# 5.3 Descriptions of Variables

The following 28 variables are used in the model to assess level of functioning for the 14 ecosystem functions listed in the previous section.



For each variable, the following information is presented:

1. Definition
2. Rationale for selection of the variable
3. A protocol for measuring the variable in the field
4. Location of reference system data in the appendices
5. A description of how reference system data were used to scale the variable
6. Scaling of the variable for use in determining level of functioning
7. Level of confidence in the scaling

## ANIMAL SIGN ($V_{ASIGN}$)

**Definition**

**Animal Sign** is the number of direct (*e.g.*, visual observation of animals) or indirect (*e.g.*, tracks, bedding, scat) observations of animal species presence in, or utilization of, the VAA.

**Rationale for Selection of the Variable**

It is very difficult to complete a reliable rapid assessment of habitat use by a range of faunal species in highly perturbed or densely populated areas. Nevertheless, rapid assessments have been shown to be necessary and useful scoping tools for various planning or regulatory purposes. Most people understand that if more detailed information is required regarding use of sites by faunal species, formal observation and/or trapping programs need to be completed.

Information commonly used to complete rapid assessments of faunal habitat functioning in riverine ecosystems include both (a) direct observation of animal use of a site, and (b) indirect indicators of animal use (*e.g.* tracks, scat, bedding areas, *etc.*) (Brinson *et al.* 1995). Specifically, in urbanizing areas, and within suburban to rural to agricultural transition zones, animal presence and use of habitat is not necessarily indicative of either (a) overall habitat suitability for several classes of animals, or (b) the preference of a given class of animals for a particular type of habitat (Thomas 1979). Data from several studies show that many classes of faunal species in developed environments adapt to habitat quality and patch sizes of last resort (Harris 1984). Unfortunately, the amount of evidence for animal use at any given site is usually controlled by a number of site specific and landscape scale factors combined with large temporal variation (*e.g.,* time of day, season, or even year of the site assessment).

Some investigators will argue that the presence or use of riverine forested waters/wetlands by several classes of faunal “indicator” species or guild leaders can be used as a good indication of *in situ* habitat structural complexity as well as habitat contiguity with the landscape (HEP Manuals, Gosselink and Lee 1989). This line of reasoning represents acceptance of the facts that rapid assessment of faunal functioning in waters/wetland ecosystems has limited application, and that intact structure will likely beget function.

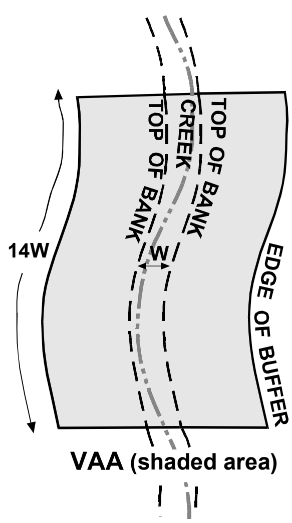
## Variable: ANIMAL SIGN ($V_{ASIGN}$)

**Measurement Protocol**

The VAA for $V_{ASIGN}$ consists of two transects: one upstream and one downstream. Theses transects originate at the main study area cross section. Their length is seven times the OHW cross section width. Thus, you will travel a total distance of fourteen times the OHW cross section width to look for Animal Sign (*i.e.*, 7 widths upstream and 7 widths downstream). The width of the transects (*i.e.*, the zone where you will look for Animal Sign) is from the outer boundary of the Santa Barbara County setback (*i.e.*, 50 ft. urban/ 100 ft. rural) on stream left to the outer boundary of the Santa Barbara County setback on stream right. Be sure to look in the air for birds, bats, etc. as your VAA for Animal Sign is a three dimendsional zone.

Start looking for direct and indirect indicators of animal use of the PAA immediately upon entering the PAA vicinity. Know that your presence may cause escape, hiding, or defense movement, alarm calls, etc. Continue actively looking and listening for, and recording animal observations during the set-up and execution of all other variable measurements. Work so as to allow for maximum time for observation of animal activites, then score the Animal Sign variable as one of the last things that you do during your time in the field.

**$V_{ASIGN}$**




During your walk, count the number of animal sightings (direct indicators) as well as other (indirect) indicators of animal use of the VAA (*e.g.,* calls, scat, browsing, scrapes or rubs, nests or nest cavities, bedding areas, trails, hair, feathers, *etc.*). Identify the type of sign and, if possible, the responsible animal species. Record your results on the Minimum Submittal Worksheets provided in Chapter 7.

Please note that for the purposes of $V_{ASIGN}$ scaling, direct and indirect animal sightings have been grouped into the following five categories: mammals, birds, amphibians, reptiles, and fish. To qualify for use in scaling of $V_{ASIGN}$, direct or indirect observations of animal use have to be recognizable as a clear sign of use of the VAA by one of the categories of animals.

Due to the fact that the actual sighting of animals is dependent upon many factors, scaling of $V_{ASIGN}$ also relies upon the use of the PAA by "indicator species". Table 5.6 lists indicator species for $V_{ASIGN}$. Before scoring this variable, scan your list of direct and indirect evidence of animal use and star (*) any indicator species. Count the starred indicator species and record the total number of indicator species on the Minimum Submittal worksheet provided in Chapter 7.

**Data** Located in Appendix B-61 through B-64

## Variable: ANIMAL SIGN ($V_{ASIGN}$)

**Table 5.6 Faunal Classes and Indicator Species For Scaling $V_{ASIGN}$**

| CLASS | COMMON NAME | GENUS / SPECIES |
|---|---|---|
| Mammals | Black Bear | *Ursus americanus* |
| | Mountain Lion | *Puma concolor* |
| Birds | *no indicator species* | |
| Amphibians | Red Legged Frog | *Rana aurora draytonii* |
| | Arroyo Toad | *Bufo microscaphus californicus* |
| | California Newt | *Taricha torosa* |
| Reptiles | *no indicator species* | |
| Fish | Steelhead Trout | *Oncorhynchus mykiss* |

### Scaling Rationale

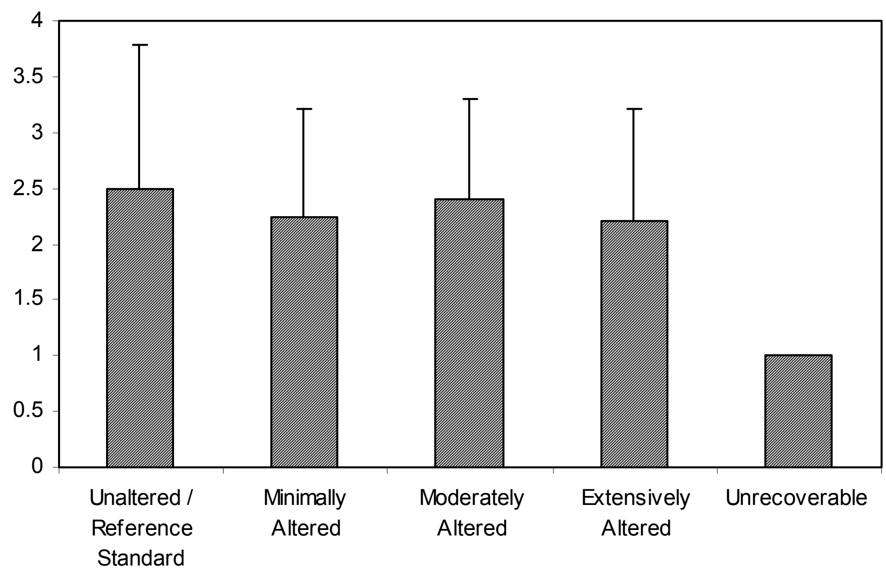
The nature and quality of the $V_{ASIGN}$ data (*i.e.,* direct and indirect observation of animal sign during the single reference sampling effort) did not justify separate treatment of High, Moderate, and Low gradient subclasses. Therefore, we grouped the animal data for all subclasses. Reference standard conditions for the $V_{ASIGN}$ variable were rarely available to us, independent of the many factors that can play into the recording of animal signs at any particular site at any particular time. Best scientific judgment was used in addition to the data collected to scale this variable.

Examination of the (grouped) $V_{ASIGN}$ data show that increasing anthropogenic alteration of riverine ecosystems in SCSBC disrupts faunal species use of this habitat by removing and/or simplifying plant community structure and thus the reduction of observed faunal groups in the VAA (Figure 5.1). Human perturbation in riparian zones appears to increase vertical and horizontal habitat fragmentation and anthropogenic edge (*e.g.,* building or parking lot to forest transitions versus native forest to native forest changes). It also appears that increased habitat fragmentation and anthropogenic edge diminishes the amount and diversity of food and cover resources available to native riparian or aquatic dependent species with relatively small or interior (riparian) forest home range requirements. Consequently, it would seem that increasing human alteration of riparian zones results in use of these sites by distinctly different assemblages of animal species. Specifically, relatively undisturbed sites with intact native vegetation and stream channel structure tended to support a variety of riparian and non-riparian dependent species with a wide variety (*i.e.,* very large to very small) of home range requirements. Intact riparian ecosystems tended to have a high proportion of interior (stenotopic)

**Variable: ANIMAL SIGN ($V_{ASIGN}$)**

species. Conversely, highly perturbed (fragmented) sites tended to have very few, if any signs of animal use. Signs that did exist in highly perturbed areas were left by generalists or non-native, edge-adapted opportunistic species with relatively large home ranges. In addition to using uplands, these edge-adapted opportunists tend to capitalize on fragmented riparian habitat and anthropogenic edges for exploitation of food and cover resources.

**Figure 5.1**
Animal use by disturbance class across all subclasses



## Variable: ANIMAL SIGN ($V_{ASIGN}$)

**Scaling for High, Moderate and Low Gradient Subclasses**

| MEASUREMENT CONDITION FOR $V_{ASIGN}$ | INDEX |
|---|---|
| a. ≥ 4 classes of animals or animal signs **or** ≥ 2 indicator species (animals or animal signs) **and**<br>b. no evidence of human alteration of the VAA within the last 50 years. | 1.00 |
| a ≥ 4 classes of animals or animal signs **or** ≥ 2 indicator species (animals or animal signs) **and**<br>b evidence of human alteration of the VAA within the last 50 years. | 0.75 |
| a ≥ 3 classes of animals or animal signs **or** ≥ 1 indicator species (animals or animal signs) **and**<br>b evidence of human alteration of the VAA. | 0.50 |
| a ≥ 2 and < 3 classes of animals or animal signs | 0.25 |
| a < 2 classes of animals or animal signs **and**<br>b the variable is recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied. | 0.10 |
| a < 2 classes of animals **and**<br>b the variable is not recoverable and not sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied. | 0.00 |

**Confidence** The Authors' confidence that reasonable logic and/or data support the variable scaling is MEDIUM to LOW for all subclasses due to limited data for all variable conditions and especially due to the absence of reference standard data.

