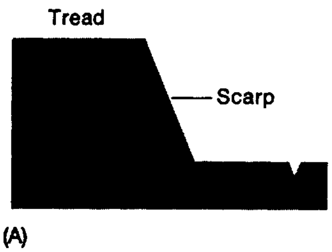


FIGURE 7.10
(A) Parts of a fluvial terrace.
(B) Terraces along the Madison River upstream from Ennis, Mont.

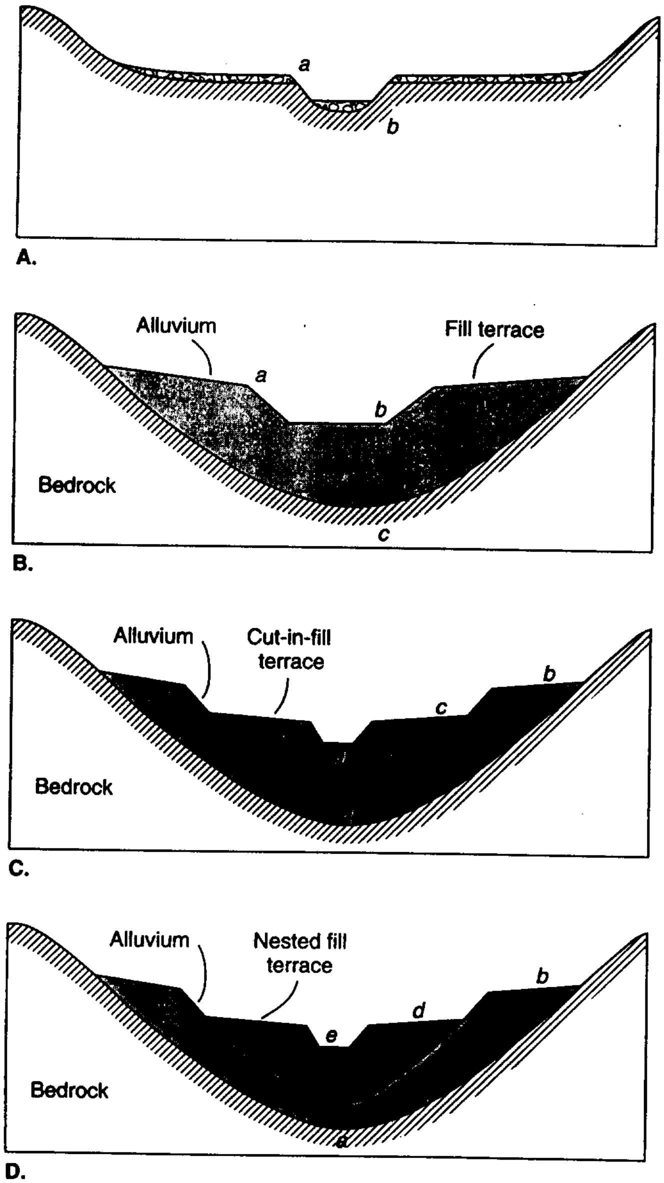
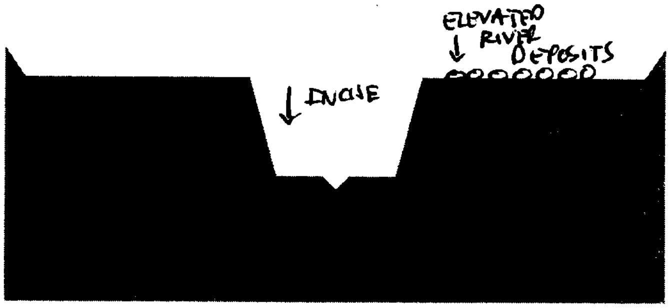
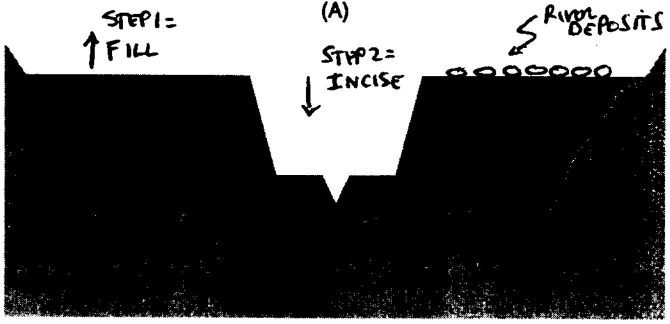


FIGURE 6–47
Types of stream terraces: (A) bedrock (cut) terrace, (B) fill terrace, (C) cut-in-fill terrace, (D) nested fill terrace.



Erosional terrace
(A)



Depositional terrace
(B)

FIGURE 7.11
(A) Erosional terrace. Thin alluvial cover with truncation of underlying bedrock along smooth, even surface.
(B) Depositional terrace. Terrace scarp underlain by alluvium that is highest level of fill deposited in valley. Note thickness of alluvium and irregular bedrock surface beneath the fill.

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PALEOFLOOD
EVIDENCE

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FIGURE 5–10
Boulders moved by the 1976 Big Thompson River flood.

