United States Department of Agriculture
Natural Resources Conservation Service

Stream Visual Assessment Protocol.2

Arizona Version

SVAP2-AZ

Preface to SVAP Version 2-AZ

This document presents a revised and updated NRCS Stream Visual Assessment Protocol Version 2 (SVAP 2) for use by conservation planners, field office personnel, and private landowners. Like its predecessor, it is a relatively easy-to-use tool for qualitatively evaluating the condition of aquatic ecosystems associated with wadeable streams, i.e., those shallow enough to be sampled without use of a boat. Such wadeable streams include those modified to improve drainage on agricultural lands, especially if these systems are part of an ecologically functional stream and/or river network. While the protocol does not require users to be experts in aquatic ecology, it does require they read the protocol's user guidance thoroughly before beginning an assessment. The SVAP and SVAP2 are tools that work best when users first identify local stream reference conditions that can effectively provide a standard for comparison. State offices are encouraged to refine the protocol based on the physical settings, stream conditions, and life history requirements of aquatic fauna found in their specific locales. ***This refinement has been completed in Arizona by Stu Tuttle, Arizona State Biologist and Kathryn Boyer, Fisheries Biologist, West National Technology Support Center, Portland, OR.***

Both versions of the Stream Visual Assessment Protocol provide a relatively basic level of ecological assessment based on qualitative descriptions. Each is designed to give a snapshot of wadeable stream ecosystem conditions that allows planners and conservationists to assist landowners with determining the quality of stream habitats located on their property. SVAP 2-AZ was developed to provide more comprehensive descriptions of several scoring elements, namely channel condition, hydrological alteration, riparian area conditions, and fish habitat complexity. Field conservationists are encouraged to use SVAP 2-AZ in those situations where more detail is needed to critically score these elements and their relative contribution to the condition of the stream, and whether it provides adequate habitat for aquatic species including fish, amphibians, benthic macroinvertebrates, and other stream-dependent species. This version lends itself to tracking trends in stream habitat conditions over time, as well as identifying resource concerns related to water quality, fish habitat, and water quantity, and their potential causes. The original SVAP is designed to be conducted with the landowner. SVAP 2-AZ can be completed with a landowner or with a conservation planning team. Background information relevant to ecological processes and functions of stream/riparian ecosystems is incorporated into both versions of the SVAP.

Introduction

This assessment procedure is a national protocol modified for Arizona that provides an initial evaluation of the overall condition of wadeable streams, their riparian zones, and their instream habitats. The majority of the nation's streams and rivers are small, often with intermittent flows, and yet they constitute a close multi-dimensional linkage between land and water management. These smaller streams and rivers are increasingly a focus of NRCS assistance to landowners. This protocol is developed for relatively small streams, be they perennial or intermittent. If the stream can be sampled during low flow or seasonally wet periods of the year without a boat, it can be assessed using the SVAP-AZ.

This SVAP 2-AZ protocol can be successfully applied by conservationists with limited training in biology, geomorphology, or hydrology. Since publication of the initial version of the SVAP, the protocol has taken on broader applications as a tool to (1) evaluate quality criteria for conservation planning, (2) establish eligibility for Farm Bill programs, (3) identify potential resource concerns, and (4) assess trends in stream and riparian conditions over time. Consequently, NRCS state offices have played a large role in modifying the protocol, updating training materials, and transferring SVAP2 technology to the field. States should continue with such efforts and pay close attention to achieving consistency in how the protocol is applied within their states and in adjacent states. It is less critical that a particular assessment discern between a score of 5 or 6 with subtle subjective differences than it is that the protocol be interpreted and applied consistently, year-to-year by multiple users. Consistency, efficiency, and effectiveness can be gained by collaborating closely with local users, and those in other states within your region. NRCS state offices are encouraged to contact appropriate National Technology Support Center (NTSC) specialists regarding refinement of this SVAP2's scoring criteria to reflect local conditions. NTSC's can also assist with coordinating regional training to improve understanding of the methodology and consistency in use of the SVAP2.

The SVAP2 is a preliminary qualitative assessment tool to evaluate features that affect overall stream conditions at the property level. The tool assesses visually apparent physical, chemical, and biological features within a specified reach of a stream corridor. Because of its qualitative nature, the protocol may not detect all causes of resource concerns, especially if such causes are a result of land use actions in other parts of the watershed. It does provide a means to assess site conditions in the context of the larger watershed. A synthesis of information gathered during the preliminary assessment and field assessment portions of the protocol can be used to provide general guidance to landowners on how watershed features and practices they employ are reflected in the quality of their stream ecosystems.

What is a Healthy Stream?

A stream's watershed captures precipitation, filters and stores water, and regulates its release through the stream channel network and eventually into a lake, another watershed, or an estuary and the ocean. Watersheds are characterized by different climates, geomorphic features, soil types, vegetation, and land uses. Their upland features control the quantity and timing of water and materials that make their way overland and into a stream system. The environmental conditions of a stream or river corridor (such as water quantity and quality, riparian and floodplain function, and habitat quality) are thus linked to the entire watershed. These linkages affect stream processes that act vertically, laterally, longitudinally, and over time. Land managers may have little control of watershed management beyond their property lines or jurisdictional boundaries. Nevertheless, activities that occur in many individual farm fields, rangelands, or pastures can have cumulative impacts on the condition of an individual landowner's stream, and those downstream. Sound watershed and stream corridor management are important for maintaining stream conditions that allow the stream to be resilient and resistant to natural disturbance and human-caused perturbations. The natural resilience of a stream to recover from floods, fire, and drought is an indicator that it is healthy (Meyer, 1997).

Streams, their floodplains and adjacent riparian areas are complex ecosystems where numerous biological, physical, and chemical processes interact (Cushing and Allen, 2001). Changes in any one feature or process in a stream ecosystem has cascading effects throughout the stream as it flows downstream and as its flows change with seasonal shifts in precipitation. Stream processes are inter-connected and these connections maintain a balance of materials that are transported and deposited by the stream, including sediment, water, wood, and nutrients. If conditions change, these processes must re-adjust to keep the stream resilient and functional for energy and material transport and aquatic fauna and flora. The conditions of a stream reflect current and past land uses and management actions. As such, they can also help predict future trends of watershed land use and conditions.

Multiple factors affect stream conditions and therefore stream quality (Figure 1). For example, increased nutrient loads alone may not cause a visual change to a forested stream. However, when combined with tree removal and channel widening, the result may shift the energy dynamics from a community based on leaf litter inputs to one based on algae and aquatic plants. The resulting chemical changes caused by photosynthesis and respiration of aquatic plants coupled with temperature increases due to loss of canopy cover will alter the aquatic community**.**

Many stream processes are in delicate balance. For example, the force of the stream flow, the amount of sediment, and the stream features that slow or hasten flow must be in relative balance to prevent channel incision or bank erosion. Increases in sediment loads beyond the capacity of the stream to transport them downstream can lead to extensive deposition of sediments and channel widening.

Lastly, the biological community of a stream corridor also affects its overall condition. As indicators of biological integrity fish, aquatic invertebrates, riparian vegetation, and all other members of a stream's community-portray a pattern of stream condition that further enhances our ability to detect concerns. For example, the prevalence of invasive plant species in the riparian zone or non-native fish in a fish assemblage of a particular stream often indicates deterioration in stream function or quality. While beyond the scope of the SVAP2, such indices of biological integrity provide an even more comprehensive picture of a stream ecosystem's condition (Giller and Malmqvist, 1998; Matthews, 1998).

Stream corridors benefit from complex and diverse physical structure. Such complexity increases "channel roughness" that dissipates the energy of water and reduces its erosive power. Structural complexity is provided by channel form (i.e., meanders, pools, riffles, backwaters, wetlands), profile (i.e., stream gradient, width, and depth), materials that have fallen into the channel (trees, leaves and bank material), overhanging vegetation, roots extending into the flow, and streambed materials (sand, gravel, rocks, and boulders). The movement of these materials and the path of flow form pools, riffles, backwaters, side-channels, floodplain wetlands, and many other types of habitats. Thus, streams with complex floodplains and a diversity of structural features generally support a higher diversity of aquatic species (Schlosser 1982; Pearsons et al., 1992; Gurnell et al., 1995).

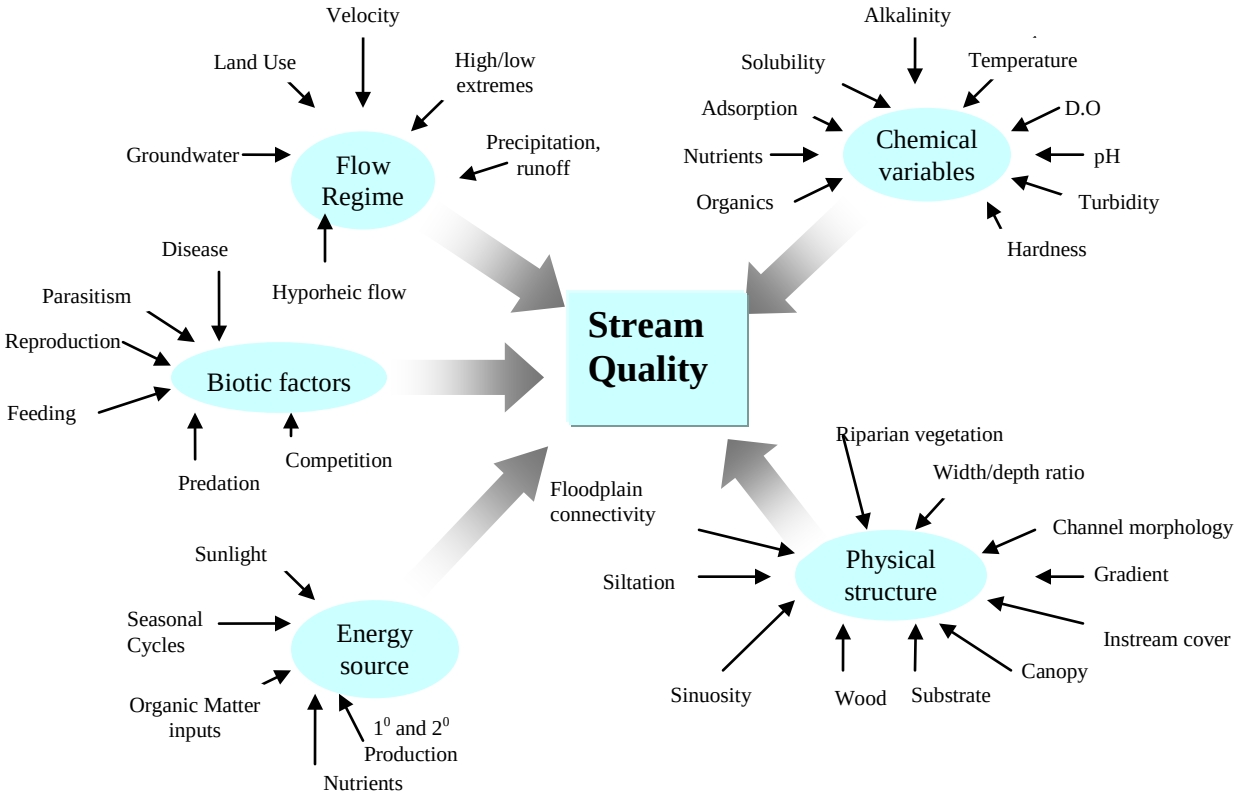


Figure 1: Factors that influence the quality or condition of streams (modified from Karr 1986).

Chemical pollution of streams and rivers diminishes stream health and harms aquatic species. The major categories of chemical pollutants are (1) oxygen-depleting sources such as manure, ammonia, and organic wastes; (2) nutrients such as nitrogen and phosphorus from both fertilizers and animal wastes; (3) acids from mining or industrial effluents; and (4) contaminants such as pesticides, salts, metals, and pharmaceuticals. It is important to note that the effects of many chemicals depend on multiple factors. For example, an increase in the pH caused by excessive algal plant growth may cause an otherwise safe concentration of ammonia to become toxic.

Finally, it is important to recognize that healthy, resilient streams, riparian areas, and floodplains operate as a connected stream corridor system. Lateral exchange of water and materials between a stream and its floodplain is the driving force for nutrient dynamics in the stream corridor community. Primary productivity of floodplain habitats ties closely to *hydroperiod*, or the length of time the floodplain is inundated or saturated. Productivity is greatest in wetlands with pulsed flooding (i.e., periodic inundation and drying) and high nutrient input, and lower in drained or permanently flooded conditions. Floodplains and their associated wetlands thus play a critical role in the health of the stream itself. An example

would be the removal of nitrogen (denitrification) in floodwaters by floodplain wetlands (Forshay and Stanley, 2005).

Riparian wetlands may also influence stream channel morphology and flows, buffering the stream channel against the physical effects of high flows by dissipating energy as waters spread out onto the floodplain. In many instances, these floodplains provide refuge habitat for aquatic species, especially during flood events. As stream flows recede, riparian wetlands provide water storage, slowly releasing water and aquatic organisms back to the stream through surface and subsurface transport, thereby influencing stream base flows during drier times of the year.

In summary, physical, chemical and biological elements that influence stream conditions also provide indicators of how well a stream is functioning and responding to natural disturbances (e.g., floods) or human actions (e.g., land clearing). A stream corridor that maintains key ecological and physical functions over time is a healthy, resilient ecosystem that can support diverse communities of aquatic species.

Using This Protocol

This protocol is intended for use in the field with the landowner or an assessment team. Conducting the assessment with the landowner provides an opportunity to discuss natural resource concerns and conservation opportunities. Before leaving the office to assess a stream, a preliminary assessment of watershed features should be conducted in the field office. The Stream Visual Assessment Summary Sheet provides a standardized form for recording information and data collected during both the preliminary and field portions of the assessment.

