Background – Why Evaluate the Physical Characteristics of a Stream?
A stream is the carpenter of its own edifice…
Stream channels and floodplains are constantly adjusting to the amount of water and sediment supplied by the watershed. Four physical characteristics of a stream are in a dynamic state of equilibrium called Lane's Balance. These characteristics are streamflow, channel slope, sediment load, and particle size. If one of these characteristics change in a stream, one or more of the other three must also change to accommodate and achieve equilibrium again. The change of streambed texture (particle size) is the first thing to change in response to a disturbance to restore equilibrium and it is the most sensitive measures of change. A Wolman Pebble Count can measure the texture of a stream. From the pebble count and a subsequent measure of point bar deposits, a riffle stability index and log relative bed stability can be calculated. These two values can provide insight into changes in sediment load carried by the stream. In other words, they can tell us if sedimentation is occurring.

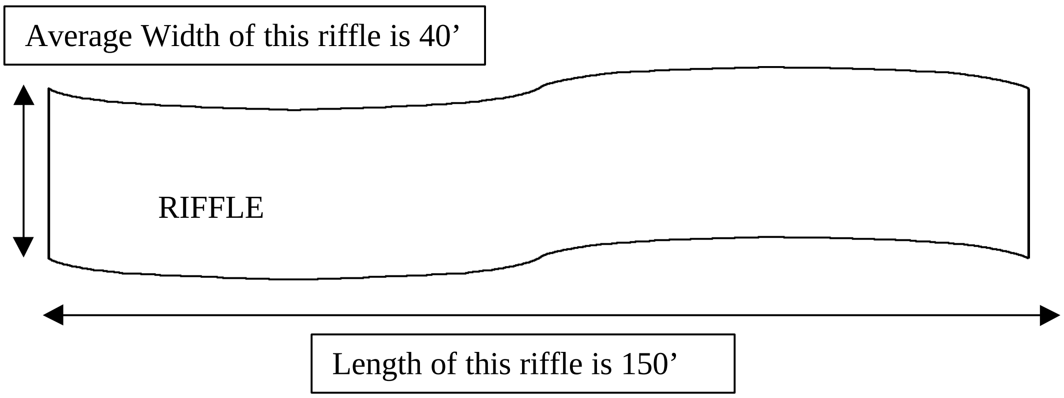
Pebble Count Method
The pebble count method is conducted on a portion of the stream to evaluate the streambed composition. The composition of the streambed can tell you a lot about the characteristics of the stream. It can illustrate the effects of flooding, sedimentation, and other physical impacts to a stream.

The basic process for the pebble count is to classify the size of at least 200 particles within a riffle. We will establish a sampling grid across the entire riffle, which consists of at least 3 transects (possibly more). Measure the particles found at 1-foot intervals across each transect. The specific methodology is outlined below, however it is important to stress that each riffle should be transected at least 3 times (at the upper part of the riffle, the low part, and in the middle) and at least 200 measurements should be made.

1. Select Riffle. A riffle is a place of shallow rapids; where the water flows swiftly over completely or partially submerged obstruction to produce surface agitation, but standing waves are absent. The riffle selected should be representative of the reach that it is in. A reach is a section of a stream with uniform physical characteristics of stream.
2. Find "Bankfull". Bankfull is the place on the bank where the stream rises during a large water event, a 1-2 year flood event. It is sometimes described as the elevation on the bank where flooding begins. Bank full it corresponds to the elevation of the top of the point bar. Evidence of bank full location on banks of stream – look for changes in slope, vegetation, no soil vs. soil, evidence of scouring activity (bare roots of trees), changes in perennial and annual vegetation.
3. Measure Riffle – Need to take 2 measurements: width of riffle and length of riffle. The width of the riffle should be taken at what appears to be the average width of the riffle. Measure the width of the riffle from bank full to bank full. Measure the length from the top of the riffle to the bottom. The top of the riffle is the point of transition

between smoother flatter water and where the velocity of the water gets faster. The bottom of the riffle is where the water starts to flatten out again.

4. To obtain at least 200 measurements of particle size, we need to determine the number of transects for the riffle. The number of transects needed = 200 divided by the width of riffle. Round this number up to the next whole number.
5. Determine the spacing between transects – divide the length of the riffle by the number of transects.



