Geomorphic Stream Classification
“A Classification of Natural Rivers”, Rosgen, D.L.
Why is Stream Classification Essential?

• Physical stream channel evolution
• Similar stream types manifest similar patterns
• Natural channel design
• Planning and management
• Riverine habitats, plants and animals are constrained by natural channel physics
We need a greater resolution on the landscape based on morphometry. It must be reproducible and measurable. We can communicate about a relatively complex description in relatively simple terms.
# Classification Level 1

## Longitudinal, Cross-Sectional, and Plan Views of Major Stream Types

<table>
<thead>
<tr>
<th>Dominant Slope Range</th>
<th>Cross Section View</th>
<th>Plan View</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 10%</td>
<td></td>
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<tr>
<td>4 - 10%</td>
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<tr>
<td>2 - 4%</td>
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<tr>
<td>&lt; 2%</td>
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<td>&lt; 4%</td>
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<td>&lt; 0.5%</td>
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<td>&lt; 2%</td>
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<tr>
<td>&lt; 2%</td>
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<tr>
<td>2 - 4%</td>
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</tbody>
</table>

### Stream Types

- **Aa+**
- **A**
- **B**
- **C**
- **D**
- **DA**
- **E**
- **F**
- **G**
Entrenchment Ratio

Entrenched
Entrenchment Ratio = 1.0 - 1.4

Stream Type A

Moderately Entrenched
Entrenchment Ratio = 1.41 - 2.2

Stream Type B

Slightly Entrenched
Entrenchment Ratio = 2.2 +

Stream Type C

Stream Type D

Stream Type E

Entrenchment Ratio
Flood-Prone Width
Bankfull Width

Flood-Prone Width = Water Level @ 2 x Max. Depth
What are the dimensionless ratios for the stable form relative to the specific reach of interest?
Distinct Morphology by Stream Type
(i.e, meander belt width)
We need to answer these concerns

- Are we comparing apples to apples? (94 basic geomorphic stream types.)
- Dimensions applied in stream design are not regionalized.
- Database and stream design dimensions are lacking.
A1a Morphology

A1a Trib. to Uncampaghre

Valley Type I, Youthful Topography
A2 - Yelm, WA

Valley Type I, Source
A3a Stream Morphology

A3a on Uncampaghre Headwaters

DELINEATIVE CRITERIA (A3)

- Landform/soil: Steep, narrow depositional slopes typical of glacial moraines and debris slid associated with unconsolidated, heterogeneous and non-cohesive materials.
- Channel materials: Predominantly cobble with a mixture of boulders, gravel and sand.
- Slope Range: 0.4 - 1.0 (A3a > 0.10)
- Width/depth Ratio: < 12
- Entrenchment Ratio: < 1.4
- Sinuosity: < 1.2
A3 less than 10% Slope

Cobble Bed, Highly Entrenched, Low Width to Depth Ratio, Low Sinuosity.

Sometimes miss-classified as a G stream type.
A5 Stream Type
Valley Types and Stream Classification

Type I

Type VI, fault control

Type VIII, Mature

A Streams

B Streams

C and D streams, high gradient

C, E, D, F, Gc

Type V Early Mature
Geomorphic Valley Types

What do William Morris Davis (1899) and Dave Rosgen have in common?
B1 Morphology

- Single Threaded
- Entrenchment 1.4 – 2.2
- Width to depth Ratio > 12
- Sinuosity > 1.2
- Slope 2 to 4%
- $B_a$ Slope range 4 to 10%
- $B_c$ Slope less than 2%

**DELINEATIVE CRITERIA (B1)**

Landform/soils: Structural controlled narrow valleys with moderate side slopes.

Channel materials: Bedrock bed with streambanks composed of boulders, cobble and gravel

Slope Range: .02 - .04 ($B_{1c} < .02$)

Entrenchment Ratio: 1.4 - 2.2

Width/depth Ratio: > 12

Sinuosity: > 1.2
B2c with a slope less than 2% (0.002 ft/ft)
B2 Step: Pool Morphology
B3 Morphology

Cobble Bed

DELINEATIVE CRITERIA (B3)

<table>
<thead>
<tr>
<th>Landform/soils:</th>
<th>Narrow, moderately steep colluvial valleys with gentle side slopes. Soils are colluvium and/or alluvium. Often in fault line valleys or on well vegetated alluvial fans.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel materials:</td>
<td>Predominantly cobble with lesser amounts of boulders, gravel and sand. Streambanks are stable due to coarse material.</td>
</tr>
<tr>
<td>Slope Range:</td>
<td>.02 - .04 (B3c, &lt; .02)</td>
</tr>
<tr>
<td>Width/depth Ratio:</td>
<td>&gt; 12</td>
</tr>
<tr>
<td>Entrenchment Ratio:</td>
<td>1.4 - 2.2</td>
</tr>
<tr>
<td>Sinuosity:</td>
<td>&gt; 1.2</td>
</tr>
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</table>
B stream Type in Valley Type II Young Valleys
**B4**
Slope 2-4%

