

San Geronimo Valley Landowner Resources

Salmonid Life History



Young steelhead and coho salmon.
Photo by Joe Pecharich.



Adult male coho salmon.

Steelhead and coho salmon are anadromous fish; they are born and rear in freshwater streams, migrate to the ocean to grow and mature, and return to freshwater to reproduce.

The life history of salmonids is relatively complex with some slight variation between species.

Steelhead and coho salmon need a variety of habitats to support each stage of their development during the journey from egg to spawning adult.

The diagram and text below outline the key stages and habitat requirements; a specific timeline for each species follows.

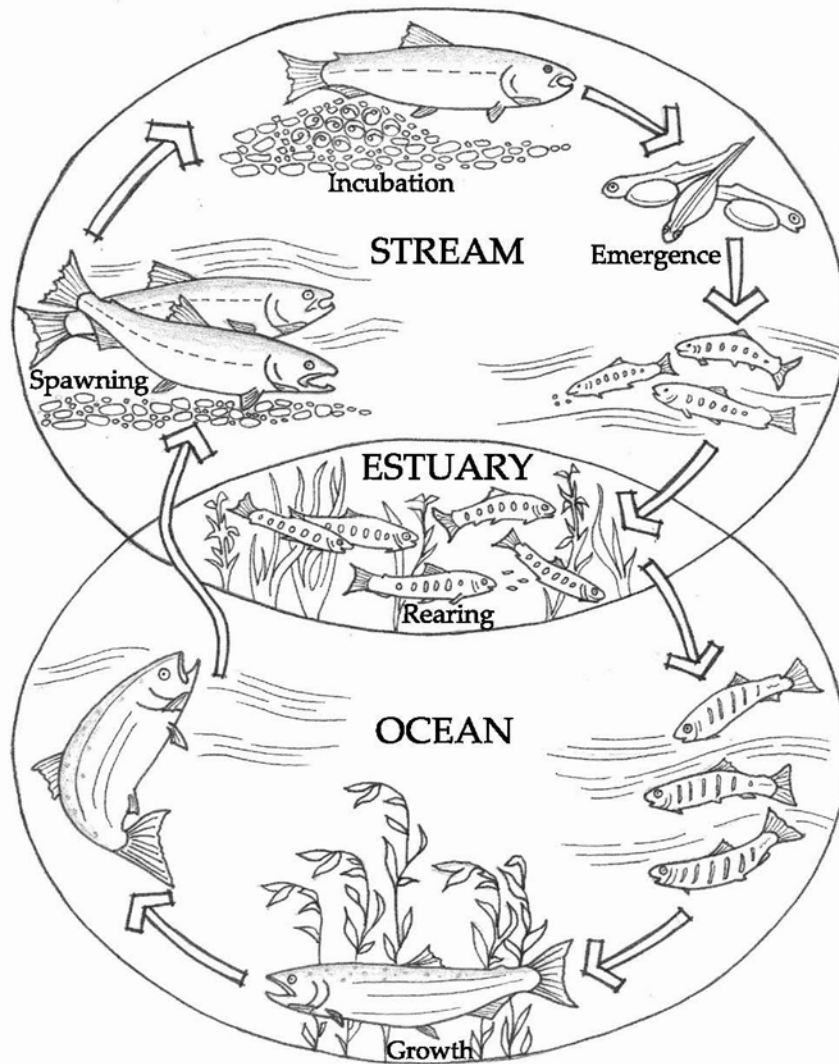


Illustration by Maggie Young

Spawning, Incubation, and Emergence

Each winter after the rains have returned, adult salmon begin to congregate at the mouth of the stream where they were born, guided by their keen sense of smell detecting small particles in the water. As they navigate upstream to select a suitable nesting site, they struggle against high winter flows and both man-made and natural obstacles. Once they reach their destination, the female selects a mate and begins **spawning**. **Redds** (salmon nests) are typically constructed at the head of riffles, where oxygenation of the developing eggs is key to development, in pea- to apple-sized gravels. Each salmon nest contains 300 to 1,200 eggs. Coho salmon die after spawning, whereas steelhead may spawn several times. The decaying fish provide nutrients to the stream and nourishment for a variety of species including their developing young.

Salmon eggs **incubate** in the gravels for several weeks - ideally in cool, well-oxygenated water free of excessive suspended particles. After hatching, small fish called **alevin** continue their development in the gravel, nourished by their attached yolk sac. Once the yolk sac is depleted, the young fish **emerge** from the gravels, typically in spring. These young fish that emerge from the gravel and begin rearing in freshwater are called **fry**.

Habitat Elements Needed for Successful Spawning, Incubation, and Emergence

- High-quality, permeable gravels
- Sufficient riffles
- Passage to habitat
- Cool water temperatures
- High dissolved oxygen
- Minimal suspended sediment

Freshwater Rearing

Coho salmon typically spend a full year in freshwater, emerging from the gravels in spring and rearing there until the follow year. Steelhead may spend one to four years, typically two.

In **winter**, young, small fish are particularly vulnerable to high stream flows during storm events. They use the spaces between gravel particles and vegetation along stream banks for safety from winter storms and predators. As they gain strength and mobility, fry begin to seek out deeper, swifter water, yet they continue to need complex, low-velocity habitats throughout their rearing period.

During the **summer** rearing period, sufficient stream flows and optimal water quality conditions (cool water temperatures, well-oxygenated water, and clear conditions) continue to be critical for development. Low summer flows can reduce the availability of rearing habitat by creating isolated pools and increasing vulnerability to predators. Riparian cover is also important because it shades the stream channel, keeping water temperatures low.

Throughout the rearing period, salmonids need plenty of insects for food. Drifting terrestrial insects produced in the riparian canopy, aquatic invertebrates produced on the substrate, and leaf litter provide the bulk of their diet.

Habitat Elements Needed for Successful Rearing

- Low-velocity backwater areas (winter) and deep pools
- Shelter in the form of roots, large wood, vegetation, cobbles/boulders
- Vegetated stream margins
- Overhead shade and well-vegetated canopy

Helpful Definitions

Redd – a salmon nest dug in the streambed where eggs are deposited.

Spawning – process of building a nest (redd) in gravel, mating, and laying eggs.

Alevin – salmonid larvae still in the gravel with their yolk sacs attached.

Fry – young salmon rearing in freshwater.

Smolt – a juvenile seaward-bound salmonid in the process of transition from fresh to saltwater.

- Food supply
- Cool water temperatures
- High dissolved oxygen
- Minimal suspended sediment
- Sufficient flow (summer)

Estuary Rearing and Beyond

In the spring after completion of freshwater rearing, young salmonids begin to transition to life in the ocean. As they migrate downstream to the estuary, where fresh and saltwater mix, juvenile fish undergo a physiological process called **smoltification**, where their body makes adjustments to be able to survive in saltwater. Young fish may remain in the estuary for days or months as they adjust to the saltwater and grow. Salmon mature in the ocean in 1 to 4 years, depending on the species, before returning to their natal stream to begin the cycle all over again.

Habitat Elements Needed for Transition from Freshwater to Ocean






- Sufficient flow to allow safe passage
- Shelter in the form of roots, large wood, vegetation, cobbles/boulders
- Estuarine conditions that allow for adequate mixing of fresh and saltwater for gradual adjustment

Timeline of Salmonid Life History Stages within California Coastal Streams






(darker shading represents periods of peak activity; lighter shading represents less active periods)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Steelhead												
Upstream migration and spawning												
Egg incubation												
Fry emergence												
Rearing												
Smolt outmigration (1 to 4 years)												
Coho Salmon												
Upstream migration and spawning												
Egg incubation												
Fry emergence												
Rearing												
Smolt outmigration (typically 1+)												






RECOMMENDED NATIVE SPECIES FOR SAN GERONIMO VALLEY RIPARIAN LANDSCAPES

Common Name	Latin Name	Planting Location C=channel, F=floodprone zone, T=top of bank	Spacing	 Exposure Sun/Shade	 Water Requirements	 Deer Tolerance	 Attracts Hummingbirds	 Attracts Butterflies
TREES								
Alder, white	<i>Alnus rhombifolia</i>	C, F	15'	Sun/Part Shade	high			yes - larvae
Arroyo willow	<i>Salix lasiolepis</i>	C	5'	Sun	moderate-high			
Big leaf maple	<i>Acer macrophyllum</i>	F	15'	Sun/Part Shade	moderate	medium		yes - larvae
Blue elderberry	<i>Sambucus mexicana</i>	F	8'	Sun/Part Shade	low-moderate			
Box elder	<i>Acer negundo var. californicum</i>	F	15'	Sun/Part Shade	low-moderate	medium		
California bay-laurel	<i>Umbellularia californica</i>	C, F, T	10'	Sun/Shade	low-moderate			
California buckeye	<i>Aesculus californica</i>	F, T	15'	Sun	low-moderate	medium		yes - larvae, adults
Coast live oak	<i>Quercus agrifolia</i>	T	15'	Sun/Shade	low	medium		yes - larvae
Douglas fir	<i>Pseudotsuga menziesii</i>	F	15'	Sun/Part Shade	low-moderate	medium		
Oregon ash	<i>Fraxinus latifolia</i>	C, F	15'	Sun/Part Shade	moderate			
Redwood	<i>Sequoia sempervirens</i>	F, T	15'	Sun/Part Shade	moderate	medium		
Valley oak	<i>Quercus lobata</i>	T	20'	Sun	low			
SHRUBS & GROUNDCOVERS								
Ceanothus	<i>Ceanothus spp.</i>	T	8'	Sun/Part Shade	low			yes - larvae, adults
Coffeeberry	<i>Rhamnus californica</i>	T	5'	Sun/Shade	low			yes - larvae, adults
Coyote brush	<i>Baccharis pilularis</i>	T	5'	Sun	low	high		yes - larvae
Fuchsia, California	<i>Epilobium californicum</i>	T	3'	Sun	low	high	yes	
Fuchsia-flowering gooseberry	<i>Ribes speciosum</i>	F, T	5'	Sun/Shade	low-moderate		yes	
Hazelnut	<i>Corylus cornuta</i>	F	8'	Part Shade/Shade	moderate	medium		
Monkeyflower	<i>Mimulus spp.</i>	T	3'	Sun/Part Shade	low-moderate	high	yes	
Mugwort	<i>Artemisia douglasiana</i>	F	2'	Sun/Shade	moderate	medium		
Ninebark	<i>Physocarpus capitatus</i>	F	8'	Part Shade/Shade	moderate	medium		
Ocean spray	<i>Holodiscus discolor</i>	F	8'	Part Shade	moderate	high		

RECOMMENDED NATIVE SPECIES FOR SAN GERONIMO VALLEY RIPARIAN LANDSCAPES

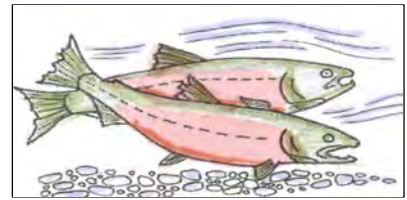
Common Name	Latin Name	Planting Location C=channel, F=floodprone zone, T=top of bank	Spacing	 Exposure Sun/Shade	 Water Requirements	 Deer Tolerance	 Attracts Hummingbirds	 Attracts Butterflies
Pink flowering currant	<i>Ribes sanguineum</i>	T	6'	Sun/Shade	moderate		yes	
Rose, California	<i>Rosa californica</i>	C, F, T	6'	Sun/Part Shade	low-moderate			yes - larvae
Rose, wood	<i>Rosa gymnocarpa</i>	F, T	4'	Part Shade/Shade	low-moderate			
Salmonberry	<i>Rubus spectabilis</i>	F	6'	Part Shade	moderate			
Snowberry	<i>Symphoricarpos albus</i>	F	4'	Part Shade	low-moderate	high	yes	
Stream dogwood	<i>Cornus sericea</i>	C, F	8'	Part Sun/Shade	moderate-high			yes - larvae
Thimbleberry	<i>Rubus parviflorus</i>	C, F	6'	Part Shade	moderate			
Toyon	<i>Heteromeles arbutifolia</i>	T	8'	Sun/Part Shade	low			
Twinberry	<i>Lonicera involucrata</i>	F	8'	Sun/Part Shade	moderate	high	yes	
Wax myrtle	<i>Myrica californica</i>	T, F	8'	Sun/Part Shade	moderate	high		
Western azalea	<i>Rhododendron occidentale</i>	F	6'	Part Shade	moderate			
Woodland strawberry	<i>Fragaria vesca</i>	F, T	2'	Sun/Part Shade	moderate			
Yerba buena	<i>Satureja douglasii</i>	T	3'	Part Shade/Shade	low-moderate	high		
VINES								
California blackberry	<i>Rubus ursinus</i>	F	5'	Sun/Shade	moderate			
Dutchman's pipe	<i>Aristolochia californica</i>	F, T	5'	Part Shade	low - moderate	high		yes - larvae
Honeysuckle	<i>Lonicera hispidula</i>	F, T	3'	Sun/Shade	low	medium	yes	yes - adults
Virgin's bower	<i>Clematis ligusticifolia</i>	F, T	5'	Sun/Part Shade	low - moderate			
Wild cucumber	<i>Marah fabaceus</i>	F	5'	Sun/Shade	low			
HERBACEOUS SPECIES								
Alum root	<i>Heuchera micrantha</i>	T	3'	Sun/Part Shade	moderate			
Bleeding heart	<i>Dicentra formosa</i>	T	3'	Part Shade/Shade	low-moderate	high		
California polypody	<i>Polypodium californicum</i>	F	2'	Part Shade/Shade	low-moderate	high		
Coltsfoot	<i>Petasites frigidus</i>	C, F	3'	Sun/Shade	high	high		
Columbine, western	<i>Aquilegia formosa</i>	F, T	2'	Part Shade	low-moderate		yes	
Cow parsnip	<i>Heracleum lanatum</i>	F	3'	Sun/Part Shade	moderate-high	high		yes - larvae
Elk clover	<i>Aralia californica</i>	F	5'	Part Shade/Shade	moderate	medium		
False solomon's seal	<i>Smilacina stellata</i>	F	3'	Shade	low-moderate			

RECOMMENDED NATIVE SPECIES FOR SAN GERONIMO VALLEY RIPARIAN LANDSCAPES

Common Name	Latin Name	Planting Location C=channel, F=floodprone zone, T=top of bank	Spacing	 Exposure Sun/Shade	 Water Requirements	 Deer Tolerance	 Attracts Hummingbirds	 Attracts Butterflies
Fringe cup	<i>Tellima grandiflora</i>	F	2'	Shade	low-moderate			
Giant chain fern	<i>Woodwardia fimbriata</i>	C, F	4'	Sun/Part Shade	low	high		
Lady fern	<i>Athyrium filix-femina</i>	F	3'	Part Shade/Shade	high	high		
Pacific iris	<i>Iris douglasiana</i>	F, T	2'	Sun/Part Shade	low	high		
Penstemon, foothill	<i>Penstemon heterophyllus</i>	T	3'	Sun	low		yes	
Western sword fern	<i>Polystichum munitum</i>	F	3'	Part Shade/Shade				
Wild ginger	<i>Asarum caudatum</i>	F, T	2'	Part Shade/Shade	moderate-high	medium		
Yarrow	<i>Achillea millefolium</i>	T	3'	Sun/Part Shade	low	high		yes - adults
GRASSES, RUSHES AND SEDGES								
Blue wildrye	<i>Elymus glaucus</i>	T	1'	Sun/Part Shade	low			
California brome	<i>Bromus carinatus</i>	T	1'	Sun	low			
California fescue	<i>Festuca californica</i>	T, F	1'	Part Shade	low-moderate			
California meadow sedge	<i>Carex pansa</i>	F, T	1'	Sun/Part Shade	moderate	high		
Creeping wildrye	<i>Leymus triticoides</i>	C, F, T	1'	Sun/Part Shade	moderate-high			
Gray rush	<i>Juncus patens</i>	F	1'	Sun/Part Shade	low-moderate	high		
Idaho fescue	<i>Festuca idahoensis</i>	T	1'	Sun	low			
Meadow barley	<i>Hordeum brachyantherum</i>	F, T	1'	Sun/Part Shade	moderate			
Pacific reed grass	<i>Calamagrostis nutkaensis</i>	F, T	3'	Part Shade	moderate	high		
Purple needle grass	<i>Nassella pulchra</i>	T	2'	Sun	low	high		
Red fescue	<i>Festuca rubra</i>	F, T	1'	Sun/Part Shade	moderate			
Santa Barbara sedge	<i>Carex barbarae</i>	C, F	1'	Sun/Shade	high	high		
Soft rush	<i>Juncus effusus</i>	C, F	2'	Sun/Shade	high	high		
Spike rush	<i>Eleocharis macrostachya</i>	C, F	1'	Sun/Part Shade	high			
Tall flatsedge	<i>Cyperus eragrostis</i>	C, F	1'	Sun/Part Shade	moderate			
Torrent sedge	<i>Carex nudata</i>	C, F	2'	Sun/Shade	high	high		

Planting recommendations for the...

ACTIVE CHANNEL



Definition: The active channel is the part of the creek which is regularly flooded. Most plants in this zone are pioneer species that colonize recently disturbed areas. They are adapted to both winter's high flows and summer's relative drought.

Opportunities: Plants in the active channel provide shade over the water, keeping temperatures cool for fish. Fallen leaves provide nutrients and food for aquatic life. Plant roots provide critical opportunities for fish to hide from predators and to shelter from fast moving water. Fallen trees in this zone, known as woody debris, also provide vital fish habitat.

Challenges: Establishing plantings in the active channel can be difficult due to plants being swept away in high flows, the inability to install automated irrigation, and potentially heavy browsing by deer.

Key species to plant

<u>Common Name</u>	<u>Latin Name</u>	<u>Plant Type</u>
Alder	<i>Alnus rhombifolia</i>	tree
Ash	<i>Fraxinus latifolia</i>	tree
Coltsfoot	<i>Petasites frigidus</i>	perennial
Dogwood	<i>Cornus sericea</i>	shrub/small tree
Horsetail	<i>Equisetum laevigatum</i>	perennial
Mugwort	<i>Artemisia douglasiana</i>	perennial
Rush	<i>Juncus effusus</i>	rush
Torrent Sedge	<i>Carex nudata</i>	sedge
Willow	<i>Salix lasiolepis</i>	tree



Willow



Sedge



Coltsfoot

Refer to master plant list for sun/shade requirements, size, habit, etc.



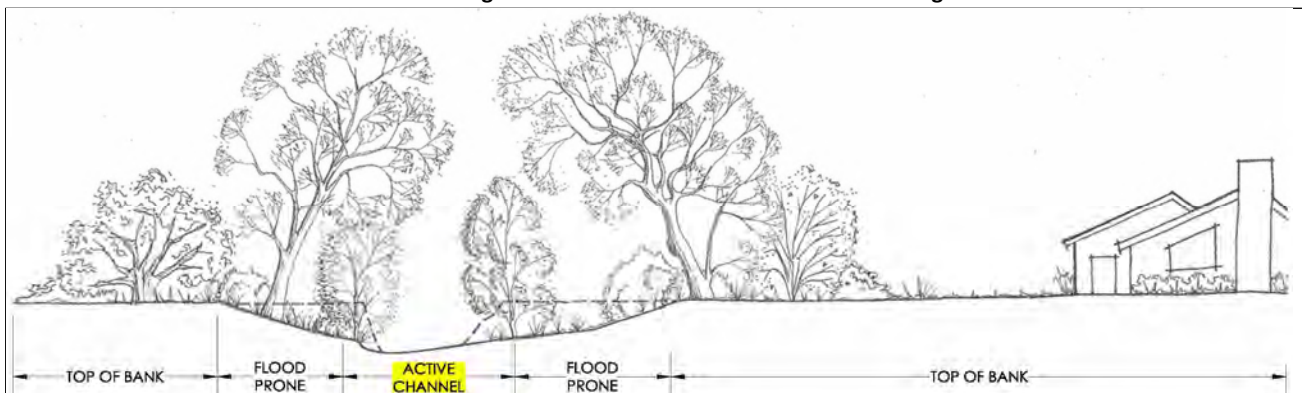
Alder



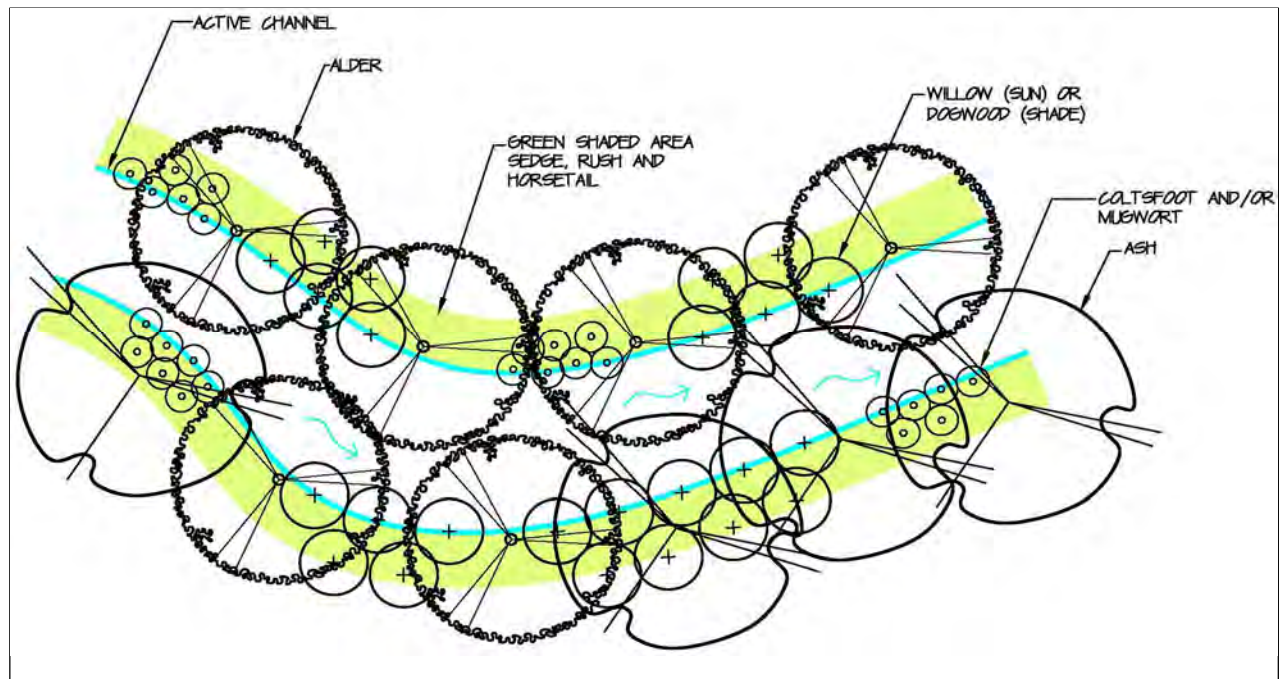
Mugwort



Dogwood



SUGGESTED PLANTING SCHEME



NOTES:

Cuttings such as willow and dogwood are best planted in the fall just before the rainy season (Nov 15th-March 15th) when plants are using energy to develop roots. Place cuttings deeply in the ground (as shown on the detail sheet) to access ground moisture and avoid being swept away during high flows.

Drip irrigation cannot be installed in the active channel because it may wash downstream. Any watering should be done by hand.

Browse protection should not be installed in the active channel during the rainy season because it may wash downstream. Install browse protection in the spring when plantings are beginning to leaf out and remove before the rainy season.

Best places to plant: In the active channel there is a natural scour line where vegetation starts to grow. This is the lower edge of the active channel planting zone, indicated by the blue line on the drawing above. Plant cuttings and plugs on slopes and look for flat benches to vegetate with plugs and container plants.

GRASSES, SEDGES & RUSHES:

In addition to Key Species listed above, use any combination of the following from plugs.

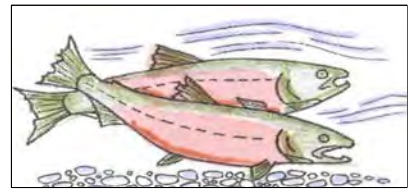
Common Name

Spike rush
Santa Barbara sedge
Tall flatsedge

Botanical Name

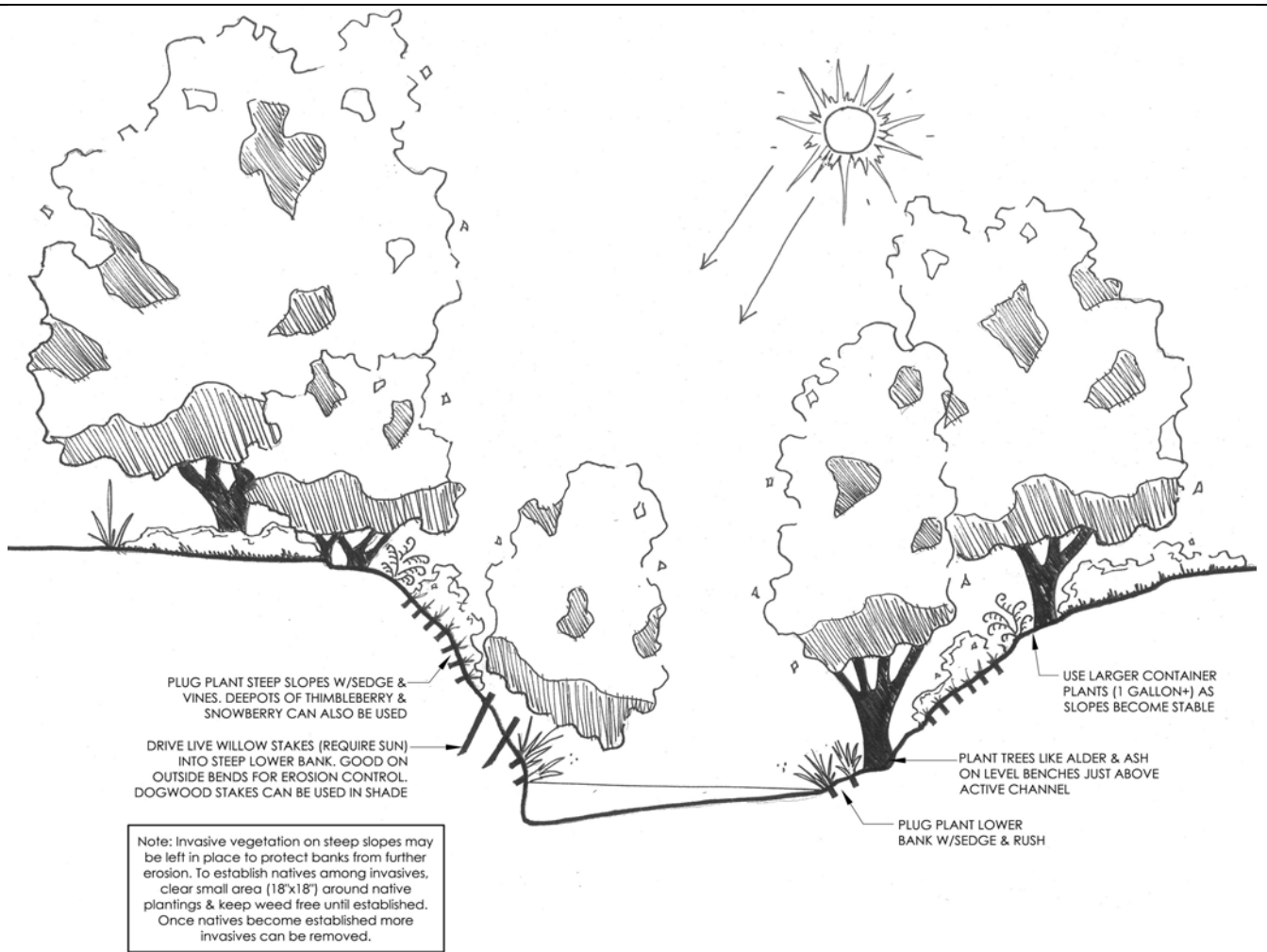
Eleocharis macrostachya
Carex barbarae
Cyperus eragrostis

Planting recommendations for...



Incised Channels

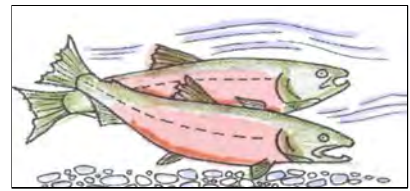
Planting the incised channel can be very challenging. These sections of creek are often dominated by invasives such as blackberry and ivy, with steep slopes that are hard to reach. Consider using a ladder for work on extremely steep banks. Planting fast growing natives, such as alder and willow among the invasives can (in some cases) effectively out-compete them. The use of plugs and cuttings are good ways to revegetate without causing much disturbance in soils already prone to erosion. As natives become established, more invasives can be removed. Keep in mind that maintenance will be required. New container plants typically need 3 years of watering, weeding, and browse protection to become fully established. Since drip irrigation will likely be vulnerable to storm damage, hand watering may be required at incised sites. Regular weeding is critical in areas with vigorous stands of established invasive plants. See *Plant Installation & Maintenance* for additional information.



Cross Section of incised channel and recommended plantings

Planting recommendations for the...

TOP OF BANK



Definition: The top of bank is the upper area on the slope and beyond where flooding does not occur. Top of bank extends all the way to the house and beyond.

Opportunities: The vegetation in this transitional zone provides a buffer between the creek and hotter, dryer upland habitats. A wide variety of native plants thrive here, offering food and shelter for bees, butterflies, birds, and other wildlife. Deeply rooted native perennial plants slow runoff, encourage infiltration of water into the soil, and help prevent erosion. Many flowering natives can be used in this zone, adding beauty to the garden.

Challenges: Dry soil, hot sun, gophers, deer browsing

Key species to plant

<u>Common Name</u>	<u>Latin Name</u>	<u>Plant Type</u>
Buckeye	<i>Aesculus californica</i>	tree
California rose	<i>Rosa californica</i>	shrub
Ceanothus	<i>Ceanothus thyrsiflorus</i>	shrub
Coast live oak	<i>Quercus agrifolia</i>	tree
Coyote brush	<i>Baccharis pilularis</i>	shrub
Coffeeberry	<i>Rhamnus californica</i>	shrub
Currant	<i>Ribes sanguineum</i>	shrub
Honeysuckle	<i>Lonicera hispidula</i>	vine
Monkey flower	<i>Mimulus aurantiacus</i>	shrub
Ocean spray	<i>Holodiscus discolor</i>	shrub
Penstemon	<i>Penstemon heterophyllus</i>	perennial
Yarrow	<i>Achillea millefolium</i>	perennial



Penstemon



Rose



Buckeye

Refer to master plant list for sun/shade, water, spacing requirements, etc.



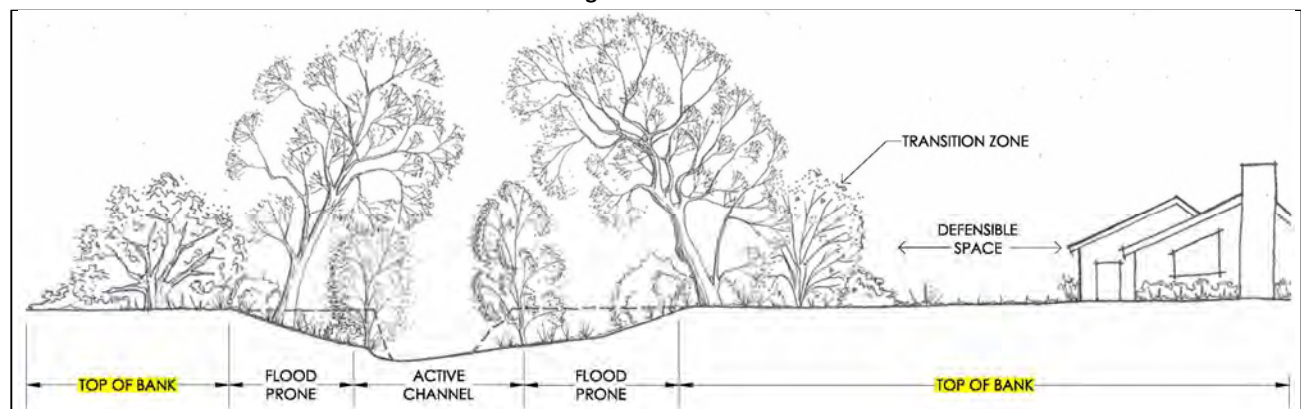
Yarrow



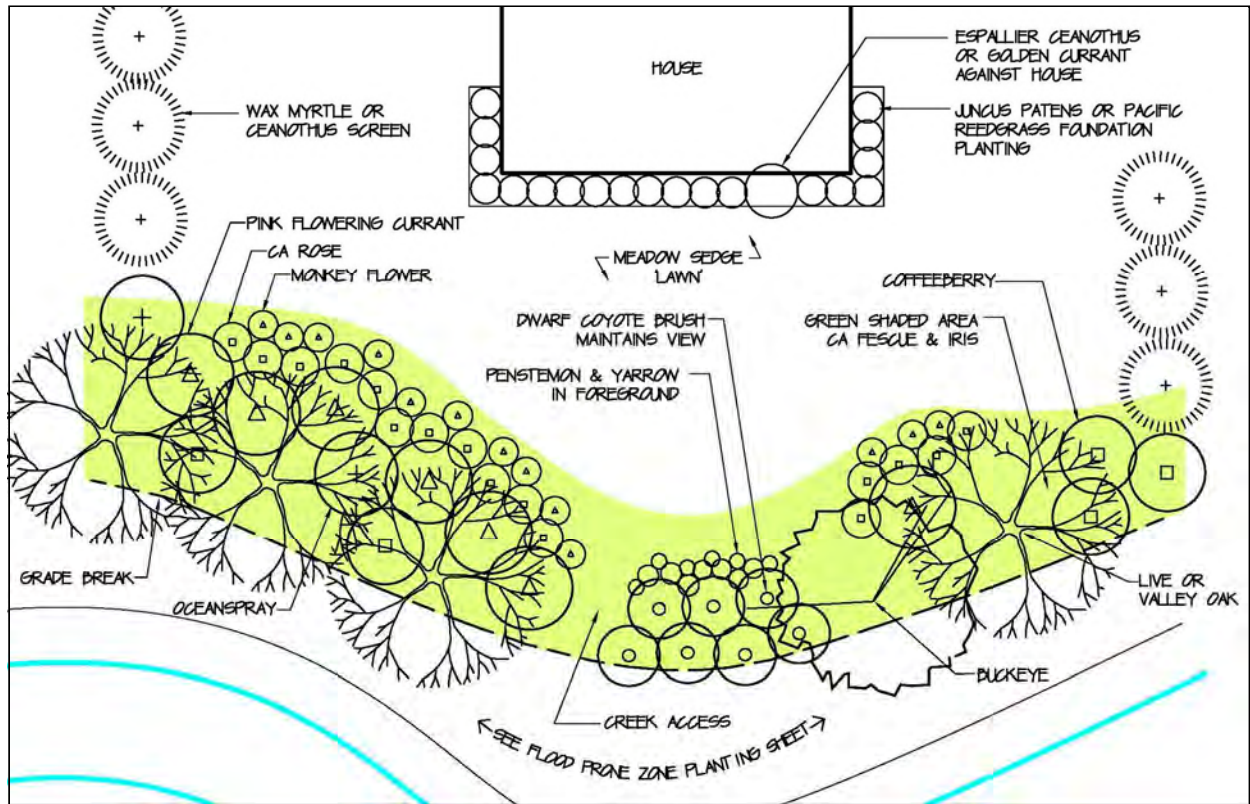
Pink flowering currant



Monkey flower



SUGGESTED PLANTING SCHEME



Additional plants recommended:

Vines, groundcovers, and other perennials: alum root, bleeding heart, Douglas iris, California fuchsia, yerba buena, virgin's bower

Shrubs: gooseberry, mock orange, California sage, toyon

Note: some other sages, such as purple sage are not native to the watershed but can be used effectively in the garden without becoming invasive.