EXAMPLE:

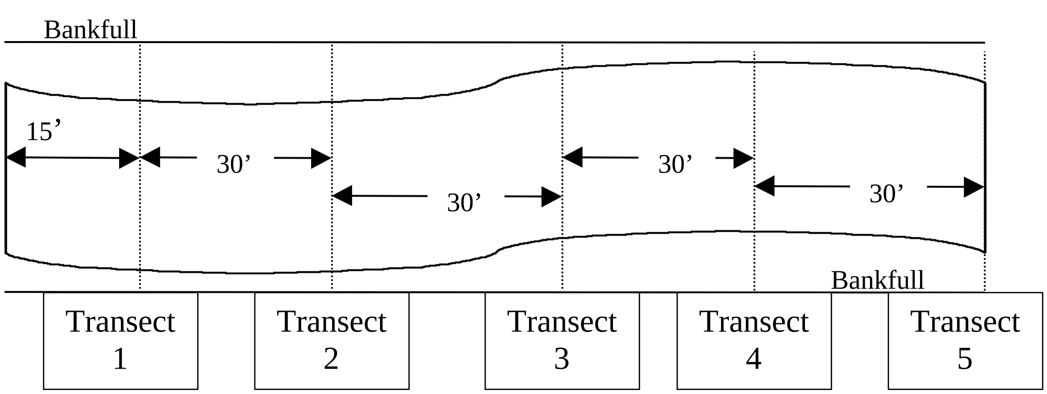
<u>Find the number of transects needed:</u>

200 (total number of samples needed) divided by 40 (width of riffle) = 5 transects

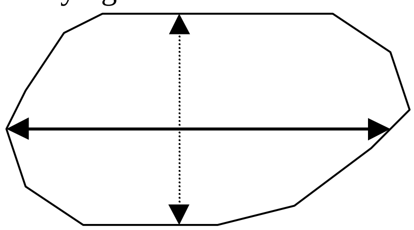
<u>Find the spacing required between transects</u>

150’ (length of riffle) divided by 5 (transects) = 30’ between transects

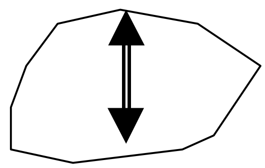
6. Set your first transect. Start downstream at the bottom of the riffle and measure ½ of the distance required between transects (in our example our transects are 30’ apart so our first transect will be set 15’ upstream from downstream endpoint of riffle). Make sure you are perpendicular to the end of the riffle and the flow of the water. Place pin at bankfull on both banks – make sure they are directly across from each other. Pull a measuring tape from one pin to another – pull the tape tight.



7. Begin your measurements. Start at the point of bankfull, using a straight rigid tool (either the ruler end of the caliper or a metal rod) allow it to drop perpendicular to the tape you have set along the riffle. Pick up the particle where the rod touches the stream bottom – make sure you select the particle the same way throughout the riffle (for example, if you select it to the right edge of the rod – always grab to the right edge).
8. Measure the diameter of the pebble to determine the particle size class. USE METRIC CALIPER MARKED OFF BY VA SOS BY PARTICLE SIZE CLASS. Use the metric caliper to measure the intermediate axis of the particle in millimeters. What is the intermediate axis? It is the axis the pebble will most likely use to travel down a stream. If you measure all 3 axis, it will be the middle value. When just starting out, measure all 3 axis to determine the intermediate axis, until you get the hang of identifying the intermediate axis.



Rock – view 1, which way will it roll? Measure the both axis.



Same Rock – view 2 (holding rock up). Measure the third access. Which is the intermediate axis (the middle measurement or the way the rock will roll downstream)? The dashed line in the first figure is the intermediate axis.