1. Preliminary Assessment of the Stream's Watershed:

   ☑ *Become familiar with watershed conditions* before going to the assessment site. Stream conditions are influenced by the entire watershed including uplands that surround the assessment site. Changes in upland conditions can change the discharge, timing, or duration of stream-flow events that affect stream conditions. Aerial photographs, topographic maps, stream gages and any other source of data available can be used to obtain information about watershed conditions before conducting the SVAP2-AZ on a stream. State agencies, watershed groups, local landowners, and federal land managers are likely to have documented relevant information about watershed conditions. Ecoregion descriptions, size of the watershed (drainage area) and upland practices often explain conditions at the assessment site and are helpful for addressing some of the elements in SVAP2-AZ.

   ☑ *Gather land use information about the watershed* to provide a context for the stream to be assessed and a better understanding of the conditions at the site. For example, road crossings and water control structures may prevent movement of aquatic species. Mining, agriculture, and urbanization, all influence water quality and quantity as well as stream corridor condition.

- ☑ *Review available water resource information* for the watershed and stream reach. Water control structures and/or activities outside of your assessment reach may be affecting streamflow. Ask the landowner if he or she is aware of upstream withdrawals (e.g., surface diversions or pump stations), drains, or any features that affect the amount of instream flow during the year. The Environmental Protection Agency's Surf Your Watershed website (http://www.epa.gov/surf) is also a good source of information.

- ☑ *Consult the Arizona Game and Fish Department* regarding stream and riparian species likely to be present in the reach and whether fish passage to or from the area is limited.

- ☑ *Become familiar with potential riparian plant species and community types* appropriate to the area to be assessed. Also, become familiar with invasive plant species that may occur along Arizona streams.

2. Delineating the Assessment Reach:

You need to assess one or more representative reaches, evaluate conditions on both sides of the stream, and indicate left and right bank conditions as you look downstream. A *reach* is a length of stream with relatively consistent gradient and channel form. *An assessment reach for this protocol is, at a minimum, a length of stream equal to 12 times the bankfull channel width*. Longer reaches may be appropriate, depending on the objectives of the assessment.

Bankfull channel width is the stream width at the bankfull discharge, or flow rate that forms and controls the shape and size of the active channel. *Bankfull discharge* or *bankfull flow* is the flow rate at which the stream begins to move onto its active floodplain if one is present. On average, the bankfull discharge occurs every 1.5 to 3 years, depending on local stream channel and weather conditions. Figure 2 illustrates the relationship between baseflow ("low flow"), bankfull flow, and the floodplain.

Bankfull width is determined by locating the first *flat* depositional surface occurring above the bed of the stream. The lowest elevation at which the bankfull surface could occur is at the top of the point bars or other sediment deposits in the channel bed. These generally occur on the inside of the meanders (white part of the figure below). Other indicators of bankfull elevation include (1) a break in slope on the bank, (2) vegetation changes or exposed roots, (3) a change in the particle size of bank material, and (4) wood or small debris left from high waters. In temperate areas of the country, vegetation can grow into depositional bars below some bankfull indicators. Therefore, look for signs of *well-established* vegetation at the elevation level with the top of point bars to help identify bankfull stage.

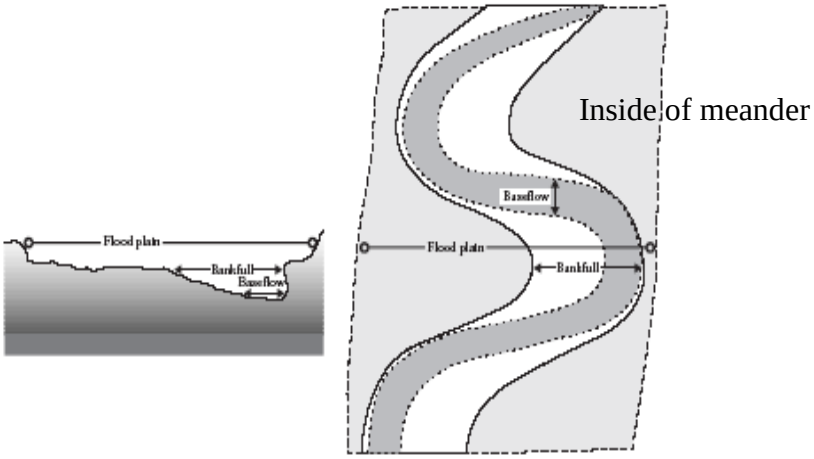


Figure 2: Baseflow, bankfull, and floodplain locations (Rosen, 1996)

The following videos and documents are excellent resources to assist field personnel in identifying bankfull discharge indicators across the coterminous United States. They can be downloaded from http://www.stream.fs.fed.us. Click on "Publications and Products."

1. *A Guide to Field Identification of Bankfull Stage in the Western United States*, a video principally narrated by Luna B. Leopold. (http://www.stream.fs.fed.us/publications/videos.html#eastandwest)

2. Harrelson, C., L. Rawlins, and J. P. Potyondy (1994). *Stream Channel Reference Sites: An Illustrated Guide to Field Technique.* USDA General Technical Report (RM-245): 61.

Often the stream length within the landowner's property boundaries is shorter than the minimum length needed to determine conditions using the SVAP2-AZ. If permission is received to cross property boundaries, it is appropriate to do so in order to evaluate an adequate length of the stream. If crossing property boundaries is not an option, the assessment reach length will be the length that is within the property boundaries. When large sections of stream are to be assessed and there are constraints that prohibit assessing the entire stream length, representative reaches of the stream on the property should be "sub-sampled." Using aerial photographs, topographic maps and various stream classification methods, streams can be stratified into smaller units (stream reaches) that share common physical characteristics such as stream gradient and average bankfull width. The degree of stratification will depend on the reason you are assessing the stream. If you are simply providing an opportunity for the landowner to learn about the general conditions of the stream, perhaps only one reach is assessed. If the SVAP2-AZ is being conducted to identify potential improvement actions, the entire stream within the property should be assessed. SVAP2-AZ scores can then be used as a preliminary and qualitative evaluation of conditions. Low scores likely indicate more quantitative assessments of geomorphic, hydrological, and biological features of the stream corridor are needed to determine what stressors are causing the problems identified. Quantitative assessments should only be completed by trained specialists (i.e., stream ecologists, hydrologists, geomorphologists, hydraulic engineers) to assure the complex features influencing stream conditions are being evaluated as accurately

as possible. If there are several stream types (reaches) within the property, multiple Stream Visual Assessments should be completed, one for each reach. Regardless of the situation, the SVAP2-AZ requires field personnel to score four elements based upon the entire length of the stream that is within a single landowner's property. These are Riparian Area Quantity, Riparian Area Quality, Canopy Cover, and Barriers to Aquatic Species Movement.

Scoring the Elements of the Stream Visual Assessment Protocol Version 2-AZ

Using the *Stream Visual Assessment Protocol Summary Sheet*, record the score that best fits the observations you make in the assessment reach. Base your observations on the descriptions in the matrix provided for each element assessed. Assign a score that applies to the conditions you observe in the assessment reach. If the conditions of the stream fit descriptions that occur in more than one column of the matrix, score the element based on the lower valued descriptions. For example, when scoring the element Hydrological Alteration, if bankfull flows occur according to the natural flow regime (Score 10 -9 column) but there is a water control structure present (Score 8-7 column), assign the score based on the lowest scoring indicator present within the reach, which in this case would be an 8 or 7. Again, evaluate conditions on both sides of the stream, and note left bank and right bank conditions as you look downstream.

Element 1. Channel Condition

Description and Rationale for Assessing Channel Condition: The shape of a stream channel changes constantly, imperceptibly or dramatically, depending on the condition of the stream corridor (channel, riparian area, and floodplain) and how it transports water and materials. Channel condition is a description of the *geomorphic* stage of the channel as it adjusts its shape relative to its floodplain. Channel adjustments resulting in a dramatic drop in streambed elevation (incision or degradation) or excessive deposition of bedload that raises the bed elevation (aggradation), affect the degree of bank shear and often decrease stream channel stability. Such channel adjustments can have substantial effects on the condition of streams, adjacent riparian areas, associated habitats, and their biota. For example, the greater the incision in a channel, the more it is separated from its floodplain, both physically and ecologically. Conversely, the greater the aggradation, the wider and shallower a stream becomes, which can affect riparian vegetation, surface water temperatures and stream and riparian habitat features. The stages of the Schumm Channel Evolution Model (CEM), as shown in Figure 3, provide a visual orientation of the pattern of streambed adjustment in an incising stream, its gradual detachment from the existing floodplain, and eventual formation of a new floodplain at a lower elevation.

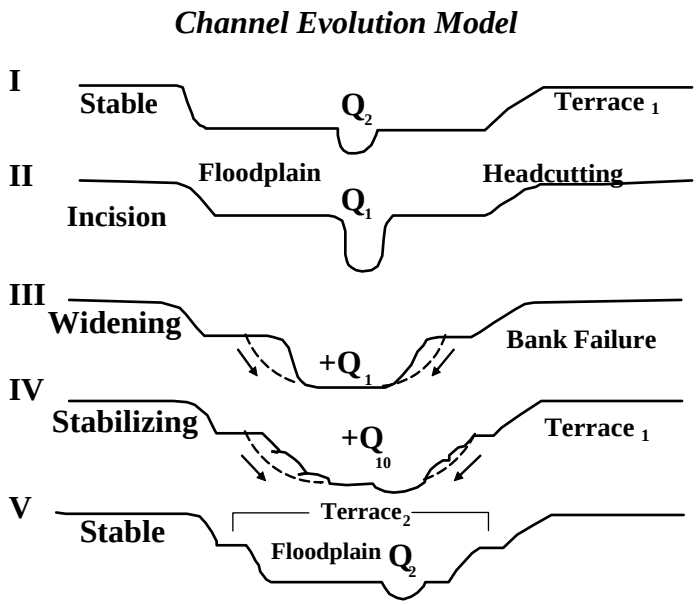


Figure 3. Channel Evolution Model, after Schumm, Harvey and Watson, 1984. Q2 indicates a flood stage interval of 2 years; Q10 indicates an interval of a 10-year flood stage (both are momentary maximum); Terrace 1 indicates the historical floodplain, now abandoned; Terrace 2 indicates a more recently abandoned floodplain.

Stage I channels are generally stable and have frequent interaction with their floodplains. The stability of the streambed and banks is due to the stream and its floodplain connection and flooding occurring at regular intervals (e.g., Q_2). Consequently, the stream's banks and floodplain are well vegetated. Depositional areas, if present, form a gradual transition into the active floodplain, as shown by the arrow in ***Figure 4***.

Figure 4: CEM Stage 1 - Typically excellent channel condition with natural bank protection. On left, a typical AZ warmwater stream. On right, a coldwater stream.

Land-use activities that increase runoff, such as land clearing or channel straightening often result in channel incision characteristic of stage II. The height of the banks increases due to downcutting of the channel and the stream and floodplain have less frequent interaction Bank vegetation becomes stressed and banks are prone to failure. Once failures begin, the channel widening of stage III begins. A Stage II channel is typically narrower at the bed relative to the depth (often referred to as low width-to-depth ratio) than a stage III channel. A stage II

channel is in an active downward trend in condition and active head-cuts are often present (Figure 5).

Figure 5: CEM stage II. Poor channel condition, head cuts common.

Figure 6: CEM stage III, with bars adjacent to vertical bank

During stage III, bank failures increase the formation of bars located next to the now relatively vertical banks. In stage III, alternating point bars are typically forming on opposite banks adjacent to vertical banks (Figure 6). Channel widening continues until the streambed is wide enough to disperse stream flows, and slow the water, beginning stage IV in channel evolution. Bank vegetation loss continues. During stage IV, sediments begin to build up in the channel instead of moving downstream, aggrading the bed. Eventually, vegetation begins to establish in the sediment deposited along the edge of the stream, creating channel roughness and further slowing the flow. An early stage IV channel indicates relatively poor conditions, while a late stage IV channel indicates an improving trend in channel condition. At this stage, the stream has become more sinuous. Alternating bar features are apparent.

Stage V begins when a new floodplain begins to form. Early in stage V, bank vegetation may not be fully established and some bank erosion is likely. In a late stage V, the original active floodplain from stage I is now a high terrace and the evolution of a stage I channel begins, with a new floodplain developing at a lower elevation than the terrace (Figure 7). In areas where heavy vegetation occurs naturally due to higher annual precipitation, eroded banks and slightly incised channels may be masked and consequently harder to observe. In these areas, try to observe bank features from a location near the channel bed. In using the scoring matrix that follows, note that a channel that is either incising or aggrading cannot score higher than an 8. Use the upper right portion of the matrix to score incising or incised channel reaches. Use the lower right portion of the matrix to score aggrading channel reaches.

Figure 7: CEM stage V channel with developing floodplain (left) and "abandoned floodplain," now a terrace, behind trees on right side of stream.

Keep this conceptual channel evolution model in mind as you visually assess the characteristics of the stream. In using the scoring matrix that follows, note that a channel that is either incising or aggrading cannot score higher than an 8. Use the upper right portion of the matrix to score incising or incised channel reaches. Use the lower right portion of the matrix to score incising or incised channel reaches. Use the lower right portion of the matrix to score aggrading channel reaches.

