6.1 EPIFAUNAL SUBSTRATE / AVAILABLE COVER

	Reference	Good	Fair	Poor
Epifaunal Substrate/ Available Cover	Greater than 70% (50% for low gradient streams) of stream bed and lower banks covered with **mix** of substrates favorable for epifaunal colonization and fish cover; substrates include snags, submerged logs, undercut banks, and unembedded cobbles and boulders (for high gradient)	40-70% (30-50% for low gradient streams) of stream bed and lower banks covered with a **mix** of substrates favorable for epifaunal colonization and fish cover	20-40% (10-30% for low gradient streams) of stream bed and lower banks covered with substrates favorable for epifaunal colonization and fish cover; few substrate types present	Less than 20% (10% for low gradient streams) of stream bed and lower banks covered with substrates favorable for epifaunal colonization and fish cover; few substrate types present

Definitions:

Epifaunal – "epi" means surface, and "fauna" means animals. Thus, "epifaunal substrate" is structures on the streambed that provide surfaces on which animals can live. In this case, the animals are aquatic invertebrates (such as aquatic insects and other "bugs"). These bugs live on or under cobbles, boulders, logs, and snags, and the many cracks and crevices found within these structures. In general, older decaying logs are better suited for bugs to live on/in than newly fallen "green" logs and trees.

Cover – "cover" is the general term used to describe any structure that provides refugia for fish, reptiles or amphibians. These animals seek cover to hide from predators, to avoid warm water temperatures, and to rest, by avoiding high velocity water. These animals come in all sizes, so even cobbles on the stream bottom that are not embedded with fine sands and silt can serve as cover for small fish and salamanders. Larger fish and reptiles often use large boulders, undercut banks, submerged logs, and snags for cover.

Figure 6.1A Reference epifaunal substrate and cover.

Evaluation:

When evaluating epifaunal substrate and available cover look at the relative **quantity** and **variety** of natural structures **in the stream**. In general, consider the entire bankfull area of the channel, but give greater weight to the area of the channel that remains wetted during lower flow conditions (such as those during late summer). A wide variety and/or abundance of submerged structures in the stream provide bugs 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 fish and bug populations to recover following disturbance decreases. **The greater the abundance and variety of structures serving as epifaunal substrate and cover, the higher the score.**

Figure 6.1B Poor epifaunal substrate and cover.

In ***high gradient*** streams look to see that there are riffles and runs with a wide variety of particle sizes (gravels to boulders). Riffles and runs are critical for maintaining a variety and abundance of invertebrates in most high gradient streams, and they serve as spawning and feeding habitat for many 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 sizes, and, in many small high gradient streams, will provide the most stable habitat. In ***low gradient*** streams, snags and submerged logs are among the most productive habitat structures for bug colonization and fish cover. Low gradient streams typically do not have the larger rock substrates found in high gradient streams, but often contain more and larger woody material such as whole fallen trees and log jams.

6.2b POOL SUBSTRATE CHARACTERIZATION (low gradient)

	Reference	Good	Fair	Poor
Pool Substrate Characterization (low gradient)	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.

Since low gradient streams are naturally depositional areas, i.e. they accumulate fine sediments, it is not appropriate to evaluate embeddedness in these streams. The bed of a low gradient stream is usually composed largely of gravel, sand and silt. These sediment types often favor the establishment of aquatic vegetation, which provides surface area for aquatic invertebrates and cover for fish.

Evaluate the **type** and **variety** of bottom substrates found in pools. Firmer sediment types (i.e. 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 fewer types of organisms that a stream that has a variety of substrate types.

Figure 6.3A Reference pool substrate condition

Figure 6.3B Poor pool substrate condition

6.3b POOL VARIABILITY (low gradient)

	Reference	Good	Fair	Poor
Pool Variability (low gradient)	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.

Definition:
This parameter rates the overall mixture of pool types found in streams, according to **size** and **depth**. The 4 pool types are: (1) large-shallow, (2) large- deep, (3) small-shallow, (4) small-deep. Large pools are wider and longer than ½ the average bankfull channel width. Deep pools are >3' deep.

Evaluation:
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 variety of habitat to support a diverse aquatic community. **An even mix of all pool types is most desirable.** In the absence of some pool types, it is better to have deep pools over shallow pools. All small-shallow pools or lack of pools entirely are the least desirable conditions.

Figure 6.5A Reference pool variability

Figure 6.5B Poor pool variability

6.4 SEDIMENT DEPOSITION

	Reference	Good	Fair	Poor
Sediment Deposition	Little or no enlargement of mid-channel bars or point bars and < 5% (20% in low gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% in low gradient streams) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% in low gradient streams) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; > 50% (80% in low gradient streams) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.

Definitions:
Sediment deposition is the accumulation of sediments on the streambed that raises the bed elevation. Sediment deposition may result in the formation of point bars, mid-channel bars, or islands.