9. Call out the size class to the data recorder. You can either do this by saying the entire size class (between 2 and 4) or saying the lowest number in the size class (2) – be sure your data recorder know which way you will be calling out the measurement!
10. Follow the tape and move 1 foot to your next sample point – remember we are sampling the entire transect at 1 foot intervals. Again select the particle using the rod, collect the particle, and measure the intermediate axis with the caliper. If you cannot pick up the rock, measure it in the stream – you should still be able to determine the intermediate axis. If you encounter bedrock, tally it in the largest size class for your measurement. If you encounter the same rock (the rock is larger than 1 foot across) – tally it as many times as you encounter it. If you encounter rock completely covered in sand or silt, select the sand or silt for the measurement and tally in that class size. If the sand or silt is just sporadic, tally the rock.
11. Continue across the stream transect at 1 foot intervals. Until you reach bankfull at the other side of your transect. Conduct your final particle selection and measurement at bankfull.
12. Move your tape/transect upstream to the next sampling point – remember in our example our spacing between transects was 30' – so move upstream 30'.
13. Follow the particle selection, measuring, and recording sequence for the subsequent transects until all transects have been measured (this should be over 200 sampling points i.e. over 200 particles measured).
14. After you have finished measuring, fill in the rest of the size class matrix. Add up the total number of pebbles, calculate the percent in each size class, and then calculate the

cumulative percent finer for each size class. The cumulative percent is found by adding the size class percents together as you move down the matrix. See the example data sheets for help with this.

15. Using a pencil and the data sheet to graph your sample. On the graph, you are plotting the cumulative percent.

What do the results of the Wolman Pebble Count mean?

The numbers generated from the Wolman Pebble Count are a unique characterization of the composition of the streambed at one particular point in time. Some interpretation can be made about the results at this time, such as percent finer. More useful interpretation of the data will come by comparing measurements over time or to a reference site (to a stream of similar classification). To provide further interpretation on data collected from a single Wolman Pebble Count measurement, we can evaluate disturbances to the stream by calculating the riffle stability index and the LRBS (Log Relative Bed Stability). Two calculate these two indexes, we need one additional piece of information, an estimate of the largest particle size the stream moves at bankfull flood events.

Riffle Stability Index (RSI) and Log Relative Bed Stability (LRBS) Method and Calculations

After you have obtained the Wolman Pebble Count and graphed the results, you can determine the Riffle Stability Index and the Log Relative Bed Stability. Lateral/point bars contain information about the stability of a riffle and/or stream bed. Riffle bed material in certain channel types is a mixture of smaller mobile materials that can move from one riffle to another during frequent flood events and larger residual particles that do not move or move only slightly and stay within the same riffle. As a riffle is increasingly loaded with sediment from upstream, the mobile component of the streambed changes, and a textural shift in the streambed changes. To use riffle substrate as an index of streambed condition, the size of the largest bedload particles mobile during frequent flood events must be known. Lateral or point bars have been identified as sources of this information. By identifying and classifying the largest particles that make up a point or lateral bar, the mobile percentile or riffle stability index can be determined. The riffle stability index in stable systems is distinctly different from that in systems that have received excessive sediment from upstream.

Below are the procedures for determining the Riffle Stability Index.

1. Go to the nearest lateral or point bar where deposition of rocks has occurred. The point or lateral bar should be in the same reach as the riffle where you conducted the Wolman Pebble Count.
2. Visually inspect the depositional bar to determine the dominant large sized particles.
3. Measure the intermediate axis of 10 – 30 of the dominant large sized pebbles. The pebbles you measure should be freshly moved (no vegetation growing on pebble) and should be the dominant large particles.
4. Record the measurement of the intermediate axis for the 10-30 pebbles sampled on the data sheet.

5. Calculate the arithmetic mean (mean bar sample grain size) of the sample and compare this with the plotted cumulative particle size distribution for the riffle.
6. On the X axis, find the mean bar sample grain size (determined in step 5). Go up to the cumulative particle size distribution and read from the Y axis the percentile this represents. This percentile is the Riffle Stability Index.

The LRBS will be calculated using an excel spreadsheet to calculate a logarithm.

What do the results of the Riffle Stability Index Mean?

The RSI interpretations are as follows:

Riffle Stability Index	Interpretation
< 40	High bedrock component to riffle (very stabile system) or channel has been scoured
40 – 70	Stream is in dynamic equilibrium – good channel and watershed stability
70 – 85	Riffle is somewhat loaded with sediment
> 85	Riffle is increasingly loaded with excess sediment

Equipment Needed

1. Metric Caliper – marked off by VA SOS
2. Clip Board
3. Fiberglass tape of 100’ or more
4. 2 Metal Pins to hold the tape across the streambed
5. Field Data Sheets

