Rapid Bioassessment Protocols
For Use in Streams and Wadeable Rivers:
Periphyton, Benthic Macroinvertebrates, and Fish
Second Edition

http://www.epa.gov/OWOW/monitoring/techmon.html

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http://www.epa.gov/OWOW/monitoring/techmon.html
Parameters to be evaluated in sampling reach:

1. **EPIFAUNAL SUBSTRATE/AVAILABLE COVER**

   *high and low gradient streams*

   Includes the relative quantity and variety of natural structures in the stream, such as cobble (riffles), large rocks, fallen trees, logs and branches, and undercut banks, available as refugia, feeding, or sites for spawning and nursery functions of aquatic macrofauna. A wide variety and/or abundance of submerged structures in the stream provides macroinvertebrates and fish with a large number of niches, thus increasing habitat diversity. As variety and abundance of cover decreases, habitat structure becomes monotonous, diversity decreases, and the potential for recovery following disturbance decreases. Riffles and runs are critical for maintaining a variety and abundance of insects in most high-gradient streams and serving as spawning and feeding refugia for certain fish. The extent and quality of the riffle is an important factor in the support of a healthy biological condition in high-gradient streams. Riffles and runs offer a diversity of habitat through variety of particle size, and, in many small high-gradient streams, will provide the most stable habitat. Snags and submerged logs are among the most productive habitat structure for macroinvertebrate colonization and fish refugia in low-gradient streams. However, “new fall” will not yet be suitable for colonization.

**Selected References**


<table>
<thead>
<tr>
<th>Habitat Parameter</th>
<th>Condition Category</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optimal</strong></td>
<td><strong>Suboptimal</strong></td>
</tr>
<tr>
<td>Greater than 70%</td>
<td>40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).</td>
</tr>
<tr>
<td>(high and low gradient)</td>
<td>(high and low gradient)</td>
</tr>
<tr>
<td><strong>SCORE</strong></td>
<td>20 19 18 17 16</td>
</tr>
</tbody>
</table>

1a. Epifaunal Substrate/Available Cover—High Gradient

Optimal Range

Poor Range

1b. Epifaunal Substrate/Available Cover—Low Gradient

Optimal Range (Mary Kay Corazalla, U. of Minn.)

Poor Range
**2a. Embeddedness—High Gradient**

**Embeddedness**

*high gradient streams*

Refers to the extent to which rocks (gravel, cobble, and boulders) and snags are covered or sunken into the silt, sand, or mud of the stream bottom. Generally, as rocks become embedded, the surface area available to macroinvertebrates and fish (shelter, spawning, and egg incubation) is decreased. Embeddedness is a result of large-scale sediment movement and deposition, and is a parameter evaluated in the riffles and runs of high-gradient streams. The rating of this parameter may be variable depending on where the observations are taken. To avoid confusion with sediment deposition (another habitat parameter), observations of embeddedness should be taken in the upstream and central portions of riffles and cobble substrate areas.

*Selected References*  

<table>
<thead>
<tr>
<th>Habitat Parameter</th>
<th>Optimal</th>
<th>Suboptimal</th>
<th>Marginal</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a Embeddedness (high gradient)</td>
<td>Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.</td>
<td>Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.</td>
<td>Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.</td>
<td>Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.</td>
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<tr>
<td>SCORE</td>
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<td>17</td>
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</tbody>
</table>

*Optimal Range*  
(William Taft, MI DNR)  
*Poor Range*  
(William Taft, MI DNR)
2b. **POOL SUBSTRATE CHARACTERIZATION**

*low gradient streams*

Evaluates the type and condition of bottom substrates found in pools. Firmer sediment types (e.g., gravel, sand) and rooted aquatic plants support a wider variety of organisms than a pool substrate dominated by mud or bedrock and no plants. In addition, a stream that has a uniform substrate in its pools will support far fewer types of organisms than a stream that has a variety of substrate types.