Trees: redwood & valley oak

Wildflowers: Spread native wildflowers seeds in the fall such as clarkia, lupine and poppy.

Screens: Suggested shrubs for evergreen screens are ceanothus, coffeeberry, and wax myrtle. Redwood trees can also make an attractive evergreen screen.

GRASSES, SEDGES & RUSHES:

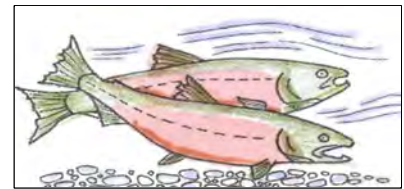
Use any combination of the following from plugs or seed. Grasses noted with an * can be purchased in gallon size pots and used effectively in mass plantings or as accents

Common Name

CA Brome
CA Fescue
Deer grass
Gray rush
Pacific reedgrass
Purple needle grass
Meadow Sedge
Three weeks fescue
Red fescue
Idaho fescue
Wild rye

Latin Name

Bromus carinatus
Festuca californica *
Muhlenbergia rigens * (not native to watershed)
Juncus patens *
Calamagrostis nutkaensis *
Nassella pulchra
Carex pansa (can be used as lawn alternative)
Vulpia microstachys (native annual will jumpstart native seed mixes)
Festuca rubra 'Molate' (can be used as lawn alternative)
Festuca idahoensis *
Leymus condensatus * (Canyon Prince is a good garden variety)



Planting recommendations for the...

FLOOD PRONE ZONE

Definition: The flood prone zone is adjacent to the active channel and becomes flooded during storm events. It is inhabited by plants that can tolerate occasional flooding.

Opportunities: The vegetation in this zone provides a protective buffer between human activity and the creek. Its diverse shrubs and trees serve as critical habitat for birds and other wildlife. The roughness of the vegetation slows fast-moving stormwater and filters sediments and pollutants before runoff enters the creek. The roots in this zone help prevent erosion, protecting adjacent properties and creek water quality.

Challenges: The flood prone zone is often dominated by invasive species because of access to moisture without the disturbance of the active channel. This zone can be shady because of mature trees. Deer browsing, irrigation constraints and flooding can also hinder establishment. Property use and development often decrease space available for plantings.

Key species to plant

<u>Common Name</u>	<u>Latin Name</u>	<u>Plant Type</u>
Hazlenut	<i>Corylus cornuta</i>	shrub
Maple	<i>Acer palmatum</i>	tree
Ninebark	<i>Physocarpus capitatus</i>	shrub
Sedge	<i>Carex barbarae</i>	sedge
Snowberry	<i>Symphoricarpos albus</i>	shrub
Sword fern	<i>Polystichum munitum</i>	fern
Thimbleberry	<i>Rubus parviflorus</i>	shrub
Twinberry	<i>Lonicera involucrata</i>	shrub
Wood rose	<i>Rosa gymnocarpa</i>	shrub



Snowberry



Ninebark



Thimbleberry

Refer to master plant list for sun/shade requirements, size, habit, etc.



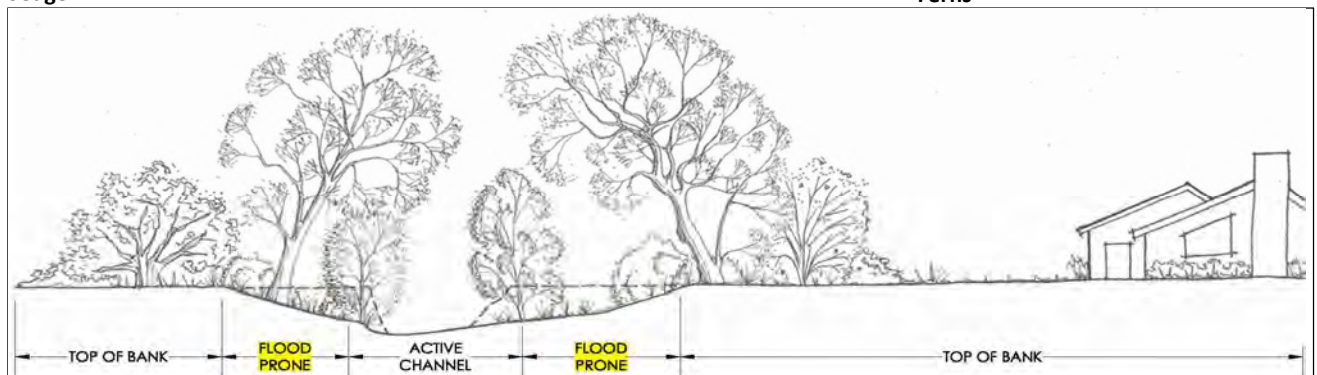
Sedge



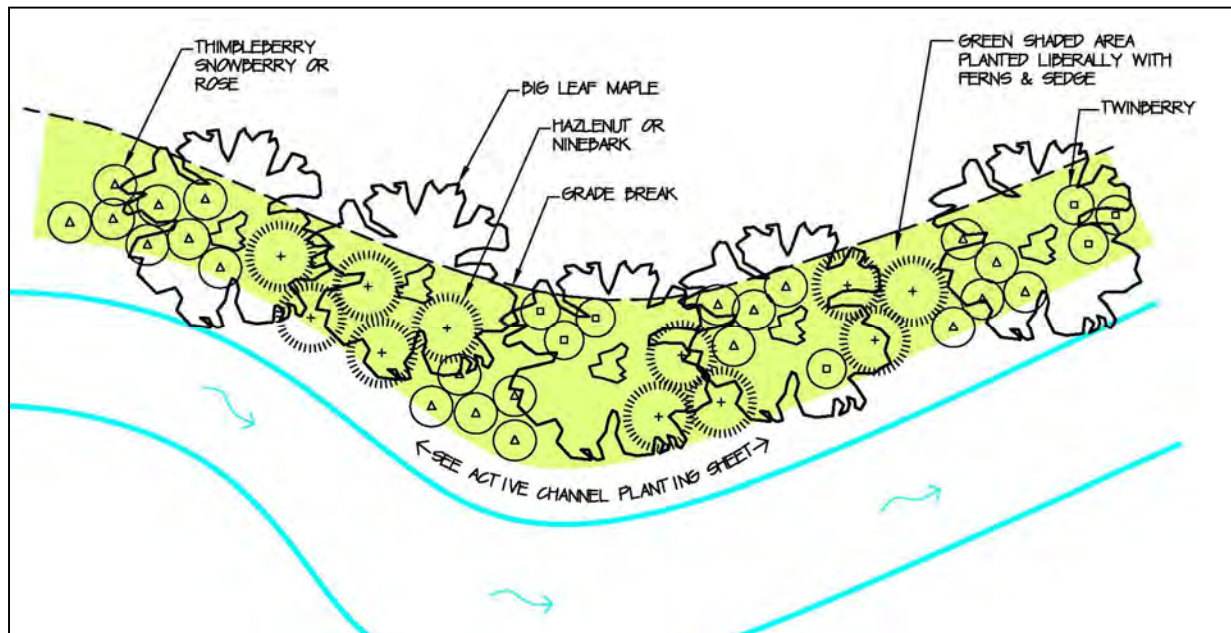
Hazlenut



Ferns



SUGGESTED PLANTING SCHEME



NOTES:

Drip irrigation cannot be installed in the lower areas of the flood prone zone because it may wash downstream. Use common sense to determine the limits of where drip irrigation can be installed. Where drip cannot be installed, watering should be done by hand.

Browse protection should not be installed in the lower areas of the flood prone zone during the rainy season because it may wash downstream. Install browse protection in the spring when plantings are beginning to leaf out and remove before the rainy season. The rainy season is typically considered to be November 15 - March 15.

Views of the creek are important to landowners. Select view corridors where low plantings can be installed such as vines, groundcovers and grasses. Plant other areas liberally with trees and shrubs.

ADDITIONAL PLANTS RECOMMENDED:

Vines and groundcovers: Douglas iris, dutchman's pipevine, fringe cup, honeysuckle, native blackberry and wild ginger

Shrubs: chain fern, elderberry, flowering currant, monkey flower, salmonberry, western azalea

Trees: bay, Douglas fir

GRASSES, SEDGES & RUSHES: Use any combination of the following from seed or plugs:

<u>Common Name</u>	<u>Botanical Name</u>
Creeping wild rye	<i>Leymus triticoides</i>
Gray rush	<i>Juncus patens</i>
Meadow barley	<i>Hordeum brachyantherum</i>
Meadow sedge	<i>Carex pansa</i>
Santa Barbara sedge	<i>Carex barbarae</i>
Tufted hairgrass	<i>Deschampsia cespitosa</i>

**SAN GERONIMO
SALMONID
ENHANCEMENT PLAN
PLANTING PLAN
CONCEPTUAL PLAN 1**



WHITE ALDER



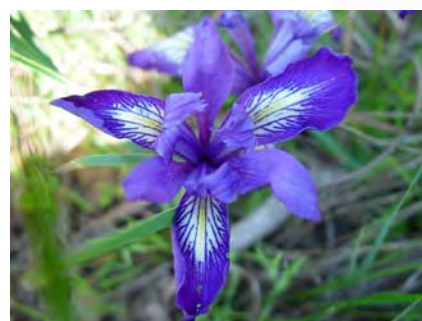
CREeping SNOWBERRY



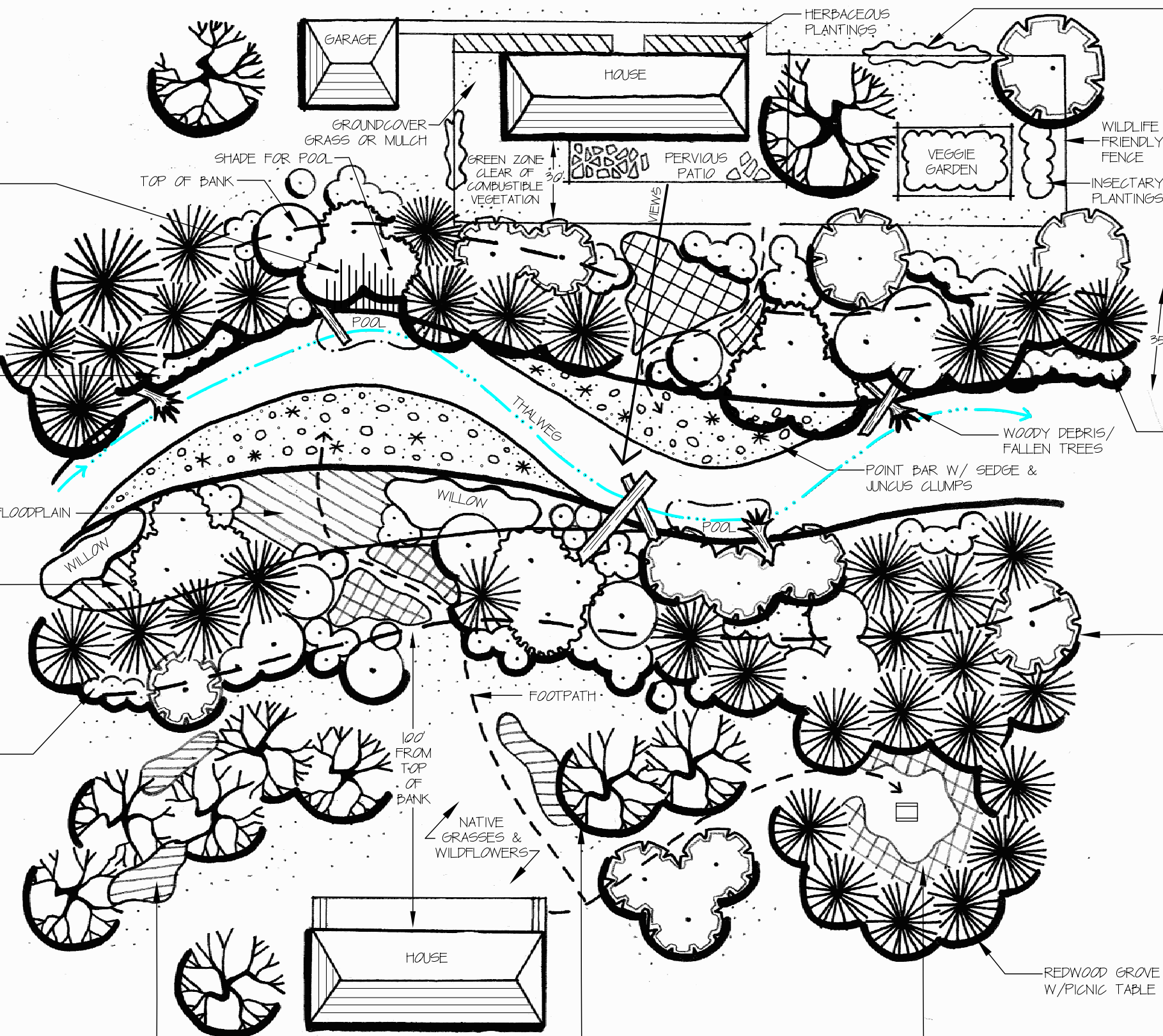
SOFT RUSH



RED-FLOWERING CURRANT



DOUGLAS IRIS



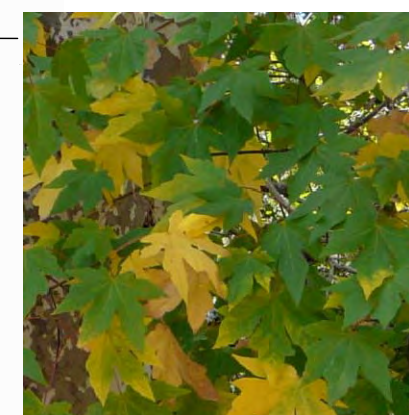
CA PIPEVINE



TWINBERRY



THIMBLEBERRY




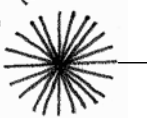
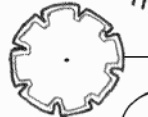
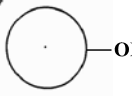
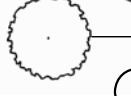
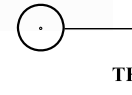
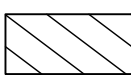

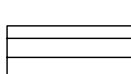
BIG LEAF MAPLE



GIANT CHAIN FERN



LEGEND

-  COAST LIVE OAK/
TAN OAK
-  REDWOOD/
DOUG FIR
-  BIG LEAF MAPLE
-  OREGON ASH
-  WHITE ALDER
-  HAZLENUT
CURRANT
THIMBLEBERRY
SNOWBERRY
-  FLOODPLAIN W/
RUSH & SEDGE
-  WOOD ROSE, FERNS
& SNOWBERRY
-  CA ROSE
DOUGLAS IRIS

PLANT LIST

Common Name	Scientific Name	Bank Position
TREES		
Alder (white)	<i>Alnus rhombifolia</i>	L
Arroyo willow	<i>Salix lasiolepis</i>	L
Big-leaf maple	<i>Acer macrophyllum</i>	U,M
California bay-laurel	<i>Umbellularia californica</i>	L,M
California buckeye	<i>Aesculus californica</i>	U,M
Coast live oak	<i>Quercus agrifolia</i>	U,M
Douglas-fir	<i>Pseudotsuga menziesii</i>	U,M,L
Oregon ash	<i>Fraxinus latifolia</i>	L,M
Redwood	<i>Sequoia sempervirens</i>	U,M,L
Tanoak	<i>Lithocarpus densiflorus</i>	U,M
Valley oak	<i>Quercus lobata</i>	U
SHRUBS & VINES		
California blackberry	<i>Rubus ursinus</i>	M
Ceanothus	<i>Ceanothus thyrsiflorus</i>	U
Coyote brush (prostrate)	<i>Baccharis pilularis</i>	U
Coffeeberry	<i>Rhamnus californica</i>	U,M
Dogwood	<i>Cornus sericea</i>	L,M
	<i>Sambucus nigra canadensis</i>	U,M,L
Elderberry		U,M,L
Hazelnut	<i>Corylus cornuta</i>	M,U
Honeysuckle, CA (vine)	<i>Lonicera hispidula</i>	M,U
Maidenhair fern	<i>Adiantum capillus-veneris</i>	M,L
Monkeyflower	<i>Mimulus spp.</i>	U,M,L
Ocean spray	<i>Holodiscus discolor</i>	U,M
Pipevine, CA	<i>Aristolochia californica</i>	U,M,L
Red-flowering currant	<i>Ribes sanguineum</i>	U,M
Rose, CA	<i>Rosa californica</i>	U
Rose, wood	<i>Rosa gymnocarpa</i>	U,M
Salmonberry	<i>Rubus spectabilis</i>	M
Snowberry (creeping)	<i>Symphoricarpos mollis</i>	M
Thimbleberry	<i>Rubus parviflorus</i>	L,M
Twinberry (vine)	<i>Lonicera involucrata</i>	L,M
Virgin's bower (vine)	<i>Clematis ligusticifolia</i>	L,M
Wild ginger (groundcover)	<i>Asarum caudatum</i>	U,M
HERBACEOUS SPECIES		
Black flowering sedge	<i>Carex nudata</i>	L
California meadow sedge	<i>Carex pansa</i>	U,M,L
Spike rush	<i>Eleocharis macrostachya</i>	Floodplain, L
Giant chain fern	<i>Woodwardia fimbriata</i>	L
Gray rush	<i>Juncus patens</i>	Floodplain, L
Pacific iris	<i>Iris douglasiana</i>	U
Santa Barbara sedge	<i>Carex barbarae</i>	Floodplain, L
Soft rush	<i>Juncus effusus</i>	Floodplain, L
Tall flatsedge	<i>Cyperus eragrostis</i>	Floodplain, L
Western sword fern	<i>Polystichum munitum</i>	L
GRASSES		
Blue wildrye	<i>Elymus glaucus</i>	U,M
California brome	<i>Bromus carinatus</i>	U,M
California fescue	<i>Festuca californica</i>	U,M
Creeping wildrye	<i>Leymus triticoides</i>	U,M
Idaho fescue	<i>Festuca idahoensis</i>	U,M
Meadow barley	<i>Hordeum brachyantherum</i>	U,M
Purple needlegrass	<i>Nassella pulchra</i>	U,M

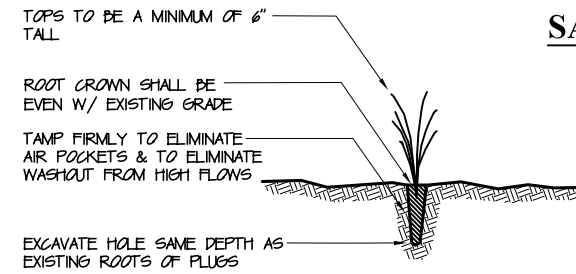
PLANTING NOTES

Planting Position: U = upper bank, M = middle bank, L = lower bank
 Plant trees in clusters of 3-9 each, spaced 15 feet apart.
 Plant shrubs, ferns and vines in clusters of 3 to 9 each, spaced 3 to 6 feet apart (within cluster).
 Plant grass, sedge, and rush 1.5' to 3' on center in clusters.
 Channel floodplain and banks should be planted with seed mix and/or plugs.
Watering: DriWater® gel packs may be used if drip is not feasible. Plants should be watered for establishment period of 3 years.

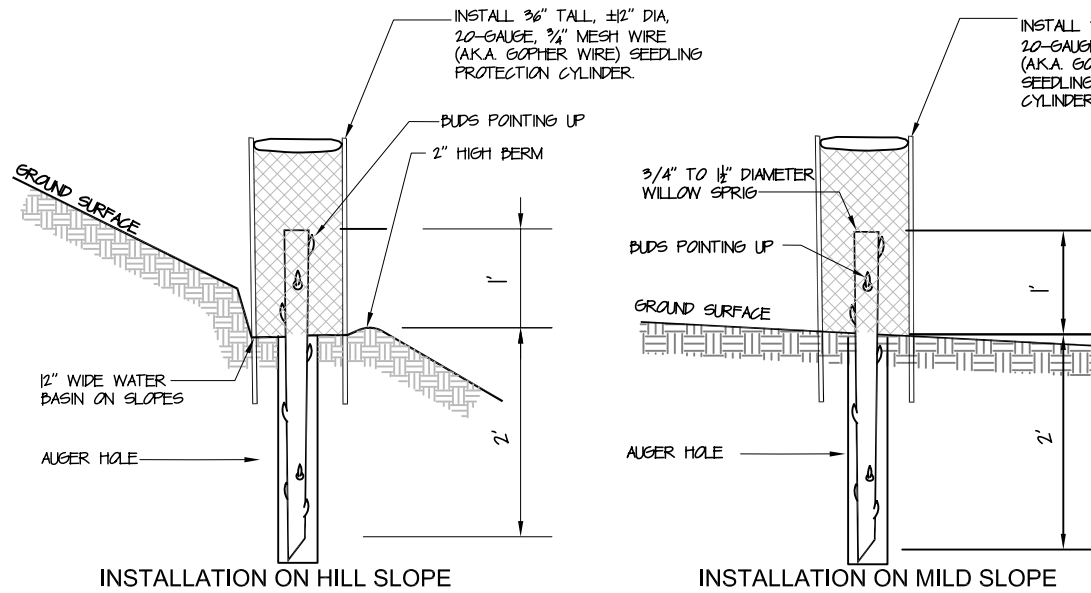
SAN GERONIMO SALMONID ENHANCEMENT PLAN

PLANT LIST & PLANTING DETAILS

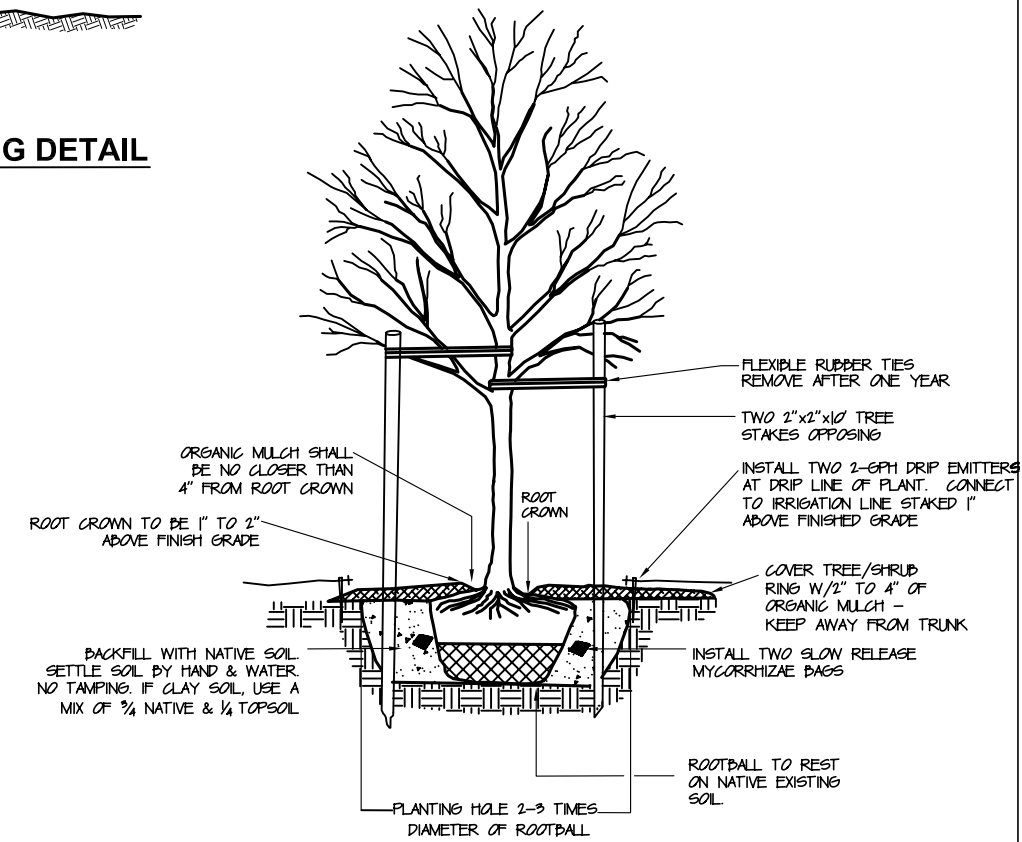
CONCEPTUAL PLAN 1



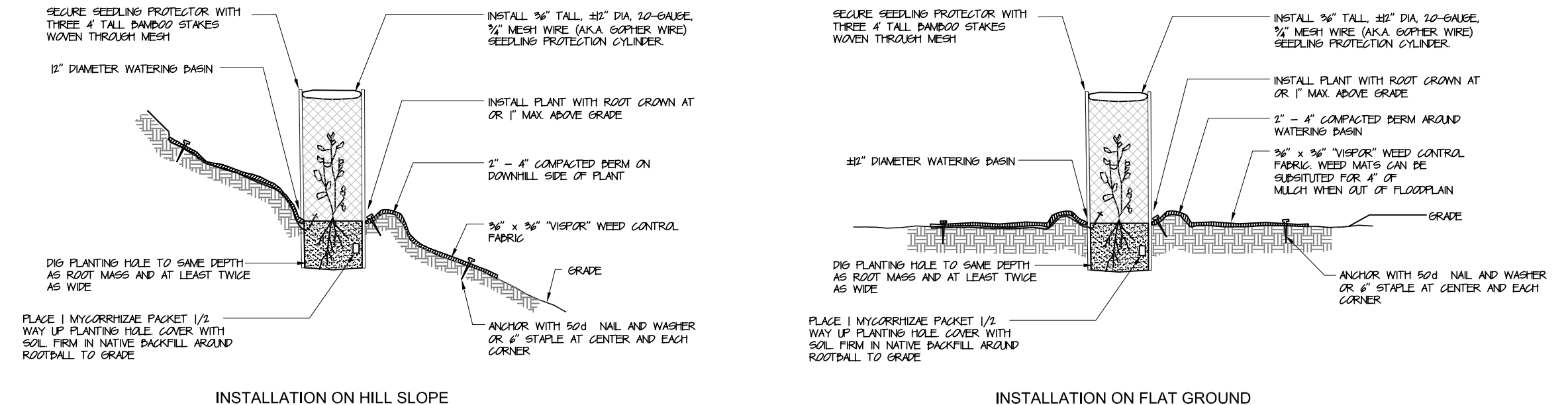
PLUG PLANTING DETAIL



WILLOW STAKE PLANTING DETAIL



TREE PLANTING DETAIL



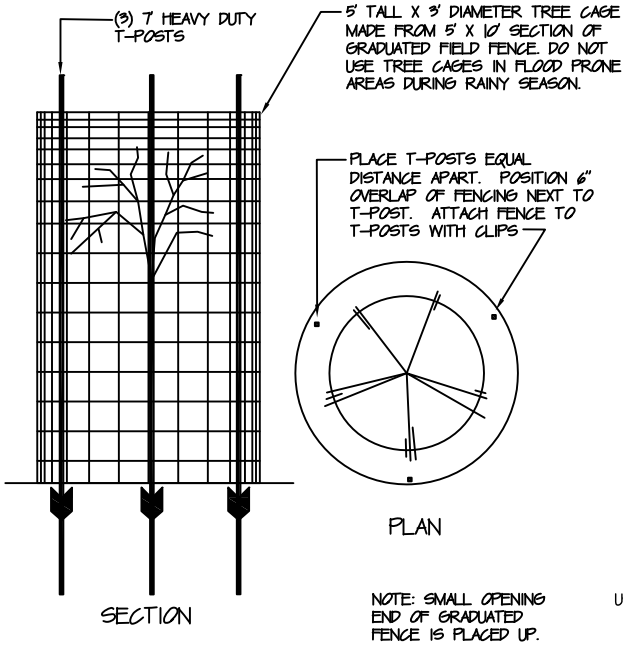
CONTAINER - GROWN PLANTS PLANTING DETAIL

PLANTING NOTES

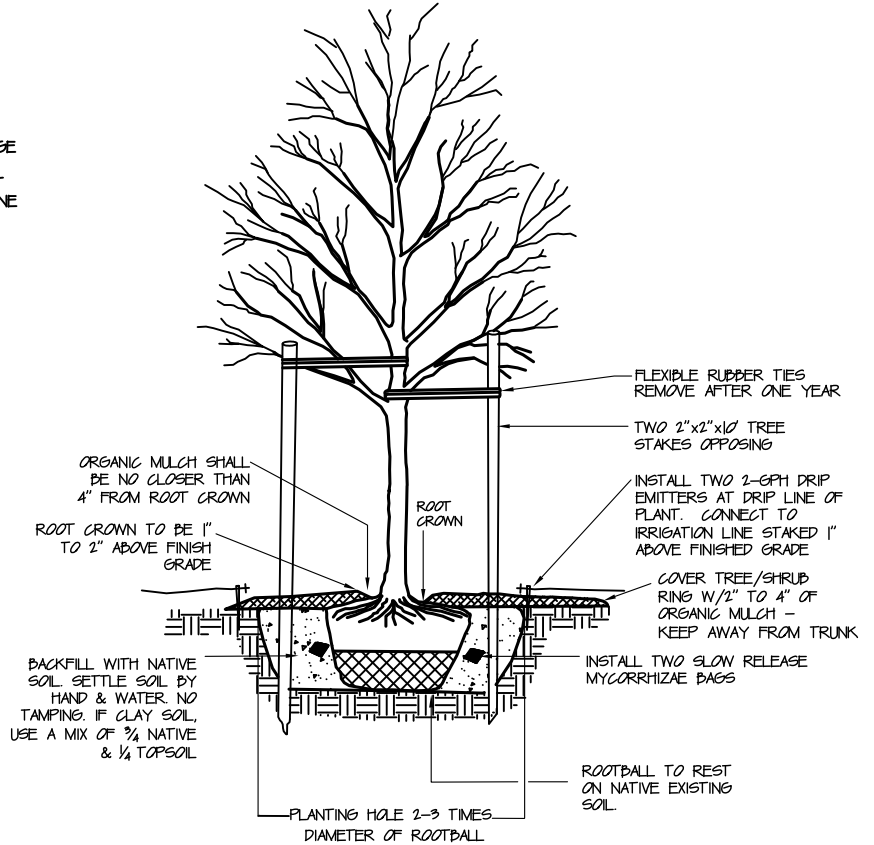
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 Plant grass, sedge, and rush 1.5' to 3' on center in clusters.
 Channel floodplain and banks should be planted with seed mix and/or plugs.

Watering: DriWater® gel packs may be used if drip is not feasible. DriWater may not be used in the Active Channel or flood prone areas.

