

CHAPTER 3

WORKING IN THE WATERSHED

All rivers and streams drain from a basin- an area called a watershed. What happens in each watershed affects the quality of the streams and the fish habitat they provide. This chapter gives a basic background on how watersheds work.

Watershed Basics

- ◆ The Watershed Approach
- ◆ What is a Watershed?
- ◆ Watershed Elements and Processes
- ◆ Water Quality

THE WATERSHED APPROACH

Understanding and managing watersheds is useful in the mitigation of local road-related environmental problems because:

- Salmon and steelhead species in our Central Coast watersheds are now listed, or proposed to be listed, as threatened or endangered under the Federal and State Endangered Species Act, leading to new legal restrictions on watershed activities.
- Many of the streams in our region are listed under the federal Clean Water Act as “impaired” by excessive sediment & temperature, triggering a requirement for Total Maximum Daily Load (TMDL) non-point source pollution limits for each stream system. You can find a list of these streams and impairments at http://www.swrcb.ca.gov/tmdl/303d_lists.html.
- Since water moves downstream in a watershed, and road work and other watershed activities can affect water quality at locations downstream, it takes a “big picture” watershed view to solve human-caused problems.
- Solutions need to address the causes and not just the symptoms of stream and fishery conditions – and the watershed approach provides a way to do this.

WHAT IS A WATERSHED?

The basic definition of a watershed is fairly simple:

Watershed – an area of land which drains water, sediment, and dissolved materials into waterways; defined by the ridges of the hills or mountains that divide them.

Other terms often used to mean the same thing include: basin, drainage, or catchment. While technically the term ‘watershed’ can refer to any size of an area, there is less confusion if terms are consistently used and defined by size. A system of terms exists for subdividing large watersheds into smaller ones, based on relative watershed size:

River Basin – A river system or a group of streams composing a coastal drainage area.

Subbasin - A geographic area representing part or all of a surface drainage area, a combination of drainage areas, or a distinct hydrologic feature. Almost all subbasins are larger than 700 square miles in size, though some in Northern California are smaller.

Watershed – The next smallest subdivision of a subbasin.

Subwatershed – A logical subdivision of an area within a watershed, based on geography (major tributary) or a distinctive feature or use (municipal water supply).

Drainage – An area within a subwatershed based on the development of the stream channel network, including draws and swales.

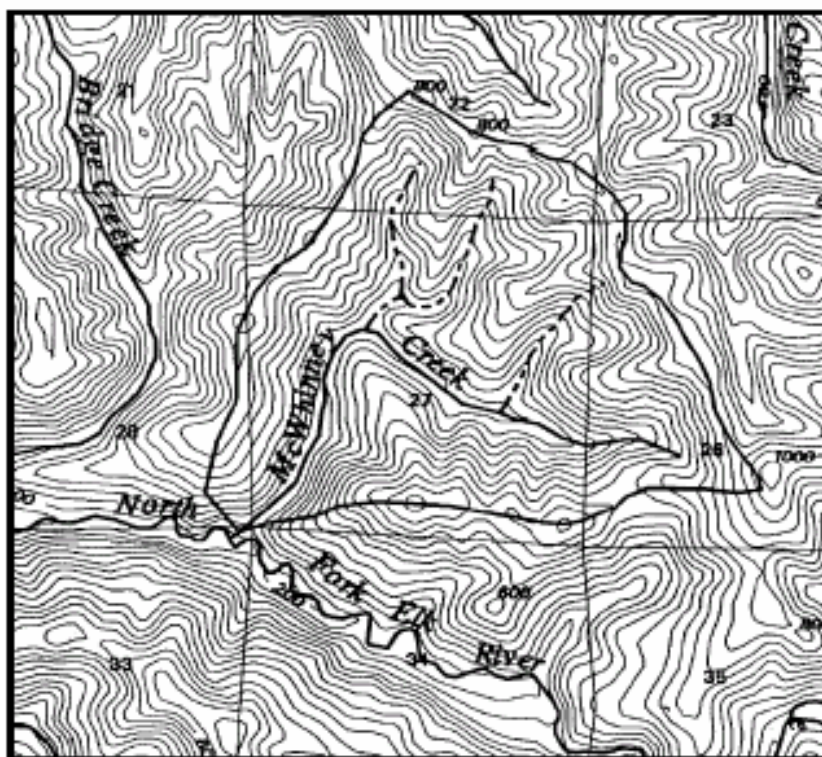


Figure 3.1 Drainage area calculation

WATERSHED ELEMENTS AND PROCESSES

Water Courses

Water flowing through channels has many different names as well: river, stream, creek, wetlands, estuaries, gulch, and ditch. Water is also stored on the surface in different types of water bodies such as lakes, lagoons, reservoirs, and ponds. Together, all of these flowing and stored surface water bodies are

