5

Stream Assessment and Restoration

Guillermo Giannico, Derek C. Godwin, and Jim Waldvogel

It is no wonder that stream enhancement projects are popular; people have something to show for their work when they are finished. However, such projects frequently are expensive and require technical expertise. In many cases, they do not achieve their goals, but nobody notices because the project was not evaluated properly. Few stream enhancement projects include adequate post-completion monitoring of long-term performance.

Chapter III-4, "Stream Ecology," provided introductory information about stream ecosystems. This chapter covers stream assessments, stream restoration and enhancement, and monitoring plans.

Assessments can be thought of in two ways: as *inventories* or as *evaluations.* An inventory simply characterizes or identifies the physical, chemical, and biological features of a stream. An evaluation determines how well the stream is functioning, based on restoration goals. (See Chapter III-1, "Riparian Areas Functions and Management.")

Although the words *restoration* and *enhancement* often are used interchangeably, in this chapter they have different meanings. Restoration seeks to bring a stream or river to a self-regulating state by reestablishing watershed components and processes. Watershed *components* include hydrologic patterns, water quality, riparian

In this chapter you'll learn:

- How to assess streams
- How stream surveys are carried out
- Basic restoration and enhancement principles
- About the importance of monitoring and evaluation plans

forests, and habitats. Examples of watershed *processes*, or *functions*, include water chemistry and temperature modification, flow regulation, gravel retention, input of litter and wood from the riparian forests, accumulation of wood in the channel, etc. *Self-regulation* implies that the stream does not require the periodic intervention of humans to maintain a state of dynamic equilibrium. Examples of restoration goals might include improving water quality and aquatic habitats in a watershed or maintaining native species diversity.

See Section II, Chapters 1–5; and Section III, Chapters 1, 2, and 4 for information related to this chapter.

Section II

1 Planning

2 Hydrology

3 Stream Processes

4 Soils

5 Assessment

Section III

1 Riparian Functions

2 Riparian Enhancement

4 Stream Ecology

In contrast, enhancement implies a narrower set of goals, such as improving a specific set of stream conditions for the benefit of a particular species (e.g., steelhead trout) or type of habitat (e.g., spawning gravel beds). Often, enhancement is aimed at achieving a more immediate, but shorter lasting, effect than restoration. Enhancement activities tend to focus on a single issue such as reducing bank erosion or recruiting spawning gravel.

The term *preservation*, as used in this chapter, differs from both enhancement and restoration. While restoration addresses only degraded ecosystems, preservation attempts to prevent negative human-induced changes to intact ecosystems. It acknowledges that ecosystems change over time (e.g., riparian vegetation succession) and that management actions (e.g., prescribed upland fires, removal or control of invasive species, etc.) might be needed to maintain the system's functions and components.

Preserving intact ecosystems should represent the priority of any watershed-scale restoration plan. Preservation initiatives are important for several reasons:

- They often are easier to implement and less expensive than restoration and/or enhancement projects.
- Intact ecosystems are important sources of biological diversity.
- Intact ecosystems serve as models that resource managers can use in their restoration projects. Modeling restoration activities on nearby intact ecosystems is preferable to using handbooks.
- The success rate of protecting fully functional sites is far higher than that of restoring degraded ecosystems.

The role of *monitoring* activities in stream restoration and enhancement is briefly discussed at the end of this chapter. Monitoring evaluates the results of projects over time and helps determine whether the goals were achieved. For additional information on this topic, see Chapter II-5, "Assessment and Monitoring Considerations."

This chapter will help you understand the basic principles used in statewide stream restoration and enhancement programs (e.g., the *Oregon Watershed Assessment Manual* from the Oregon Watershed Enhancement Board). It also suggests field exercises and references for additional information and training.

WHY DO WE NEED STREAM ASSESSMENTS?

An assessment is the first step in establishing stream components and functions that provide maximum potential benefits to fish and other aquatic life, wildlife, and humans. A stream assessment can:

- Inventory existing components and functions
- Evaluate the state of stream components and how functions are working
- Recommend and prioritize projects or determine that restoration or enhancement is not presently needed

For example, assessments commonly are used to characterize a stream reach and its relation to the adjacent land, to evaluate fish habitat quality and quantity, or to estimate the abundance and distribution of fish.

BASIC COMPONENTS OF STREAM ASSESSMENTS

A stream assessment can identify the physical (stream channel), chemical (water quality), and biological (aquatic organisms) characteristics of a stream. These characteristics were described in Chapters II-2, “Watershed Hydrology,” and III-4, “Stream Ecology.” Table 1 (page 4) summarizes the basic components of stream assessments.

How this information is used to evaluate stream function and recommend changes depends on goals, local conditions, constraints, and possible incentives. (See Chapter III-1, “Riparian Area Functions and Management.”)

Stream assessments constitute the first step in any restoration plan. Assessments are most useful when conducted with a *watershed perspective*, thus taking into account upstream processes, which might affect the restoration project’s success. They must be sufficiently detailed to show the stream reaches or habitat units where restoration work is needed.

Preliminary field evaluations help identify:

- Reaches that are not degraded by human activities and might be worthy of preservation

Table 1.–Basic components of a stream assessment.

Stream channel	Biological	Water quality
Number and quality of habitat units (pools, riffles, glides, etc.)	*Fish population estimates (number of juveniles, spawning adults, etc.)	*Suspended sediment and bedload movement
Width, depth, and length of habitat units	Presence of different fish species	Turbidity
Streambed materials (gravel, cobble, boulders, sand, etc.)	*Abundance of fish utilizing available habitat	Stream temperature
Stream gradient (slope)	Number and type of macroinvertebrates	Dissolved oxygen
Relation of stream to its floodplain		pH
Single or multiple channel		Bacteria
Riparian condition and stream bank erosion		Nutrients (nitrogen, phosphorus, potassium)
Cover for fish (large wood, boulders, stream banks)		

*These components are more expensive and usually are obtained only by resource agencies.

- Reaches where restoration is feasible through changes in land-use practices or relatively low-cost projects
- Reaches where restoration is possible only at very high costs and where the chance of failure is high
- Reaches where restoration is not technically possible

CONSIDERATIONS WHEN CHOOSING AN ASSESSMENT

Assessments can be complex and labor intensive because they seek to capture the broad variety of watershed processes, land uses, climates, geologies, and other factors that affect streams. A combination of techniques that evaluate physical, chemical, and biological conditions is needed to characterize a stream.

There are different types of assessments; many are time-consuming and require specific technical skills. Choose an assessment that will work for you or your group, always taking into consideration your time, money, and access to technical expertise and training. Chapter II-5, "Assessment and Monitoring Considerations," provides additional information about the complexity of assessment.

It is recommended that you select assessments that gather information in an existing standard format. Doing so allows the information to be analyzed and used by many different stakeholders (e.g., state and federal agencies, private consultants, and other watershed groups). Such methods include the basic and advanced stream habitat surveys developed by the Oregon Department of Fish and Wildlife (ODFW), the water-quality assessment and monitoring techniques devised by the Department of Environmental Quality (DEQ), and the methods included in the *Oregon Watershed Assessment Manual* of the Oregon Watershed Enhancement Board (OWEB).

When selecting an assessment, the first step is to list the questions you want to answer. Then choose an assessment that collects adequate data to answer these questions. To simplify these steps, look for examples of the questions most common stream assessments answer and the type of data they gather. Chapter III-2, "Riparian Area Evaluation and Enhancement," discusses several considerations for designing riparian assessments. These considerations also apply to stream assessments.

Divide the stream to be assessed into manageable segments (i.e., *reaches*). This will give you more flexibility in using the data for planning projects and management changes. Streams can be divided into segments based on:

- Land use or management type
- Stream type (e.g., small versus large, flows year round versus seasonally)
- Valley type (e.g., wide floodplain versus steep canyon)
- Resource values (e.g., different types of fish or water use)

Using standard methods allows the information to be analyzed and used by many different stakeholders (e.g., state and federal agencies, private consultants, and other watershed groups).

EXAMPLES OF STREAM CHANNEL ASSESSMENTS

ODFW stream habitat surveys

Stream habitat surveys are designed to obtain basic information about fish habitat. The data collected will help identify “good” fish habitat to be maintained, “poor” fish habitat needing enhancement, and factors contributing to present habitat functions and conditions. The data also will help you establish monitoring programs and management plans.

The Oregon Department of Fish and Wildlife (ODFW) has developed a methodology for fish habitat surveys that is designed to be compatible with other stream habitat inventory and classification systems. It involves recording data about fish habitat units, amounts of large wood in the stream, and characteristics of the riparian area. These data are recorded on various forms.

This section describes the ODFW method and includes adapted excerpts from the *Ecosystem Workforce Project Curriculum* and *Methods for Stream Habitat Surveys*. Detailed survey techniques and definitions are found in *Methods for Stream Habitat Surveys* (see “References” section). Appendices A-1 through A-5 show the forms used for recording data. To obtain quality data with this survey, training and supervision by experienced personnel are required.

Stream fish habitat surveys are based on continuous walking surveys along major streams and tributaries in a watershed. Surveys move from a stream’s mouth (at the ocean, lake, or estuary) or its *confluence* (where it joins another stream) all the way to its *headwaters* (where it originates). This approach relies on visual observations and regular measurements to estimate fish habitat area and characteristics.

The data collected will help identify “good” fish habitat to be maintained, “poor” fish habitat needing enhancement, and factors contributing to present habitat functions and conditions.

Every stream is divided into sections called *reaches*. A reach is arbitrarily defined as a segment between tributaries or between two points marked by a change in valley and channel form, riparian vegetation, land use, or ownership. Reaches vary in length from approximately 1,500 feet to 5 miles. Data that describe channel form, valley form, valley width, streamside vegetation, land use, water temperature, stream flow, location, and other features used to define reaches are recorded on the Stream Reach form (Appendix A-1).

A fish habitat survey describes each reach as a sequence of *habitat units*. Each unit has relatively uniform slope, flow pattern, and substrate characteristics. This information is recorded on the Unit-1, Unit-2, Wood, and Riparian forms (Appendices A-2 through A-5). Habitat units are longer than the *active channel* is wide. (*Active* *channel width* is the distance across the channel at annual high flow. It can be recognized by bank slope breaks, high water marks, and changes in vegetation).

Unit-1 and Unit-2 forms

Information on stream habitat units is recorded on Unit-1 and Unit-2 forms (Appendices A-2 and A-3). The following are examples of the most common types of stream fish habitat units (for diagrams of these units see Appendix A-6):

- *Riffles*–shallow units where turbulent, fast water flows over submerged or partially submerged gravel and cobble. They usually have a 0.5 to 2 percent slope. Riffles offer habitat to many of the aquatic invertebrates used as food by salmon and trout. These gravel-rich units also provide prime spawning beds for salmon and trout, and juvenile steelhead and cutthroat use them as summer nursery habitat.
- *Rapids*–units characterized by swift, turbulent flow swirling around boulders and a slope that ranges from 2 to 8 percent. They may include chutes and small falls. Between 15 and 50 percent of the stream surface is covered by whitewater. Rapids normally do not sustain high fish densities, but young steelhead trout and resident cutthroat trout can be found in pockets of slow water velocity behind boulders and near the banks.
- *Cascades*–fast, turbulent flow with many hydraulic jumps, strong chutes, and eddies. They usually have a 3.5 to 10 percent slope. Whitewater normally covers 30 to 80 percent of the surface area of a cascade, and most of the exposed substrate is formed by boulders or bedrock bars. Cascades sometimes represent important natural barriers to fish migration. However, many salmonids are able to pass small step cascades at times of high water flows.
- *Falls*–single step cascades with a height ranging from a few feet to more than 100 feet. As with cascades, falls often are impassable to most fish. In some mountain streams, the formation of falls has isolated many small, distinctive populations of resident cutthroat trout since the end of the last glacial age some 10,000 years ago.
- *Glides* (or *runs*)–units of generally uniform depth along their entire length and relatively fast water flow with no surface turbulence. They tend to have relatively stable banks and, in the middle reaches of a watershed, a substrate dominated by gravel and sand. In floodplain reaches, however, they are deeper and have slower water velocities; as a result their substrate is finer, often formed by a thick layer of silt rich in organic matter.

Juvenile coho salmon and trout can be found in this type of habitat unit, provided water temperature and oxygen concentrations are within their tolerance range.

- *Pools*–units that normally have a water surface slope of zero (flat). They are shallower at both ends and have slow water velocity. The substrate of pools tends to be fine because their relatively slow-moving waters allow suspended particles to precipitate and accumulate in the deepest areas of the unit. Pool habitat is used predominantly by juvenile coho salmon and, to a lesser extent, by steelhead/rainbow and cutthroat trout. During periods of high flow (i.e., fall–winter in coastal watersheds and spring in interior ones), juvenile salmonids often seek shelter in off-channel habitat (i.e., lateral ponds, side channels, etc.) or in the deepest pools in the main channel. They especially favor pools that offer the best shelter from water currents. Examples include backwater and lateral scour pools.

  There are different types of pools. The most common ones are:

  - *Backwater pools*–units carved into one of the banks by eddies on the downstream side of structures such as boulder or logs. These pools tend to be shallow, with extremely low water velocity and a substrate dominated by sand and gravel.
  - *Lateral scour pools* (a.k.a. corner or side pools)–units that are deeper on one side than the other. As water moves around the outside of a channel bend or a partial obstruction, it speeds up. Thus, during high flows, it digs deeper into the substrate near the “outside” bank.
  - *Straight scour pools*–units formed by scouring of the gravel/cobble substrate in the middle of the channel.
  - *Trench pools*–long, central, and relatively narrow slots carved in the substrate, often found in bedrock-dominated channels. They tend to have a U-shaped cross-section.
  - *Plunge pools*–units created by water passing over a complete or near complete channel obstruction and dropping vertically into the channel below. They tend to sustain high densities of juvenile salmonids, possibly because their depth and water surface turbulence provide protection from bird predation.
  - *Dammed pools*–units formed by water dammed behind some kind of channel obstruction, such as a cluster of boulders or debris jam. These pools can be natural or created by beavers or humans.

Surveyors collect and record the following information for each fish habitat unit:

- Channel form (length, width, slope, and depth measurements)
- Streambed materials or substrate composition (size class and percent distribution)
- Boulder counts (number of boulders protruding above the water surface at low flow)
- Woody material (amount, size, and complexity, particularly as it influences fish habitat)
- Exposure of the stream to the sun (denoted as “shade left” and “shade right” on the data form)
- Stream bank characteristics (tendency to erode and amount of undercut banks)

Wood and riparian forms

The wood inventory estimates the volume and distribution of large wood in the stream reaches. *Large wood material* is defined as wood greater than 6 inches in diameter and longer than 10 feet. (Root wads do not have to meet the length criteria.) The wood is counted and measured, and its location and configuration are recorded on the wood form (Appendix A-4).

The riparian inventory is designed to provide additional information about the kinds, quantities, and sizes of riparian vegetation. Measurements are taken along a line (*transect)* to describe vegetation, land surface and slope, and canopy closure in the riparian zone. For example, a transect across a stream channel is used to indicate where water velocity, substrate composition, or other indicators are recorded. A transect in the riparian zone normally is set perpendicular to the stream channel and is used as a guide to where vegetation, soil, and other samples or measurements are taken. All of these data are entered on the riparian form (Appendix A-5).

Note: If your main goal is related to the riparian area, a survey more specific to vegetation is needed. (See Chapter III-1, “Riparian Area Functions and Evaluation.”)

From survey to assessment

Stream survey information allows fish habitat and channel structure evaluations as well as comparisons among streams. It also helps locate potential problems, enhancement sites, and unique features.

Habitat unit descriptions indicate fish habitat potential (spawning, rearing, and cover habitat) and habitat components that are missing. For example, stream bank classification and riparian forms indicate channel stability, sediment sources, and riparian conditions influencing in-stream habitat. Large wood forms describe how much large woody material is actively influencing habitat or might be available in the future.

OWEB's Oregon Watershed Assessment Manual

Two chapters of the OWEB's *Oregon Watershed Assessment Manual* describe techniques for evaluating physical stream characteristics. They are: *Channel Habitat Type Classification* and *Fisheries Assessment*. The following section includes excerpts from these chapters.

Channel Habitat Type classification

OWEB has developed basic channel types for Oregon streams called Channel Habitat Types (CHT). This classification system is designed to help identify which parts of a watershed have the highest potential for fish utilization and how various channel types respond to land-use impacts or restoration efforts. This information, in turn, will help you prioritize restoration projects that are likely to benefit fish habitat the most. The assessment utilizes and complements Oregon Department of Forestry stream classification maps and ODFW's stream habitat information.

CHTs are organized on a valley segment scale. Examples are illustrated in Figure 1. CHTs are defined by channel gradient (slope), channel pattern, degree of valley constraint and, in some cases, stream size. Stream size is considered primarily because the role of woody debris differs in small and large streams.

Other information used to describe CHTs includes the ratio between valley width and active channel width, the position of the channel within the drainage network, and the gradient of the confining side slopes. Finally, field measurements that further describe CHTs include the degree of entrenchment or depth of the channel, the nature and size of the materials making up the channel banks, and the size of particles on the streambed.

CHTs are identified and mapped using U.S. Geological Survey Department (USGS) topographic maps and aerial photos. Field visits help verify CHTs that are difficult to characterize or identify based on maps and photos. The OWEB's *Oregon Watershed Assessment Manual* provides the following information for each CHT:

- Physical description
- Fish utilization information
- Riparian management considerations
- Riparian enhancement and channel restoration options

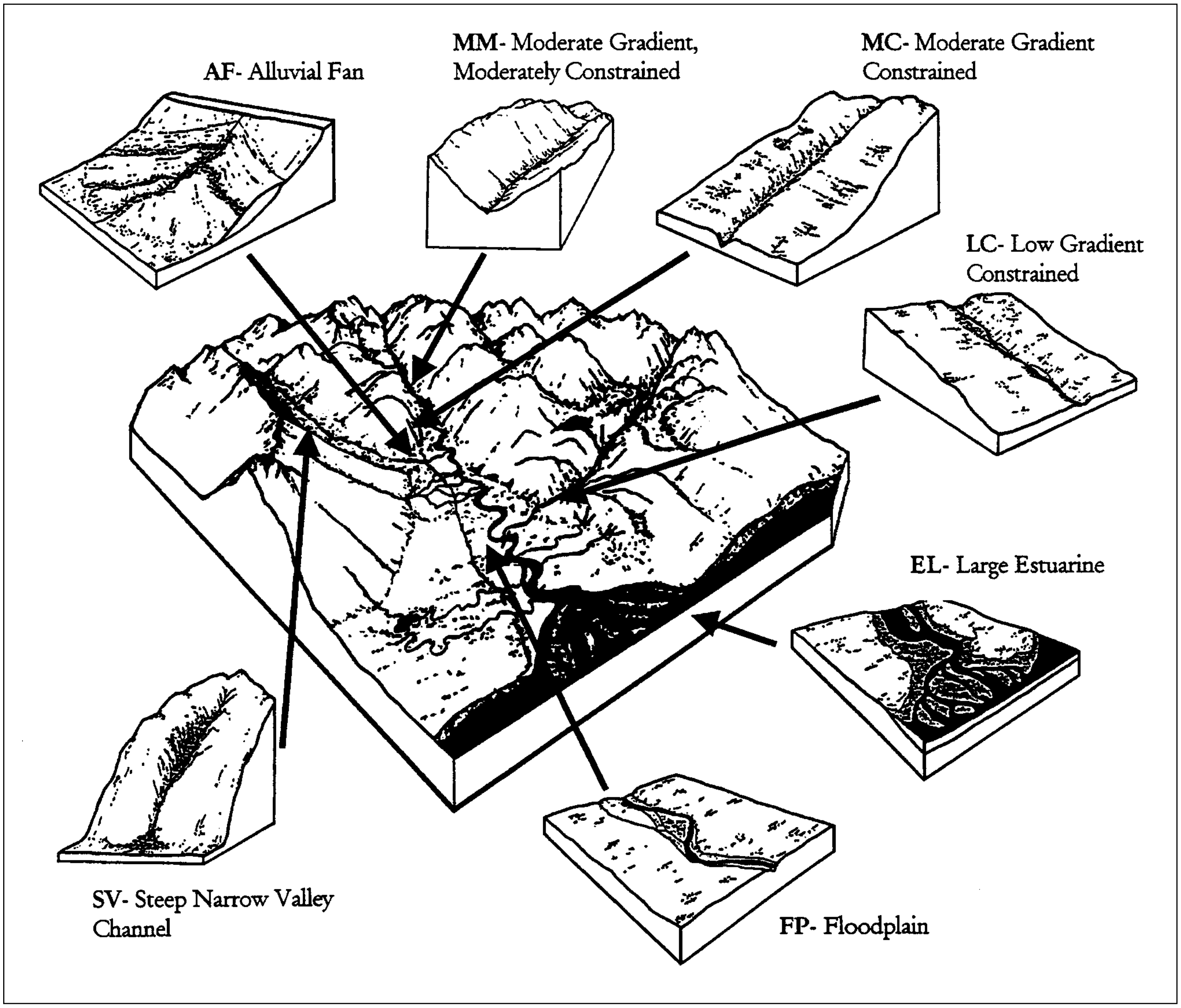


Figure 1.–Channel habitat type descriptions. (Source: Oregon Watershed Assessment Manual, *Oregon Watershed Enhancement Board, Salem, 1998)*

Fisheries assessment

This assessment is designed to:

- Identify fish species present in the watershed, their distribution, and population characteristics
- Identify potential interactions between species of interest
- Compare measured habitat data to preestablished ODFW/ NMFS (National Marine Fisheries Service) benchmarks to evaluate in-stream habitat functions and components
- Identify human-caused barriers to fish passage and prioritize their removal or modification

An example of a form used for compiling and evaluating habitat conditions is included in Appendix B.

ASSESSMENTS OF STREAM BIOLOGICAL CHARACTERISTICS

Macroinvertebrate surveys

Macroinvertebrates are those invertebrates that can be observed easily without magnifying equipment. They often are abundant and diverse in streams. Their habitat units are much smaller than those of fish. For example, a macroinvertebrate might spend much of its life on a single piece of bark or patch of leaf litter. There can be 30–100 different species in a single pool or riffle, and their total numbers often reach several hundred in a square foot of stream substrate.

Invertebrates vary a great deal in their sensitivity to sedimentation, oxygen levels, and other disturbances. Some species readily reoccupy areas that have been disturbed. Thus, invertebrates serve as good indicators of changes in streams and often are used to indicate responses to a wide array of human activities. The DEQ has specific protocols for sampling macroinvertebrates and using their relative abundance and diversity to evaluate stream conditions (i.e., water quality and fish habitat).

Surveys classify macroinvertebrates in different ways, but most classifications are based either on how different species obtain their food or how tolerant they are of water pollution and changes in oxygen concentration.