## BUFFER CONDITION ($V_{BUFFCOND}$)

**Definition**

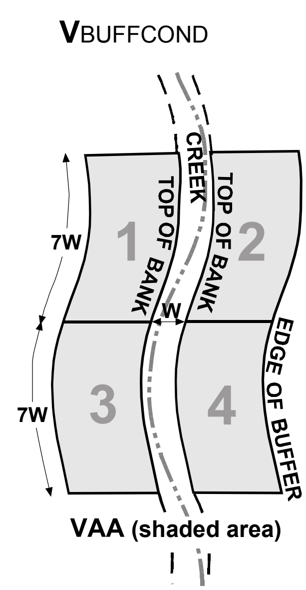
**Buffer Condition** describes the predominant (>50% areal extent) land use or condition within the Santa Barbara County designated stream buffer or setback (rural, 100 ft; urban, 50 ft).

**Rationale for Selection of the Variable**

Maintenance of riparian buffers in or near the Reference Standard condition is an important consideration that, in conjunction with $V_{BUFFWIDTH}$ and $V_{BUFFCONT}$, provides (a) the basis for development of channel and floodplain structure, (b) suitable substrates and soil conditions for biogeochemical processing, and (c) suitable habitat for establishment and maintenance of native plant and animal communitites. Buffers in or near Reference Standard conditions also provide opportunities for movement and cover for faunal species. Intact plant communities within buffers increase channel bank shear strength through the production and maintenance of underground fine root biomass. Specifically, intact roots provide (a) structural support necessary to help maintain channel geometry, and (b) substrates and energy sources for microbial activity that are vital in maintaining biogeochemical functions. In addition, intact vegetated communities provide roughness within riverine ecosystems. Roughness has direct, indirect, and cumulative effects on the spatial and temporal flow conditions, or hydrologic complexity of a stream. Roughness allows for complex contacts between water and soil at several flow conditions. This contact helps facilitate the filtering of particulates and thus the removal of sorbed or chelated nutrients, organic matter, and contaminants (Peterjohn and Correll 1984).

**Measurement Protocol**

The VAA for $V_{BUFFCOND}$ consists of two transects: one upstream and one downstream. These transects originate at the main cross section. Their length is seven times the OHW cross section width. Thus, you will travel a total distance of fourteen times the OHW cross section to look for dominant land use conditions within the buffer (*i.e.* 7 OHW widths upstream and 7 OHW widths downstream). The width of the VAA for $V_{BUFFCOND}$ (*i.e.*, the zone wherin you will look for buffer land use conditions) is the width of the designated Santa Barbara County buffer. Specifically, the buffer starts at the "top of bank" or "edge of existing riparian vegetaion," on stream left and stream right, and extends to the outer boundary of the designated Santa Barbara County setback (i.e., 50 ft. urban/ 100 ft. rural)(Figure 5.2).



**Variable: BUFFER CONDITION ($V_{BUFFCOND}$)**

Walk upstream and downstream within and next to the VAA. Use aerial photographs, maps, and other remote sensing tools to assist you in developing an estimate of dominant (*i.e.*, > 50%) land use within the Santa Barbara County designated buffer (urban, 50 ft; rural, 100 ft.). Work within four zones; (1) upstream left, (2) upstream right, (3) downstream left, and (4) downstream right. Develop your overall estimate for the VAA using an average of the four zones (Figure5.2)

In (relatively rare) cases where there is an equal partitioning of land use conditions within the buffer (*e.g*. 50% forest, 50% road), develop and document a clear and defensible logic as to why you assume that one buffer condition is dominant over another. For example, in lower Arroyo Burro, a 50% riparian forest, 50% road buffer condition exists along the right-of-way of Las Positas Road (Highway 225) northeast of its intersection with Las Positas Place. However, the presence, noise, runoff, and general disruption of the five lane, high traffic road in the riparian zone is so dominant over the "cover" or "habitat" offered by the remnant, highly degraded riparian forest on stream right that we would chose to weigh the "road" conditions over "forest" conditions for the purposes of scoring $V_{BUFFCOND.}$

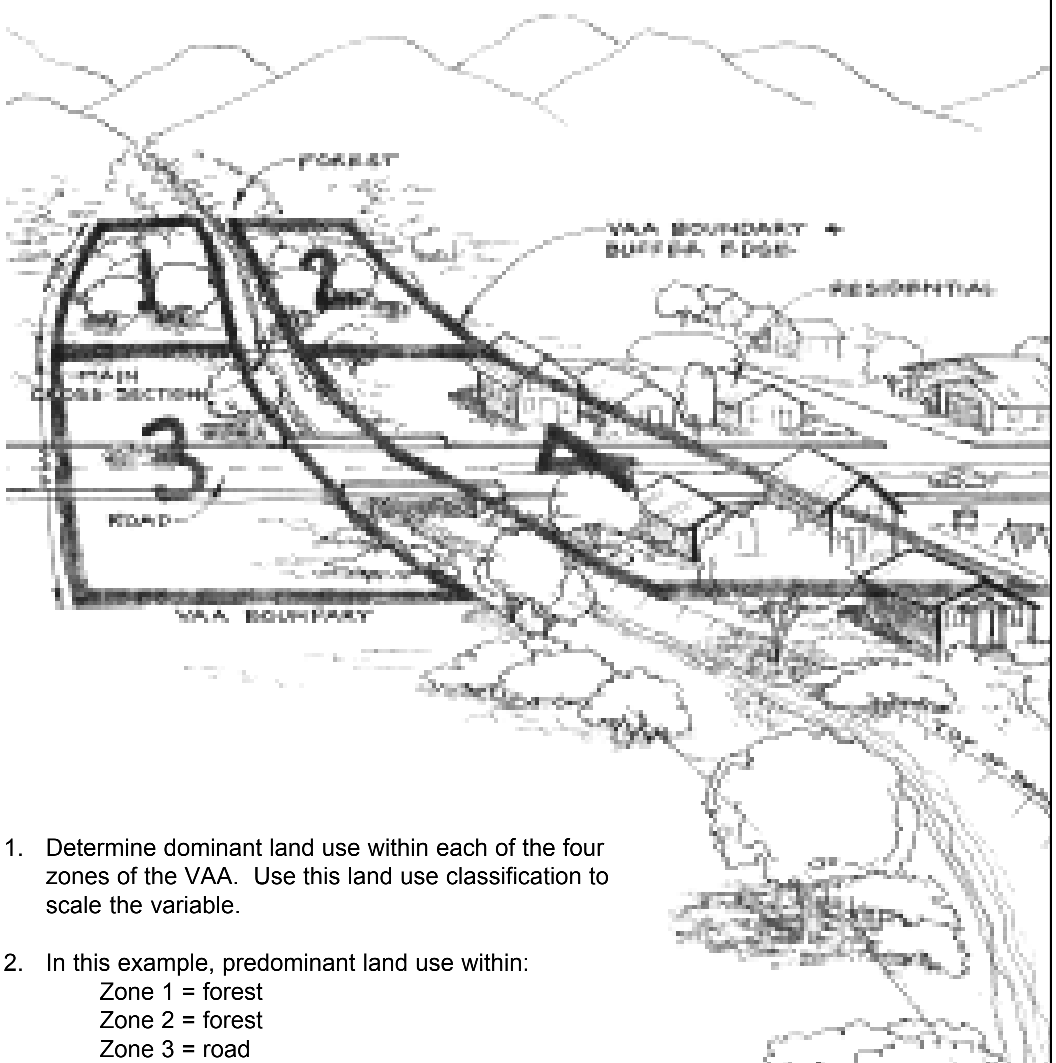
**Data** Not applicable.

**Scaling Rationale** The Santa Barbara County Code for land use stipulates that a specified width of land must be maintained surrounding a stream to protect biological diversity, water quality, and hydrological characteristics of the stream (SB Coastal Plan, p. 136). As discussed elsewhere in this *Draft Guidebook,* the required width of the buffer varies by adjacent land use (*i.e.,* in an "urban" zone, buffer width is 50 ft from the "top of bank" or "intact riparian vegetation"; in a "rural" zone, buffer width is 100 ft [Coastal Plan 9-37]). The regulated buffer zone in Santa Barbara County is measured horizontally (*i.e.,* perpendicular to the direction of flow) from the top of bank landward.

It is well substantiated in the literature that the width and condition of land surrounding a stream is highly correlated with the geochemical and habitat functioning of a riparian ecosystem (Peterjohn and Correll 1984). We scaled this variable based upon our local knowledge of land use and/or condition within the SCSBC. At the top of our scaling, we selected land uses and/or conditions that best maintained and supported the structural integrity and geometry of a stream and associated floodplain. Thus, the scaling is consistent with the County's intent to protect biological productivity, water quality, and hydrological characteristics of a stream.

**Variable: BUFFER CONDITION ($V_{BUFFCOND}$)**

**Figure 5.2 Measurement protocol for the buffer condition variable ($V_{BUFFCOND}$)**




1. Determine dominant land use within each of the four zones of the VAA. Use this land use classification to scale the variable.

2. In this example, predominant land use within:
   Zone 1 = forest
   Zone 2 = forest
   Zone 3 = road
   Zone 4 = residential
   Therefore: Index = 0.75 because dominant land use (forest) is minimally altered by human activity.

**Variable: BUFFER CONDITION ($V_{BUFFCOND}$)**

**Scaling for High, Moderate, and Low Gradient Subclasses**

| MEASUREMENT OR CONDITION FOR $V_{BUFFCOND}$ | INDEX |
|---|---|
| a. Dominant land use / condition within the buffer is unaltered by human activity. | 1.00 |
| a. Dominant land use / condition within the buffer is minimally altered by human activity (*e.g.,* one -lane dirt roads and/or narrow human trails, open space park and/or recreation facilities, low density housing (1 house/100 acres), *etc.*) | 0.75 |
| a. Dominant land use / condition within the buffer is moderately altered by human activity (*e.g.,* paved roads, moderate density housing (1 house/ 10 acres), lawnsand/or ornamental gardens, non-hardened flood control structures, *etc.*) **and**<br>b. ≤ 50% of the VA A has been cleared of vegetation. | 0.50 |
| a. Dominant land use / condition within the buffer is extensively altered by human activity (*e.g.,* paved roads, parking lots, hardened flood control structures, high density housing (>1 house/acre), commercial development, *etc.*) **and**<br>b. > 50% but ≤ 95% of the VA A has been cleared of vegetation, **or**<br>c. Vegetation has been cleared and replaced by row crops, orchards, *etc.* | 0.25 |
| a. Dominant land use / condition within the designated buffer is extensively altered and/or continuously cleared by human activity (*e.g.,* paved roads, parking lots, hardened flood control structures, high density housing (>1 house/acre), commercial development, *etc.*) **and**<br>b. > 95% of the VA A has been cleared of vegetation, **and**<br>c. The variable is recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied. | 0.10 |
| a. Dominant land use / condition within the designated buffer is characterized completely by anthropogenic impervious surfaces (*e.g.*, roads, parking lots, buildings) **and**<br>b. The variable is neither recoverable to reference standard conditions nor sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied. | 0.00 |

**Confidence** The Authors' confidence that reasonable logic and/or data support the variable scaling is MEDIUM to HIGH for all subclasses.

