## Description and List of Reach-Scale Habitat Characteristics

Detailed descriptions and lists are given below for collecting general reach information and transect data. Two example field forms for use at wadeable sites are shown in field forms 3 and 4 (see Field Forms at back of report). An example for recording reach gradient channel cross-section data on USGS level notes is shown in figure 12. Optional information on riparian vegetation (point-quarter and vegetation plots) and sediment characteristics (Wolman counts and sediment collection) should be recorded on waterproof paper in field note books.

### General Reach Information

Detailed field methods for collecting general reach data are listed below. An example form is shown in field form 3. Items listed in **bold** are required for NAWQA national data aggregation. Abbreviations in parentheses are parameter codes for the NAWQA habitat data dictionary. These data are stored in files called "Reach" and "Gcu" in the habitat data dictionary.

1. **Study Unit (SUID)**—Use the 4-letter code designated for each Study Unit.
2. **Station identification number (C001 or STAID)**—List the USGS station identification number for the site.
3. **Date (DATE)**—Record the date as month, day, and year (4-digit year).
4. **Reach (REACHSEQ)**—Reach sequence letter, usually an "A." If more than one reach is characterized at the station, then assign sequential letters.
5. Station name (C900)—Record the USGS stream name.
6. Description of reference location (REFLOC)—Provide a general description of the reference location (for example, "gage on left bank just below Highway 1462 bridge" or "Highway 1462 bridge, upstream edge"). The reference location should be a permanent structure. If no permanent structure is present, a semipermanent marker (such as an iron pipe) should be installed at the location. The reference location provides the geographic link to habitat data collected at the segment and basin scale. Photos of the reference location should be taken. If the reference location is a bridge, a photograph of the reach from the bridge will be useful for documenting changes in the overall character of the reach over time.

7. **Investigators (INVEST)**—Names of the investigators are useful if followup information is necessary. The team leader's name is logged in the NAWQA habitat data dictionary.
8. **Quality of habitat sampling effort (RCHQUAL)**—This is used to denote the quality of the data.
9. **Comments on habitat sampling or conditions (REACHCOM)**—Note the general conditions of the reach. Be sure to note factors, such as recent flood history, beaver activity, and weather conditions.
10. Stage (STAGE)—Record water level as measured to a known point at the time of habitat sampling. Usually, at fixed sites, this information will come from the gaging station. If no gaging station is present and data may be collected at the site more than once, measure from a known point on a bridge or other permanent object. Be sure to note units of measure.
11. Stage method (STAGEMD)—The method used to measure stage, such as automatic data recorder (ADR), staff, or tape-down.
12. **Instantaneous discharge (DISCH)**—If no gaging station is present, measure discharge by using USGS techniques (Rantz and others, 1982). Use USGS form 9-275-F. Habitat data should be collected during stable low-flow conditions. This discharge measurement reflects base flow, which is an important habitat feature (Johnson and others, 1995) and is useful for comparing sites.
13. **Discharge method (DISCHMD)**—Record method used for discharge measurement: gaging station, wading rod, estimated (describe how), other.
14. **Channel modification at reach (CHMOD)**—Note any amount of channel modification at the reach. Choose from categories of concrete lined, stabilized, dredged, channelized but not stabilized, wing dams, lightly affected, or not modified. If only a small section is modified, use "lightly affected."
15. Mean channel width (MCW)—The wetted channel width is measured from the left edge of water to the right edge of water along the existing water surface. This channel-width measurement is used for estimating the needed reach length. Select the appropriate location that represents the average reach width. Make three measurements of wetted channel width and calculate the mean channel width. To provide consistency in measurement, protruding logs, boulders, stumps, or debris surrounded by water are included in the measurement of the water surface. Islands are not included in the measurement. Any solid accumulation of inorganic sediment particles protruding above the water and supporting woody vegetation is considered an island.
16. **Curvilinear reach length (REACHLEN)**—The curvilinear reach length is measured by following the path of the thalweg (the part of the stream with the deepest water and most flow). If there is no distinct thalweg (a possibility in a run), then follow the center of the channel. The reach length is computed by multiplying the mean channel width by 20. For wadeable streams, the minimum and maximum reach lengths are 150 and 300 m, respectively; for nonwadeable streams, the minimum and maximum reach lengths are 500 and 1,000 m, respectively.
17. Distance between transects (TRANDIS)—Eleven equidistant transects are spaced evenly within the reach. The distance between transects is the reach length divided by 10. The distance between transects is measured by following the thalweg of the channel. If no thalweg is observable, follow the center of the channel.
18. **Curvilinear distance from reference location to reach ends (USRCHEND and DSRCHEND)**—Measure the curvilinear distance (follow the thalweg) from the reference location to the upstream and downstream reach boundaries by using a range finder or tape measure. If either