called **watercourses**. In contrast, the body of water stored beneath the surface of the ground is called **groundwater**.

Connectivity is a term that refers to the physical connection between tributaries and the river, between surface water and groundwater, and between wetlands and water sources. Roads can also be connected to the stream system when runoff flows along the road system before entering the stream network (also called “hydrologically connected road.”). In this manual, our goal is to disconnect roads from streams.

Stream Channels

- ◆ Stream channels carry runoff flows from precipitation in the watershed. The channel is carved by the flowing water. Bankfull is defined as the typical flow that forms the shape of the existing channel. Most rivers reach bankfull stage, at approximately a two-year reoccurrence interval. If the sediment load in a stream is greater than the stream’s capacity to move sediment, it becomes deposited in the stream channel, causing it to fill or aggrade. Too little sediment, compared to what the stream was historically carrying, can cause the channel to downcut or degrade in elevation. When either of these conditions occurs, the stream channel must adjust upstream and downstream. Streambank erosion, channel widening, and headcut (an abrupt step in the channel profile) erosion are some of the symptoms of this readjustment.
- ◆ Stream crossings on roads, particularly bridges, can be seriously effected by the changes in stream channel depth and width.

Stream Order

Stream channels connect like the veins on a leaf. This network of smaller tributaries flowing into increasingly larger streams, has several numbering systems. The stream “order” system refers to numbering tributaries starting in the headwaters.

1. First-order streams have no tributaries;
2. Second-order streams have only first order channels as tributaries, or they occur where two first-order streams come together;
3. A third-order stream is formed by the joining of two second-order streams, and so on.

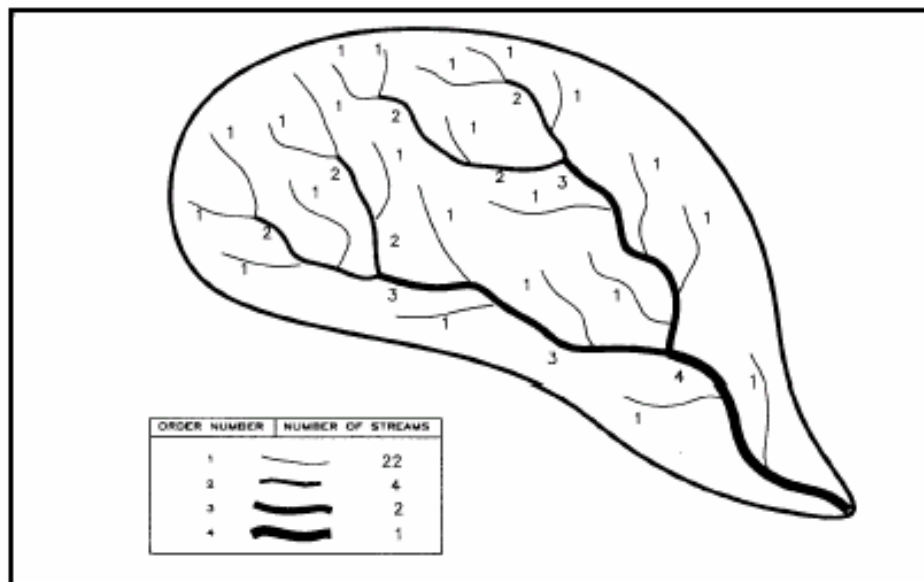


Figure 3.2 Stream order designation (Strahler 1957)

Stream Categories

Streams are often identified by their flow condition:

- perennial – those streams which carry water the year round, except for infrequent and extended periods of severe drought.
- ephemeral – streams consisting of a dry channel throughout most of the year, bearing water only during or immediately after a rain..
- intermittent – stream channels which carry water only part of the year and are dry the other part, but which receive flow from the groundwater table when it is high enough.