Lastly, as you conclude assessment of this element of SVAP, *remember that* ***Channel Condition*** *is of critical importance to overall stream health, yet difficult to assess visually. Scores of less than 5 for channel condition may indicate substantial channel adjustments are occurring and a quantitative assessment by well-trained specialists is warranted*

ELEMENT 1. Channel Condition Scoring Matrix

Natural, stable channel with established bank vegetation.	**If channel is incising (appears to be downcutting or degrading), score this element based on the descriptions in the upper section of the matrix:**		
No discernible signs of incision (such as vertical banks) or aggradation (such as very shallow multiple channels); Active channel and floodplain are connected throughout reach, and flooded at natural intervals; Streambanks low with few or no bank failures; Stage I : Score 10 Stage V: Score 9 (if terrace is visible)	Evidence of past incision and some recovery; some bank erosion possible; Active channel and floodplain are connected in ***most*** areas, inundated seasonally; Streambanks may be low or appear to be steepening; Top of point bars are below active flood floodplain and regeneration of preferred species is occurring. Stage I: Score 8 Stage V: Score 7-8 Stage IV: Score 6	Active incision evident; plants are stressed, dying or falling in channel; Active channel appears to be disconnected from the floodplain, with infrequent or no inundation; Steep banks, bank failures evident or imminent; Point bars located adjacent to steep banks. Stage IV: Score 5 Stage III: Score 4 Stage II: Score 3	Headcuts or surface cracks on banks; active incision; vegetation very sparse Little or no connection between floodplain and stream channel, and no inundation; Steep streambanks and failures prominent; Point bars, if present, located adjacent to steep banks. Stage II or III, scores ranging from 2 to 0, depending on severity.
	8 7 6	**5 4 3**	**2 1 0**
	If channel is aggrading (appears to be filling in and is relatively wide and shallow), score this element based on the descriptions in the lower section of the matrix:		
No more than 1 bar forming in channel	Minimal lateral migration and bank erosion; A few shallow places in reach, due to sediment deposits; Minimal bar formation (less than 3).	Moderate lateral migration and bank erosion; Deposition of sediments causing channel to be very shallow in places; 3-4 bars in channel	Severe lateral channel migration, and bank erosion; Deposition of sediments causing channel to be very shallow in reach; Braided channels (5 or more bars in channel.
10 9	**8 7 6**	**5 4 3**	**2 1 0**

- **Channel is not incising or aggrading**. A score of 10 is appropriate for a stage I channel (Figure 8) with a frequently inundated floodplain that often covers the width of the valley. A late stage V channel with a lower active (frequently flooded) floodplain, well-established vegetation on the banks, and a higher terrace (abandoned floodplain) from previous channel evolutions would score 9 (Figure 9).

Figure 8: CEM stage 1. Score: 10

Figure 9: CEM stage 5. Score: 9

- **Channel appears to be incising.** Scores of 8, 7, or 6 indicate *degrees* of observable detachment between the active bankfull channel and the floodplain. The top of the point bars are below the elevation of the floodplain. A stage I or V channel that has an active, but *less frequent* out-of-bank flow into the floodplain would score an 8 (Figures 10 and 11 below).

Figure 10: CEM stage I. Point bars below bank. Score: 8

Figure 11: CEM stage V. Slight flood-plain detachment. Score: 8

- **Channel is incising.** If active channel erosion is apparent on the outside of meanders of a stage V and it is forming a new floodplain and out-of-bank flows still occur, lower the score to a 7 (Figure 12).

Figure 12: CEM stage V. Score: 7

- **Channel is incising**. Active bank erosion is causing sediment build up in channel, forming depositional features of a stage IV channel. The channel is still adjusting its width. If top of bars are below active floodplain, score a 6 (Figure 13). Lower score to 5 if top of bars of the stage IV channel are *adjacent* to steep banks as shown by arrow in Figure 14.

Figure 13: CEM stage IV, Score: 6

Figure 14: CEM stage IV. Score: 5

- C**hannel is incising**. There is disconnect between the floodplain and the bankfull channel (Figure 15), with riparian vegetation compromised by lack of seasonal flooding and lowered water table. Channel appears to be widening in areas of sediment build-up, typical of Stage III channels (score 4).

Figure 15: CEM stage III. Score 4. Note point bar adjacent to steep bank (where person is standing).

- **Channel is incising**, with no connection between the active floodplain and the vegetation. Tensile cracks or headcuts often present in a Stage II channel; score would be a 3 (Figure 16).

Figure 16. CEM stage II. Score 3.

- **Channel is deeply incised** and completely disconnected from floodplain, usually characteristic of a Stage II or III depending on whether channel widening has begun. Scores range from 2 to 0 depending on observed conditions (Figures 17 and 18).

Figure 17: CEM stage III, with active point bars forming. Score: 2 or 1.

Figure 18: CEM stage II. Score: 1 or 0.

What to look for (aggrading channels):

The removal of willows and other kinds of riparian vegetation will decrease bank stability and contribute to streambank failure. Excessive streambank failure and *lateral migration* (the process of a stream shifting from side to side within a valley or other confinement) often result in wider and shallower channels unable to transport sediments downstream. Excessive channel filling occurs when a stream channel can no longer transport both the size and load of sediments associated with the watershed runoff conditions. Streams with no pools that previously had pools and riffles are most likely aggraded. Stream segments that are excessively wide and shallow with multiple center bars are often aggraded. Streams that once maintained single- or dual-threaded channel patterns, but have converted to a braided system (three or more channels at bankfull discharge), are typically aggraded. Excessively aggraded systems are unstable and channel adjustments from side to side can be rapid.

☑ **Channel is aggrading.** The streambed appears to be filling with sediment faster than it can be transported downstream. Deposits appear "over-steepened" and unstable, as in Photo 18. Channel appears to be wider and shallower than in other reaches of stream. Some bank erosion is evident. Some mid- channel bars may be forming or present. Bed features such as pools and riffles appear to be less discernable or segregated. Lateral migration of channel is apparent. Point bar(s) may be separated from their floodplain. Scores range from 8 to 6 depending on degree of impairment from stable reference conditions (Figures 19 and 20)

Figure 19: Aggrading channel with point bar separated from floodplain. Score: 8

Figure 20: Aggrading channel with shallow areas in reach. Score: 6 -7

Figure 21. Aggrading channel, downward trend with lateral migration evident. Score 5.

- **Channel is aggrading.** Channel is wide and shallow and the banks are actively eroding. Extensive deposition such as center bars and sidebars are present. The streambed appears to have less pool-riffle feature with a more consistent riffle-plane bed. Bank vegetation is sparse. Pools that would have typically formed in the meander bend portion are shallow and featureless. Scores range from 5 to 3 (Figures 21 and 22).

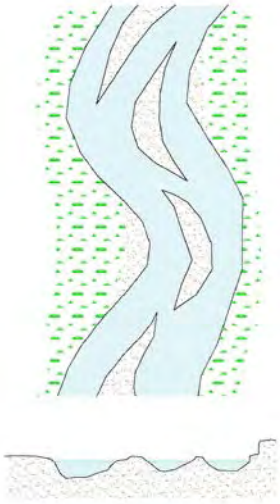
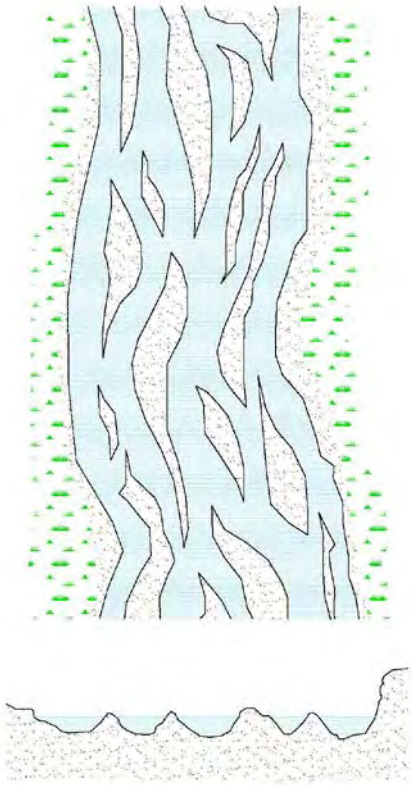


Figure 22: Multiple aggraded wide and shallow channels, with actively eroding streambanks. Score: 4

- **Channel is aggrading.** Channel is extremely wide and shallow with interconnected channels (Figures 23 and 24). Streambanks are typically unstable and highly eroded with sparse vegetation. Excessive deposition is common throughout the active channel. Multiple bars, both center and side bars, are located throughout the active channel. Lateral migration is common.

Figure 23: Aggraded channel. Score: 2

Photo 24: Aggraded channel. Score: 1-0



Description and Rationale for Assessing Hydrologic Alteration. Hydrologic alteration is the degree to which *hydrology* and stream flow conditions differ from natural, unregulated flow patterns. Streamflow regime affects the distribution and abundance of stream species and influences the health of streams through several physical and chemical processes. Naturally occurring daily and annual flow variations provide ecological benefits to floodplain ecosystems and the aquatic and terrestrial organisms that depend upon them. With respect to fish, natural stream flow variations provide cues for spawning, egg hatching, rearing, and swimming to off-channel floodplain habitats for feeding or reproduction, and migration.

Water and land management practices that alter the timing, duration, magnitude, frequency, or rate of change of streamflow patterns can substantially alter riparian and instream habitat along regulated stream reaches (Calow and Petts, 1994). Water withdrawals, watershed and floodplain development, agricultural or wastewater effluents, and practices that change surface runoff (e.g., dikes and levees) or subsurface drainage (e.g., tile drainage systems) affect the amount and quality of water in a stream channel across the water year. The effects of water withdrawals on aquatic resources and stream condition are readily observed.

Element 2. Hydrologic Alteration Scoring Matrix

Bankfull flows occur in accordance with the flow regime typical of the site, generally every 1 to 3 years, and No dams, dikes, or development in the floodplain‡, or water control structures are present; and Natural flow regime† prevails.	Bankfull flows occur only once every 4 to 5 years, or less often than the local natural flow regime. Developments in the floodplain, water withdrawals, flow augmentation, or water control structures may be present *but* do not significantly alter the natural flow regime†.	Bankfull flows occur only once every 6 to 10 years, or less often than the local natural flow regime. Developments in the floodplain, stream water withdrawals, flow augmentation, or water control structures alter the natural flow regime†.	Bankfull flows rarely occur. Stream water withdrawals completely de-water channel; and/or flow augmentation, stormwater, or urban runoff discharges directly into stream and severely alters the natural flow regime†.
10 9	**8 7 6**	**5 4 3**	**2 1 0**

‡ "Development in the floodplain" refers to transportation infrastructure (i.e., roads, railways, etc.), commercial or residential development, land conversion for agriculture or other uses, and similar activities that alter the timing, concentration, and delivery of precipitation as surface runoff or subsurface drainage.

† As used here, "natural flow regime" refers to streamflow patterns unaffected by water withdrawals, floodplain development, agricultural or wastewater effluents, and practices that change surface runoff (e.g., dikes and levees) or subsurface drainage (e.g., tile drainage systems).

What to look for:

- ☑ Ask the landowner about the frequency of bankfull, overbank, and low flows, referring to Figure 2 as needed. Be cautious—water in an adjacent field does not

necessarily indicate natural flooding. The water may have flowed overland from a low spot in the bank outside the assessment reach or be an artifact of irrigation or drainage management.

- ☑ Look for indicators that help identify bankfull stage (refer to Channel Condition element). If you see newly deposited debris (e.g., leaves, branches, etc.) or unvegetated mineral sediments (mud lines, sands and silts) near the edge of the active channel, it is very likely that bankfull or higher flows have occurred in recent months.

- ☑ If channel bars are present, inspect the type and general age of vegetation. A vegetative community dominated by invasive species or seedlings less than two years old is a good indicator that bankfull or higher flows have occurred in the last two years, or with some regularity. An absence of vegetation on bars could be interpreted in the same manner, unless the stream is braided (three or more channels with excessive sand, gravel and/or cobble substrates and a notable lack of permanent vegetation) and/or streamflow is significantly regulated.

- ☑ Evidence of flooding includes high water marks (such as water stain lines), sediment deposits, or stream debris well above the stream channel. Look for these on streambanks, trees or rocks, or other structures (such as bridge pilings or culverts).

- ☑ Water control structures are any feature that alters streamflow. Examples commonly include stream surface intakes (e.g., pump stations, flashboard or full-round risers, drop pipes, stop log structures, screw, or flap gate structures), streamside infiltration galleries or ring wells, diversions, dikes, or dams (both temporary and permanent). Any water control structures that divert water directly out of a stream should be suitably "screened" to prevent entrapment or capture of fish.

ELEMENT 3. Bank Condition

Description and Rational for Assessing Bank Condition. Stable streambanks are essential components of functional physical habitat and unimpaired biological communities. Simon et al. (2000) found that unstable streambanks could contribute as much as 85 percent of the total sediment yield in an entire watershed. Severely unstable streambanks can result in the loss of valuable farmland, force changes in water tables, and endanger transportation infrastructure and other floodplain features. Bank erosion is a natural mechanism in alluvial rivers, cannot be completely eradicated, and provides important physical and ecological functions to the evolution of stream channels and floodplains (Wolman and Leopold, 1957; Hooke and Redmond, 1992). Excessive bank erosion usually occurs where riparian areas are degraded or when a stream is unstable because of changes in land management practices, hydrology, sediment dynamics, or isolation from its floodplain. Bank failures are generally attributed to the interaction of fluvial and gravitational forces (Thorne, 1982)—high, steep banks with undercutting occurring at the base of the slopes are very prone to erosion or collapse.

A healthy riparian corridor with a well-vegetated floodplain contributes to bank stability. The roots of some perennial grasses, sedges, and woody vegetation can help hold bank soils together and physically protect the bank from scour during bankfull and higher flow events.