According to their feeding habits, macroinvertebrates can be sorted into four feeding groups: shredders, collectors (which either filter the water for food or gather food particles from the substrate), scrapers (or grazers), and predators. Chapter III-4, "Stream Ecology," provides additional information on these groups and the roles they play in a stream ecosystem.

Insects with exposed gills (particularly mayflies, stoneflies, and caddisflies) generally are intolerant of low oxygen levels, high temperatures, and high levels of suspended silt. Their presence is a good indicator of high water quality and good habitat conditions. Stream degradation tends to result in reduced populations of these species.

The following section provides an overview of how to survey macroinvertebrates and how to use the resulting information. However, additional training is needed to apply these techniques effectively. The methodology described was obtained from *Field Procedures for Analysis of Functional Feeding Groups of Stream Macroinvertebrates* (see "References"). Many agencies (e.g., DEQ), institutions, and private organizations have adapted these procedures for their own use.

General sampling methods

The best times to conduct macroinvertebrate surveys are midwinter through early spring or mid to late summer. At these times, individuals in the winter or summer populations have grown to full size and are easy to observe. Invertebrates usually are collected from three to five of the following habitat types:

- Coarse particulate organic matter, such as leaves, needles, bark, and twigs (>1 mm in size)
- Large wood, large branches, and logs
- Fine particulate organic matter (between 0.5 um and 1 mm)
- Periphyton (the thin layer of algae that is attached to the surface of the stream substrate, submerged rocks, and wood)
- Rooted plants (only if extensive plant beds or moss cover is present)

To do a macroinvertebrate survey, surveyors collect a handful-size sample from each habitat type. All sample areas should be the same size, approximately 1 square foot, to make comparisons among sites possible.

Sampling of invertebrates from the stream's substrate relies on the use of *kick nets* (fine mesh nets shaped like "butterfly nets" with rectangular mouths supported by wooden or metallic frames). A net is placed on the downstream edge of the sample area with its opening facing into the flow. All stones and debris within the sample area are brushed or rubbed gently by hand to loosen the substrate invertebrates, which are swept into the net by the water current. The net is turned inside out and gently rinsed in a bucket half full of stream water. All macroinvertebrates are subsequently picked and sorted according to some classification system.

The sampled macroinvertebrates are classified by feeding group, sorted into separate containers (ice cube trays work well), and counted. Appendix C provides a key to feeding (or functional) groups and a sample sheet for recording data.

After counting individuals, the next step is to compare total numbers in each group and calculate proportions of one group to another. Differences in the proportional representation of the feeding groups can be used to characterize stream habitat. Changes in these proportions over time are useful indicators of possible habitat alterations.

From survey to assessment

Macroinvertebrate surveys are used to assess water quality and fish habitat. Combining macroinvertebrate surveys with physical habitat and water-quality analyses results in a very thorough examination of stream functions. For example, a small stream with few trees in the riparian area will have a different shredder/collector ratio than a stream with many riparian trees. A stream reach dominated by riffle habitat will have different ratios than another stream reach with more pool habitat. A stream with poor water quality will have fewer organisms, and of different types, than a system with good water quality. Contact DEQ for specific examples and assessment protocols.

Fish population surveys

When assessing stream components and functions, it is important to consider fish. Fish population surveys identify and estimate fish resources. Salmonids have different life-cycle patterns; therefore, choose sampling techniques that are appropriate for the species or life stage you plan to sample. See Chapter III-4, “Stream Ecology,” for more information about salmonid life cycles.

All fish sampling and data collection must be approved by and coordinated through a local ODFW biologist. The listing of many salmonid populations under the Endangered Species Act requires permits from the National Marine Fisheries Service (NMFS) and/or U.S. Fish and Wildlife Service (USFWS) to conduct fish surveys.

Fish population surveys document populations in a specific tributary or watershed. Depending on your objectives, the following information might be necessary for evaluating fish populations:

- Presence or absence of species
- Spawning area distribution
- Species composition
- Relative abundance (i.e., the number of adults or juveniles)
- Timing of spawning or of juvenile migration
- Upper and lower limits of fish distribution in the watershed

The techniques you choose depend on what type of information you need. The simplest survey might consist of noting whether a species is present in a particular stream, whereas a more exhaustive examination might require a comprehensive analysis of a fish population in the entire watershed. Surveys might entail researching existing information and/or collecting new data.

You can obtain much of the information you need without capturing fish, in other words by using *noncapture* techniques. Use these techniques whenever possible because capture techniques might stress, injure, or kill fish.

Noncapture techniques

Noncapture techniques can be used to document what fish are present, how many are present, and how they are using certain habitats during different life stages. These techniques are categorized as *stream bank* (above water) or *direct* (underwater) observations. Examples of stream bank observation are:

- Visual spawning counts–number of live adults, carcasses, or redds (groups of nests) in a survey area
- Visual verification of the presence or absence of juvenile or adult fish
- Surveys of existing sport fishery catches (*creel census*)
- Photographic or video surveys
- Hydroacoustics (the use of systems such as sonar or acoustic tags to monitor fish movement)

Spawning counts are used to create an *index of escapement* (the number of adult fish that *escaped* fishing and returned to spawn in a defined survey area). These surveys provide good population estimates when conducted over a period of many years.

Spawning data are collected by counting live fish, carcasses, redds, or combinations of all three. Most spawning surveys of coho and chinook salmon use live fish and carcass counts. Redd counts commonly are used for steelhead since these fish return to streams over a rather extended spawning season, and many of them survive spawning and migrate back to the ocean. Appendix D shows the proper procedure for conducting a valid spawning survey on small coastal streams.

Walking stream banks during summer low flow conditions is a good way to verify the presence or absence of fish. Juvenile fish can be observed in small streams using polarized glasses. However, it can be difficult to identify specific species of juvenile fish from the bank.

Direct underwater observation is a common technique to identify species, estimate numbers, or determine how different species and ages are utilizing a variety of habitats. Experienced divers can quickly identify and count juvenile and adult fish. Underwater observations usually are conducted in pools and glides, not in riffles. This technique requires snorkeling equipment, a wet or dry suit, and trained divers.

Where sport fisheries exist, some methods of creel census are utilized. These surveys randomly sample sport angler catches. They are useful for identifying species and ages of fish, or for gathering return data for marked hatchery fish. Volunteer samplers and

Fish sometimes die during collection or after being captured; therefore, it is important to choose the proper technique.

experienced biologists can collect data from large river sections using this method.

Photographic or video observations are used to identify species or count migratory fish. They frequently are used at fish ladders or other passage restrictors (traps, tunnels, or culverts). These techniques require technicians and expensive equipment.

Fishery researchers sometimes use hydroacoustic tracking methods. Sophisticated equipment is required, and technicians are needed to operate it.

Capture techniques

Fishery biologists use several types of *capture* techniques to gather detailed information about fish populations. (See *Methods for Stream Habitat Surveys* in the “References” section.) These methods involve capturing, handling, sometimes marking, and releasing fish. Fish might be stressed, injured, or killed during collection or while captured. Therefore, it is important not only to choose the proper capture technique for the species and life stage being sampled but also to be careful in handling the fish.

Capture techniques include seining, trapping, electrofishing, and sport fishing. All of these methods require permits from ODFW.

Seining is a standard fish surveying technique. Seining is a simple and safe technique that, if used properly, does not cause fish mortality.

Beach seining (which requires boat assistance to extend and close the net) can be used in estuaries and large rivers to monitor fish growth and movement. Small mesh seines catch juveniles, which then are measured and identified. Seining also can be used to capture adults in the lower river for tagging and migration studies.

Pole seining is used to catch juvenile salmonids in streams that are shallow enough to be waded. Two people use a 10- to 30-foot long net with each end attached to a 6- to 8-foot long pole. The poles are used to handle the net and maneuver it around in-stream structures.

Traps and *weirs* can be used to capture adult or juvenile fish and to monitor their movements. Minnow traps (small wire mesh cylindrical baskets with funnel-shaped openings at each end) are used to catch small fish. If properly baited and placed, they can be very effective at catching juvenile salmonids. Fixed pipe traps and floating screw traps are used in tributaries or small rivers to monitor the out-migration of smolts. Weirs (or guiding in-stream fences) and slot traps are used together to capture up-migrating adults or out-migrating smolts. The effectiveness of traps depends on flow conditions. The downside of this technique is that traps might be washed downstream during high flow events.

Electrofishing is used to estimate populations of juvenile salmonids. Fish are stunned by electrical current and netted before they recover. Fish are released after species and length data are collected. Only experienced fish biologists with permits can use this technique. Electrofishing is dangerous (water is a good conductor of electricity), and fish mortality can be high if not done properly.

Sport fishing techniques can be used in isolated areas where juvenile fish exist and identification from the bank is difficult (e.g., riffles, waterfalls, or deep pools). Lure and fly-fishing gear catches most juvenile salmonids. However, fishing tends to catch fish of a certain size, and success depends on season and water clarity.

The following publications contain detailed explanations of proper procedures for stream fish surveys:

- *How to Do Spawning Fish Surveys* (Salmon Trout Enhancement Program (STEP), Oregon Department of Fish and Wildlife). See Appendix D.
- *California Salmonid Stream Habitat Restoration Manual*, Chapter IV (California Department of Fish and Game, 1994)
- *Fisheries Techniques*, by L. Nielsen and D. Johnson (American Fisheries Society, 1983)
- *A Review of Capture Techniques for Adult Anadromous Salmonids*, Information Report 96-5 (Oregon Department of Fish and Wildlife)

WATER-QUALITY ASSESSMENTS AND MONITORING

Water-quality assessments and monitoring are discussed in Chapter III-8, "Water-quality Monitoring."

STREAM RESTORATION AND ENHANCEMENT

Although the terms restoration and enhancement often are used interchangeably, they do not necessarily mean the same thing. It is important to understand the distinction between them because they imply very different goals. The main goal of *restoration* activities is to reestablish self-sustaining natural processes among the aquatic, riparian, and terrestrial ecosystems.

Restoration reinstates essential *stream components* (e.g., large in-stream wood, riparian vegetation) and *processes* or *functions* (e.g., water temperature and flow regulation, gravel retention, riparian forest regeneration, etc.). Thus, it brings the system to a self-regulating state that maintains channel stability, fish habitat, and water quality among other things. A restored system does not require periodic human intervention (e.g., log placement or gravel addition).

Restoration can be *passive* or *active*. It is passive when it merely entails halting human activities causing degradation or preventing recovery. For example, riparian vegetation might recover after human-caused disturbances stop. This vegetation usually can cope with natural disturbances such as fires, landslides, and floods, but is not able to deal with the intensity and/or frequency of human-induced changes.

Passive restoration sometimes is insufficient because of other influences on the stream system. For example, the elimination of beavers, introduction of reed canarygrass or bull frogs, or flow regulation by dams might prevent a stream from returning to a state of dynamic equilibrium. (See Chapter II-2, “Watershed Hydrology.”) Under such circumstances, *active* restoration can be considered. Active restoration includes the reintroduction of animal or plant species that have been eliminated from the area, the control of invasive species, the placement of in-stream logs, flow-release plans that emulate natural flow regimes, etc.

Remember that the main goal of restoration is to restore a system that can function without human management.

In contrast, the main goal of *enhancement* activities is to improve a particular condition for the benefit of a species or type of habitat.

Due to their tendency to focus on one species or on a particular habitat component, enhancement activities run the risk of creating unnatural conditions in the stream system. For example, certain in-stream structures, such as rock current deflectors, have been used with the objective of protecting banks and enhancing salmonid habitat. However, these structures can have a negative impact on sediment transport, bank erosion processes, and the hydrologic connection between the stream and riparian vegetation. When boulders are piled against a stream bank, conditions might no longer be suitable for the natural establishment of riparian vegetation nor for channel adjustments to accommodate natural variation in sediment transport and stream flow.

From a watershed perspective, enhancement projects represent short-term fixes. They are justifiable, however, for very specific goals in stream reaches where restoration is not possible. These projects must be engineered appropriately and take into consideration the system’s hydrology and channel characteristics.

Prioritizing projects

Restoration work often is driven by opportunity when working with private landowners. However, it is very important to develop watershed-scale strategic plans to identify priority stream reaches and actions that maximize the benefits from restoration efforts.

When developing restoration plans for a watershed, keep in mind that the best results likely will be obtained in stream reaches identified as having rapid recovery capacity. Only after these types of reaches are improved should efforts be directed toward reaches showing a low recovery capacity. In such areas, in addition to determining the causes of degradation, it is most useful to identify the reasons behind the lack of recovery (e.g., changes in species composition, altered hydrology, etc.).

There are many areas where stream restoration is not economically, socially, or technologically possible (e.g., urban areas, dredged mine sites, etc.). In these types of scenarios, stream enhancement work can be very useful, particularly if it diminishes harm to downstream riparian and aquatic ecosystems.

Urban streams, because they often lie in valley floors or low-gradient areas, sometimes provide critical fish habitat. Although they are not likely to be fully restored, some enhancement projects might successfully create fish habitat. However, the ecological benefits of many projects are dwarfed by the negative impacts of thousands of acres of pavement, thousands of cars polluting the air and roads, thousands of gardens treated with a battery of chemicals, and storm runoff washing everything into ditches, creeks, streams, and rivers. In this context, one of the important aspects of urban aquatic enhancement projects is their visibility and public education value. Therefore, their importance should not be underestimated, and their potential contribution to raising public awareness about streams and fish habitat always should be evaluated.

Remember that no stream enhancement project will succeed if upland and riparian conditions influencing the stream are not addressed first. To maximize project success, a multidisciplinary approach is recommended. Obtain technical guidance from hydrologists, fish biologists, engineers, geologists, etc. See Chapters II-2, “Watershed Hydrology,” II-3, “Stream Processes,” II-4, “Watershed Soils, Erosion, and Conservation,” and III-1, “Riparian Area Functions and Management,” for more information.

All projects require consultation and permits from regulatory agencies. Contact your local ODFW or Oregon Division of State Lands office for information. The NMFS and the state are developing an *Oregon Aquatic Habitat Restoration Guide* under the Oregon Plan. These guidelines must be followed to get relief from

Remember that no stream enhancement project will succeed if upland and riparian conditions influencing the stream are not addressed first.

Section 9 taking prohibitions under the Endangered Species Act, where applicable.

Examples of stream restoration projects

Stream rewatering and livestock management

The two most common examples of successful passive restoration in the western United States are the rewatering of streams after years of excessive withdrawal for agricultural or municipal purposes and the adequate management of livestock in riparian zones.

Livestock grazing is one of the most important land uses affecting riparian zones. These areas, because of their relatively high plant productivity and close proximity to water, are preferred by livestock and tend to be overgrazed. Overgrazing of riparian zones causes:

- Loss of riparian vegetation
- Alterations to channel morphology and stream banks
- Soil compaction
- Lowering of the water table
- Reduction of summer stream flows
- Water pollution
- Increased summer water temperatures
- Increased winter icing

All of these changes have a negative effect on wildlife, fish, and other aquatic organisms. For additional information, see Chapter III-3, "Livestock and Forage Management in Oregon Riparian Areas," "The effects of livestock grazing on Western riparian and stream ecosystem," and "Range ecology, global livestock influences." (See "Resources.")

Combining the return of permanent in-stream flows with the end of riparian grazing has resulted in the relatively fast recovery of riparian and in-stream habitats.

Combining the return of permanent in-stream flows with the end of riparian grazing has resulted in the relatively fast recovery of riparian and in-stream habitats. The Mono Basin in California and McCoy Creek in eastern Oregon are good examples. Field reviews of fish habitat restoration and enhancement projects in eastern Oregon have clearly indicated that preventing livestock overgrazing of riparian areas is the single most effective approach to naturally restoring salmonid habitats. See "Field review of fish habitat improvement projects in the Grande Ronde and John Day river basins of eastern Oregon" and "Fish habitat improvement projects in the Fifteenmile Creek and Trout Creek basins of central Oregon: Field review and management recommendations." (See "Resources.")

Barriers to fish passage

Projects that remove barriers to fish passage might easily make miles of good-quality habitat available to fish. These projects are good examples of active restoration.

The assessment of barriers to fish passage is very important because salmonids migrate both upstream and downstream. Resident salmonids (e.g., rainbow, cutthroat, and bull trout), as well as other fishes (e.g., suckers), make extensive seasonal migrations in search of spawning or winter habitat, food, and suitable water quality.

Wherever barriers occur, fish can no longer access needed resources. As a result, their survival and the viability of their populations might be compromised. In many watersheds, fish populations are reduced by the simple inaccessibility of many miles of spawning or nursery habitat.

Many streams contain small dams or other artificial barriers that do not provide adequate fish passage. Fish passage is a major concern at stream–road crossings. In the past, road culverts were installed with little consideration for fish migrations. Hence, thousands of miles of valuable fish habitat are off-limits to migratory species because of street, highway, or logging-road crossings.

Culverts can create barriers to fish migration in the following ways (Figure 2, page 22):

- A steep slope or a small culvert results in water velocity that is too fast for the fish to swim against.
- There is no pool below the culvert where fish can jump and rest, so they cannot make it into the culvert.
- There is no resting pool above the culvert, so the fish are washed back downstream.
- Water in the culvert is so shallow during low flows that fish cannot swim through it.
- The culvert is so high above the stream that fish cannot jump into it.

One or more of these conditions can prevent fish upstream movement. It is not always clear whether a culvert is affecting fish passage. Some culverts become velocity barriers during high flows, but allow fish to swim upstream easily during low flows. Other culverts are not deep enough during summer low flows, but are adequate during higher flows. For these reasons, it is important to know the species of fish that occur in a watershed and when they tend to migrate in order to evaluate the impact of culverts on migration.

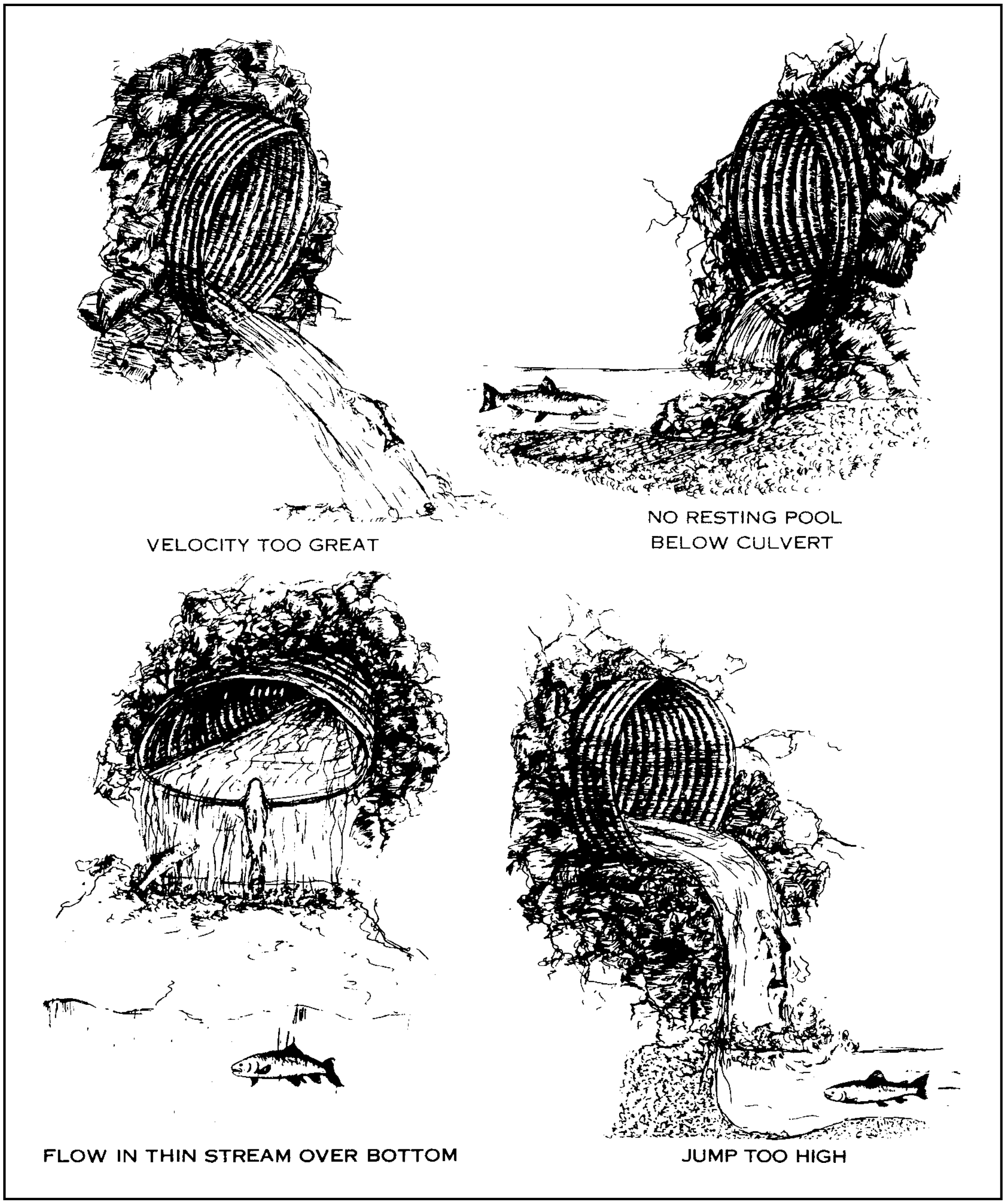


Figure 2.–Culvert installations that block fish passage.

The ability of fish to jump and swim against strong flows depends on species, body size, and how long the fish have been migrating. In general, adult steelhead trout and chinook salmon jump the highest and have the swiftest short-term burst speeds among salmonids. Chum salmon are not very agile jumpers and sometimes try to find a way through or underneath barriers rather than going over them.

ODFW allows a maximum jump height of 12 inches for adult salmon and steelhead and 6 inches for adult cutthroat trout, adult kokanee, and juvenile salmonids of all species. The minimum recommended resting pool depth is 1.5 times the jump height. When flows are too fast, wider bottomless culverts might solve the fish passage problem. When the jump is too high, a fish ladder might be needed.

Appendix E-1 summarizes basic criteria for determining fish passage based on guidelines provided in ODFW's *Interim Fish Passage and Culvert/Bridge Sizing Guidance for Road Crossing.* Appendix E-2 provides a copy of ODFW's Culvert Evaluation Form. The guidelines and evaluation form will help you determine the status of culverts you encounter while assessing streams.

If cost is not a constraint, replace culverts with free-spanning bridges. However, this is not always possible. The following two options often are used to improve fish passage through culverts: open-bottom culverts and oversized culverts. Open-bottom culverts have the shape of an inverted U or arch, and their bottom is that of the natural stream. Open-bottom and regular culverts should be oversized to avoid constraining flow during periods of high discharge. Their width should be at least two-thirds of the bankfull width.

As a temporary fix, culverts often are fitted with baffles (winglike structures attached to the walls and bottoms of culverts) to allow upstream fish migration. Because baffles reduce the capacity of the culvert to pass water, it is important to determine whether the culvert still will be able to accommodate the highest water discharges. There are several types of baffles, but all are designed to reduce water velocity and increase water depth in culverts.