Riffle Stability Index

Size Class (mm)		No.	Percent	Cumulative percent	
0 - 2					sand
2 - 4					v.fine gravel
4 - 8					fine gravel
8 - 16					med. gravel
16 - 32					crs. gravel
32 - 64					v. crs. gravel
64 - 128					sm. cobble
128 - 256					lrge cobble
256 - 512					sm. boulder
512 - 1024					med boulder
1024 - 2048					large bouldr
2048 - 4096					v lrge bouldr

TOTAL: ________

Enter the intermediate diameters of 10 - 30 bar samples (mm)

1__________ 11___________ 21___________
2__________ 12___________ 22___________
3__________ 13___________ 23___________
4__________ 14___________ 24___________
5__________ 15___________ 25___________
6__________ 16___________ 26___________
7__________ 17___________ 27___________
8__________ 18___________ 28___________
9__________ 19___________ 29___________
10__________ 20___________ 30___________

Arithmetic mean of the samples: ____________

Compare the average diameter of the common large particle on a fresh depositional area with the cumulative size distribution to determine the Riffle Stability Index.

RIFFLE STABILITY INDEX FIELD PROCEDURE

The Riffle Stability Index procedure is best applied to stream channels with gradients from 1.5 to 5 percent. The channel is best described as a Rosgen B-2, B-3, B-4or F-2, F-3, F-4 type. Three riffles are measured within each uniform Rosgen reach. Each riffle selected for measurement should be representative or typical within the reach. An ideal riffle is located in a straight section of reach, has uniform depth in the cross-section, and is at a point of thalweg crossover. Flow is evenly distributed across the channel and is not concentrated toward either bank. For each riffle, field data are gathered to determine the distribution of particle sizes present. An estimate of the common large size of particle capable of movement at bankfull flow is obtained by sampling a nearby bar deposit.

1. Particle Size Distribution on the Riffle

A particle size distribution is obtained on the riffle by a bed material sampling procedure called a "Wolman Pebble Count". A sample size of at least 200 is necessary for RSI. The sample points are identified by establishing a sampling grid over the riffle, with transects across the channel from bankfull to bankfull over the entire length of riffle. Samples are taken every foot along the transect. Thus, bankfull width in feet will equal the number of samples per transect. Dividing 200 by the number of samples per transect and rounding up will determine the number of transects needed. Spacing between transects is determined by dividing the length of riffle by the number of transects needed. For each sample, the intermediate axis of the particle is measured using a metric caliper, and is tallied by size class. For very large particles, count the same particle as many times as you encounter it. The cumulative percent finer is then calculated for each size class, and plotted on the graph.

2. Dominant Large Particles on a Bar

Measure 10 to 30 of the freshly moved dominant large particles residing on a bar or similar depositional feature to estimate the largest particle size transported at flows of bankfull and above. Freshness is evaluated by lack of growing vegetation and lack of embeddedness of the particles. The depositional feature must be in close proximity to the riffle being examined, and can include laterally attached bars, side bars, and central bars. The entire bar should be visually inspected to identify the dominant large size of particle present. If a bar deposit cannot be found, trained field personnel may select the large mobile particles from within the riffle. When this is done, a sample size of at least 20 is needed. For each of the particles, the intermediate axis is measured and recorded to the nearest millimeter. Calculate the arithmetic mean of the sample, and compare this with the plotted cumulative particle size distribution for the riffle. On the X axis, find the mean bar sample grain size. Go up to the cumulative particle size distribution, and read from the Y axis the percentile this represents. This
percentle is the Riffle Stability Index.

RIFFLE STABILITY INDEX

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Location Information:

Forest or Area Identifier:______________________________
District or Unit Identifier:______________________________
Hydrologic Unit Code:________________________________
Stream Name:_____________________________________
Reach Number_____________________________________
R.S.I. Number______________________________________
Rosgen Channel Type______________________________
Geology:____
Survey Date:(mm/dd/yy)____________________________
Surveyor 1____
Surveyor 2____
Surveyor 3____
Channel Elevation (from USGS quad map)______________