Therefore, the type of vegetation covering streambanks is an important component of bank stability. For example, many trees, shrubs, sedges, and rushes have the type of root masses capable of withstanding high streamflow events, while Kentucky bluegrass does not. Further, native riparian vegetation generally provides better erosion resistance and bank stability than invasive species (Tickner et al., 2001). Finally, surface and subsurface soil types also influence bank stability. For example, banks with a thin soil cover over gravel or sand are more prone to collapse than are banks with deep, cohesive soil layers.

Element 3. Bank Condition Scoring Matrix

Banks are stable; protected by roots of natural vegetation, wood, and rock†; >75% of bank surface is covered by perennial grasses, forbs, shrubs, and or trees with deep, binding root masses. No artificial structures present on bank; No excessive erosion or bank failures‡; No recreational or livestock access.		Banks are moderately stable, protected by roots of natural vegetation, wood, or rock or a combination of materials; > 50 to 75% of the bank has evidence of a deep, binding root mass. Limited number of structures present on bank; Evidence of erosion or bank failures, some with re-establishment of vegetation; Recreational use and, or grazing do not influence bank condition.	Banks are moderately unstable; very little protection of banks by roots of natural wood, vegetation, or rock; >25% to 50% of the streambank has evidence of a deep binding root mass Artificial structures cover more than half of reach or entire bank; Excessive bank erosion or active bank failures; Reational and/or livestock use are contributing to bank instability.	Banks are unstable; no bank protection with roots, wood, rock, or vegetation; 25% or less of the streambank has evidence of a deep, binding root mass. Riprap, and/or other structures dominate banks; Numerous active bank failures; Recreational and/or livestock use are contributing to bank instability.
Right Bank	10 9	8 7 6	5 4 3	2 1 0
Left Bank	10 9	8 7 6	5 4 3	2 1 0

† Natural wood and rock does not mean riprap, gabions, log cribs, or other artificial revetments.

‡ "Bank failure" refers to a section of streambank that collapses and falls into the stream, usually because of slope instability.

Score each bank individually and average the total to report a single, composite Bank Condition Score: _____

What to look for:

- ☑ Evaluate the entire length of all banks along the assessment reach, and then consider the proportion of unstable to stable banks. Obviously, if a quantifiable portion of the reach shows signs of accelerated erosion or bank failures, then bank stability is a problem and should be scored lower. Conversely, if the majority of the reach shows minimal erosion and no signs of bank failure, bank stability is likely good. Finally, it is best to score this element during the summer or whenever flows in your assessment reach are low.

- ☑ Signs of erosion and possible bank stability problems include unvegetated stretches, exposed tree roots, and scalloped edges (sections of eroded bank between relatively intact sections).

- ☑ When observing banks from within the active channel or below bankfull elevation, look for piping holes, rills, and or gullies. Each of these concentrated flow paths is associated with eventual bank stability problems or outright failures.

- ☑ Look for tension cracks while walking along streambanks. Tension cracks will appear as vertical fissures or crevices running along the top of the streambank roughly parallel to the flow.

- ☑ Evidence of construction, vehicular, or animal paths near banks or grazing areas leading directly to the water's edge suggest conditions that may lead to bank collapse.

- ☑ Sections of streambank lying instream adjacent to existing banks are a telltale sign of active bank erosion and instability.

ELEMENTS 4 and 5. Riparian Area Quantity and Quality

Description and Rational for Assessing Riparian Area Conditions. Riparian areas are the vegetated areas adjacent to stream channels that function as transitional areas between the stream and uplands. Riparian vegetation thrives on the moisture provided by stream flow and ground water associated with the stream corridor. Riparian areas may or may not include floodplains and associated wetlands, depending on the valley form of the stream corridor. For example, steep mountainous streams in narrow V-shaped valleys often do not have obvious floodplains. Riparian areas are among the most biologically diverse habitats of western landscapes and they are sources of wood, leaves, and organic matter for the stream. These areas provide important habitat and travel corridors for numerous plants, insects, amphibians, birds, and mammals.

Ecological processes that occur in the stream corridor are linked to those in uplands via intact riparian areas. Riparian areas themselves also provide valuable functions that maintain or improve stream and floodplain conditions (see below). The capacity for riparian areas to sustain these functions depends in part on the quality and quantity of the riparian vegetation and how it interacts with the stream ecosystem. The *quality* of the riparian area increases with the width, complexity and linear extent of its vegetation along a stream. A complex

riparian community consists of diverse plant species native to the site or functioning similarly to native species, with multiple age-classes providing vertical structural diversity characteristic of the area in which the stream is located. As discussed previously, the quality of riparian areas is influenced by the hydrological features of the stream, as well as upland and bank conditions.

Well-established and connected riparian areas provide critical functions for maintaining healthy, resilient stream ecosystems. For this reason, it is important to evaluate both the quantity and the quality of the riparian area, and if possible, *score the riparian conditions of the entire stream within a property bounda*ry. If the stream length is too extensive to score using SVAP2-AZ, score only the assessment reach visually and use recent aerial photos (less than 2 years old) to score those riparian areas of the stream outside of the assessment reach.

Element 4. Riparian Area Quantity Scoring Matrix

Natural plant community extends 90-100% over the entire active floodplain and is generally contiguous throughout property.		Natural plant community extends over 75 to 90% of active floodplain and is generally contiguous throughout property. Vegetation gaps do not exceed 20% of the estimated length of the stream on the property.	Natural plant community extends at least 50-75% of active floodplain. Vegetation gaps do not exceed 30% of the estimated length of the stream on the property.	Natural plant community extends over 25 to 50% of active floodplain. Vegetation gaps exceed 40% of the estimated length of the stream on the property.	Natural plant community extends less than 25% of the bankfull width or less than ¼ of active floodplain. Vegetation gaps exceed 50% of the estimated length of the stream on the property.
Left	**10 9**	**8 7**	**6 5**	**4 3 2**	**1 0**
Right	**10 9**	**8 7**	**6 5**	**4 3 2**	**1 0**

Score each bank separately. Scores should represent the entire stream riparian area within the property. Score for this element = left bank score + right bank score /2: _____

What to look for:

- ☑ This element rates the extent of the riparian area on the property (length *x* width). Estimate the width of the vegetation area from the edge of the active channel outward to where natural riparian vegetation ends and other land-use/land cover begin.

- ☑ Vegetation gaps are lengths of streamside with no natural vegetation ecologically suitable for the site and at a density and spacing uncharacteristic of the plant community being assessed. Estimate gap percentage by dividing the total length of gaps by the total length of the stream within the property boundary multiplied by 100.

- ☑ For this element, "natural plant community" means one with species native to the site or introduced species that have become "naturalized" and function similarly to native species of designated reference sites, growing at densities characteristic of the site. Regional plant guidebooks are useful to have in the field for scoring this element.

- ☑ Compare the width of the riparian area to the bankfull channel width. In steep, V-shaped valley forms, there may not be enough room for a floodplain riparian area to extend as far as one or two active channel widths. In this case, a score may be adjusted to a higher value, based on reference site conditions.

Element 5. Riparian Area Quality Scoring Matrix

	Ecological site Similarity Index Score > 60 and: Diverse age class representing new seedlings through mature plants	Ecological site Similarity Index Score 40 up to 60 and: Moderately diverse age class with 1 stage not well represented	Ecological site Similarity Index Score 20 up to 40 and: Uneven age class representation with more than 1 or stage not well represented or 1 class missing	Ecological site Similarity Index Score <20 and: Age class limited to mature or decadent plants with no reproduction.
Left	**10 9**	**8 7 6**	**5 4 3**	**2 1 0**
Right	**10 9**	**8 7 6**	**5 4 3**	**2 1 0**

Score should represent the entire stream riparian area within the property.
Score for this element = left bank score + right bank score /2, unless both banks are similar in composition and quality: _____

What to look for:

- ☑ Diverse age classes of plants listed in the Ecological Site Description, particularly of trees and shrubs, well represented from seedlings through mature plants.
- ☑ Plant species should be native or naturalized and consist of multiple structural layers (grasses and forbs, shrubs, or trees as appropriate for the ecological site). Forested sites should also have a diverse mix of shrubs, understory trees, and new shrub and tree regeneration. Early successional sites (recently disturbed by fire, tree harvesting, grazing, land clearing) should have representative native species (typically herbaceous, woody and tree seedlings). Continually disturbed sites usually have only a few species and often these include non-native invasive species. As "early" vegetation matures, the structure of the plant community becomes more diverse with a multi-layer canopy. Finally, the plant community reaches a mature stage with regeneration, growth, and mortality occurring in all layers. In forested streams, mature trees with potential for falling into the stream are present. Regional plant guidebooks are useful for scoring this element.

- ☑ Vigorously growing vegetation in the riparian area on both sides of the stream is important for healthy stream and riparian conditions. In doing the assessment, examine both sides of the stream and note on the site diagram (Page 4 of the

Summary Sheet) which side of the stream has problems. For the highest ratings, there should be no evidence of concentrated flows through the riparian area that are not adequately buffered, and no non-native invasive species.

☑ The type, timing, intensity, and extent of activities in riparian areas are critical in determining the impact on these areas. Note these in the summary sheet. Riparian areas that have roads, agricultural activities, residential or commercial structures, re-occurring excessive animal use, or significant areas of bare soils have reduced functional value for the stream and its watershed.

ELEMENT 6. Canopy Cover

Description and Rationale for Assessing Canopy Cover. In forested riparian areas, shading of the stream is important because it keeps water cool and limits algal growth. Cool water has a greater oxygen holding capacity than warm water. In many cases, when streamside trees are removed, the stream is exposed to the warming effects of the sun causing the water temperature to increase for longer periods during the daylight hours and for more days during the year. This shift in light intensity and temperature often causes a decline in the numbers of certain species of fish, insects, and other invertebrates and some aquatic plants. They may be replaced altogether by other species that are more tolerant of increased light intensity, lower dissolved oxygen, and warmer water temperature. For example, trout require cool, oxygen-rich water, and may rely on food organisms produced by detritus-based food chains. Loss of streamside vegetation that causes increased water temperature and decreased oxygen levels, contributes to the decrease in abundance of trout and salmon from many streams that historically supported these species. Warmwater species also benefit from canopy cover to keep streams from exceeding optimal temperatures. Increased light and the warmer water also promote excessive growth of submerged macrophytes (vascular plants) and algae that can cause a shift from a detritus-based to an algae-based food chain, thus altering the biotic community of the stream. Although some stream food webs are detritus-based, others (especially some warmwater streams) are algae-based and require a certain amount of light to be naturally productive. *Therefore, this element is particularly sensitive to the type of stream (stream class) and fish community that is being assessed and calibration of scoring may be necessary.* Remember that many of the features of this element are highly affected by the degree of upstream shading. Therefore, the element is assessed for canopy over the entire property rather than at a single assessment reach. Choose the matrix appropriate for the stream and its native fauna. For example, if the stream is a "trout stream," use the matrix for Coldwater Streams. If the stream is naturally warmer than 70°F, use the matrix for Warmwater Streams. Lastly, percentages in the scoring matrix should be modified according to the site's potential for plant communities that will provide shade to the stream.

Element 6. Canopy Cover: Coldwater Streams Scoring Matrix

>75% of water surface shaded within the length of the stream in landowner's property.	75% to 50% of water surface shaded within the length of the stream in landowner's property.	49% to 20% of water surface shaded within the length of the stream in landowner's property.	<20% of water surface shaded within the length of the stream in landowner's property.
10 9	8 7 6	5 4 3	2 1 0

Element 6. Canopy Cover: Warmwater Streams Scoring Matrix

50 to 75% of water surface shaded within the length of the stream in landowner's property.	>75% of water surface shaded within the length of the stream in landowner's property.	49% to 20% of water surface shaded within the length of the stream in landowner's property.	<20% of water surface shaded within the length of the stream in landowner's property.
10 9	8 7 6	5 4 3	2 1 0

What to look for:

- ☑ Estimate the percent of the stream surface area that is shaded over the entire property using a vertical sighting tube on a systematic grid or a spherical densitometer. If neither instrument is available, refer to the chart below in Figure 4. This may require cover estimates at several points within and outside the assessment reach. Time of the year, time of the day, and weather can affect your observation of shading. Therefore, the relative amount of shade is estimated by assuming that the sun is directly overhead and the vegetation is in full leaf-out. To enhance accuracy of the assessment, aerial photographs taken during full leaf-out should be used to supplement your visual assessments. The following illustration may be used as a guide for both visual and aerial estimates.