Point Bars - unvegetated deposits of sediment located on the inside of a channel bendway, adjacent to the stream bank, typically higher than the average water level.

Mid-channel Bars: unvegetated deposits of sediment located in the middle of the channel away from the banks that split the channel flow, except under very low flow conditions; typically higher than the average water level; generally found in areas where the channel runs straight.

Islands – mid-channel bars that are above the average water level and often above the bankfull elevation; vegetated with well-established woody vegetation.

Evaluation:
This parameter evaluates the amount of sediment deposition that has accumulated in pools and the changes that have occurred to the streambed as a result of the deposition. Deposition occurs from large-scale movement of sediment. It results in the formation of bars and islands and the filling-in of runs and pools. Usually deposition is evident in areas that are obstructed by natural or manmade debris and areas where the stream flow velocity decreases, such as on the inside of bends.

High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for many aquatic organisms. While point bars are typical of a healthy stream system, if they are not excessively large or steep, mid-channel bars are indicative of channel instability, and usually occur when the channel is over-widened and thus does not have enough stream power to move the sediment through the channel. The channel may appear braided. While this is a natural condition in parts of the country (i.e. in glacial-fed rivers), it is not naturally common in Vermont.

Look for the presence of unvegetated mid-channel bars, filling-in of pools with fine sediments, and overly steep and large point bars (compared to other point bars in the system) as signs of sediment deposition. Refer to section 5.1 on the Field Notes form. Note there is one situation where the occurrence of a mid-channel bar(s) may not indicate problematic sediment deposition. Often a mid-channel bar will develop just downstream from where a tributary enters the channel as a result of sediments being delivered to the channel from the tributary. This is usually a localized deposition and does not indicate large-scale sediment deposition problems. If this is the only mid-channel bar or similar depositional feature you observe in the segment (or reach), then the segment is not likely being negatively affected by sediment deposition.

Figure 6.6A Reference sediment deposition

Figure 6.6B Poor sediment deposition

6.5 CHANNEL FLOW STATUS

	Reference	Good	Fair	Poor
Channel Flow Status	Water reaches base of both lower banks, and <10% of channel bed substrate is exposed.	Water fills >75% of the available channel; or <25% of channel bed substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.

This parameter evaluates the degree to which the channel is filled with water. It includes evaluation of whether a system is being affected by 1) water withdrawals and/or 2) stream adjustments in response to changes in land use, but can also consider naturally occurring low flow conditions due to a channel's underlying geology. 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, cobble and gravel substrates in riffles are exposed; in low-gradient streams, the decrease in water level exposes logs and snags, thereby reducing available habitat.

When measuring this parameter you should consider the area from the toe of streambank to the opposite streambank. Whether due to natural runoff patterns or human-induced impacts, streams have different flow characteristics ranging from intermittent, to variable, to uniform. A stream that is naturally variable or intermittent is more likely to exhibit poorer channel flow status condition than a uniform stage stream. Be sure to evaluate only what you observe on the day of survey; however, if you have knowledge that the stream flow is high due to a recent storm or goes dry on a regular basis, or similar knowledge due to your familiarity with the stream, be sure to include these as a comment on the bottom of the field form.

Flows are decreased if large quantities of water are withdrawn or impounded for:

$ hydropower
$ irrigation
$ public water supplies
$ snowmaking
$ recreation and flood control reservoirs

Figure 6.7B Poor channel flow status

Figure 6.7A Reference channel flow status

6.6 CHANNEL ALTERATION

	Reference	Good	Fair	Poor
Channel Alteration	Channelization in the form of dredging, straightening, berms or streambank armoring absent; stream with natural pattern.	Some channel alterations present along 10-20% of segment, usually in areas of bridge abutments; evidence of past channelization, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization along 20-80% of stream segment ; riprap or armoring present on both banks.	Over 80% of the stream segment channelized and disrupted. Instream habitat greatly altered or removed entirely.

Definitions:
Activities defined as channel alteration include: berms (Section 1.3), dredging (5.4), straightening (5.4), and streambank armoring (3.1, bank revetments).

Evaluation:
This parameter 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, irrigation, or other property protection purposes. Such streams have far fewer natural habitats for fish, aquatic invertebrates, and plants than do naturally meandering streams. Channel alteration is present when armoring or berms are present; when the stream is straight for long distances, or when dredging has occurred. Evidence of past dredging may be difficult to determine in the field; look for excavation scars or spoil piles. Local knowledge of nearby residents or town/state officials may also help. (You may have acquired information in Phase 1 and Section 5.4 of Phase 2 that will help you assess channel alterations.) In general, channel alteration that occurred several decades ago from which the stream is in the process of recovering rates higher than **recent** channelization of similar magnitude.

Figure 6.8A Reference condition: channel alteration absent.

Figure 6.8B Poor condition: excessive channel straightening.