Stream channel restoration

The active restoration of stream channels to a predisturbance state is a big challenge. However, there are examples of fish habitat restoration in uniform stream reaches using riffle–pool sequences and/or rebuilding the natural channel configuration. A channel reconfiguration project has been completed in a reach of the lower Umatilla River in northeastern Oregon.

Properly designed rock riffles or rapids can be constructed in uniform stream channels to reestablish some habitat. These habitat units recruit gravel, induce pool formation, and assist fish passage. Before attempting to rebuild a riffle–pool sequence, it is important to:

- Determine whether the existing channel conditions are the result of natural processes or human activities
- Establish what channel width and depth are needed for stream discharge during floods
- Find out whether pool and riffle creation will improve the desired habitats

These three tasks require a thorough analysis of the drainage basin, a survey of the reach to be restored, evaluation of the habitat requirements of the fish species in the watershed, and design of artificial riffles and pools that are as stable as natural ones. For a detailed description of a 10-step stream channel analysis and design process with examples, see *Stream Analysis and Habitat Design: A Field Manual* (see “Resources”).

Examples of stream enhancement projects

There are many types of stream enhancement projects. They differ according to the desired objectives and the species of fish involved. Each species has different life-cycle requirements and habitat needs. Consider the needs of the species that occupy your stream. See Chapter III-4, "Stream Ecology," for more information on salmonid habitat needs.

For example, juvenile coho salmon use small streams as nursery habitat and need protection from water velocity during high flows. As a result, coho habitat restoration projects tend to focus on increasing backwater pools, off-channel areas, and wood in the channel. Techniques and specific designs depend on stream characteristics.

Many techniques have been used with varying degrees of success. They have evolved from "let's just try this and see" to engineered designs. Most mistakes occur when people design structures without studying the basic characteristics of the river or the specific needs of the fish. Remember, the goal of improving fish habitat with structures is to imitate what would occur naturally in a particular stream type.

In-stream structures

Various in-stream structure designs try to emulate natural obstructions that alter the flow of water and sediment. By influencing *hydraulic conditions* (the movement of water), structures store and sort sediment, enhance scour, deposit streambed material, diversify velocity and depth, and fix the position of bars and pools. As water and gravel are slowed down or forced under, over, around, or between structures, the streambed is scoured or material

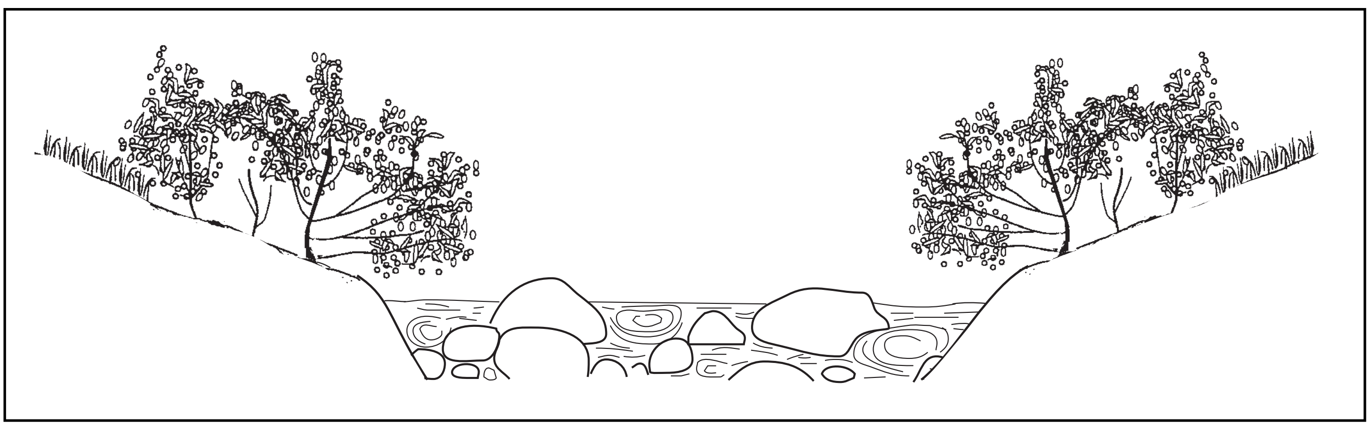


Figure 3.–Boulders are placed in stream reaches in order to increase channel complexity and alter flow patterns in a manner that creates more diverse fish habitat.

is deposited. The result is increased channel complexity and fish habitat diversity.

In-stream boulder placement (Figure 3) is a common technique used to create hiding and resting places for fish in channels that are very uniform and lack pool habitat. The boulders are scattered so that they alter the pattern of water flow and help create scouring areas and pools. Scouring results from the faster, more turbulent water flow around large rocks.

A deficit of large pieces of wood in streams is common throughout much of the Pacific Northwest. The main reasons for this deficit are historical riparian logging practices, splash damming, agricultural conversion, and active removal of wood from streams. Because the natural recruitment of wood can be slow, the artificial placement of logs might temporarily improve stream habitats until the riparian forest once again can contribute large logs and root wads.

The size of wood (length and diameter) must be proportional to the width of the stream channel to ensure wood stability. This eliminates the need for anchoring techniques. Wood should be at least twice as long as the active channel width (1.5 times the width for wood with a root wad attached). It also must meet diameter, stream size, and slope requirements as outlined in the ODF and ODFW publication *A Guide to Placing Large Wood in Streams* (see "Resources").

Current wood placement projects try to load the stream with wood that can be redistributed during peak flows and work with the stream to create pools, store gravel, and provide cover. They do not try to create artificial habitat by following a preconceived blueprint. Figure 4 shows the effects of various placements of large wood in a channel.

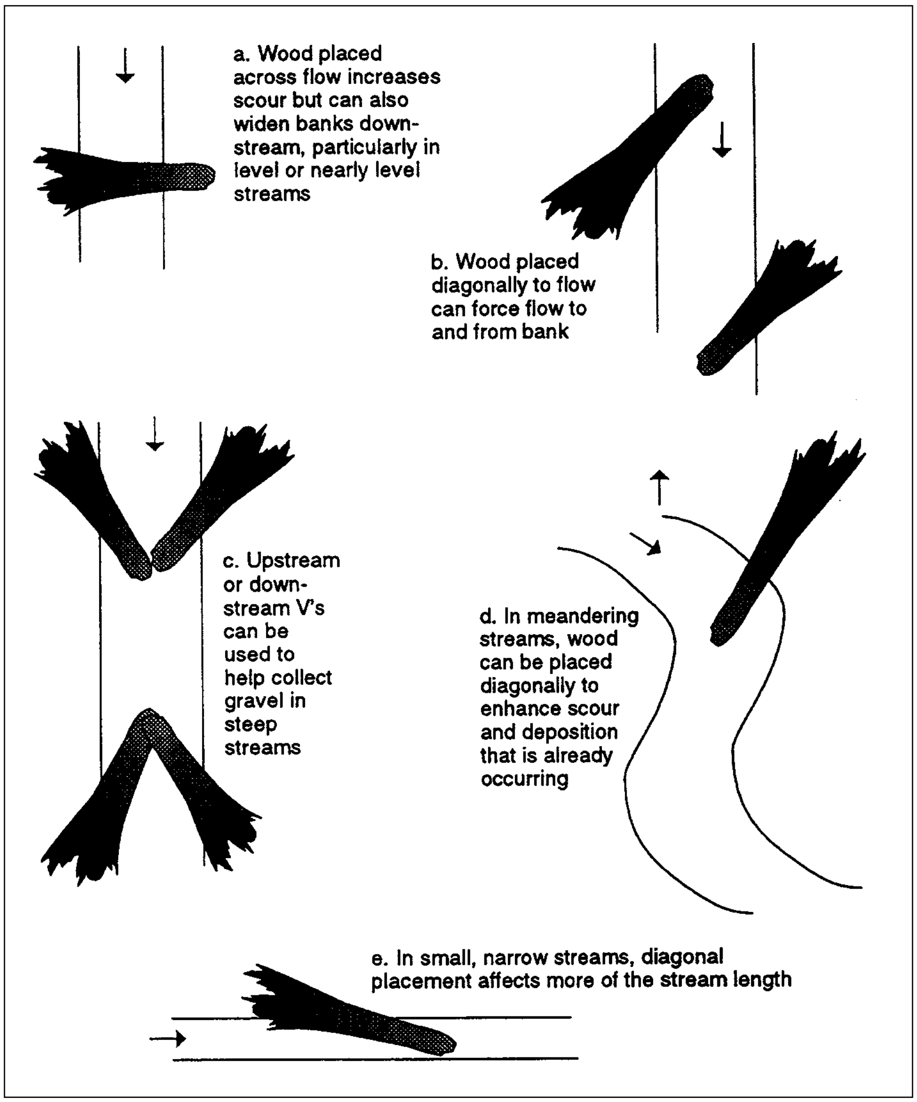
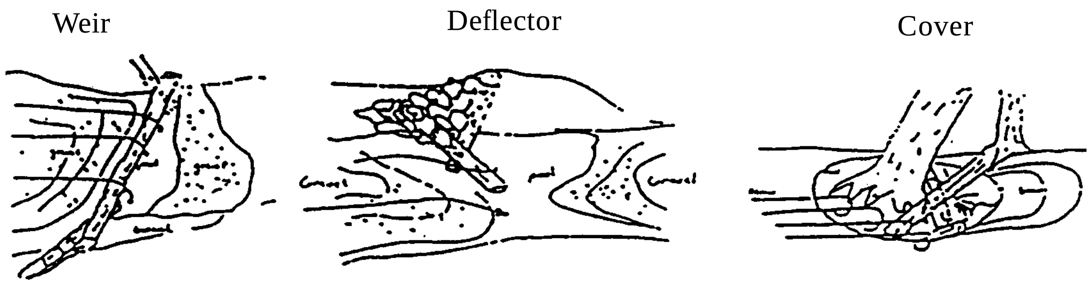


Figure 4.—Effects of various placements of large woody debris. (Source: A Guide to Placing Large Wood in Streams, *Oregon Department of Forestry and Oregon Department of Fish and Wildlife, May 1995)*



Purpose	Purpose	Purpose
Collects gravel	Scours pools	Creates winter refuge
Creates plunge pools and dammed pools	Deflects flow	Escape cover
	Bank protection	Stratifies velocity
Spawning, rearing	Spawning, rearing	Rearing habitat

Figure 5.—Types of in-stream structures. (Source: Ecosystem Workforce Project Curriculum, *Oregon State University and LERC at the University of Oregon, 1996)*

NMFS, the *Oregon Aquatic Habitat Restoration Guide*, and the new authorization for the Division of State Lands discourage in-stream structures that are anchored to boulders, logs, and trees. Most earlier stream enhancement projects used these techniques. However, water flow cannot easily rearrange cabled structures. As a result, they might end up increasing bank erosion or interfering with stream processes rather than enhancing fish habitat.

Weirs, deflectors, and cover structures are three common types of in-stream structures (Figure 5). Rocks, logs, or a combination of both are used in their construction. Weirs are placed across the stream channel, perpendicular or at an angle to the stream flow. They are anchored to the stream banks and bottom. Their main functions are to reduce water velocity, collect spawning gravels, and create pools (both dammed and plunge). A series of weirs often is used to create a succession of steps that raise the water level to reach the downstream opening of culverts.

Deflecting structures are much shorter than weirs. They are anchored to one bank, extend only one-fourth to one-half the distance across the channel, and are placed diagonal to the stream flow. Their main functions are to deflect water flow from the bank to reduce erosion and, simultaneously, to create scour or back pools and collect gravel.

Logs and root wads often are used to provide cover and winter refuge to salmonids. These structures also reduce water velocity, allowing sediments, gravel, and organic material to collect. They might provide seeding beds for riparian plants and, depending on their position in the channel, might reduce bank erosion and help narrow and deepen the stream. Cover logs can be any shape and length, but the best results are obtained with large logs with limb stubs and branches.

It is important to know that numerous studies have indicated that these structures are not very useful for enhancing fish habitat in the long term or for increasing fish productivity in a stream. At best, they might improve local conditions and, as a result, attract fish to the treated reach. Thus, they seem to boost fish rearing densities at a local scale but do not increase the size of the fish population in the entire watershed *(Oregon Aquatic Habitat Restoration Guide)*.

Some key considerations when designing and using structures include (excerpted from the *Oregon Aquatic Habitat Restoration Guide*):

- Is this a stream that would be expected to have large woody debris given its known range in variability? Some meadow-based systems should not be expected to have large wood. Similarly, steep (high-gradient) reaches on large streams in most cases cannot hold wood.
- Is the lack of wood a major contributing factor in declining fish populations in the reach? Sometimes other factors, such as a fish passage blockage, are more important in the decline of fish. In this case, adding wood makes little difference.
- Does present upslope and riparian management make large woody debris available for natural addition to the stream? Does it encourage stable banks and sediment dynamics, which in turn stabilize the channel?
- Is large wood in the candidate stream reach currently depleted compared to expected values? (ODFW has information on Oregon's benchmark values and on some individual streams.)

Stream bank stabilization projects

The goals of single-site stream bank stabilization projects are to:

- Slow the water velocity, causing sediment to deposit and build stream bank rather than to scour
- Reduce stream bank erosion with vegetation
- Begin to establish riparian vegetation
- Provide some in-stream fish habitat where possible

One type of bank stabilization involves burying boulders or log deflectors into the bank and letting them extend into the stream channel. These structures deflect flow away from the bank and help stabilize the bank until vegetation is established. Deflectors also increase stream velocity at the tip of the structure and cause a scour pool on the downstream side of the deflector. The scour pool dissipates some of the stream's energy and might provide some fish habitat.

Other designs that stabilize a stream bank and help reestablish the riparian area use rock, wood, and trees to decrease velocities, deposit sediment, and grow vegetation. These designs are known as *bioengineering* methods and are discussed in Chapter III-1, “Riparian Evaluation and Enhancement.” Contact the Natural Resources Conservation Service and Division of State Lands for information, designs, and technical assistance.

MONITORING PLANS

Monitoring is an important part of stream enhancement projects. Chapters II-5, “Assessment and Monitoring Considerations,” and III-2, “Riparian Area Evaluation and Enhancement,” discuss monitoring plans in detail. This section will briefly review the key points of monitoring plans.

What are monitoring plans for?

Monitoring will determine the results of your restoration or enhancement project. It can help you avoid repeating mistakes and, therefore, wasting resources (whether private or public) in future projects. If monitoring shows the restoration or enhancement project has not achieved the desired stream functions, you should consider implementing a corrective plan and, in turn, monitor and evaluate the outcome of the new plan.

Basic components of a monitoring plan

Most stream monitoring plans use the assessment and survey techniques discussed in this chapter. These techniques help you evaluate present stream components and functions as well as how they change over time in response to the restoration or enhancement project. Any monitoring plan has three main components:

- Identification of the goals and objectives of the restoration or enhancement project
- Selection of specific monitoring techniques and parameters to be measured
- A process for evaluating whether goals and objectives are met and for deciding whether a change in monitoring techniques and/or measured parameters is necessary

A monitoring plan starts with a clear statement of goals and objectives (the questions you want to answer with monitoring). Choose monitoring techniques that will collect data that answer the questions. Make sure the techniques are appropriate for you or your group. Take into account factors such as cost, technical requirements, training, available equipment, and access.

Monitoring should indicate whether your projects are helping the stream achieve the desired goals. If a project is not meeting your goals, the monitoring plan should help you identify factors causing the problem and ways to solve it.

Example of a monitoring plan

Assessment of present components and functions

Current state/limiting factors: Assessments indicate a forested section of the coastal stream has very few pools. The riparian alder-dominated forest shades the stream and provides important nutrients to the stream but is not a good source of large wood. As a result, the stream channel lacks structural complexity, and salmon spawning and nursery habitat has been reduced.

Probable cause: Evaluations of historic information indicate that past forest practices included removing wood from the stream and did not reestablish mixed stands of conifer and hardwood trees in the riparian area.

Monitoring . . . can help you avoid repeating mistakes and, therefore, wasting resources (whether private or public) in future projects.

Goals and objectives

Goal: Improve salmonid spawning and nursery habitat in the forested stream reach by increasing gravel bars and pools. Improve future supply of large wood in the stream by increasing the number of conifers in the riparian zone.

Objective: Collect spawning gravel and increase number of pools by placing large woody material, twice the size of the active stream channel width, in key locations. Convert half of the alder-dominated riparian forest to conifers by removing some alders so that existing conifers in the understory can grow.

Enhancement projects implemented

Following ODF and ODFW guidelines, 20 large conifer logs were strategically placed in the stream channel and banks to create 9 pools with cover. Following ODF Forest Practices Rules, conifer trees were manually released from the understory of alders in the riparian zone. The project improved fish habitat and established a future supply of large wood to the stream and riparian area.

Monitoring techniques and parameters measured

- An ODFW aquatic habitat inventory was conducted prior to project implementation. It will be repeated 1 year following implementation and once every 5 years thereafter. This inventory will monitor stream habitat and riparian conditions.
- All logs were surveyed and locations marked on a map. Logs will be resurveyed once a year for the first 5 years to evaluate movement of logs and stream conditions.
- Photos will be taken at permanently established photo points before and after the project is implemented and once every 5 years at the same time the habitat survey is done.
- A riparian area survey to assess tree survival will be conducted once every year for the first 2 years, then once every 5 years. Thinning will be carried out as needed to ensure maximum tree growth.
- Spawning surveys will be conducted to count spawning fish and map their locations to see whether they are using the newly created spawning areas.

Follow-up evaluation

If monitoring shows that projects have not achieved goals, a new (corrective) enhancement project and a monitoring plan will be implemented. If the monitoring data do not describe stream components and functions adequately, different monitoring techniques will be used.

Summary/Self review

Stream assessments are carried out to inventory the physical, chemical, and biological characteristics of streams and/or to evaluate how well the stream is functioning based on restoration goals. Assessments are necessary to identify restoration and enhancement opportunities, and they are the foundation of any monitoring plan.

A variety of assessment methods is available. Physical stream assessments evaluate habitat types; width, depth, and length of units; streambed materials; stream bank stability; relation of the stream to its floodplain; stream gradient; riparian characteristics; large wood availability; and cover for fish. Biological stream assessments evaluate fish populations (juveniles, smolts, spawning adults), fish species present, abundance of fish utilizing available habitat, and the abundance and type of macroinvertebrates.

Stream restoration projects aim to reestablish essential physical, biological, and chemical components and processes between the stream and the riparian ecosystems. The goal is to reinstate channel stability, water quantity and quality, and the aquatic habitat for many organisms (not just fish).

Stream enhancement projects try to solve more localized and immediate habitat problems and often are directed to one or a few target species. They are not self-sustaining and, therefore, have a limited life span. They might be useful to reduce the downstream impact of severely altered reaches (e.g., urban, industrial) and/or to increase the chances of success of larger scale restoration initiatives. In high-traffic areas, their visibility makes them important educational projects.

Watershed processes dictate that restoration and enhancement projects take into account upstream and upland management considerations.

Monitoring plans include three main components:

- Goals and objectives
- Specific monitoring techniques and parameters to be measured
- An evaluation process to see whether desired conditions are being met and/or monitoring techniques are adequate

EXERCISES

You can do these exercises on your own, but it's helpful to work as a group so you can compare notes and discuss your observations.

Stream assessment

Volunteer to help an agency or private consultant conduct two different assessments of at least two sites (preferably a degraded site and one with a complex channel structure, good water quality, and a well-developed riparian forest). Review the analysis of data and discuss different enhancement projects recommended to achieve a desired condition.

Restoration and enhancement

Get involved with two stream restoration and/or enhancement projects. Review the assessments used to plan these activities.

Monitoring

Establish a monitoring program for a site where a restoration or enhancement project has been implemented. Review an existing monitoring program that has evaluated a project for several years in a stream that is reaching the desired condition.

RESOURCES

Training

Contact your local watershed council, OSU Extension Service office, Soil and Water Conservation District office, or resource agency office (Oregon Department of Forestry, Oregon Department of Fish and Wildlife, U.S. Forest Service, Bureau of Land Management, etc.) for training events or personal consultation.

Information

"An ecological perspective of riparian and stream restoration in the western United States," by J.B. Kauffman, R.L. Beschta, N. Otting, and D. Lytjen, *Fisheries* 22(5):12–24 (1997).

"Applied river morphology," by D. Rosgen. In *Wildland Hydrology* (1996).

California Salmonid Stream Habitat Restoration Manual, by G. Flosi and F. Reynolds (California Department of Fish and Game, 1997).

Ecosystem Workforce Project Curriculum, various authors (Oregon State University and LERC at the University of Oregon, 1996).

"Estimating total fish abundance and total habitat area in small streams based on visual estimation methods," by D. Hankin and G. Reeves, *Canadian Journal of Fisheries and Aquatic Sciences* 45:834–844 (1988).

A Guide to Field Identification of Bankfull Stage in the Western United States, video (USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Stream Systems Tech. Center, Fort Collins, CO, 1995).

A Guide to Placing Large Wood in Streams (Oregon Department of Forestry and Oregon Department of Fish and Wildlife, May 1995). Available from the Oregon Department of Forestry, 2600 State St., Salem, OR 97310.

Field Procedures for Analysis of Functional Feeding Groups of Stream Macroinvertebrates, by K. Cummins and M. Wilzbach (Appalachian Environmental Laboratory, University of Maryland, 1985).

"Field review of fish habitat improvement projects in the Grande Ronde and John Day river basins of eastern Oregon," by R.L. Beschta, W.S. Platts, and J.B. Kauffman. In DOE/BP-21493-1 (U.S. Department of Energy, Bonneville Power Administration, Portland, OR, 1991).

Fisheries Techniques, by L. Nielsen and D. Johnson (American Fisheries Society, 1983).

"Fish habitat improvement projects in the Fifteenmile Creek and Trout Creek basins of central Oregon: Field review and management recommendations," by J.B. Kauffman, R.L. Beschta, and W.S. Platts. In DOE/BP-18955-1 (U.S. Department of Energy, Bonneville Power Administration, Portland, OR, 1993).

How to Do Spawning Fish Surveys (Salmon Trout Enhancement Program, Oregon Department of Fish and Wildlife, undated).

Methods for Stream Habitat Surveys, Information Report 97-4, by K. Moore, K. Jones, and J. Dambacher (Oregon Department of Fish and Wildlife, Research and Development Section, Corvallis, OR, 1997).

Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska, EPA 910/9-91-001, by L. MacDonald and R. Wissmar (U.S. Environmental Protection Agency, 1991).

Monitoring Primer for Rangeland Watersheds, EPA 908-R-94-001, by T. Bedell and J. Buckhouse (U.S. Environmental Protection Agency, 1994).

Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management on Western Rangeland Streams, by S. Bauer and T. Burton (Idaho Water Resources Research Institute, University of Idaho, Moscow, ID, 1997).

Oregon Aquatic Habitat Restoration Guide: Under the Oregon Plan for Salmon and Watersheds (National Marine Fisheries Service and Oregon Department of Fish and Wildlife, 1998). Available from ODFW, PO Box 59, Portland, OR 97207.

Oregon Watershed Assessment Manual (Oregon Watershed Enhancement Board, Salem, 1998).

Photo Plots (Oregon Watershed Enhancement Board, Salem, 1993).

"Range ecology, global livestock influences," by J.B. Kauffman and D.A. Pyke. In *Encyclopedia of Biodiversity*, 5:33–52 (Academic Press, 2001).

A Review of Capture Techniques for Adult Anadromous Salmonids, Information Report 96-5 (Oregon Department of Fish and Wildlife, undated).

"Streambank and shoreline protection." In *Engineering Field Handbook* (Natural Resources Conservation Service, 1996).

Stream Analysis and Fish Habitat Design: A Field Manual, by R. Newbury and M. Gaboury (Newbury Hydraulics Ltd., Box 1173, Gibsons, BC, Canada V0N 1V0, 1994).

"The effects of livestock grazing on western riparian and stream ecosystem," by C. Armour, D. Duff, and W. Elmore, *Fisheries* 19(9):9–12 (1994).

Woodland Workbook (Oregon State University Extension Service, Corvallis, OR).

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself and your watershed group ahead in understanding stream assessment and enhancement.

1.____

2.____

3.____

Appendix A–Forms for a stream habitat survey.

A-1–Stream reach form

REACH

STREAM: ____________________ PAGE: ______ OF: ______

BASIN: ____________________ CREW: ____________________

USGS 7.5' MAP NAMES: ____________________

DATE	REACH #	UNIT NUMBER	CHANL FORM	VALLEY FORM	VWI	VEG CLASS DOM.	VEG CLASS SUB-DOM.	LAND USE DOM.	LAND USE SUB-DOM.	WATER TEMP	STRM FLOW	LOCATION TWN-RNG-SEC-1/4	PHOTO # /TIME	REACH NOTE
													/	

UNIT-1

PAGE:________ OF:________

STREAM:______________________ DATE:______________ ESTIMATOR:______________________

REACH	UNIT	UNIT	CHANL	%	UNIT	UNIT	SLOPE	SHADE (0-90)		ACTIVE CHANNEL		FLOOD PRONE		TERRACE			NOTE
#	#	TYPE	TYPE	FLOW	LENGTH	WIDTH	%	LEFT	RIGHT	HT.*	WIDTH	HT.	WIDTH	HT.	WIDTH	VWI	

* MEASURE FROM THE STREAMBED TO THE TOP OF THE ACTIVE CHANNEL. TAKE THE MEASUREMENT AT POOL TAIL CREST ON POOL UNITS.

A-3—Unit-2 form

UNIT-2

PAGE:_______ OF:_______

STREAM:_______________________ DATE:_______________ NUMERATOR:_______________

UNIT	UNIT	DEPTH*	DEPTH**	VERIFIED			PERCENT SUBSTRATE					BLDR	% ACTIVE	% UNDER	COMMENT	NOTE
#	TYPE		PTC	LENGTH	WIDTH	S/O	SND	GRVL	CBLE	BLDR	BDRCK	COUNT	EROSION	CUT	CODES	
V																
V																
V																

* MAX DEPTH POOLS - MODAL DEPTH IN FAST WATER UNITS

** ONLY MEASURED @ POOLS (EXCEPT OFF-CHANNEL POOLS)

WOOD

PAGE:______ OF:______

STREAM:______________________ DATE:______________ NAME:______________________

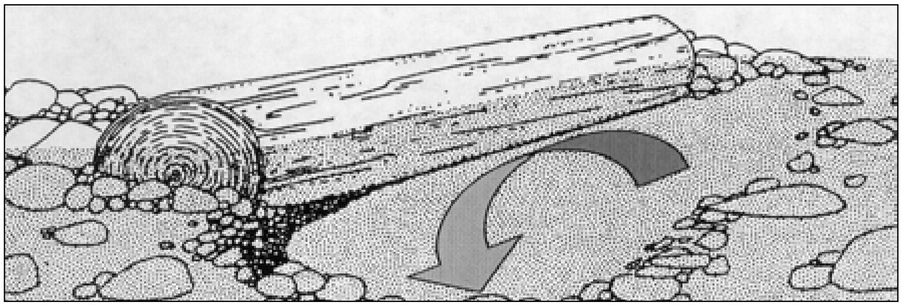
UNIT	UNIT	DEBRIS			DBH	LENGTH CLASS (m)												WOOD NOTE
NUMBER	TYPE	CONFIG	TYPE	LOCAT	CLASS	RW <3	3	6	9	12	15	18	21	24	28	32	36+	

RIPARIAN

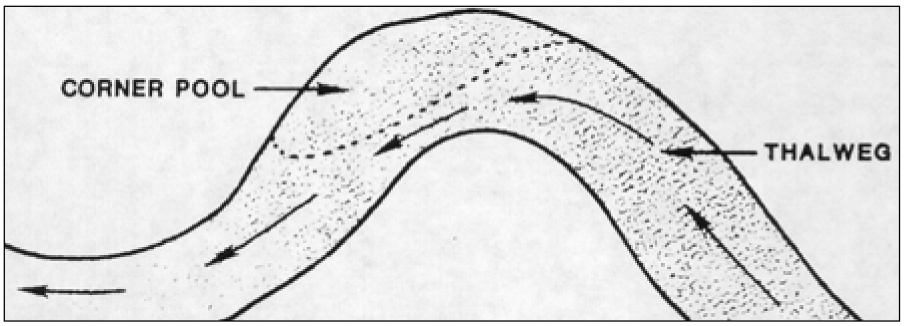
PAGE:______ OF:______

STREAM:______________________ DATE:______________ NAME:______________________

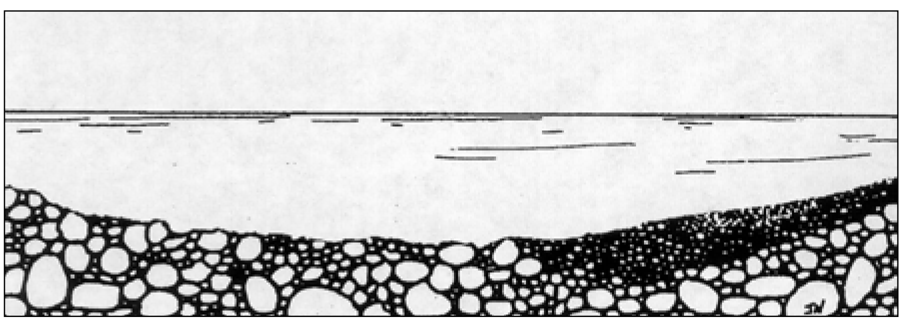
UNIT NUMBER	SIDE	ZONE	SURFACE	SLOPE	CANOPY CLOSURE	SHRUB % COVER	GRASS/FORB % COVER	TREE	COUNT (DBH in CENTIMETERS) 3-15	15-30	30-50	50-90	90+	RIPARIAN NOTE
	LEFT	1						CONIFER						
								HARDWOOD						
		2						CONIFER						
								HARDWOOD						
		3						CONIFER						
								HARDWOOD						
	RIGHT	1						CONIFER						
								HARDWOOD						
		2						CONIFER						
								HARDWOOD						
		3						CONIFER						
								HARDWOOD						
	LEFT	1						CONIFER						
								HARDWOOD						
		2						CONIFER						
								HARDWOOD						
		3						CONIFER						
								HARDWOOD						
	RIGHT	1						CONIFER						
								HARDWOOD						
		2						CONIFER						
								HARDWOOD						
		3						CONIFER						
								HARDWOOD						



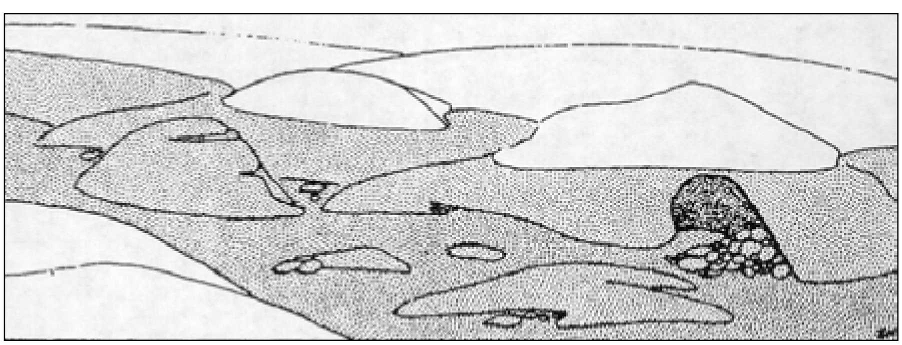
Lateral scour pool (LP): Formed by water against one stream bank or partial obstruction (logs, root wad, bedrock).



Lateral scour pool (LP): Often forms corner pools in meandering lowland or valley bottom streams.

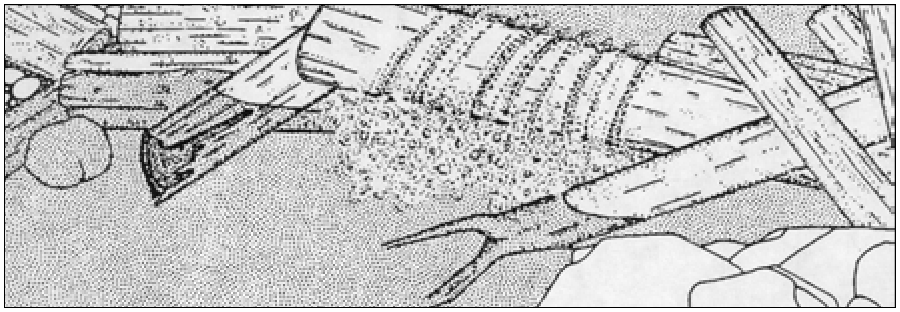


Straight scour pool (SP): Formed by midchannel scour, generally with a broad scour hole.

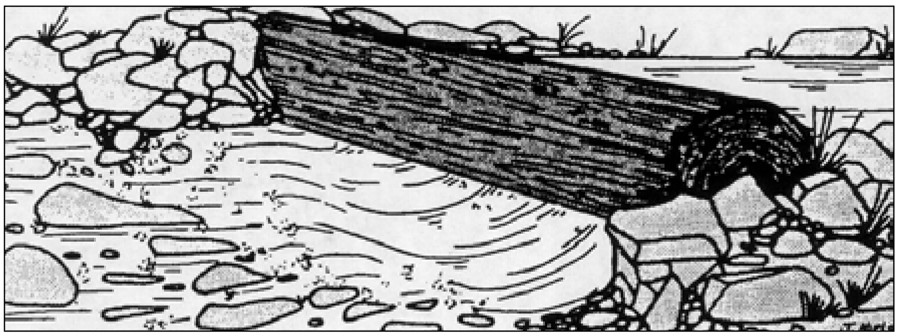


Trench pool (TP): a relatively long, slotlike depression in the streambed, often found in bedrock-dominated channels.

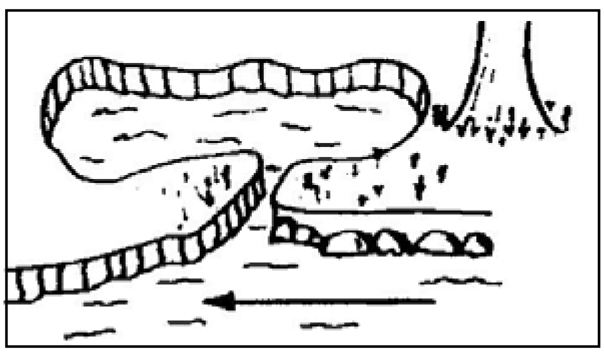
A-6—Types of habitat units, continued



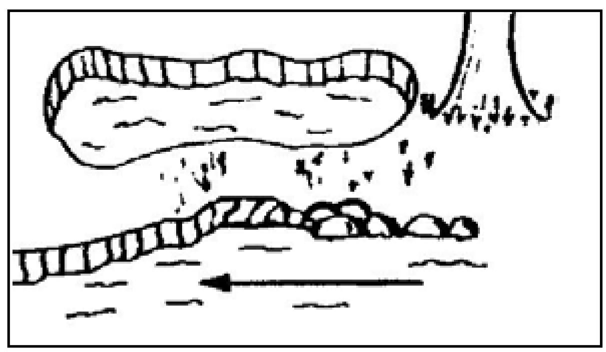
Plunge pool (PP): Formed by water passing over a complete or nearly complete channel obstruction (e.g., logs, boulders, bedrock).



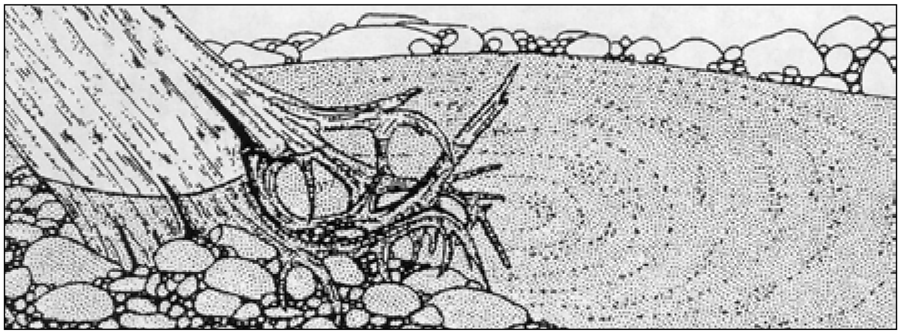
Dammed pool (SP): Sometimes formed by scouring under a stream obstruction such as a log.



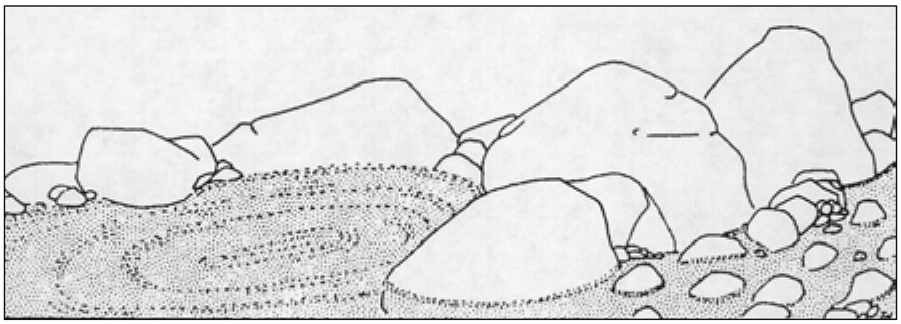
Alcove (AL): A backwater along the shoreline; not scoured during typical high flows.



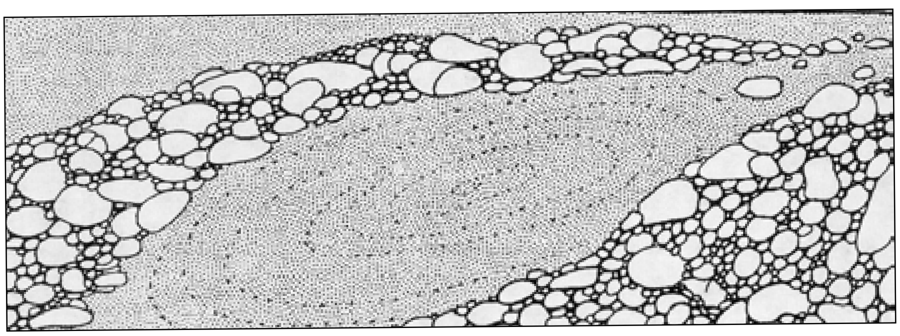
Isolated pool (AL): Pools formed outside the primary wetted channel but within the active channel.



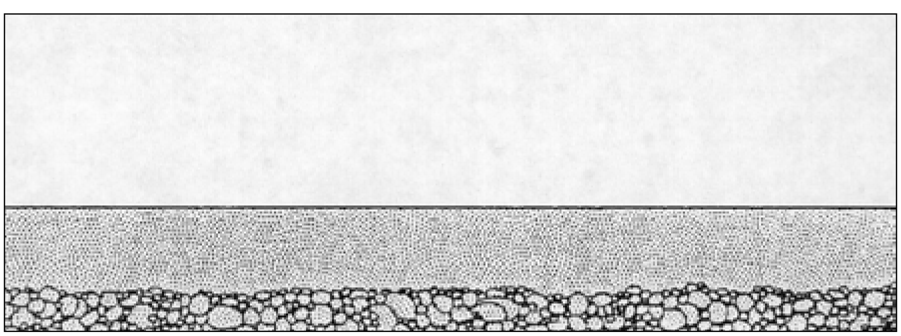
Backwater pool (BW): Formed along channel margins by an eddy around obstructions such as boulders, root wads, and woody debris or behind gravel bars.



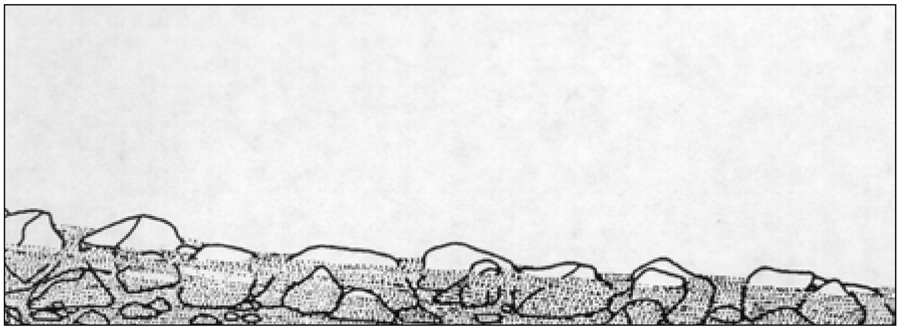
Backwater pool (BW): Formed along channel margins by an eddy around obstructions such as boulders, root wads, and woody debris or behind gravel bars.



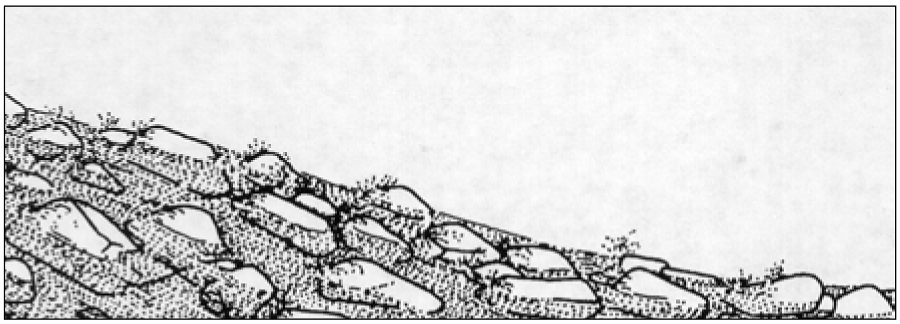
Backwater pool (BW): Formed along channel margins by an eddy around obstructions such as boulders, root wads, and woody debris or behind gravel bars.



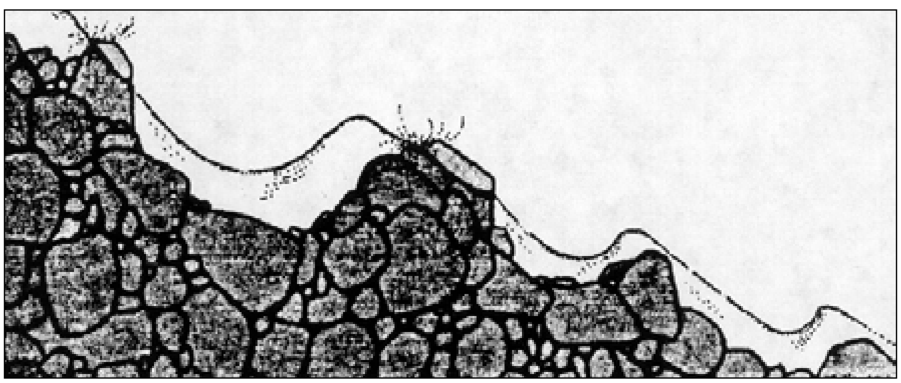
Glide (GL): Generally uniform depth and flow with no surface turbulence, low gradient (0–1 percent slope).



Riffle (RI): Fast, turbulent, shallow flow over gravel or cobble substrates, low gradient (0.5–2 percent slope, rarely up to 6 percent), 5–15 percent surface area with whitewater.



Rapid with protruding boulders (RB): Swift, turbulent flow with chutes and hydraulic jumps, moderate gradient (usually 2–4 percent slope, occasionally 7–8 percent), 15–50 percent of surface with whitewater.



Cascade over boulders (CB): Fast, turbulent flow, step-pool structure, 30–80 percent whitewater, high gradient (usually 3.5–10 percent slope), sometimes greater.

Source: Graphics in Appendix A-6 are from *Glossary of Stream Habitat Terms*, William T. Helm, ed. (American Fisheries Society, Bethesda, MD, 1985).

Appendix B–Habitat condition summary form

(Source: *Oregon Watershed Assessment Manual)*

FORM F-2: Habitat Condition Summary: This form will be filled out for each sub-watershed where ODFW or other comparable habitat data exists measured values are recorded & compared to rating criteria.

Name: **Date:** **Page of**

Subwatershed:

Channel Habitat Type Code*	Miles of CHT in Sub watershed	Miles of CHT surveyed	Survey Date	Pool Area		Pool Frequency		Gravel Availability (% gravel in riffles)		Gravel Quality (% fines in riffles)		Overall Rating
				Measured	**Rating**	**Measured**	**Rating**	**Measured**	**Rating**	**Measured**	**Rating**	
FP1												
FP2												
FP3												
AF												
LC												
MM												
MC												
MV												
BC												
SV												
VH												
MH												
Other:												
Other:												

* see Channel Habitat Type section for a description of the codes.

These rating criteria are applied to evaluate Measured values:

Poor: Measured conditions less than 75% of the ODFW/NMFS benchmark
Fair: Measured conditions levels close to benchmark (>75% and <125%).
Good: Measured conditions exceed benchmark (>125%).

These criteria are used to develop an overall rating:

GOOD: all parameters are rated Good or Fair
INDET: one or two parameters are rated Poor
POOR: three or more parameters are rated Poor
ND: No data.