## BUFFER CONTINUITY ($V_{BUFFCONT}$)

**Definition**

**Buffer Continuity** is the linear extent of the vegetated buffer on both sides of the stream channel, parallel to the top of bank.

***Please Note:*** To exist for the purposes of scaling the $V_{BUFFCONT}$ variable, the buffer must be:

(a) Vegetated; that is, dominated by either native or non-native trees, shrubs, or undergrowth species rooted in soil. For example, orchards or perennial row crops of nearly level to moderate (<15%) slopes, lawns, ornamental planting, etc. are OK; "can yards" of container stock, any annual agricultural crops, or orchards or perennial row drops on slopes >15% are specifically excluded.

**and**

(b) At least 25% of the width required by Santa Barbara County for the PAA.

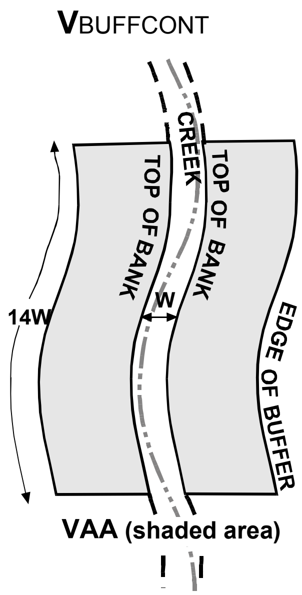
**Rationale for Selection of the Variable**

Maintenance of the riparian buffers in or near the Reference Standard conditions of continuity is an important consideration that, in conjunction with $V_{BUFFCOND}$ and $V_{BUFFWIDTH}$, provide (a) the basis for development of channel and floodplain structure, (b) suitable substrates and soil conditions for biogeochemical processing, and (c) suitable habitat for establishment and maintenance of native plant and animal communities. Continuity of the buffer also provides movement opportunities and cover for faunal species. Channel development and floodplain structure is influenced by the continuity of the plant communities in the buffer. Specifically, intact plant communities within the buffer increase bank shear strength through the production and maintenance of underground fine root biomass. Intact fine roots provide structural support of the channel banks which, in turn, helps to maintain channel geometry. In addition, continuous vegetative communities within the buffer provide horizontal and vertical structure and complexity for faunal habitat and/or cover (*e.g.,* layers or strata of vegetation within the riparian zone*;* resting, hiding, escape, reproductive, and thermal cover). Buffer continuity is also important in providing hydraulic roughness within the riparian zone. Roughness slows surface water flows, and provides habitat and/or cover for aquatic and semi-aquatic vertebrates and invertebrates. In addition, roughness creates hydraulic complexity at the contact among water, soil and roots. Complex contact facilitates the filtering of particulates and thus the removal of sorbed or chelated nutrients, organic matter, and contaminants (Peterjohn & Correll 1984).

## Variable: BUFFER CONTINUITY ($V_{BUFFCONT}$)

**Measurement Protocol**

The VAA for $V_{BUFFCONT}$ consists of two transects: one upstream and one downstream. These transects originate at the PAA cross section. As with $V_{BUFFCOND,}$ their length is seven times the OHW cross section width. Thus an observer travels a total distance of fourteen times the OHW cross section width to look for and record breaks in the continuity of the buffer (*i.e.*, 7 OHW widths upstream and 7 OHW widths downstream).




By definition, the minimum width of the VAA for $V_{BUFFCONT}$ (*i.e.*, the minimum width of the zone wherein you need to look for breaks in buffer continuity) is > 25% of the width of the buffer required by Santa Barbara County for the PAA. If the buffer width is less than 25% of the required width, then it does not exist.

Along the $V_{BUFFCONT}$ transect, a buffer can be "broken" as many times as the width becomes less than 25% of the County requirement. For example, if a 100-foot buffer is required for the PAA and buffer width along the $V_{BUFFCONT}$ transects narrows four times to < 25' in width, then the buffer is "broken" four times, once for each narrowing (Figure 5.3).

Using the guidance above, count the number of times that the Santa Barbara County designated buffer (urban, 50 ft; rural, 100 ft) is "broken", and/or interrupted by man-made structures and/or human activities. Be sure to include activites that result in a narrowing of the buffer to less than the minimum width stipulated above. Examples of man-made structures and/or human activities that may cause breaks or interuptions in the buffer are dirt or paved roads, bridges, power line rights-of-way, annual crops, orchards, hiking and/or biking trails, lawns and/or ornamental gardens, parking lots, flood control structures, *etc.* Record your results on the Minimum Submittal Worksheets provided in Chapter 7.

**Data**

Not applicable.

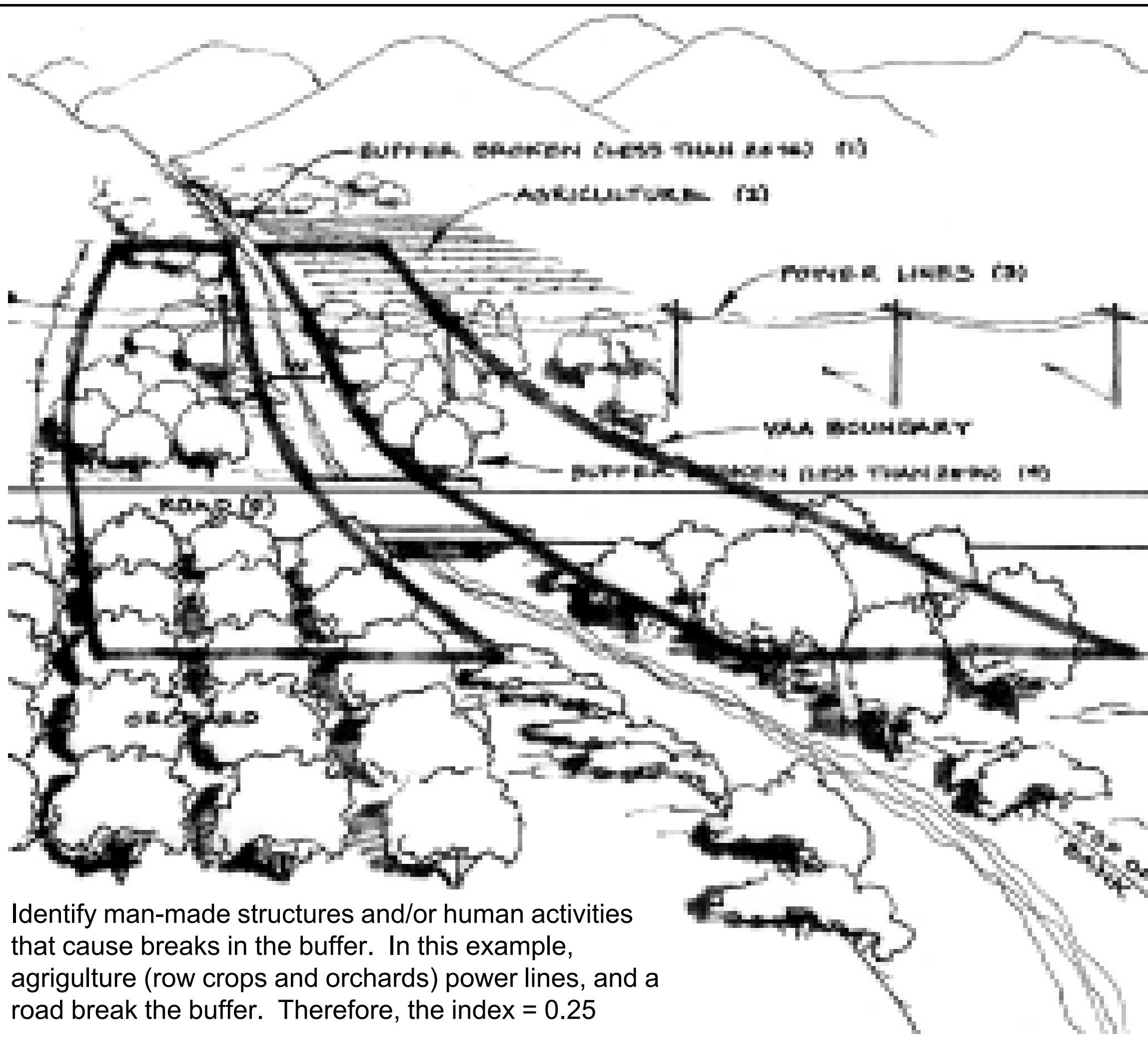
**Scaling Rationale**

In the SCSBC region, a designated width of land surrounding a stream (urban, 50 ft; rural, 100 ft) is maintained to protect biological diversity, water quality, and hydrological characteristics of the stream (SB County Coastal Plan 9-37). Buffer width is measured horizontally (*i.e.,* perpendicular to the direction of flow) from the top of bank(TOB) or "edge of intact riparian vegetation" landward. The team considered the interruption of the linear connectivity of the vegetative buffer (Figure 5.3) to be degradation. It is well substantiated in the literature that the width, condition, and/or continuity of land surrounding a stream is highly correlated with the geochemical and habitat functioning of a riparian ecosystem (Peterjohn & Correll 1984).

**Variable: BUFFER CONTINUITY ($V_{BUFFCONT}$)**

Scaling of this variable was based upon our reference sampling observarions of the effects of various types of land uses on the linear continuity of the buffer. A scale was seleceted based on those land uses and/or conditions that best maintained complete linear integrity of the required buffer and thus, the functioning of the stream ecosystem. The scaling is consistent with the County's overall intent to protect biological productivity, water quality, and hydrologic characteristics of a stream ecosystem.

**Figure 5.3 Measurement protocol for the buffer contiguity variable ($V_{BUFFCONT}$)**




Identify man-made structures and/or human activities that cause breaks in the buffer. In this example, agrigulture (row crops and orchards) power lines, and a road break the buffer. Therefore, the index = 0.25

## Variable: BUFFER CONTINUITY ($V_{BUFFCONT}$)

**Scaling for High, Moderate, and Low Gradient Subclasses**

| MEASUREMENT CONDITION FOR $V_{BUFFCONT}$ | INDEX |
|---|---|
| a. Vegetated buffer (rural 100 ft; urban 50 ft) is continuous on both sides of the stream channel, throughout the VAA | 1.0 |
| a. Vegetated buffer (rural 100 ft; urban 50 ft) is broken at one point and not continuously by human activities on either side of the stream channel within the VAA (*e.g.,* road or power line intersects at one point; annual agriculture or orchard or perennial row crop production on slopes >15%, trail intersection at one point; flood control structures, *etc.*) | 0.75 |
| a. Vegetated buffer (rural 100 ft; urban 50 ft) is broken by human activities once, but not continuously on each side of the stream channel **or**<br>b. Twice, but not continuously on one side of the channel within the VAA (*e.g.,* roads, power lines, annual agriculture or orchard production on slopes > 15%, trails, bridges, flood control structures, *etc.*) | 0.50 |
| a. Vegetated buffer (rural 100 ft; urban,50 ft) is broken by human activities repetitively (≥ three times) on either or both sides of the stream channel within the VAA (*e.g.,* roads, power lines, annual agriculture or orchard or perennical row crop production on slopes > 15%, trails, flood control structures, *etc.*) | 0.25 |
| a. Vegetated buffer (rural 100 ft; urban 50 ft) does not exist on either or both sides of the stream channel, within the VAA **and**<br>b. Variable is recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied (*e.g.* recovering/restored annual row crop field; abandoned dirt road, etc.). | 0.10 |
| a. Vegetated buffer (rural 100 ft; urban 50 ft) does not exist on either or both sides of the stream channel, within the VAA **and**<br>b. Variable is not recoverable and not sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied (*e.g.*, parking lot, concrete channel, commercial and/or residential buildings, *etc.*) | 0.00 |

**Confidence** The Authors' confidence that reasonable logic and/or data support the variable scaling is MEDIUM TO HIGH for all subclasses.