**B4c** is very common
Slope < 2%

**DELINEATIVE CRITERIA (B4)**

<table>
<thead>
<tr>
<th>Landform/soils:</th>
<th>Narrow, moderately steep colluvial valleys, occasionally on well vegetated stable alluvial fan, or in fault line valleys.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel materials:</td>
<td>Gravel dominated with lesser amounts of boulders, cobble and sand.</td>
</tr>
<tr>
<td>Slope Range:</td>
<td>.02 - .04 (B4c &lt; .02)</td>
</tr>
<tr>
<td>Entrenchment Ratio:</td>
<td>1.4 - 2.2</td>
</tr>
<tr>
<td>Width/depth Ratio:</td>
<td>&gt; 12</td>
</tr>
<tr>
<td>Sinuosity:</td>
<td>&gt; 1.2</td>
</tr>
</tbody>
</table>
Often may have numerous cobbles present but
D$_{50} < 64$mm
B5-Sand

Very Sensitive to Disturbance

B5 Stream Type
B6
Not very common but present in steep loess country

**DELINEATIVE CRITERIA (B6)**

**Landform/soils:** Narrow, moderately steep valleys with gentle sloping sideslopes. Soils either residual, alluvial and/or colluvial.

**Channel materials:** Silt/Clay with lesser amounts of sand.

**Slope Range:** 0.02 - 0.04 (B5c, < 0.02)  
**Entrenchment Ratio:** 1.4 - 2.2  
**Width/depth Ratio:** > 12  
**Sinuosity:** > 1.2
B6 forming on Palouse
Not Common
C Stream Type
Morphology
Classic Pool: Riffle Morphology
Well-Attached Floodplain

C3, C4, and C5 are some of the most common stream types.
Valley Type VIII
Multiple Terraces

Common valleys for C type streams, sometime Es. However, D, F, and G types can be found depending on stream and riparian conditions.
C Morphology

Sinuosity > 1.2
Slope, 0.01 to 2%
C_b slope 2-4%
C_c- slopes < 0.1%

Single and thread channel
Entrenchment Ratio > 2.2
Width:Depth Ratio > 12
C Morphology Restored
C1
Bedrock control cobbles and boulders present
Not a common type

DELINIEATIVE CRITERIA (C1)

Landform/soils: Broad, gentle gradient structural controlled alluvial valleys.
Channel materials: Bedrock bed with alluvial banks (cobble, gravel and sand).
Slope Range: < .02 (C1c-.001) Entrenchment Ratio: > 2.2
Width/depth Ratio: >12 Sinuosity: >1.2
C4 Current Stable Analog-North Cascades
The C4 Stream Type is a Key Stream Type for Salmonids.
C4 Morphology, very common, very important on the landscape
C5 Sand Bed

DELINEATIVE CRITERIA (C5)

Landform/soils: Broad, gentle gradient alluvial valleys, river deltas, broad plains. Soils are depositional such as lacustrine, glacial outwash, eolian.

Channel materials: Predominantly sand bed and banks, with occasional gravel and silt/clay. Streambanks may contain finer particles than bed material.

Slope Range: < .02 (C5c: .001) Entrenchment Ratio: > 2.2
Width/depth Ratio: >12 Sinuosity: >1.4
C6 Morphology

Usually very gentle slopes often associated with lacustrine valley development

**DELINEATIVE CRITERIA (C6)**

**Landform/soils:** Broad gentle valleys, plains, and deltas. Depositional soils (alluvium), associated with cohesive materials from riverine and lacustrine processes. Often associated with tidal influence deltas, marshes and other wetland complexes.

**Channel materials:** Silt-clay predominates, however many of these C6 stream types are associated with a high organic component including peat.

**Slope Range:** $< .02$ ($C6c - .001$) ($0.001$ more common)

**Width/depth Ratio:** $> 12$ (generally lowest of Cs)

**Entrenchment Ratio:** $> 2.2$

**Sinuosity:** $> 1.4$
D4 Braided

DELINATEIVE CRITERIA (D4)

Landform/soils: Moderately steep glacial valleys, alluvial fans, narrow fluvial mountain valleys and terraced valleys in coarse alluvium. Can occur in gravel splays, and coarse delta deposits.