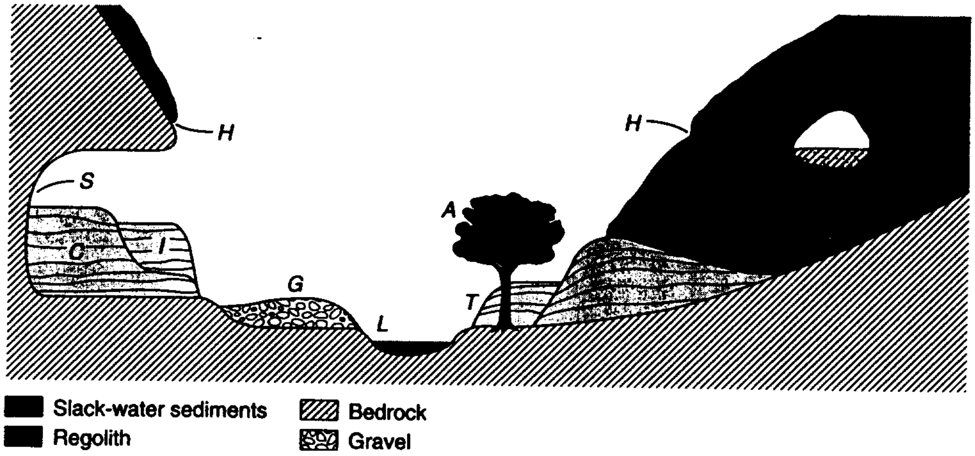

FIGURE 5–13
Idealized cross section of a bedrock canyon river. *A* is a tree with adventitious roots growing on flood deposits; *B* is high-level slack-water sediment in a cave on the canyon wall; *C* is a cave deposit of slack-water sediments; *G* is a gravel and boulder bar on the canyon floor; *H* is a high-water mark created by scour of soil on the canyon walls; *I* is inset slack-water sediments; *L* is the low-flow channel of active river; *M* is tributary-mouth, slack-water deposits; *S* is the silt line of a paleoflood preserved in a cave; and *T* is a slack-water terrace. (After Baker, 1987)

74N

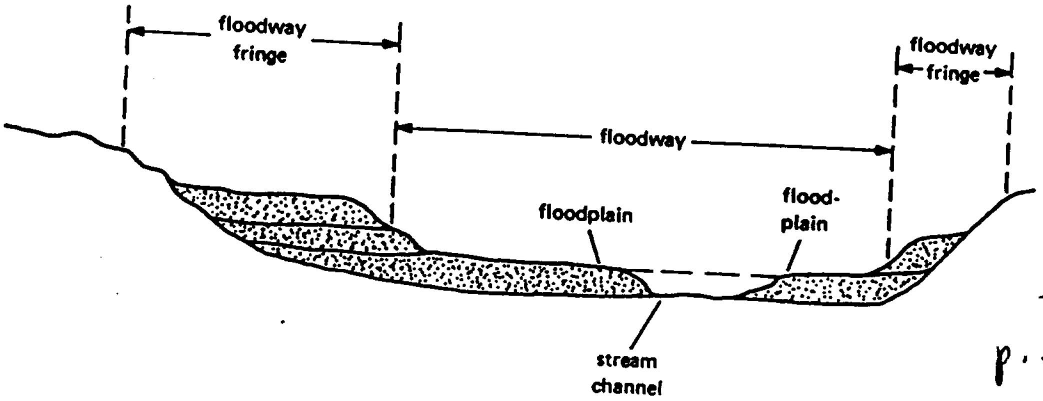

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Figure 11.1. View across a river. The floodway is the area along the river which is frequently flooded, an area over which the flood discharge moves with great velocity. The floodway fringe includes areas which are further from the actual channel and which are infrequently flooded by rare events. The floodway fringe is that area flooded by the "100-year" flood.

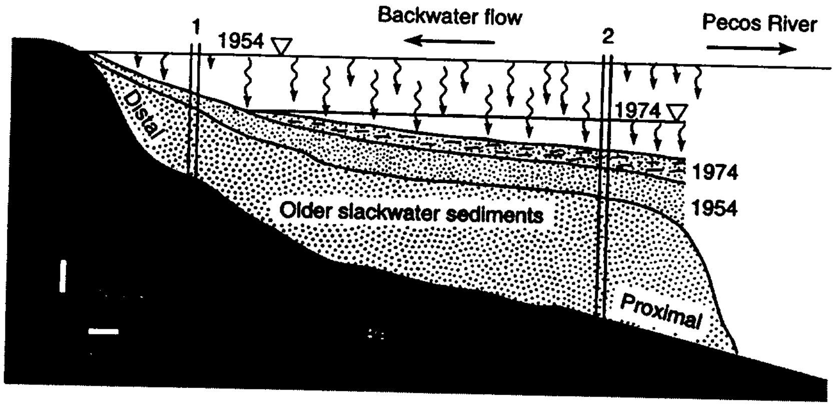

FIGURE 5.37

Schematic of on- and off-lap sequences and peak flood stage in a tributary valley for the 1954 and 1974 floods on the Pecos River, Texas. Sections in the proximal region (area 2) contain both floods, while distal regions (area 1) farther up the tributary record only the larger 1954 flood. Paleostage reconstructions are based on the elevation of the most distal sediments of each flood unit.

(Kochel et al. 1982)

10.
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