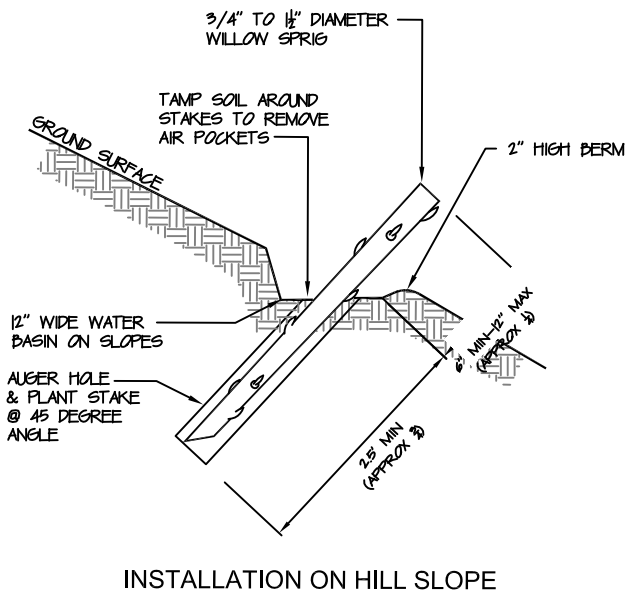
Planting Details



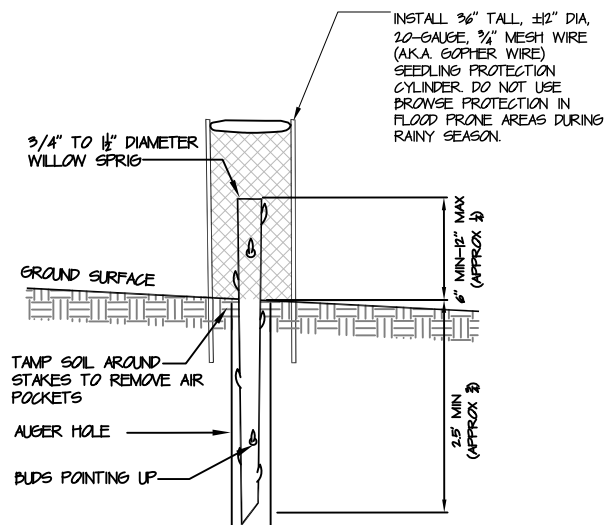
TREE CAGE DETAIL



TREE PLANTING DETAIL

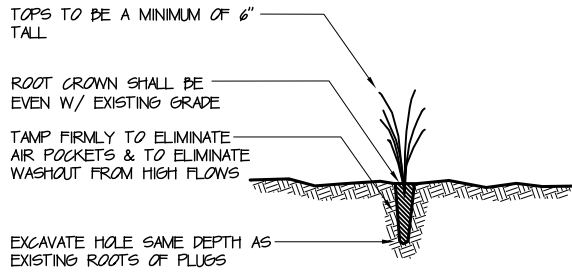


INSTALLATION ON HILL SLOPE

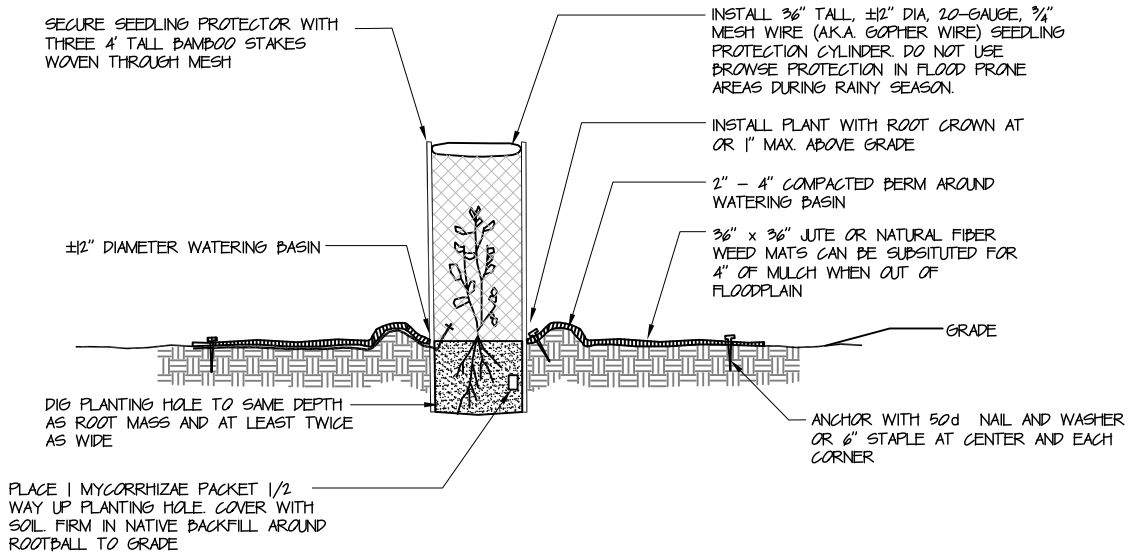


INSTALLATION ON MILD SLOPE

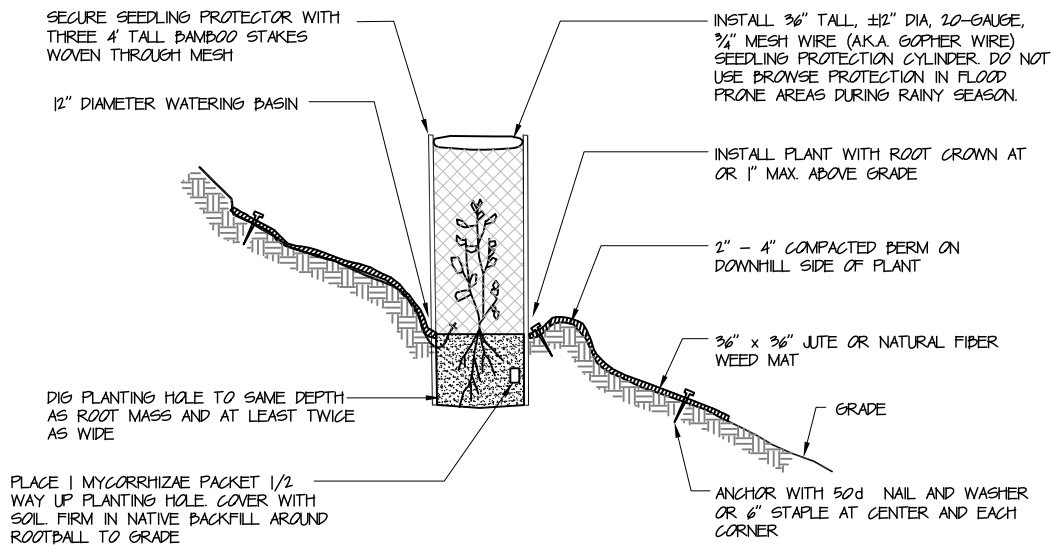
WILLOW & DOGWOOD STAKE PLANTING DETAIL



PLUG PLANTING DETAIL

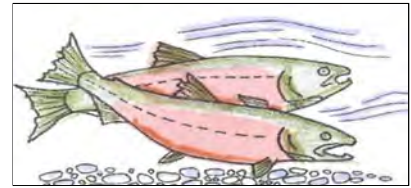


INSTALLATION ON FLAT GROUND



INSTALLATION ON HILL SLOPE

CONTAINER - GROWN PLANTS PLANTING DETAIL



Plant Installation & Maintenance Notes

Start with good materials: Using high quality native plant materials is important to your project's success. Try to purchase your planting materials locally. Plant sources should be from Marin or from the San Francisco Bay region.

Container Sizes: Typically shrubs, vines and groundcovers will come in 1 gallon pots. Trees can be purchased in treepots, or in gallon sizes. Installing trees that are 5 gallon or larger can give you a head start at a 'grown in' look. Herbaceous species such as sedges, rushes and grasses can be purchased as small plugs.

Planting Time: In most cases, the best time to plant is in November or December. Plants will be sending energy to their roots, rather than developing leaves and will be watered in naturally with winter rains. When planting the active channel or areas exposed to high flows, springtime planting (February-March) may be best (except for cuttings). The ground will still be moist, but plants will not be washed away with high flows. If planting in spring, hand watering will be required. Regardless of season, remember to water plants in thoroughly after planting to avoid air pockets in the soil.

Installation Techniques: See tree and container planting details for installation techniques.

Weeds: Planting area should be scalped and weed free; refer to sheets on invasive weed control for specifics. Create a 3' diameter weed free area around new plantings

Fertilizer: Native plants do not need chemical fertilizer. If planting an area that has poor soils, then amend soil with compost or use mycorrhizal fungi to help support plant health.

Compost: A healthy planting soil should contain approx. 5% organic matter. Compost can be mixed into existing soil at a ratio of 1/4 compost to 3/4 topsoil. Typically, a uniform layer of compost spread at a depth of 2"-3" should be enough to amend most soils. Compost can be tilled into or used as topdressing on existing soil. For landscapes adjacent to the creek it is important to use low nutrient compost. Low nutrient compost should be mature, screened, weed free and should not contain animal waste or chemical fertilizers.

Mulch or Weed Mats: Use wood chip mulch or natural fiber weed mats to suppress weed growth. If using mulch, be sure that it is organic and weed free. Keep mulch at least 2"-3" away from a plant's root crown to avoid rot. Mulch approx. 4" deep to suppress weeds. Remember to replenish mulch approx. twice per year. In flood prone areas, use weed mats instead of mulch. Weed mats should be made from a natural fiber, such as hemp or jute, so they can biodegrade. Using recycled jute coffee bags is a great way to suppress weeds. Pin corners securely with long nails or ground staples. Plugs and vines do not typically require weed mats.



Good quality plant materials



Browse protection & recycled weed mat



Plant installation on top of bank

Browse protection: Browse protection from deer is important to planting success. See tree cage detail and container planting detail for recommended browse protectors. Traditional plastic mesh protectors (e.g., Vexar) are not ideal for many container plantings as they constrain growth, but they can be effective for use on willow and dogwood cuttings.

Browse protection should not be used in the active channel or areas prone to flooding during the rainy season as they can wash away downstream. However, protection can be installed in spring and removed before the rainy season to protect new growth.

Gopher Baskets: Gopher baskets are recommended for all plantings outside of the active channel with the exception of plug plantings.

Irrigation: Most native container plantings will benefit from some irrigation while they become established. Usually, this is only needed during the dry season (April-October). Supplemental irrigation may also be required during extended dry spells in the winter.

Watering can be done by hand or, in areas that do not flood, with drip irrigation. Drip irrigation should be installed at planting time. Native plants are typically watered with 1-2 gallons each (total) per week. Split watering times up so plants get watered approx. 2 times per week. Each site is different so be sure to check the moisture levels in your soil after setting your controller. The top ½" of soil should be dry after 2 days to avoid fungus growth – this is important especially for oaks.

Use 2 gallon per hour (gph) emitters for native plants. These are less prone to clogging than ½ or 1 gph emitters. Trees should have 2 emitters spaced evenly at the edge of the rootball. Do not install emitters directly on the stem or base of a plant - this will cause rot. Be especially careful of overwatering oaks and ceanothus. If planting on a slope place emitters uphill of the plant. Do not install drip irrigation in flood prone areas because it will wash downstream.

Plug plantings do not typically receive irrigation via drip, so planting during the rainy season is important. Grass seed should also be sown at the beginning of the rainy season.

Cuttings: The best time to harvest willow (or dogwood) is in the fall and winter during dormancy (after leaf drop, before budding). Try to harvest cuttings from native stands. Willow stakes should be approx. 1" diameter and 3' long. Cut willow at a 45 degree angle, avoid peeling and splitting bark. Plant cuttings within two days of harvesting and keep moist, cool and shaded. See willow stake planting detail.

Maintenance: Typically the establishment period for native plants is 3 years. During this time the new plantings should be watered, weeded, monitored and replaced as needed. Irrigation can be phased out by the end of the 3rd year. Browse protection should be removed as the plants begin to outgrow their caging.

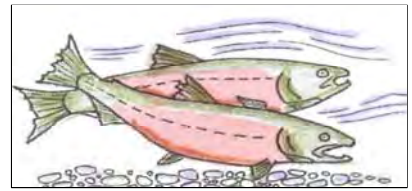


Plant establishment on gravel bar



Sprouting willow stake

Planting recommendations for...



Non-Natives in the Garden

Planting a garden around your home does not need to be limited exclusively to native plantings. Natives and non-natives can blend together brilliantly. There are a wide variety of non-natives for the garden that are not invasive, will beautify your home and provide habitat to beneficial insects. Non-natives should be used on top of bank and around the home; they should not be mixed into the flood prone or active channel zones, or mixed into intact native vegetation. Some plants listed are California natives but are not native to this watershed, or are hybrids developed from natives; these are marked with an asterisk.

<u>Common Name</u>	<u>Latin Name</u>	<u>Plant Type</u>
Autumn sage	<i>Salvia greggii</i>	perennial
Artemisia silver spreader	<i>Artemisia caucasica</i>	perennial
Beard tongue	<i>Penstemon campanulatus</i>	perennial
Black eyed Susan	<i>Rudbeckia hirta</i>	biennial
Ceanothus*	<i>Ceanothus 'Concha'</i>	shrub
Cleveland sage*	<i>Salvia clevelandii</i>	shrub
Clematis	<i>Clematis armandii</i>	vine
Creeping thyme	<i>Thymus spp.</i>	groundcover
Echinacea	<i>Echinacea purpurea</i>	perennial
Feather reed grass	<i>Calamagrostis 'Karl Foerster'</i>	grass
Japanese anemone	<i>Anemone hupehensis</i>	perennial
Lavender	<i>Lavendula spp.</i>	perennial
Lion's tail	<i>Leonotis leonurus</i>	perennial
Mexican sage	<i>Salvia leucantha</i>	perennial
Muhly grass	<i>Muhlenbergia capillaris</i>	grass
Ornamental oregano	<i>Origanum rotundifolium</i>	perennial
Pin cushion flower	<i>Scabiosa columbaria</i>	perennial
Pineapple sage	<i>Salvia elegans</i>	perennial
Rockrose	<i>Cistus incanus</i>	shrub
Rosemary	<i>Rosmarinus officinalis</i>	shrub
Strawberry tree	<i>Arbutus unedo</i>	tree
Stonecrop	<i>Sedum 'Autumn Joy'</i>	perennial
Sunflower	<i>Helianthus annuus</i>	annual
Whirling butterflies	<i>Gaura lindheimeri</i>	perennial
Rose	<i>Rosa spp. (not eglanteria)</i>	shrub/vine
Yarrow (yellow)	<i>Achillea 'Moonshine'</i>	perennial



Echinacea



Ornamental oregano



Feather reed grass & stonecrop



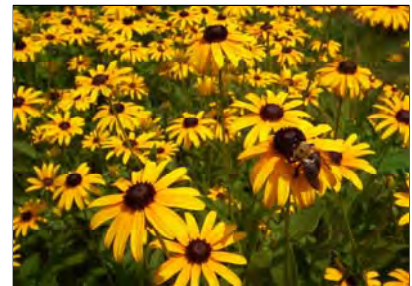
Rock rose



Pin cushion flower



Lion's tail



Black-eyed Susan

Controlling Invasive Plants



Challenge:

A handful of invasive plant species are serious pests along streams in the San Geronimo Valley. Most of these plants were introduced as ornamental species, but soon escaped into and transformed natural habitats. With their dense and aggressive growth patterns, these plants can virtually eliminate the lowest-growing native plants. The ivy species climb into trees and shrubs, eventually smothering, weighing down, and even killing them. The sprawling ivies and periwinkle may appear to be stabilizing streambanks, but their roots are shallow and do not hold soil as securely as native trees, shrubs, rushes and sedges.

Some of the most common and problematic invasive plants in San Geronimo are shown below with notes on removal strategies and a few native species that may be appropriate as replacements. Following this table, general strategies for invasive removal are described. See *Recommended Plants for San Geronimo Riparian Landscapes* for a full detailed list of native species appropriate for these settings.

Invasive Species, Removal and Replacement Recommendations



Blackberry, Himalayan

(Rubus armeniacus)

Sprawling shrub (thicket-forming); spreads by seed and rooting of cane tips.

Removal by digging out rootstocks is slow but effective. Cutting stems first by hand or brush cutter can make this easier.

Potential native replacements: California blackberry, snowberry, flowering currant, cow parsnip, rushes, sedges, honeysuckle, ferns



Broom, French (*Genista monspessulana*) (left)

Broom, Scotch (*Cytisus scoparius*) (right)

Shrubs; spread by seed

For these two similar species, pull seedlings and use a weed wrench for larger plants. After removal of mature shrubs, watch for and control new seedlings. Seedbank in the soil can be large.

Potential native replacements: Hazelnut, creambush, flowering currant, toyon



Cotoneaster

(Cotoneaster pannosa)

Shrub; spreads by seed (often transported by birds)

Pull seedlings; use a weed wrench for larger plants. Be sure to dispose of all seed during removal efforts.

Potential native replacements: California rose, ninebark, toyon



Ivy, English (*Hedera helix*)(top)
Ivy, Cape or German (*Delairea odorata*) (bottom)

Perennial vines; spread by rooting from stem and stem fragments; English ivy also spreads by seed.

For both of these ivies, prioritize removal from trees; they can kill mature trees and/or cause branch breakage. If vines are firmly attached to trees and cannot be pulled down, cut the vines on the trunk with pruners or loppers and let upper portions of plant die in place.



Rakes or McLeods can be useful for raking up aboveground plant parts and exposing stems for removal. Or try working inward from the edge of a patch, chopping a line into the infestation with a hoe or hoedad, then rolling the plant mat (including roots) back on itself, continuing to chop roots as you go.

These plants can sprout from stem or root fragments, so be thorough and expect to repeat removal a number of times. Very old English ivy rootstocks may need to be dug out with a shovel or mattock.

Potential native replacements: California blackberry, sword fern, Dutchman's pipevine, false Solomon's seal, clematis



Japanese knotweed
(Fallopia japonica, previously Polygonum cuspidatum)

Perennial herb; spreads by rhizomes and root fragments

This species prefers sunny, moist areas. Cut aboveground stems and dig out rhizomes; repeated treatments probably needed. Away from stream flows, covering infested areas with heavy tarps can help kill plants.

Potential native replacements: Elk clover, twinberry, thimbleberry, rushes and

sedges, horsetail, ferns



Periwinkle
(Vinca major)

Perennial groundcover; spreads by stolons, stem and root fragments

In dense stands, use a McLeod or rake to rake up stems and stolons, then pull roots up. Be careful not to leave fragments behind.

Potential native replacements: California blackberry, snowberry, wild ginger, Dutchman's pipevine

General Strategies for Removal

- **Prioritize new infestations**, plants at the edge of an existing infestation, or infestations within high-quality native habitat for removal. In large patches, work from the edges inward.
- During removal, **avoid impacts to existing native plants**, which, if left intact, may help suppress the invasive species.
- **Hand removal** is labor-intensive but often one of the most effective treatments. Pay careful attention to removing all plant parts capable of resprouting or germinating (e.g. root fragments, stem fragments, developing or mature seed). Remove all viable plant parts from the site.
- **Sheet mulching** can be an effective strategy or complement to hand removal for low-growing species. This entails covering infested areas with heavy layers of cardboard to deprive plants of sunlight and eventually kill them. Be sure to overlap layers of cardboard thoroughly, and pin down with 12-18" metal pins to reduce chances that plants will find their way through. Wetting the cardboard will also help settle it into place. On level ground (but not in the flood prone zone), cover with wood chip mulch to increase effectiveness and help the cardboard blend into the landscape. This approach may not stop an invasive completely, but it can slow down reinfestation to a more manageable level. Holes can be easily cut into the cardboard for plantings.
- **Mowing or string-trimming** is not generally recommended for most perennial invasive species as many resprout with vigor after being cut and new plants can grow from even tiny stem fragments. However in some cases, mowing or string-trimming can be a helpful first step to make the rooted portions of plants more visible and accessible for further removal. If you do mow or string-trim, be sure not to pile cuttings in un-infested areas.
- **Monitoring for resprouts**, removing them, and replanting the area with native plants are critical steps for successful control. The best time to plant natives is early in the rainy season, when plants can take advantage of naturally cool, moist soils.

Special Considerations for Riparian Settings

- To minimize the risk of erosion from invasive removal on creek banks, avoid denuding large areas at once. **Work on areas of manageable size** where you can remove invasives completely and replant with natives rather than attempting to eradicate across an area too big to thoroughly treat and replant.
- **Consider the timing of invasive removal and replanting.** Generally, the safest and easiest time to remove invasives in the active channel and flood-prone zone is in spring, when ground is soft but storms and high flows have passed. However, replanting in the spring will mean that more irrigation is needed to help plants get established, and grass seed may not thrive. To protect exposed soil while waiting for plant establishment, cover bare areas with natural fiber (hemp, coir, or jute) weed mat that is securely pinned to the ground.
- Replacing invasive plants and restoring a more natural plant community is generally beneficial to native wildlife. However, some wildlife species do use some invasive riparian plants for shelter and/or food. **Schedule work outside of bird nesting season**, remove

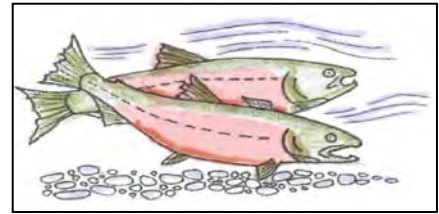
large infestations in stages, and replant promptly with native species to minimize negative effects on wildlife.

- Use of **chemical controls**, especially in a riparian setting, is usually considered a last resort—but may be worth considering in some situations if contamination of water or soil can be avoided. Details on chemical control methods for these and many other species are available from www.cal-ipc.org and other sources.
- **Avoid spreading invasive plants through flowing water**; many can resprout from even small fragments floating downstream. Bag & dispose of in your trash bin or at county dump.

Ongoing Management

- If the invasive infestation extends beyond your own property, talk to your neighbors. Your efforts are much more likely to succeed if a joint effort is possible. If not, be vigilant about cutting or pulling back plants encroaching from outside. For especially difficult infestations, putting a plastic barrier in place can help slow down plants spreading in from outside your yard. These are often used to control bamboo and are typically made of heavy black polyethylene. Choose a size that will extend 6" below the roots of the plant and at least 3-4" aboveground.
- Mulching heavily with wood chips, or sheet mulching with cardboard as described above, after invasive removal can help slow the return of these plants. However, be sure not to pile mulch up against a tree; this can injure the tree and lead to fungal and insect problems. Keep mulch 6" away from the trunk of a mature tree. Wood chips are not appropriate in the flood prone zone, where they are likely to be swept into the creek.
- Unfortunately, there's no simple cure for transforming an invaded habitat into a native habitat. No single method or single replacement plant species will succeed in all settings. Consider this a chance to get to know your own landscape better. Experiment, observe, and be patient but diligent in your efforts to reduce invasive species. Once you find the native plants that are best suited to your landscape, they will grow, spread and thrive, providing beauty, wildlife habitat, and an important link to the wilder places of San Geronimo Valley.

For further information, see the California Invasive Plant Council's website (www.cal-ipc.org); and additional information sheets *Removing Invasive Ivy from Riparian Trees* and *Recommended Native Species for San Geronimo Valley Riparian Plantings*.



Controlling Invasive Ivy in Riparian Trees

Challenge:

Two invasive vines—English ivy (*Hedera helix*) and Cape or German ivy (*Delairea odorata*)—have had serious effects on riparian habitat in the San Geronimo Valley and throughout coastal California. Both of these non-native species were introduced to the U.S. as ornamentals or houseplants, but soon escaped into and have transformed natural habitats. These ivies are sprawling, climbing perennials well-adapted to coastal California conditions. They spread rapidly by vegetative means—even from small fragments—and English ivy also reproduces by seeds, which birds readily transport. These species climb into trees and shrubs, eventually killing them by preventing access to sunlight, or weighing branches down and causing breakage.



English ivy rootlets exude a glue-like substance to adhere to tree bark, helping it climb high into the canopy.



Dead madrone covered with English ivy.

When native redwoods, oaks, bays, and alders are damaged or killed, the losses of these keystone riparian species have many repercussions for San Geronimo Valley. Stability of creek banks is diminished with the loss of deep, extensive tree root systems. Shading of creek waters for salmonid habitat is reduced. Falling limbs or trees can pose a hazard to nearby structures. And both English ivy and Cape ivy pose a host of other problems where they carpet the forest floor, crowding out native plants and reducing the diverse cover and food resources that native shrubs and herbs supply to birds and other wildlife.

The following guidelines will help you control ivy in riparian trees. Also see the *Controlling Invasive Plants* information sheet for more on how to control ivy in general.

To remove English or Cape ivy from trees:

- Wear protective clothing (long sleeves, long pants, and work gloves); ivies have toxic compounds and can cause skin irritation when handled.
- Where possible, pull runners down from trees. For larger vines, cut through the vine near the base of the tree to kill the upper portions. Use pruners, loppers or a pruning saw. Be careful not to wound the bark of the tree.
- Pull as much ivy as possible from around the base of the tree. The wider an area you can clear, the longer the tree will stay free of ivy. Be careful to remove all plant fragments from the site to avoid resprouting.
- Remove as much of the plant's roots and stems as possible to prevent resprouting. If this entails significant soil disturbance, protect soil with mulch or natural fiber weed mat, and/or replant with native plants, to minimize erosion.
- Do not leave removed ivy on the ground or in a home compost system. Bag it and dispose of it in trash bin or at landfill.
- If you have an extensive infestation of ivy, it will be essential to monitor the ivy for regrowth, and retreat as needed. Control of these species usually entails a multi-year or ongoing effort.
- For more information on these and other invasive species, see www.cal-ipc.org, the California Invasive Plant Council website.



Cape ivy. Photo by Forest & Kim Starr.



English ivy.

A black and white photograph of tall grasses, possibly coastal grasses, with a central white rectangular box containing text. The grasses are in the foreground and background, creating a sense of depth and texture. The central box is framed by a thin black border.

GROUNDWORK

A HANDBOOK FOR SMALL-SCALE EROSION CONTROL IN COASTAL CALIFORNIA

GROUNDWORK:

A HANDBOOK FOR SMALL-SCALE EROSION CONTROL IN COASTAL CALIFORNIA

2nd Edition

*Marin Resource Conservation District
Marin County Stormwater Pollution Prevention Program*

Groundwork was first written in 1987 through a grant from the State Coastal Conservancy to the Marin Resource Conservation District. This revision has been largely funded by Marin County Stormwater Pollution Prevention Program and a grant from the State Water Resources Control Board to the Marin County Department of Public Works. Additional funds were generously provided by the Marin Community Foundation, North Coast Resource Conservation and Development Council, and from Marin Municipal Water District funds through the State Water Resources Control Board.

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This handbook, in both its first incarnation and this revision, is a collective creation. We are deeply grateful to everyone who contributed—the practitioners who tried and improved many of the techniques, the landowners and agencies who encouraged experimentation, and all who worked to revive *Groundwork*. This revision is dedicated to Don McIsaac, George Flanders and Leo Cronin, who each in his own way, helped keep the coho returning to Lagunitas Creek.



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SOIL, EROSION AND SEDIMENT

Soil is more than that brown mud the dog tracks into the house after a rainstorm; it is an intricate ensemble of living microorganisms, **humus** (partially and completely decayed organic matter) and inorganic particles worn down from parent rocks. The process from rock to soil is a slow one. An average inch of topsoil, richest of the soil layers in organic matter and the creatures that decompose such material, takes a thousand years or more to form.

As any home gardener knows, soils vary widely in fertility, mineral content, physical structure and the way they react to wind and water. Some soils drain slowly, making them poor choices for unsurfaced roads or septic systems. Others are highly erodible, and the smallest disturbance can lead to a gully or streambank washout. The type and depth of soil play a major role in determining what kind of plants grow in an area. The plant community in turn affects what species of fish and other animals, both domestic and wild, can survive there.

Erosion is a natural process. It shapes our hillsides, valleys, rivers and streams; it creates fertile floodplains and it helps distribute nutrients throughout the watershed. Erosion provides necessary sediments to creeks and rivers and allows them to create a rich variety of habitats such as spawning gravels, deep pools and sandbars where new vegetation can take hold. Erosion in upper watersheds is needed to form our coastal beaches.

In stable watersheds, the rate of erosion is slow and in balance with natural restorative cycles. But in many watersheds, human use of the land has accelerated the rate of change beyond nature's short-term healing capabilities—in some places even beyond long-term recovery. The desertification process occurring in many arid and sub-arid regions is a dramatic example of how human-induced changes in vegetation and soil can lead to wide-scale ecologic and economic collapse.



KEY TO EROSION CONTROL PRACTICES



Try these yourself. These techniques are relatively simple with little risk of causing unintended, significant damage. Under most circumstances, they do not require permits. However if threatened or endangered species are present, contact your city or county planning department, the local Natural Resource Conservation District office, or the California Department of Fish and Game (Chapters 12 and 13) just to make sure your action won't cause harm.



These techniques require careful planning, but can be installed without professional assistance in some situations. We try to describe when permits are needed and the limits of safe use with each practice or group of practices. Seek professional help whenever a building, utility or road is threatened. The box in Chapter 3 has more information on when you need a registered professional designer.



This group requires engineered designs and in most cases, permits from multiple agencies. We provide only a general description of these methods.

The effects of soil erosion are not limited to the site where the soil was lost. The detached soil, called **sediment**, enters the water system and settles out—at a culvert inlet, in a stream channel, in a lake or an estuary. Some sediment is needed to enrich and create aquatic ecosystems, but too much sediment is destructive. In much of coastal California, erosion and sedimentation have been major culprits in the decline of coho salmon and steelhead trout. Fine soil particles fill in spawning gravels, reduce oxygen levels, and cement stream bottoms into uniform surfaces that no longer provide nooks and crannies to shelter young fish and the aquatic animals they eat. Larger material settles in pools so that fish no longer have deep, cool water for summer shelter. Excessive sedimentation has changed the natural functioning of bays and estuaries up and down the California coast.

Climate changes within the next twenty years are predicted to increase the frequency and severity of winter storms which in turn will likely lead to higher rates of erosion. As more stress is put on the environment, high quality habitat will become even more critical for the survival of steelhead, salmon and many other aquatic species. Repairing and preventing erosion now may save dollars and diversity in the future.

Although individual erosion problems may seem too small to fill in a bay or threaten a whole species, together they contribute vast amounts of sediment to our waterways. The purpose of this handbook is twofold: to help landowners and land managers better understand erosion processes, and to describe practices for repairing small-scale erosion problems common to northern coastal California. Each practice is labeled with one of the symbols shown in the box.

Five Basic Rules for Preventing Common Erosion Problems

1. **Protect bare soil surfaces.** Vegetation is the best protection because it both absorbs and uses water. Gravel, straw, wood chips and other mulches are also effective. If you use an impermeable substance, such as temporary plastic sheeting, be careful where you direct the runoff. You don't want to fix one erosion problem while creating another.
2. **Don't concentrate water flow unless absolutely necessary.** On undisturbed slopes, water percolates through soil slowly and relatively uniformly. When all the runoff from a single area is focused on one spot, such as by a culvert or a roof gutter, the natural protection of the ground surface is often not sufficient to prevent this extra flow from breaking through to bare soil. If you must focus runoff, protect the outflow area with an energy dissipator, such as rock or securely anchored brush, that will withstand stormflows.
3. **Limit livestock and human use of vulnerable areas.** Livestock and people can exacerbate mild erosion by disturbing vegetation and creating trails that channel the flow. Stream areas, steep or fill slopes, winter swales, unsurfaced roads, old landslides and any sites that show signs of recent soil loss are areas of special concern.
4. **Disturb existing vegetation as little as possible.** Plants hold topsoil and often subsoil in place with their roots, regulate the speed of water flowing through and over soil, and provide cover and food for wildlife. The native plant community is especially well adapted to specific soil and rainfall conditions. Once native plant cover is disturbed, the soil below becomes much more susceptible to erosion.
5. **Encourage infiltration.** The more water you can keep in the soil instead of on top of it, the less erosion you'll have. Percolation through vegetation and soil also cleans nutrients and other pollutants from water, and increases soil fertility and moisture content. Use permeable pavements instead of concrete or asphalt. Collect and spread runoff from roofs or paddocks. Plant native trees and shrubs not just along creeks, but in upland areas as well. See Chapter 7 for ways to increase infiltration on your property.



HEALING EROSION: GENERAL GUIDELINES

Most coastal California erosion problems share the common ingredients of exposed soil, flowing water and an agent, usually human or climatic, that disrupted a pre-existing equilibrium. The following guidelines will help you understand and repair all common erosion problems:

1. Watch the problem and try to determine the cause. The most essential tools for erosion control in northern California are a pair of rubber boots and a good rainsuit. The action happens during the rains. You can see firsthand how problems develop and grow, and you can catch little things before they become catastrophes.
2. Keep in mind stormflow. As you plan or execute a repair, especially during the dry season, stand back and visualize what will happen during a heavy storm. Will water shoot out beyond the rock you've placed under your culvert? Will it eddy around your brush mattress and cut a new hole in the streambank?
3. Work very carefully. Flowing water is not forgiving. It finds the tiniest crack and undermines the best intentions. Good craftsmanship creates durability as well as beauty.
4. Be patient. Every site is unique, and it may take years of observation and modification to fine-tune a repair to fit the problem precisely.
5. Be creative. For example, sometimes a handful of leaves works better than a truckload of gravel to seal a small checkdam. Be careful, though, not to add toxins or garbage to the watershed or to create a new problem downstream.
6. Work with nature. The best repairs disappear over time. You want to nudge the natural healing process, not fight it. A willow repair won't thrive, for example, under a redwood canopy. Sloping a

vertical streambank back to a more gradual, stable slope may take more room, but in the end require much less cost and maintenance than building a retaining wall.

7. Coordinate with your neighbors, especially if you are tackling streambank erosion. Erosion and the processes that create it rarely stop at property boundaries.
8. Obtain the proper permits. County, state and federal agencies have regulatory roles over most structural repair in stream channels. If threatened or endangered species are present, additional agencies may become involved. Road repairs or other grading activities may require county permits. Coastal zone work comes under the auspices of the Coastal Commission. Local zoning and ordinances restrict activities that can occur along streams. Chapter 12 has more information on permits and other environmental compliance regulations.