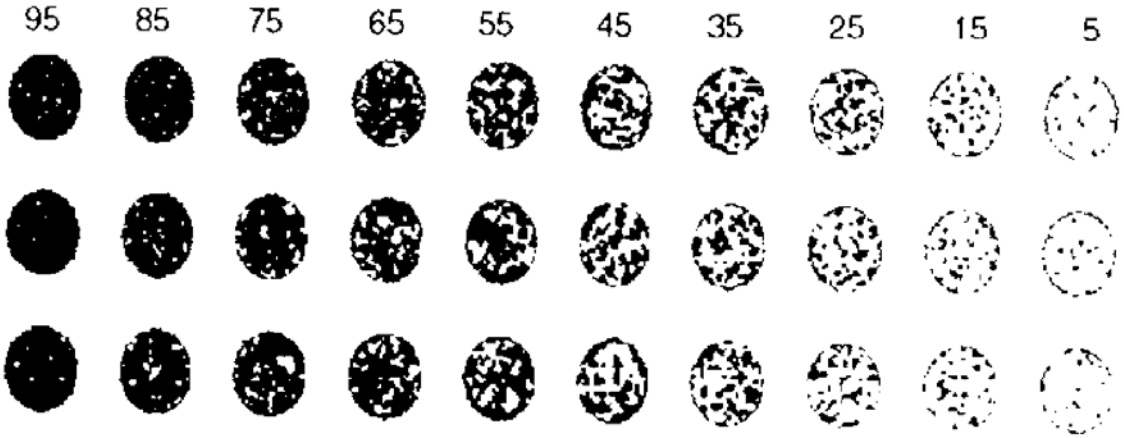


Figure 4. Percent canopy cover. Numbers above the ovals refer to the percent black (= shade/cover). From USDA Forest Service FIA Manual

ELEMENT 7. Water Appearance

<u>Description and Rationale for Assessing Water Appearance.</u> The water appearance assessment element compares turbidity, color, and other visual characteristics of the water with those of a reference stream. The assessment of turbidity is the depth to which an object can be clearly seen. Clear water indicates low turbidity. Cloudy or opaque water indicates high turbidity. Turbidity is caused mostly by particles of soil and organic and inorganic matter suspended in the water column. Streams often show some turbidity after a storm event because of soil and organic particles carried by runoff into the stream or suspended by

turbulence. Intrinsic characteristics of a watershed, such as geology and soils unaffected by human activities, should be considered in reference conditions and assessment. For example, glacial flour creates high turbidity and is considered a natural process of erosion in glacial streams. Tea-colored water due to tannins from a natural process in bogs and wetlands may also affect clarity in some streams. Altered clarity due to natural processes would not receive low ratings.

Element 7. Water Appearance Scoring Matrix

Very clear, or clarity appropriate to site (3-6'). No motor oil sheen on surface; no evidence of metal precipitates in streams.	Slightly turbid, especially after storm event, but water clears rapidly (>1.5-3'); no motor oil sheen on surface; no evidence of metal precipitates in stream.	Turbid most of the time (0.5-1.5') and/or presence of metal precipitates and/or motor oil sheen present in slackwater areas.	High turbidity most of the time (<0.5') and/or considerable amount of metal precipitates and/or motor oil sheen present throughout reach.
10 9 8	**7 6 5**	**4 3 2**	**1 0**

What to Look For:

- ☑ Clarity of the water is an obvious and easy feature to assess. The deeper an object in the water can be seen, the lower the amount of turbidity. This measure should be taken after a stream has had the opportunity to "settle down" following a storm event.

- ☑ A stream should not smell like oil or have pronounced motor oil sheen on its surface.

- ☑ Use the depth that objects are visible only if the stream is deep enough to evaluate turbidity using this approach. For example, if the water is clear but only 1 foot deep, do not rate it as if an object became obscured at a depth of 1 foot.

Visibility Depth Range Guidance:

Clear Visibility	3-6'
Slightly Turbid	1.5-3'
Turbid	0.5-1.5'
High Turbidity	<0.5

ELEMENT 8. Nutrient Enrichment

Description and Rationale for Assessing Nutrient Enrichment. Nutrients are necessary for stream food webs by promoting algal and aquatic plant growth, which provide habitat and food for aquatic organisms. However, an excessive amount of algal and plant growth is detrimental to stream ecosystems. High levels of nutrients (especially phosphorus and nitrogen) lead to increased growth of algae and aquatic plants. Subsequently, respiration and decomposition of plant organic matter consume dissolved oxygen in the water, lowering the

concentration of oxygen available to aquatic organisms, and possibly contributing to significant die-offs. A landowner may have seen fish gulping for air at the water surface during warm weather indicating a lack of dissolved oxygen. Streams respond differently to nutrient loading. The presence of algal blooms - thick mats of algae and an overabundance of aquatic plants (i.e., macrophytes) - are often indicators that nutrients are high. However, the absence of such blooms may not always be indicative of nutrient concentrations. Stream velocity, light availability, temperature, and types of stable substrate present in a stream are important factors that affect algal and plant abundances. Water quality problems that arise from excess turbidity, herbicides, human waste and manure or salinity will also affect the abundance or absence of algae or macrophytes. If there is little or no algal growth, assess the factors described in the "*what to look for*" section, and summarize your findings accordingly.

Element 8. Nutrient Enrichment Scoring Matrix

Clear water along entire reach; little algal growth present.	Fairly clear or slightly greenish water; moderate algal growth on substrates.	Greenish water particularly in slow sections; abundant algal growth, especially during warmer months; and/or slight odor of ammonia or rotten eggs; and/or sporadic growth of aquatic plants within slack water areas.	Pea green color present; thick algal mats dominating stream; and/or strong odor of ammonia or rotten eggs, and/or dense stands of aquatic plants widely dispersed.
10 9	8 7 6	5 4 3	2 1 0

What to look for:

- ☑ **Velocity**: Streams with high velocity >.33 ft/sec and high concentrations of nutrients are typically not dominated by filamentous algae. Thus, the water may appear very clear yet still have high nutrient concentrations.

- ☑ **Light:** If light is a limiting factor, due to shading from riparian vegetation, look for algal growth on rocks and boulders in reaches exposed to light.

- ☑ **Temperature:** Most algae grow more rapidly at higher temperatures. Within a range of 32° F to 77° F, increasing temperature by 18° F typically doubles the rate of algal growth.

- ☑ **Substrate:** Low complexity of substrate reduces filamentous algal growth.

- ☑ **Macrophyte Presence:** The presence of dense stands of aquatic macrophytes may be an indicator of nutrient availability. Diversity within the aquatic plant community should be noted and considered. Some species typically associated with springs, such as watercress, may not be associated with heavy nutrient loading. Clear water and a diverse, dispersed aquatic plant community are optimal for this characteristic.

ELEMENT 9. Pools

Description and Rationale for Assessing Pools. Regardless of the stream channel type, pools are important resting and feeding habitat for fish. Streams with a mix of shallow and deep pools offer diverse habitat for different species. In fish-bearing streams, a general rule of thumb to distinguish deep pools from shallow pools is this: a deep pool is 2 times deeper than the maximum depth of its upstream riffle, while a shallow pool is less than 2 times deeper than the maximum depth of its upstream riffle. This general rule may not apply to extremely high gradient streams, dominated by cascades, however. Continuous pools (those not separated by riffles, wood jams, rock "steps", or fast-water) provide less diverse habitat and are indicative of poor stream structure and should not be considered for scoring in the first 3 boxes (only the last). Fish use such cover to rest, hide from predators, catch food items in the swirling currents that occur around submerged structures, and avoid territorial conflicts. Isolated pools occur when stream flows are so low that portions of the stream are essentially de-watered temporarily. If deep enough, these isolated pools serve as refuges for stranded fish and other aquatic species until rains restore continuous flow in the system and re-connect the pools to their temporarily dry riffles.

Fish are often limited by the amount of available cover in pools, such as submerged logs, boulders, tree roots and undercut banks. Stream alteration often reduces the amount and complexity of pools, thus degrading fish habitat. On the other hand, beavers often create pools in streams that may add habitat diversity and enhance pool habitats; however, their effects may also inundate riffles and other shallow water habitats. Thus, it is important to assess SVAP2-AZ stream reaches in the correct context, i.e., in relation to local reference conditions. States are encouraged to modify scoring of this element according to local pool-to-riffle ratios generally present in reference stream reaches. Remember, you are assessing representative reaches of streams throughout the area and if conditions should change dramatically within the property due to alteration, or other influences affecting the structure and function of the stream, additional reaches should be assessed.

Only one pool morphology type (low gradient OR high gradient) should be used per assessment reach.

Element 9. Pools: Low-Gradient Streams Scoring Matrix (<2%)

More than 2 deep pools separated by riffles, each with greater than 30% of the pool bottom obscured by depth, wood, or other cover. Shallow pools also present.		One or 2 deep pools separated by riffles, each with greater than 30% of the pool bottom obscured by depth wood, or other cover; at least one shallow pool present.			Pools present but shallow (< 2 times maximum depth of the upstream riffle). Only 10 – 30% of pool bottoms are obscured due to depth or wood cover.			Pools absent, but some slow water habitat is available; no cover discernible. or Reach is dominated by shallow continuous pools or slow water.		
10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**

What to look for:

- ☑ The number of pools per assessment reach is estimated based on walking the stream or probing from the streambank with a stick or pole. You should find deep pools on the outside of meander bends. Pools are typically separated by riffles or other shallow water habitats. In drier climates, deep pools may be temporarily isolated from their riffles, yet still provide important refuge habitat. Pools are formed by obstructions in the stream channel, such as fallen trees, accumulations of wood (jams), beaver dams, boulders, root wads, rock outcrops, beaver dams, and accumulated plant debris.

- ☑ Assess pool cover by estimating the percent of the pool bottom that is obscured by cover features, or depth, assuming you are positioned directly over the feature looking straight down at the stream bottom. In shallow, clear streams, a visual inspection may provide an accurate estimate.

Element 9. Pools: High-Gradient Streams (>2%) Scoring Matrix

More than 3 deep pools separated by boulders or wood, each with greater than 30% of the pool bottom obscured by depth, wood, or other cover. For small streams, pool bottoms may not be completely obscured by depth, but pools are deep enough to provide adequate cover for resident fish. Shallow pools also present.	Two to 3 deep pools, each with greater than 30% of the pool bottom obscured by depth wood or other cover; at least one shallow pool present. For small streams, pool bottoms may not be completely obscured by depth, but pools are deep enough to provide *some* cover for resident fish. At least one shallow pool also present.	Pools present but relatively shallow, with only 10 – 30% of pool bottoms obscured by depth or wood cover. For small streams, pool bottoms may not be completely obscured by depth, but pools are deep enough to provide *minimal* cover for resident fish. No shallow pools present.	Pools absent.
10 9	**8 7 6**	**5 4 3**	**2 1 0**

What to look for:

- ☑ In high-gradient streams, energy is dissipated by alternating slow and fast water conditions with step/pools and rapids/scour pools. Step/pools operate similar to stair steps with water dropping vertically over nearly complete channel obstructions (often a large rock and/or large wood) scouring out small depressions, or plunge pools (Hunter, 1991). Streams with step/pool conditions usually have gradients >4% and

pools are spaced at 1 pool every 1.5 to 4 bankfull channel widths. Pool spacing decreases as gradient increases (Rosen, 1996).

- ☑ Streams with gradients between 2 and 4% are often rapids and lateral scour pool dominated. Scour pool spacing is typically 1 pool every 4 to 5 bankfull channel widths and is created by channel confinements and wood or sediments.

- ☑ Plunge pools and scour pools are important aquatic habitat features providing resting and hiding cover for fish and aquatic species. With these pools, turbulence, large rock, wood, and the depth of water all contribute hiding cover for fish.

ELEMENT 10. Barriers to Aquatic Species Movement

Description and Rationale for Assessing Barriers to Aquatic Species Movement. Most aquatic organisms move around their habitats, or undertake daily, seasonal, or annual migrations. For example, anadromous trout and salmon spawn and rear in freshwater, move to marine environments to grow to adulthood, and return to freshwater after a period of months or years to reproduce and die (Groot and Margolis, 1991). Other fish commonly use estuaries, river mouths, and the lower reaches of rivers within a span of a few days for feeding, sheltering, or as refuge from predators (Gross et al., 1988). Still others use headwater streams for spawning, and downstream lakes or rivers for feeding as they mature. Consequently, barriers that block the movement of fish or other aquatic organisms are important components of stream assessment.

Instream features or water management practices can create barriers that limit or prohibit the passage of aquatic organisms seasonally or annually. Passage barriers may prevent the movement or migration of fish, deny access to important breeding or foraging habitats, and isolate populations of fish and other aquatic animals. Both natural and manmade barriers occur within river and stream systems, and natural physical barriers include waterfalls, cascades, and large rapids. Common manmade physical barriers include dams, diversions, culverts, weirs, excessively high-grade control structures, or buried sills with broad crests. Chemical and biological barriers such as water quality and quantity (e.g., temperature and low stream flows) and predation from non-native species also exist in many rivers across the United States. However, these types of passage problems are often seasonal and can be difficult to identify with limited field time and site-specific data. Passage barriers are typically categorized by characteristics such as water velocity, water depth, and barrier height in relation to the passage requirements of a given species and/or life stage.
Three commonly used barrier classes are:

- *Partial* – impassable to some species or certain age classes all or most of the time;
- *Temporary* – impassable during some times to all or most species and/or age classes (e.g., during low flow conditions);
- *Complete* – impassable to all fish at all times.

For example, a poorly designed or damaged culvert may be a temporary barrier to upstream migrating adults when flows are high because velocities within the culvert barrel exceed their natural swimming capabilities. Some highly migratory fishes like Pacific salmonids can leap six feet or more to bypass a waterfall, whereas shad in the same river will be faced with a complete barrier (Bell, 1990; Haro and Kynard, 1997). Many State and Federal Agencies

have laws that are applicable to this element. Conservationists should become familiar with state-applicable regulations as part of the Preliminary Assessment.

Barriers to aquatic species movement may be needed to prevent non-native species from accessing a specific reach. For example, a concrete barrier can prevent introduced fish or crayfish from moving past a specific point to protect a population of native fish. However, it will also reduce the range of the native species and therefore should score below seven.

Element 10. Barriers to Aquatic Species Movement Scoring Matrix

No artificial barriers that prohibit movement of desirable aquatic organisms during any time of the year. And: No non-native species in the reach	Physical structures or, water withdrawals *seasonally* restrict movement of desirable aquatic species, And: No non-native, species in the reach	Physical structures, water withdrawals, and/or water quality restrict movement of aquatic species *throughout the year* or are needed to prevent movement of non-native species.	Physical structures, water withdrawals, and/or water quality *prohibi*t movement of aquatic species and/or do not adequately prevent movement of non-native species.
10	**9 8 7**	**6 5 4 3**	**2 1 0**

When addressing this element, assess a length of stream at least 12 times the bankfull width, or the entire stream length on the landowner's property, whichever is greater. Be sure to detail in the notes the species and life stages of aquatic organisms for which you are evaluating barriers.