CHANNEL GEOMETRY DATA

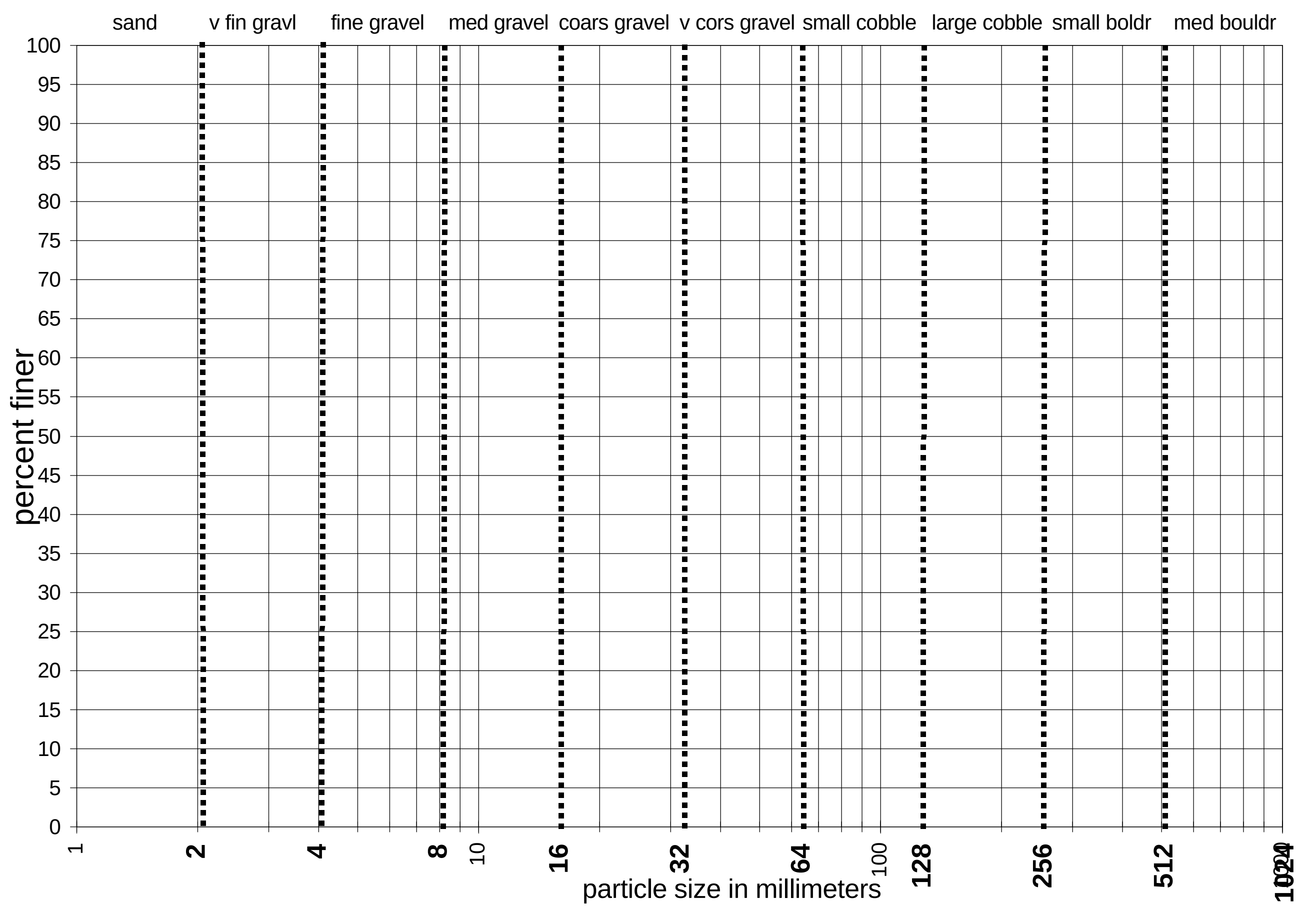
Bankfull Width:(w)______________________________
Riffle Length:__________________________________
Surveyed Channel Gradient:(e / d)_______________
Difference in Elevation (e) ___________________
Distance (d) _______________________________
Average Depth at Bankfull (1/4, 1/2, 3/4)__________
Maximum Depth at Bankfull_____________________

Width at twice max. bankfull depth (p)_____________
Entrenchment Ratio (p / w)____________________

Pfankuch Channel Stability Rating

Rating (numerical)__________________________

Excellent Good Fair Poor



sand
v fin gravl
fine gravel
med gravel
coars gravel
v cors gravel
small cobble
large cobble
small boldr
med bouldr
percent finer
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1
2
4
8
10
16
32
64
100
128
256
512
1024
particle size in millimeters