These stream types are indicated on topographic (“topo”) maps of the U.S. Geological Survey (USGS), with perennial streams identified by solid blue lines (“blue line streams”) and intermittent streams by dash-dot blue lines. However, these USGS map indications are only estimates made at the date of the original map development, and should not be used as a substitute for more accurate descriptions of current conditions – especially for smaller creeks.

Stream Class

Another way to categorize streams is by the water’s use, such as for aquatic species or domestic water supply. The terms below are also commonly used, particularly by the California Dept. of Forestry and Fire Protection (CDF) and the Dept. of Fish and Game (DFG) to help define the degree of state forestry regulations:

Class I Watercourse: A stream (or lake) that is used for a domestic water supply (including springs) on the site and/or within 100 feet downstream of the operations area; and/or fish always or seasonally present onsite, including habitat to sustain fish migration and spawning. (It typically flows year round, but may flow seasonally.)

Class II Watercourse: A stream (or lake) that has fish always or seasonally present offsite within 1000 feet downstream, and/or aquatic habitat for nonfish aquatic species; excludes Class III waters that are tributary to Class I waters. (These streams may flow year round or seasonally; many springs and wetlands are also included.)

Class III Watercourse: A stream channel (or lake) with no aquatic life present but showing evidence of being capable of sediment transport to Class I or II waters under normal high water flow conditions.

Class IV Watercourse: Man-made watercourses, usually downstream, for established domestic, agricultural, hydroelectric supply or other beneficial use.

Other stream terms are often based on legal definitions from one or more laws. The Clean Water Act refers to “Waters of the U.S.”, and “Ordinary High Water Mark”, both of which are defined under the Act in *Chapter 2 – Regulations and Permits*.

Flood Frequency and Floodplain Size

Floods are natural events and should be expected. Most rivers reach bankful stage at approximately a two-year reoccurrence interval. Bankful is defined as the typical flow that forms the shape of the existing

channel. While bankful flows are a common occurrence, catastrophic floods may occur any year. The probability of occurrence of a particular size flood, based on the years of record, is often used to predict the frequency of floods for planning purposes. Potential frequency of 25, 50, and 100 year flood events are commonly used.

The overflow onto the floodplain makes this area part of the river system during larger storms. Floodplains occur in large river valleys and also in the valleys of creeks just a few feet wide, but are usually not present along most headwater tributaries. Structures that encroach onto this floodplain – such as roads and buildings – are encroaching on the stream’s ability to move laterally under higher flows, and may be damaged or destroyed when flows onto the floodplain occur. The “100-year floodplain” represents the area potentially inundated for an unusual but possible flood event with the probability of occurring once every 100 years on the average. This potential 100-year flood scenario is being used more and more for engineering designs for any structures within a stream channel or floodplain.

Flood Frequency & Size Concepts: (Mount, 1995)

1. The probability that a 100-year flood will strike a river in California is the same every year, regardless of how long it has been since the last 100-year flood.
2. It is not certain that the 100-year event will occur sometime in the next 100 years (although it is pretty likely).
3. In California, where historic data sets are small, the 100-year floodplain is likely to grow following a major flooding event.
4. It is a virtual certainty that the defined 100-year floodplain is not the actual 100-year floodplain.

WATERSHED PROCESSES

Understanding the physical processes that shape a watershed’s condition can help in making better decisions about road management practices. The quality of the stream and its fish habitat is directly influenced by these watershed processes.

Rainfall, Streamflow, and Runoff

- ◆ **Hydrologic cycle** is the term used to describe the continuous circulation of the Earth’s waters from the ocean, to the atmosphere, to the land, and then back to the ocean. **Hydrology** is the science of water, or the study of water and its environment in the hydrologic cycle. Water falling to earth, or **precipitation**, can be in the form of rainfall or snow. Rainfall or snowmelt entering a stream channel becomes stream flow.
- ◆ **Runoff** occurs when the ground in the watershed is no longer capable of absorbing the precipitation.
 - Some soils absorb water from rainfall more easily than others, so runoff occurs less rapidly.
 - Vegetation can affect the rate of runoff, with more runoff usually coming off bare areas.
 - Urban or paved areas speed the movement of water and shorten the time between rainfall and runoff. The effects of urbanization and deforestation can alter the hydrograph, increasing peak run-off flows in a watershed and increase chance or frequency of flooding.
- ◆ **Precipitation** affects runoff based on the following aspects:
 - Intensity of rainfall – measured in inches per hour – varies from low to high; high intensity rainfall leads to large amounts of runoff.
 - Duration of rainfall, together with intensity, affects the runoff – the longer the rain storm, the greater the amount of water to runoff.