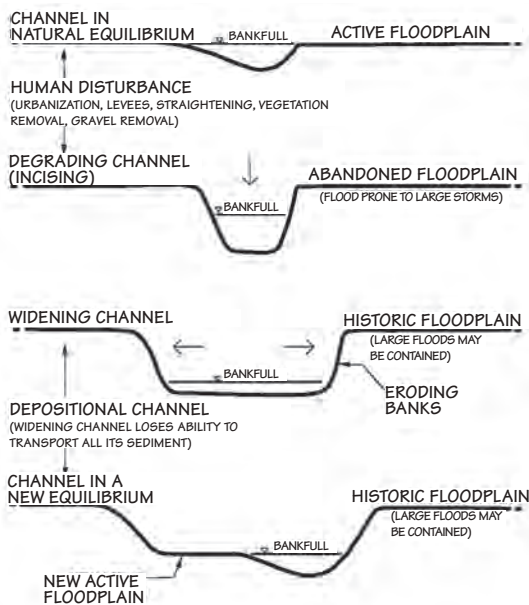
CHANNEL EROSION

Stream systems consist of the water and sediment flowing through them, the channel and its floodplain, and the community of plants and animals living in and next to the water. The climate, topography, soil, plants and land use of the stream's watershed together determine the stream's **morphology**, or form, and behavior. Stream morphology includes: 1) **dimension**—the shape of the stream in cross section, 2) **pattern**—the configuration of the stream in plan view as if you were looking down at it from an airplane, 3) and **profile**—the stream slope or drop in elevation.

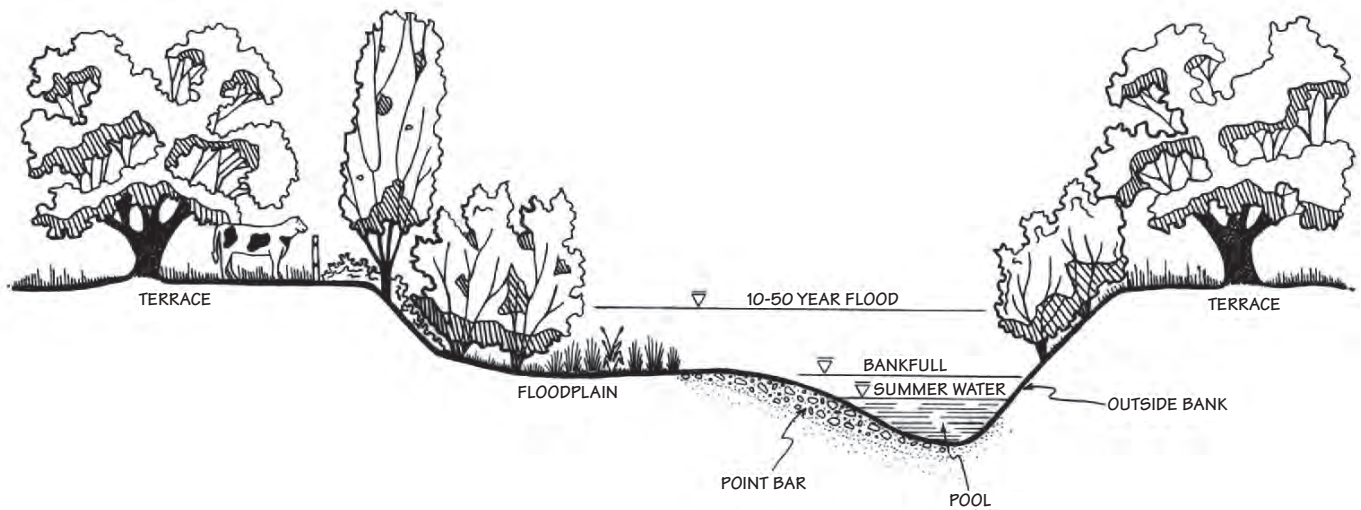
Streams are dynamic. Bank erosion, bed scour, and sediment transport and deposition are always occurring as streams adjust their morphology. A stable stream is in a state of dynamic equilibrium with small and gradual adjustments. Large changes in the watershed, major storms, for example, or increasing urbanization, can throw the system out of equilibrium. Channel adjustments, often in the form of erosion, will occur more frequently and with more severity when the stream system is out of equilibrium.

Natural disturbances such as wildfire, floods or landslides can add vast quantities of sediment into stream systems. Human uses, both current and historic, also contribute extra sediment and change the amount and timing of water entering streams and rivers. Parking lots and roofs, for example, can cause storm water to drain into waterbodies much faster than it did when the rain fell on grass and forests. Streams often adjust to this sudden change by cutting deeper (**downcutting**) or flooding. However, even a stream in balance with its sediment load and water inputs will slowly change its shape as sediment moves downstream. Unless it is solid rock, what appears to be a stable bank will, at some point, move.

The channel evolution model shown helps explain how channels change over time after disturbances to their dynamic equilibrium.



Channel evolution model

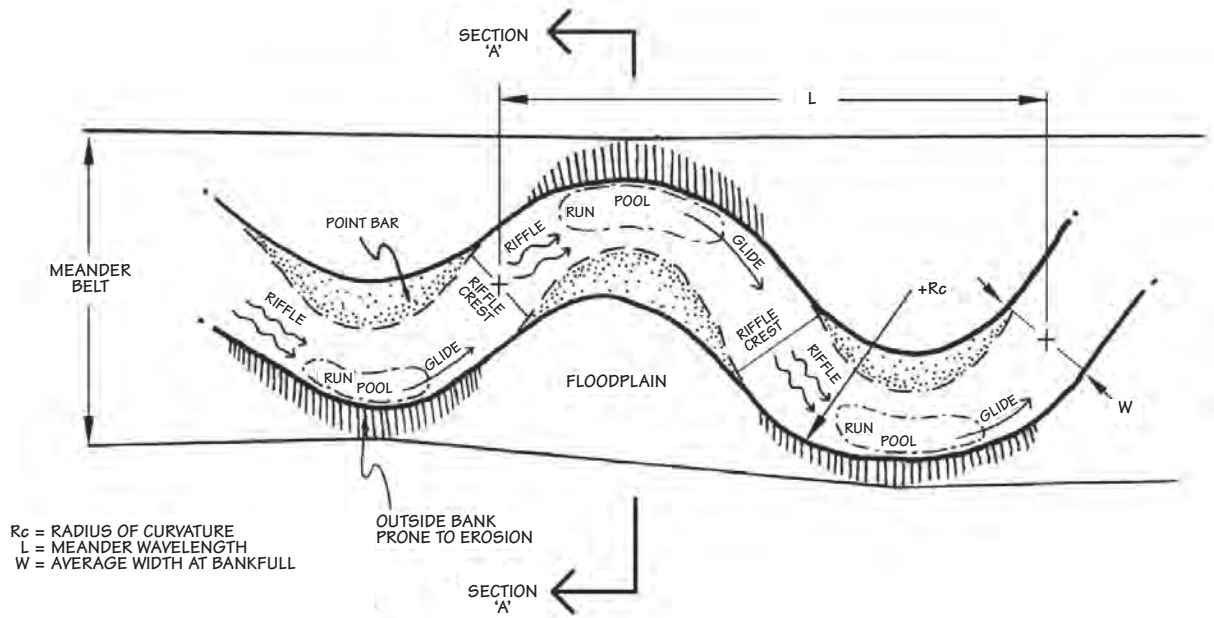


Stream dimension (section view) showing stream section 'A' from plan view.

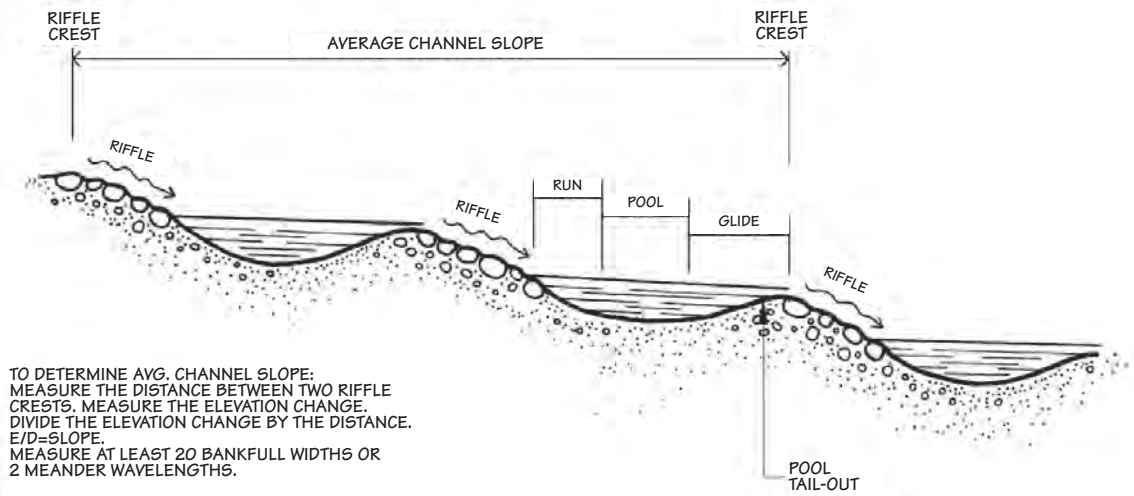
Before undertaking a major restoration project along your reach of stream or river, it is important to determine what stage of evolution your reach is in and what you can expect over the next ten or twenty years. Several of the references listed in Chapter 13 under River Science and Management describe channel evolution in depth. River scientists in private restoration firms and in many public agencies can also advise you.

A stream's basic shape is maintained by high frequency, storms that occur approximately every 1.5 years. These storm events are referred to as **bankfull**, or channel forming, flow. The pools, riffles, and undercut banks critical for the survival of fish and many other aquatic species are maintained through the bankfull flows and the erosion and deposition they cause. Stream terraces and floodplains are created by larger and less frequent storms. These features provide room for water to spread out and slow down during high flow events, as well as serve as some of the most important habitat for California's native birds and other wildlife.

Streams are classified as perennial, intermittent, and ephemeral. **Perennial** streams flow all year. **Intermittent** streams flow during the wet season and dry up for at least part of the summer. **Ephemeral**



Stream pattern (plan view)



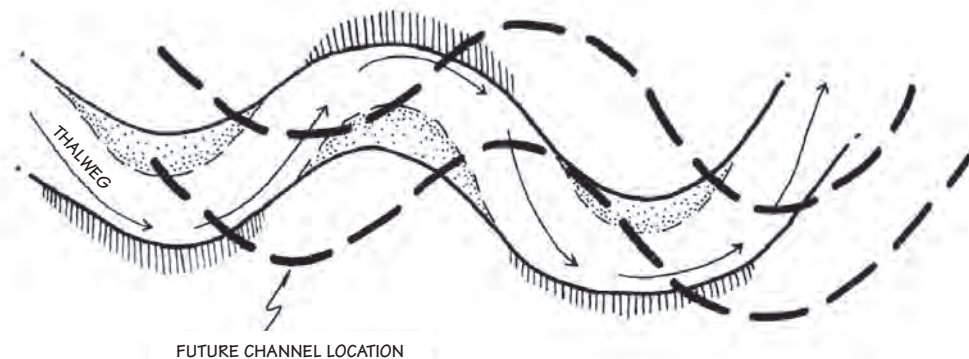
Stream profile

streams have surface flow only immediately after winter storms and in some dry winters may not flow at all. A **swale** is a depression that moves water during rainfall, but unlike a stream, it moves little or no sediment. Swales are commonly covered with grass or forest duff.

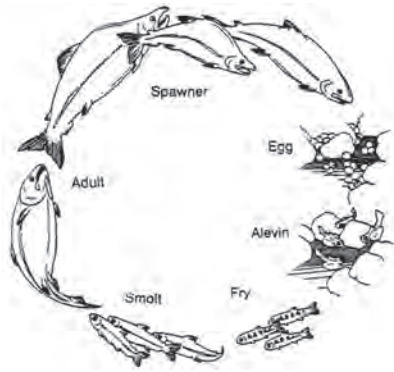
Gullies are channels that have cut into unprotected soil, creating severe, accelerated erosion. They can form in swales or ephemeral streams that have been overwhelmed by concentrated runoff. Gullies are characterized by their rapid and excessive downcutting. Unprotected culverts and poorly designed roads often cause gullies. Many of the techniques used to repair eroding stream channels also apply to gullies. Chapter 4 covers practices specific to gully stabilization, and Chapter 6 addresses road erosion.

Once they leave their steep upper tributaries, streams and rivers curve through their floodplains in meanders. In a system in balance, the width of the **meander belt** remains approximately constant, even though the meanders themselves move downstream over time as soil on the outside curves is eroded and then deposited downstream. This is a handy concept to understand when building a riparian fence, for example, or planting grapes or vegetables. Keeping them outside the meander belt gives them a much better chance of staying where you put them.

Sinuosity is a measure of the stream's length divided by the valley length. The greater the sinuosity, the curvier the stream.



Channel migration



Salmonid life cycle. Courtesy of Santa Cruz County Resource Conservation District

Preserving fish passage

Anadromous fish, such as steelhead trout and salmon, spawn in fresh water and mature in salt water. At key points in their life cycles, they need to move up and down stream channels. In winter adult fish leave the ocean to swim into the tributaries and upper mainstem reaches to spawn. The timing of the adult migration varies geographically, but in Marin County's coastal streams, coho usually spawn from November through January and steelhead from January through March. After one full year in the stream for coho, and one to two years for steelhead, most of the young fish migrate back out to the ocean in the spring. Before they leave, juvenile fish need to move up and down the stream to find food, cover and deep pools. Erosion repairs in streams with anadromous fish must allow fish to move freely during all stages of their lives.

Woody debris and erosion

Although downed trees and piles of branches can force streamflow into banks and cause erosion, they are vital for healthy streams. Fallen trees and branches, also known as **large woody debris** or **LWD**, trap sediments for spawning gravels and nutrients to feed the aquatic insects that form the foundation of a stream's food web. They create pools, shade and hiding places for fish, and perches for birds and turtles. In a 1996 report on the decline of salmon populations, the National Research Council stated "perhaps no other structural component of the environment is as important to salmon habitat as large woody debris." During the summer, woody debris jams may appear to block fish passage, but this is actually rarely the case. In winter high flows, fish can usually swim over or under the wood. Even in low flows, fish are skillful at navigating through most piles.



Susan Pinkerton

Wood in streams is regulated by the California Department of Fish and Game (CDFG). If you are concerned about erosion or genuine obstruction of fish movement, contact CDFG before you start moving the wood. (See Chapter 12 for contact information.) Remember that erosion is a natural part of a healthy stream. If no structures or roads are threatened, the benefits of the wood in the stream may well outweigh the risk of erosion damage. If property is threatened, consider altering the wood to reduce the risk while maintaining some habitat benefits. Exposed branches from fallen trees can be trimmed while

leaving the main trunk and root wad intact. Moving logs so that they are more parallel to the streambank will help focus flow away from vulnerable banks and prevent the downed wood from collecting more debris. See References #11 and #48 for more information on how to preserve fish habitat while moving LWD.

Treating Channel Erosion

Chronic, severe streambank erosion indicates a major imbalance within the watershed. Treating the symptoms may save one section of streambank, but it might just move the problem to a neighbor. Many watersheds have plans or studies that evaluate habitat issues and erosion processes for entire streams or stream reaches. These plans can be very helpful in giving individual landowners a context in which to select a repair with the best chance of satisfactory long-term results. Check with your county planning department or Resource Conservation District for information about your stream. Often, watershed plans and studies also help landowners access grant funding or design and permitting assistance. Consider joining forces with your neighbors to tackle streambank erosion with a coordinated strategy.

In this section, we will present three types of repair techniques as described in the introduction. The first group includes methods that landowners can use themselves safely in most conditions. Techniques in the second group can be used without professional help to stabilize relatively minor streambank erosion sites (3 feet high or less and 15 feet long or less) that are not immediate emergencies and where there is little or no danger of property or habitat damage should the repair fail. If in doubt, contact the Department of Fish and Game, your local Resource Conservation District, or your county or city stream expert.

The third group covers stabilization methods used for severe erosion, where property is threatened, or where changes in the stream could cause damage to neighboring land or important habitat. The methods in this group almost always require engineered designs to fit the specific conditions of your site and to meet regulatory requirements.

Before you get started on your stream repair effort, here are two important questions to ask yourself:

Is the problem urgent? Many streambank erosion sites heal themselves as the creek adjusts to watershed changes. Sometimes the best course



Try yourself



Can be used by the layperson under the circumstances described



Requires professional design and installation

WHEN DO YOU NEED A REGISTERED PROFESSIONAL DESIGNER?

Registered professional designers include engineering geologists, geotechnical engineers, civil engineers and landscape architects. They are licensed to practice in special areas of expertise, but any of them should be able to direct you to the one best suited to help you. They are needed:

- If a building or other important utilities and infrastructure (such as a road or septic system) are threatened.
- To get a grading permit or creek permit from many counties and cities.
- If you need to build retaining walls higher than 3 or 4 feet depending on the local building code.
- If you need to move more than a few wheelbarrow loads of soil or rock to stabilize your streambank.
- If fill is required in the active stream channel.

Fluvial geomorphologists and hydrologists are scientists who study the processes of river formation. They can also help design sound erosion control and restoration projects.

of action is to watch your site over a winter or two. However, if there is any chance that safety, roads or important structures are at risk, get help immediately. Getting a project designed with permits in place and built before the rainy season starts often takes six months to a year.

What is causing the erosion? Has a newly formed sediment bar or fallen tree shifted the main flow of the stream over to your bank? Is the whole channel deeper with banks on both sides slumping into the creek? Does surface runoff, maybe excess water from your lawn or stormflow from a driveway or roof downspout, cause or exacerbate the erosion? It's not always easy to tell the root cause, and you may need help from an engineer or restoration specialist. As the landowner or resident, however, you can contribute vital information on how your property has changed over time.

Once you understand the cause and have determined that you need to take action, you can begin selecting a repair strategy. Remember that streams are highly regulated by federal, state and local agencies. Check Chapter 12 for regulations that apply to your project.

Channel erosion on the outside curve

Sediment in a streambed is deposited where the gradient flattens out (where the stream becomes less steep) or where rocks, roots or some other mass slows the flow. In a typical scenario, the main line of flow, called the **thalweg**, moves to one side of the sediment buildup or point bar and cuts into the opposite bank. As more sediment is added from upstream erosion, the flow further erodes the outside bank, which in turn adds even more sediment. Obstructions such as fallen trees or improperly designed bank repairs can also change the thalweg and divert it directly into streambanks.

Solutions to address meander-related erosion in the stream include protecting the bank, deflecting the flow away from the erosion, or re-aligning the curve. All can have serious side effects and should be carefully evaluated. As water cuts the outside bank, it expends energy. If it can't cut there, it may cut somewhere else—either on a downstream bank, or in the case of channel straightening, in the bottom of the channel causing widespread bank failure.

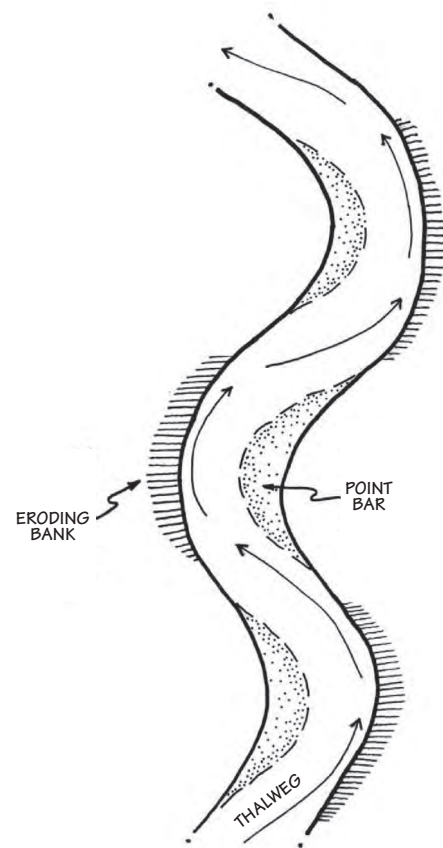
Studying a **reference stream reach** can help with selecting and designing an appropriate repair. Reference reaches are stable lengths of channel

in the same or a neighboring watershed that have similar characteristics as the problem area. They have the same average rainfall. They are located in about the same position in the watershed—both in the lower, flatter parts of the watershed, for example, instead of one in the valley and one up in a steep tributary. They are similar in size and carry about the same amount of flow. They run through the same kind of soil or parent material. Reference reaches can show you how your channel could look, at what angle the banks are stable, what kind of plants thrive there, and what size rocks or smaller sediment cover the channel bottom. In designing a streambank repair, reference reaches are used primarily to determine the appropriate channel geometry for your site.

1. Protecting eroding banks

Three types of bank protection can be used to protect eroding streambanks: vegetation by itself, bioengineering, and armoring with hard surfaces. Vegetation alone is only effective on very gentle slopes with slow moving water. Chapter 5 contains specifications for seeding and planting. Traditional hard armoring methods, such as rock riprap and walls made of concrete, gabions or other non-organic materials, frequently cause other problems. Such methods fix a stream channel in place and do not let it respond to future changes in its watershed. They can also exacerbate downstream erosion and flooding. Instead of being slowed by tree roots and boulders, storm flows speed past hard, smooth surfaces with more erosive force. Hard armoring significantly reduces habitat values for fish and other aquatic and riparian wildlife. Failure rates of solid impermeable repairs can be high as water pressure builds up behind the structure. In recognition of these issues, permitting agencies have been less willing to approve hard armoring techniques than they have in the past.

Bioengineering methods incorporate structural repairs with vegetation. When they work well, they disappear into the riparian habitat within a few years. They use materials that either degrade, such as coconut fiber mats, or are natural to the stream, such as native plants, logs and rock. They add wildlife habitat value by increasing cover and shade in the stream channel, and providing food and shelter for the animals that use the stream corridor. Some bioengineering repairs are relatively straightforward for small-scale streambank erosion. Check the box earlier in the chapter to see if you need an expert.



Channel erosion, plan view



Tree roots protecting a bank and creating habitat.



Willow sprig

Many of the following bioengineering techniques utilize willows. Willows are the backbone of many coastal California ecosystems and are often the first woody plant to colonize disturbed areas. They root easily and once established can survive high flows. They do need sun to thrive, so don't try a willow-based repair in a deeply shaded red-wood reach. All willow cuttings should be collected and planted when the plant is dormant, usually from late September through December. In order to beat the winter flows, October and early November are the best times to install bioengineering repairs.

We recommend using wood stakes and manila rope (a natural fiber) whenever staking and binding are called for, instead of rebar and nylon rope or wire. Natural materials will degrade over time, and will not strangle growing plants or cause serious injury to people or animals. When bioengineering techniques are used near the top of a streambank or on dry slopes, drip irrigation may be required for the first two to three years to firmly establish plant growth.

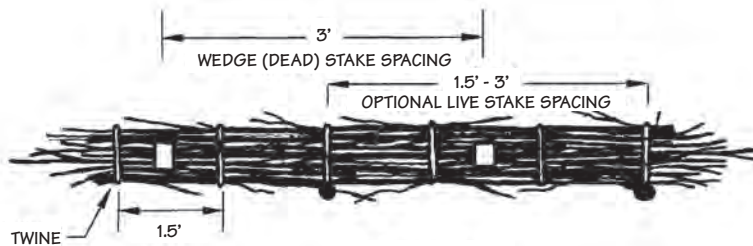
The following repair methods are arranged in order of complexity. The first group can be used without professional design at most sites. Always consult a professional designer if any of the conditions identified in the box titled "When do you need a registered professional designer?" exist.



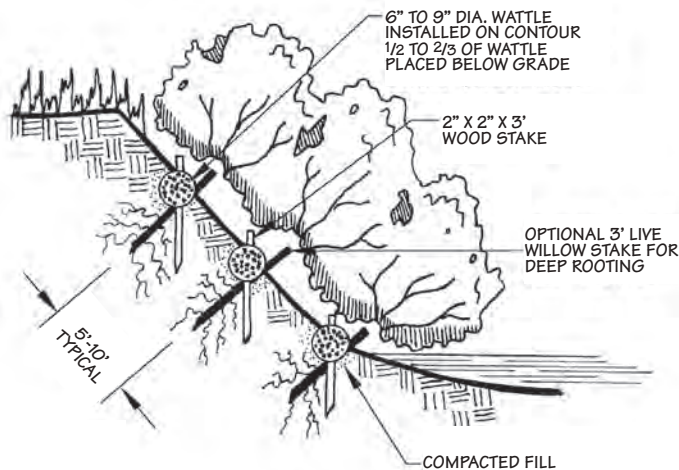
Willow sprigs are simply sturdy willow cuttings planted directly into the ground. Chapter 5 describes planting details and gives guidelines for deciding if willow is the right plant for your streambank. Willow poles are longer, stouter cuttings that can be driven deeper into the bank to withstand high flows or secure other structures, such as willow walls.



Wattles or **live fascines** are bundles of live cuttings, usually willow, bound together by rope. They can be staked by themselves in shallow trenches along the contour, or used in concert with other bioengineering techniques for toe stabilization. Willow wattles lend themselves beautifully to volunteer efforts and are easier to assemble when many hands, even very small ones, help.



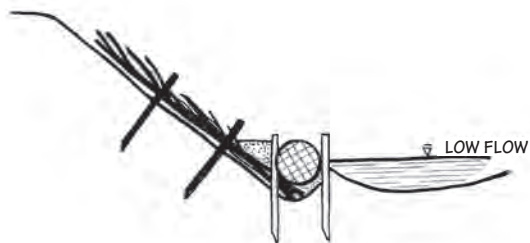
TOP VIEW



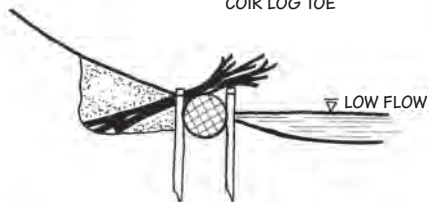
NOTE:
BLANKET OR MULCH CAN
BE USED W/SEED IN
BETWEEN WATTLES.

SECTION

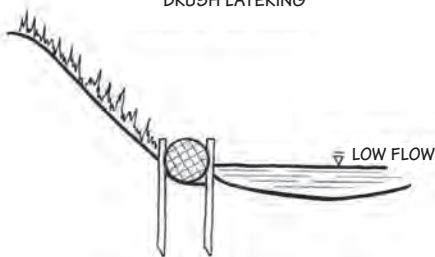
Series of willow wattles on slope



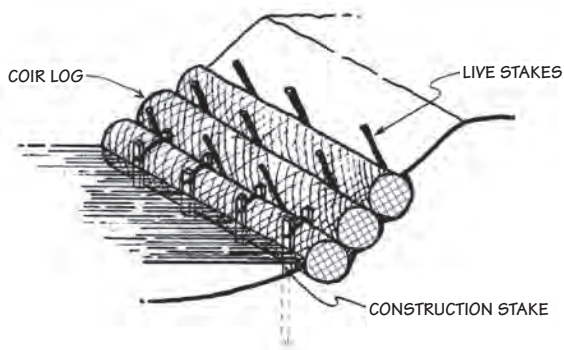
BRUSH MATTRESS WITH
COIR LOG TOE



COIR LOG WITH
BRUSH LAYERING



COIR LOG TOE PROTECTION



Coir log revetment with live willow staking



Coir logs are manufactured cylinders of tough coconut fiber that come in different lengths and diameters. They are commonly used at construction sites to slow runoff and trap sediment. Coir logs can be stacked and staked to provide protection in low-flow channels at the toe of banks or on gentle slopes. Willow sprigs make excellent stakes in sunny sites. Make sure that the logs are very securely staked to withstand high velocities. If they get loose in the stream, they can damage wildlife and divert flow.

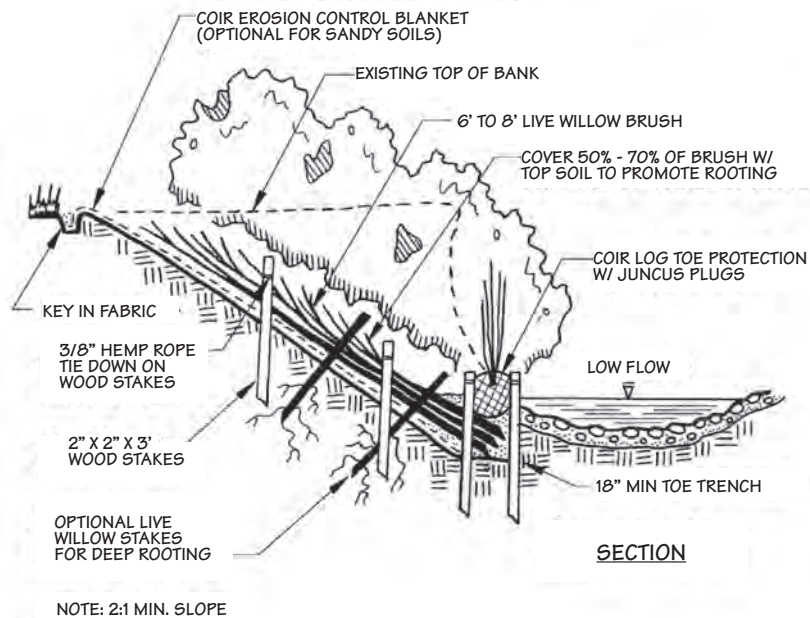
The next group of techniques may be built by the layperson under the specified conditions. However, we recommend that you consult with National Resource Conservation Service (NRCS), your local Resource Conservation District (RCD), County staff trained in biotechnical repairs, or a restoration consultant before you design and install these repairs. Because these structures will be exposed to high velocities and strong erosive forces, improper placement or inadequate keying into the bank can easily create worse problems than you started out to fix. Unless fill, such as rock, is added below the ordinary high water mark (active channel or bankfull depth), permits from the Army Corps of Engineers are not necessary. However, a permit from the California Department of Fish and Game (CDFG) is needed when working from the bed of the stream through the riparian habitat along the stream-bank. Other permits may also be required, especially if threatened or endangered species are present (Chapter 12).



A **brush mattress** is a dense layer of branches that is staked and firmly secured with rope. The butt ends of the brush are placed in a toe trench where they can be protected by coir logs or willow wattles. If willow branches are used and the site has sufficient moisture and sunlight, the branches will sprout. In shady areas, the mattress can be made with any brush and then interplanted with shade tolerant trees and shrubs. Use brush mattresses on banks with slopes no greater than 2:1 (2 feet in horizontal run for every 1 foot of vertical rise). If you think you need rock to protect the toe, seek professional advice. Remember that using rock in the channel may also increase the number and complexity of permits required.



Brush mattress

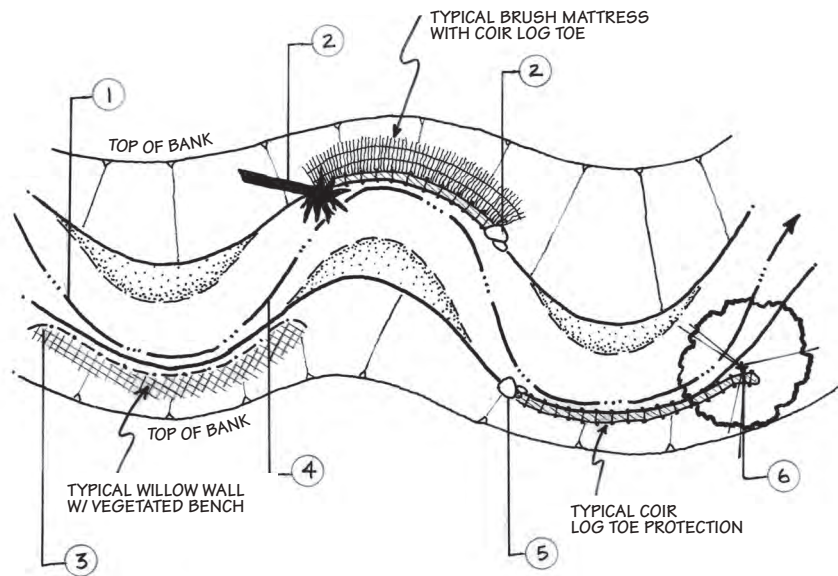


Brush mattress, section view

THE KEY TO SUCCESS IS THE KEY.

When planning a streambank project, careful consideration must be taken to properly keying in or securing the upstream and downstream ends of the repair. The key will prevent the project from unraveling or being scoured out during the first big storm. The diagram shows the following key considerations and alternatives:

1. Begin streambank projects upstream of the point where the thalweg meets and runs along the outside bank.
2. Look for existing stable stream features such as rootwads, logs or large boulders to key the project into.
3. Key willow walls, coir logs, wattles and other structures into the bank by digging a small keyway trench at both the upstream and downstream ends. The trench should be sized for a snug fit. Consider installing extra willow sprigs or poles in these locations to provide deep roots and additional anchors for securing the structure.
4. Extend projects downstream of the point where the thalweg begins to cross over to the opposite bank. This varies by stream size, but 10 to 25 feet is common.
5. If a suitable area for a key is not present, installation of a few large boulders into the toe of the bank or the engineered placement of a rootwad with stem can provide good keys for most bioengineering techniques. Remember that adding fill in the active channel, such as rock or a rootwad, will increase the need for permits and professional assistance.
6. A favorite key technique is to tuck biotechnical repairs behind existing trees that have large, stable root masses.