Channel materials: Gravel bed with smaller quantities of cobble. Typical is a bi-modal distribution of sands. Stream bank materials generally finer than bed, actively eroding.

Slope Range: < .04
Width/depth Ratio: > 40

Entrenchment Ratio: N/A (not incised)

Sinuosity: Low, channel slope = valley slope
Braided (DA_) Anastomosed

Mature natural stable type braided stream with multiple low width to depth ratio channels, most highly biologically productive per linear stream distance. Often found in estuaries, lacustrine bed very flat valleys and outlets to lakes.
Is your river an anastomosed braided system or in a highly perturbed braided condition?
E Channel Morphology (at bankfull)

Upper Sanpoil River, WA, ER = 19, Average Depth 3.1 feet
Average Width 16, Average slope 0.002 ft/ft, Valley type X
E Channel Morphology

Single Thread channel
Entrenchment Ratio > 2.2
Width to Depth Ratio < 12
Sinuosity > 1.5
Slope < 2%
$E_b$, Slope ranges 2-4%, not common
Valley Type X: Often E or C
E4 Stream Type
E3 Channels
Not Common but present in high mountain meadows

DELINEATIVE CRITERIA (E3)

Landform/soils: Broad, gentle to moderately steep alluvial valleys.

Channel materials: Cobble dominated with fewer accumulations of gravel and sand. Stream banks have gravel/sand matrix mixed with dense root mats/organic material. Very stable.

Slope Range: < .02 (E3, .02-.04)
Entrenchment Ratio: > 2.2
Width/depth Ratio: < 12
Sinuosity: > 1.5 (less if E3.)
E4 Stream Type
E5, Sand Bed
F Channel Morphology

Highly Entrenched > 1.4

High Width to Depth Ratio > 12

Sinuosity > 1.2

Slopes < 2.0% (0.02ft/ft)

F_b Slopes, 2 to 4%
THE MORPHOLOGICAL DESCRIPTION

Crab Creek

F4 - Colorado

F4 - California

F4 - Texas
G Stream Types

- Entrenchment Ratio < 1.4
- Width Depth Ratio < 12
- Sinuosity > 1.2
- Slope, 2-4%
- $G_c$ Slopes < 2% Common on Ag. Landscape, Schumm Stage II, Rapid Channel adjustment

Floodplain

Swan Creek, WA
THE MORPHOLOGICAL DESCRIPTION

DELINEATIVE CRITERIA (G4)

G4 - Nevada

G4 - California

G4 - Maryland
Before and After

Six years and two large floods later
Channel Change Adjustments and Evolution
Five years Later

1997
Channel Evolution Model

Schumm, Harvey, Watson (1984):

I
Stable Floodplain $Q_{1.5}$ Terrace 1

II
Incision $Q_{10}$ (Headcutting)

III
Widening $+Q_{10}$ (Bank Failure)

IV
$+Q_{10}$ Stabilizing /Deposition

V
Stable Floodplain $Q_{1.5}$

Terrace 1

Modified by W. Barry Southerland, 2003
Floodplain Abandonment

Schumm Channel Evolution Model and Bank Height Ratio (BHR)

BHR = Top of the Bank / Bankfull Height. This is a measure of the degree of incision.
Bank height ratio

This variable is a field measurement that determines the degree of channel incision. It is calculated by dividing the maximum bankfull depth into the height of the lowest bank.

A) \( \frac{\text{Lowest Bank Height}}{\text{Max Bankfull Depth}} = \text{BHR} = 1.0 \) (Stable)

B) \( \frac{\text{Lowest Bank Height}}{\text{Max Bankfull Depth}} = \text{BHR} = 1.1 \) (Moderately Unstable)

C) \( \frac{\text{Lowest Bank Height}}{\text{Max Bankfull Depth}} = \text{BHR} = 1.45 \) (Unstable)

D) \( \frac{\text{Lowest Bank Height}}{\text{Max Bankfull Depth}} = \text{BHR} = 1.63 \) (Highly Unstable)
Why BHR?