**Selected References**

<table>
<thead>
<tr>
<th>Habitat Parameter</th>
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<th>Suboptimal</th>
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<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2b. Pool Substrate Characterization (low gradient)</td>
<td>Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.</td>
<td>Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.</td>
<td>All mud or clay or sand bottom; little or no root mat; no submerged vegetation.</td>
<td>Hard-pan clay or bedrock; no root mat or submerged vegetation.</td>
</tr>
<tr>
<td>SCORE</td>
<td>20</td>
<td>19</td>
<td>18</td>
<td>17</td>
</tr>
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</table>

2b. **Pool Substrate Characterization—Low Gradient**

**Optimal Range**
*(Mary Kay Corazalla, U. of Minn.)*

**Poor Range**
3a. Velocity/Depth Regimes—High Gradient

Patterns of velocity and depth are included for high-gradient streams under this parameter as an important feature of habitat diversity. The best streams in most high-gradient regions will have all 4 patterns present: (1) slow-deep, (2) slow-shallow, (3) fast-deep, and (4) fast-shallow. The general guidelines are 0.5 m depth to separate shallow from deep, and 0.3 m/sec to separate fast from slow. The occurrence of these 4 patterns relates to the stream’s ability to provide and maintain a stable aquatic environment.

Selected References

<table>
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<tr>
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<th>Optimal</th>
<th>Suboptimal</th>
<th>Marginal</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a. Velocity/Depth Regimes (high gradient)</td>
<td>All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is &lt;0.3 m/s, deep is &gt;0.5 m)</td>
<td>Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).</td>
<td>Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).</td>
<td>Dominated by 1 velocity/depth regime (usually slow-deep).</td>
</tr>
<tr>
<td>SCORE</td>
<td>20</td>
<td>19</td>
<td>18</td>
<td>17</td>
</tr>
</tbody>
</table>

Optimal Range (Mary Kay Corazalla, U. of Minn.)
(arrows emphasize different velocity/depth regimes)

Poor Range (William Taft, MI DNR)
3b. **POOL VARIABILITY**

*Rates the overall mixture of pool types found in streams, according to size and depth. The 4 basic types of pools are large-shallow, large-deep, small-shallow, and small-deep. A stream with many pool types will support a wide variety of aquatic species. Rivers with low sinuosity (few bends) and monotonous pool characteristics do not have sufficient quantities and types of habitat to support a diverse aquatic community. General guidelines are any pool dimension (i.e., length, width, oblique) greater than half the cross-section of the stream for separating large from small and 1 m depth separating shallow and deep.*

*Selected References* Beschta and Platts 1986, USEPA 1983.

<table>
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<th>Suboptimal</th>
<th>Marginal</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3b. Pool Variability (low gradient)</td>
<td>Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.</td>
<td>Majority of pools large-deep; very few shallow.</td>
<td>Shallow pools much more prevalent than deep pools.</td>
<td>Majority of pools small-shallow or pools absent.</td>
</tr>
<tr>
<td><strong>SCORE</strong></td>
<td>20 19 18 17 16</td>
<td>15 14 13 12 11</td>
<td>10 9 8 7 6</td>
<td>5 4 3 2 1 0</td>
</tr>
</tbody>
</table>

3b. **Pool Variability—Low Gradient**

*Optimal Range* (Peggy Morgan, FL DEP) *Poor Range* (William Taft, MI DNR)
4 SEDIMENT DEPOSITION

high and low gradient streams

Measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition. Deposition occurs from large-scale movement of sediment. Sediment deposition may cause the formation of islands, point bars (areas of increased deposition usually at the beginning of a meander that increase in size as the channel is diverted toward the outer bank) or shoals, or result in the filling of runs and pools. Usually deposition is evident in areas that are obstructed by natural or manmade debris and areas where the stream flow decreases, such as bends. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for many organisms.