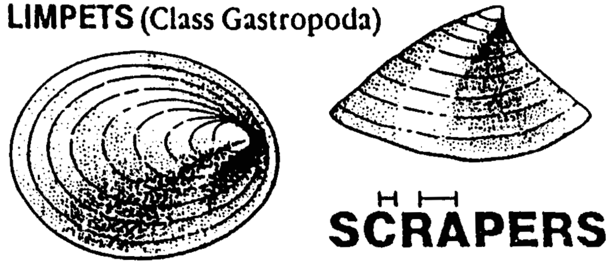
Appendix C–Key 1. Key for identifying stream macroinvertebrates and sample data form. (Source: *Field Procedures for Analysis of Functional Feeding Groups of Stream Macroinvertebrates*)

KEY TO FUNCTIONAL FEEDING GROUPS

Indicates size or range of sizes

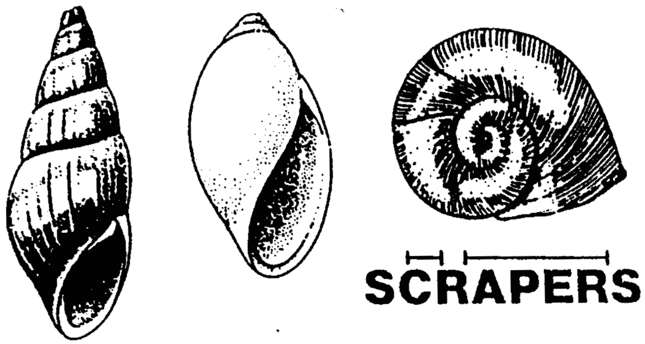
1. ANIMALS IN HARD SHELL (Phylum Mollusca)

   a. LIMPETS (Class Gastropoda)



SCRAPERS

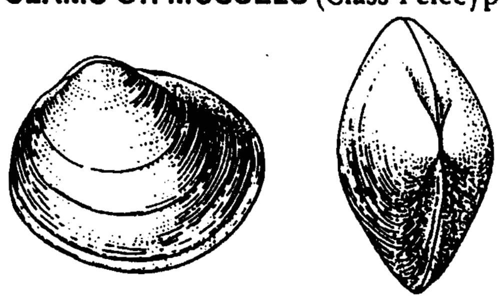
   b. SNAILS (Class Gastropoda)



SCRAPERS

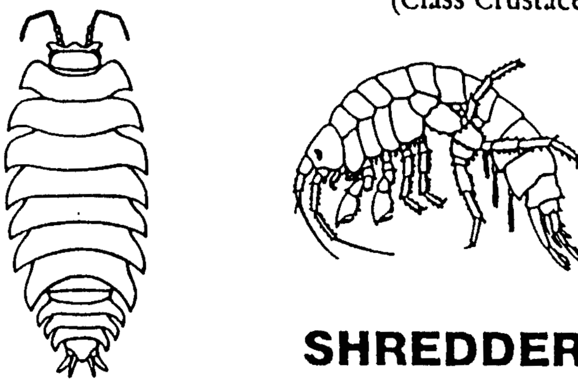
Snails are generalized (facultative) feeders and can also function as Shredders.

   c. CLAMS OR MUSSELS (Class Pelecypoda)



FILTERING COLLECTORS

2. SOW BUG OR SHRIMP-LIKE ANIMALS (Class Crustacea)



SHREDDERS

Generalized, can also function as Gathering Collectors.

3. LARVAE IN PORTABLE CASE OR "HOUSE"

4. LARVAE IN FIXED RETREAT WITH CAPTURE NET

   Note: Care must be taken when collecting to observe nets.

5. WITHOUT CASE OR FIXED RETREAT

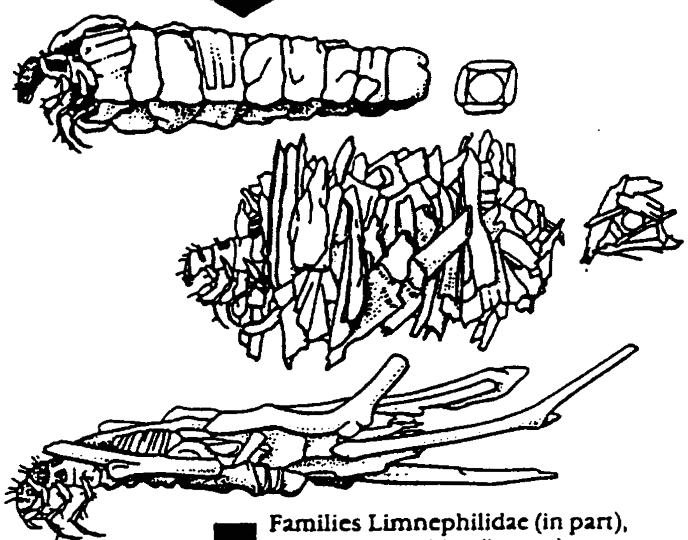
   a. WORM-LIKE LARVAE WITHOUT JOINTED LEGS

   b. NYMPHS OR ADULTS WITH JOINTED LEGS

FIRST LEVEL OF RESOLUTION

LARVAE IN PORTABLE CASE
Caddisflies (Order Trichoptera)

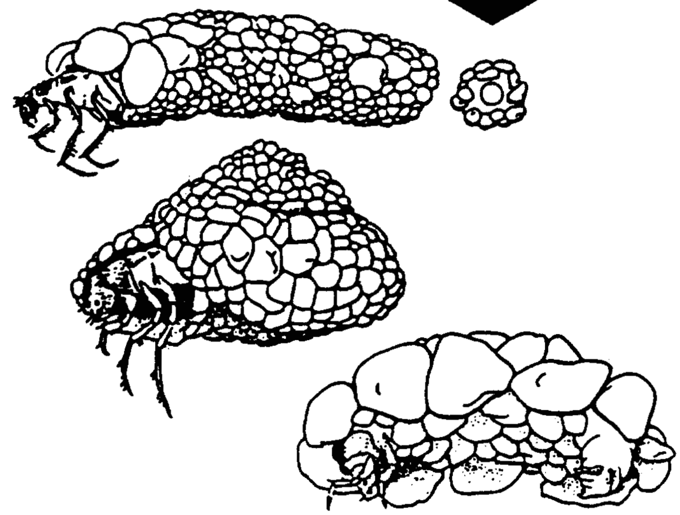
CASES ORGANIC
Leaf, stick, needle, bark



Families Limnephilidae (in part), Lepidostomatidae (in part), Phryganeidae, Leptoceridae (in part)

SHREDDERS

CASES MINERAL
Sand, fine gravel



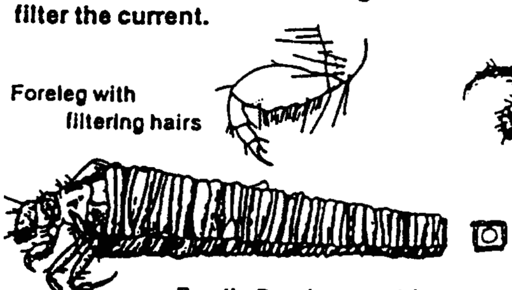
Families Glossosomatidae, Limnephilidae (in part), Helicopsychidae

SCRAPERS

SECOND LEVEL OF RESOLUTION considers a few fairly common caddisflies that would be misclassified above on the basis of case composition alone.

CASES ORGANIC

Cases square in cross section and tapered, with no bark or flat leaf pieces included. Front attached to substrate. Larvae extend legs and filter the current.



Family Brachycentridae

FILTERING COLLECTORS

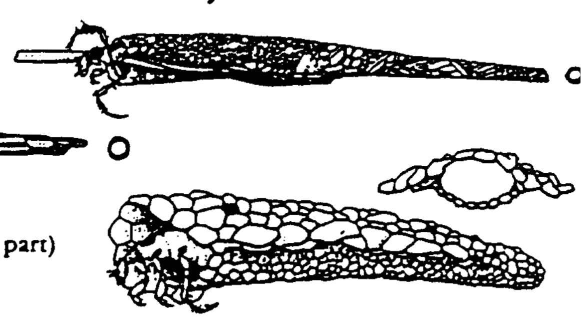
Cases long, slender, and tapered, made of plant material

Family Leptoceridae (in part)

GATHERING COLLECTORS

CASES MINERAL

Cases long, slender, and tapered (mostly fine sand) *or* cases ovoid and very flat in cross section



Family Leptoceridae (in part)

GATHERING COLLECTORS

FIRST LEVEL OF RESOLUTION

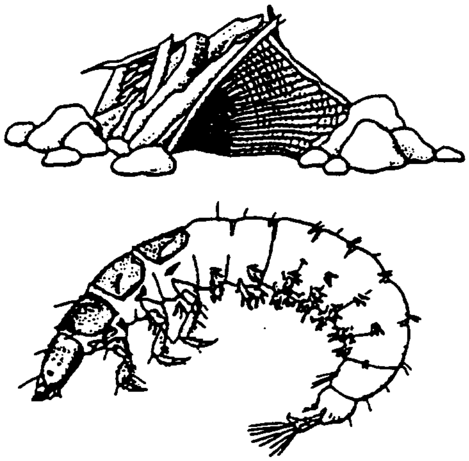
LARVAE WITH FIXED RETREAT AND CAPTURE NET

Note: Care must be taken when collecting to observe nets.

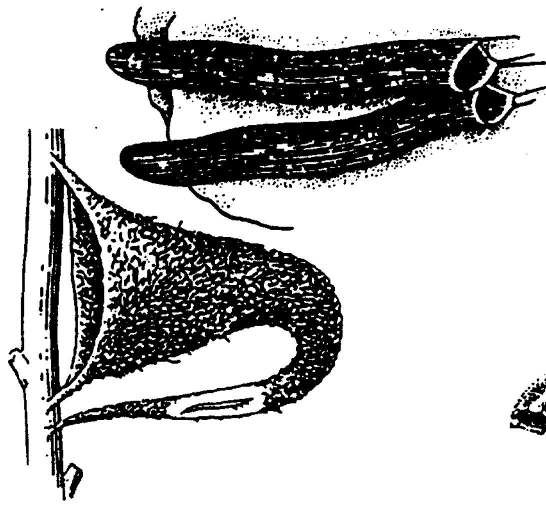
Caddisflies (Order Trichoptera)

True Flies (Order Diptera)

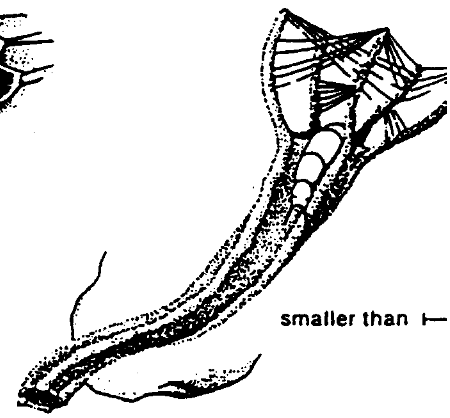
COARSE NET IN "SCAFFOLDING"



FLATTENED SOCK-LIKE OR TRUMPET-SHAPED NET OF FINE MESH



TUBE WITH SILK STRAND STRUNG BETWEEN TERMINAL PRONGS



True Midges (Family Chironomidae

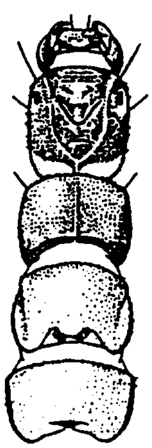
Families Hydropsychidae, Philopotamidae, Polycentropodidae

FILTERING COLLECTORS

SECOND LEVEL OF RESOLUTION separates from free living larvae those net spinning caddisflies that may have been inadvertently collected without being associated with their nets.

NET SPINNING CADDISFLIES

Frequently separated from their nets



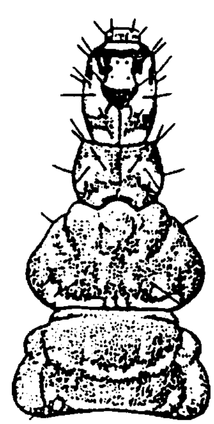
HEAD AS WIDE AS THORAX

Especially Philopotamidae (bright yellow) and Hydropsychidae (bright green or brown)

FILTERING COLLECTORS

FREE LIVING CADDISFLIES

Non net spinning

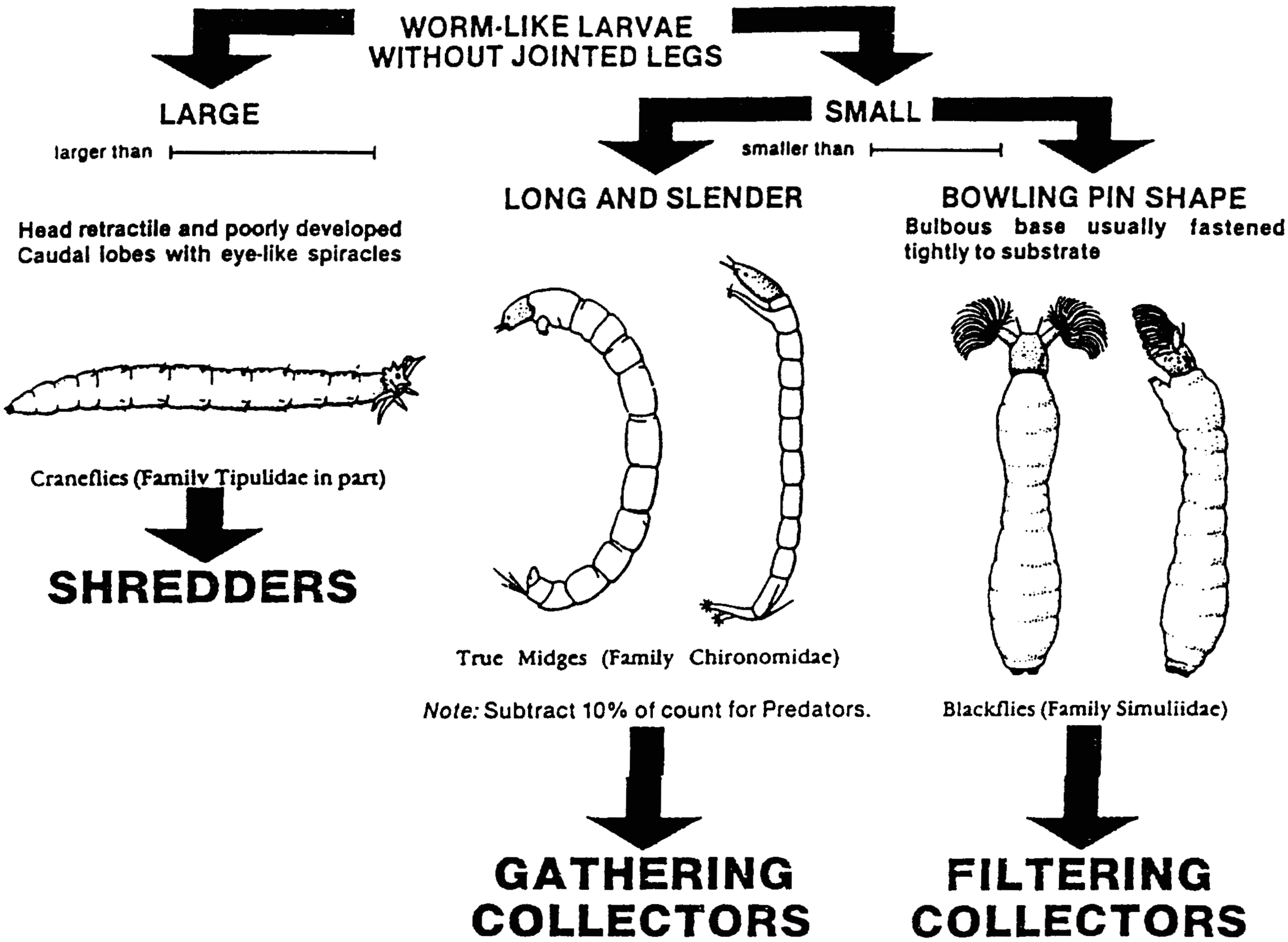


HEAD LONG, SMALL, AND NARROWER THAN THORAX

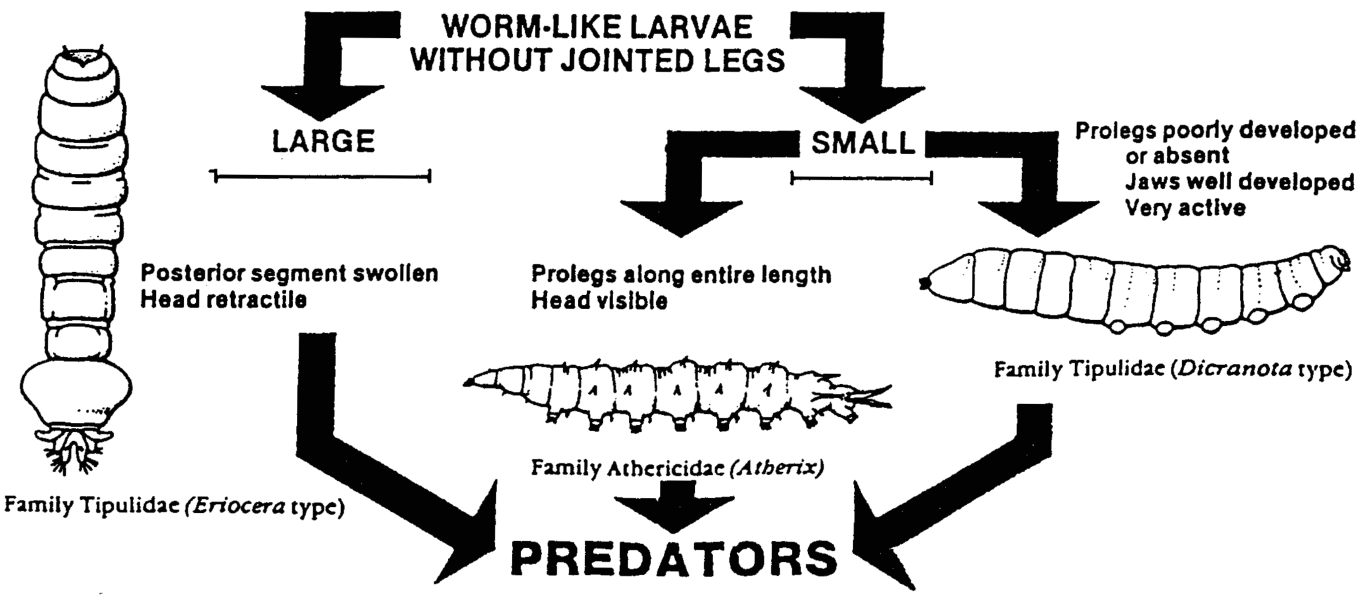
Rhyacophilidae (often bright green)

PREDATORS

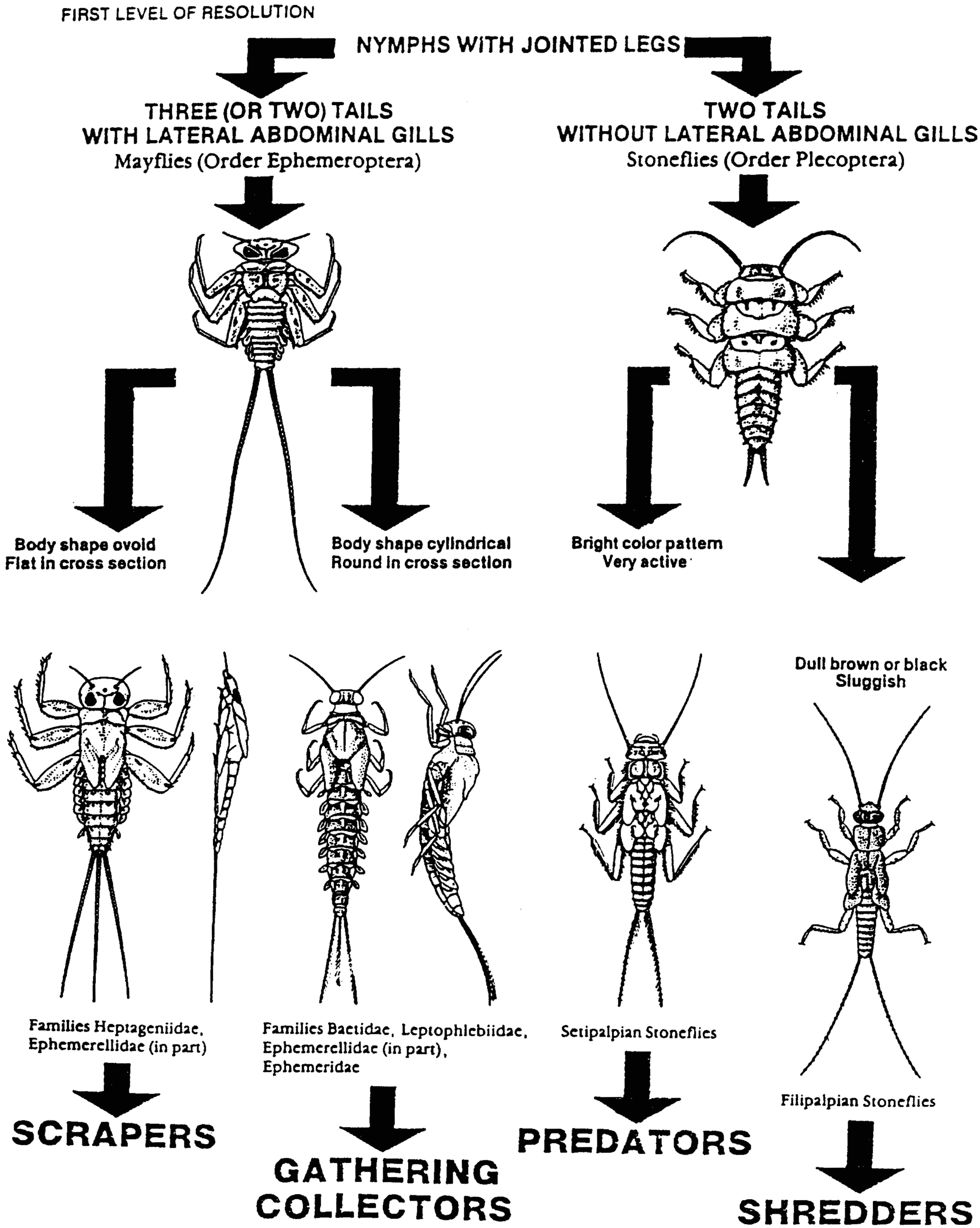
FIRST LEVEL OF RESOLUTION



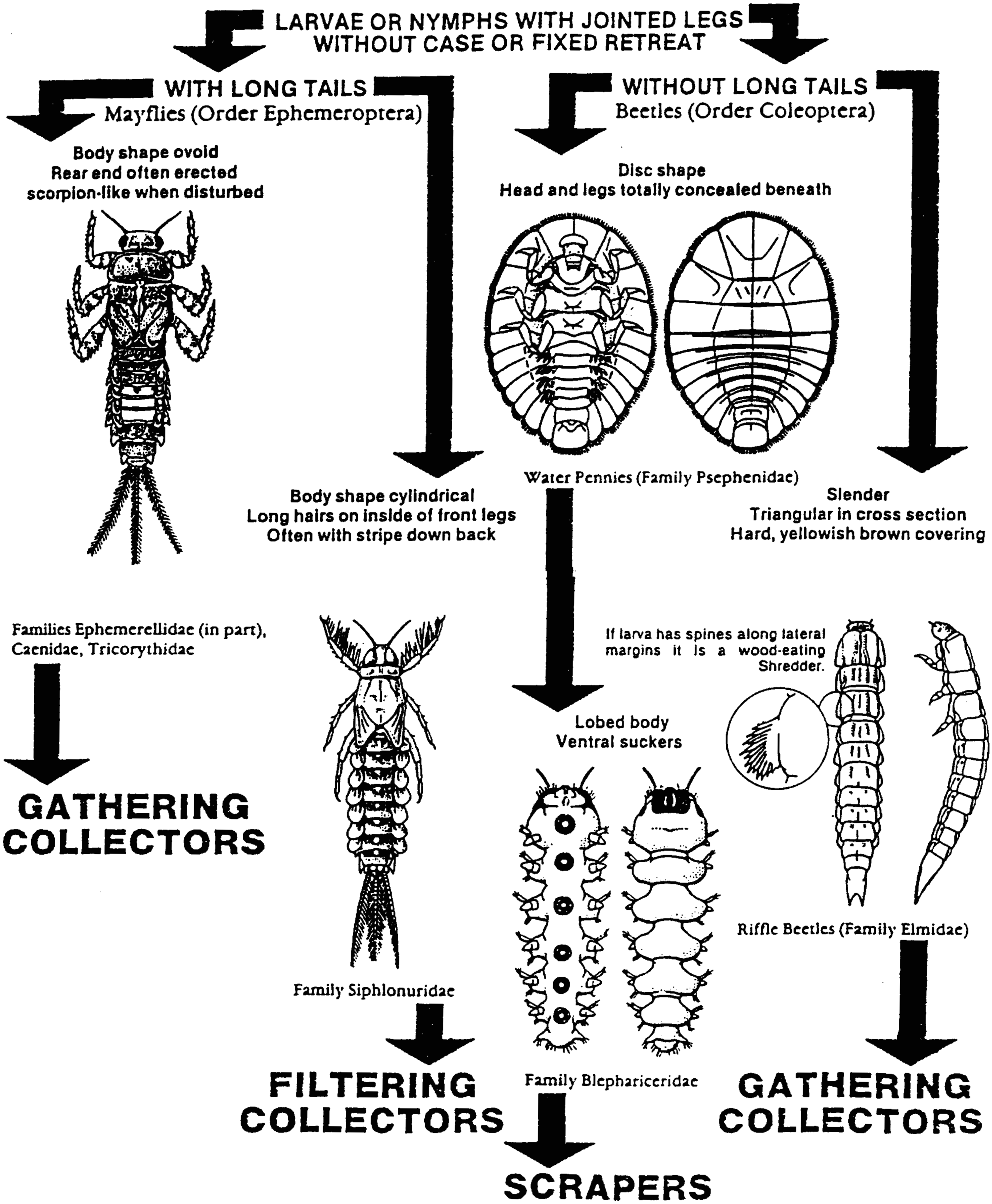
SECOND LEVEL OF RESOLUTION considers some common worm-like Predators that would be misclassified in the above key.