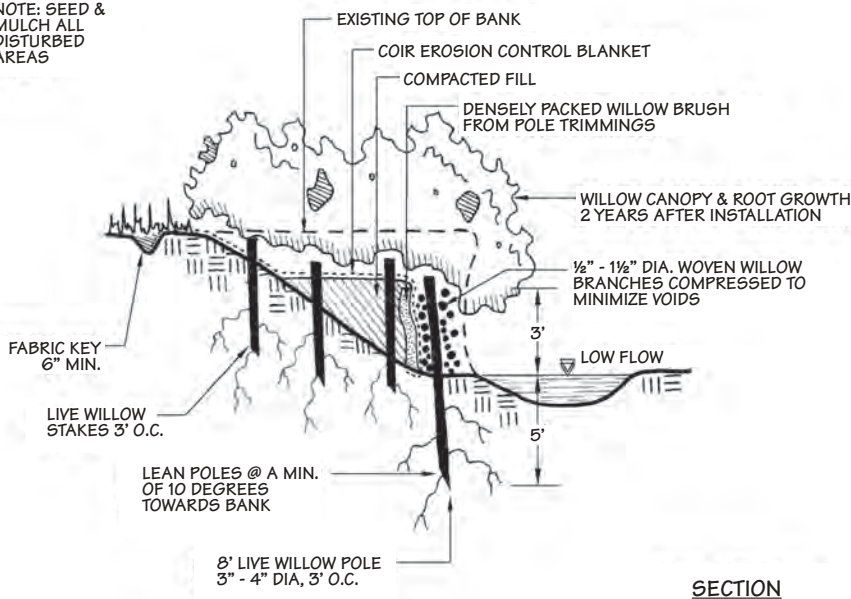


Willow walls are living retaining walls. Willow poles are driven into the ground and long willow branches are woven tightly between them. A natural fiber erosion control blanket and/or a layer of small brush is packed behind the wall, and the wall is then backfilled with soil. As with brush mattresses, the toe is often protected with a coir log, wattles, brush layering or loose rock. Both the poles and the woven branches sprout to form a dense willow thicket. Typically, you can use willow walls without professional design if the repair is only one wall high, if the height of the wall does not exceed 30 inches, and if you are able to securely key in the structure to existing stream features, such as trees. Get professional help if you need a series of walls, higher walls, or for any repair requiring rock at the toe or complex key installation.



Willow walls

NOTE: SEED & MULCH ALL DISTURBED AREAS

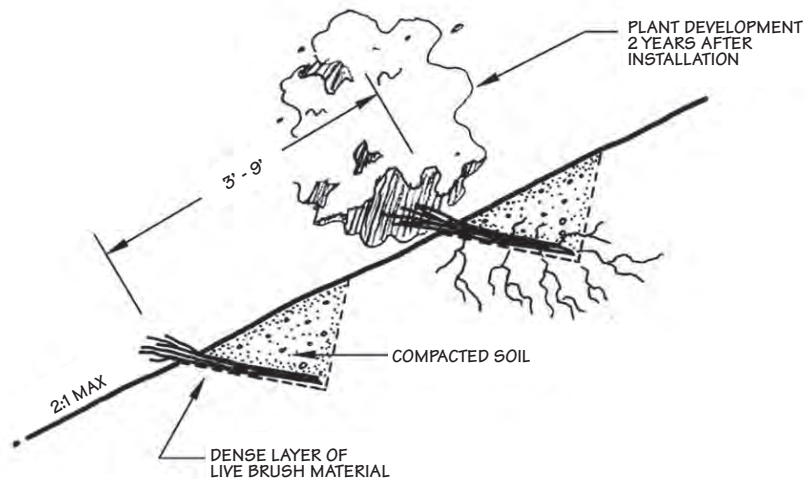


Willow wall, section view

The following techniques require professional design and usually require construction with heavy equipment. Because they use fill within the stream channel, they also require the full range of stream permits.



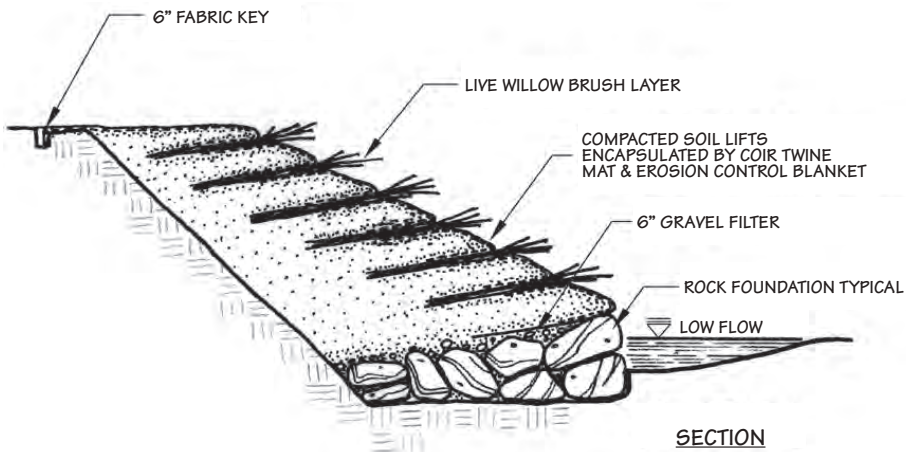
Brush layering is used on cut and fill slopes, and to repair small slumps caused by seeps. Layers of brush are placed perpendicular to the slope's contour in benches carved into the face of the cut slope or between lifts of compacted fill. The tips of the brush extend approximately 18 inches past the surface of the slope where they trap sediment and slow runoff. As the brush grows, the roots hold the soil in place. Although willows are often used for brush layering, other live woody cuttings such as dogwood (*Cornus sericea*), ninebark (*Physocarpus capitatus*) and cottonwood (*Populus spp.*) also sprout.



Brush layering, section view



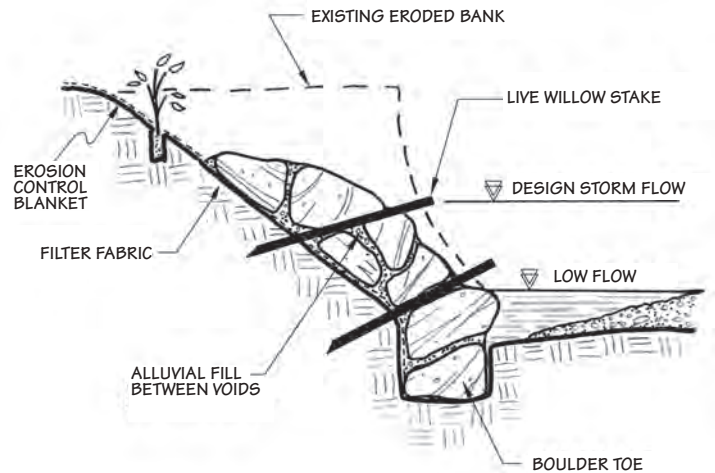
Fabric reinforced earth fill (FREF) is one of the strongest bioengineering techniques. Similar to brush layering, FREFs consist of layers of fill interplanted with brush layers. However, the face of each soil lift is wrapped in coir mats to form a structure similar to a stack of quesadillas. The fabric encapsulates the soil to provide instant erosion protection and allows FREFs to be used in situations where they will be immediately subjected to flowing water. As the plants grow, their roots form a dense, stable matrix to create even greater protection. A FREF must be built on a stable foundation, often rock.



Fabric reinforced earth fill, section view



Vegetated boulder revetments combine traditional structural stabilization with vegetation. Boulders are a “hard” repair and should be used only at high risk sites where conditions preclude a successful vegetation-only solution. Sprigs, poles or rooted plants are planted in between the boulders either as the revetment is being built, or plastic pipes are inserted as place holders during construction and the plants installed when the rainy season begins. Holes between the rocks can be filled with gravel and soil to improve natural revegetation.



Vegetated boulder revetment, section view



Large woody debris bank protection. Repair by Wildland Hydrology.



Large woody debris (LWD), especially big root wads, can be used to protect banks and create excellent instream habitat. Correct placement is critical so that the structures stay in place and function as intended. Rock or cables are sometimes used to anchor the LWD.

2. Deflecting the Flow



Deflectors, vanes, barbs and sills are obstacles attached to one bank, extending at an angle into the channel. They steer flow away from eroding banks or slow it along the near bank. At best, they are elegant repairs that buy time for the eroding sites, trapping sediment to allow vegetation to become established and secure the bank. At worst, they can cause additional erosion by aiming flow at unprotected banks.

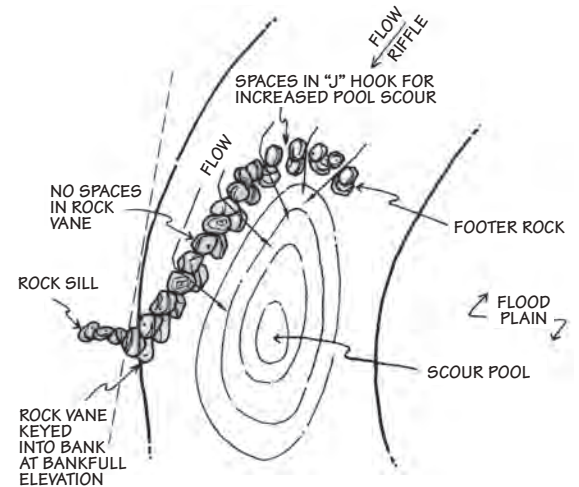
Deflectors can be constructed of logs, rock or even willow poles and branches. Some are designed to carve pools into the channel bottom for fish habitat. All should be securely anchored into the bank and checked frequently during the winter to make sure they are not causing unintended damage.

Because deflectors are built in the active channel, they require permits from the Army Corps of Engineers, the Regional Water Quality Control Board, and the California Department of Fish and Game. An experienced stream engineer or restoration specialist should design deflectors.



Boulder J-Vane

NOTE: THE "J" VANE REDUCES NEAR BANK SHEAR STRESSES UPSTREAM AND DOWNSTREAM OF THE STRUCTURE, MINIMIZING BANK EROSION WHILE CREATING POOL HABITAT. THE STRUCTURE MAINTAINS CHANNEL FLOW CAPACITY. ORIGINAL CONCEPT DEVELOPED BY D. ROSSGEN.



NOTE: THE PROPER INSTALLATION OF THIS STRUCTURE REQUIRES HYDROLOGIC, HYDRAULIC AND GEOMORPHIC ANALYSIS.

Boulder J-Vane, plan view

3. Realigning the Channel

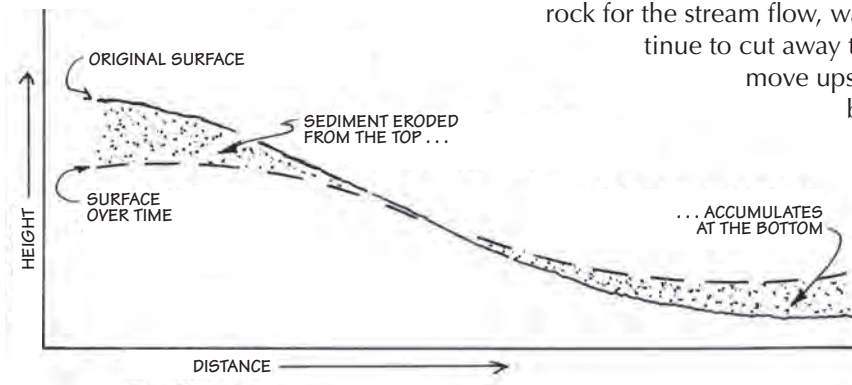
Channel realignment is a major undertaking that should be done only with sound, professional advice and all the necessary permits in your pocket. Straightening a curve without careful planning is practically guaranteed to move the erosion problem just a short distance downstream and probably make it worse. The straightened reach covers the same vertical drop in elevation over a shorter distance. Like a skier heading straight down the mountain instead of curving back and forth, the flow gains in speed and erosive power.

Realignment can be a useful tool in the restoration of long stream reaches to re-establish equilibrium between flows and sediment loads. If designed well, built to sustain instream habitat elements such as pools and riffles, and followed with bank stabilization and rigorous revegetation, realignment can be very effective.

Downcutting

The laws of gravity dictate that soil and rock move downhill. Upper reaches of streams cut deeper into the hillsides, sending sediment to accumulate at the lower reaches. As with meandering, in many watersheds this natural process has been speeded up by human activity in the watershed, which increases the rate of storm runoff beyond the stream's capacity to handle it safely.

Downcutting in streams is the same process as headcut movement in a gully. Headcuts or nickpoints are abrupt changes in gradient. If the streambed is not adequately protected by bedrock or the right size of rock for the stream flow, water pouring over the nickpoint will continue to cut away the channel bottom and the nickpoint will move upstream. As the channel bottom drops, the banks slough back in order to find a stable angle. Tributaries entering the downcutting channel also begin to cut deeper. In many coastal California streams, this process causes the stream to become so deep that it is disconnected from its floodplain—even in heavy rains the flow



may not be able to reach the floodplain to spread out and slow down. Confined in its narrow channel, flow speeds up and cuts deeper. Riparian forests, left high and dry on the abandoned floodplain, lose vigor as the water table drops and may eventually die.



+ **Grade stabilization structures** are built to control downcutting, but their use is perilous. Unless they are very carefully designed, they can flatten channel slopes and increase upstream channel meandering. Boulder step pools, boulder weirs or roughened rock ramps are methods that allow the stream to gradually transition from one level to the next while also allowing fish and other aquatic creatures to swim up and down the structure. Because of the risk of profound changes to channel stability and habitat, all grade stabilization structures should be designed by experienced river restoration professionals.

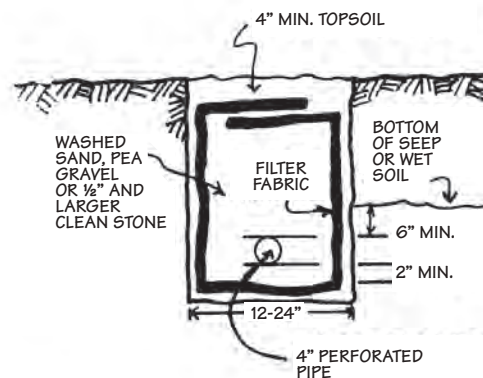
Surface and subsurface flow

Excess surface runoff and subsurface water flowing from the land adjacent to the streambank can worsen existing bank erosion and occasionally be a primary cause. Surface runoff erodes the bank face, undermining whatever armor has been placed or planted there to protect the bank. Inordinate amounts of subsurface flow can saturate banks and make them far more vulnerable to outside-curve erosion and downcutting.

Surface and subsurface flow can usually be controlled at the source. Roofs, foundation drains, road grading and over-irrigation are common sources of excess flow. If the source cannot be eliminated, berms can trap surface flow and subsurface drains can intercept ground water before they reach vulnerable banks. Remember to redirect the captured flow to a well-protected, nonerrodible point.



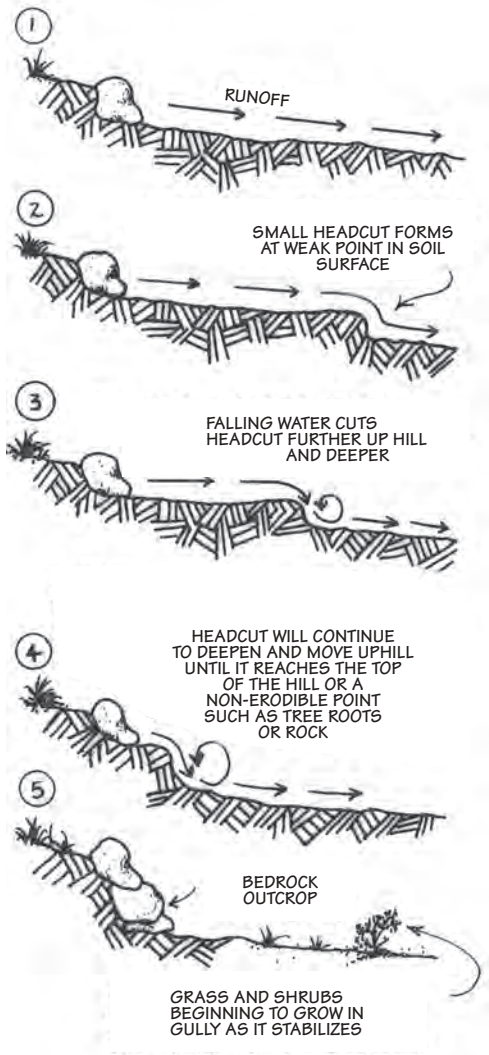
A series of boulder step pools in a restored channel.



Subsurface drain



GULLIES



Headcut movement

Gully erosion is the accelerated downcutting of existing channels or the creation of new channels from concentrated runoff. In this handbook, we use the term **gully** to refer to newly cut hillslope channels where none existed before—below a ditch relief culvert, for example—or former swales that are now actively eroding with areas of recently exposed soil. Gullies have steep gradients and unstable bottoms. Many of the techniques described in Chapter 3 to treat streambank erosion apply to gullies.

Depending on soil type, how the gullies were caused, the amount of water flowing into them and the rate of runoff from the surrounding watershed, gullies can range in size from ruts to junior canyons. Some grow slowly while others seem to devour land, often spreading into tributary drainages as they race upslope. Because of this variability, it is important to understand some of the basic concepts of gully action so that you can tailor the repair techniques to your particular gully. What works wondrously in one can be ineffective, and frustrating, in another.

Most gullies are formed by one of two processes. The first occurs when the bottom of the stream channel downstream of the gully has been lowered. As the nickpoint moves upstream, all of the tributaries, even small swales, will cut down to meet the new base level of the downstream channel. The second process occurs when runoff is concentrated and then directed to an area that is not accustomed to handling that amount and intensity of flow. At some vulnerable point, sometimes a gopher hole or just a slightly steeper spot, the soil integrity will break down and topsoil will begin to wash away. Undersized and poorly maintained culverts are a significant cause of gully erosion in coastal California.

Gullies move upslope. The frontline is the primary **headcut**, the sharp break in slope gradient at the top of the gully. As water falls over the headcut, it continuously erodes the cut face, and the gully expands

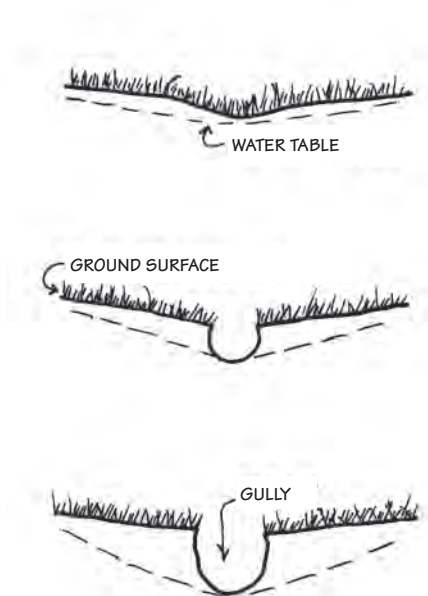
up the hill. Some gullies have more than one primary headcut, each spreading into a subdrainage.

Secondary headcuts or **nickpoints** work within the gully by the same action, undermining the gully floor and thereby deepening the channel. Some gullies have relatively uniform bottoms, with no secondary headcuts. Others stairstep up the slope with a series of nickpoints. As gullies deepen, the toes of the banks are weakened, the banks slump down and the gullies grow wider. Deep gullies can lower the groundwater table. In rangeland, this in turn can have a profound effect on the surrounding vegetation, often making it easier for hardier weedy species to overwhelm more succulent forage plants.

Before you tackle a gully, always try to figure out what started it and what is making it worse. Does a dirt road above the gully focus water into the gully drainage? If so, your most cost-effective repair may be to modify the road drainage. (See Chapter 6.) Anything that disrupts the natural drainage pattern is a potential culprit. If most of the drainages within a watershed are gullied, then the problem may be a fundamental imbalance such as an increase in the rate of runoff due to soil compaction or a major change in vegetative cover. If feasible, it is wise to address these more fundamental problems while also treating their symptoms.

Below are steps for repairing most gullies. Descriptions of specific techniques and caveats for their use follow the steps. Remember that work in gullies may require the same permits that apply to streams (Chapter 12).

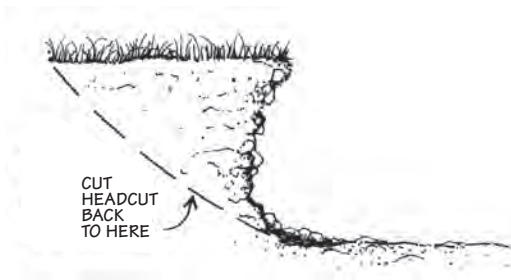
1. Try to discover why the gully formed. If possible, address the cause. Reducing flow will reduce its erosive power.
2. Stop the headcutting. Stabilizing the gully head will at least prevent the gully from lengthening.
3. Restrict livestock access if the gully is on grazing land and plant native grass and woody species wherever you can on the gully banks. Sometimes these first three steps are enough to significantly slow the erosion and allow the gully to heal. If erosion is too active to allow for plants to become established or if downcutting threatens headcut repairs, move to steps 4, 5 and 6 before planting.
4. Stop the downcutting. If active secondary headcuts within the



Gully impact on groundwater table

gully are not stabilized, they may creep upslope and undermine whatever work you have done upstream. Downcutting may be treated by protecting the secondary cuts just as you would the headcut and/or constructing grade stabilization structures across the floor of the gully. As we cautioned in Chapter 3, grade stabilization is tricky business. We strongly recommend that you seek experienced, professional advice before installing checkdams or grade stabilization structures.

5. Consider raising the level of the gully. Checkdams are a form of grade stabilization structure that allows sediment to settle out in the slower water above the dam. Alternately, the channel can be filled behind the structure at the time of construction. As the floor of the gully rises, the water table also rises, and the banks of the gully become shorter and more stable. Plants are able to take root because the soil stays in place instead of continually washing away. Checkdams are best used in steep (5% slope or greater), ephemeral channels.
6. Slope the banks of the gully back to a stable angle. With the headcutting and downcutting stabilized, this will usually occur naturally in time. However, sloping the banks allows vegetation to become established and speeds up the recovery process.
7. Revegetate the gully with grass seed and/or other native plants (Chapter 5). The primary purpose of the structural work is to hold the soil still long enough for plants to take over the job.



Shaping a gully headcut

Stopping the frontline: headcuts

As the fastest eroding part of the gully, headcuts are hard to stop. All the techniques listed below have been used successfully in coastal California, but they are not all appropriate for every headcut. Whatever method you use, follow the guidelines carefully and be vigilant about checking the site and repairing any damage promptly during the first two or three winters. **Get professional advice for any headcut greater than 3 feet in height or if any of the conditions identified in the Professional Designer box in Chapter 3 exist on the site.**

For most repairs, we recommend first shaping the headcut. Pulling back the headcut to an angle of repose and smoothing the soil surface distributes the runoff flowing into the gully over a wider area and

reduces the energy given off as water falls a vertical distance. Once the headcut is shaped, the surface soil needs to be protected with one of the methods described below. Planting specifications for seeding and mulch, sprigs and container plants are in Chapter 5.

Type of Headcut Repair	Gully Activity*	Watershed drainage area	Common Reasons for Failure
Shaping and revegetation, herbaceous cover with fabric	low to moderate	1-5 acres	Poor germination rate due to late or early seeding or incorrect seed mixture; mulch or fabric does not stay in place; slope too steep
Shaping and revegetation, other trees and shrubs	low	1-5 acres	High flows tear out plants; insufficient water in dry season; slope too steep; animal damage. Best used after headcut is stabilized with other methods.
Shaping and revegetation, willow sprigs	low to high	1-5 acres	Sprigs planted upside down, too sparsely, not deep enough or too late; sprigs too small; site too shady; insufficient water in dry season; slope too steep; animal damage
Wattles	low to moderate	1-5 acres	Site too shady; insufficient water in dry season; animal damage
Shaping with brush mattress or brush layers; willow wall on shaped or vertical surface	moderate to high	1-10 acres	Anchoring not secure; site too shady; insufficient water in dry season; animal damage
Shaping and rock	moderate to high	Any size	Rock too small; no filter under rock; rock not tightly placed; slope too steep.
Shaping, rock and woody plants	high	Any size	Insufficient water in dry season; slope too steep; animal damage; rock too small; no filter under rock; rock not tightly placed

* Low–Headcut is shallow (less than 2 feet deep) and does not grow noticeably during heavy rainfall. Banks are gently sloped and mostly covered with grass, tree roots or other vegetation.

Moderate–Headcut is shallow, but expands noticeably during winter storms. Banks are gently sloped and mostly covered with vegetation with occasional steep areas of raw, exposed soil.

High–Headcut is more than 2 feet deep and moves rapidly uphill during heavy rainfall. Banks are steep with little vegetation.



Try yourself



Can be used by the layperson under the circumstances described



Requires professional design and installation



Shaping and Revegetation with Herbaceous Cover

In shallow gullies with low flow velocities and good sun exposure, perennial grass forms a strong, dense mat that withstands high flows. Seed mixtures that contain several kinds of grasses are recommended because they provide long-term protection and a backup in case one kind of seed doesn't perform well at the site. Using native grass species supports native wildlife and creates a small reserve for these plants to spread into neighboring areas. Protect the seed with mulch and a natural fiber blanket as described in Chapter 5. You can also try sedge and rush plugs planted 12 inches apart.



Shaping and Revegetation with Other Trees and Shrubs

Rooted native trees and shrubs can also be planted in headcuts and other gully points, but they are not recommended for active gullies until the headcut has been stabilized with other techniques. Since trees and shrubs are best planted during the rainy season, they won't have a chance to grow strong root systems before stormflows, and unlike willows, you can't bury 75% of their length and expect them to live. Coyote brush (*Baccharis pilularis*) is excellent for droughty sites, and sedges (*Carex spp.*) and dogwood (*Cornus sericea*) for shady sites. Use coconut mats to protect exposed soil.



Shaping and Revegetation with Sprigs

Willow sprigs are an effective and inexpensive way to armor active headcuts and gully banks in small gullies, but they require soils that stay moist through the dry season. In fact, by absorbing and using water, they can help dry out an oozing headcut. Remember that willows need a sunny site to thrive. Dogwood cuttings can be used in shady sites.



Willow Wattles, Brush Mattress, Brush Layering, or Willow Wall With or Without Shaping

These techniques, described in Chapter 3 for streambank stabilization, are excellent candidates for headcut repair. Willow wattles or fascines are best in small gullies that drain less than 5 acres; brush mattresses and brush layering can be used in larger gullies that drain under 10 acres. As when using these techniques for streambank repair, we recommend that you consult with NRCS, your RCD, County staff or a professional designer to help select the best method and adapt it to your site.



Shaping and Rock

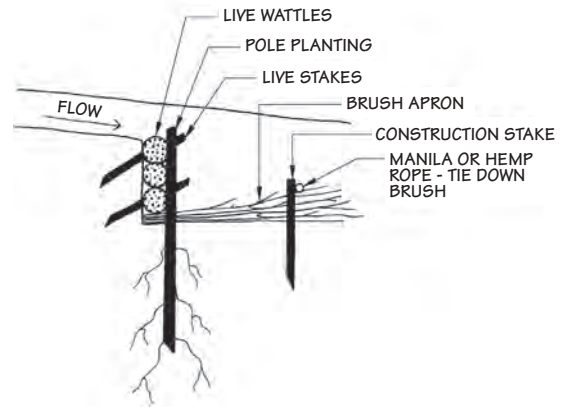
Rock is commonly used to armor headcuts and nickpoints of large and highly active gullies. Unlike purely vegetative repairs, it remains in the landscape and fixes the gully in place, even when you would rather have it disappear. However, there are times when rock is needed to halt severe erosion. Seek professional assistance before using rock to repair a headcut and make sure to check if you need permits (Chapter 12).

Rock must be carefully sized and installed to stay in place during stormflows. The two most common causes of failure are piping and rock movement. Piping occurs when water finds a cranny between the soil and the rock layer and proceeds to wash away the soil underlying the riprap. A layer of gravel or filter fabric below the rock allows water to percolate through without moving the soil.

Filter fabric is easy to transport and install, but it can inhibit vegetation from becoming established between the rocks. Generally, filter fabric is recommended for slopes steeper than 2:1 (2 feet horizontal run for a 1 foot vertical rise) and gravel for gentler slopes.

Big storms can wash away the most carefully installed rock, but you can substantially reduce the chances of failure by following these guidelines:

1. Slope the headcut back at a gentle angle. A 3:1 is best; 1:1 is minimal and should be used only on slopes less than 2 feet tall.
2. Use angular, not rounded rock.

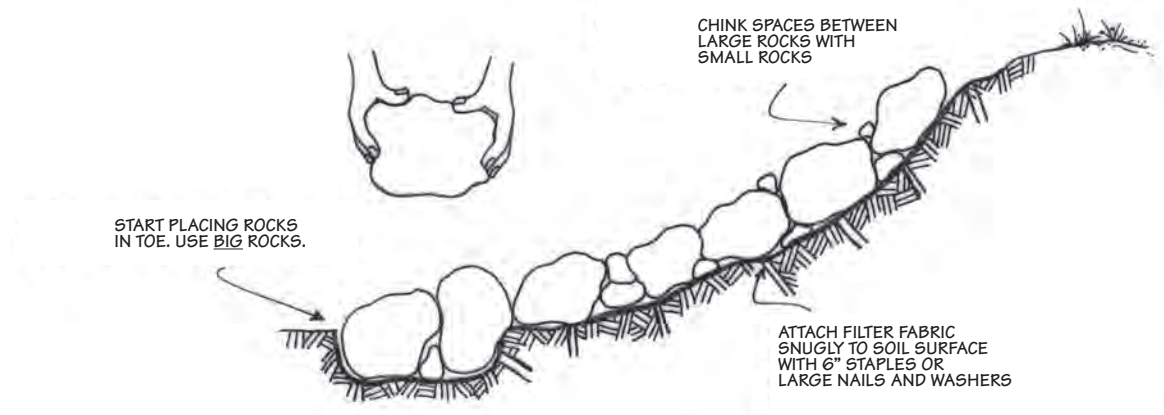


Headcut repair with willow wattles or fascines

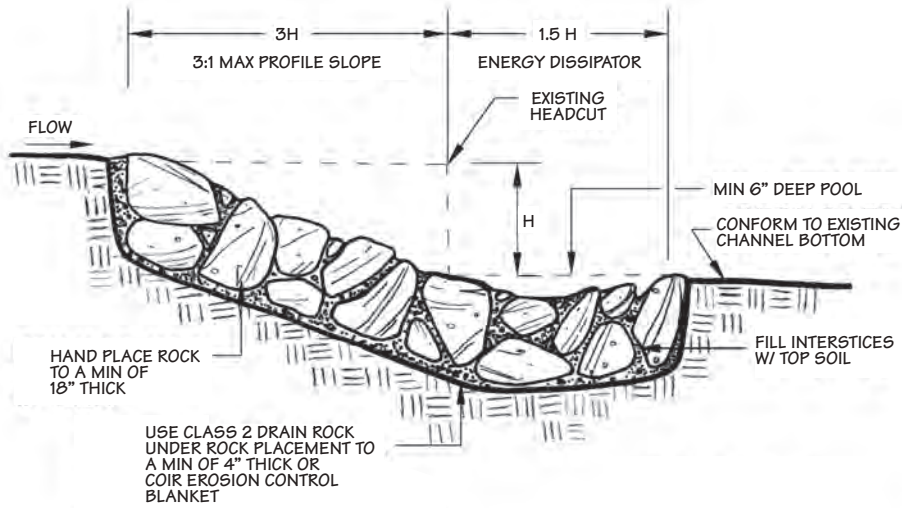


Willow wall headcut repair

3. Lock large rocks tightly together with smaller ones. Placing rock is like putting together a jigsaw puzzle—you have to search through the pile to find the right rock for each spot. You should be able to walk on the rock-covered surface without wiggling individual rocks.
4. Use dense rock. Riprap should have a minimum specific gravity of 2.5, which means that a cubic foot of rock weighs 2.5 times a cubic foot of water. Do not use concrete chunks; they have a much lower specific gravity and can be toxic to wildlife.
5. Size the rock according to the flow velocity. It's good also to look at neighboring drainages with similar flow velocities and see what size rock stays in place there. Bigger is always better.
6. Check the rock work frequently during the first two to three winters. If you see any cavities, rearrange the rocks securely, or pack them tightly with stones or flexible, leafy brush.