Selected References

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>4. Sediment Deposition (high and low gradient)</td>
<td>Little or no enlargement of islands or point bars and less than 5% (&lt;20% for low-gradient streams) of the bottom affected by sediment deposition.</td>
<td>Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.</td>
<td>Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.</td>
<td>Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.</td>
</tr>
<tr>
<td>SCORE</td>
<td>20 19 18 17 16</td>
<td>15 14 13 12 11</td>
<td>10 9 8 7 6</td>
<td>5 4 3 2 1</td>
</tr>
</tbody>
</table>
4a. Sediment Deposition—High Gradient

Optimal Range

Poor Range
(arrow pointing to sediment deposition)

4b. Sediment Deposition—Low Gradient

Optimal Range

Poor Range
(arrows pointing to sediment deposition)
5

CHANNEL FLOW STATUS

high and low gradient streams

The degree to which the channel is filled with water. The flow status will change as the channel enlarges (e.g., aggrading stream beds with actively widening channels) or as flow decreases as a result of dams and other obstructions, diversions for irrigation, or drought. When water does not cover much of the streambed, the amount of suitable substrate for aquatic organisms is limited. In high-gradient streams, riffles and cobble substrate are exposed; in low-gradient streams, the decrease in water level exposes logs and snags, thereby reducing the areas of good habitat. Channel flow is especially useful for interpreting biological condition under abnormal or lowered flow conditions. This parameter becomes important when more than one biological index period is used for surveys or the timing of sampling is inconsistent among sites or annual periodicity.

Selected References


<table>
<thead>
<tr>
<th>Habitat Parameter</th>
<th>Condition Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Channel Flow Status (high and low gradient)</td>
<td>Optimal</td>
</tr>
<tr>
<td>Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.</td>
<td>Water fills &gt;75% of the available channel; or &lt;25% of channel substrate is exposed.</td>
</tr>
</tbody>
</table>

| SCORE | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
5a. Channel Flow Status—High Gradient

Optimal Range

Poor Range
(arrow showing that water is not reaching both banks; leaving much of channel uncovered)

5b. Channel Flow Status—Low Gradient

Optimal Range

Poor Range
(James Stahl, IN DEM)
Parameters to be evaluated broader than sampling reach:

6 CHANNEL ALTERATION

Is a measure of large-scale changes in the shape of the stream channel. Many streams in urban and agricultural areas have been straightened, deepened, or diverted into concrete channels, often for flood control or irrigation purposes. Such streams have far fewer natural habitats for fish, macroinvertebrates, and plants than do naturally meandering streams. Channel alteration is present when artificial embankments, riprap, and other forms of artificial bank stabilization or structures are present; when the stream is very straight for significant distances; when dams and bridges are present; and when other such changes have occurred. Scouring is often associated with channel alteration.

Selected References

<table>
<thead>
<tr>
<th>Habitat Parameter</th>
<th>Condition Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Channel Alteration (high and low gradient)</td>
<td>Optimal</td>
</tr>
<tr>
<td>Channelization or dredging absent or minimal; stream with normal pattern.</td>
<td>Channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.</td>
</tr>
</tbody>
</table>

SCORE

|   | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|----|----|----|----|----|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|---|

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5-21
6a. Channel Alteration—High Gradient

Optimal Range

Poor Range

(arrows emphasizing large-scale channel alterations)

6b. Channel Alteration—Low Gradient

Optimal Range

Poor Range

(John Maxted, DE DNREC)
FREQUENCY OF RIFFLES (OR BENDS)

Is a way to measure the sequence of riffles and thus the heterogeneity occurring in a stream. Riffles are a source of high-quality habitat and diverse fauna, therefore, an increased frequency of occurrence greatly enhances the diversity of the stream community. For high gradient streams where distinct riffles are uncommon, a run/bend ratio can be used as a measure of meandering or sinuosity (see 7b). A high degree of sinuosity provides for diverse habitat and fauna, and the stream is better able to handle surges when the stream fluctuates as a result of storms. The absorption of this energy by bends protects the stream from excessive erosion and flooding and provides refugia for benthic invertebrates and fish during storm events. To gain an appreciation of this parameter in some streams, a longer segment or reach than that designated for sampling should be incorporated into the evaluation. In some situations, this parameter may be rated from viewing accurate topographical maps. The “sequencing” pattern of the stream morphology is important in rating this parameter. In headwaters, riffles are usually continuous and the presence of cascades or boulders provides a form of sinuosity and enhances the structure of the stream. A stable channel is one that does not exhibit progressive changes in slope, shape, or dimensions, although short-term variations may occur during floods (Gordon et al. 1992).