## BUFFER WIDTH ($V_{BUFFWIDTH}$)

**Definition**

**Buffer Width** is the average width of the existing vegetated buffer within the buffer zone/stream setback required by Santa Barbara County (Santa Barbara County Coastal Plan pp. 9-37).

> **Please Note:** To exist (and thus for the purposes of scaling the $V_{BUFFWIDTH}$ variable), the buffer must be vegetated; that is, dominated by either native or non-native trees, shrubs, or undergrowth species rooted in soil [*e.g.* orchards or perennial row crops of nearly level to moderate (<15) slopes, lawns, ornamental plantings, etc. are OK; “can yards” of container stock, any annual agricultural crops, or orchards or perennial row crops on slopes > 15% are specifically excluded].

**Rationale for Selection of the Variable**

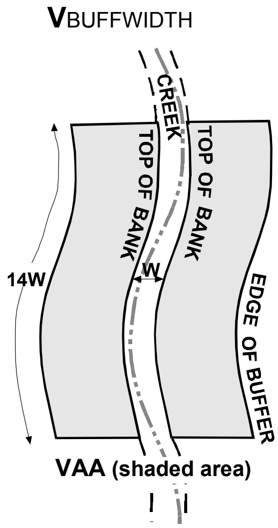
In SCSBC, buffers are required because they reflect the County’s concerns regarding protection of biological productivity, water quality, and hydrological characteristics of a stream (Santa Barbara County Coastal Plan, pp 9-37). Generally, the minimum buffer width in rural areas is 100 ft from the “top of bank” or existing riparian vegetation, whichever is greater. A width of 50 ft is stipulated for urban areas.

Maintenance of riparian buffers in or near the Reference Standard conditions of buffer continuity is an important consideration that, in conjunction with $V_{BUFFCOND}$ and $V_{BUFFCONT}$, provides (a) the basis for development of channel and floodplain structure, (b) suitable substrates and soil conditions for biogeochemical processing, and (c) suitable habitat for establishment and maintenance of native plant and animal communities. Intact buffers also provide movement opportunities and cover for faunal communities. As discussed throughout this document, plant communities within buffers have important influences on channel development and floodplain structure. Intact plant communities within the buffer increase bank shear strength through the production and maintenance of underground fine root biomass, providing structural support to the channel geometry. In addition, buffer width provides the necessary structure and complexity for faunal habitat and/or cover (*e.g.,* resting, hiding, escape, reproductive, and thermal). Buffer width also influences hydraulic roughness within and adjacent to the riparian zone. Roughness is important in slowing water flows entering the riparian zone. Roughness also provides habitat and/or cover for aquatic and semi-aquatic vertebrates and invertebrates. Intact buffers enhance the filtering of particulates and thus the removal of sorbed or chelated nutrients, organic matter, and contaminants (Peterjohn & Correll 1984).

**Variable: BUFFER WIDTH ($V_{BUFFWIDTH}$)**

**Measurement Protocol**

The VAA for $V_{BUFFWIDTH}$ is defined as the Santa Barbara County required buffer or setback on stream left and stream right along a stream reach that extends from the main PAA cross section, seven OHW widths upstream and seven OHW widths downstream.




Walk upstream and downstream within the VAA, as described above. Utilize air photos to facilitate your examination of buffer widths if they are helpful. Start at the stream right top of bank (TOB) on the PAA cross section. Measure the width of the existing buffer required by the County (*i.e.*, from the top of bank point outward and perpendicular to the channel to a maximum distance of 100 ft for rural areas and 50 ft for urban areas). Walk to the upstream and downstream ends of the VAA (*i.e.,* a distance equal to 7 channel widths up and downstream from the main PAA cross section) and complete similar measurements at the top of bank points on stream right and stream left (Figure 5.4). Sum the three sets of measurements (*i.e.,* 6 measurements total) and divide by six to obtain an estimate of the average buffer width within the VAA. Record your results on the Minimum Submittal Worksheet provided in Chapter 7.

**Data**

Not applicable.

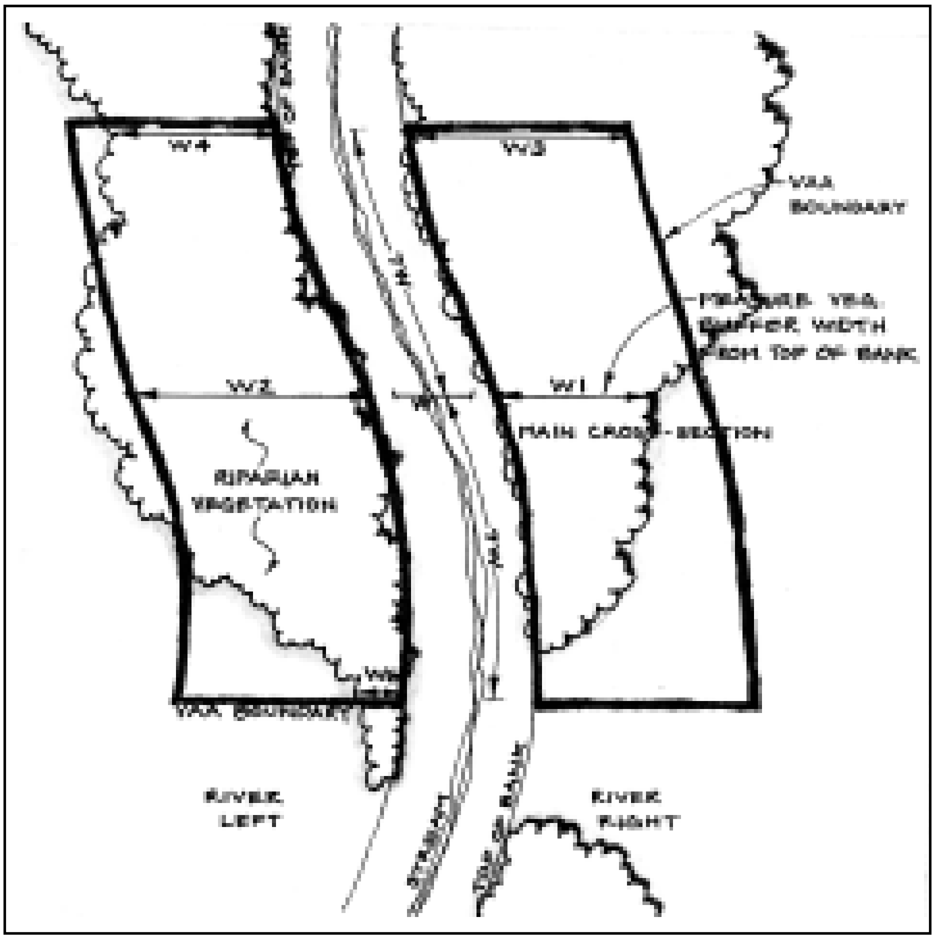
**Scaling Rationale**

In SCSBC, a designated width of land is maintained surrounding a stream to protect biological diversity, water quality, and hydrological characteristics of the stream (SB County Coastal Plan pp9- 37). The buffer is measured horizontally (*i.e.* perpendicular to the direction of flow) from the top of bank landward. The required width of the buffer varies by adjacent land use. In an "urban" zone, buffer width is 50 ft; in a "rural" zone, buffer width is 100 ft (Santa Barbara County Coastal Plan pp9-37).

It is well substantiated in the literature that riparian buffer widths, condition, and continuity are highly correlated with geochemical and habitat functioning (Peterjohn & Correll 1984). The Authors scaled this variable based upon their local knowledge of land use and buffer widths within the SCSBC and selected a scale of those land uses and/or widths that best maintained and supported the structural integrity and geometry of a stream and associated floodplain. Thus, the scaling is consistent with the County's intent to protect biological productivity, water quality, and hydrological characteristics of a stream.

**Variable: BUFFER WIDTH ($V_{BUFFWIDTH}$)**

**Figure 5.4 Measurement protocol for the buffer width variable ($V_{BUFFWIDTH}$)**



## Variable: BUFFER WIDTH ($V_{BUFFWIDTH}$)

**Scaling for High, Moderate and Low Gradient Subclasses**

| MEASUREMENT CONDITION FOR $V_{BUFFWIDTH}$ | INDEX |
|---|---|
| a. If zoned "rural" by Santa Barbara County, then the average vegetated buffer width within the VAA is ≥ 100 ft **or**<br>b. If zoned "urban" by Santa Barbara County the average vegetated buffer width within the VAA is ≥ 50 ft. | 1.00 |
| a. If zoned "rural" by Santa Barbara County, then the average vegetated buffer width within the VAA is ≥ 75 ft but <100 ft **or**<br>b. If zoned "urban" by Santa Barbara County, then the average vegetated buffer width within the VAA is ≥ 38 ft but < 50 ft. | 0.75 |
| a. If zoned "rural" by Santa Barbara County, then the average vegetated buffer width within the VAA is ≥ 50 but <75 ft l **or**<br>b. If zoned "urban" by Santa Barbara County, then the average vegetated buffer width within the VAA is ≥ 25 ft but < 38 ft. | 0.50 |
| a. If zoned "rural" by Santa Barbara County, then the average vegetated buffer width within the VAA is ≥ 25 ft but < 50 ft **or**<br>b. If zoned "urban" by Santa Barbara County, then the average vegetated buffer width within the VAA is ≥ 13 ft but < 25 ft. | 0.25 |
| a. If zoned "rural" by Santa Barbara County, then the average vegetated buffer width within the VAA is <25 ft **or**<br>b. If zoned "urban" by Santa Barbara County, then the average vegetated buffer width within the VAA is <13 ft **and**<br>c. The variable is recoverable and sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied. | 0.10 |
| a. If zoned "rural" by Santa Barbara County, then the average vegetated buffer width within the VAA is <25 ft **or**<br>b. If zoned "urban" by Santa Barbara County, then the average vegetated buffer width within the VAA is <13 ft **and**<br>c. Variable is neither recoverable nor sustainable to reference standard conditions through natural processes if the existing land use is discontinued and no restoration measures are applied. | 0.00 |

**Confidence** The Authors' confidence that reasonable logic and/or data support the variable scaling is HIGH for all subclasses.