- Frequency of rain storms during a period of time – multiple storms over a short period of time create greater runoff than single storms or those spread out over a long period of time.
- Type of precipitation – rain or snow – controls the timing of runoff; snowpack spreads out the effects of storms, leading to delayed runoff in warmer months.

Geology and Soil Landscape

- ◆ **Geology** is the science of the earth. A more specific study is **geomorphology**, or the study of the physical features of the surface of the earth. Understanding the regional landscape of Central California requires reference to these sciences.
- ◆ Soils are weathered rocks mixed with other organic materials. The stability of soils in the region varies by type, and is closely associated with the qualities of their underlying rocks. Two soil types known for their high tendency for erosion are:
 - “Blue goo” soils in the Coastal Franciscan formation; these soils are derived from incompetent schist high in clay content and tend to act very “slippery” on steep slopes. Slopes composed of this type of soil are often hummocky and grass-covered.
 - Decomposed granite (or “DG”) soils; these soils do not stick together well (are “non-cohesive”) due to high sand and low silt and clay content.

Soil Erosion and Sedimentation

- ◆ **Erosion Processes**
 - Soil erosion is mainly caused by water and wind.
 - Erosion is a natural process linked to the hydrologic cycle.
 - Not all soil that is eroded enters the stream or drainage system. Streams do work by eroding, transporting, and depositing material (silt, sand, gravel, cobbles, boulders). Examples of this process include streambank erosion, muddy streams, and new gravel bars.
- ◆ **Types of Erosion**
 - Gully – An erosion channel formed by concentrated runoff, usually larger than one foot deep and wide. Gullies often form where road surface or ditch runoff is directed onto unprotected slopes.
 - Sheet & Rill – Sheet erosion is the loss of soil in thin layers of soil across a large surface area, while rill erosion is a small erosion channel (larger channels are called gullies). Rill erosion can be seen where rainfall and surface runoff is concentrated on unprotected hillslopes, cutbanks, and ditches.
 - Dry Ravel – On steeper slopes, gravity can bring dry soil downhill. Frost heaves can create this condition also. Raveling is most obvious along bare, steep road cuts.
 - Landslides - The downslope movement of a mass of earth caused by gravity. Examples include debris slides, torrents, rock falls, debris avalanches, and soil creep. They may be caused by natural erosional processes, natural disturbances (earthquakes, floods, fires), or human disturbances.
- ◆ **Sedimentation**
 - Soil erosion that enters the stream channel or drainage system (ditches, storm water drains, etc.) becomes sediment.
 - Natural levels of sediment in a stream system are referred to as “background levels”.
 - Excessive levels of sediment are those amounts above background, and can cause habitat problems when pools and spawning gravels are filled with fine sediment.

- High levels of sediment suspended in the stream flow cause cloudy water, or turbidity. Persistent muddy appearance is usually due to high silt and clay content.
- Sediment becomes deposited in the stream channel when the flows slow down, such as in gravel or sand bars, pools, or other areas of the stream bed. Floods can cause sediment to deposit outside of the channel in the flood plain.

With land use activity, the natural background rate of erosion can be accelerated or result in chronic delivery of sediment to stream channels over many decades. Three geomorphic processes are responsible for most sediment delivery from upland areas. These are:

- Chronic surface erosion from bare soil areas
- Fluvial erosion, including gully and stream channel erosion
- Mass wasting or landslides

Understanding these processes is necessary to conduct successful upslope assessment and restoration. Most of these processes, once initiated, result in erosion of sediment, which transports to hillslopes or stream channels. Whether the sediment remains in storage either on the hillslope or within the stream channel depends on the sediment types, and the timing, magnitude and frequency of storm events within a region. Once sediment suspends in water, or is mobile within the stream bed, sediment becomes part of the “net watershed sediment yield.”