Selected References


<table>
<thead>
<tr>
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<th>Condition Category</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optimal</strong></td>
<td><strong>Suboptimal</strong></td>
</tr>
<tr>
<td>Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream &lt; 7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.</td>
<td>Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.</td>
</tr>
<tr>
<td><strong>SCORE</strong></td>
<td>20</td>
</tr>
</tbody>
</table>
7a. Frequency of Riffles (or bends)—High Gradient

**Optimal Range**
(arrows showing frequency of riffles and bends)

**Poor Range**

7b CHANNEL SINUOSITY

*low gradient streams*
Evaluates the meandering or sinuosity of the stream. A high degree of sinuosity provides for diverse habitat and fauna, and the stream is better able to handle surges when the stream fluctuates as a result of storms. The absorption of this energy by bends protects the stream from excessive erosion and flooding and provides refugia for benthic invertebrates and fish during storm events. To gain an appreciation of this parameter in low gradient streams, a longer segment or reach than that designated for sampling may be incorporated into the evaluation. In some situations, this parameter may be rated from viewing accurate topographical maps. The “sequencing” pattern of the stream morphology is important in rating this parameter. In "oxbow" streams of coastal areas and deltas, meanders are highly exaggerated and transient. Natural conditions in these streams are shifting channels and bends, and alteration is usually in the form of flow regulation and diversion. A stable channel is one that does not exhibit progressive changes in slope, shape, or dimensions, although short-term variations may occur during floods (Gordon et al. 1992).

**Selected References**
7b. Channel Sinuosity—Low Gradient

<table>
<thead>
<tr>
<th>Habitat Parameter</th>
<th>Optimal</th>
<th>Suboptimal</th>
<th>Marginal</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>7b. Channel Sinuosity (low gradient)</td>
<td>The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)</td>
<td>The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.</td>
<td>The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.</td>
<td>Channel straight; waterway has been channelized for a long distance.</td>
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<td>SCORE</td>
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<td>19</td>
<td>18</td>
<td>17</td>
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</table>

Optimal Range

Poor Range
BANK STABILITY (condition of banks)

*high and low gradient streams* Measures whether the stream banks are eroded (or have the potential for erosion). Steep banks are more likely to collapse and suffer from erosion than are gently sloping banks, and are therefore considered to be unstable. Signs of erosion include crumbling, unvegetated banks, exposed tree roots, and exposed soil. Eroded banks indicate a problem of sediment movement and deposition, and suggest a scarcity of cover and organic input to streams. Each bank is evaluated separately and the cumulative score (right and left) is used for this parameter.

**Selected References**


<table>
<thead>
<tr>
<th>Habitat Parameter</th>
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</thead>
<tbody>
<tr>
<td>8. Bank Stability (score each bank)</td>
<td>Optimal</td>
</tr>
<tr>
<td>Note: determine left or right side by facing downstream (high and low gradient)</td>
<td>Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. &lt;5% of bank affected.</td>
</tr>
<tr>
<td>SCORE ___ (LB) Left Bank</td>
<td>10</td>
</tr>
<tr>
<td>SCORE ___ (RB) Right Bank</td>
<td>10</td>
</tr>
</tbody>
</table>
8a. Bank Stability (condition of banks)—High Gradient

Optimal Range
(arrow pointing to stable streambanks)

Poor Range
(arrow highlighting unstable streambanks)

8b. Bank Stability (condition of banks)—Low Gradient

Optimal Range
(Peggy Morgan, FL DEP)