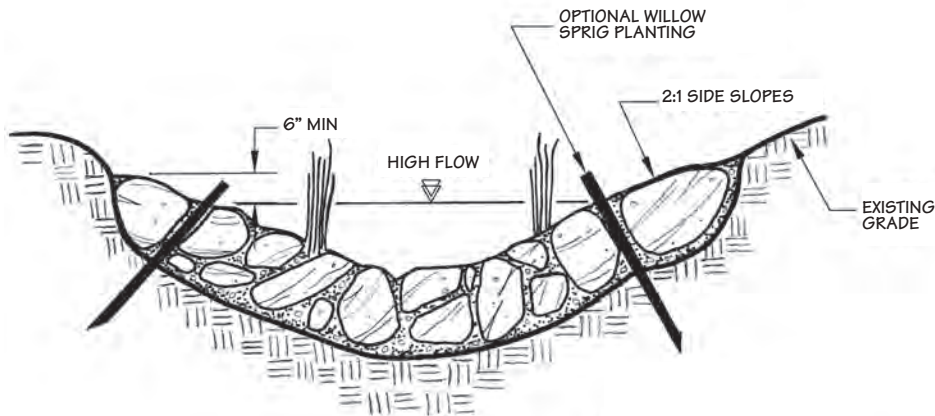


Hand rock placement



NOTE: "H" = HEIGHT OF EXISTING HEADCUT

Rock headcut repair, profile



Rock headcut repair, section



Shaping, Rock Riprap and Woody Plants

Willow sprigs or other trees and shrubs planted between rocks add both wildlife value and stability to headcut repairs. The sprigs are best driven into the headcut first and the rock placed around carefully them. However, if the rock work needs to be installed before the willows are dormant, PVC pipe can be inserted while the rock is placed, and then removed and replaced with sprigs. Gravel works best under the rock instead of filter fabric when adding plants, although willow sprigs can be poked through fabric on the sides of the headcut.



to



Diverting Flow

Diverting the water from a gully can be an effective but risky way to reduce headcutting. This method is best used when the gully has clearly been caused by channeled drainage, as in the case of a road culvert focusing the runoff from a wide area into a narrow channel. Because rain and groundwater will collect in the gully even if the major flow has been rerouted, the headcut will still require armoring, although it need not be as sturdy as without the diversion. Diversion alternatives include the following:

- Redistributing the runoff to better match natural runoff patterns. An example is the outsloping of ranch and forest roads (Chapter 6) to allow water to drain evenly off the entire road surface instead of through a few culverts.
- Redirecting the runoff to a different area. Extreme care must be taken with this method because it can recreate the same problem in a new spot. It should be used only when no other options are available and then with some good professional advice. The runoff should be directed to a stable area, either a natural rock outcrop or an energy dissipator as described for road repairs in Chapter 6.

Preventing downcutting: grade stabilization

Once the headcuts are stopped, another option is to slow down the flow and to raise the level of the gully. Checkdams or grade stabilization structures accomplish both of these tasks. Checkdams extend above the gully bottom and trap sediment over time. Grade stabilization structures are backfilled at the time of construction. They allow more control over the gully flow and final shape, but they typically require heavy equipment. We recommend you seek professional assistance for both techniques.

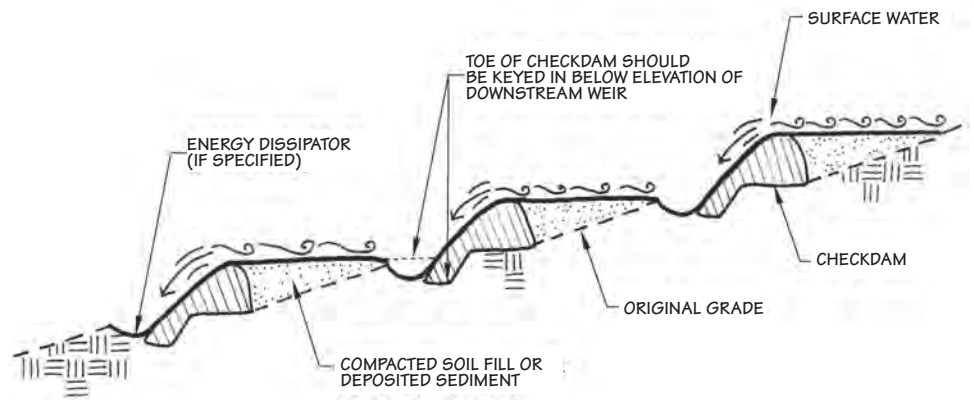
Checkdams fall into two broad categories: porous and impermeable. Porous checkdams allow water to percolate through the dam face. Sediment is deposited more slowly upstream than if the water was completely stopped, but such dams are more resistant to blowouts than impermeable dams and they are able to adjust to small changes in the shape of the gully bottom. Materials used to construct porous checkdams include strawbales, woven willow branches, brush, loose rock and logs. Impermeable checkdams include board, compacted earth, mortared rock and concrete structures. In this handbook, we focus on porous dams because they are safer and generally more effective over time.

As long as the basic guidelines are followed carefully, many other on-site or readily available materials can be used for constructing checkdams. Since the dams are in watercourses, avoid using toxic materials, such as creosoted railroad ties, concrete chunks or pressure-treated peeler poles. Remember also that the dam will last only as long as the materials used to construct it, unless deeply-rooted vegetation is either planted in the deposited soil or allowed to grow back naturally.

Guidelines for Checkdam Construction

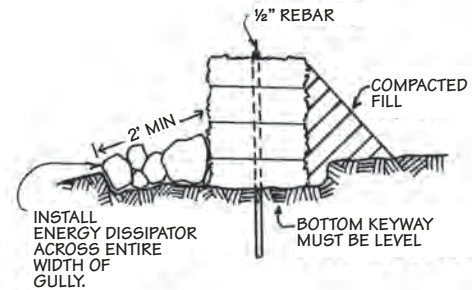
1. Leave plenty of room for water. You want your gully channel to be able to carry stormflows safely without causing additional erosion.
2. A series of short checkdams is usually more effective than fewer tall structures. If one dam fails, the entire gully repair will not be threatened. Also, since taller dams work harder, holding back a greater volume of water and soil, small flaws in construction are more likely to cause major failures. Short dams can be raised over a period of years, if necessary, to heal a deep gully. No dam should have an effective height of more than three feet without being designed by an engineer.

3. Use a level to space the checkdams so that the toe of one is level with or slightly below the crest or spillway weir of the downstream dam (see illustration). Otherwise, the gully will continue to deepen and undermine the upper checkdam.
4. Most checkdams require a spillway to contain overflows and prevent cutting of the gully banks. For gullies where there is little or no risk to property or safety, the spillway should be large enough to accommodate a 10-year storm if the drainage area is less than a few acres. Repairs in gullies that do pose significant risks should be designed by a registered design professional. In a small gully, you can experiment with the size of the spillway. Start bigger than you think, and be prepared to enlarge it during the winter. Your NRCS field office can help you determine spillway size. Be careful to aim the spillway at the bottom of the gully, not the sides, even if this requires that the spillway be off-center.
5. Always provide a nonerrodible energy **dissipator** (or apron) at the downstream end of the structure for the checkdam overflow. Rock and securely anchored brush are two of the most commonly used materials. During high flows, the aprons are subject to tremendous force. Aprons that are too short or not strong enough are frequent causes of checkdam failure. A piece of filter fabric or a layer of gravel should be placed under the rock to prevent the soil from washing away. The apron should extend across the entire width of the gully.



Checkdam placement

6. The top of the checkdam must be level. Even with a large spillway, stormflows sometimes overtop the dam. If the water is focused on one bank, your dam will probably fail.
7. Key all checkdams securely into the gully banks and bottom. Key depth varies according to the size and type of dam and is discussed further in the following descriptions of checkdams. The soil around the keys should be firmly tamped in 6-inch lifts. Only soil, no rocks, should be used. If the soil is very dry or very wet, it won't compact well.
8. Construct checkdams perpendicular to the flow. This is easy in a straight gully, but a little tricky in a more typical, sinuous one.
9. Make sure you have all the necessary permits. Many gully repairs, particularly those that use rock, are subject to the same permits as streambank repairs. Any work where threatened or endangered species occur also requires permits.



Strawbale checkdam



Strawbales

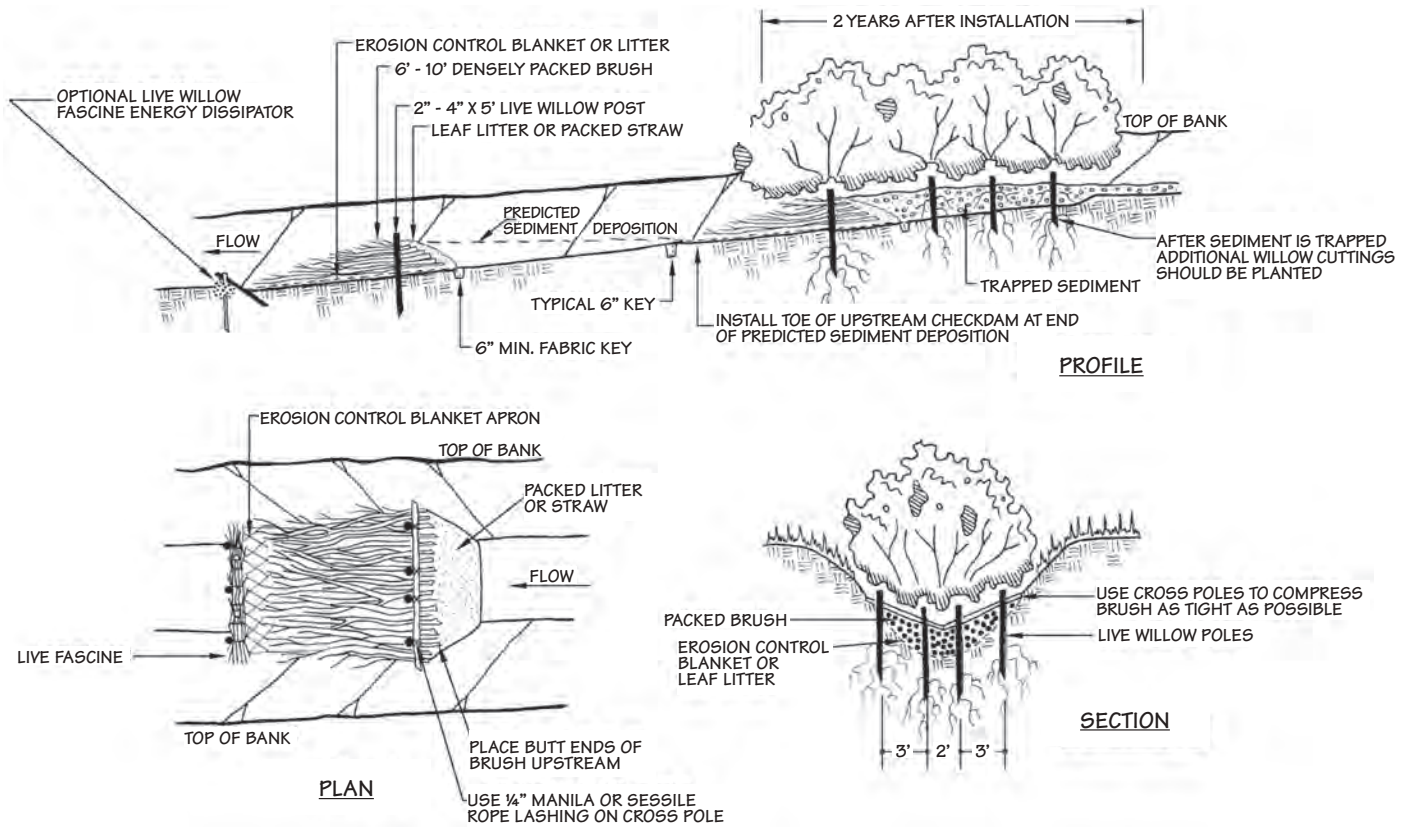
Strawbales are an inexpensive and easy-to-install form of checkdam for use in mild, shallow gullies. They perform best in gullies with relatively stable sides and some existing grass cover. Since the bales deteriorate in two to three years, it is essential that vegetation be well established on the deposited sediment within that time. Bales should be keyed into the bank as shown and secured with two pieces of rebar or stakes per bale. Multiple bales can be used in a row across the gully floor. Use rebar with caution. Once the bales disintegrate, the standing rebar can hurt livestock or people. Generally, single strawbale checkdams are constructed without spillways. Multiple strawbale dams can be arranged so that the center is lower than the sides.



Brush Checkdams

Brush checkdams are especially useful for hard-to-reach, small gullies with a plentiful source of woody branches nearby. Brush checkdams

are usually anchored with wooden poles, preferably willow, but $\frac{3}{4}$ -inch rebar or steel t-posts (triangular fence posts) can also be used. A 6-inch layer of organic litter is laid on the gully floor both upstream and downstream of the posts, and then green branches are stacked on top of the litter, butt end upstream, packed down securely and then tied to the posts with strong rope. Longer branches should be placed on the bottom, extending further downstream, to form the energy dissipator. Leaf litter or erosion blanket is placed at the upstream end of the checkdam to catch fine sediment. References #14 and #15 have more information on constructing brush checkdams.



Brush checkdam



Log Checkdams

Checkdams made from on-site logs are suitable for small gullies with a width of 3 feet or less. Unless backed with filter fabric, log dams should be used only where the runoff is rich in organic litter. Most available wood can be used, but remember that some species, such as California bay and alder, rot too quickly for plants to become established. The closer the logs fit together, the more effective the dam will be in trapping sediment. The logs should be inserted at least 1 foot deep into the banks and 6 inches into the gully bottom. A spillway should be cut into the top log, but always leave at least 4 inches of the log diameter intact or the log may break under force. The apron can be either rock over a layer of litter or filter fabric, or a thick layer of securely anchored leafy brush. If filter fabric is not used, the upstream toe of the dam should be sealed with a 6-inch layer of organic litter held in place with small rocks, or with small gravel (3/4 inch or smaller) mixed with pebbles and coarse sand. The upstream rocks need not be as large as those forming the apron, since the dam itself will prevent them from rolling downstream.



Rock grade control structures

These are constructed in large, actively eroding gullies either at grade (the same level as the existing gully bottom) to prevent downcutting, or above grade and backfilled to restore a more stable gully slope. They require professional design and installation. If all of the structures needed cannot be built at one time, find a stable base point such as a flat slope, a bedrock outcrop or a culvert, and begin installing them upstream of this point so they won't be undercut as nickpoints move upstream.

USING PLANTS TO PREVENT AND REPAIR EROSION



COMMON MARIN INVASIVE PLANTS

Giant reed *Arundo donax*
Periwinkle *Vinca major*
Scotch broom *Cytisus scoparius*
French broom *Genista monspessulana*
Spanish broom *Spartium junceum*
Himalayan blackberry *Rubus discolor*
Tree-of-heaven *Ailanthus altissima*
Bamboo
Pampas grass *Cortaderia selloana*
German or cape ivy *Delairea odorata*
English ivy *Hedera helix*
Acacia spp.
Ice plant *Carpobrotus edulis*
Medusahead *Taeniatherum caput-medusae*
Oblong spurge *Euphorbia oblongata*
Italian thistle *Carduus pycnocephalus*
Barbed goatgrass *Aegilops triuncialis*
Yellow starthistle *Centaurea solstitialis*
Purple starthistle *Centaurea calcitrapa*
Distaff thistle *Carthamus lanatus*
Gorse *Ulex europaeus*
Harding grass *Phalaris aquatica*
Veldt grass *Ehrharta spp.*
Velvet grass *Holcus lanatus*

Living plants provide the best erosion control in most situations. Even when a hardened surface is needed, plants can usually be incorporated into the repair, as we describe in the chapters on streambank and gully stabilization. Restoring native plants to a disturbed area provides the raw materials for healing to continue when new erosion develops. Alder seeds, for example, wash downstream to settle and germinate on newly deposited sediment.

Anyone who has ever tried to dig up a patch of native grass knows just how deep and dense the roots grow. It's hard to even pierce the soil surface with your shovel, no matter how hard you stomp on it. While roots hold soil in place and absorb water, the plant's leaves intercept raindrops before they hit the ground, thereby reducing their erosive force.

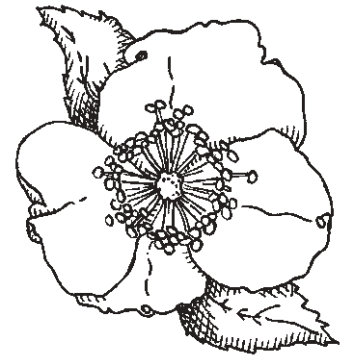
Native plants have evolved to fit specific soil and climate conditions and to provide food and shelter for native wildlife. When you use native trees, shrubs, grasses and wildflowers for your erosion control, you help restore habitat for birds, salmon and steelhead, pond turtles, butterflies and many other wild animals. When you use exotic species, you crowd out native plants and reduce habitat value. Marin County Stormwater Pollution Prevention Program (MCSTOPPP) has more information on native plants on their website, as well as two guides, *Creek Care* and *Go Native* with plant lists, instructions, and local nurseries (References #26 and #27).

Never use invasive exotic plants for erosion control. These plants, such as the giant reed (*Arundo donax*) or cape ivy (*Delairea odorata*), aggressively out-compete native plants to dominate entire areas.

Here are a few basic tips for plant selection for stream and gully restoration:

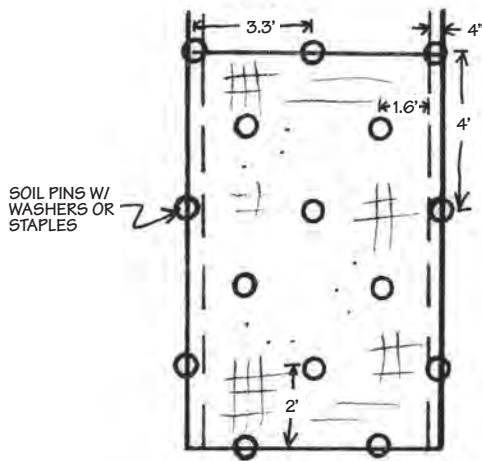
1. Use native plants that belong in your area.

2. Find a reference reach in the same watershed or in a neighboring one. Reference reaches, defined more thoroughly in Chapter 3, are well functioning areas where you can see which plants thrive and where they grow best.
3. Choose a variety of plants. If one is weak or slow to get started, the others can fill in. Plant diversity also increases the types of shelter and food for wildlife.
4. Be careful where you plant willow sprigs, especially shrubby arroyo willows (*Salix lasiolepis*). Although they provide outstanding habitat and erosion control, they can spread across channels in slow moving streams. Do not plant them in channel bottoms or near bridge or culvert openings. In situations where exuberant growth could cause problems, consider planting other willow species that grow in less aggressive, tree forms.
5. Promote structural diversity to encourage bird diversity. A mixture of herbaceous plants, shrubs and trees provide the best protection from predators and the greatest choice of nesting sites.
6. Plant the same species in clusters of 3 plants or more.
7. For stream plantings, plant extra trees on the south bank to promote shade.
8. If trees don't work for your site or management needs, don't give up on planting. Grasses, sedges, and shrubs all provide excellent erosion control and important wildlife habitat.



Seeding

Seeding grass and other herbaceous plants, such as clovers and wildflowers, is best done in September and early October. California native perennial grasses are now commercially available. Different species do better in sun or shade, heavy soils or sandy soils, droughty sites or wet sites. A common erosion control mixture for Marin and Sonoma Counties includes blue wildrye (*Elymus glaucus*), meadow barley (*Hordeum brachyantherum*) and California brome (*Bromus californica*). Your seed vendor or the other native plant nurseries can help you select a seed mix that fits your site depending on soil type, soil moisture regime, and amount of shade. Although native perennial seed costs more than many of the typical introduced annual seed mixes, the long-term

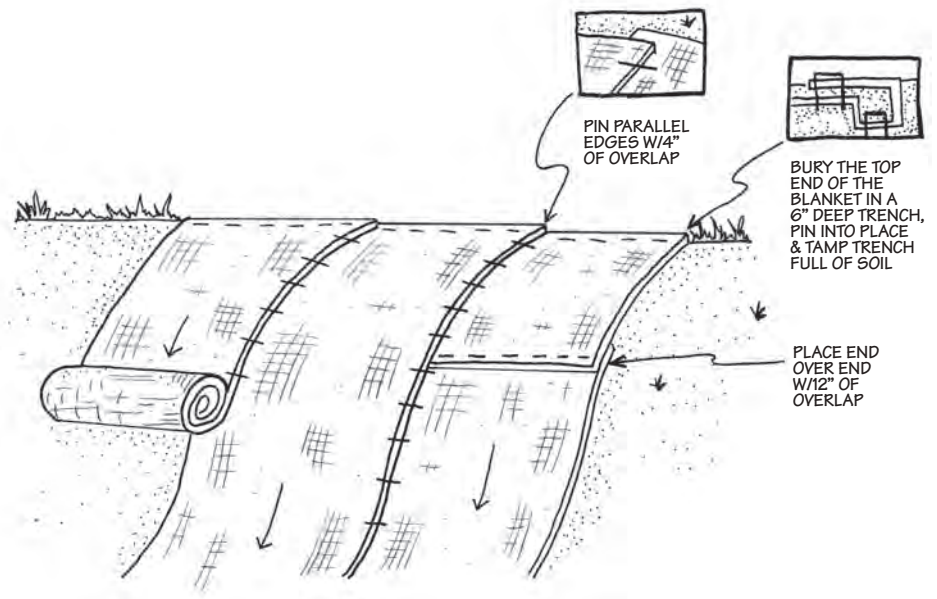


Pin spacing for erosion control blanket on a 2:1 slope

benefits in longevity and deep root structure may well overtake any short term savings.

Before seeding, areas of bare soil should be smoothed and raked on contour to minimize uneven surfaces and reduce any potential concentration of water which may cause rilling. If the soil is compacted, deeper ripping or disking may be required. Broadcast seed at a rate of 40-60 pounds per acre or 1-1½ pounds per 1000 square feet. Many seed dealers rent hand spreaders (sometimes called “belly-grinders”) that can be set at the required rates. Otherwise, hand broadcast the seed as uniformly as possible. Immediately following seed application, lightly rake the seed on contour or roll it with a lawn roller but do not bury seed more than one-quarter inch deep. It’s fine for some seed to be showing.

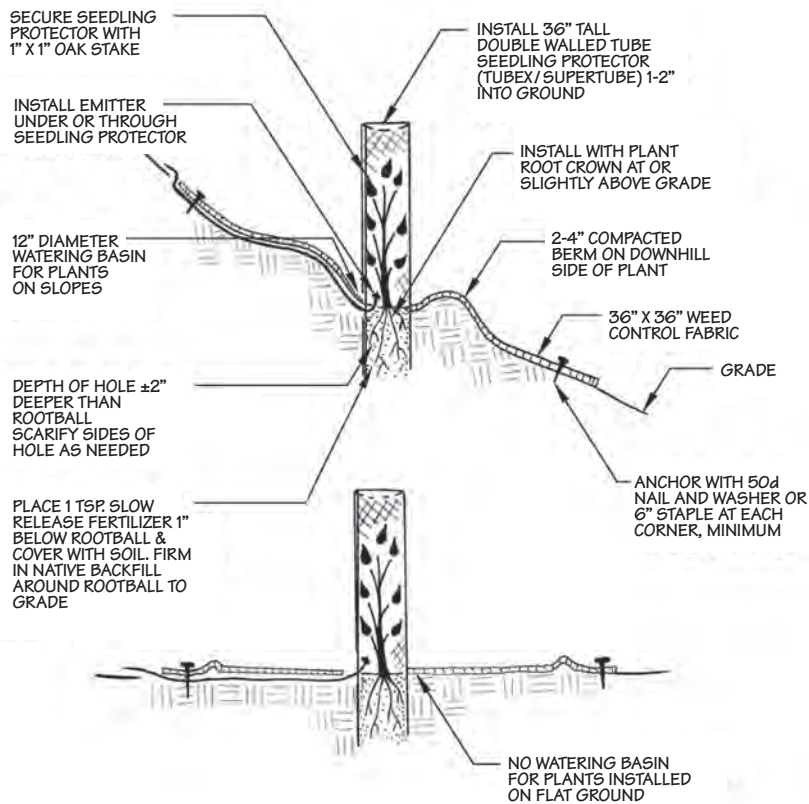
The surface should then be covered with a mulch, both to hold the seed on the slope and to protect it from hungry birds and small mammals. Where slopes are gentler than 2:1 (2 feet of horizontal distance for 1



Erosion control fabric installation

foot of vertical distance), spread a layer of weed-free rice straw approximately one inch thick, or 3,000 pounds per acre. Some soil should be showing through the straw. When finished spreading the straw, water it so that it doesn't blow away. You may need to water it again or apply a tackifier if the straw dries out too much before the rainy season. A scheduled regular watering can speed up the germination process so that your seeding has a head start before the heavy rains come.

In areas of steeper slopes, or swales that will be carrying flow, cover



NOTE: REMOVE SEEDLING PROTECTOR AFTER 3 YEARS OR WHEN PLANT IS WELL ESTABLISHED

Planting details for slopes and flat ground

the seed with a straw or coconut erosion control blanket following the manufacturer's instruction. Do not use blankets with plastic netting which can trap birds, snakes and other small wild animals. The blanket must be secured evenly across a smooth soil surface to avoid tenting.

Planting woody plants

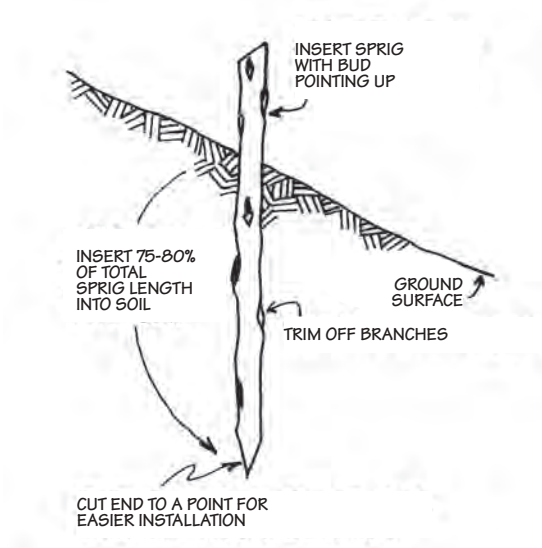
Rooted trees and shrubs are best planted in the winter when they are dormant. Small plants are inexpensive and with care, may quickly catch up in growth with 15-gallon or larger plants. Make sure your plant's roots are not jammed into its pot. Trees that have been grown in long Treepots or Deepots often transplant more successfully than those grown in shorter containers in which the roots may spiral and eventually girdle the plant.

Weed mats or mulch will keep weeds from choking out new plants, and plant protectors keep browsers at bay. When planting trees, consider how your site will look when the trees are 20 feet tall and 10 feet wide. You don't want to plant them so close together that you need to thin them out. And you definitely don't want to plant a tall-growing tree under a power line.

Some plants, such as oaks and buckeyes, can be grown directly from seed. See Chapter 13 for information resources on growing plants from seed.

Willows are among the first plants to break dormancy, and should be collected and planted from October through December. Willows respond well to heavy pruning, so don't be too worried about collecting generously from a grove. Thin, however, instead of clearcut in order to leave cover for the resident fauna. Cut branches back to the main stem or a bud which will re-sprout.

For sprigging, use straight willow branches that are between 3/4 to 1 1/2-inch in diameter and about 3 feet long. Be sure to plant the willows right-side up. One almost foolproof method is to cut an angle on the planting end of the sprig right after it is pruned from the tree. Use a heavy digging bar to prepare a hole, and then step around the sprig to firm the soil. The sprigs should be inserted into the soil 75 to 80% of their total length. If you can't get it in as deeply as you like, trim the sprig with loppers to achieve the right ratio. Remember to choose the right type of willow for your site. (See Planting Tip 4.)



Willow sprig

A PARTIAL LIST OF WOODY PLANTS IN MARIN COUNTY

		Tolerates partial shade	Tolerates clay soil	Tolerates wet conditions	Tolerates dry conditions	Evergreen
Trees						
<i>Acer macrophyllum</i>	big leaf maple				☞	
<i>Acer negundo</i>	boxelder			☞		
<i>Aesculus californica</i>	Calif. buckeye		☞	☞	☞	
<i>Alnus rhombifolia</i>	white alder	☞		☞		
<i>Cornus sericea</i>	American dogwood	☞	☞	☞		
<i>Crataegus douglasii</i>	hawthorn		☞	☞		
<i>Fraxinus latifolia</i>	Oregon ash	☞	☞	☞		
<i>Juglans californica</i> var. <i>hindsii</i>	Calif. black walnut		☞	☞		
<i>Myrica californica</i>	waxmyrtle			☞		☞
<i>Quercus agrifolia</i>	coast live oak				☞	☞
<i>Quercus kelloggii</i>	black oak				☞	
<i>Quercus lobata</i>	valley oak		☞	☞		
<i>Salix</i> spp.	willows		☞	☞		
<i>Sequoia sempervirens</i>	coast redwood	☞		☞		☞
<i>Umbellularia californica</i>	Calif. bay-laurel	☞	☞	☞	☞	☞
Shrubs						
<i>Baccharis pilularis</i>	coyote brush		☞	☞	☞	☞
<i>Calycanthus occidentalis</i>	spice bush	☞	☞	☞		
<i>Corylus cornuta</i>	hazelnut	☞			☞	
<i>Heteromeles arbutifolia</i>	toyon - christmas berry	☞			☞	☞
<i>Lonicera hispidula</i>	Calif. honeysuckle	☞				
<i>Rhamnus californica</i>	coffeeberry	☞			☞	☞
<i>Ribes sanguineum</i>	pink flowering currant	☞				
<i>Rosa californica</i>	Calif. rose		☞	☞		
<i>Rubus ursinus</i>	Calif. blackberry	☞	☞	☞		☞
<i>Sambucus mexicana</i>	blue elderberry					
<i>Symphoricarpos mollis</i>	creeping snowberry	☞				
<i>Vaccinium ovatum</i>	huckleberry	☞			☞	☞
<i>Vitis californica</i>	Calif. grape	☞	☞	☞	☞	

NOTE: These species are available from native plant nurseries and have been used successfully in restoration projects.

Wet conditions = low bank, floodplain

Dry conditions = upland slopes

The spacing of the sprigs depends upon the activity of the erosion. In more stable areas with relatively small watersheds, the sprigs can be placed 2 feet apart. In large or rapidly eroding gullies, space the sprigs 1 foot to 18 inches apart.

Cattle and deer find tender, young willow sprouts quite delectable. Be forewarned, and protect your plantings if you expect them to be exposed to heavy browsing.

Caring for your planting

Woody container plants need maintenance for several years. All require weeding and eventual removal of the plant protector. Although some plants can live without watering, survival rates are much higher for many container-grown species with two to three years of summer water. Unless you are caring for only a few plants within reach of your garden hose, you will probably want to install drip irrigation or a slow-release gel pack (such as DriWater® or Rain Bird® Irrigation Supplement). The gel slowly releases water into the root zone. The packs must be replenished two to four times per season depending on conditions and the manufacturer's recommendations. When using drip or hand watering, allow the soil surface to dry out between waterings to prevent root rot. Depending on soil texture and solar exposure, watering once or twice per week should be adequate.

Where trunk girdling by mice is a problem, consider a commercially available spiral tree wrap. If deer browsing is severe, consider building tall wire cages around individual trees or erecting temporary deer-net fencing. Be careful not to block wildlife migration corridors or allow flood waters to carry away the plant protectors.



Susan Pinkerton



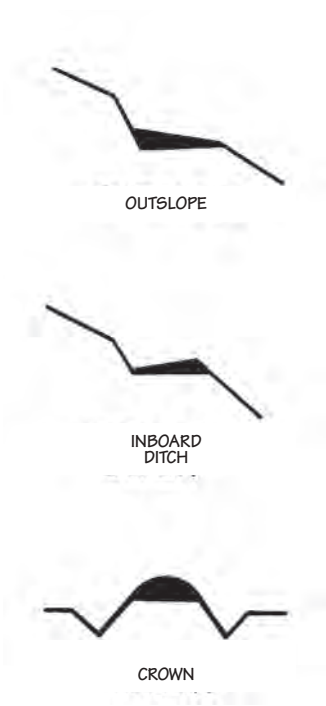
ROADWAYS

Unsurfaced roads, driveways and even horse trails and footpaths contribute sediment directly, as well as cause and accelerate other erosion problems. When building a new roadway, most of the typical problems can be avoided. However, in many areas of northern coastal California, the unsurfaced roads were built many years ago, often to access logging or remote ranchland, and have been plaguing watersheds ever since. References #11, #30 and #32 are excellent handbooks for designing, constructing and maintaining safe and nondestructive small roads. We recommend that you seek experienced professional help for repairing significant road drainage problems, all culvert and bridge installation, and designing and building new roads. Work on trails and driveways where there is no risk of damaging structures, other roads, utilities, or streams, where you can accomplish your work with a shovel and your hands, and where you can check it regularly during winter, can usually be done safely by landowners. If in doubt, contact your local NRCS or RCD office.

The following process can help get an eroding unsurfaced road, driveway or trail in shape, as well as provide guidance for avoiding the same mistakes when constructing new roadways.

Evaluate, and if necessary, modify the surface drainage.

Most road erosion and related problems, such as gullies and landslides, are due to the way runoff reacts to the road surface. Through grading, the road drainage can be modified to reduce or eliminate such problems. The objective is to have the runoff travel as short a distance as possible before safely crossing the road and leaving at a well protected, non-erodible point. The longer the water travels along the road surface, the more likely it is to concentrate into rills and washouts.