Figure 6.8C Example of berm and streambank armoring with stone wall. Dirt on top of stone wall is an old berm; note large tree growing in berm that was present before berm was constructed. Saplings on top of berm have grown up since berm was built several decades ago. Berm height above average water level is approximately 10 feet.

6.7b CHANNEL SINUOSITY (low gradient)

	Reference	Good	Fair	Poor
Channel Sinuosity (low gradient)	The bends in the stream increase the stream length 2.5 to 4 times longer than the straight down-valley length.	The bends in the stream increase the stream length 1.5 to 2.5 times longer than the straight down-valley length.	The bends in the stream increase the stream length 1 to 1.5 times longer than the straight down-valley length.	Channel straight; waterway has been channelized for a long distance.

Definition:
Sinuosity is the ratio of channel length to direct down-valley length. Sinuosity may also be expressed as the ratio of down-valley slope to channel slope (see Section 2.9). It is used to evaluate the “curviness” of the stream. Curves, or meanders, help to absorb and dissipate stream energy. Those streams with a high sinuosity have many meanders, while straighter streams will have a low sinuosity. Sinuosity is in part a reflection of the slope of the channel, and the slope of the valley. Steep streams in steep valleys have low sinuosity, while low gradient streams meandering through broad valleys can be highly sinuous.

Evaluation:
This parameter 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 meanders 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 or recent aerial or orthophotos. Refer to your evaluation of sinuosity in Section 2.9 on the Field Notes form when scoring this parameter.

The "sequencing" pattern of the stream morphology is important in rating this parameter. In "oxbow" streams 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).

Figure 6.10A Reference sinuosity

Figure 6.10B Poor sinuosity

6.8 BANK STABILITY

	Reference	Good	Fair	Poor
Bank Stability (score each bank) *Note: determine left or right side by facing downstream.*	Banks stable; evidence of erosion or bank failure absent or minimal; < 5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly re-vegetated. 5-30% of bank in segment (or reach) has areas of erosion.	Moderately unstable; 30-60% of bank in segment (or reach) has areas of erosion; high erosion potential from crumbling, unvegetated banks during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.

This parameter 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, freshly exposed tree roots, and exposed soil. Refer to Section 3.1 on the Field Notes form.

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.

Figure 6.11A Reference bank stability

Figure 6.11B Poor bank stability

6.9 BANK VEGETATIVE PROTECTION

	Reference	Good	Fair	Poor
Bank Vegetative Protection **(score each bank)** *Note: determine left or right side by facing downstream.*	More than 90% of the streambank surfaces and <u>immediate riparian zone</u> covered by native vegetation, including trees, understory shrubs, or herbaceous vegetation; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.

Definitions:
<u>Immediate Riparian Zone</u>**:** This is the area where the root binding capacity of the vegetation serves to stabilize the streambank. This is a function of bank height. Grasses cannot stabilize banks that are over ½ meter high (~1.5 ft.), and shrubs and woody vegetation cannot stabilize banks that are over 1.5 meters (~4.5 ft.). Banks that are higher than 1.5 meters are beyond the root-binding capacity of the vegetation.

<u>Potential plant height</u>**:** the height to which a plant, shrub or tree would grow if undisturbed.

Evaluation:
This parameter measures the amount of vegetative protection afforded to the streambank and the near-stream portion of the riparian zone. Refer to Section 3.1 on the Field Notes form. 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 aquatic 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).

Figure 6.12A Reference riparian

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.

Figure 6.12B Poor riparian buffer

Riparian buffers provide structure to the banks of a stream. The roots of the vegetation hold the soil in place, and the grass, shrubs or trees provide friction to slow down the floodwaters. Vermont ANR has developed guidance on the width of riparian zones for stream stability, habitat, and removal of nutrients, sediment and bacteria.

6.10 RIPARIAN VEGETATIVE ZONE WIDTH

	Reference	Good	Fair	Poor
Riparian Vegetative Zone Width (score each side of channel)	Width of **naturally vegetated** riparian zone >100 feet; human activities, (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) and grazing have not impacted zone.	Width of riparian zone 50 - 100 ft; human activities and grazing have impacted zone only minimally.	Width of riparian zone 25 - 50 ft.; human activities and grazing have impacted zone a great deal.	Width of riparian zone < 25 feet: little or no riparian vegetation due to human activities.

Evaluation:

This parameter measures the width of natural vegetation from the edge of the stream bank out through the riparian zone. Refer to section 3.2 on your Field Notes form. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and organic input to the stream. A relatively undisturbed riparian zone supports a robust stream system; narrow riparian zones occur when roads, parking lots, fields, lawns, animal pasture, bare soil, rocks, or buildings are near the stream bank. Residential developments, urban centers, golf courses, and animal pasture 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 and in the process of growing up to shrubs and trees), 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. Each bank is evaluated separately and the cumulative score (right and left) is used for this parameter.