Vegetation

The type and extent of vegetation throughout the watershed affects the amount and pattern of storm runoff in the watershed and influences the amount of erosion that occurs.

Upland Vegetation

- Vegetation on the slopes helps to slow runoff, which allows better seepage of rainfall into the soils and groundwater and better water storage for summer streamflows.
- Plant roots hold soil in place, with deeper-rooted trees helping to prevent deep seated erosion like landslides.
- Plant litter, such as dead leaves, needles and branches, provides a protective layer over the soil from the erosive impacts of rainfall and snowmelt.
- Loss of vegetation, from fires, disease, logging, grazing, or urbanization, can increase soil erosion and increase the rate of runoff.

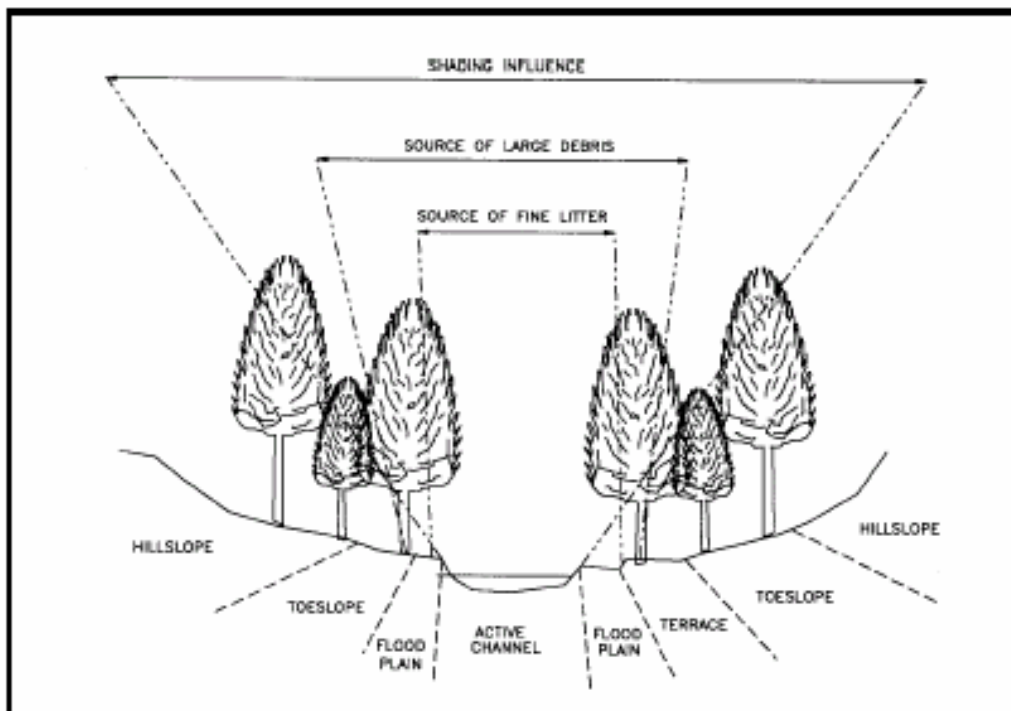
Riparian Vegetation

- ◆ Streams provide both surface and underground water to riparian vegetation.. Streamside vegetation provides many benefits to a healthy stream, such as:
 - Shade to the stream helps provides the cold water that salmonids need;
 - Food for fish from insects, leaf litter and organic material falling into the stream (also known as allocthanus material);
 - Protection from bank erosion through root strength;
 - Structure for instream habitat when trees fall into the stream (also known as Large Woody Debris, or LWD), which helps create scour pools and traps sediment for slow release during storms;
 - Filter or buffers from sources of surface erosion, thus minimizing instream sedimentation;
 - During floods, slows the energy of the flow and causes sediment to deposit in the floodplain instead of in the channel.

- This narrow riparian plant zone offers habitat for many animal species dependent on its unique features.

Riparian Zone

The riparian zone borders the stream and is the transition area to the upper watershed. The zone interacts with the channel and bears strongly on the structure and function of the aquatic ecosystem. The structure and composition of the riparian zone can be affected by the stream type and its active channel, as well as by geologic and topographic features (Figure 3-3).