## CHANNEL ROUGHNESS ($V_{CHANROUGH}$)

**Definition**

**Channel roughness** is an indicator of the hydraulic resistance produced by natural or anthropogenic immobile features of the channel system below ordinary high water (OHW).

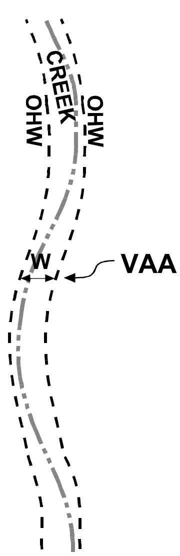
**Rationale for Selection of the Variable**

Channel roughness affects both temporal and spatial flow conditions (*e.g.,* turbulence, velocity of water, flow paths, *etc.*) in riverine ecosystems. Channel roughness also influences the kinetic energy of water flowing in the channel, and thus has direct effects on sediment mobilization, transport, deposition, and storage processes. Channel roughness can contribute to improved water quality by providing increased contact of water with diverse channel surfaces. Turbulence, created by channel roughness, increases the dissolved oxygen content of stream waters. Channel roughness also contributes to aquatic habitat diversity by providing a variety of hydraulic conditions in a given channel reach. Hydraulic complexity provides resting, hiding, feeding, thermal, and escape cover for a wide array of aquatic and semi-aquatic vertebrates and invertebrates.

Depending upon the type and timing of natural events, as well as land uses, channel roughness can vary widely within and among subclasses. Examples of features that produce resistance to flow in channels include (a) boulders transported to the site by episodic large events such as debris flows, (b) large, buried, and fixed coarse woody debris, (c) rip-rap, (d) bridge abutments, (e) bedrock, *etc.* Channel roughness is expressed as percent of the channel cross sectional area below OHW occupied by roughness elements that are relatively immobile during flood events.

**Measurement Protocol**

$V_{CHANROUGH}$

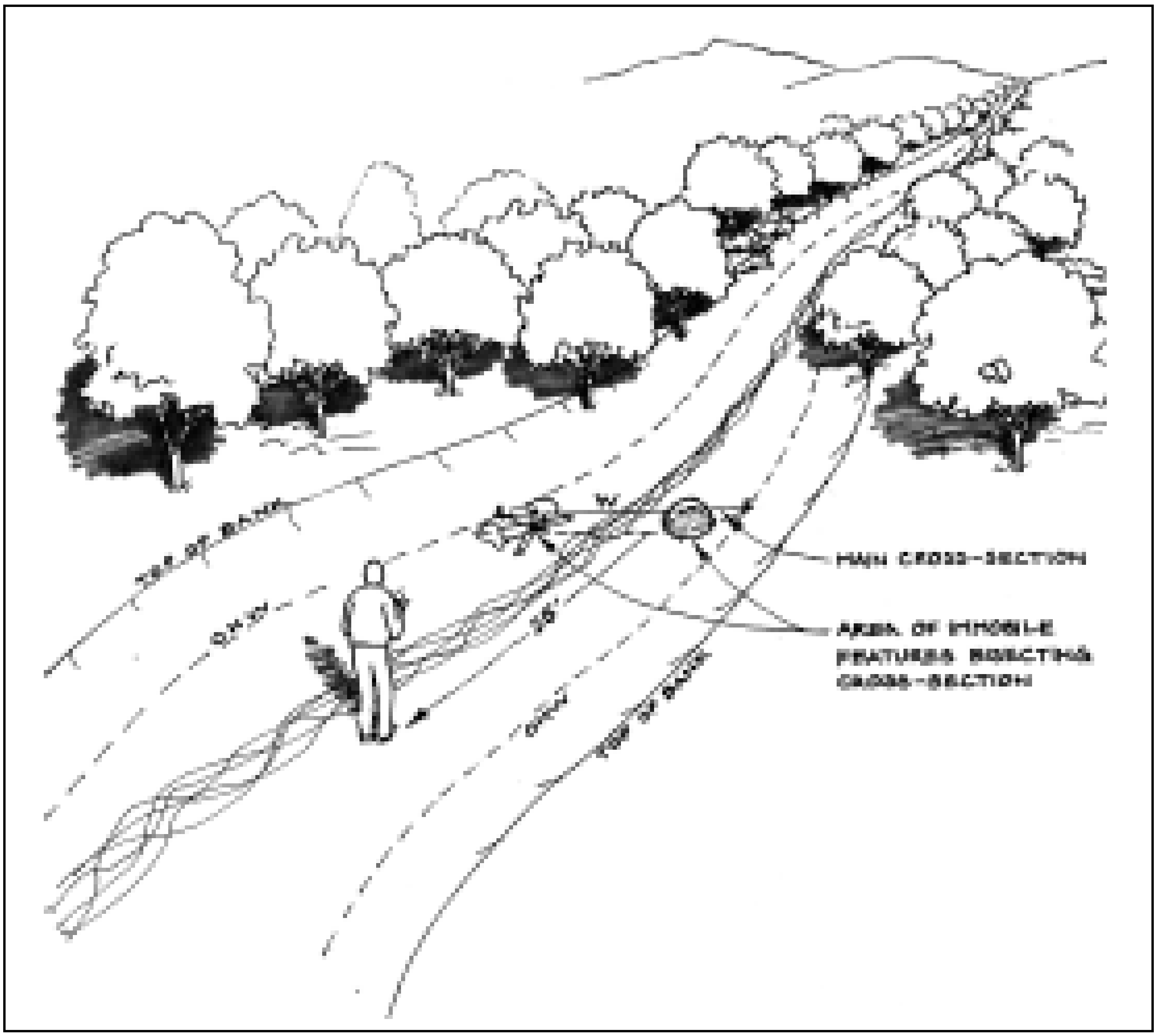



The VAA for $V_{CHANROUGH}$ is defined as the cross-sectional area of the PAA channel cross section below OHW. To measure $V_{CHANROUGH,}$ stand 25 ft downstream from the PAA cross section and imagine a vertical plane (*i.e.*, a curtain) extending from the cross section tape at the OHW level down to the channel bed (Figure 5.5). Identify natural and anthropogenic features in the cross section (*i.e.,* features that intersect the PAA cross section below OHW) that will not move during annual flood events and which contribute to channel roughness. Natural immobile features in a stream channel are generally the largest 15% of the observed channel bed material. For example, in a moderate to high gradient system, a Guidebook user could expect an embedded boulder (Figure 5.8) not to move during an annual flooding event. However, it is important to note that immobile materials can move through other hydrologic processed such as winnowing. See Section 4.7 for further discussion. Anthropogenic immobile features include riprap, debris, engineered structures, *etc.* Use the photos and line drawings in Figure 5.6 to estimate the percentage of the channel cross section occupied by roughness elements. Record your results on the Minimum Submittal Worksheet provided in Chapter 7.

**Variable: CHANNEL ROUGHNESS ($V_{CHANROUGH}$)**

An alternative, and more accurate, protocol for measurement of channel roughness is to actually measure the area of all the roughness elements within the channel cross section below OHW. Sum these measurements to develop an estimate of the total area ($ft^2$) of roughness elements. Divide the estimate of the roughness elements by the total area of the channel cross section below OHW and multiply by 100 to express the result as percent (%) of the main channel cross section occupied by roughness elements.

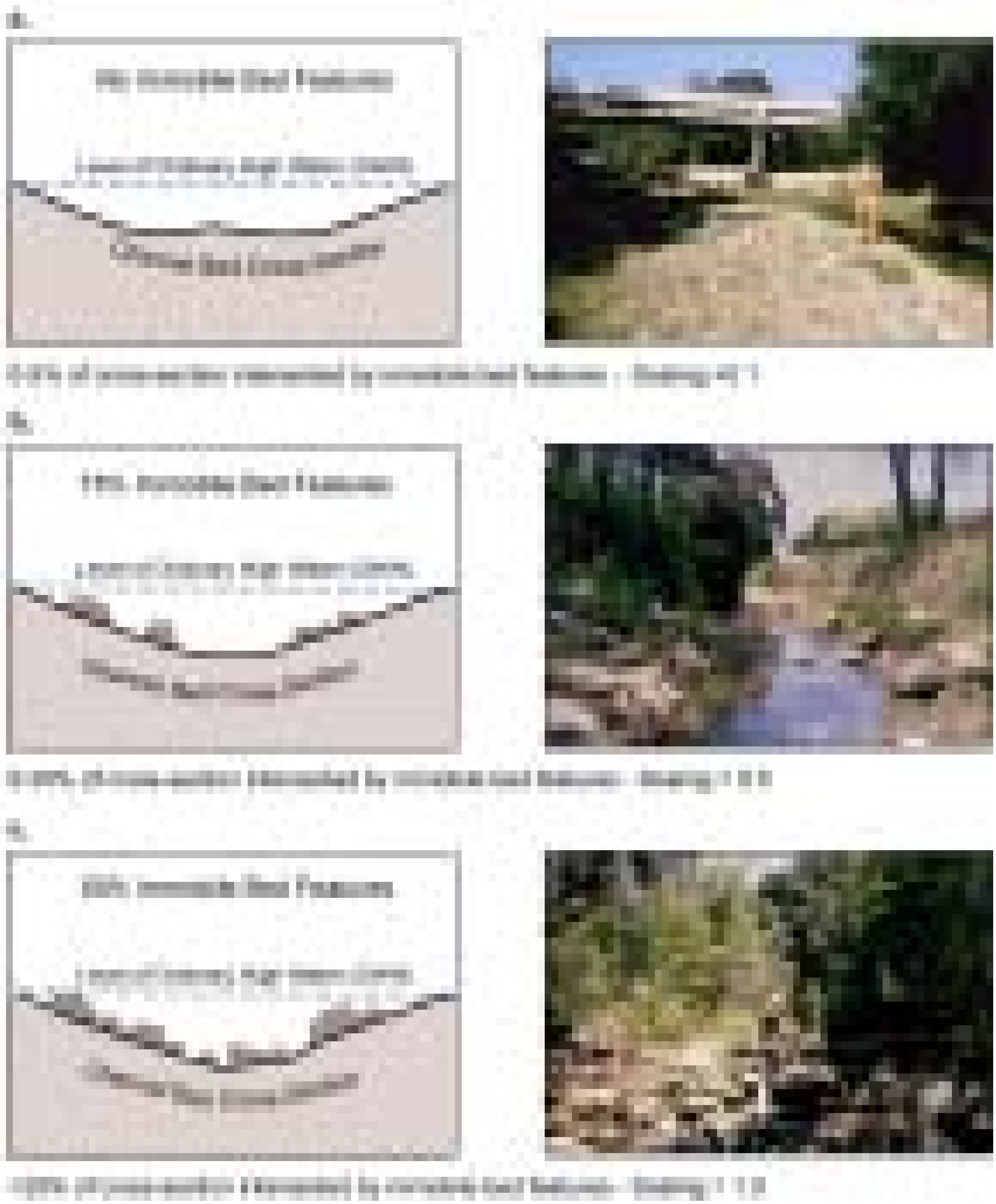
**Figure 5.5 Measurement protocol for the channel roughness variable ($V_{CHANROUGH}$)**




**Data** Located in Appendix B-13 through B-20

**Variable: CHANNEL ROUGHNESS ($V_{CHANROUGH}$)**

**Figure 5.6 Channel bed roughness categories**



## Variable: CHANNEL ROUGHNESS ($V_{CHANROUGH}$)

**Scaling Rationale**

Reference system data vary significantly among the three subclasses. For example, reference standard channel roughness conditions in the High gradient subclass ranged from 0% to 52% of the channel cross section occupied by roughness elements, with an average of 21%. All Moderate gradient streams sampled varied from 0% to 44% of the channel cross section occupied by roughness, with an average of 9%. The Authors were not able to discern reference standard conditions for the Low gradient subclass. All low gradient streams sampled varied from 0-8% channel roughness with an average of 2%. The least altered sites observed in the Low gradient subclass (*e.g.,* lower Gaviota) were relatively degraded, dominated by willows (*Salix* spp.) and supported only a sparse coverage by coarse woody debris.