What to look for:

- ☑ Ask the landowner about any dams or other barriers that may be present 3 to 5 miles upstream or downstream of his or her property.
- ☑ Note the presence of natural barriers along the assessment reach, their size.
- ☑ Beaver dams generally do not prevent fish migration and should not be identified as passage barriers unless supporting information exists.
- ☑ Livestock and/or equipment crossings can be passage barriers if water flows fast and shallow (less than 6 inches) across smooth or uniform surfaces at least half as wide (from upstream to downstream) as the bankfull width. For example, a 12-foot wide hardened vehicle ford that crosses a stream with a bankfull width of 20 feet is likely a temporary passage barrier.
- ☑ Low-head dams are most likely temporary or complete barriers, especially if outfitted with a concrete apron that covers the streambed along the entire downstream face. Determine if the barrier is in place to prevent non-native access before scoring.

- ☑ Culverts can be especially problematic to migratory aquatic organisms. Unless specifically designed with passage in mind, most culverts are partial upstream passage barriers for the smallest life stages of native fish. Culverts should be scored as temporary or complete passage barriers if the culvert:
    - width is less than bankfull width
    - slope is greater than channel slope
    - is not countersunk
    - is perched (elevated) above the outlet pool
    - inlet is plugged with debris
    - inlet or outlet shows sign of erosion or instability
    - alignment doesn't match the stream

ELEMENT 11. Fish Habitat Complexity

Description and Rationale for Assessing Fish Habitat Complexity. The dynamic features of stream corridors create diverse habitat types and conditions for fish and other aquatic species. Quality fish habitat is a mosaic of different types of habitats created by various combinations of water quality and quantity, water depth, velocity, wood, boulders, riparian vegetation, and the species that inhabit stream corridors. The greater the variety of habitat features, the more likely a stream is to support a diversity of aquatic species. Fish require these *complex* habitats with diverse types of hiding, resting, and feeding cover in parts of the stream and variable flow features. For example, deep pools (with slower currents) provide cover, thermal refuge, and a place to rest. Riffles (with faster currents) provide benthic invertebrates to prey on. Fast water is well-aerated, providing more oxygen to the stream ecosystem. The more types of different structural features, the more resilient the habitat is to natural disturbances (such as floods) as well as human perturbations (such as water withdrawals). The dynamic nature of instream habitat features assures fish and other species are able to find suitable areas to rear, feed, grow, hide, and reproduce during the course of their life histories. Because fish habitat needs and types vary considerably from species to species and throughout the country, states should adjust scoring of this element to reflect reference conditions and species habitat features characteristic of their region.

Element 11. Fish Habitat Complexity Scoring Matrix

10 or more habitat features available, at least one of which is considered optimal in reference sites (e.g., large wood in forested streams.)	8 to 9 habitat features available.	6 to 7 habitat features available.	4 to 5 habitat features available.	<4 habitat features available.
10 9	**8 7**	**6 5**	**4 3**	**2 1 0**

Fish habitat features: Logs/Large wood, deep pools, other pools (i.e. scour, plunge, shallow, pocket) overhanging vegetation, boulders, cobble, riffles, undercut banks, thick root mats, dense macrophyte beds, backwater pools, and other off-channel habitats.

What to look for: Within the entire assessment reach, observe the number of different habitat features that provide diverse and complex habitats for fish. Each habitat feature must be present in appreciable amounts to score (as compared to suitable reference sites). Features include:

- ☑ **Logs, large wood** — fallen trees, or parts of trees that are submerged in the water and large enough to remain in the assessment reach during normal flows. Minimum **2/reach; #/reach_____**

- ☑ **Small wood accumulations** — submerged accumulations of small wood pieces, twigs, branches, leaves, and roots. Though likely to be temporary components of stream habitats, their pieces will continue to provide structural complexity as the debris moves within the reach. **Minimum 1/reach**; **#/reach ____**

- ☑ **Deep pools -** areas of slow water with smooth surface and deep enough to provide protective cover for fish species likely to be present in the stream. **Minimum 2/reach; #/reach:____**

- ☑ **Secondary pools** (i.e., scour, plunge, pocket pools) – pools formed by boulders or wood that divert water and scour depressions below turbulent flows. **Minimum 4/reach; #/reach: ____**

- ☑ **Overhanging vegetation –** tree branches, shrub branches, or perennial herbaceous vegetation growing along the streambank and extending outward over the stream's surface, providing shade and cover. **Minimum 3/reach; #/reach: ____**

- ☑ **Large boulders –** submerged or partially submerged large rocks (> 20" diameter) **Minimum 3/reach if no wood; minimum 2/reach if wood present. #/reach____**

- ☑ **Small boulder clusters –** groups of 2 or more smaller rocks (>10 inches and < 20 inches in diameter) interspersed relatively close together in the channel. **Minimum 3/reach. #/reach: ____**

- ☑ **Cobble riffles –** fast, "bubbly" water flowing amongst and over small rocks between 2 and 10 inches in diameter. Minimum **2/reach. #/reach: _____**

- ☑ **Undercut banks –** water-scoured areas extending horizontally beneath the surface of the bank, forming underwater pockets used by fish for hiding and thermal cover. Minimum **3/reach or 25% of bank area; #/reach: ____**

- ☑ **Thick root mats - mats** of roots and rootlets, generally from trees but sometimes from mature dense shrubs at or beneath the water surface. **Minimum 3/reach; #/reach: ___**

- ☑ **Macrophyte beds** – beds of emergent, submerged, or floating leaf aquatic plants thick enough to serve as cover. Minimum **1/reach; #/reach: ____**

- ☑ **Off-channel habitats** - side-channels, floodplain wetlands, backwaters, alcoves. **Minimum 2/reach; #/reach: ____**

ELEMENT 12. Aquatic Invertebrate Habitat

Description and Rationale for Assessing Aquatic Invertebrate Habitat. Four functional groups characterize the feeding functions of most aquatic invertebrates: **shredders, collectors, grazers, and predators**. Some species can be placed in more than one functional feeding group. The groups are typically present in all streams, although the dominance of groups will vary from headwater streams to larger streams and rivers. These functional feeding groups help predict the location and diverse **substrate needs** of specific invertebrates within the stream. **Substrates** are materials that provide a base for invertebrates to live and colonize. In a healthy stream, substrates are varied, free of sediment, abundant, and in place long enough to allow colonization by invertebrates. High stream velocities, high sediment loads, and frequent flooding may deplete substrate or cause it to be unsuitable habitat, at least temporarily until re-colonization occurs.

Wood and riffle areas with boulders\cobbles support the bulk of the invertebrate community in temperate streams (Benke et al., 1984). Wood typically supports a more diverse invertebrate community, while boulders and cobble within riffles typically support higher numbers (abundance) of species. High numbers of habitat types for fish often equate to high invertebrate habitat types. The scale of habitat assessment is necessarily much smaller for invertebrates because their range of mobility limits the size of their habitat, or *micro*habitat. Therefore, an array of different types of habitat should be found within a smaller area of the reach.

Element 12. Aquatic Invertebrate Habitat Scoring Matrix

At least 9 types of habitat present; A combination of wood with riffles should be present and suitable in addition to other types of habitat. (If non-forested stream, consider reference site's optimal habitat type needed for this high score.)	8 to 6 types of habitat; Site may be in need of more wood or reference habitat features, and stable wood-riffle sections.	5 to 4 types of habitat present	3 to 2 types habitat present	None to 1 type of habitat present
10 9	8 7 6	5 4	3 2	1 0

Aquatic invertebrate habitat types, in order of importance: Logs/large wood, cobble within riffles, boulders within riffles. Additional habitat features should include leaf packs, fine woody debris, overhanging vegetation, aquatic vegetation, undercut banks, pools, and root mats

What to look for:

- Observe the abundance of wood and riffles with boulder\cobbles. Remember these two types of substrate play a significant role in invertebrate diversity and abundance.

- Observe the number of different types of habitat *within a representative subsection of the assessment reach* that is equivalent in length to five times the active channel width.

- Habitat types should be present in appreciable amounts (as expected in reference conditions or least impaired conditions) to score.

  - ✓ **Logs, large wood** — fallen trees, or parts of trees that are submerged or partially submerged in the water and large enough to remain in the assessment reach during normal flows. Minimum **2/subreach: #/sub-reach___**
  - ✓ **Large boulders within riffles–** submerged or partially submerged large rocks (> 20" diameter) **Minimum 2/sub-reach if no wood; minimum 1/sub-reach if wood present. #/sub-reach____**
  - ✓ **Small boulders in riffles clusters –** groups of 2 or more smaller rocks (>10 inches and < 20 inches in diameter) interspersed relatively close together in the channel. **Minimum 2/sub-reach. #/sub-reach: ____**
  - ✓ **Fine woody debris** —accumulations of twigs, branches, leaves, and roots. Though likely to be temporary components of stream habitats, their pieces will continue to provide structural complexity and substrate for invertebrates as the debris moves within the reach. **Minimum 2/sub-reach**; **#/sub-reach ___**
  - ✓ **Overhanging vegetation –** tree branches, shrub branches, or perennial herbaceous vegetation growing along the streambank and extending outward over the stream's surface, providing shade, cover, and food. **Minimum 1/sub-reach; #/sub-reach: ___**
  - ✓ C**obble riffles –** fast, "bubbly" water flowing amongst and over small rocks between 2 and 10 inches in diameter. Minimum **1/sub-reach. #/sub-reach: ___**
  - ✓ **Undercut banks –** water-scoured areas extending horizontally beneath the surface of the bank, forming underwater pockets used by aquatic insects for resting and feeding. Minimum **1/sub-reach or 25% of bank area;**

    #/sub-reach: ____
  - ✓ **Pools--** Slow water, deeper than riffles**. No minimum 1/sub-reach. #/sub-reach: ____**
  - ✓ **Thick root mats -** mats of roots and rootlets, generally from trees but sometimes from mature dense shrubs at or beneath the water surface. Minimum **1/sub-reach; #/sub-reach: ____**
  - ✓ **Macrophyte beds** – emergent submerged, or floating leaf aquatic plants thick enough to serve as cover. Minimum **1/sub-reach; #/sub-reach: ____**
  - ✓ **Other locally important habitat features (describe) _____**

ELEMENT 13. Aquatic Invertebrate Community

Description and Rationale for Assessing Aquatic Invertebrate Community. This important element reflects the ability of the stream to support aquatic invertebrates such as crayfish, mussels, dragonflies, and caddisflies. However, successful assessments require knowledge of the life cycles of some aquatic insects and other macroinvertebrates and the ability to identify them. For this reason, this is an optional element.

Aquatic invertebrates include crustaceans (such as crayfish), mollusks (such as snails), spiders, and aquatic insects. These organisms are important to aquatic food webs. To better understand aquatic invertebrate functions, habitat needs and interrelationships within the food web, ecologists have categorized these organisms into 4 major functional feeding groups:

1) ***Shredders*** process leaves, sticks and twigs. Their habitats are distinguished by areas that trap and retain organic matter, (i.e., leaf packs). They are generally found in headwater streams.
2) ***Collectors*:** Two types of aquatic invertebrates make up the Collectors, also found generally in headwater streams:
   - ***a. Filterers*** process smaller organic matter, suspended in water. Their habitats are large rocks or logs.
   - ***b. Gatherers*** actively collect their food. Their habitat is usually medium to large rocks.
3) ***Grazers*** feed on algae in areas of streams receiving sunlight. Their habitat is medium to large rocks.
4) ***Predators*** feed on other animals. Their habitats include logs, medium to large rocks, water column, pools, and leaf litter.

The presence of a diversity of intolerant macroinvertebrate species (pollution sensitive) indicates healthy, resilient stream conditions. Macroinvertebrates such as stoneflies, mayflies, and caddisflies, are sensitive to pollution and do not tolerate polluted water. These intolerant orders of insects comprise Group I. Group II macroinvertebrates are facultative, meaning they can tolerate limited pollution. This group includes damselflies, aquatic sowbugs, and crayfish. The dominant presence of Group III macroinvertebrates, including midges, craneflies and leeches without the presence of Group I, suggests the water is significantly polluted. The presence and abundance of only one or two species from Group I species in a reach community does not generally indicate diversity is good.

Element 13. Aquatic Invertebrate Community Scoring Matrix

Invertebrate community is diverse and well represented by Group I or intolerant species; One or two species do not dominate.	Invertebrate community is well represented by Group II or facultative species, and Group I species are also present; one or two species do not dominate.	Invertebrate community is composed mainly of Groups II and III, and/or 1 or 2 species of any group may dominate.	Invertebrate community composition is predominantly Group III species and/or only 1 or 2 species of any group is present and abundance is low.
10 9 8	7 6 5	4 3 2	1 0

What to look for: Figure 5 (below) contains illustrations for each of the three groups of macroinvertebrates with the listing of invertebrate taxonomic order. This rating is qualitative and therefore potential biases should be avoided to provide accurate representation of each site.

- Collect macroinvertebrates by picking up cobbles, gravel, leaf packs, silt, fine woody debris, and other submerged objects in the water. Sample all types of potential insect habitat (refer to Insect/Invertebrate Habitat Element) for an equal amount of time to reduce biases and improve accuracy.

- A healthy and stable invertebrate community will be consistent in its proportional representation (evenness) of species, though individual species abundance may vary in magnitude. Note the kinds of macroinvertebrates (group type), approximate number of each species, and relative abundance of each species sampled. Determine if one or two species dominate the aquatic invertebrate community. An abundance of an individual species, such as caddisflies or snails, is often equated to a tolerance of stress and lower diversity.