boundary is upstream from the reference location, its value is negative; otherwise, it is positive. This information will be used to locate the reach in the future.

19. Location of boundary markers (USBMBK, DSBMBK)—Note the location of the boundary markers to aid in locating them in the future. Record whether the semipermanent boundary marker is on the left bank, the right bank, or both banks (looking downstream).

20. Boundary marker descriptions (USBMDESC, DSBMDESC)—Describe the type of boundary marker and measure the distance from the channel (top of bank or water's edge) (for example, "iron bar, painted orange, about 2 m from the wetted channel") and the distance and compass direction to other landmarks that may help in locating the boundary marker in the future. A record of this information is key to finding the location of the reach in the future.

21. **Reach water-surface gradient (RCHGRAD)**—Reach water-surface gradient is the difference between the water-surface elevation at the top and bottom of the reach divided by the curvilinear reach length. The water-surface gradient provides a good estimation of the energy gradient, which is an important parameter in the hydraulic power of the stream and, therefore, an important influence on a variety of other habitat measurements. This measurement is made with a surveyor's level for low-gradient streams, or can be estimated with a clinometer or Abney hand level for high-gradient streams (fig. 6). For a clinometer measurement, first mark a pole or use a stadia rod to get "eye height" of the person who is holding the clinometer. Flag this mark so that it can be viewed from a distance. Next, have each person stand at the water's edge, preferably at each transect or at observable breaks in the water surface. Look through the clinometer with one eye and view the staff or rod with the other, raising or lowering the clinometer until the cross hairs line up with the correct mark on the pole or rod. Record the slope in dimensionless units. If the clinometer measures percentage, divide the values by 100 to get dimensionless units. Make sure you know what scale you are using on the clinometer! The number of sightings also can be reduced by skipping transects and moving to the farthest transect that can still be sighted effectively; however, there can be a lot of variability in just a few measurements of water's edge, so be sure enough measurements are made. For double-checking, it could be advantageous to take measurements at the same distance along both right and left edges of water. Also, some reaches may be too flat to get an accurate estimation by using this technique. Note that the gradient of the channel bed may be very different from the water surface; thus, one cannot be substituted for the other. Also, the water-surface gradient at low flow will not always be the same as the water-surface gradient at bankfull flow. Depending on Study Unit goals, it may be useful to measure water-surface gradient, gradient of the channel bed thalweg (THGRAD), and gradient at bankfull (flood-plain gradient). Record data on USGS field notes or in a field book. Use the reach field form (field form 3) to record final calculations of reach water-surface gradient.

22. **Method used to measure reach gradient (RCHGRAMD)**—Record the method used, such as surveying level, clinometer, hand level, or other.

23. **Geomorphic channel units (GCUSEQ, GCUTYPE, GCULEN)**—While mapping the reach, draw (see diagrammatic mapping) and record all riffles, runs, or pools that are greater than 50 percent of the channel width, and measure and record the length of each. These data provide information on spatial dominance and diversity of habitat types. See previous discussion for information about identifying GCU's. Use additional space as needed.