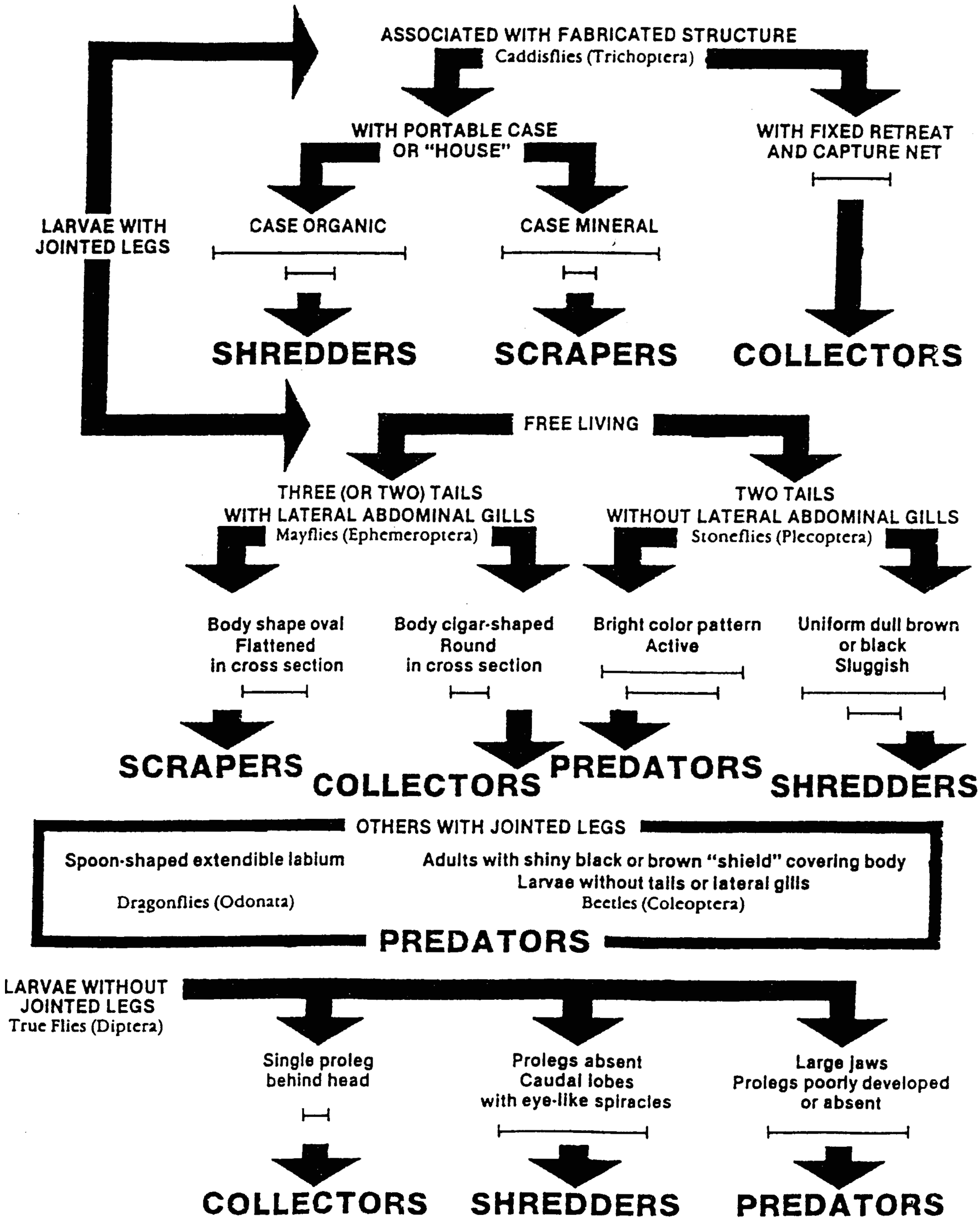
Appendix C–Key 5



SECOND LEVEL OF RESOLUTION considers some fairly common insects that do not fit in the above key or would be misclassified on the basis of body shape alone.



SUMMARY OF FEEDING GROUPS



Data Sheet for Macroinvertebrate Functional Group Analysis Date________ Name________

Site________ Description________

Functional Group	Habitat-Organic Resource Categories										
	Leaf Pack		Rock (Periphyton)		Fine Sediments (Pools)		Wood		Vascular Plants		
	Count	F*	Count	F*	Count	F*	Count	F*	Count	F*	Σ
Shredders (SH)											
Collectors - Total (C)											
Filtering (FC)											
Gathering (GC)											
Scrapers (SC)											
Total w/o Predators (T)											
Predators (P)											
Total with Predators (PT)											

*F = Recruitment factor to indicate importance of new generations entering a given group

RATIOS (General ranges in parentheses)	Stream Orders 1-3 (Approx. 0.5-10 m wide)		Stream Orders 4-6 (Approx. 10-0 m wide)	Stream Orders > 6 (Approx. > 30 m wide)
Riparian Habitat	Shaded well developed, trees and/or shrubs	Open low shrubs and/or herbs and/or grasses	Open variable, trees and/or shrubs	Variable, flood plain or "green belt" forest
Functional Group Ratios	Calculated (Examples)	Calculated (Examples)	Calculated (Examples)	Calculated (Examples)
SH/C	(> 0.30)	(> 0.15)	(< 0.10)	(< 0.05)
SC/C	(< 0.25)	(> 0.25)	(> 0.25)	(< 0.10)
FC/GC	(< 0.50)	(~ 0.40)	(~ 0.50)	(~ 0.50)
SH/T	(> 0.25)	(> 0.10)	(< 0.05)	(< 0.01)
C/T	(> 0.50)	(> 0.40)	(> 0.50)	(> 0.75)
SC/T	(< 0.10)	(~ 0.25)	(> 0.40)	(< 0.10)
P/PT	(~ 0.10)	(~ 0.10)	(~ 0.10)	(~ 0.10)

Appendix D—*How to Do Spawning Fish Surveys* (Source: Salmon Trout Enhancement Program, Oregon Department of Fish and Wildlife)

STEP

SALMON TROUT ENHANCEMENT PROGRAM

Oregon Department of Fish and Wildlife

HOW TO DO SPAWNING FISH SURVEYS

INTRODUCTION

Spawning fish surveys are done regularly on many streams by Department of Fish and Wildlife field biologists. The information collected is vital to assessing the escapement of salmon and steelhead runs. It is an index to the status of those populations and helps predict future runs. They offer insight to whether a stream is being adequately seeded by spawners in a given year. Selected typical sections of streams are surveyed throughout the spawning season to cover the peak run. Adult salmon and steelhead are counted and fish per mile are calculated.

The department needs additional spawning escapement information on most streams. Volunteers doing spawning surveys will add valuable data that can guide Salmon and Trout Enhancement Program (STEP) efforts.

Some training, provided by ODFW personnel, is needed to prepare volunteers to do this survey. As with all STEP projects, certain procedures and guidelines must also be followed:

1. The volunteer must submit a project proposal for approval by ODFW staff. Your local STEP biologist will assist in making the application, and in selecting a stream to survey.
2. Contact landowners along the stream for permission to cross their property.
3. Training by ODFW personnel is required (about 2 hours). Classroom, hatchery and/or field trip to stress fish identification.
4. A "Volunteer Partial Liability Release Form" must be submitted and is available from STEP biologists.

GEAR AND EQUIPMENT

1. Map of stream section. Copy of USFS, BLM or USGS map in 2 inches/mile scale or larger.
2. Rain gear, hip boots or waders, warm clothes. Footgear should have non-slip material on soles, such as felt or outdoor carpet.
3. Walking stick, polarized glasses, knife, tape measure, thermometer.
4. Recording material; pencils, clipboard, stream survey form, scale envelopes (supplied by ODFW).
5. Knapsack, lunch, plastic bags for fish snouts, miscellaneous.

TIME COMMITMENT

Spawning surveys should be at least one-half mile long or longer. Under normal conditions, it takes about 1-2 hours to survey one mile of stream, plus be surveyed once every 7-10 days for duration of spawning period, which varies with species. Average 8-10 weeks. Total, about 8-10 half-days.

INSTRUCTIONS FOR SPAWNING SURVEY

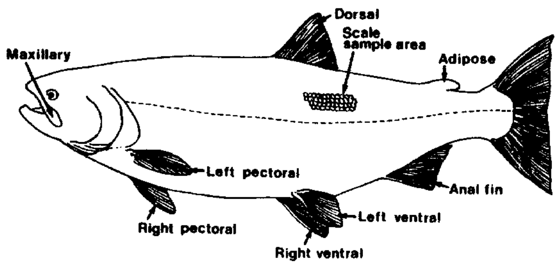
Your STEP biologist will help you select a stream section to survey. He will also help you prepare a map.

Once the section has been selected, mark the upper and lower ends so that you can return to the same spot each time you survey. Note on the map, and on the Section Description Form the STEP biologist will fill out, the beginning and end points and how it is marked.

SAMPLING FISH CARCASSES

While doing surveys, be on the lookout for carcasses of marked hatchery fish. One or more fins may be missing. If found, list under comments and include species, sex, length and fins missing. If the adipose fin (on back in front of tail) is missing, it may mean a coded-wire tag is imbedded in the fish's nose. Cut off the snout as close to the eyes as possible, note identification of stream, species, sex, date, and size in inches on slip of paper and put in plastic sandwich bag with snout and turn it in to the STEP biologist.

The biologist may ask you to collect some scales from carcasses you find. Take several scales from the side of the fish in the area below the dorsal fin and above the lateral line (see illustration). The STEP biologist will provide scale envelopes. The daily survey form slips should be turned in each week.



SUMMARY

It is highly advisable to work in pairs while doing these surveys, with extra eyes helping to observe for all spawners in the section. Since surveys are often done in rough terrain and in isolated areas, working in pairs also adds a measure of safety.

After the first time or two on the survey, you will learn where fish tend to spawn and the hiding places they use. Look under overhanging brush, under logs or cut banks and other likely places. You will soon get the hang of it and be spotting the fish with ease.

EXAMPLE: SPAWNING FISH SURVEY FORM

BASIN	Nestucca R.	WEATHER	0
SUBBASIN	Three Rivers	FLOW	M
SURVEY	Alder Cr.	VIS.	1
DATE	Nov. 15, 1984	TEMP.	43°

	LIVE		DEAD			
	A	J	M	F	J	U
CHF						
CO						

Redds	

Basin: Main river name, e.g. Nestucca River

Sub-basin: Fork creek branch, e.g. Three Rivers

Survey: Creek name, e.g. Alder Creek

Date: Date of survey

Weather: C=clear, O=overcast, F=foggy, R=rain, S=snow

Flow: Record the streamflow as L=low, M=moderate, H=high, F=flooding

Visibility: The ability to see in the water:
1=can see well on riffles and in pools
2=can see on riffles
3=cannot see on riffles or in pools

Temperature: Record water temperature in nearest whole degree Fahrenheit

Fish Observed: Mark abbreviations in column on side: CHF=fall chinook

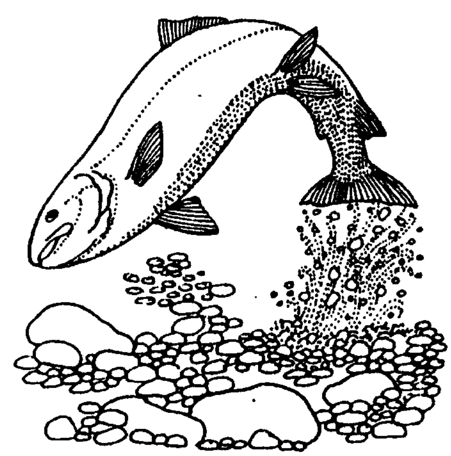
Species: CHS=spring chinook, Co=coho, CS=chum salmon, STW=winter steelhead, STS=summer steelhead

Live: Make tally marks for fish seen A=adults (over 20 inches), J=jacks (under 20 inches). At end of survey add total at bottom and circle, e.g. twenty

Dead: Record all carcasses seen with tally marks, or lengths if desired. M=male, F=female, J=jacks, U=unidentifiable. Total at bottom and circle, e.g. seventeen

Redds: Tally the number of redds observed (optional). Total and circle, e.g. eleven

Comments: Note any conditions or occurrences that are appropriate



Oregon Department of Fish & Wildlife Guidelines and Criteria for Stream–Road Crossings

Criteria for Upstream Movement of Adult Fish

Adult anadromous fish generally expend approximately 80% of their stored energy reserve during normal upstream migration to suitable spawning areas. Undue exertion or delay at stream–road crossings due to unsuccessful passage attempts at inadequate (blocking) structures can lead to reduced spawning success and prespawning mortality.

Where fish passage is required by ODFW (in general, wherever fish are present), the following guidelines shall be utilized for preliminary design. Design flows for culvert passage are calculated based on monthly periods when fish migrate.

<u>Maximum Water Velocities</u>

Table 1: Average Water Velocity (fps) at High Flow Design Discharge for:

Culvert Length (ft)	Salmon & Steelhead	Adult Trout (>6")	Juvenile Salmonids
Under 60'	6.0	4.0	2.0
60' to 100'	5.0	4.0	2.0
100' to 200'	4.0	3.0	*See note below*
200' to 300'	3.0	2.0	*See note below*
Over 300'	2.0	1.0	*See note below*

Note: For juvenile fish, only designs incorporating streambed simulation solutions will be considered for culverts over 100' in length. “Streambed simulation” refers to the situation where substrate and flow conditions in the crossing structure mimic the natural streambed above and below the structure.

Table 1 presents the hydraulic criteria for the design of culverts for passage of salmonids. Satisfaction of these criteria is essential to the adequacy of a culvert installation to meet fish migration needs. These criteria are based on several references.

In a natural stream channel, the average water velocities indicated in Table 1 are often exceeded. The diversity of natural channel beds and formations, however, provides paths of access with suitable depths, velocities, and resting opportunities with only brief exposure to excessive conditions. Velocity requirements noted above may be exceeded within structures with natural beds upon approval by the ODFW Fish Passage Coordinator, Portland.

Minimum Depth at Low Flow Discharge

For nonembedded culverts, minimum water depth during expected fish passage periods shall be:

Twelve (12) inches for adult steelhead and chinook salmon;
Ten (10) inches for salmon other than chinook, sea-run cutthroat trout and other trout over 20 inches in length; and
Eight (8) inches for trout under 20 inches, kokanee, and migrating juvenile salmon and steelhead.

For embedded (stream simulation) culvert designs, minimum depth at low flow discharge during expected fish passage periods must meet or exceed conditions found in the adjacent natural channel.

Entrance Jump; Maximum Vertical Height

A backwatered or partially submerged culvert entrance is preferred, but the following maximum jumps are allowable where justified:

One(1) foot for salmon and steelhead adults
Six (6) inches for trout and kokanee adults and salmon and steelhead juveniles.

The above are also the maximum jump heights when a series of jumps and pools are required.

In cases where entrance jumps are planned, a jump pool of at least 1.5 times the jump height or a minimum 2 feet deep must be provided.

When planning for any jump into a culvert, project designers must show why the culvert could not be designed with no jump.

Criteria for Upstream Migration of Juvenile Salmonids

Upstream juvenile migration occurs in response to instream habitat conditions, predation, and population pressures. Juvenile migration and redistribution is a means for increased survival and optimizing production. An obstruction to juvenile migration can limit production both upstream and downstream from the barrier.

Juvenile salmonids, by virtue of their small size, are less capable swimmers when compared to adults. Therefore, maximum water velocity, jump, and swimming distance criteria are necessarily lower than those for adults.

Preferred Road–Stream Crossing Structures

Where fish passage facilities are required by ODFW, the following structure types shall be considered for use in the displayed order of preference:

1. Bridge (with no approach embankment into the main channel)
2. Streambed simulation strategies using a Bottomless Arch or embedded culvert designs
3. Streambed simulation strategies using embedded round metal or concrete box culvert designs
4. Nonembedded culvert; placed at less than 0.5% slope
5. Baffled culvert (various designs); placed at 0.5 to 12% slope or a structure with a fishway.

Again, streambed simulation refers to the situation where substrate and flow conditions in the crossing structure mimic the natural streambed for fish passage flows.

The landowner or agency must justify their proposed structure type if a more preferred structure type is not selected.

General Considerations

At any given flow, slope is an important factor affecting water velocity in culverts. Culvert size also affects velocities, especially when a structure is considerably undersized and a head (pooling above culvert) is developed.

Gradients (slope) for nonembedded, nonbaffled culverts shall not exceed 0.5% unless a tailwater situation exists to backwater the culvert to a suitable depth for its length. Properly baffled or weired culverts are appropriate for steeper gradients depending on design. Structures with fishways (i.e., fish ladders or culverts with weir-type baffles) generally will be required where culvert gradients exceed 5% and streambed simulation is not employed.

Corrugated metal culverts are generally preferred over smooth-surfaced culverts. Deep corrugations are preferred over shallow corrugations.

Bottomless arches and all styles of embedded culverts shall be placed at or near the same gradient as the natural streambed and shall be at least as wide as the active stream channel (i.e., no lateral encroachment on the active stream channel). All embedded culverts (round or arch) must be embedded 1 foot deep or at least 20% of its height, whichever is more.

When deciding between bottomless arch and embedded culvert designs, the primary consideration is foundation substrate. If considerable bedrock is present, an open bottom arch is generally the appropriate choice; embedding a culvert would require extensive excavation. Where deep unconsolidated gravel and cobble are present, failure (undermining) of a bottomless arch foundation is a major concern.

Hydraulic controls may be required to (1) improve culvert entrance and exit conditions (e.g. using a beveled inlet configuration; providing resting pools at culvert entrance and exit), (2) concentrate low flows, (3) prevent erosion of streambed and banks, or (4) allow passage of bedload material. The need for, and design of, these project features should be developed in consultation with ODFW.

If water-crossing structures are placed in spawning areas, they must incorporate mitigation measures, as necessary, to achieve no-net-loss of spawning area.

Trash racks are discouraged at culvert inlets. But if necessary, these should be installed only above the high passage flow water level.

For culverts over 200 feet in length, illumination may be required. Contact the ODFW Fish Passage Coordinator, Portland, for a case-specific determination.

ODFW Culvert Evaluation Form

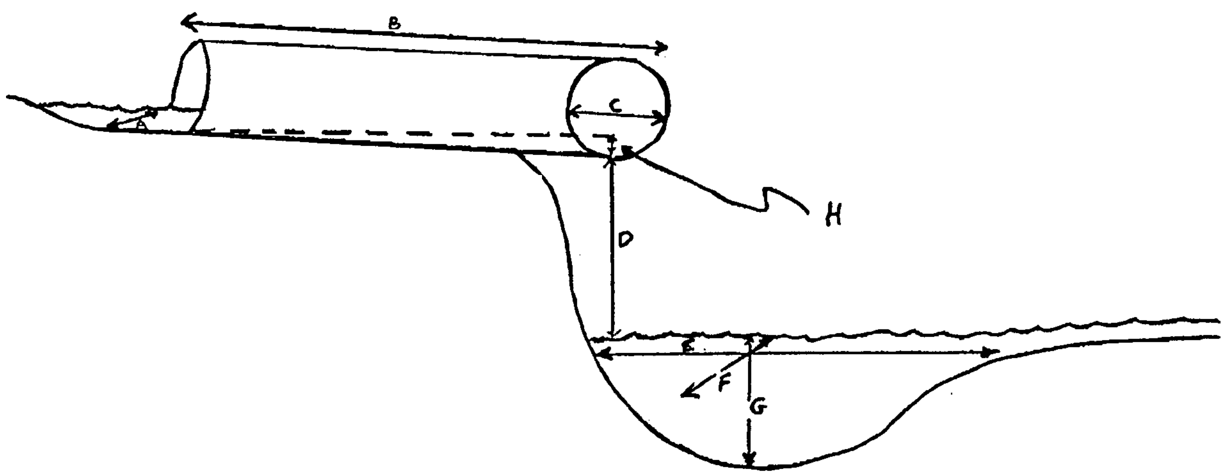
Evaluators:______________________________ Date:________________________

Stream:____

Subbasin or fork:______________________ Basin:_______________________

Legal description: T.__________ R.__________ Sec._________

Road and crossing location:____



Factor	Measurement	Record
A: Width of stream above culvert		Nearest foot
A: Estimated winter width of stream		Nearest foot
B: Length of culvert		Nearest foot
C: Diameter of culvert		Feet and inches
D: Height of culvert		Feet and inches
E: Pool length below culvert		Nearest foot
F: Pool width below culvert		Nearest foot
G: Pool depth below culvert		Nearest foot
H: Drop of culvert from horizontal		Inches

ODFW Culvert Evaluation Form, page 2

Questions

What is the type of culvert?
❒ steel ❒ tarred steel ❒ aluminum ❒ concrete ❒ wood ❒ other

Who owns and maintains the culvert?