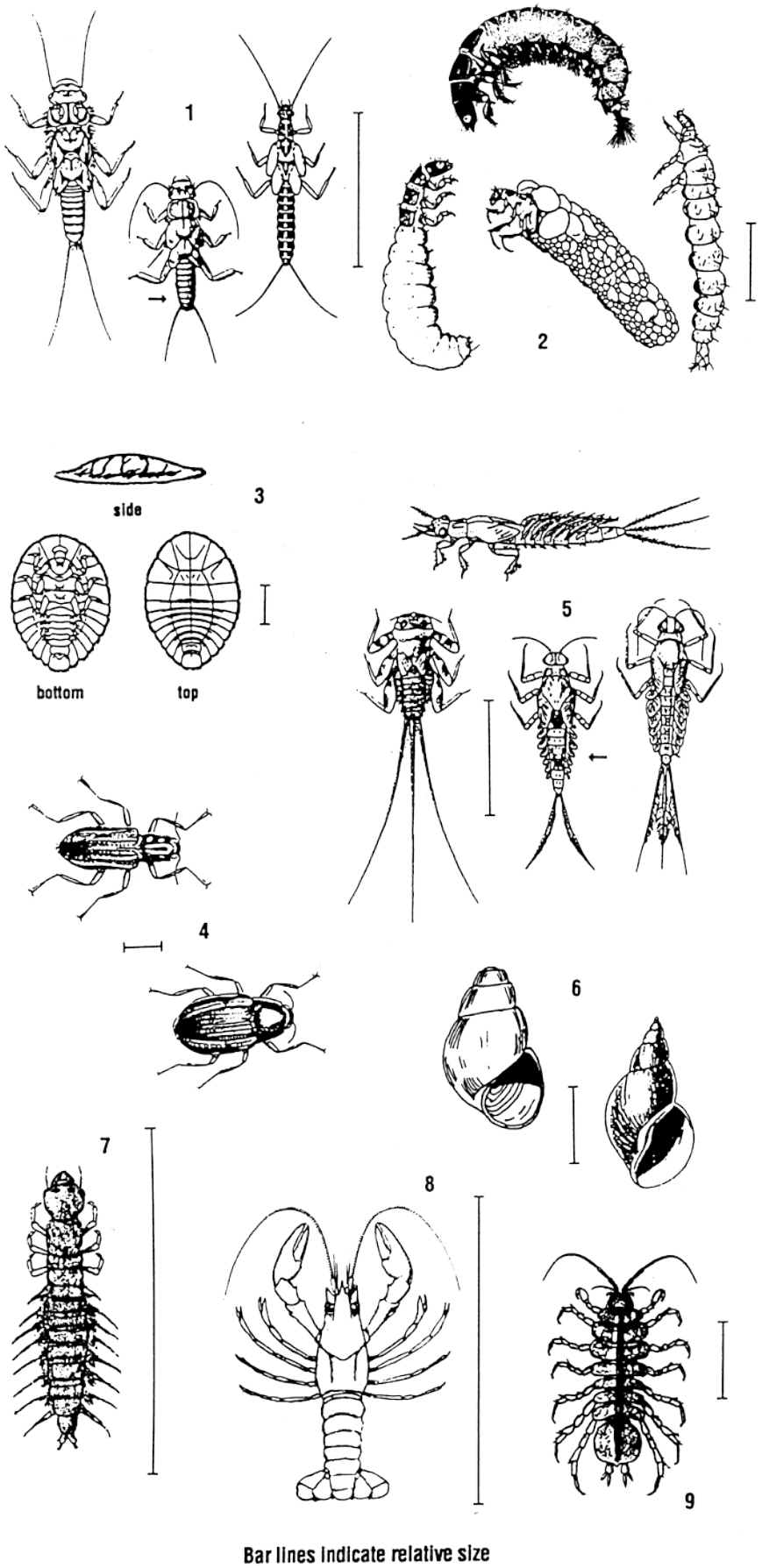


Figure 5. Stream Invertebrates. Source: Izaak Walton League of America, 707 Conservation Lane, Gaithersburg, MD 20878-2983. (800) BUG-IWLA

Group One Taxa: Pollution-sensitive taxa found in good quality water.

1 Stonefly Order Plecoptera. .5 to 1.5”, 6 legs with hooked antenna, 2 hairline tails. Smooth (no gills) on lower half of body (see arrow).

2 Caddisfly: Order Trichoptera. Up to 1", 6 hooked legs on upper third of body, 2 hooks at back end. May be in a stick, rock, or leaf case with head sticking out. May have fluffy gill tufts on under- side.

3 Water Penny: Order Coleoptera. 1/4", flat saucer- shaped body with a raised bump on one side and 6 tiny legs and fluffy gills on the other side. Immature beetle.

4 Riffle Beetle: Order Coleoptera. 1/4", oval body covered with tiny hairs, 6 legs, antennae. Walks underwater. Swims beneath surface.

5 Mayfly: Order Ephemeroptera. 1/4" to 1", brown, moving, plate-like or feathery gills on sides of lower body (see arrow), 6 large hooked legs, antennae, 2-3 long hair-like tails that ,may be webbed together.

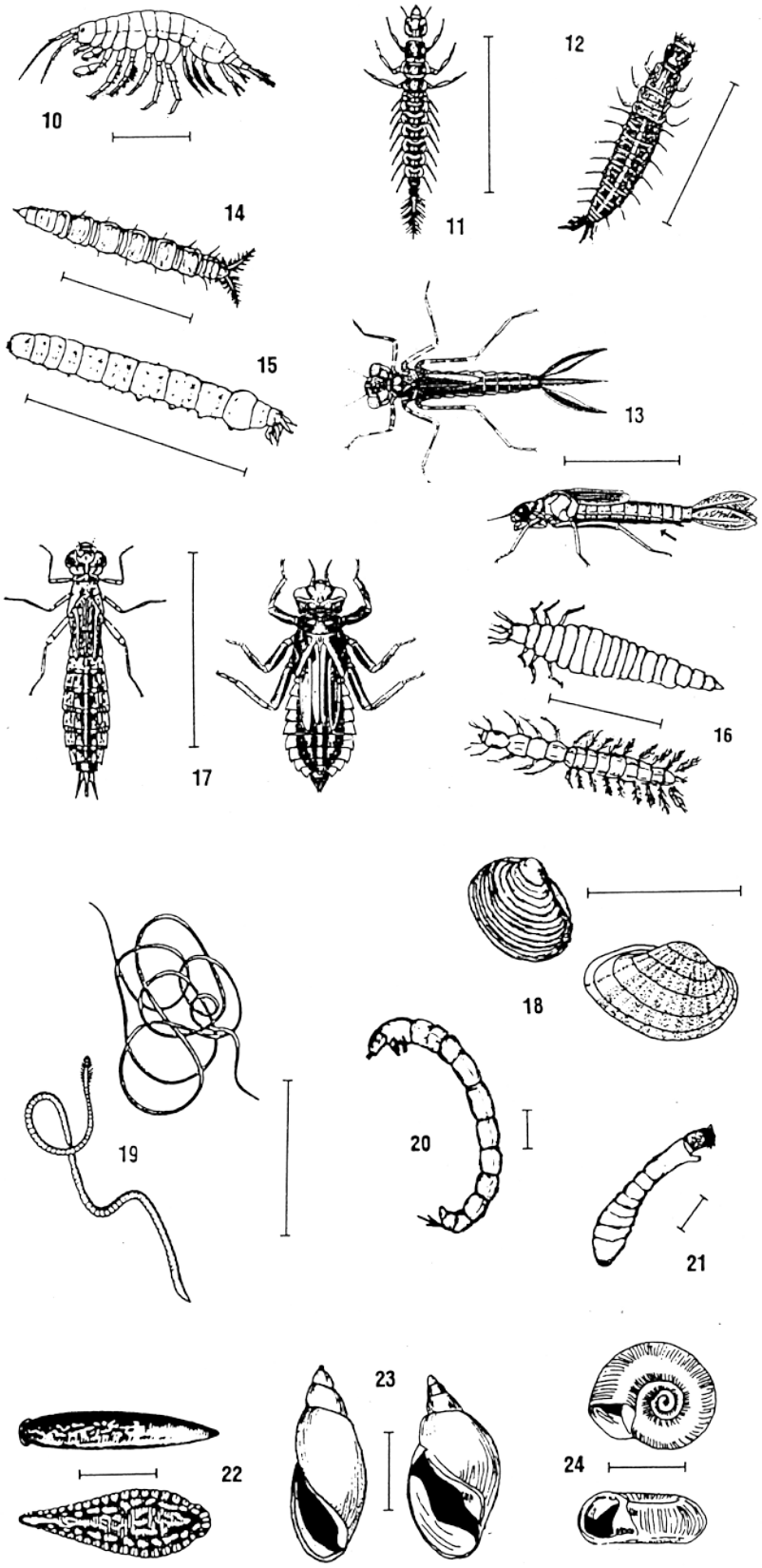
6 Gilled Snail: Class Gastropoda. Shell opening covered by thin plate called operculum. When opening is facing you, shell usually opens on right.

7 Dobsonfly (hellgrammite): Family Corydalidae. 3/4" to 4", dark-colored, 6 legs, large pinching jaws, eight pair of feelers on lower half of body with paired cotton-like gill tufts along under-side, short antennae, 2 tails, and 2 pair of hooks at end.

Group Two Taxa: Somewhat pollution tolerant taxa found in good or fair quality water.

8 Crayfish: Order Decapoda. Up to 6", 1 large claw, 8 legs, resembles lobster.

9 Sowbug: Order Isopoda. 1/4" to 3/4", gray oblong body wider than it is high, more than 6 legs, and long antennae.



Bar lines indicate relative size

Group Two Taxa (*Continued)*

10 Scud: Order Amphipoda. 1/4", white to gray, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp.

11 Alderfly Larva: Family Sialidae. 1" long. Looks like small Hellgrammite but has long, thin, branched tail at back end (no hooks), no gill tufts below.

12 Fishfly Larva: Family Cordalidae. Up to 1 1/2" long. Looks like small hellgrammite, but often light reddish-tan color, or with yellowish streaks. No gill tufts underneath.

13 Damselfly: Suborder Zygoptera. 1/2" to 1", large eyes, 6 thin hooked legs, 3 broad oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body (arrow).

14 Watersnipe Fly Larva: Family Athericidae (Atherix). 1/4" to 1", pale to green, tapered body, many caterpillar- like legs, conical head, and feathery "horns" at back end.

15 Crane Fly: Suborder Nematocera. 1/3" to 2", milky, green, or light brown, plump caterpillar-like segmented body, 4 finger-like lobes at back end.

16. Beetle Larva: Order Coleoptera. 1/4" to 1", light-colored, 6 legs on upper half of body, feelers, antennae.

17 Dragon Fly: Suborder Anisoptera, 1/2" to 2", large eyes, and 6 hooked legs. Wide oval to round abdomen.

18 Clam: Class Bivalvia.

Group Three Taxa: Pollution-tolerant organisms can be in any quality of water.

19 Aquatic Worm: Class Oligochaeta, 1/4" to 2", can be tiny, thin worm-like body.

20 Midge Fly Larva: Suborder Nematocera. Up to 1/4", dark head, worm-like segmented body, 2 legs on each side.

21 Blackfly Larva: Family Simulidae. Up to 1/4", one end of body wider. Black head, suction pad on other end.

22 Leech: Order Hirudinea. 1/4" to 2", brown, slimy body, end with suction pads.

23 Pouch Snail and Pond Snails: Class Gastropoda. No operculum. Breathe air. When opening is facing you, shell usually open to left.

24 Other Snails: Class Gastropoda. No operculum. Breaths air. Snail shell coils in one plane.

ELEMENT 14. Riffle Embeddedness

Description and Rationale for Assessing Riffle Embeddedness. *Embeddedness* measures the degree to which gravel and cobble substrates are surrounded by fine sediment. It relates directly to the suitability of the stream substrate as habitat for macroinvertebrates, fish spawning, and egg incubation. Riffles are areas, often downstream of a pool, where the water is breaking over rocks, cobbles, gravel, or other substrate material on the bed of a stream, causing surface agitation. Riffles are critical for maintaining high species diversity and abundance of insects for most streams and for serving as spawning and feeding grounds for some fish species. This element is sensitive to regional landscape differences and should therefore be related to locally established reference conditions. ***Do not assess this element unless riffles or swift-flowing water and coarse substrates are present or are a natural feature that should be present.***

Element 14. Riffle Embeddedness Scoring Matrix

Gravel or cobble substrates are <10% embedded.	Gravel or cobble substrates are 10-20% embedded.	Gravel or cobble substrates are 21-30% embedded.	Gravel or cobble substrates are 31-40% embedded.	Gravel or cobble substrates are >40% embedded.
10 9	**8 7**	**6 5**	**4 3**	**2 1 0**

What to look for:

- ☑ This element should be used only in riffle areas and in streams where this is a natural feature.

- ☑ The measure is the depth to which objects are buried by sediment. This assessment is made by picking up particles of gravel or cobble with your fingertips at the fine sediment layer. Pull the particle out of the bed and estimate what percent of the particle was buried.

- ☑ Some streams have been so smothered by fine sediment that the original stream bottom is not visible. Test for complete burial of a streambed by probing with a measuring stick. Does substrate move easily when you move the substrate around with your feet? If not, substrate material is likely > 40% embedded.