24. Diagrammatic mapping (not in data dictionary)—Draw a schematic or representative map of the reach (see, for example, fig. 5). The mapping of all GCU's and habitat features can provide critical information needed to evaluate temporal trends in habitat. The map should include the

locations of GCU's, habitat features, and bank and flood-plain land use and land cover to approximate scale. Include the reference location, bridges, road names, reach boundaries, locations of semipermanent boundary markers, and transect locations relative to the geomorphic units. Draw the approximate aspect of the reach. Include a north arrow and the direction of streamflow. For reference, paste an example map or explanation to the clipboard used for drawing the maps.

### Transect Information

An example transect form is shown in field form 4 (see Field Forms at back of report) for recording information for wadeable streams. One form is filled out for each transect. Items in **bold** are required for NAWQA national data aggregation. Other features listed are helpful to the Study Unit for documenting long-term changes and revisiting the site. These data are stored in files called "Transect," "Chfeat," "Habfeat," and "Tranpnt" in the habitat data dictionary.

1. **Station identification number (C001 or STAID)**—List the USGS station identification number for the site.
2. **Reach (REACHSEQ)**—Reach sequence letter, usually an "A." If more than one reach is characterized at the station, then assign sequential letters to additional reaches.
3. **Date (DATE)**—Record the beginning date of reach and transect sampling as month, day, and year (4-digit year).
4. **Transect number (TCTNO)**—The sequential number of each transect is recorded (usually 1 through 11) for each site.
5. Habitat type (HABTYPE)—Record whether the transect is located in a riffle, pool, or run. Sometimes it is useful to analyze features in each type of habitat, and this information will help in grouping transect information on the basis of habitat type. For example, it might be useful to distinguish between substrate type in riffles and substrate type in pools.
6. Photodocumentation (not in data dictionary)—Note whether or not photos were taken at the transect. Record the exposure number in the blank. Optimally, stream conditions at each transect, especially those at the reach boundaries, are photographed. Photographs are taken facing upstream, perpendicular to the channel, and downstream, from either the left or right banks, and they should include a scale reference. Color slide film is preferred. Use of the same type of film at all sites and at the same site over time increases comparability of repeat photographs and reduces variability related to film development. The inclination and aspect of the camera lens are important and can be measured with a compass. A level camera is preferred because inclination complicates the perspective of the view and makes accurate duplication of repeat photographs difficult. The aspect of the camera can be noted by pointing a compass at the central aiming point in the view and recording the compass reading. Camera lens size, camera type, exposure, film type, and other appropriate documentation information for taking 35-mm color photographs should be recorded. Semipermanent markers can be established at these locations to facilitate taking repeat photographs.
7. **Wetted channel width (CHWIDTH)**—Measure the wetted-channel width along the transect from the left edge of the water to the right edge of the water. Do not include bars, shelves, or islands in width.

8. **Bankfull channel width (BFWIDTH)**—Measure bankfull channel width along the transect from the top edge of the left bank to the top edge of the right bank. See previous discussion for useful indicators of banks and bankfull stage.

9. **Channel width method (CHWIDRM)**—Record the method used to measure wetted and bankfull channel width.

10. **Channel features (CHFEAT, CFWIDTH)**—If channel bars, shelves, or islands are present, measure width using a tape measure or rangefinder. Channel bars are the lowest prominent geomorphic feature higher than the channel bed (fig. 7). Channel bars are typically devoid of woody vegetation and consist of relatively coarse sand, gravel, and cobbles. Shelves are bank features extending nearly horizontally from the flood plain to the lower limit of persistent woody vegetation (Hupp and Osterkamp, 1985). Shelves are most common along relatively high-gradient streams. Islands are mid-channel bars that have permanent woody vegetation, are flooded once a year on average, and remain stable except during large flood events.

11. Aspect (CHANHEAD)—The aspect of the downstream flow is recorded in degrees (0 to 360) using a compass. At the midpoint of the transect, face downstream and point a compass parallel to streamflow.