Considering the wide range of variation in conditions of channel roughness described above, and the need for maintenance of a rapid assessment protocol and efficient field procedures in this *Draft Guidebook*, the Authors chose to lump the High and Moderate gradient subclasses for the purposes of scaling and separate the Low gradient subclass, and scale the channel roughness variable using a combination of reference data and best scientific judgment. Specifically, in the field and in some of the data for all subclasses, the Authors observed a relatively consistent trend for channel roughness to decrease with increasing human alteration to channel systems (Tables 5.7 and 5.8).

**Table 5.7 Mean, standard deviation and range of the average immobile bed roughness for the High and Moderate gradient subclasses**

| Disturbance Gradient | Sample Size | Average Immobile Bed Roughness (mean, sd, range) | |
|---|---|---|---|
| Unaltered / Reference Standard | 4 | 23 ± 23 | (0 to 52) |
| Minimally Altered | 10 | 18 ± 10 | (4 to 35) |
| Moderately Altered | 16 | 7 ± 11 | (0 to 44) |
| Extensively Altered | 8 | 1 ± 3 | (0 to 7) |
| Unrecoverable | 0 | N A | |

**Table 5.8 Mean, standard deviation and range of the average immobile bed roughness for the Low gradient subclasses**

| Disturbance Gradient | Sample Size | Average Immobile Bed Roughness (mean, sd, range) | |
|---|---|---|---|
| Unaltered / Reference Standard | 0 | N A | |
| Minimally Altered | 2 | 2 ± 2 | (0 to 3) |
| Moderately Altered | 3 | 1 ± 1 | (0 to 2) |
| Extensively Altered | 12 | 3 ± 3 | (0 to 8) |
| Unrecoverable | 2 | 0 | |

## Variable: CHANNEL ROUGHNESS ($V_{CHANROUGH}$)

**Scaling for High and Moderate Gradient Subclasses**

| MEASUREMENT CONDITION FOR $V_{CHANROUGH}$ | INDEX |
|---|---|
| a. ≥ 25% of the channel cross sectional area is occupied by natural roughness elements such as boulders, imbedded logs, bedrock, *etc.,* **and**<br>b. there is no evidence historic human disturbance of channel roughness. | 1.00 |
| a. ≥ 25% of the channel cross sectional area is dominated by natural roughness elements such as boulders, embedded logs, bedrock, *etc.,* **and**<br>b. there is evidence of human disturbance of channel roughness | 0.75 |
| a. ≥ 5 and <25% of the channel cross sectional area is occupied by roughness elements that may include both natural and anthropogenic material (*e.g.* boulders, concrete fragments and/or structures, *etc.*) **and**<br>b. Channel cross section is dominated by natural roughness elements (*e.g.* boulders, rocks, coarse embedded logs, *etc.*) | 0.50 |
| a. ≥5% and < 25% of the channel cross sectional area is dominated by anthropogenic elements that consist of material(s) that by their placement or construction provide roughness (*e.g.* rip rap, concrete fragments and/or structures, pipe and wire bank stabilization, storm drain discharges, *etc.*) **and**<br>b. Channel cross section is dominated by anthropogenic roughness elements (*e.g.* rip rap, concrete fragments, engineered structures that are not hardened with concrete or mortar, *etc.*) | 0.25 |
| a. <5% of the channel cross sectional area is dominated by roughness elements that consist of anthropogenic material(s) **and**<br>b. Variable is recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied. | 0.10 |
| Channel cross section is smooth and concrete or mortared rip rap on both sides and the variable is not recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied (*e.g.*, concrete trapezoidal channel, parking lot, box culvert, roads, *etc.*) | 0.00 |

**Variable: CHANNEL ROUGHNESS ($V_{CHANROUGH}$)**

**Scaling for the Low Gradient Subclass**

| MEASUREMENT CONDITION FOR $V_{CHANROUGH}$ | | INDEX |
|---|---|---|
| a.<br>b | $\geq$ 5 % of the channel cross sectional area is occupied by natural roughness elements such as boulders, embedded logs, bedrock, *etc.,* **and**<br>there is no evidence historic human disturbance of channel roughness | 1.00 |
| a<br>b | $\geq$ 5 % of the channel cross sectional area is occupied by natural channel roughness elements such as boulders, embedded logs, bedrock, *etc.* **and**<br>Evidence historic human disturbance of channel roughness is present | 0.75 |
| | >0 and <5% of the channel cross sectional area is occupied by roughness elements **that may include** both natural and anthropogenic material (*e.g.,* concrete fragments and/or structures, rip rap, *etc.*) | 0.50 |
| | >0% and <5% of the channel cross sectional area is **dominated** by anthropogenic roughness elements that by their placement or construction provide roughness (*e.g.* pipe and wire structures, rip-rap walls, rivetment, concrete fragments and/or structures, *etc.*) | 0.25 |
| a<br>b | Channel cross section is smooth and rip-rap or post and wire on one side **and**<br>Variable is recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied (*e.g.* "dirty" rip rap or rivetment hardening of 1/2 channel cross section; post and wire confinement of the channel on one side of the channel) | 0.10 |
| a<br>b | Channel cross section is smooth and concrete on both sides **and**<br>Variable is not recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied, *e.g.*, concrete trapezoidal channel, parking lot, box culvert, roads, *etc.* | 0.00 |

**Confidence** The Authors' confidence that reasonable logic and/or data support the variable scaling is MEDIUM to HIGH for the High and Moderate gradient subclasses and MEDIUM for the Low gradient subclass.

## IN-CHANNEL COARSE WOOD DECOMPOSITION ($V_{DECOMP}$)

**Definition**

**In-Channel Coarse Wood Decomposition** is a measure of the most frequently occurring decomposition class (mode) and the average number of decomposition classes of coarse woody debris (CWD) below ordinary high water (OHW) and within the active channel.

**Rationale for Selection of the Variable**

Multiple decomposition classes within a channel reach are often good indicators of the production of detritus and thus, organic carbon . Organic carbon serves as an energy source that provides the basis for numerous ecosystem processes (*e.g.,* decomposition, nutrient cycling, energy transfer, *etc.*). The most frequently occurring (*i.e.,* modal) decomposition classes can be used as an indicator of the stage of detritus and organic carbon production within a stream ecosystem (Brinson *et al.* 1995). This is important in SCSBC, where human activities can have significant effects on the number of pieces and/or volume of CWD within a channel reach. For example, the removal of in-channel CWD for flood control purposes directly reduces rates and/or amounts of decomposition, nutrient cycling, energy transfer, *etc.*

**Measurement Protocol**

The VAA for $V_{DECOMP}$ consists of a channel reach length that is seven (7) times the OHW width of the main PAA cross section. The VAA is “centered” on the main PAA cross section, so that 3.5 OHW Channel widths are upstream, and 3.5 OHW channel widths are downstream from the main PAA cross section. Walk the VAA stream reach and identify all pieces of CWD (*e.g.,* down trees, branches, logs, dimensional lumber, *etc.,* >3” diameter) below OHW (Figure 5.7). Include any piece of CWD >3" diameter that intersects the OHW line but extends above OHW. Record a decomposition class for each piece of CWD using the summary of decomposition classes as outlined in the Minimum Submittal Worksheets in Chapter 7. Determine the most frequently reported decomposition class (mode), as well as the range (number) of different classes identified within the active channel reach.

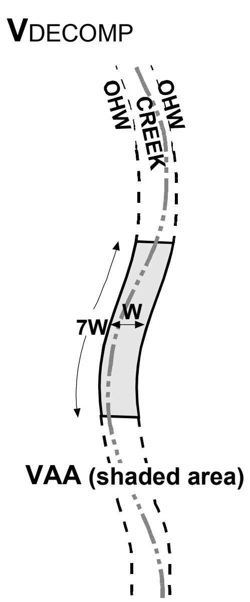



**Table 5.9 The 5 decomposition classes for CWD**

| Decomposition Class | Description |
|---|---|
| 1 | CWD recently fallen, bark attached, leaves and fine twigs present |
| 2 | CWD with loose bark, no leaves and/or fine twigs, fungi present |
| 3 | CWD without bark, few branches present, fungi present |
| 4 | CWD without bark, and branches, heartwood in advanced state of decay |
| 5 | CWD decayed into organic material on ground |