Types of surface road erosion

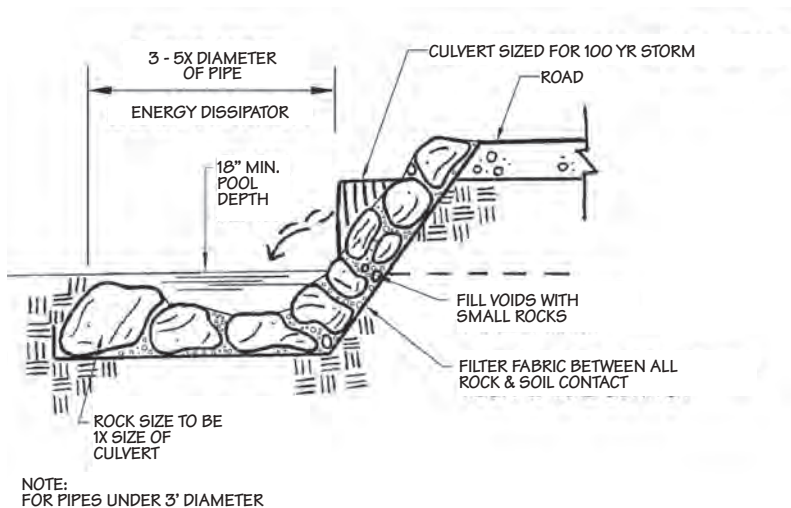
One road can incorporate several kinds of drainage to achieve this objective. There are four basic types:

- **Inboard ditch.** The road is graded into the slope. Water from the road and the hillside above it collects in a ditch and either runs the entire length of the hill or exits through culverts or water-bars. When properly constructed and rigorously maintained, the advantage of this method is that runoff is carefully controlled and can be channeled to well-protected areas. However, often poor construction and infrequent maintenance lead to plugged culverts, washouts and gullies.
- **Crown.** The road surface is sloped gently towards both sides. This is usually used only on high-quality roads, often in conjunction with large cut and fill slopes. It is relatively uncommon on lightly used roads. Ditches and culverts carry runoff to either side, depending on slope.
- **Outslope.** The road is graded with the slope at a gentle angle. Culverts and ditches are not necessary, except where streams cross the road, because runoff sheets evenly from the road surface. Outsloping is the least destructive method to the natural drainage patterns. However, it may present a safety hazard on roads in clay soils, especially on curves.
- **Middle of the road.** Some old roads were constructed straight down the middle of a creek or as a trough cutting through a hill. The only safe way to get water off them is to direct it into lined ditches on one or both sides of the road. In some cases, the only way to prevent serious erosion on such roads is to abandon, recontour and revegetate them, and build a better road elsewhere.

Herbaceous vegetation also helps protect road surfaces and slow runoff. On seldom-used roads, a grass-seed mixture can be sown directly on the roadbed to protect it during the winter season. Existing low plants should not be graded from roads unless they pose a fire hazard or dangerously limit visibility.

Transport water safely across the roadway.

Whenever there are ditches, or where streams and winter swales cross an unsurfaced road, look for erosion problems. Even a slight washout or rilled area that has to be regraded every year can contribute tens of tons of sediment to the nearest stream over a few years. One way to get

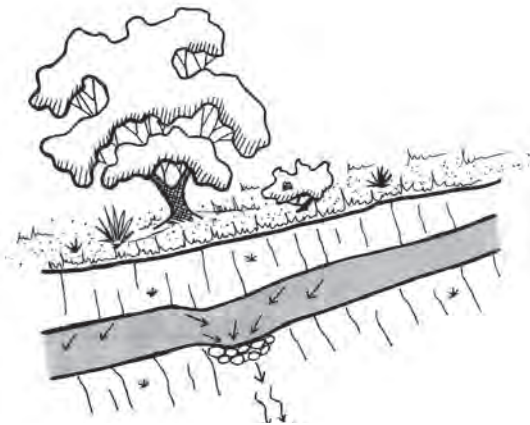


Rock energy dissipator under culvert

a handle on how much soil has washed away from a seemingly stable road surface is to lay a flat stick or board across the road. Assuming that the road was once graded to a relatively flat surface, the ground between the stick and the current surface has been lost.

All types of cross-drainage except outsloping require that the water leave the road into well-vegetated, low-gradient ground or a protected outlet. Rock energy dissipators are the most common form of protection. The rock should be placed over gravel or a filter fabric blanket with voids between the larger rocks filled with smaller ones. As with all rock used for erosion control, it should be angular and large enough to withstand heavy flows. Rock energy dissipators should be built into a bowl or trough-shaped depression dug into the ground with the downstream end rocks at the same elevation as the natural ground. Make sure that the water does not discharge into fill or easily erodible native soil once it leaves the dissipator.

The method employed to transport flow across the road depends on how much use the road receives, the volume of flow, whether the road is regularly maintained and, of course, your budget. The last item can be deceptive, since more costly methods, such as bridges, often quickly make up for the high price of installation in reduced long-term maintenance costs. All methods must be sized to handle the desired stormflows. Here are four possible choices:



Rolling dip

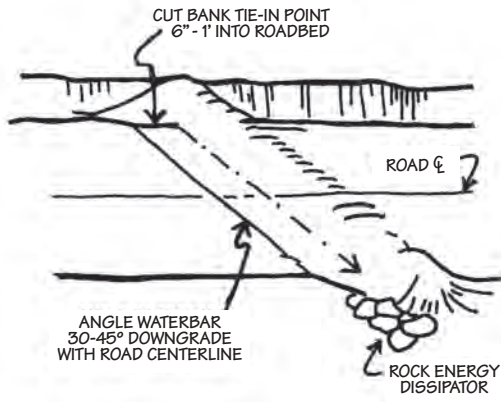


Rolling Dips

Rolling dips are smooth depressions in the road surface used in outslopped roads. The uproad side of the dip is outslopped and has a gradual, gentle cut below the original road surface. The downroad side comes back up to the road grade at a slightly steeper slope to keep the water from breaking out of the dip. Rolling dips are permanent features and should be constructed so that they are easy to drive over. They need to be placed at sufficient intervals to prevent the road surface from rilling, but far enough apart for uninterrupted vehicle travel. Make sure that they exit at a stable, protected area. Rolling dips should not be constructed in unstable fill slopes or for road gradients over 12%.

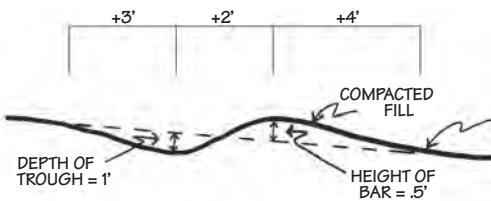


Waterbars



Waterbars are a temporary means of breaking surface flow over sloped sections of seasonal road. In a pinch, they can be constructed with hand tools. They consist of a shallow ditch and rounded berm placed diagonally across the road surface. Often they must be reconstructed every year because they either wear down during the summer or are so annoying to those who regularly use the road that they are graded out. As with rolling dips, make sure the waterbars direct flow to a protected area that will not erode.

Waterbars can be made more palatable by increasing the width and thereby reducing the slope of both the ditch and the berm. Installing a series will reduce the flow volume and hence the cutting action in each waterbar.



Water bar

WATERBARS

Estimated Hazard Rating	Road or Trail Gradient			
	10% or less	11-25%	26-50%	50% or more
extreme	100	75	50	50
high	150	100	75	50
moderate	200	150	100	75
low	300	200	150	100

Maximum distance between waterbars in feet. (California Forest Practice Rules, 1999)



Fords

Fords can be used to carry ephemeral or intermittent streams across roads with very light traffic, such as ranch roads. They are essentially rolling dips surfaced with rock or concrete and should be designed for specific sites with help from NRCS or a registered professional designer. Ford construction requires permits from those agencies regulating work in watercourses (Chapter 12).



Culverts

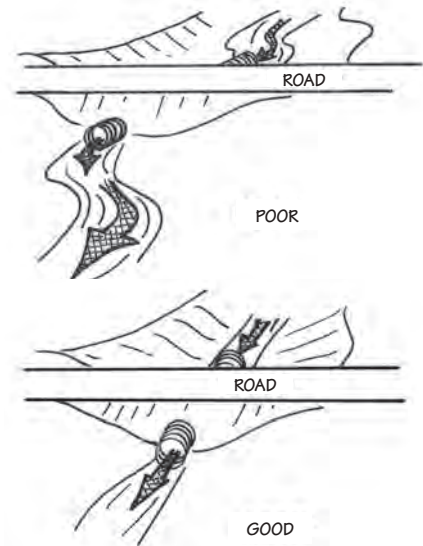
Installing a culvert is one of the riskiest management actions one can take. Culverts confine and concentrate flow. They interrupt sediment transport and frequently block fish. They are a major source of sedimentation in many watersheds through road failures and gully erosion. However, if they are properly sized and installed in the right place, they can be very handy. Specifications for spacing and installing culverts are given in Reference #32, but we will emphasize several critical guidelines here. Culvert installation in streams of any size requires permits from those agencies regulating work in watercourses (Chapter 12). Ditch relief culverts used to carry winter runoff solely collected from the road surface during rains may not require permits.

Culverts carrying ephemeral or intermittent stream flow should follow the natural stream alignment. They should be set below the original stream grade to allow for a natural streambed to form inside the culvert. Those that carry flow from inboard ditches should exit where they will not cause subsequent erosion. Place large rock carefully underneath the outflow as described above to protect the underlying soil. If the runoff has to travel over fill slopes or unstable areas after it leaves the energy dissipator, make sure to carry it through a downspout or rock-lined channel. Never let a culvert extend in the air and shoot the discharged water onto the soil below. This invariably causes severe erosion and road failure.

Culverts carrying perennial streamflow or wherever fish are present should be designed by a certified professional designer. Fish, as well



Concrete Ford



Culvert alignment under road



Arch culvert with natural stream bottom



Traditional box culvert with concrete bottom

as the stream's sediment load and flows from 100-year storms, must be able to pass through the culvert. Arch, open bottom or box culverts are often used so that the natural stream bottom can remain intact.

Plugged culvert inlets are one of the most common causes of road washouts. They should be cleaned before the rainy season and checked during storms. If a culvert plugs after every major storm, consider using another method and/or addressing the upstream source of debris. Trash racks or perforated risers can also help keep the culvert open, but they are certainly not maintenance-free. Culverts should be sloped downward to prevent sediment from accumulating inside.



Bridges

Where they are feasible, bridges are the ultimate drainage solution because they leave fish passage and stream function intact. Many pre-built bridges are now available for small roads and trails. Railroad flatcars have been used successfully in numerous Marin and Sonoma County sites for ranch road crossings. They do require engineered abutments and County permits.

Undertake a regular maintenance program.

Many road erosion problems can be nipped in the bud if the road is well maintained. A good dry-season maintenance program should include replacing energy dissipators that have washed away, cleaning culverts, replacing inadequate culverts with larger ones or another type of cross-drainage, adding additional cross-drainage if necessary, smoothing rills to prevent them from growing into gullies, modifying the surface drainage as needed and, in early fall, seeding the roadbed or adjoining areas of exposed soil. When grading the road surface, spread the scraped soil evenly over the road edge instead of forming berms which collect and channel flow. In winter, energy dissipators should be inspected and reinforced if necessary, culverts and ditches kept clean, and rill erosion checked by constructing waterbars. Winter is also the best time to note where changes in surface or cross-drainage are needed. As the major causes of road erosion are repaired, maintenance will become easier and our streams cleaner.

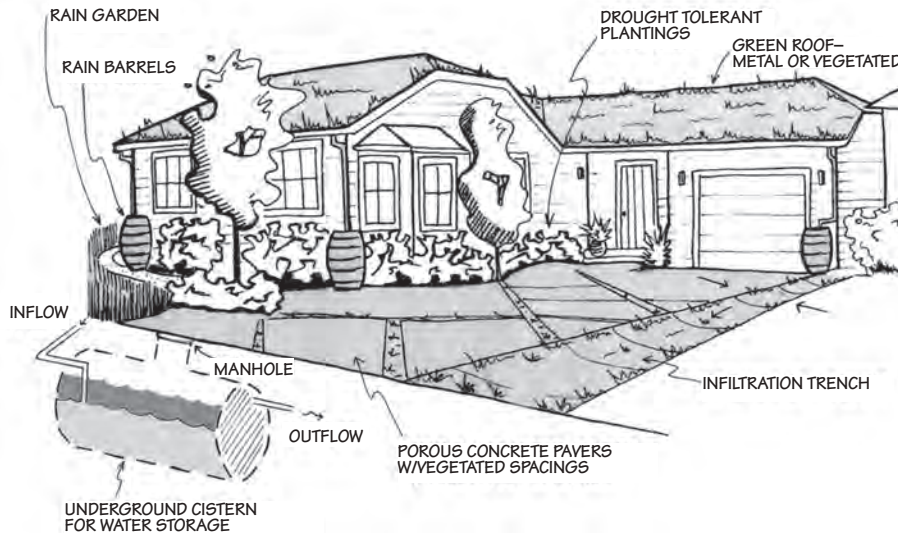


NEW CONSTRUCTION

Building anything, whether a standing structure, a road, a parking lot or a playground, almost always involves removing vegetation and changing drainage patterns—actions which can provoke and accelerate soil loss. This chapter is divided into two main sections—one on designing your project to reduce storm runoff and increase infiltration, and the other on preventing erosion and sedimentation during construction.

Design for Better Infiltration

Through incorporating materials and practices that reduce storm runoff into new construction, you can prevent erosion and help maintain the natural function of your watershed. Check Chapter 13 for resources for design ideas, specifications and local examples. The following are



Infiltration techniques at home

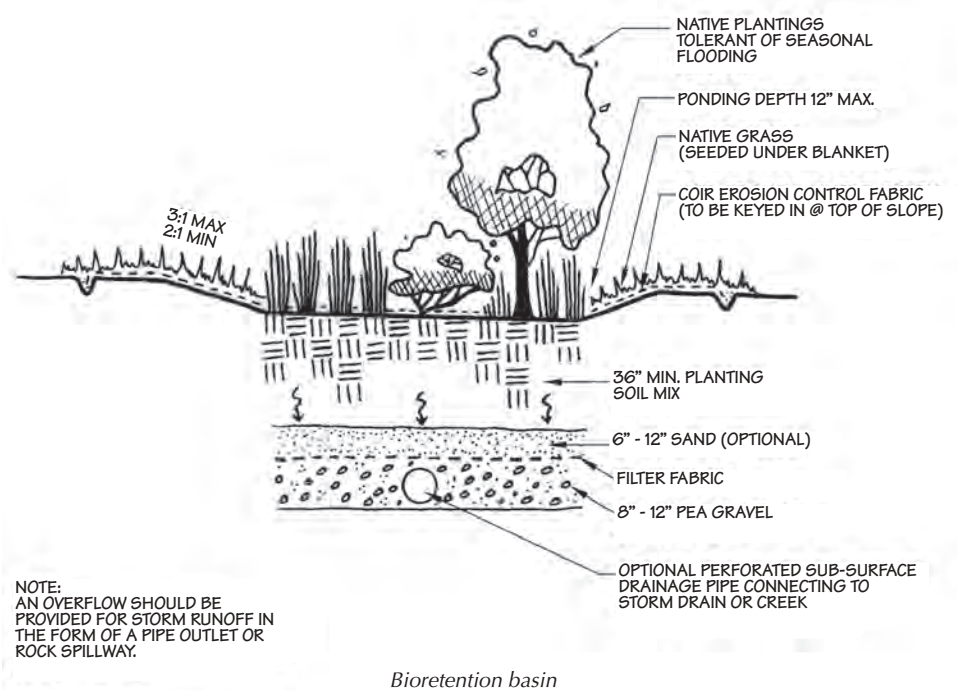
basic elements to consider to increase the amount of rainfall captured and retained on your site:

1. Reduce impervious surfaces.

Hard surfaces including roofs, streets, parking lots and paved drive-ways do not allow any water to soak into the soil. Consider using gravel, strips of concrete with grass or gravel in the middle, pervious concrete, concrete unit pavers or other permeable pavements for drive-ways and paths. Incorporate vegetated islands and grass-lined swales into parking areas. The adventurous may want to investigate green roofs that are built to accommodate living grass and other plants on either part or all of the roof surface.

2. Capture and dissipate runoff.

When hard surfaces are necessary, direct the resulting runoff into an area or structure where it can slow down and soak into the ground. Foundation plantings, for example, can break the force of rain falling off



a roof. Roofs can also be used to collect water which can be directed into dry wells to recharge groundwater or stored in rain barrels or cisterns for irrigation or other uses. **Bio-filtration swales**, shallow ditches planted with dense grass, can transport water slowly from a downspout or driveway outlet while simultaneously allowing much of it to percolate into the soil. **Rain gardens** and **bioretention basins** pond water and use soil, organic mulch and both woody and herbaceous plants to trap sediment, increase infiltration and remove pollutants.

3. Disconnect surface runoff.

Leave or install permeable areas between roofs, driveways, parking lots and streets to slow and disperse flow instead of creating a speedway for storm runoff.

4. Keep existing plants...and plant more.

Vegetation is the best defense against erosion. Protect trees and shrubs during construction, and consider planting more. Remember that native plants support birds and other wildlife as well as protect soil.

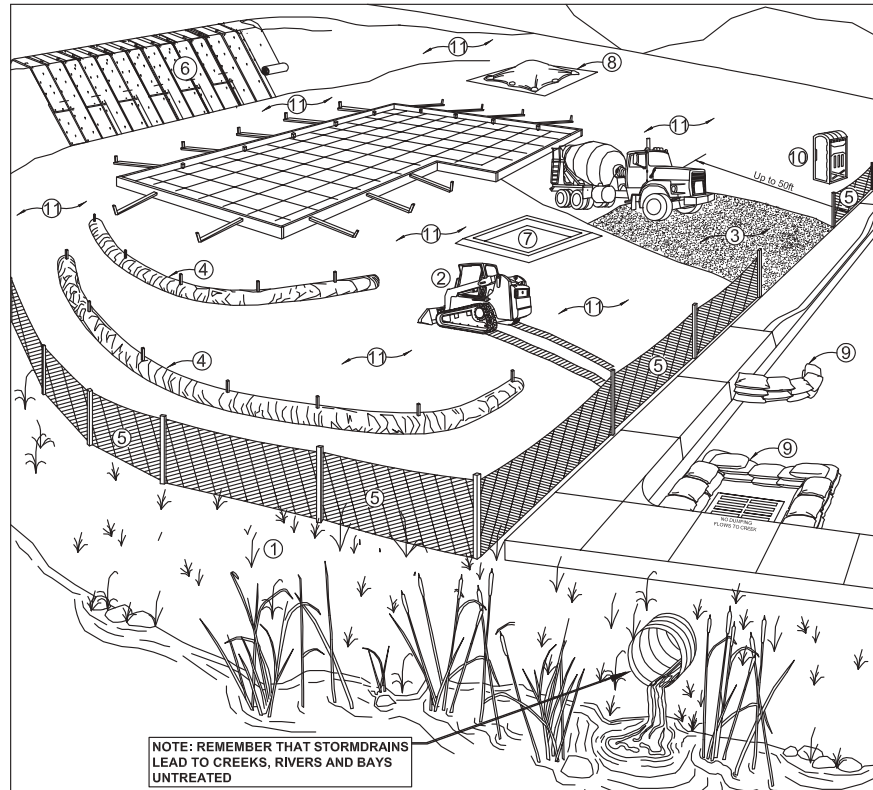
Erosion Control at Construction Sites

Stormwater pollution from development sites is regulated through the State Water Resources Control Board's General Permit for Discharges of Storm Water Runoff Associated with Construction. Construction-related pollution sources include oil and grease, asphalt, concrete, paint and solvents, sanitary waste and pathogens from temporary restrooms, and of course, sediment from disturbed and stockpiled soil. Most cities and counties have enacted local ordinances to comply with the General Permit. The Marin County Stormwater Pollution Prevention Program (MCSTOPPP) and the Sonoma County Permit and Resource Management Department (PRMD) both have helpful websites to guide builders to the right ordinance (Chapter 13).

In addition, owners of any construction project that disturbs 1 or more acres of soil must submit a Notice of Intent to the State Water Resource Control Board and prepare and implement a **Storm Water Pollution Prevention Plan (SWPPP)**. The SWPPP should include a site map that shows drainage patterns as well as both existing and proposed buildings, roads, and other features. The SWPPP must also list **Best Management Practices (BMPs)** that will be used to prevent storm water pollution, and

MINIMUM EROSION CONTROL MEASURES FOR SINGLE FAMILY HOME CONSTRUCTION

1. Check with Marin County Planning Department or Flood Control District for creek set-back requirements.
2. During grading phase, track-walk up and down slopes, not parallel.
3. Stabilize site entrance and temporary driveway with 3" crushed rock up to 50' to prevent tracking soil off site.
4. Install straw wattles along contour at or >2:1 slope, keyed into ground at least 3" deep (25 to 50' apart).
5. Install silt fence as secondary measure along contours to keep sediment onsite and to minimize vehicle and foot traffic beyond limits of site disturbance.
6. Install erosion blankets on any disturbed area at or > 2:1 slope.
7. Construct a concrete washout site adjacent to stabilized entrance. Clean as needed and remove at end of project.
8. Cover all stockpiles and landscape materials, keep behind silt fence, and away from water bodies.
9. Use pea-gravel bags around drain inlets located both onsite and within gutter as a last line of defense.
10. Place port-a-potty near stabilized site entrance and away from storm drain inlets and water bodies.
11. Cover all exposed soil with straw or straw/tackifier.



Note: Sediment and erosion control shall be continually maintained throughout the local rainy season and to remain effective during construction phase. Continue inspection and maintenance of BMPs before and after rain events.

From Marin County Stormwater Pollution Prevention Program

identify where they will be used. Chapter 12 includes information on where you can learn more about the General Permit requirements, BMPs and SWPPP preparation.

Here are some common BMPs that apply to many construction sites. Remember that you need to find and use BMPs that specifically address potential pollution generated by work on your site.

Educate your construction workers.

Explain to your workers why clean water is important and what actions you are taking to keep sediment and other pollutants out of storm drains and waterways. Ask them for their help and their ideas.

Schedule construction activities during dry weather.

Construction that moves soil, disturbs vegetative cover or requires use of unsurfaced roads should be completed before the winter rainy season; in northern coastal California, October 15 is the standard date used to mark the official end of dry weather. Large earth-moving projects should be scheduled between April 15 and October 15. If unfinished work needs to be held over until spring, exposed soil must be protected and sediment trapped before leaving the site.

Be ready for rain.

Check the weather forecast and make sure you have all of the materials you need to quickly protect your site.

Protect existing vegetation. Plant more.

Wherever possible, plants already growing on the site should be spared, unless the cleared area is to be immediately replanted or landscaped. Even then, be cautious about removing vegetation. It may take many years for new plantings to duplicate the character and sturdy root systems of the on-site trees and shrubs. Thinning groves of mature trees, especially on ridgetops, may make the remaining trees more susceptible to windthrow. And remember that changing vegetation changes the wildlife use of an area. If you have grown to enjoy the flocks of warblers migrating through your new piece of property every fall, don't expect them to return after you have removed all the undergrowth.

Where construction calls for mass disturbance of wildland vegetation, such as large cut and fill slopes, the native plant community should be

restored through revegetation. Large-scale revegetation projects differ from home or commercial landscaping in that the plants receive minimal maintenance. The area is overplanted with the expectation that some of the plants will die. Plants are grown from seeds or cuttings collected on or near the construction site so that they will be well-adapted to specific soil and weather conditions at the site and thus have a better chance of surviving. Since it takes one to two years to grow a plant big enough to install, revegetation projects should be planned well in advance of actual construction.

Protect bare areas and spoils piles with seed, mulch or plastic sheeting.

All bare soil, including temporary spoils piles, should be protected well before the rains begin. Follow the seeding and mulching recommendations in Chapter 5. Annual grains, such as oats and barley, are frequently used as one-time winter cover because they are relatively inexpensive and reseed poorly. “Re-Green”, a sterile wheat, is available through some local suppliers. Hydroseeding, a mechanical process of applying a slurry of seed, fertilizer, mulch and a tackifier, is useful for establishing grass cover on slopes. Erosion control blankets should be installed on any slopes greater than 2:1.

Install silt fence and straw wattles on contour to prevent concentrated flow.

Straw wattles should be buried 3 to 4 inches into the soil and staked every 4 feet. They should be used only on 3:1 or gentler slopes. Silt fences should be trenched 6 inches into the soil, staked every 6 feet, and placed 2-5 feet from the toe of the slope (Sonoma County PRMD). Straw bales have a high failure rate as sediment fences; the straw is better used as mulch on your construction site. Check wattles and silt fences regularly during the winter and repair them if necessary.

Stabilize entrances with crushed rock.

Vehicle wheels carry sediment and other pollutants onto nearby roadways, causing both hazards and pollution.

Protect drainage inlets.

Use gravel bags or straw wattles to trap and filter any polluted water that may escape your site despite your best efforts.

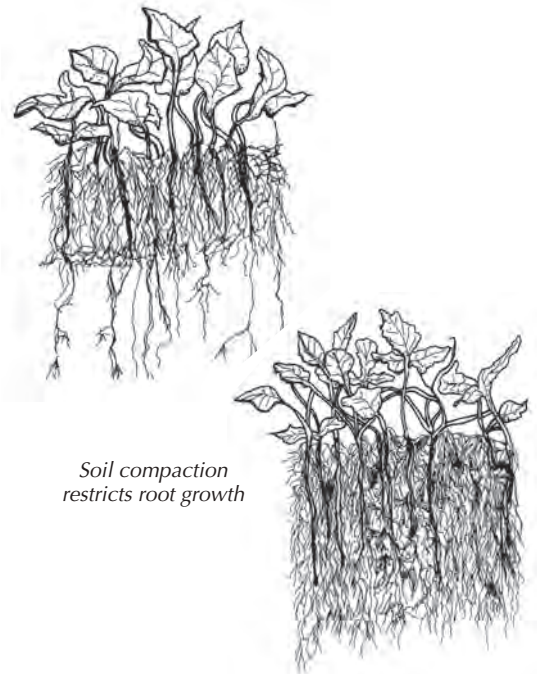


LIVESTOCK AND EROSION

California's grasslands evolved over thousands of years with grazing animals. Many native grasses and wildflowers depend on regular grazing for fertilization, keeping competing plants in check, and removing dead thatch. The net impact of prehistoric grazing was to keep rangeland vegetation healthy and soils alive and permeable. This harmony has been challenged by the replacement of native grasses and forbs with introduced annual species, the confinement of large numbers of animals in fenced pastures, and the complete removal of grazing from some grassland areas. Grazing management is the art and science of using animals to produce and sustain desired range conditions. Ranchers and range managers for public lands can use different types of livestock, fencing, water development, seeding and other tools to maintain healthy, productive grasslands and reduce erosion.

Horses, sheep, cattle and other livestock can affect erosion in many ways. Concentrated in a small area, livestock can completely denude the soil surface, exposing it to sheet and rill erosion. The weight of the animals can compact the soil to concrete-like hardness, which in turn increases the speed of runoff and activates gully and streambank erosion lower in the watershed. Compaction can also occur in large pastures if the land has been heavily grazed for many years.

Livestock change the vegetation by selectively eating certain species, giving other hardier, less-palatable plants room to flourish. Some plants, such as oak seedlings, may eventually die from repeated browsing. Larger animals can cause mechanical damage to stream and gully banks by walking on them and crushing or eating the new vegetation that might stabilize the banks. On the other hand, livestock can also be used to restore and maintain plant vigor in grasslands, thereby reducing runoff rates and resulting erosion. They reduce thatch, the mass of dead leaves, that impedes new growth and stifles wildflowers. They



can fertilize and gently disturb soil to create seed beds, and weed out undesirable species.

Several excellent range management resources are identified in Chapter 13, including a new grazing handbook produced for the Sotoyome Resource Conservation District (reference #41) and riparian grazing management guidelines from the Marin Resource Conservation District (reference #40). NRCS and UC Cooperative Extension also offer information and site specific recommendations.

Following are some ideas and tools to reduce erosion caused by livestock:

Protect riparian areas

Riparian zones are the vegetated areas along streams, rivers and lakes. They are extremely valuable to many wildlife species because they provide a safe transition between water and upland areas as well as a rich food supply and plentiful cover. Healthy riparian habitat cools water and captures nutrients and pollutants before they wash away. Riparian zones are particularly vulnerable to livestock induced erosion.

Animals can break down bank stability, damage or destroy plants that hold soil in place, and help deliver sediment directly into streams. Ranchers and land managers can protect stream areas in several ways.

Exclusion fences keep livestock out of the riparian zone all or most of the time. They should be built with gates in case livestock, often calves or lambs, get trapped inside. Exclusions require minimal livestock management, although they often require regular management of invasive weeds or over-exuberant willow growth. They offer the best protection for re-establishing native riparian trees and shrubs.



Riparian Fencing

Exclusion fences can present formidable challenges for livestock managers. Since the animals can no longer drink from the creek, alternative water sources must be developed. Bridges or protected cattle crossings may be needed to move livestock and ranch vehicles. In large floodplains, fences may wash out every few years unless they are placed so far from the stream that the rancher loses the use of large areas of highly-productive land.

Riparian pastures are designed to allow carefully-managed grazing within the riparian zone. Fences can be set farther back from the channel to give the stream room to evolve. Clear goals must be established to make riparian pastures work as both grazing land and stream protection. Regular monitoring should be conducted to modify the grazing prescription as needed to meet the goals. If planting is included, livestock should be kept out for at least three years to give the plants time to become firmly established. For planting within either exclusions or riparian pastures, consider leaving an un-planted strip along the fence to allow vehicle access inside the fence and to discourage livestock from pushing against the fence, thereby weakening it, while browsing on low branches.

The size of a riparian pasture varies with the topography and other landscape features, and the planned use. The Sotoyome RCD's Grazing Handbook states that, "Ideally, riparian pastures should be of a size that will allow the herd to make use of available forage over a few days, allowing ample regrowth of vegetation between grazing periods" (Reference #41). Determining the best times to allow grazing depends on the value of the forage, the stability of the bank and the needs of riparian wildlife. Point Reyes Bird Observatory recommends avoiding grazing during the nesting season which can last from mid-March through late July (Reference #45.)

Cross-fencing creates pastures perpendicular to the stream. Some pastures can be rested while others are grazed. Although this system does not create the level of protection of either exclusion fencing or riparian pastures, it can be a useful tool when alternative water sources are not available and when intensive grazing management is practiced.

Provide alternate water and salt sources.

Increasing the number of places where livestock have access to water and salt spreads them over the available range and reduces the compaction and overgrazing near existing water sources.



Seed and fertilize pastures. Use no-till and minimum-till cultivation.

Increasing the quality and density of vegetation will slow runoff, allowing it to percolate down to replenish groundwater supplies, and reduce sheet and rill erosion. In no-till cultivation of hay and silage crops, the new seed is planted through the old stubble. The land is not plowed, and therefore the soil is never exposed to winter rains. A special seed drill is used that injects the seed and fertilizer all at one time. The field is lightly plowed in minimum-till cultivation, enough to break the soil but not to remove all the stubble. With either method, the field may occasionally have to be clean-tilled, with all stubble plowed in, for weed control. Detailed information is available from NRCS.

No-till and minimum-till cultivation are highly recommended for sloped fields, especially those with recurring rill erosion. Sheet and rill erosion can be deceiving. A quarter inch of soil lost evenly over a 40-acre field yields 900 tons of earth washed into the nearest stream.

Modify your grazing.

Grazing programs manipulate the number of animals in a given area, how long and when they graze there, and the amount of forage and available water to provide maximum, sustainable use of the land. Most grazing systems require fencing and regular rotation of livestock from pasture to pasture. Some call for an even distribution of animals over the range; some call for the intense use of small areas of land for a short time. The best grazing management combines scientific research with the landowner's own specific knowledge and needs. Resources for more information are listed in Chapters 12 and 13.

Separate clean runoff from contaminated runoff.

Clean storm water should be captured and diverted around barns, manure storage areas, paddocks and other areas that produce sediment and/or manure laden water. Roof gutters and downspouts should be installed and maintained on agricultural buildings. In heavily used dairy paddocks, consider using covered loafing barns.

Grass-lined swales, berms and surface drains can be used to collect and divert clean water. Always make sure to deliver and dissipate the captured water to a safe, non-erodible place such as a low-gradient, grassy area.

Locate paddocks away from streams and steep slopes.

Keep horses and other confined animals well away from streams. Even small, ephemeral channels should be protected with grass buffers as they pick up nutrients, pathogens and sediment during rainfall and carry them downstream. Where possible, also keep confined animals off steep hillsides.

Use vegetation to slow and filter runoff.

Maintain well-vegetated buffer strips between horse paddocks, along unsurfaced roads and parking areas, around manure and soiled bedding storage areas, and adjacent to wetlands and natural drainages. Vegetation filters sediment, absorbs nutrients and allows soil bacteria to break down many toxins. In perennial and seasonal streams, trees and shrubs along with grass and understory plants should be used to provide shade, bank stability and wildlife habitat. For ephemeral streams and other areas, grass is an excellent filter. See Chapter 5 for planting guidelines.

Keep confined-animal paddocks dry and well-drained.

Protecting paddock surfaces with sand, wood chips or other porous materials keeps the soil in place. Fibar®, an engineered wood product placed over geotextile fabric, has been used successfully in west Marin County paddocks to keep horses out of the mud without getting stuck in their feet.



Horse paddocks separated from vegetated swale.



LANDSLIDES



In Marin County, small rotational slumps often occur in droves after unusually severe storms and typically stabilize and revegetate by themselves within a few years. Larger landslides are not so readily resolved. Although they are notoriously difficult to predict or repair, there are ways to at least not make them worse.

- No construction should occur on known landslides. If you have any doubts, contact a registered geologist or a geotechnical engineer.
- Runoff from roads, roofs, or any other surfaces should never be directed to a known slide area.
- Existing dirt roads that are cut into landslides should be outsloped or better yet, reshaped to the original contour, seeded, and abandoned. (See Chapter 6 on road erosion.) We strongly recommend that you get professional help before making any alterations to road drainage through landslides.
- Existing vegetation should be left undisturbed.



WILDLIFE

Halting gullies and repairing road washouts do more than keep soil on the ground and out of our waterways—erosion control helps wildlife in both immediate and long-term ways. Examples of quick benefits include the creation of a woody oasis for birds a couple of years after planting willows in a pasture gully, and the instant shade and protection from predators provided for fish by Large Woody Debris.