12. **Canopy angles (LCANANG, RCANANG, CANANG)**—Open canopy angle or sun angle is formed by the angles from midpoint of the transect (midpoint of the channel width) to the visible horizon at either bank. It is a measure of the amount of sunlight potentially reaching the stream. From the midpoint of the transect, use a clinometer to determine the angle from the line of sight of the investigator to the tallest structure (for example, tree, shrub, building, or grass) on the left bank; this is called the left canopy angle (in the general area of the transect). The same procedure is done for the right bank (right canopy angle). The sum of these angles is computed and subtracted from 180 degrees. The result, the open canopy angle or sun angle (fig. 9), also can be converted to percentage of open canopy ((sun angle/180) x 100) or percentage of shade ((right canopy angle + left canopy angle/180) x 100). On narrow streams, note the measurement at eye height. A solar pathfinder (Platts and others, 1987) may be useful for more detailed measurements of seasonal or monthly solar radiation at a site.

13. **Riparian canopy closure (LBSHAD, RBSHAD, CANCLOSR)**—Riparian canopy closure is measured with a concave spherical densiometer by use of techniques outlined in Platts and others (1987). Measurement of canopy closure (the sky area that includes vegetation) is preferred over measurement of canopy density (the sky area that is blocked by vegetation), because measurements of canopy closure are less affected by seasonality than canopy density. The densiometer is modified by taping a right angle on the mirror surface (fig. 10). This modification uses only 17 of the possible 37 points and helps eliminate bias introduced by the overlap of vegetation reflected in the concave mirror when readings are taken at the same position. At transects with woody vegetation in wadeable streams, riparian canopy closure is measured with a spherical densiometer at two positions along the transect—at the water's edge and along both sides of the stream. At the water's edge, the densiometer is held on the transect line perpendicular to the bank 30 cm from and 30 cm above the shoreline. The number of line intersections surrounded by vegetation are counted for canopy closure (fig. 10). For consistency and repeatability of measurements, it is extremely important to maintain the same position for the densiometer. This position accounts for vegetation most directly over the banks and also incorporates any vegetation that overhangs the water (important for fish habitat (Platts and others, 1987)). A total of two readings (34 points) is made per transect. To convert the readings to percentage of canopy closure

for the reach, readings from each transect are summed, divided by 374 (34 x 11), and multiplied by 100. If no woody vegetation is present, a value of "0" is recorded.

14. **Dominant riparian land use/land cover (LBLULC, RBLULC)**—At each transect, the dominant riparian land use is recorded for each bank within an approximate 30-m distance (use a rangefinder or other method for approximating 30 m) from the top of the bank into the flood plain. Only one land-use category should be recorded for each bank for each transect, representing a visual band on either side of the transect. The percentage of each type of land use for the reach can be estimated by summing the number of occurrences of each land use, dividing by 22 (2 each at 11 transects) and multiplying by 100. The categories are modified from Simonson and others (1994a):

| | |
|---|---|
| Agricultural: | |
| Cropland (annually harvested row crops, hay fields, or orchards) | CR |
| Pasture (regularly grazed by livestock, wooded, or open) | PA |
| Farmstead/barnyard (feedlots, confined livestock areas, farm buildings) | FM |
| Silviculture (tree plantation or logged woodland) | SI |
| Developed: | |
| Urban residential/commercial (houses, apartments, commercial buildings, parking lots) | UR |
| Urban industrial (industrial buildings and parking lots) | UI |
| Rural residential (low-density housing development in a rural setting) | RR |
| Right-of-way (paved or unpaved roads, railroads, paved paths, powerlines) | RW |
| Less disturbed: | |
| Grassland (grass/hedges not subject to regular mowing or grazing) | GR |
| Shrubs or woodland (woody plants) | SW |
| Wetland (covered by water much of the year; may be forested, shrubby, or open) | WE |
| Other (exposed rock, desert, and so on) | OT |

If the 30-m riparian zone is a slumped bank or bluff, record the land use at the top of the bank or bluff. For national consistency, a riparian distance of 30 m was selected to encompass the majority of riparian conditions across a wide range of environmental settings. At the local or regional scale, however, effects of riparian width on water quality are varied and depend on the type of vegetation and geologic setting. The Study Unit may use additional methods to characterize riparian vegetation or human disturbance depending on Study Unit issues and environmental setting. Depending on Study Unit goals, more quantitative data on species dominance, frequency, and distribution can be collected through point-quarter techniques and vegetation plots (refer to discussion of point-quarter techniques for more details).