***NOTE:*** *IF NO CWD IS FOUND IN THE VAA REACH, THEN NO DECOMPOSITION CLASS IS ASSIGNED*

## Variable: IN-CHANNEL COARSE WOOD DECOMPOSITION ($V_{DECOMP}$)

**Data** Located in Appendix B-1 through B-12

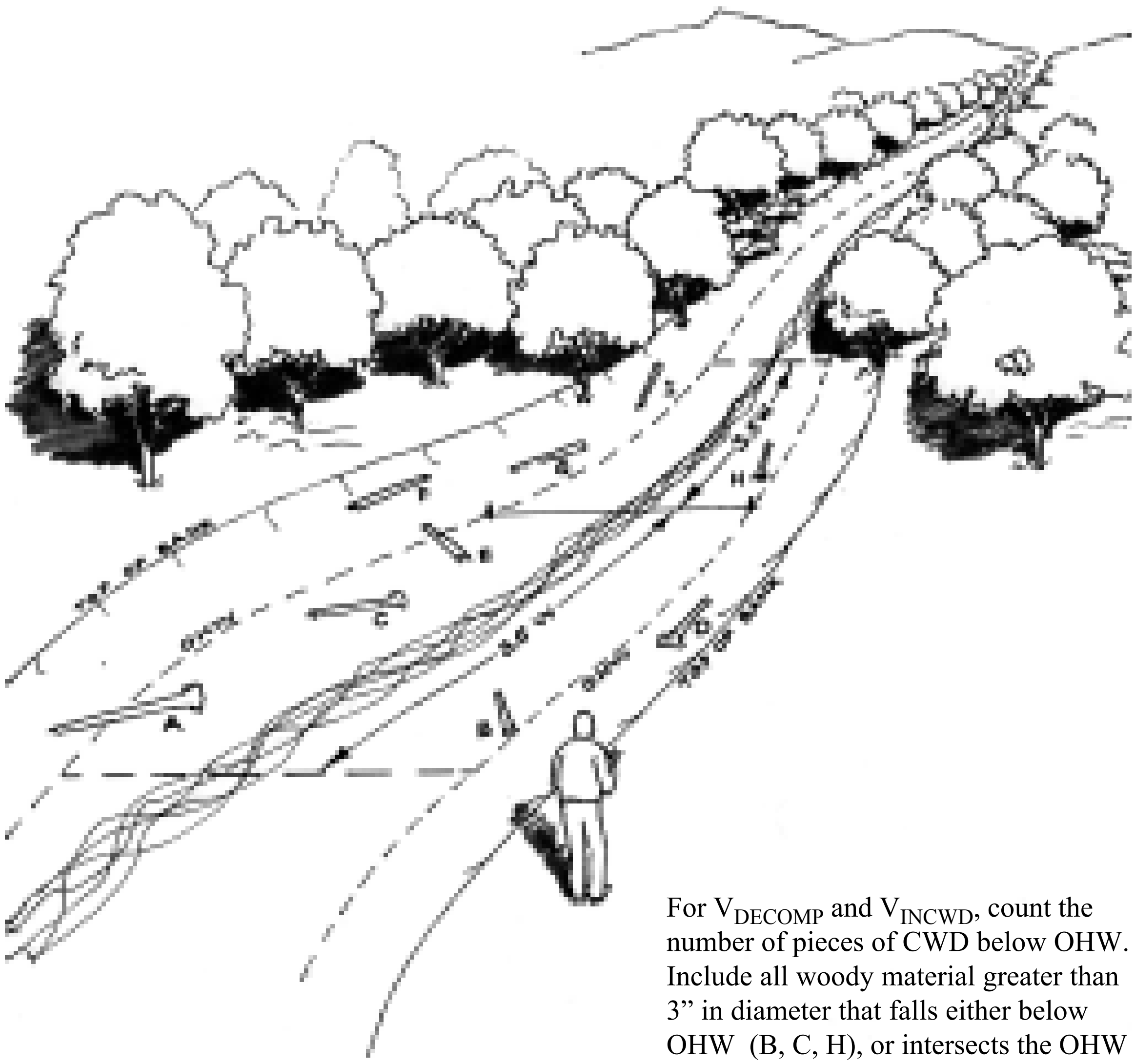
**Scaling Rationale** The Authors scaled $V_{DECOMP}$ using a combination of reference system data, field observations, and best scientific judgment. At first, data for each subclass were analyzed separately. The Authors lacked reference standard conditions for the Low gradient subclass and had only one observation within the Moderate gradient subclass. Next, the Authors examined the effects of grouping all subclasses for analyses, especially in light of the Authors' lack of reference standard data for the Low gradient subclass and only sparse data for the Moderate gradient subclass. In the grouped data, the Authors observed a consistent trend, across all subclasses, of decreasing ranges and modes of decomposition classes with increasing human alterations of the stream channel and associated riparian ecosystems (see Table 5.10 below). This trend was consistent with the Authors' field observations and best judgment. Therefore, for the purposes of scaling $V_{DECOMP}$, the Authors assumed that a greater number of coarse woody debris pieces in advanced stages of decomposition was nearer to reference standard conditions than a few pieces of undecomposed coarse wood, or no coarse wood at all.

**Table 5.10** **Mean, standard deviation and range of the total CWD volume below OHW for the High, Moderate and Low Gradient subclass**

| Land Use Gradient | Sample Size | Mode of Decomposition Classes Below OHW | Average Number of Decomposition Classes Below OHW (Mean, SD, Range) | |
|---|---|---|---|---|
| Unaltered / Reference Standard | 4 | 3 | 2.62 ± 0.74 | (2 to 4) |
| Minimally Altered | 12 | 3 | 1.79 ± 0.93 | (0 to 3) |
| Moderately Altered | 19 | 2 | 1.24 ± 0.98 | (0 to 4) |
| Extensively Altered | 20 | 0 | 0.7 ± 0.85 | (0 to 3) |
| Unrecoverable | 0 | 0 | | 0 |

**Variable: IN-CHANNEL COARSE WOOD DECOMPOSITION ($V_{DECOMP}$)**

**Figure 5.7 Measurement protocol for the decomposition variable ($V_{DECOMP}$), in channel course woody debris variable ($V_{INCWD}$) and off channel course woody debris variable ($V_{OFFCWD}$)**



For $V_{DECOMP}$ and $V_{INCWD}$, count the number of pieces of CWD below OHW. Include all woody material greater than 3" in diameter that falls either below OHW (B, C, H), or intersects the OHW line (A, E). Pieces D, C, G & I in this example would not be counted.

**Variable: IN-CHANNEL COARSE WOOD DECOMPOSITION ($V_{DECOMP}$)**

**Scaling for High, Moderate, and Low gradient subclasses**

| MEASUREMENT CONDITION FOR $V_{DECOMP}$ | INDEX |
|---|---|
| a. Total number of decomposition classes below OHW is ≥ 3 **and**<br>b. Mode (most frequent occurrence) of decomposition class is ≥ 3. | 1.00 |
| a. Total number of decomposition classes below OHW is ≥ 3 **and**<br>b. Mode (most frequent occurrence) of decomposition class is ≥ 1 and < 3. | 0.75 |
| a. Total number of decomposition classes below OHW is 2 and<br>b. Mode (most frequent occurrence) of decomposition class is ≥ 3. | 0.50 |
| a. Total number of decomposition classes below OHW is 2 **and**<br>b. Mode (most frequent occurrence) of decomposition class is ≥ 1 and < 3. | 0.25 |
| a. Total number of decomposition classes below OHW is ≤ 1 **and**<br>b. Variable is recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and restoration measures are applied. | 0.10 |
| a. Total number of decomposition classes below OHW is ≤ 1 **and**<br>b. Variable is not recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and restoration measures are applied. | 0.00 |

**Confidence** The Authors' confidence that reasonable logic and/or data support the variable scaling for Moderate and High gradient subclasses is HIGH. For the Low gradient subclass, the Authors' confidence is MEDIUM.

## EMBEDDEDNESS OF LARGE CHANNEL MATERIALS ($V_{EMBED}$)

**Definition**

**Embeddedness** is the degree to which "large class" channel bed material is buried in "finer" sediment. Specifically, embeddedness is the percent burial of the material the stream system has the capacity to move (D84 or larger channel bed material) in material that the channel usually moves (D50 material).

**Rationale for Selection of the Variable**

The degree of embeddedness of relatively large channel bed material (or D84 material) in finer sediment (*e.g*., D50 materials) is a good indication of the percent total sediment load in a stream channel system that ceases to move (or which resides or is stored) in the stream channel system on the falling stage of the hydrograph. Knowledge of sediment dynamics is important, because the distribution of sediment particle sizes in the stream channel, their residence time, and their characteristics of movement through riverine ecosystems is directly related to maintenance of water quality in the riverine ecosystems of SCSBC (Water Quality Analysis Report, Rain Year 1999-2000, Santa Barbara County Public Works Department/Public Health Department).

The size of particles that surround large channel bed materials, and the degree to which large channel bed materials are embedded can indicate (a) the permeability of stream beds, and (b) the amount of energy that will be required to mobilize large size channel bed materials. Thus, from the standpoint of the hydrologic functioning of Santa Barbara riverine ecosystems, embeddedness can be indicative of the rate, timing and volume of water inputs into, through, and out of stream channels, hyphorheic zones, and associated riparian waters/wetlands. Similarly, embeddedness can indicate the amount of "work" (kinetic energy) that will be required to mobilize some or all of the sediment in a channel system

**Measurement Protocol**

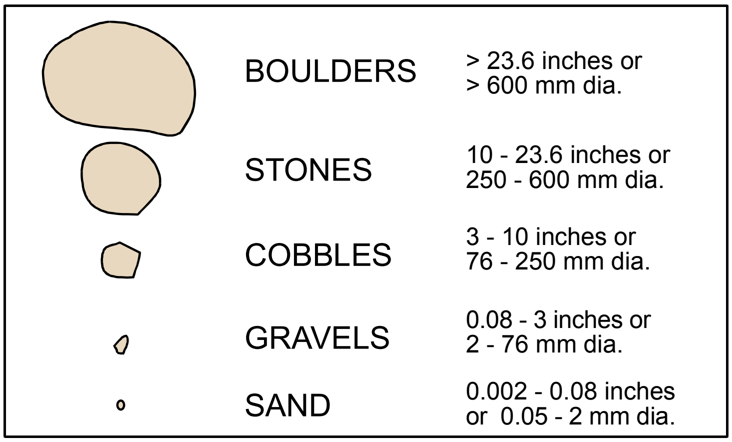
The VAA for $V_{EMBED}$ consists of a channel reach length that is seven (7) times the OHW width of the main PAA cross section. The VAA is centered on the main PAA cross section, so that 3.5 OHW channel widths are upstream, and 3.5 OHW channel widths are downstream from the PAA cross section.

To measure $V_{EMBED,}$ begin at the main PAA cross section. Walk upstream and downstream a total of 3.5 times the OHW cross section width in each direction (*i.e.,* a total length of seven times the OHW cross section width). During this walk, observe the range of sizes of material in the streambed/active channel area below OHW (*e.g*.. boulders to sand below OHW. Identify the size classes (*e.g.,* boulders, stones, cobbles, gravel, sand) of the most frequently occurring streambed materials using Figure 5.8. Note the total number and type of size classes on the Minimum Submittal Worksheet provided in Chapter 7 (*e.g.,* five size classes total consisting of boulders, stones, cobbles, gravel, and sand). Identify the three largest size classes, and pick the middle size class as your "target" size class. For example, if you observe boulders, stones, cobbles, gravel, and sand in the channel, the top three size classes would be boulders, stones and cobbles. Stones would be selected as the "target" size class. If the material in

**Variable: EMBEDDEDNESS OF LARGE CHANNEL MATERIALS ($V_{EMBED}$)**

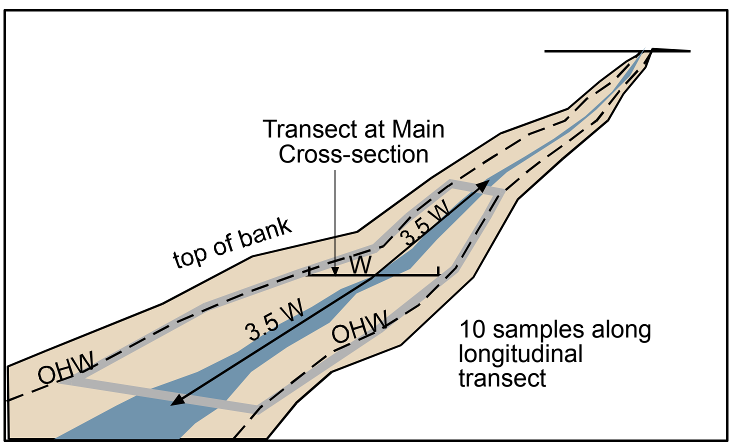
**Figure 5.8 Measurement protocol for the embeddedness of large channel materials variable ($V_{EMBED}$)**

1.