Is the culvert in good condition?

Is the culvert easily accessible from the road for fish-passage repair work?

What species and estimated size of fish are observed in the pool *below* the culvert?

What species and estimated size of fish are observed in the first pool *above* the culvert?

In your judgment, could adult fish pass upstream through the culvert in winter?
If not, why not? What would be needed to improve passage?

In your judgment, could juvenile fish pass upstream through the culvert in winter?
If not, why not? What would be needed to improve passage?

Do you have other comments about this culvert?

6

Managing Rural Homes and Small Acreages to Protect Watersheds

Garry Stephenson
and Linda J. Brewer

The property you live on, no matter its size, is part of a larger mosaic of properties. Water drains over and through this land into streams, rivers, lakes, and eventually the ocean. Even if there are no streams on your property, water eventually makes its way to these bodies of water from your land. Thus, the quality of water before and after it leaves your property is critical for human consumption, fish habitat, and many other uses.

It might seem that small properties can't contaminate water resources or do much to improve water quality. But the combined impact of many rural homes and small acreages can represent a significant source of pollution or clean water depending on how well the land is managed. Your property is an important part of the watershed processes discussed in Chapter II-2, "Watershed Hydrology."

This chapter discusses several key sources of water-quality contamination on rural homesites and small farms and suggests ways to reduce water-quality problems.

The kind of pollution we're concerned with in this instance is *nonpoint source pollution.* This kind of pollution comes from many sources, some quite small. These sources might not be easy to identify, but added together they're a major contributor to water

In this chapter you'll learn:

- The role of soil in water quality
- How to manage home landscapes and gardens to protect water quality
- How to manage your domestic well and septic system to protect water quality
- How to manage livestock pastures to protect water quality
- How to manage manure and compost piles to protect water quality

contamination. *Point source pollution*, on the other hand, comes from easily identified sources such as factories or sewage plants.

The "Resources" section at the end of this chapter includes additional materials with more in-depth coverage of these topics.

MANAGING YOUR LANDSCAPE AND GARDEN TO PROTECT WATER QUALITY

See Section II, Chapter 2 and 4, and Section III, Chapter 3 for information related to this chapter.

Section II

2 Hydrology

4 Soils

Section III

3 Livestock

Home landscapes and gardens can be a source of water contamination in the form of eroding topsoil and excess fertilizers and pesticides. Pounding rain and runoff carry away soil particles, organic matter, plant nutrients, and soil contaminants. This mix of water, soil, and chemicals can make water turbid or cloudy, stimulate excess algae growth, and contaminate aquatic life and drinking water.

Fortunately, you can minimize erosion and runoff with some fairly basic land management practices. The key is to minimize the amount of contaminated water that runs off your property by using fertilizers and pesticides correctly. Do not overapply any fertilizer or pesticide to your lawn, garden, or landscape.

Home landscape design and materials

The design of your landscape and the materials you use can have a major impact on how water behaves on your property. Water leaving a site as runoff is more likely to carry pollutants than water that has soaked through the soil and leaves as groundwater. When water soaks through the soil, the soil filters the water to a greater extent than when the water just runs off.

In general, more than 90 percent of the rain that falls on pavement runs off. Lawns have about 25 percent runoff, and dense forests have about 10 percent runoff. Therefore, when designing a landscape, it's best to have fewer hard surfaces and more grass, trees, and natural landscaping.

It's a good idea to select plants that are native or well adapted to your area. Often these plants require less supplemental water and fertilizer and fewer pesticides to remain healthy and attractive. By using fewer of these inputs, you decrease the cost of the landscape as well as the potential for water contamination.

The same is true for lawns. Consider using low-maintenance groundcovers instead of grass, particularly in areas where grass doesn't grow well, such as dense shade.

Home landscapes and gardens can be a source of water contamination in the form of eroding topsoil and excess fertilizers and pesticides.

The role of soil in water quality

Soil as a filter

Eroding topsoil, fertilizer, petroleum products, and pesticides are some of the materials that degrade the quality of water that passes through or over soil. The type of soil you have and how you manage it help determine whether these contaminants reach bodies of water.

Activity in soil is a complex interplay of chemical and biological reactions. Most soil has a negative electrical charge, which allows it to attract and hold positively charged ions. Many plant nutrients and soil contaminants have a positive charge and therefore can be held by soil particles. In this case, soil acts as a chemical filter.

Soil also contains immense quantities of microorganisms that feed on organic matter and other material in soil. These organisms act as a biological filter when they degrade, alter, or inactivate contaminants.

There are many kinds of soil, and each has characteristic drainage patterns. Sandy soil has large pore spaces that permit water to drain quickly. Clay soil has very small pore spaces, so water moves through it very slowly. The pore sizes of silt loam, silty clay loam, and clay loam lie between those of sand and clay.

Each of these drainage characteristics has water-quality consequences. Soils with quick drainage reduce runoff but permit nutrients and contaminants to travel quickly into and through the soil toward groundwater. Soil with slower drainage reduces the rate of contaminants traveling into the soil profile but causes standing water and surface runoff. The soil type, slope, and rate and amount of rainfall or snow melt influence the exact amount of water flowing into and across soil (Figure 1).

Soil as a contaminant

Soil suspended in water causes clouding or turbidity. Soil contains organic matter and nutrients that can reduce the oxygen content of water. Fish and other aquatic animals suffer because of limited dissolved oxygen in the stream.

Clay soil particles, because of their small size, can be carried along in streams, keeping them cloudy. Heavier soil particles such as silt or sand settle out of flowing water more easily, especially where the flow slows. In these places, they build up, changing the course of the stream over time. Soil deposited on stream bottoms can cover or smother nurturing habitats for fish eggs as well as the insect eggs upon which fingerlings depend.

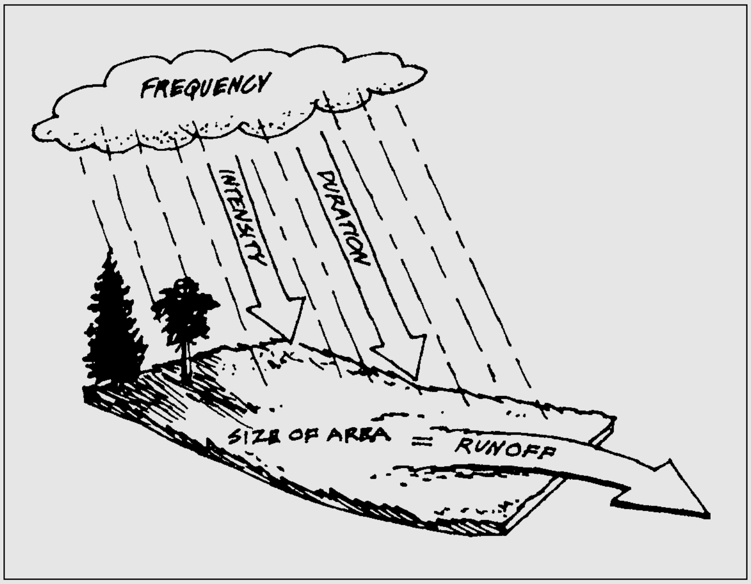


Figure 1.–Rainfall characteristics help to determine amounts of runoff. (Source: Water Quality Protection Guide, *Oregon Department of Agriculture, 1993)*

Continued

THE ROLE OF SOIL IN WATER QUALITY

continued

How organic matter improves soil

Organic matter is an important ingredient in a healthy soil system. It can be supplied as crop residue, dead grass, or animal manure. When applied to the surface, it reduces erosion and the compaction caused by raindrop splash.

Organic matter, like soil, has a negative charge and attracts and holds positively charged plant nutrients and other materials. Thus, organic matter "ties up" nitrogen and pesticides, slowing their leaching into surface and groundwater.

Organic matter also acts like a sponge, slowing the flow of water through soils. This characteristic is especially beneficial to sandy soils. In clay soils, organic matter creates larger soil pore spaces, increasing the amount of air in the soil and enhancing drainage.

Chapter II-4, "Watershed Soils, Erosion, and Conservation," contains more information about how soils fit into the entire watershed picture.

Always mulch or plant some type of cover crop over bare soil. These techniques protect the soil from erosion and add organic matter.

Managing weeds

Weeds are plants that have a detrimental effect on agriculture, recreation, wildlife, or humans. Weeds cause production losses to agriculture, endanger native plants and animals by encroaching on forest and conservation areas, hamper the use of recreational areas, and can be poisonous or harmful to humans and animals.

Weeds also can be a source of conflict between neighbors when weed control is not practiced. Many states mandate that noxious weeds be controlled on lands managed privately or publicly. Regardless of enforcement, it is everyone's responsibility to control noxious weeds.

Several plants can be characterized as "plant barbarians." These plants invade and aggressively spread, dominating other, more favorable plants. They can harm humans, poison livestock, and make land unattractive and virtually unusable.

Riparian and wetland areas are susceptible to several very aggressive plants. If these plants are present, manage them so they do not spread, or plan to remove them. For instance, reed canarygrass (*Phalaris arundinacea*) is used as a pasture grass in many wet areas. Efforts should be made to keep it from escaping into riparian or wetland areas where it is not welcome. Proper grazing can keep this plant in check. In many areas, purple loosestrife (*Lythrum salicaria*) is a threat to wetlands. It always should be removed.

When possible, it's a good idea to allow native plants or plants highly compatible with native plants to dominate the uncultivated areas of your farm. You will find these plants are easy to manage, encourage appropriate wildlife, often assist in preventing weeds, and maintain important natural functions such as the water-filtering role of wetlands.

Reduce weed problems on your property with these guidelines for weed control:

- Know the difference between a weed and a benign plant.
- Control weeds when they are seedlings or are actively growing.
- Cut or kill weeds before they go to seed.
- Sow grasses or groundcovers on bare spots to compete with weeds.

- Don’t disturb areas larger than you can reasonably manage when establishing garden sites, landscaping, pastures, and other improvements.
- Compost manure before spreading to reduce weed seeds.

Using fertilizers correctly

Homeowners usually add fertilizer to their landscapes and gardens to enhance plant growth. However, if you overapply compost, manure, or synthetic fertilizers, water can carry excess nutrients into streams or leach them into groundwater.

A soil test to determine the nutrients available to your plants will help you avoid adding unnecessary fertilizer. Information on how to test soil and the location of analytical labs is available from your county office of the OSU Extension Service.

When using fertilizer, use only the amount recommended. In some cases, plants can achieve adequate growth with less than the recommended amount of fertilizer.

Time fertilizer applications to match the plants’ needs so the nutrients are not lost in runoff or leaching. Plants take up nutrients most vigorously during the active growing season. Don’t add any kind of nitrogen during the short, cool days of late autumn and winter, when plant growth slows significantly. Most plants have reduced nutrient demands at this time, and nitrogen is easily leached into groundwater by precipitation.

It’s best to fertilize trees and shrubs just before or as new growth begins in the spring. Fertilize grass and flowers when they’re actively growing. Use slow-release fertilizers when possible. They release nutrients into the soil in small amounts over time and are less prone to leaching.

Excessive irrigation after a fertilizer application promotes runoff and leaching. Match the application of water to the needs of plants. Install irrigation timers if needed.

Manure can be a valuable fertilizer and soil conditioner and, when applied appropriately, will produce minimum ground- and surface water contamination. Land application is a logical and time-proven method of disposing of manure. To avoid water contamination, apply manure between periods of intense rainfall, when the ground is neither frozen nor saturated. Because the nitrogen in manure is so water soluble, try to apply it as the soil warms up and plants are growing vigorously.

It’s also helpful to incorporate manure lightly into the soil. In permanent landscape plantings, apply up to 1 inch and work it into the surface with a hand rake or similar tool.

Cover and compost stockpiled manure to conserve its fertilizer value.

Using pesticides appropriately

Pests in gardens and landscapes fall into three major categories: weeds, insects, and diseases. There is an arsenal of organic, least-toxic, and highly toxic pesticides and methods available to control these problems. As with fertilizer, the tendency is to overuse pesticides. These excess chemicals threaten surface and groundwater quality.

When dealing with a problem in your yard, it's a good practice to begin to solve the problem by using the least-toxic method at your disposal. Then, if the problem continues, you can use more toxic methods until you achieve success. This strategy will decrease your use of more toxic pesticides, minimize your handling of pesticides, protect your family and pets, and limit environmental impacts.

Start by adjusting cultural practices to give your plants optimum growing conditions. A healthy plant is less susceptible to pest attack. Choose plants carefully based on the conditions of your yard. If you do encounter pest problems, consider using cultural, mechanical, and biological controls first.

Some "pest problems" are not problems at all. Good plant selections for home landscapes tolerate low levels of insect and disease damage. Putting up with some landscape imperfection reduces labor and chemical inputs.

Always use pesticides–organic or synthetic–for their intended purpose. Apply them at the recommended rate and follow label directions. Never dump pesticides into household drains, storm drains, or on the ground. Instead, either use the pesticide for its intended purpose or take advantage of a pesticide collection event. Your local garbage collection service or landfill can provide information on these collection events. Purchase only the amount of pesticide you'll need for a single growing season. In the case of pesticides, bigger is not necessarily better.

Limiting pesticide use

Here are just a few ways to limit pesticide use in your home landscape:

- Use disease-resistant plant varieties.
- Practice good sanitation.
- Use insect traps and barriers.
- Remove pests by hand.
- Create habitat for beneficial organisms.

MANAGING YOUR WELL AND SEPTIC SYSTEM

Domestic wells

Most rural homes get their drinking water or irrigation water from a well. By properly managing your wellwater system, you can protect groundwater and your drinking water supply. Proper management requires inspection and maintenance of all wells on your property and special attention to any practice that could potentially contaminate groundwater.

The location of your well relative to other farming activities is very important in protecting your drinking water. Common sense dictates that potential contaminants be located as far from a well as possible. For public health reasons, states and counties set minimum distances between wellheads and common pollution sources. These structures and activities include:

- Septic tanks
- Confined animal feeding or holding operations
- Animal waste holding ponds, lagoons, or other waste storage sites
- Pesticide or fertilizer storage
- Above-ground and buried fuel storage tanks
- Sewage disposal systems such as pit privies or septic system drainfields

Contact your county sanitarian to determine whether there are minimum setback limits regulating the placement of these or other structures in relation to your well.

Inspect your well to see whether it is properly constructed. See Figure 2. The well casing should extend 12 to 18 inches above the

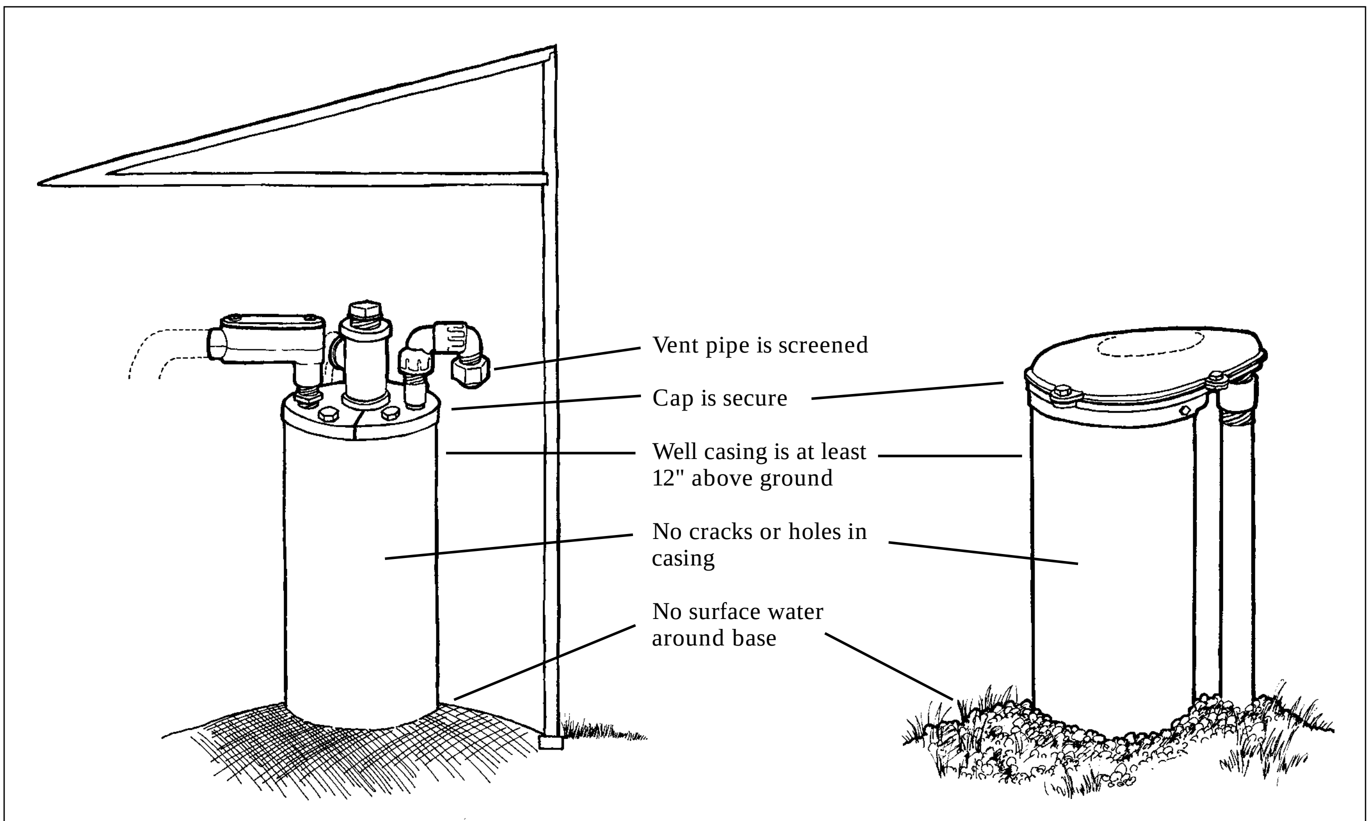


Figure 2.–A properly constructed well protects against contaminants entering your drinking water system.

ground surface, and there should be a concrete or soil pad surrounding and sloping away from the casing. This design protects the wellhead from contamination by surface water. If your wellhead does not extend above the ground surface, a shallow trench around the wellhead is recommended to protect the well from surface water.

Check the sanitary well cap to make sure the bolts are tight and that no gaps or cracks are visible in the cap or casing. Replace old and cracked sanitary seals, especially when surface water, as from flooding, can cover your wellhead. Make sure there is a screen covering the vent pipe to prevent insects and mice from entering your well.

It's a good idea to locate all of the wells on your property (Figure 3). Wells no longer in use present a high risk of groundwater contamination. These old wells provide a direct conduit for pollutants to reach groundwater. Abandoned wells may be visible only as an unnatural depression, a ring of bricks or rocks, or a pipe sticking out of the ground. Always abandon old wells properly and document their location. Pass this information on to the next property owner.

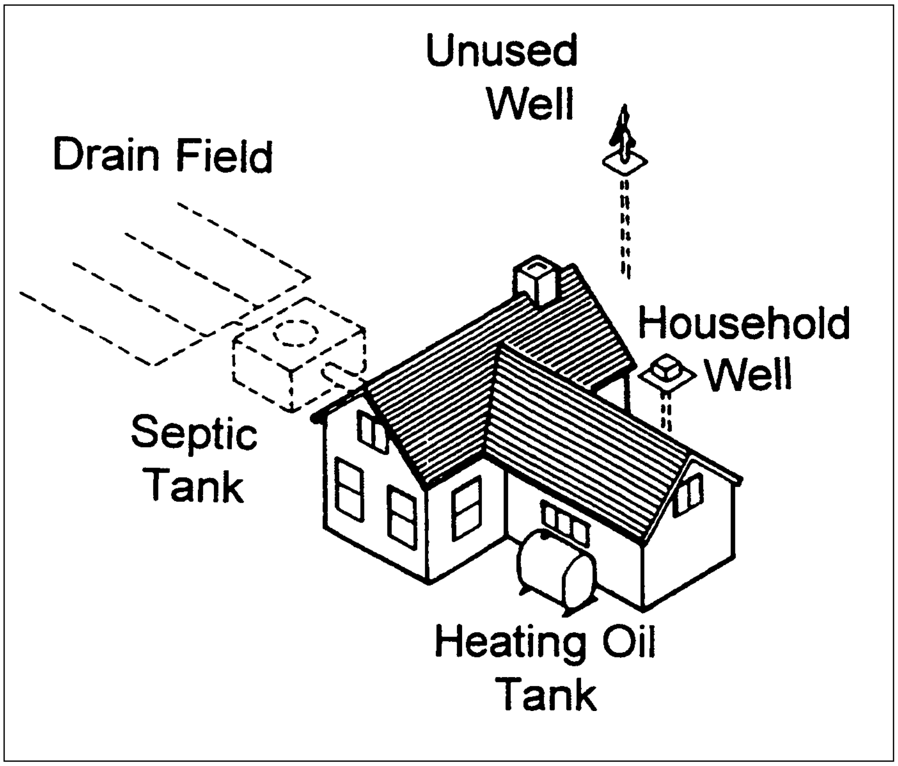


Figure 3.–Know the location of all active and abandoned wells on your property.

If your household well is located in a pasture, fence the wellhead to prevent urine and manure from reaching the well. If your soil is sandy (porous), remember that fecal bacteria can travel in groundwater as well as surface water.

Don't store pesticides and fertilizers in your well house. One spill could contaminate your drinking water. Find a suitable dry location for these materials away from your well.

Install an antibackflow or antibacksiphoning device on all outdoor faucets. These devices prevent contaminants from pesticide sprayers, livestock tanks, and so on from being siphoned into your household water system. As an alternative, never put the end of the hose in liquid–always maintain a gap between the end of the hose and any potential contaminant.

Test your water annually for bacteria and nitrate. These two tests serve as an indicator of the condition of your wellwater.

Septic systems

Properly operating septic systems safely process household wastewater and sewage. Failing septic systems are major groundwater and surface water hazards, as well as sources of odor and bacteria. Through routine inspection and maintenance, you can protect your household water supply as well as the surface water and groundwater in your watershed.