15. **Bank angle (LBANGLE, RBANGLE)**—A clinometer is used to measure the angle formed by the downward-sloping bank as it meets the stream bottom. The angle is determined directly from a clinometer placed on top of a surveyor's rod or meter stick that is aligned parallel to the bank along the transect. If the height and shape of the bank are such that more than one angle is produced, an average of three readings is recorded. If the bank is undercut, the bank angle may be more than 90 degrees. Both left bank and right bank (facing downstream) angles are recorded. A flat bank will have a reading close to 0 degrees.

16. **Bank height (LBHIGH, RBHIGH)**—Determine the left and right vertical distance from the channel bed (thalweg) to the top of the bank. If the distance can be measured directly, use a surveyor's rod and a hand level. If the bank height cannot be measured directly, estimate the height. Note that the bottom of the bank is the deepest part of the channel. At large, nonwadeable reaches, topographic maps may be useful in determining bank height. See previous section on identification of banks and bankfull stage for more information.

17. **Bank substrate (LBSUB, RBSUB)**—Record type of dominant bank substrate. In streams with flood plains, the texture of bank substrate may vary based on the depositional environment of the sediment and the current location of the channel. Also, a coating of sediment from the top of the bank may cover the entire bank during low flow, and the substrate may not be the same beneath the coating. Thus, determination of what best represents the overall bank material may be difficult and requires some consideration of sampling the material most available to the stream. Coring of flood-plain sediment may be useful depending on Study Unit goals. Choose from the following categories for substrate type:

| | |
|---|---|
| Smooth bedrock/concrete/hardpan | 1 |
| Silt, clay, marl, muck, organic detritus | 2 |
| Sand (>0.063–2 mm) | 3 |
| Fine/medium gravel (>2–16 mm) | 4 |
| Coarse gravel (>16–32 mm) | 5 |
| Very coarse gravel (>32–64 mm) | 6 |
| Small cobble (>64–128 mm) | 7 |
| Large cobble (>128–256 mm) | 8 |
| Small boulder (>256–512 mm) | 9 |
| Large boulder, irregular bedrock, irregular hardpan, irregular artificial surface (>512 mm) | 10 |

18. **Bank vegetative cover (LBVEG, RBVEG)**—Bank vegetation acts to resist erosion and contributes to bank stability (Platts and others, 1987). Bank vegetative cover is evaluated by visually estimating the percentage of the bank covered by vegetation to the nearest 10 percent. Roots usually are considered part of the vegetation cover. If the bank is completely covered with vegetation, it receives a value of 100 percent. If the bank is not vegetated, it receives a value of 0 percent.

19. **Bank erosion (LBEROS, RBEROS)**—Record the presence or absence of bank erosion at each end of the transect.

20. **Habitat cover features (WD, OV, UB, BO, AM, MS, TB, NO)**—Determine the presence/absence of all types of habitat cover that are found at five locations (within about a 1-m zone) along the transect at the three points where velocity, depth, substrate, and embeddedness measurements are made and also at the left and right water edges. Habitat cover consists of any mineral or organic matter that produces shelter for aquatic organisms (mainly fish) to rest, hide, or feed and includes natural features of a stream, such as large boulders, woody debris, undercut banks, and aquatic macrophyte beds, as well as artificial structures, such as discarded tires, appliances, and parts of automobiles. For fish cover, these features need to be at least 0.3 m long, 0.3 m wide, 0.3 m high, and in or just above (<0.1 m) water that is at least 0.3 m deep (Simonson and others, 1994a). For example, a woody debris accumulation in 5 cm of water is not considered to be a significant habitat cover for fish. However, small features in shallow water may be important for invertebrates; thus,