Poor Range
(arrow highlighting unstable streambanks)
BANK VEGETATIVE PROTECTION

*high and low gradient streams*

Measures the amount of vegetative protection afforded to the stream bank and the near-stream portion of the riparian zone. The root systems of plants growing on stream banks help hold soil in place, thereby reducing the amount of erosion that is likely to occur. This parameter supplies information on the ability of the bank to resist erosion as well as some additional information on the uptake of nutrients by the plants, the control of instream scouring, and stream shading. Banks that have full, natural plant growth are better for fish and macroinvertebrates than are banks without vegetative protection or those shored up with concrete or riprap. This parameter is made more effective by defining the native vegetation for the region and stream type (i.e., shrubs, trees, etc.). In some regions, the introduction of exotics has virtually replaced all native vegetation. The value of exotic vegetation to the quality of the habitat structure and contribution to the stream ecosystem must be considered in this parameter. In areas of high grazing pressure from livestock or where residential and urban development activities disrupt the riparian zone, the growth of a natural plant community is impeded and can extend to the bank vegetative protection zone. Each bank is evaluated separately and the cumulative score (right and left) is used for this parameter.

**Selected References**

<table>
<thead>
<tr>
<th>Habitat Parameter</th>
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<tbody>
<tr>
<td>9. Vegetative Protection (score each bank)</td>
<td>Optimal</td>
</tr>
<tr>
<td>Note: determine left or right side by facing downstream. (high and low gradient)</td>
<td>More than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.</td>
</tr>
<tr>
<td>SCORE ___ (LB)</td>
<td>Left Bank</td>
</tr>
<tr>
<td>SCORE ___ (RB)</td>
<td>Right Bank</td>
</tr>
</tbody>
</table>
9a. Bank Vegetative Protection—High Gradient

Optimal Range
(arrow pointing to streambank with high level of vegetative cover)

Poor Range
(arrow pointing to streambank with almost no vegetative cover)

9b. Bank Vegetative Protection—Low Gradient

Optimal Range
(Peggy Morgan, FL DEP)

Poor Range
(MD Save Our Streams)
(arrow pointing to channelized streambank with no vegetative cover)
10 RIPARIAN VEGETATIVE ZONE WIDTH

*high and low gradient streams* Measures the width of natural vegetation from the edge of the stream bank out through the riparian zone. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream. A relatively undisturbed riparian zone supports a robust stream system; narrow riparian zones occur when roads, parking lots, fields, lawns, bare soil, rocks, or buildings are near the stream bank. Residential developments, urban centers, golf courses, and rangeland are the common causes of anthropogenic degradation of the riparian zone. Conversely, the presence of "old field" (i.e., a previously developed field not currently in use), paths, and walkways in an otherwise undisturbed riparian zone may be judged to be inconsequential to altering the riparian zone and may be given relatively high scores. For variable size streams, the specified width of a desirable riparian zone may also be variable and may be best determined by some multiple of stream width (e.g., 4 x wetted stream width). Each bank is evaluated separately and the cumulative score (right and left) is used for this parameter.


<table>
<thead>
<tr>
<th>Habitat Parameter</th>
<th>Condition Category</th>
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<tbody>
<tr>
<td>10. Riparian Vegetative Zone Width (score each bank riparian zone)</td>
<td>Optimal</td>
</tr>
<tr>
<td>(high and low gradient)</td>
<td>Width of riparian zone &gt;18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.</td>
</tr>
<tr>
<td>SCORE ___ (LB)</td>
<td>Left Bank</td>
</tr>
<tr>
<td>SCORE ___ (RB)</td>
<td>Right Bank</td>
</tr>
</tbody>
</table>
10a. Riparian Vegetative Zone Width—High Gradient

Optimal Range
(arrow pointing out an undisturbed riparian zone)

Poor Range
(arrow pointing out lack of riparian zone)

10b. Riparian Vegetative Zone Width—Low Gradient

Optimal Range
(arrow emphasizing an undisturbed riparian zone)

Poor Range
(MD Save Our Streams)
(arrow emphasizing lack of riparian zone)