ELEMENT 15. Salinity (if applicable)

Description and Rationale for Assessing Salinity. The origin of *elevated* salinity levels in streams is often associated with irrigation of salt laden soils, dryland crop/fallow systems that produce saline seeps, oil and gas well operations, and animal waste. Salt accumulation in streambanks can cause break down of soil structure, decreased infiltration of water, and toxicity. High salinity in streams affects aquatic vegetation, macro-invertebrates, and fish. If observed impacts of salt are a product of natural weathering processes of soil and geologic material un-influenced by humans, this element should not be scored.

Element 15. Salinity Scoring Matrix

No wilting, bleaching, leaf burn or stunting of aquatic vegetation, no streamside salt-tolerant vegetation present that is not appropriate to the site; crusting, if present, is appropriate to site.	Minimal wilting, bleaching, leaf burn, or stunting of aquatic vegetation; some salt-tolerant streamside vegetation.	Aquatic vegetation may show significant wilting, bleaching, leaf burn, or stunting; dominance of salt-tolerant streamside vegetation.	Severe wilting, bleaching, leaf burn, or stunting; presence of only salt tolerant aquatic vegetation; most streamside vegetation is salt tolerant.
10 9 8	**7 6 5**	**4 3**	**2 1 0**

Do not assess this element unless *elevated* salinity levels caused by people are suspected.

What to look for:

- ☑ High salinity levels can cause a "burning "or "bleaching" of riparian vegetation. Wilting, loss of plant color, decreased productivity, and stunted growth are visible signs.

- ☑ Other indicators include whitish salt accumulations on streambanks and displacement of salt intolerant vegetation by species that are more tolerant.

Stream Visual Assessment Protocol
Summary Sheet

Owner's name _____ Evaluator's name_____

Stream name _____ Tributary to: _____ HUC: _____

1. Preliminary Assessment

A. Watershed Description:

Ecoregion or MLRA_____ Watershed Drainage area (acres or sq miles)_____

Watershed management structures: (no.): dams___ water controls _____ irrigation diversions_____

No. of miles of contiguous riparian cover/mile of entire stream in watershed (estimated)_____

Land use within watershed (%): cropland _____ hayland _____ grazing/pasture _____ forest ____

urban _____ industrial _____ other (specify) _____

Agronomic practices in uplands include _____

Confined animal feeding operations (no.) _____ Conservation (acres) _____ industrial (acres) _____

Number of stream miles on property_____ Number of total stream miles_____

Stream hydrology: _____intermittent; months of year wetted: _____

____ perennial; months of year at base flow: _____

B. Stream/Reach Description:

Stream Gage Location/Discharge: _____/_____cfs

Applicable Reference Stream: _____ Reference Stream Location: ____/_____

Information Sources:

2. Field Assessment

A. Preliminary Field Data:

Ecological Site Description (ESD) No./ Name_____

Date of Field Assessment_____ Weather conditions today_____
(ambient temp.\cloud cover

Weather Conditions over past 2-5 days: _____
(No. of days precip/average daytime temperature.)

SVAP2_AZ Start Time/Water Temp: _____/_____SVAP2-AZ End Time/Water Temp: _____/_____

Reach Location (UTM or Lat./Long.) _____/_____ Channel Type/classification scheme_____/___

Reach Length (12X bankfull width) _____

Riparian Cover Type(s) in Percent %: Forest____ Shrub ____ Herbaceous____ Mixed____ None____

Average Height of woody shrubs_____ft. Method used: _____

Average height of trees _____ ft. Method used: _____

Bank Profile: Stratified___ Homogeneous____ Cohesive Soil___ Non-Cohesive Soil ____

Gradient (√ one): Low (0-2%) ____ Moderate (>2<4%) ____ High (>4%) ____

Bankfull channel width _____ Floodplain width_____ Floodplain wetlands, if present acres)_____

Average riparian zone width _____ft. Method used (e.g., Range Finder):_____

Dominant substrate (%): boulder _____ (> 250 mm) cobble _____ (60-250mm) gravel _____ (2-60 mm) sand_____ (2-.06 mm) fine sediments _____ (< .06 mm)

Photo Point Locations and Descriptions:

Photo Pt. #	GPS Coordinates/Waypoints	Description
1		
2		
3		
4		
5		
6		

Notes:

B. SVAP2-AZ Scores (Score of 5 and greater meets minimum Quality Criteria)

Element	Score	Suspected causes of scores < 10	Primary Resource Concern(s)	Potential Practices to Improve score
1. Channel Condition			**Soil Erosion- Bank**	**332, 386, 393, 342, 528, 580, 584**
2. Hydrologic Alteration			**Excess / Inefficient Water; Insufficient Water**	**390, 391, 393**
3. Bank Condition			**Soil Erosion- Streambank; Water Quality – - Excessive Sediment**	**322, 332, 342, 390, 391, 395, 393, 580**
4. Riparian Area Quantity			**Degraded Plant Condition- Inadequate Structure/ and Composition; Inadequate Habitat for Fish and Wildlife**	**390, 391, 612, 657, 659, 580**
5. Riparian Area Quality			**Degraded Plant Condition- Inadequate Structure/ and Composition; Undesirable Plant Productivity and Health; Wildfire Hazard; Inadequate Habitat for Fish and Wildlife**	**314, 338, 390,391, 395, 643, 647**
6. Canopy Cover			**Degraded plant condition- Inadequate Structure; Inadequate Habitat for Fish and Wildlife**	**391, 612, 644**
7. Water Appearance			**Water Quality Degradation – Nutrients, Pathogens, Pollutants, Sediment**	**390, 528, 595, 657, 659**
8. Nutrient Enrichment			**Water Quality Degradation – Nutrients, Elevated Temperature**	**390, 528, 659**
9. Pools			**Inadequate Habitat for Fish and Wildlife**	**395, 659, 644**
10. Barriers to Movement			**Inadequate Habitat for Fish and Wildlife**	**396, 314, 500**
11. Fish Habitat Complexity			**Inadequate Habitat for Fish and Wildlife**	**395,734, 657, 659, 644**
12. Aquatic Invertebrate Habitat			**Inadequate Habitat for Fish and Wildlife**	**395, 580, 734, 644**
13. Aquatic Invertebrate Community			**Inadequate Habitat for Fish and Wildlife; Soil Erosion- Streambank**	**395, 580, 734, 644**
14. Riffle Embeddedness			**Water Quality Degradation – Sediment; Soil Erosion; Inadequate Habitat for Fish and Wildlife**	**322, 390, 528**
15. Salinity			**Water Quality Degradation – Salinity**	**390, 393**

A. Sum of all elements scored _____

B. Number of elements scored _____

Overall score: A/B _____ **Rating** _____

1 to 2.9 Severely Degraded	3 to 4.9 Poor	5 to 6.9 Fair	7 to 8.9 Good	9 to 10 Excellent

C. Site Diagram: indicate approximate scale, major features, resource concerns, etc.

Provide notes related to each element scored on back of site diagram, as needed

Glossary

Active channel width: The width of the stream at the bankfull discharge. Permanent vegetation generally does not become established in the active channel.

Active floodplain: That part of a floodplain that is frequently inundated with water.

Aggradation: Geologic process by which a stream bottom or flood plain is raised in elevation by the deposition of material.

Alluvial: Deposited by running water, such as sediments.

Bankfull discharge: The stream discharge (flow rate, such as cubic feet per second) that forms and controls the shape and size of the active channel and creates the floodplain. This discharge generally occurs once every 1.5 years on average.

Bankfull flow: discharge where water just begins to leave the stream channel and spread onto the floodplain. Bankfull flow is roughly equivalent to channel-forming (conceptual) and effective
(calculated) discharge for alluvial streams in equilibrium, and generally occurs every one to two years (on average).

Bankfull stage: The stage at which water starts to flow over the flood plain; the elevation of the water surface at bankfull discharge.

Baseflow: The portion of streamflow that is derived from natural storage of precipitation that percolates to ground water and moves slowly through substrate before reaching the channel. Baseflow sustains streamflow during periods of little or no precipitation and is the average stream discharge during low flow conditions.

Benthos: Bottom-dwelling or substrate-oriented organisms.

Boulders: Large rocks measuring more than 10 inches across.

Channel: With respect to streams, a channel is a natural depression of perceptible extent that periodically or continuously contains moving water. It has a definite bed and banks that serve to confine the stream's water.

Channel form: The morphology of the channel is typically described by (1) thread (single or multiple channels in valley floor), and sinuosity (amount of curvature in the channel).

Channel roughness: Physical elements of a stream channel upon which flow energy is expended including coarseness and texture of bed material, the curvature of the channel, and variation in the longitudinal profile.

Channelization: Straightening of a stream channel to make water move faster.

Cobbles: Medium-sized rocks which measure 2.5 to 10 inches across.

Confined channel: A channel that does not have access to a flood plain.

Concentrated flow: Undispersed flow, usually flowing directly from an unbuffered area of overland flow; concentrated flow generally contains sediments and/or contaminants from areas beyond the stream corridor.

Degradation: Geologic process by which a stream bottom is lowered in elevation due to the net loss of substrate material. Often called downcutting.

Detritus: Materials such as leaves, twigs, or branches that enter a stream from uplands or riparian areas.

Downcutting: See Degradation.

Ecoregion: A geographic area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.

Embeddedness: The degree to which an object is buried in steam sediment.

Emergent plants: Aquatic plants that extend out of the water.

Ephemeral stream: A stream with a channel that is above the water table at all times and thus carries water only during and immediately after a rain event.

Floodplain: The level area of land near a stream channel, constructed by the stream in the present climate, and overflowed during moderate flow events (after Leopold, 1994).

Flow augmentation: Artificially adding water to a stream channel with timing and magnitude that disrupts the natural flow regime. Examples include irrigation deliveries, trans-basin diversions, or wastewater from irrigated lands, treatment plants, or commercial facilities.

Fluvial: A feature of or pertaining to the action of moving water.

Forb: Any broad-leaved herbaceous plant other than those in the Gramineae (Poceae), Cyperacea, and Juncaceae families (Society for Range Management1989).

Gabions: A wire basket filled with rocks; used to stabilize streambanks and control erosion.

Geomorphology: The study of the evolution, process, and configuration of landforms.

Glide: A fast water habitat type that has low to moderate velocities, no surface agitation, and a U-shaped, smooth, wide bottom.

Gradient: Slope calculated as the amount of vertical rise over horizontal run expressed as ft/ft or as percent (ft/ft * 100).

Gravel: Small rocks measuring 0.825 to 2.5 inches across.

Habitat: The area or environment in which an organism lives.

Herbaceous: Plants with non-woody stems.

Hydrology: The study of the properties, distribution, and effects of water on the Earth's surface, soil, and atmosphere.

Hyporheic: Below the surface of the streambed, including interstitial spaces.

Incised channel: A channel with a streambed lower in elevation than its historic elevation in relation to the flood plain.

Intermittent stream: A stream that flows only certain times of the year, such as when it receives water from springs, groundwater or surface runoff.

Lateral migration: The adjustment of a stream channel from side to side often involving the recession of a streambank. In a braided river system, both streambanks may be recessing due to excessive channel filling and limited bedload transport capabilities, e.g. Photo 15.

Macrophyte bed: A dense mat of aquatic plants.

Macrotopography: Depositional features within a floodplain developed by water flow and greater than 6 inches than the average land surface of the floodplain.

Microtopography: Features within a floodplain developed by water flow and less than 6 inches than the average land surface of the floodplain.

Meander: A winding section of stream with many bends following the channel, that is at least 1.2 times longer than its straight-line distance. A single meander generally comprises two complete opposing bends, starting from the relatively straight section of the channel just before the first bend to the relatively straight section just after the second bend.

Macroinvertebrate: A spineless animal visible to the naked eye or larger than 0.5 mm.

Natural flow regime: the full range of daily, monthly, and annual streamflows critical to sustaining native biodiversity and integrity in a freshwater ecosystem. Important flow regime characteristics include natural variations in streamflow magnitude, timing, duration, frequency, and rates of change (see Poff et al. 1997 for further detail).

Nickpoint: The point where a stream is actively eroding (downcutting) to a new base elevation. Nickpoints migrate upstream (through a process called headcutting).

Oligotrophic: Having little or no nutrients and thus low primary production**.**

Perennial stream: A steam that typically flows continuously throughout the year.

Point bar: A gravel or sand deposit on the inside of a meander; actively mobile deposits.

Pool: Deeper area of a stream with slow-moving water.

Reach: A section of stream (defined in a variety of ways, such as the section between tributaries or a section with consistent characteristics).

Riffle: A shallow section in a stream where water is breaking over rocks, wood, or other partly submerged debris and producing surface agitation.

Riparian Areas: Riparian areas are transitional areas between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect waterbodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems.

Riprap: Rock material of varying size used to stabilize streambanks and other slopes.

Run: A fast-moving section of a stream with a defined thalweg and little surface agitation.

Scouring: The erosive removal of material from the stream bottom and banks.

Sedge: A grass-like, fibrous-rooted herb with a triangular to round stem and leaves that are mostly three-ranked and with close sheaths; flowers are in spikes or spikelets.

Stormwater runoff: overland runoff from a precipitation event not absorbed by soil, vegetation, or other natural means.

Substrate: The mineral or organic material that forms the bed of the stream; the surface on which aquatic organisms live.

Surface fines: That portion of streambed surface consisting of sand/silt (less than 6 mm).

Thalweg: The line followed by the streamflow and connects the lowest or deepest points along the bed.

Turbidity: Murkiness of water caused by particles, such as fine sediment and algae.

Water control structures: any physical feature located in or adjacent to a stream used to control the direction, magnitude, timing, and frequency of water for instream or out-of-stream uses. Examples include dams, pumps, water treatment or power plant outfalls, gated culverts, subsurface drains.

Watershed: A ridge of high land dividing two areas that are drained by different river systems. The land area draining to a waterbody or point in a river system; catchment area, drainage basin, drainage area.

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