size limitations are given only as a guide and not as a rule. In turbid wadeable reaches and in nonwadeable reaches, only those habitat cover features that are easily determined are recorded. Note the presence/absence of the following habitat cover types:

| | |
|---|---|
| Natural woody debris pile | WD |
| Overhanging vegetation (terrestrial) | OV |
| Undercut banks | UB |
| Boulders | BO |
| Aquatic macrophytes (emergent, submergent, and floating) | AM |
| Manmade structure | MS |
| Too turbid to determine | TB |
| None | NO |

21. **Transect point (TCTPNO, THALWEG)**—The numbers of the three transect points are recorded and the thalweg is noted.
22. Distance from left edge of water (LEWDIST)—The distance from the transect point to the left edge (facing downstream) of water is recorded. This is useful for checking data.
23. **Depth (DEPTH)**—In wadeable reaches, water depth between the water surface and the bed substrate is measured with a wading rod and recorded. In nonwadeable reaches, a sounding line or hydroacoustic system may be necessary to determine depth. When using a hydroacoustic system, the investigator maneuvers the boat along the transect with the meter operating, so as to produce a continuous recording of water depth along the transect.
24. **Velocity (VELOCITY)**—In wadeable reaches, record the average water-column velocity using a Price AA current meter, pygmy meter, or Gurley meter. In nonwadeable reaches, use a velocity meter appropriate for velocity determinations at that site. Velocity is recorded at 60-percent depth where depth is less than 1 m. At depths greater than or equal to 1 m, two velocity measurements, one at 20-percent depth and the other at 80-percent depth, are taken and the average is recorded.
25. **Dominant bed substrate (BEDSUB)**—Determine dominant substrate at each transect point by using the same categories listed for bank substrate. In turbid wadeable reaches and in all nonwadeable reaches, a sample of the substrate can be obtained by using an appropriate device, such as a sediment corer, Ponar sampler, or Ekman dredge. In turbid wadeable reaches where sampling devices cannot yield a sample, the substrate type can be determined by touch. In nonwadeable reaches where sampling devices cannot yield a substrate sample, acoustic recording of the stream bottom along the transect can detect boulders and bedrock. An average and standard deviation from the 33 substrate measurements can be calculated and used in analyses. Edsall and others (1997) has more information on alternative methods for characterizing substrate in nonwadeable reaches. Alternative methods include side-scan sonar, RoxAnn, or remotely operated underwater camera systems. Bed substrate data at nonwadeable streams are not required for NAWQA national data aggregation.
26. **Embeddedness (EMBED)**—The attribute of embeddedness refers to the degree to which the larger substrate particles (boulder, cobble, or gravel) are surrounded or covered by fine-grained sediment (sand, or finer). As the percentage of embeddedness decreases, biotic productivity is thought to decrease (Platts and others, 1983). Embeddedness is estimated by determining the percentage of the surface area of the larger-sized particles (by visual estimation) covered by fine

sediment. Five relatively large (gravel to boulder size) substrate particles are examined at the three transect points. The percentage (to the nearest 10 percent) of each particle's height that was buried in sediment is noted by the extent of discoloration of the particle surface. The percentage of fine sediment covering the large substrate particles is determined from calculating the average percentage of coverage for the five particles. In turbid wadeable reaches and in nonwadeable reaches, a sample of the substrate may be obtained by use of a shovel, Ponar sampler, or Ekman dredge, but data from nonwadeable reaches are not required for NAWQA national data aggregation.

27. Silt present (SILT)—Record the presence or absence of significant areas of silt at each of the three points. A percentage for the presence of silt in a reach can be calculated by dividing the number of occurrences of silt by 33 (3 points in channel per 11 transects) and multiplying by 100.