In a properly working septic system, liquids and solids from the household are separated in the septic tank (Figure 4). Liquids are passed from the tank into the drainfield, where they're leached into the soil. Solids are partially digested by micro-organisms, and the remaining solids settle and slowly fill the tank.

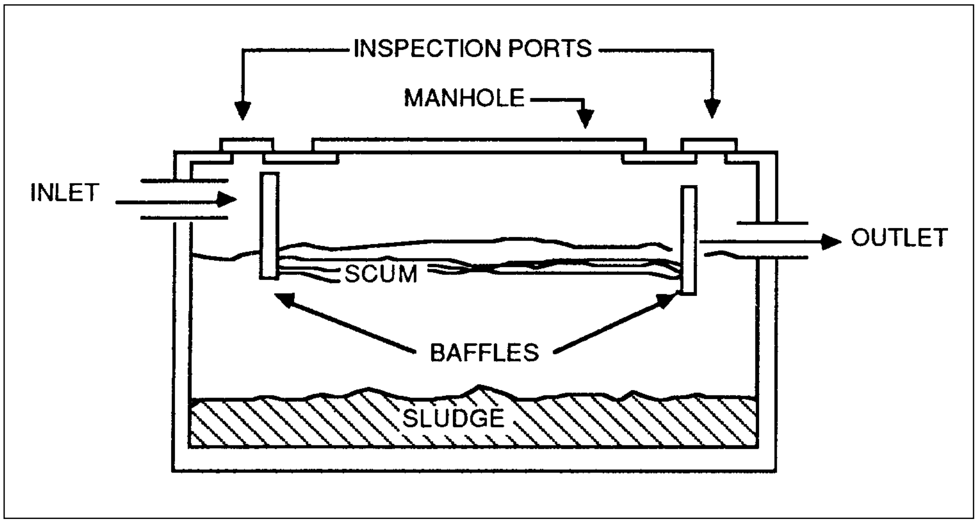


Figure 4.–Cross-section of a septic tank.

Most legally installed septic systems consist of a septic tank and a soil leach field. The proper size depends on the size of the dwelling, expected water use, and leach field soil type. States specify the size of septic tanks in newly constructed systems. The drainfield also must be the correct size for the household. You can obtain specific guidelines from your county sanitarian.

Have your septic tank inspected regularly by trained personnel. A properly sized tank should be pumped out every several years to remove accumulated solids. The pumping schedule varies with the size of the household and the size of the system. An overfilled tank can pass solids to the drainfield, thus clogging it and leading to leach field failure and costly repairs.

Don't flush material into your septic system that doesn't decompose readily or that might clog the system or interfere with the decomposing activity. These items include diapers, fats, grease, solvents, oils, paints, or pesticides. Using a garbage disposal also contributes to the accumulation of solids in the tank; more frequent pumping is required when garbage disposals are used. Normal use of household cleaning products and laundry bleach doesn't affect the system.

There is no need to purchase additives to increase the rate of decomposition in your system. Pumping the tank to remove solids is the most important maintenance you can schedule for your septic system.

Keep runoff from roofs and pavement away from your drainfield to avoid saturating the soil. Saturated soil won't accept any more wastewater. Don't allow water that doesn't need treatment to be added to the amount of wastewater in the septic system. Examples are water softener backwash water, basement floor drain sumps, and roof runoff water. Water-saving fixtures and other conservation practices also reduce the amount of wastewater entering your system.

Plant grass over the drainfield. The roots from trees and large shrubs can clog it. Avoid soil compaction over the drainfield. Compacted soil can damage the system or interfere with its function. Don't use the area for a parking spot or a road. Don't drive large equipment over it or allow large animals to stand on it, especially when the soil is wet. Don't cover the drainfield with plastic, cement, or other impermeable material. These materials reduce the soil's ability to "breathe," thus inhibiting proper function of the drainfield.

MANAGING SMALL PASTURES

Owning livestock often is an important benefit of living on a small farm. In areas with sufficient rainfall and soil fertility, pastures can supply large quantities of high-quality feed for animals. Maintaining the quantity and quality of feed in a pasture saves money and promotes healthy animals. The type of management that promotes high-quality pastures also protects water quality.

Here are some basic management recommendations. Each is discussed below:

- Base the number of animals you keep on the size and productivity of your land.
- Do not overgraze your pasture.
- Cross-fence pastures to provide several paddocks, then rotate grazing.
- Keep animals off saturated pastures.

Base the number of animals you keep on the size and productivity of your land.

One of the challenges of managing livestock on a small acreage is taking care of the needs of the animals in a small area without overusing it. Land has a limit to how much forage it can produce. If the number of livestock is in balance with the amount of forage produced, your land is considered to be within its carrying capacity. If the number of animals exceeds this amount, pastures are overgrazed, the quantity and quality of forage declines, weeds invade, and the soil becomes compacted from too much animal traffic.

In overgrazed and overused conditions, sediments and pollutants are no longer filtered by a vigorous stand of grass and can run directly into streams. The soil can't absorb excess water and isn't protected with a thick groundcover so it is more likely to erode. Too many animals produce excess manure and urine, perhaps supplying more nutrients than can be cycled naturally through the pasture.

The amount of pasture required for livestock varies by region and is dictated by climate, soil type, and other factors. Even within a given region, some land is more productive and can support more animals. Some land has limitations and can't support the recommended number of animals or isn't appropriate for every type of livestock. Some land is so wet that it simply isn't appropriate for livestock use except during the driest time of the year. Contact your local Extension Service office, USDA Natural Resources Conservation Service (NRCS) office, or Soil and Water Conservation District (SWCD) for specific information about your land's carrying capacity for livestock.

One of the challenges of managing livestock on a small acreage is taking care of the needs of the animals in a small area without over-using it.

Do not overgraze your pasture.

Pasture plants, like other plants, require leaf growth. When the leaves of pasture plants are continuously nipped close to the ground, the plants lose vigor and might die. On the other hand, when plants are grazed and then given time to recover, they remain healthy and vigorous. The rest period allows the plants to grow and store energy so they can withstand future grazing.

It is generally recommended to graze a pasture to about 3 inches in height and then allow it to rest until it regrows to about 6–8 inches. Correct grazing height varies somewhat depending on the type of grass.

This technique maintains vigorous pasture plants and decreases weeds and bare spots. A vigorous pasture does a great job of filtering sediments and using nutrients from manure that otherwise might run off into streams.

The plants typically grown in pastures require some additional fertilizer in order to maintain a productive stand. In addition to chemical fertilizers, manure and urine deposited by grazing stock contribute to pasture fertility. Periodic harrowing to distribute manure will promote general pasture quality. Legumes included in a pasture mix also can contribute to pasture fertility.

Cross-fence pastures and rotate grazing.

Dividing or cross-fencing your land into several small pastures allows one part of a pasture to rest while animals are grazing another. You then can rotate animals from one pasture to another. This method increases the productivity of pastures, decreases feed costs, and protects the soil with a heavy sod that filters runoff.

Pastures can be cross-fenced with permanent fencing or temporary electric fencing. Cross-fencing systems should have at least three pastures. Four are recommended; more are even better (Figure 5).

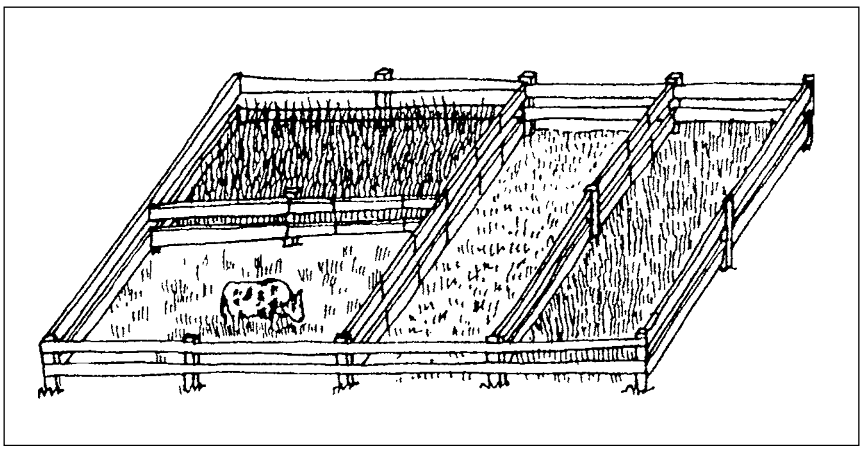


Figure 5.–Rotational grazing. (Source: Water Quality Protection Guide, *Oregon Department of Agriculture, 1993)*

The system for rotating pastures is simple. Put animals into the first pasture when the grass is about 6–8 inches tall. When the grass has been eaten to about 3 inches tall, move the animals to the next pasture.

The rest period needed varies depending on time of year and climate. Pastures grow fastest during spring and summer; during winter they grow very little if at all. The goal is to not return to a pasture until it has regrown to 6–8 inches tall.

Keep animals off saturated pastures.

During winter, pastures grow very slowly or stop growing altogether and sometimes are saturated with water. This is a good time to move your animals to a well-drained area or an all-weather paddock to avoid damaging the pasture.

When animals stay on wet pastures, they overgraze what little feed there is. They also compact and damage the soil and generally create a muddy mess. Pastures that have livestock on them all winter usually don't support a good stand of grass the following year, cause stress for animals, and are a source of sediment in streams.

Sometimes landowners “sacrifice” an area for livestock to stay on during the winter. If you use this method, make sure the area is on high, well-drained ground and well away from streams.

On small farms, a good investment is to construct an all-weather paddock for animals to stay on until pastures are ready to graze in the spring (Figure 6). In addition to saving your pasture, these well-drained areas keep animals and their feet drier and provide a convenient area for winter feeding. If they’re large enough, they also can be used as an exercise area or arena.

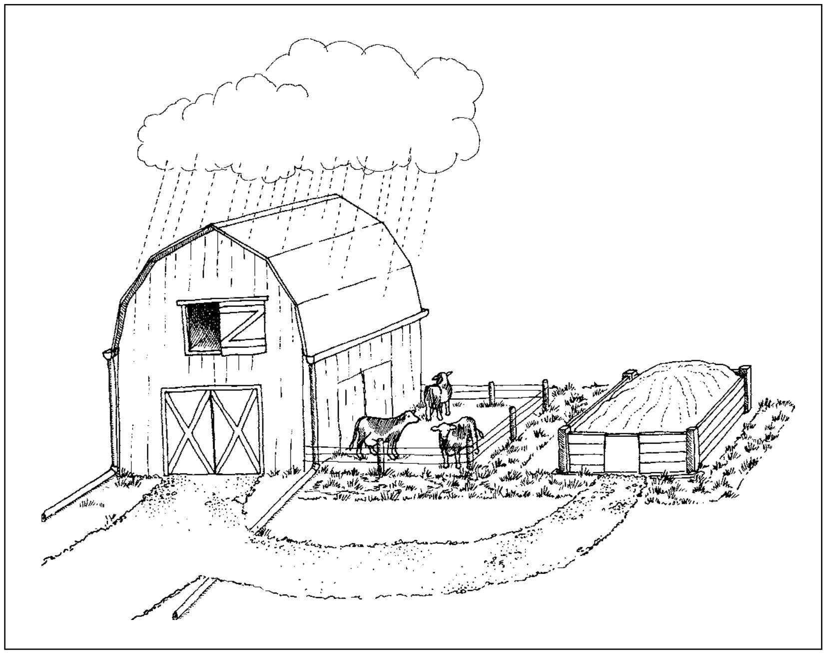


Figure 6.—Careful management of grazing, manure storage, and clean water runoff can protect surface water and groundwater from contamination during wet weather.

MANAGING COMPOST AND MANURE PILES TO PROTECT WATER QUALITY

Composting waste materials from the household, barn, and garden is a popular and effective way to generate fertilizer and organic matter to add to soil. Although composting is a good method of recycling nutrients, it can be a source of sediment, excess nutrients, and bacteria in streams when managed incorrectly.

Any accumulating mass of organic waste can threaten water quality. Common sources are large amounts of fresh manure and urine-soaked bedding generated from horse barns and other small livestock farms. These wastes contain both nutrients and potential disease-causing organisms.

The following suggestions, each discussed below, can help you minimize the possibility that waste will contaminate surface or groundwater:

- Site waste piles properly.
- Use buffer strips to trap flowing contaminants.
- Apply manure and compost when and where plants can use it.

Site waste piles properly.

It’s important to control the flow of water through compost and manure piles. Covering piles is an effective way to do this

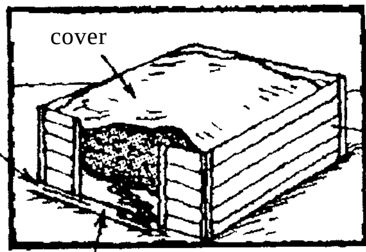


Figure 7.–Covered manure storage. (Source: Water Quality Protection Guide, *Oregon Department of Agriculture, 1993)*

(Figure 7). It also enhances the composting process and prevents the loss of nitrogen from water percolating through the pile.

If you keep horses or other livestock in a confined area during the winter, you'll need to store manure in piles so you can spread it on pastures later. When choosing a spot for long-term organic waste storage, consider the soil types on your property. Refer to the sidebar on soils (pages 3 and 4) for more information on how water and pollutants move through different soils.

Also consider the flow of surface water before siting a waste pile. Don't locate piles in low spots where drainage water flows. If necessary, divert surface water to prevent it from moving through the pile. Site the pile downslope from your well. A 200-foot separation ensures maximum wellwater protection. Be sure all waste is above the floodplain so it won't be carried downstream during floods.

Consider using a roofed, concrete pad for storage of large amounts of waste. Gutters divert clean rainwater downslope away from stored materials. Curbs further divert surface flows away from the pad, thus protecting water quality and manure nutrient content. Smaller amounts of waste can be stored on the ground, provided they are covered by weighted tarps during the rainy season.

Adequate, correctly sited manure storage space can reduce the pressure to dispose of manure by winter's end. The number and type of animal and the type of bedding affect the amount of space needed for manure storage. The following table can be used to estimate the area needed per animal for 6 months.

Animal	Cu ft/animal/6 months
Horse	175
Cattle	150
Sheep	10
Pig	27
Alpaca	16

On a practical level, assuming a pile 4 feet high, one horse requires about 45 square feet of storage space for a 6-month period. Keep in mind that these numbers are for manure only and do not include additional storage space for bedding.

Use buffer strips to trap flowing contaminants.

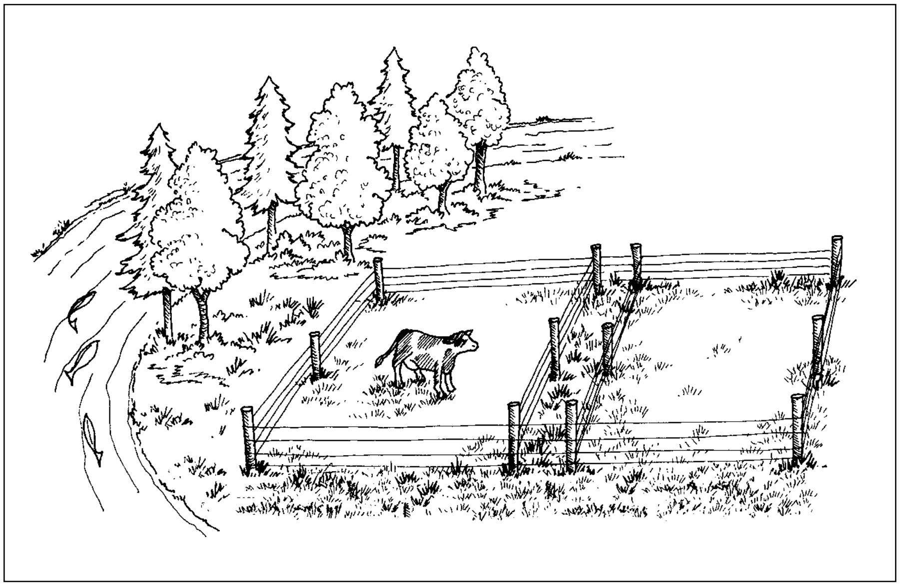


Figure 8.—Use vegetated filter strips to slow runoff, increase infiltration, and filter pollutants from runoff water.

Protect streams by maintaining a buffer strip between manure piles or sacrifice areas and streams. Buffer strips are areas planted with grasses and groundcovers (Figure 8). They enhance water quality by slowing runoff, promoting infiltration, and reducing the transport of pollutants. They serve as water filters and reduce amounts of sediment, nutrients, and microorganisms reaching the stream.

These vegetated strips take up dissolved nutrients before they reach the stream. Deeply rooted plants can recover nutrients that move deep into the soil.

Buffer strips must be protected from grazing and compaction by animal hooves, especially during wet weather. If you want to mow a buffer strip, do so only during the dry season. Set the mower high to promote lush, vigorous growth of grasses.

As a property's slope increases, the width of the buffer strip also must increase. A wider buffer provides increased filtration on sites where the volume and rate of water flow is high. For a 0–3 percent slope, provide 25–50 feet of buffer. For a 3–8 percent slope, 50–100 feet of buffer is necessary for effective filtration. These are minimum recommendations. Steeper slopes require even greater widths to protect streams from contamination.

Apply manure and compost when and where plants can use it.

Spread manure and compost only when actively growing plants can take up their nutrients. The safest times of year to apply manure to soils are:

- Just before planting, provided the soil isn't frozen or waterlogged
- When crops or pasture are actively growing

Summary/Self review

The quality of water before and after it leaves your property is critical for human consumption, fish habitat, and other uses. The combined impact of many rural homes and small acreages can represent a significant source of pollution or clean water depending on how the land is managed.

Soil has an important role in maintaining water quality. It can act as a filter of pollutants or, if eroding, can become a pollutant itself. The organisms that live in soil and organic matter help digest and tie up pollutants. Plants growing on the soil, such as grass buffer strips, utilize excess nutrients. These functions prevent pollutants from reaching bodies of water.

Soil suspended in water causes clouding or turbidity. Soil contains organic matter and nutrients that can reduce the oxygen content of water. Fish and other aquatic animals suffer as a result of less dissolved oxygen in the stream.

Home landscapes and gardens can be a source of water contamination in the form of eroding topsoil and excess fertilizers and pesticides. Landscapes should be designed to reduce water runoff. Use pesticides and fertilizers only when needed and according to directions.

Manage household wells and septic systems to prevent contamination of household water and groundwater. Protect household wells from sources of pollution, and have water tested routinely for nitrate and coliform bacteria. Septic systems should be pumped and inspected regularly by a trained person.

Base the number of livestock you keep on the size and productivity of the pasture. Provide adequate fertility for pasture plants to maintain a good stand. Manage livestock to prevent overgrazing. Minimize mud by avoiding use of pastures during the rainy season and by providing an all-weather paddock or sacrifice area.

Cover manure and compost piles to prevent leaching. Apply compost only when plants are actively growing. Maintain grass buffers to prevent sediment and excess nutrients from reaching bodies of water.

EXERCISES

You can do these exercises on your own.

Learning about your soil

Locate your property on the soil survey for your county. Soil surveys are available at county offices of the OSU Extension Service, local Natural Resources Conservation Service offices, and many public libraries. Study the drainage and erosion characteristics of the soil types on your property. Soil surveys also offer estimates for numbers of animals that can be supported by different soil types.

Managing compost piles

Look for water sources at risk from manure contamination. Plan for drainage and create a cover for manure piles.

Evaluating your well and septic system

Put together a file on your domestic well and septic system. When was the septic system last pumped? Locate your septic tank and drainage field and sketch a map of them. Do you have records of when the system was installed or repaired and its capacity? On the same map, sketch the location of your domestic well and any other wells on your property, abandoned or in use.

RESOURCES

Print materials

Gardening and Water Quality Protection: Using Nitrogen Fertilizers Wisely, EC 1493, by G. Glick Andrews (Oregon State University Extension Service, Corvallis, 1998).

Home Fruit, Vegetable, and Ornamental Garden Fertilizer Guide, EC 1503, by J. Hart and R. McNeilan (Oregon State University Extension Service, Corvallis, reprinted 2000).

*Home*A*Syst/Farm*A*Syst Assessment System* Home*A*Syst is a set of 20 publications dealing with protecting the groundwater that supplies drinking water. It is a voluntary self-assessment system to help homeowners identify and reduce environmental hazards. Home*A*Syst and Farm*A*Syst (a similar program for farmers) are national programs supported by the USDA Cooperative State Research Education and Extension Service (CSREES), USDA Natural Resources Conservation Service (NRCS), and U.S. Environmental Protection Agency (EPA). The national office provides guidelines and educational support to states. Nearly every state currently operates or is developing a Home*A*Syst /Farm*A*Syst program.

Manure Management in Small Farm Livestock Operations: Protecting Surface and Groundwater, EM 8649, by D. Godwin and J.A. Moore (Oregon State University Extension Service, Corvallis, 1997).

Manure Storage and Compost Facilities for Operations with Limited Numbers of Livestock, USDA-NRCS and Washington County Soil and Water Conservation District, Hillsboro, OR, no date)

Septic Tank Maintenance, EC 1343, by J.A. Moore (Oregon State University Extension Service, Corvallis, reprinted 2000).

*Stream*A*Syst: A Tool to Help You Examine Stream Conditions on Your Property*, EM 8761, by G. Glick Andrews (Oregon State University Extension Service, Corvallis, 2001).

Twelve Simple Things You Can Do to Protect Your Well Water, EM 8651, by G. Glick Andrews (Oregon State University Extension Service, Corvallis, 1995).

Weeds of the West, Tom Whitson, ed. (University of Wyoming & Society of Weed Science, revised 2001).

Your Yard and Water Quality: Simple Things Gardeners Can Do to Prevent Water Contamination, EB 1744, by V. Bobbitt, R. Fox, H. Kenell, C. Moulton, G. Pinyuh, and M. Robson (Washington State University Cooperative Extension, Pullman, revised 1994).

Web sites

Fact Sheets: Functions and Values of Riparian Areas (Massachusetts Department of Fisheries and Wildlife). http://www.magnet.state.ma.us/dfwele/river/rivfstoc.htm

*Farm*a*Syst* (University of Wisconsin). http://www.uwex.edu/farmasyst

*Home*a*Syst* (University of Wisconsin). http://www.uwex.edu/homeasyst

Surf Your Watershed (U.S. Environmental Protection Agency). http://www.epa.gov/surf/

Water Quality Information Center (National Agriculture Library). http://www.nal.usda.gov/wqic/

Oregon Small Farms (Oregon State University). http://smallfarms.orst.edu/

Backyard Conservation fact sheets (Natural Resources Conservation Service). http://www.or.nrcs.usda.gov/

Wellwater program (Oregon State University). http://wellwater.orst.edu/

MOVING FORWARD–THE NEXT STEPS

On your own, use the lines below to fill in steps, actions, thoughts, contacts, etc. you'll take to move yourself ahead in improving your ability to protect water quality on your property.

1.____

2.____

3.____