BHR ~ 1.05

BHR > 1.2, early incision begins to show impacts

Wenas Stream

Sanpoil Stream

Bankfull
Channel Succession
Slight entrenchment but with meander confinement,

Schumm Stage V — E4 Channel
Aquatic Habitat Response to Stream Type Change

<table>
<thead>
<tr>
<th>Variable</th>
<th>C→G</th>
<th>G→F</th>
<th>F→C</th>
<th>C→D</th>
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<tbody>
<tr>
<td>Instream Cover</td>
<td>↓</td>
<td>↓</td>
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<td>↓</td>
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<tr>
<td>Overhead Cover</td>
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<td>↓</td>
<td>↑</td>
<td>↓</td>
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<tr>
<td>Substrate Composition</td>
<td>↑</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
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<tr>
<td>Pool Quality</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Holding Cover Velocity</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
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<tr>
<td>Temperature</td>
<td>→ →</td>
<td>↑</td>
<td>↓</td>
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<tr>
<td>Oxygen</td>
<td>→ →</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
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<tr>
<td>Macro Invertebrates</td>
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<td>↓</td>
<td>↑</td>
<td>↓</td>
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<tr>
<td>Spawning Habitat</td>
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<td>↓</td>
<td>↑</td>
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<tr>
<td>Diversity</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
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<tr>
<td>Rearing</td>
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<tr>
<td>IBI Score</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Schumm</td>
<td>Rosgen</td>
<td>Treatment Strategies</td>
<td>Typical Practices</td>
<td></td>
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<td>--------------------------------------------</td>
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<td></td>
</tr>
<tr>
<td>I Stable</td>
<td>C and E for meandering streams</td>
<td>Maintain Watershed (W/S) Discharge (Qw), &amp; Sediment (Qs) Maintain riparian</td>
<td>Spot Treat. Soil Bio. Stakes, fascines, Rooted stock Whole Plant</td>
<td></td>
</tr>
</tbody>
</table>
## Pot. Treat. Options Low Banks (<8 ft.), Low Gradient, Rosgen Stream Type & Schumm CEM Stage

<table>
<thead>
<tr>
<th>Schumm</th>
<th>Rosgen Type</th>
<th>Treatment Strategies</th>
<th>Typical Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage II</td>
<td>F &amp; Gc Type</td>
<td>Reduce W/S Qw &amp; Qs. May need to raise the channel and reconnect floodplain, increase sinuosity (K) and improve riparian</td>
<td>Channel re-alignment and grade control. Use soil bioengineering only with other stability practices</td>
</tr>
<tr>
<td>Schumm et al.</td>
<td>Rosgen</td>
<td>Treatment Strategies</td>
<td>Typical Practice</td>
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</tr>
<tr>
<td>Early Stage III</td>
<td>F Type</td>
<td>Reduce W/S Qw. &amp; Qs. May need to excavate (shape) a flood plain &amp; banks for to obtain protection</td>
<td>Grading with long term toe protection Soil bioengineer-ing &amp; whole plant transplants</td>
</tr>
<tr>
<td>Schumm et al.</td>
<td>Rosgen</td>
<td>Treatment Strategies</td>
<td>Typical Practice</td>
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<tr>
<td>Late Stage III of Widening</td>
<td>F &amp; Bc</td>
<td>Maintain existing W/S, Qw &amp; Qs. May need to grade for more flood plain and shape banks for toe protect. &amp; riparian improvement</td>
<td>Grading w/ long term toe protection and needed soil bio. no independent soil bio.</td>
</tr>
</tbody>
</table>
### Pot. Treat. Options Low Banks (<8 ft.), Low Gradient, Rosgen Stream Type & Schumm CEM Stage

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<th>Rosgen</th>
<th>Treatment Strategies</th>
<th>Typical Practice</th>
</tr>
</thead>
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<tr>
<td>Stage IV Deposition</td>
<td>F &amp; Bc</td>
<td>Maintain existing W/S Qw &amp; Qs; soil bio. to improve riparian</td>
<td>Minor grading and needed soil bioengineering</td>
</tr>
<tr>
<td>Schumm et al.</td>
<td>Rosgen</td>
<td>Treatment Strategies</td>
<td>Typical Practice</td>
</tr>
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<td>--------------</td>
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<td>------------------</td>
</tr>
<tr>
<td>Late Stage IV Deposition</td>
<td>C &amp; E</td>
<td>Maintain existing W/S Qw &amp; Qs; soil bioengineering to improve riparian</td>
<td>Minor grading and needed soil bioengineering</td>
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<tr>
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</tr>
<tr>
<td>Stage V</td>
<td>C &amp; E</td>
<td>Maintain existing W/S Qw &amp; Qs; Maintain riparian corridor; May need isolated soil bioengineering to improve riparian</td>
<td>Spot treatment w/ fascine, live stake w/ rooted stock or grasses</td>
</tr>
</tbody>
</table>
Streambank slope relative to structure

Photo by WBS, Ohio Creek, CO, 6/2005
Thank you. Questions, please?

Who’s your Mommy now?