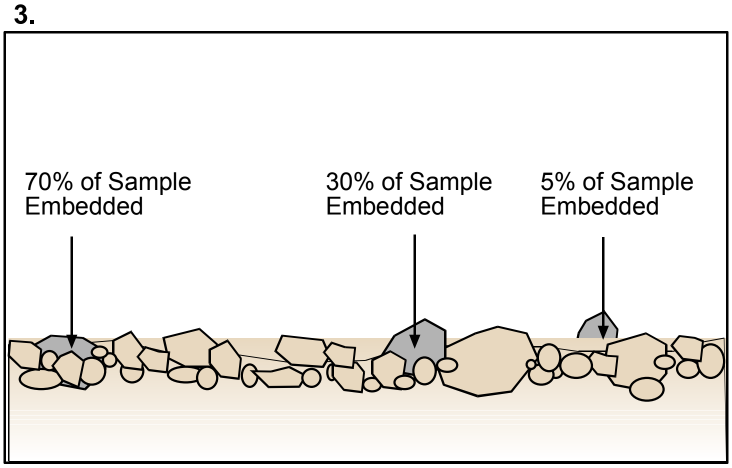

STEP 1:
Determine size class to sample by identifying the three largest size classes and picking the middle size class. With all size classes present, the target size class would be stones.

2.




STEP 2:
Start at the main cross-section and walk upstream 3.5 OHW channel widths and downstream 3.5 OHW widths. Select 10 samples.

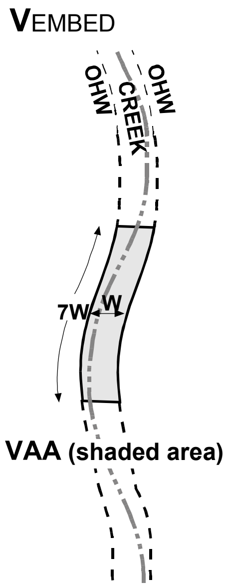
3.




STEP 3:
Determine sample embeddedness and put into categories:

(a) >50% embedded
(b) 5-50% embedded
(c) <5% embedded

**Variable: EMBEDDEDNESS OF LARGE CHANNEL MATERIALS ($V_{EMBED}$)**




the channel consists of only one class of material (*e.g.,* sand), there can be no embeddedness. If the material in the channel consists of only two size classes, pick the larger of the two as your "target" size class.

Within the downstream reach, select ten representative samples of material within the "target" size class. Repeat these measurements in the upstream reach of the VAA. Be sure to thoroughly cover the VAA, both upstream and downstream and completely across the active channel, for selection of your representative samples.

Before you pick up a sample, note its orientation in the stream bed. Specifically, note (a) the top of the sample, (b) the vertical axis of the sample as it is embedded (*in situ*) in the channel, (c) the points on the sample where the embedding material is touching the sample ("touch points"), and (d) the type of material that the sample is embedded in (*e.g.,* sand, gravel, loamy material, *etc*). Then, if possible, use your hands, a shovel, or a bar to expose and/or pick up the sample. (Note: If the size of the sample is prohibitively large, make the following measurements with the sample in place).

Orient each sample on the ground or in your hands in a manner that allows you to obtain a side view of its former (*in situ*) orientation in the stream channel. Use indicators such as (former) touch points, color changes (*e.g.* wetting lines, algal lines, sediment lines), or particles adhered to the sample and to estimate the proportion (record as %) of the vertical axis of the sample that was buried or "embedded" in and below the surrounding sediment (Figure 5.8). Record this estimate (percent embededdness) for each of the twenty downstream samples on the Minimum Submittal Worksheet provided in Chapter 7. Use the 20 estimates of "embededdness" to develop an average large channel material embeddedness (%) estimate for the VAA study reach.

**Data** Located in Appendix B-13 through B-20

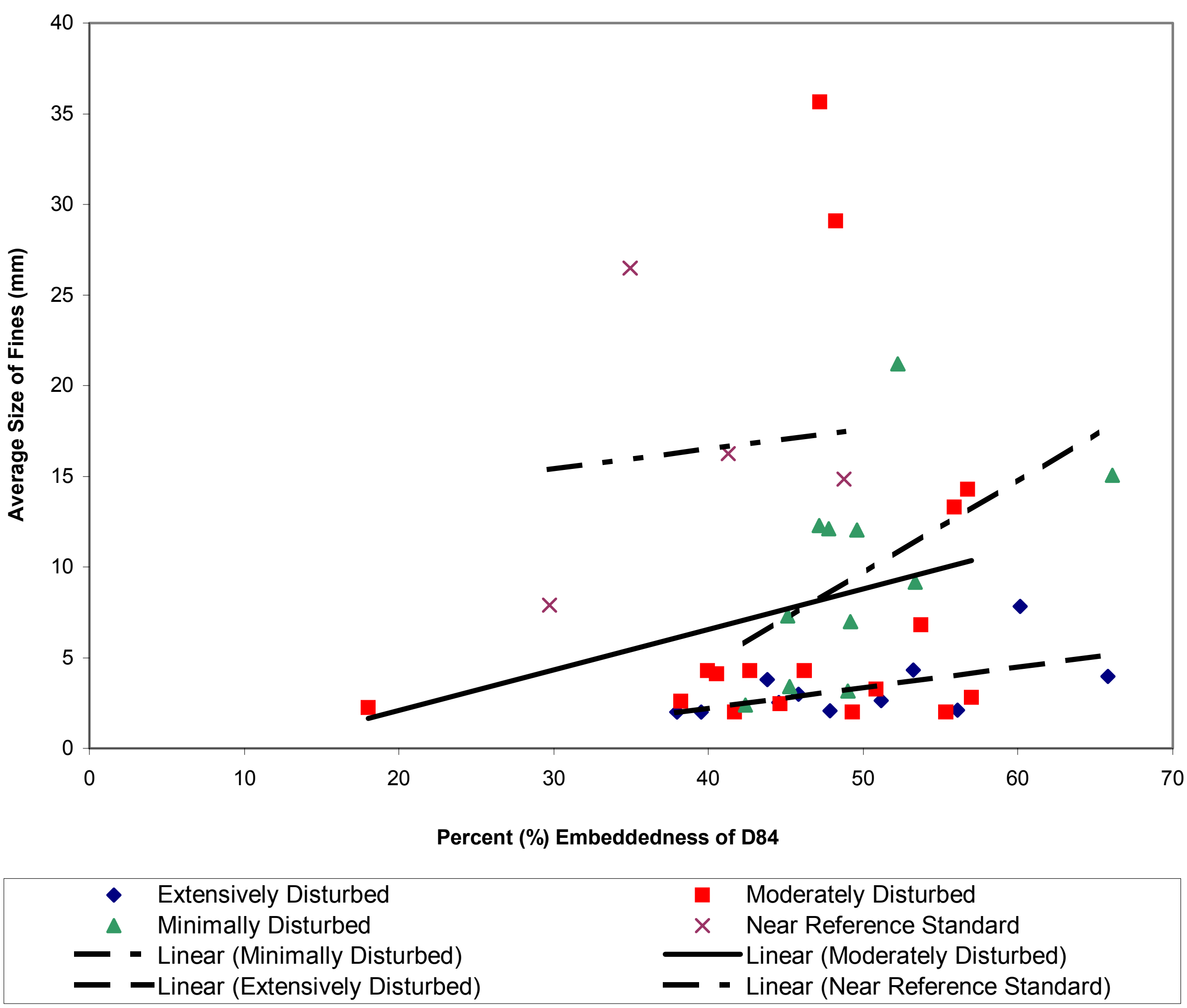
**Scaling Rationale** The embeddedness variable was scaled using a combination of field measurements of embeddedness, soils data, and best scientific judgment. At first, the Authors sorted data for all sites by subclass. We lacked reference standard conditions for the Low gradient subclass and had only one observation within the Moderate gradient subclass. Where possible, reference standard sites and non-reference standard site data were sorted and compared. Using this approach, for all subclasses, no significant differences in embeddedness data were evident. However, despite the lack of reference standard data, the Authors' collective field observations and soil particle size class information from in-channel sites (Appendix B-17 through B-24) indicated a shift in the distribution of particle size classes to finer channel bed materials with increasing anthropogenic perturbation (Figure 5.9). The Authors also suspect that our

**Variable: EMBEDDEDNESS OF LARGE CHANNEL MATERIALS ($V_{EMBED}$)**

field protocols for measurement of embeddedness may have underrepresented the channel bed materials <2mm in size (*i.e.*, fine earth fraction).

Considering the data and observations outlined above, we had some confidence in our ability to articulate reference standard (1.0) and highly degraded (0.1 - 0.0) variable conditions. However, lacking significant trends in the embeddedness data, we used an assumption of particle size distribution linearity and soils particle size class data to estimate the 0.50 variable conditions.

**Figure 5.9 Percent embeddedness of large channel (D84) material and the average size of fine channel material**



## Variable: EMBEDDEDNESS OF LARGE CHANNEL MATERIALS ($V_{EMBED}$)

**Scaling for High, Moderate and Low Gradient Subclasses**

| MEASUREMENT CONDITION FOR $V_{EMBED}$ | INDEX |
|---|---|
| Larger class channel bed material is embedded $\geq$50% along its vertical axis in either skeletal sands (sand with >35% gravel, cobbles and stones) or a cobble and stone matrix that is mixed with little to no loamy material. | 1.00 |
| Larger class channel bed material is embedded:<br>a. <50% along its vertical axis in a matrix **predominated** by skeletal sand (sand with >35% gravel, cobbles and stones) or cobbles and stones **or**<br>b. >50% along its vertical axis in loamy or finer material. | 0.50 |
| a. Larger class channel bed material is:<br>1. Embedded < 50% along its vertical axis in a matrix consisting of skeletal sands (sand with >35% gravel, cobbles and stones) mixed with a relatively high proportion (>33%) of loamy or finer material, **or**<br>2. Not embedded by virtue of the size class distribution of channel bed materials (*e.g.* channel bed materials consist of sand and/or loamy material with no larger particles) **and**<br>b. Variable is recoverable to reference standard conditions and sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied. | 0.10 |
| a. Channel bed is concrete or other impervious material that will not allow materials to become embedded, **and**<br>b. Variable is neither recoverable to reference standard conditions nor sustainable through natural processes if the existing land use is discontinued and no restoration measures are applied. | 0.00 |

**Confidence** The Authors' confidence that reasonable logic and/or data support the variable scaling is LOW for all subclasses because embeddedness data were highly variable within and among subclasses.