Functions of the riparian zone include:

- Controlling the amount of light reaching the stream which affects temperature and productivity.
- Providing litter and invertebrate fall.
- Providing stream bank cohesion and buffering impacts from adjacent uplands.
- Providing large woody debris.

Wetlands:

- ◆ These areas generally include, but are not limited to, marshes, bogs, estuaries, and similar areas. Some are near or directly connected to the stream channel system. They can also include manmade

wetlands found in but not limited to ditches behind soil berms or shallow excavations. If a wetland area is encountered while working in the field, the appropriate regulatory agencies must be contacted.

- ◆ Wetland plants aid in trapping sediment and filtering excess nutrients, which can improve water quality.
- ◆ Wetlands help slow floodwaters and function to recharge groundwater areas or aquifers.
- ◆ Many wildlife species are dependent upon wetlands for their habitat.

WATER QUALITY

Clean water means good water quality. Water quality is considered impaired, for example, when a stream is too muddy (or turbid) or too warm to support the natural and human uses dependent on the water. These natural and human uses are termed “beneficial uses” and include recreation, drinking water, and cold water for salmon fisheries. Control of the sources of water pollution is a major focus of state and federal laws.

Types of Water Pollution

Pollution from sewage and industrial wastes – usually entering the water from pipes – is known as point source pollution. Runoff or indirect pollution – from a variety of less obvious sources – is called nonpoint source (NPS) pollution. Rural roads and road maintenance activities have the potential to contribute to nonpoint pollution, the major type of water pollution problem in California today. Road maintenance yards and other “industrial” type facilities, if not managed well, can be the source of runoff or “storm water” pollution and even hazardous waste contamination of the surface (stream) and ground waters.

Water Quality Protection and Improvement

A watershed approach looks at both point and non-point sources of pollution and looks for solutions across all land ownerships. Ways can be found to prevent, reverse, and eliminate damage caused by both types of pollution. Sometime the solutions, especially for nonpoint runoff sources, need to be quite creative as standard pollution treatment plants will not work. Prevention is always the first and best approach, and the cheapest.

Water quality protection laws and programs seek to prevent pollution or to clean it up. For this region, water quality objectives are set, and beneficial uses are stated for each water body in the Regional Basin Plans adopted by the Regional Water Quality Control Boards (RWQCB) and the State Water Resources Control Board (SWRCB). These objectives relate to many water quality factors, such as temperature, sediment, turbidity, oil and grease, bacteria, toxicity, pesticides, and specific chemicals. For more information, refer to the section on the Clean Water Act in Chapter 2: *Regulations and Permits*.

Finding cooperative ways to protect and restore watershed health among all of the owners and users of a watershed is becoming a common aspect of the “watershed approach”. Community-based watershed groups form and seek common solutions to the watershed’s problems. Often, a watershed assessment of the current and historic conditions is performed, followed by a jointly prepared strategy or plan for solving identified problems. For county road issues, this cooperative approach can be of benefit when other road ownerships are part of the problem or when non-county upslope or upstream sources create erosion or runoff problems on county roads

TMDLs – Coming to a River Near You!

TMDL = Total Maximum Daily Load = pollution limits by stream and by pollutant type

When a river does not meet state and federal water quality standards, it usually becomes earmarked for a remedial strategy under the federal Clean Water Act. The state has identified streams that are polluted with various pollutants. This list of “impaired water bodies” was adopted by the State Water Resources Control Board and the Regional Water Quality Control Boards in 1998 and is referred to as the “303(d) list”, which refers to a section of the Clean Water Act. The 303(d) list was updated in 2002. Also mandated by the act is the establishment of Total Maximum Daily Loads (TMDLs) as a means to address each pollutant.

The amount and sources of each pollutant are identified, and a strategy is developed for restoring the stream to state standards. Since roads are a known source of sediment, each of the sediment TMDLs will be addressing limits to the amount of erosion and sediment that will be allowable from roads: both public and private. The methods will be outlined in an Implementation Plan. Getting ahead of the curve in meeting this challenging regulation by implementing the BMPS contained in these guidelines will benefit counties and county road managers. You can view the 303(d) list at http://www.swrcb.ca.gov/tmdl/303d_lists.html.

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