Long-term soil stabilization has slower but even more important effects on wild animals. Point Reyes Bird Observatory reports that the number of birds in riparian fencing and revegetation projects in Marin and Sonoma Counties grows from just a few species to over 20 species in 10 to 15 years (California Partners in Flight, 2006). Many of these species are neotropical songbirds that breed in North America and migrate to Central and South America during the winter. Although common in the recent past, many are now seriously threatened by habitat destruction in all parts of their range.

Sediment reduction has been a key factor in steelhead and coho salmon recovery strategies throughout coastal California. After a population crash in the 1970s and 80s, Lagunitas Creek now has one of California's largest coho runs. Although research is still being conducted to better understand their recovery and what they need to



California red-legged frog

continue to thrive, twenty years of concerted attention to reducing fine sediments in Lagunitas Creek and its major tributaries has undoubtedly contributed to the coho's success.

Salmonids are vulnerable to excessive sedimentation at many phases of their life cycles. Fine particles in spawning beds

COMMON RIPARIAN BIRDS

Acorn woodpecker • American robin
Anna's hummingbird • belted kingfisher
Bewick's wren • black phoebe
black-headed grosbeak • bushtit
California towhee
chestnut-backed chickadee
common yellowthroat
downy woodpecker • hermit thrush
Nuttall's woodpecker • osprey
Pacific-slope flycatcher • red-shouldered hawk
ruby-crowned kinglet • song sparrow
Swainson's thrush • tree swallow
warbling vireo
Western scrub-jay • Wilson's warbler

Adapted from Bringing the Birds Back: A Guide to Habitat Enhancement in Riparian and Oak Woodlands for the North Bay Region.

SPECIAL-STATUS FISH AND WILDLIFE SPECIES OF MARIN COUNTY*

This list includes animals identified as threatened, endangered and California Species of Concern

tidewater goby	saltmarsh common yellowthroat
coho salmon	tricolored blackbird
steelhead	yellow warbler
chinook salmon	California clapper rail
Tomales roach	California black rail
Myrtle's silverspot butterfly	northern spotted owl
California freshwater shrimp	burrowing owl
California red-legged frog	San Pablo song sparrow
foothill yellow-legged frog	salt-marsh harvest mouse
western pond turtle	Point Reyes mountain beaver
western snowy plover	

*For a complete list of all special-status species occurring in your area, visit the Sacramento Fish and Wildlife Service (www.fws.gov/sacramento) and California Department of Fish and Game ([HYPERLINK "http://www.dfg.ca.gov"](http://www.dfg.ca.gov)).

can reduce the number of eggs that hatch by impeding circulation of oxygen and other nutrients. Larger particles fill in the pools that rearing fish use for shelter and rest. Chronic, long-term sedimentation has reduced estuary volume in many California streams, which in turn affects the timing and duration of sandbar formation. As sandbars remain closed longer into the winter, some salmonids, such as coho who move upstream primarily in December and January, can never enter the stream to spawn.

California red-legged frogs, western pond-turtles, California freshwater shrimp and a host of wetland species from Dungeness crabs to California clapper rails also benefit from controlling accelerated erosion and maintaining healthy, well-functioning watersheds. Many of these species have special federal and/or state protection and cannot be harmed, even as an inadvertent side effect of a restoration or soil stabilization project. If you have questions about whether or not protected species live on your property, contact the California Department of Fish and Game (CDFG). CDFG also maintains an on-line database of species of concern, the California Natural Diversity Database (CNDDDB), that identifies threatened and endangered species observed in specific areas. Chapter 13 includes information on how to access this database.

Fencing our homes often excludes wildlife unnecessarily from theirs. As we move into wildlife corridors, we need to preserve their migration corridors, feeding and resting areas, and access to water. Creating fencing to meet the needs of the landowner and wildlife is possible with a little property evaluation and planning. Depending on your needs (livestock, gardens, or property boundary), simple adjustments to spacing, height, and materials can help create wildlife friendly fencing. For detailed information see Reference #38.

- Property boundaries: Consider using trees and shrubs to create a natural boundary to your property. You will attract wildlife to your area while keeping a distinct property line.
- Livestock fencing: Spacing, height, and fencing materials can accommodate some wildlife and exclude others.
- Exclusion fencing: Try to fence small areas if your goal is to exclude wildlife completely. Fence off a garden or barn as opposed to the entire property to allow animals to pass through the rest of your property.



MAINTENANCE AND MONITORING

All erosion repair and restoration projects require monitoring, and many will require periodic maintenance, especially in the first few years. Monitoring should start before you begin your repair project with clear goals and documentation of the existing conditions. Effectiveness monitoring is making sure that your project is achieving the desired goals. As you check your work in different weather conditions and over several years, you can make adjustments to the repairs, find out which techniques and plants perform best on your site, and note any unintended results, either beneficial or problematic.

Photographic monitoring is an excellent and inexpensive way to track long-term changes. Choose at least two monitoring stations before you begin work and mark them with stakes or GPS. Remember that plants grow—many a photo monitoring station has been consumed by riparian forest after a few years—and select stations that will show your work even with dense vegetation. Take photographs during and after construction, and then periodically thereafter at regular intervals. Taking them at the same time of year will allow you to make more accurate comparisons of changes.

If you are interested in tracking changes in habitat and water quality parameters, check with UC Cooperative Extension, your local RCD, or MCSTOPPP to find out where to get training and equipment (Chapter 13). Some wildlife populations, such as birds and many insects, are relatively easy to monitor while others, such as coho salmon and steelhead, may require special expertise and assistance from the Department of Fish and Game or other agencies. Plant survival and changes in plant composition can be readily monitored with a field guide or two. NRCS and UC Cooperative Extension can help you design a program to monitor range conditions, or lead you to other resources in your area.

Always include time and cost for maintenance when you plan an

erosion control project. Revegetation maintenance is described in Chapter 5 and road maintenance in Chapter 7. Even simple problems, such as tall grass stuck on a fence that diverts water around a headcut repair, can lead to expensive fixes if they are not addressed early.



Before restoration.



A few years after restoration.



PERMITS

Work along creeks or the coast, within riparian and other wildlife habitat, or just about any place where construction activity may potentially affect our common resources requires permits from regulatory agencies. Consultation with agencies should begin as soon as you have a project in mind as the review process can take anywhere from a few weeks to several months after an application is submitted. It is best to start with your local city or county planning department, then move to the regional, state, and federal agencies.

Keep track of communication in writing and ask for copies of your permit applications and letters of authorization as you continue with your project. Some permits require a follow-up visit, monitoring, or a report at the completion of the project. Agencies tend to guide the process along, notifying other agencies or informing landowners about other required permits.

If you are unsure how to obtain regulatory compliance, ask for help. The MCSTOPPP website is a good place to start (<http://www.mcstoppp.org/>). Professional services are available to assist with permit acquisition, which may be a good idea, especially with more complex projects. The list below offers an overview of the major regulatory requirements in California, although there may be additional regulations and local or regional permits that apply to your project.

Marin County has monthly project coordination meetings to review and guide projects. These meetings are attended by representatives from the regulatory agencies to streamline the permit process. Landowners may present their projects (bring photos, sketches, or conceptual plans) to receive feedback from the regulators. To be added to the agenda, call Marla Lafer, San Francisco Regional Water Quality Control Board at (510) 622-2348 or Liz Lewis, Marin County Public Works at (415) 499-7226.

Projects in the San Francisco Bay Area further benefit from another streamlined process known as the Joint Aquatic Resource Permit

Application (JARPA). The JARPA allows applicants to apply for permits to many state and federal agencies with one application. The San Francisco Estuary Project oversees the JARPA form (510) 622-2315.

<http://sfep.abag.ca.gov/projects/JARPA/JARPA.html>

County and City Public Works and Planning Departments:

These are good starting places to find out about local regulations and permits. They are also good sources of aerial photographs, resource inventories and maps, regional know-how and references for additional information.

Marin County Public Works (415) 499-6528

<http://www.co.marin.ca.us/depts/PW/Main/index.cfm>

Sonoma County Permit and Resource Management Department:
(707) 565-1900

<http://www.sonoma-county.org/prmd/>

Regional Water Quality Control Board (RWQCB) §401 Certifications under California Environmental Quality Act (CEQA):

RWQCB §401 certifications regulate projects that may result in a pollutant discharge to a water body. Discharges are not limited to typical construction materials; they also include sediment in the form of dust, mud, and silt. The RWQCB has the right to authorize, waive, or deny projects in order to protect the State's waterbodies. Whenever a §404 permit is needed from the U.S. Army Corps of Engineers, a §401 certification is also required.

San Francisco Bay Region (510) 622-2330

<http://www.waterboards.ca.gov/sanfranciscobay/>

California Department of Fish and Game (CDFG) §1602 Streambed Alteration Agreement under California Environmental Quality Act (CEQA):

Under §1600 et seq. of the California Fish and Game Code, CDFG has jurisdiction over any activity in a creek or river where an existing fish or wildlife resource exists or where such resources derive benefit. Projects affecting or potentially affecting fish and wildlife must obtain an agreement from CDFG, which usually imposes conditions to protect the environment. Project areas with special status (endangered, threatened, or rare) species require additional protection measures. The CDFG web-

site provides access to information about special status species through the California Natural Diversity Database (CNDDDB) USGS quad maps. These maps provide general information for a regional area and are a starting point for researching protected species.

State Headquarters: (916) 445-0411
Bay Delta Region 3: (707) 944-5500
<http://www.dfg.ca.gov/1600/>
<http://www.dfg.ca.gov/whdab/html/cnddb.html>

State Water Resources Control Board, Division of Water Quality:

Compliance with the National Pollutant Discharge Elimination System (NPDES) of the Clean Water Act requires a permit for stormwater discharges associated with construction activity. Construction activity does not include routine maintenance to re-establish original line and grade, hydraulic capacity, or original purpose of a facility, nor does it apply to emergency construction activities required to protect public health and safety. For construction projects disturbing an area greater than one acre, a Notice of Intent (NOI) must be filed and a Stormwater Pollution Prevention Plan (SWPPP) must be prepared and kept onsite. The SWPPP is used to determine the scope of the construction activity and identify Best Management Practices (BMPs) to prevent pollutants from entering stormwater.

State Water Resources Control Board General Line (916) 341-5250
Division of Water Quality (916) 341-5536
<http://www.waterboards.ca.gov/stormwtr/construction.html>

State Water Resources Control Board, Division of Water Rights:

The Division of Water Rights (DWR) has the authority to issue water rights appropriations or registrations to landowners for a variety of projects, including small reservoirs. DWR regulates water licenses for water taken from a surface or underground flow as well as the storage of the water.

Division of Water Rights (916) 341-5300
<http://www.waterrights.ca.gov/forms/>

California Coastal Commission (CCC): San Francisco Bay Conservation and Development Commission (BCDC):

Work in coastal water bodies requires additional authorization. BCDC jurisdiction includes all of San Francisco Bay, defined to include lands within the first 100 feet inland from the shoreline, including some tributaries.

BCDC regulates a variety of actions that include construction, remodeling, or repair of a structure, grading or subdivision of property, substantial change in use of a property, dredging, or the placement of solid material in the bay. In addition, the CCC requires a permit for development within the coastal zone. Your local planning office should be able to assist with coastal zone permits.

Bay Conservation and Development Commission (415) 352-3600
<http://www.bcdc.ca.gov/>

California Coastal Commission Headquarters (415) 904-5200
<http://www.coastal.ca.gov/cdp/cdp-forms.html>

U.S. Army Corps of Engineers §404 Permits under National Environmental Policy Act (NEPA) and the Clean Water Act:

The Corps regulates the release of dredged or fill material to any channel or tributary to a channel that is a navigable water of the US or that has real or potential interstate commerce value. Discharges include sediment or rock as well as other pollutants. By definition, a channel is a watercourse with a bed and bank and an ordinary high water mark. While our creeks are often not considered navigable waters, they mostly drain to navigable waters (including San Francisco, San Pablo and Tomales Bays), resulting in a need for consultation with the Corps.

Army Corps of Engineers San Francisco District Office (415) 977-8659
<http://www.spn.usace.army.mil/>

National Oceanic and Atmospheric Administration (NOAA) Fisheries:

NOAA requires permits for activities affecting threatened and endangered marine and anadromous fish species under the Endangered Species Act.

U.S. Fish and Wildlife Service (USFWS):

The USFWS, part of the Department of the Interior, requires permits for activities affecting threatened and endangered fish and wildlife species under the Endangered Species Act.

With such a daunting list of potential regulations that may affect your project, landowners may be tempted to work without the benefit of permits. Don't do it! Violators incur fines for illegal work, must repair work to satisfy regulators, and may be required to mediate for damage done to the environment.



WHERE TO GET MORE HELP

ORGANIZATIONS

The following organizations provide information and, in some cases, on-site assistance with identifying and repairing erosion problems.

County and City Public Works and Planning Departments:

These are good starting places to find out about local regulations and permits. They are also good sources of aerial photographs, resource inventories and maps, regional know-how and references for additional information.

Marin County Public Works:

(415) 499-6528

<http://www.co.marin.ca.us/depts/PW/Main/index.cfm>

Sonoma County Permit and Resource Management Department:

(707) 565-1900

<http://www.sonoma-county.org/prmd/>

Marin County Stormwater Pollution Prevention Program:

Marin County's website has information for streams and stormwater-related issues with resources and links for local and general use.

(415) 499-6528

<http://www.mcstoppp.org/>

Resource Conservation Districts:

Most California counties have one or more RCDs that offer assistance to agricultural landowners for projects

that benefit water and soil resources. RCDs often fund watershed-wide studies and individual landowner projects in cooperation with many local, state, and federal agencies.

Marin and Sonoma County RCDs:

<http://www.sonomamarinrcds.org/>

Marin RCD (415) 663-1170

Southern Sonoma RCD (707) 794-1242

Sotoyome RCD (707) 569-1448

Gold Ridge RCD (707) 874-2907

East and West Lake RCD (707) 263-4180

Mendocino County RCD (707) 468-9223

California Association of RCDs: <http://www.carcd.org/>

USDA Natural Resources Conservation Service (NRCS):

NRCS can provide technical specifications; information about possible financial assistance from government cost-sharing programs; soils information; on-site advice on selecting an appropriate repair; and help with finding a contractor, consultant or unusual materials. They usually have well-stocked libraries of their own publications and other erosion control references. Local offices have available to them geologists, engineers, wildlife biologists, agronomists and a host of other specialists at the service of the public.

(707) 794-1242, Petaluma Field Office

<http://www.nrcs.usda.gov/>

**University of California Cooperative Extension (UCCE)
University of California's Agriculture and Natural
Resources Department:**

UCCE offers a wealth of research and expertise to the public. They have offices in most counties with advisors for farms, 4-H, nutrition, family and consumer sciences. Master Gardeners are available to assist with gardening, plant resources, and pest control. Extension staff make site visits to help with specific problems, offer financial assistance, and extensive libraries for the public.

(415) 499-4204, Marin
(707) 526-6797, Sonoma
<http://ucanr.org/index.cfm>

California Division of Mines and Geology:

This group offers a goldmine of maps and reports on landslides and related geological features that both affect and help explain erosion problems. A list of publications and prices is available from the Department of Conservation, Division of Mines and Geology, Publications and Information Office, P.O. Box 2980, Sacramento, CA 95812, (916) 445-5716.

Environmental Protection Agency (EPA):

The EPA has a wealth of information pertaining to watersheds on their website. Their non-point source pollution page has background information as well as technical reports and links to additional resources. General Information (Washington DC) (202) 566-1155, Environmental Information Center toll free (866) EPA-WEST

Non-point source: <http://www.epa.gov/owow/nps/categories.html>

General watershed: <http://www.epa.gov/owow/>

FishNet4C: The Fishery Network of the Central California Coastal Counties has a website containing information on local projects in the local area and great links to other helpful sites. Marin County Fishnet Project (415) 499-7331
<http://fishnet4c.org/index.html>

US Fish and Wildlife Service (USFWS): Also part of the Department of the Interior, USFWS can provide information on threatened and endangered species, and on enhancing and protecting wild animal habitat. (800) 344-WILD
<http://www.fws.gov/>

US Forestry Service (USFS): Another Service of the Department of Agriculture, USFS has done much pioneering research on erosion control methods. They have many fine publications available describing erosion problems and practical ways to fix them. DC office: (202) 205-8333, Pacific Southwest Region (707) 562-8737
<http://www.fs.fed.us/>

US Geological Survey (USGS): Part of the Department of the Interior, USGS studies and inventories geological and related resources. They have a wealth of maps, aerial photos, infrared photos and many other useful land management tools. California Water Science Center (916) 278-3000, Western Regional Offices (650) 853-8300
<http://www.usgs.gov/>

Russian River Watershed Directory: The Sotoyome RCD has released a directory of useful references for watershed-related work in their district. Many listings extend beyond Sonoma County and could be used to determine what help is available to you. (707) 569-1448
<http://sotoyomercd.org/publications.htm>

SELECTED REFERENCES

The following is by no means an exhaustive list, but it should get you started.

River Science and Management

1. Downs, Peter W. and Kenneth J. Gregory. 2004. *River Channel Management: Towards Sustainable Catchment Hydrosystems*. Oxford University Press.

2. Dunne, Thomas and Luna Leopold. 1978. *Water in Environmental Planning*. W.H. Freeman, Inc.
3. Kansas State Conservation Commission. *Kansas River and Stream Corridor Management Guide*. This well written guide is a wonderful primer on river systems, dynamics, and erosion control. Available free online. <http://www.accesskansas.org/ksc/KSRiversGuide.pdf>
4. Leopold, Luna. 1996. *A View of the River*. Harvard University Press.
5. Leopold, Luna, Gordon Wolman and John Miller. 1964. *Fluvial Processes in Geomorphology*. W.H. Freeman, Inc.
6. Leopold, Luna. 1997. *Water, Rivers and Creeks*. University Science Books.
7. Riley, Ann L. 2003. *A Primer on Stream and River Protection for the Regulator and Program Manager*. Technical Reference Circular W.D. 02-#1. San Francisco Bay Regional Water Quality Control Board. An outstanding and accessible resource for regulators, public land managers and anyone interested in how rivers work and how human development affects natural processes.
8. Riley, Ann L. 1998. *Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens*. Island Press.
9. Rosgen, Dave. 1994. *Applied River Morphology*. Wildland Hydrology.
10. **Soil Surveys** of most counties are available from the Natural Resources Conservation Service. These map different soil types and describe their properties in relation to construction, septic systems, plant growth, erodibility, wildlife habitat, recreational use and many other factors.
11. California Department of Fish and Game. 1998 with updated sections. *California Salmonid Stream Habitat Restoration Handbook*. This guide contains background and techniques for those interested in restoration of fish-bearing streams. Written by staff of CDFG, this is the place to begin research for fish-friendly restoration. Available free online or by mail for a shipping charge of \$7. <http://www.dfg.ca.gov/nafwb/manual.html>
12. Eubanks, Ellen and Dexter Meadows. 2002. *A Soil Bioengineering Guide for Streambank and Lakeshore Stabilization*, U.S. Department of Agriculture Forest Service. This stunning guide is an easy to read and detailed guide to streams and bioengineering. Contents include background, planning, and techniques. Available free online. <http://www.fs.fed.us/publications/soil-bio-guide/>
13. Gray, Donald H. and Robbin Sotir. 1996. *Biotechnical and Soil Bioengineering Slope Stabilization: A Practical Guide for Erosion Control*. John Riley and Sons, Inc. New York, NY. Principles, repair considerations, techniques and methods for bioengineered erosion control.
14. Heede, Burchard H. 1976. *Gully Development and Control: The Status of Our Knowledge*. U.S.D.A. Forest Service. Research Paper RM-169. Rocky Mountain Forest and Range Exp. Station, Ft. Collins, CO 80521. This is one of many publications by Heede based on his extensive experiments on repairing gullies. Contains specifications for many types of checkdam.
15. Kraebel, Charles J. and A.F. Pillsbury. 1934. Reissued 1980. *Handbook of Erosion Control in Mountain Meadows*. US Forest Service. Clear, down-to-earth explanations of how gullies grow and how to repair them. Includes specification for willow sprigging, wattling, and brush checkdams.

Erosion and Bioengineering

16. Lowdermilk, W.C. 1953, Revised 1975. *Conquest of the Land through 7000 Years*. USDA Soil Conservation Service, Ag. Info. Bull. No. 99. A delightfully written and fascinating (though sobering) account of how soil erosion has eradicated many ancient cities, and even entire civilizations.
17. Natural Resource Conservation Service (Soil Conservation Service). 1992. *Engineering Field Handbook*. Chapter 16, Streambank and Shoreline and Chapter 18, Soil Bioengineering for Upland Slope Protection and Erosion Reduction are especially useful. Available free online. <http://www.info.usda.gov/CED/ftp/CED/EFH-Ch16.pdf>
<http://www.info.usda.gov/CED/ftp/CED/EFH-Ch18.pdf>
18. Schiechl, Hugo. 1980. *Bioengineering for Land Reclamation and Conservation*. University of Alberta Press, Edmonton, Alberta. A creative and historic look at biotechnical erosion control, full of intriguing methods.

Plants

19. Best, Catherine, et.al. 1996. *A Flora of Sonoma County*. California Native Plant Society.
20. California Native Plant Society:
<http://www.cnps.org/>
21. Faber, Phyllis and Robert F. Holland. 1988. *Common Riparian Plants of California*. Pickleweed Press.
22. Howell, J.T. 1970. *Marin Flora*. University of California Press, Berkeley.
23. Schmidt, Marjorie. 1980. *Growing California Native Plants* University of California Press, Berkeley.
24. *Sunset Western Garden Book*. 1995. Sunset Publishing Corporation.
25. Young, James A. and Cheryl G. Young. 1992. *Seeds of Woody Plants in North America*. Dioscorides Press (an imprint of Timber Press). Detailed text and drawings describing collection, germination, and the planting of woody plants from seed.

Several informative and free booklets available from MCSTOPPP:

26. *Creek Care, A Guide for Urban Marin Residents*.
27. *GO NATIVE, Using Native Plants for Your Yard, Patio, Creek*.
28. *Invasive Weeds of Marin and Sonoma Counties*, by the Marin Sonoma Weed Management Area.

Roads

29. *California Salmonid Stream Habitat Restoration Manual*. See #11
30. FishNet 4C. 2004. *Guidelines for Protecting Aquatic Habitat and Salmon Fisheries for County Road Maintenance*. Written for County and agency roads staff, this resource offers background and BMPs for road maintenance near salmonid habitat.
31. Marin Municipal Water District has developed a Memorandum of Understanding for the maintenance and management of unpaved roads in the Lagunitas Creek Watershed. The focus is to reduce sediment on unpaved roads. Available online. <http://www.marinwater.org/>
32. Weaver, William E, and Danny K. Hagans. *Handbook for Forest and Ranch Roads: A guide for planning, designing, constructing, reconstructing, maintaining and closing wildland roads*. An indispensable resource for constructing and maintaining ranch and fire roads. Available from the Mendocino RCD, <http://mcrd.org/>

New Construction

33. Bay Area Stormwater Management Agencies Association. *Start at the Source: Design Guidance Manual for Stormwater Quality Protection*. This helpful guide suggests various methods for reducing runoff on properties from homes to large industrial complexes. Available free online. <http://www.basmaa.org/documents/index.cfm?fuseaction=documents&doctypeID=3>
34. CalTrans has extensive information about stormwater best management practices (BMPs) and stormwater pollution prevention plans (SWPPPs) on their website. A SWPPP template is available for public use. <http://www.dot.ca.gov/hq/construc/stormwater/manuals.htm>
35. San Francisco Regional Water Quality Control Board. 1996. *Erosion and Sediment Control Field Manual*. This manual borrows heavily from the CalTrans BMPs to condense the information and make for a more user-friendly guide. http://www.informinc.org/cwp2Field_Manual.pdf

Livestock and Erosion

36. Alameda County RCD has a series of fact sheets for horse owners. <http://www.acrcd.org/eqine.html>
37. Anderson, M.K. 2005. *Tending the Wild: Native American Knowledge and the Management of California's Natural Resources*. University of California Press, Berkeley.
38. Buckman, Allan. Wildlife Friendly Fencing Guidelines. Available online. <http://www.nswg.org/april05fencing.htm>
39. Edwards, S.W. 1992. "Observations on the Prehistory and Ecology of Grazing in California." *Fremontia* 20:3-11
40. Marin Resource Conservation District. 2005. *Managing Riparian Pastures in the Marin Resource Conservation District*.
41. Sotoyome Resource Conservation District. 2006. *Grazing Handbook: A Guide for Resource Managers in Coastal California*. Text by Lisa Bush. Available from the Sotoyome RCD. <http://sotoyomercd.org/index.html>

Landslides

Contact USGS and NRCS (above) for additional resources. NRCS likely has many of these references in their library.

42. CA Division of Mines and Geology. 1986. *Landslide Hazards in the Southeastern Part of the Petaluma Dairy Belt, Sonoma County, California*. Open File Report 86-5 SF.
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44. Rice, S.J. and G.B. Chase. 1973. *Geology and Geologic Hazards of the Novato Area, Marin County*, by CA Division of Mines and Geology. Preliminary Report 21.

Wildlife

45. Kreitinger, Kim and Tom Gardali. 2006. *Bringing the Birds Back: A Guide to Habitat Enhancement in Riparian and Oak Woodlands for the North Bay Region*. California Partners in Flight Regional Bird Conservation Plan No. 1. http://www.prbo.org/calpif/pdfs/north_bay.pdf
46. *Guidelines for Protecting Aquatic Habitat and Salmon Fisheries for County Road Maintenance*. See #30.

47. House, Freeman. 1999. *Totem Salmon: Life Lessons from Another Species*. A beautiful book about the intertwined lives of people and salmon, and the effort to restore the Mattole River. The book ends with, "There is no separate life."

48. Marin Municipal Water District has developed a memorandum of understanding regarding large woody debris in the Lagunitas Creek watershed. The MOU outlines clear, informative language about the benefits of woody debris in creeks. Available online. <http://www.marinwater.org/>

49. Wildlife friendly fencing guidelines. See #38

Several websites offer images and information:

50. American Fisheries Society:
<http://www.afs-calneva.org/>

51. The Audubon Society: <http://www.audubon.org/>

52. Marin Chapter: <http://www.marinaudubon.org/>

53. Madrone (Sonoma County) Chapter:
<http://audubon.sonoma.net/>

54. CalPhotos is a web collection of photos of wild-life, plants, landscape, and people and culture. Photos can be searched by type, name and location making identification a little easier.
<http://calphotos.berkeley.edu/>

55. Northern California Herpetology Society:
<http://www.norcalherp.com/>

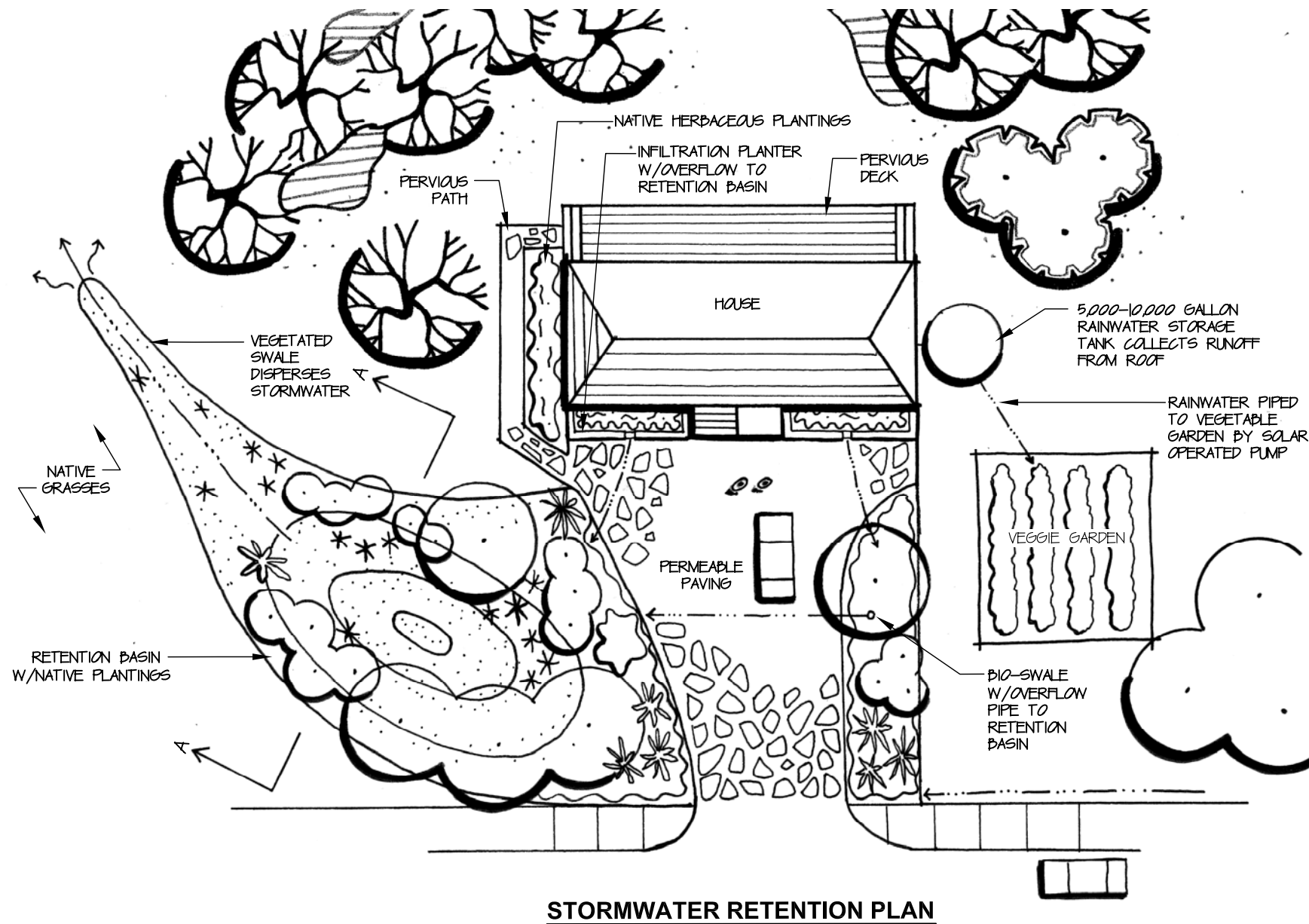
56. Point Reyes Bird Observatory: <http://www.prbo.org>

57. SF Bay Area Chapter of The Wildlife Society:
<http://www.tws-west.org/bayarea/index.htm>

58. The Xerces Society for Invertebrate Conservation:
<http://www.xerces.org/>



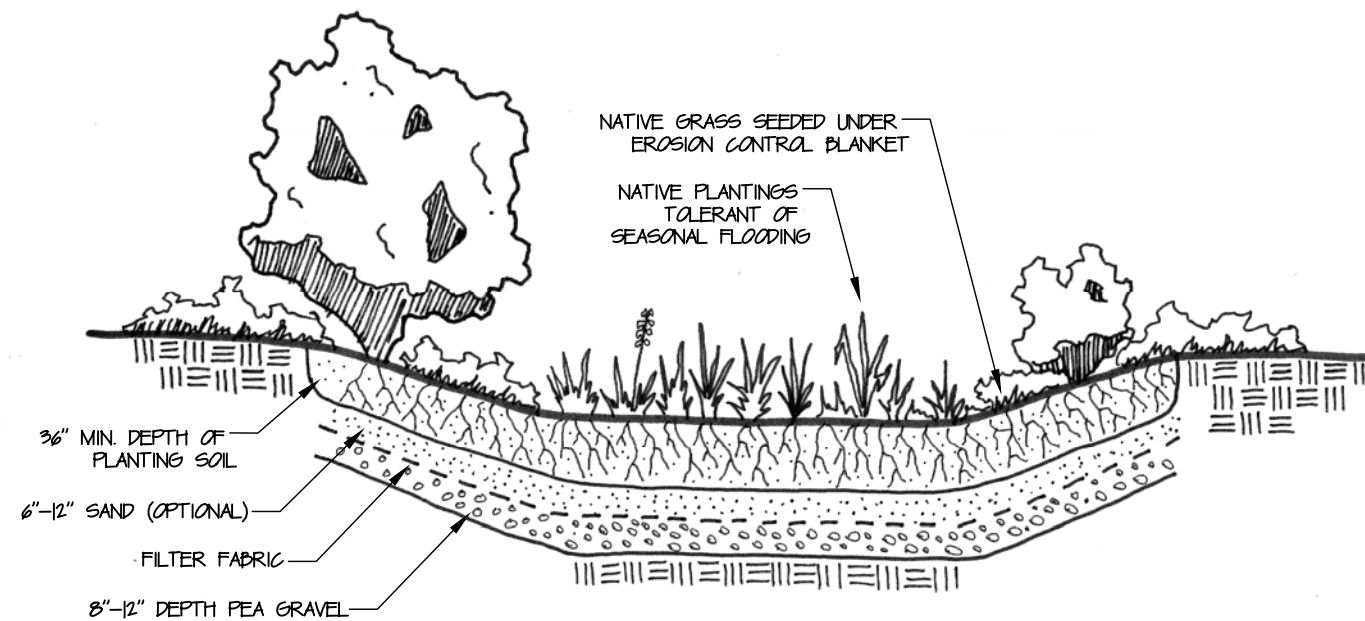
SAN GERONIMO SALMONID ENHANCEMENT PLAN
STORMWATER RETENTION
 CONCEPTUAL PLAN 3



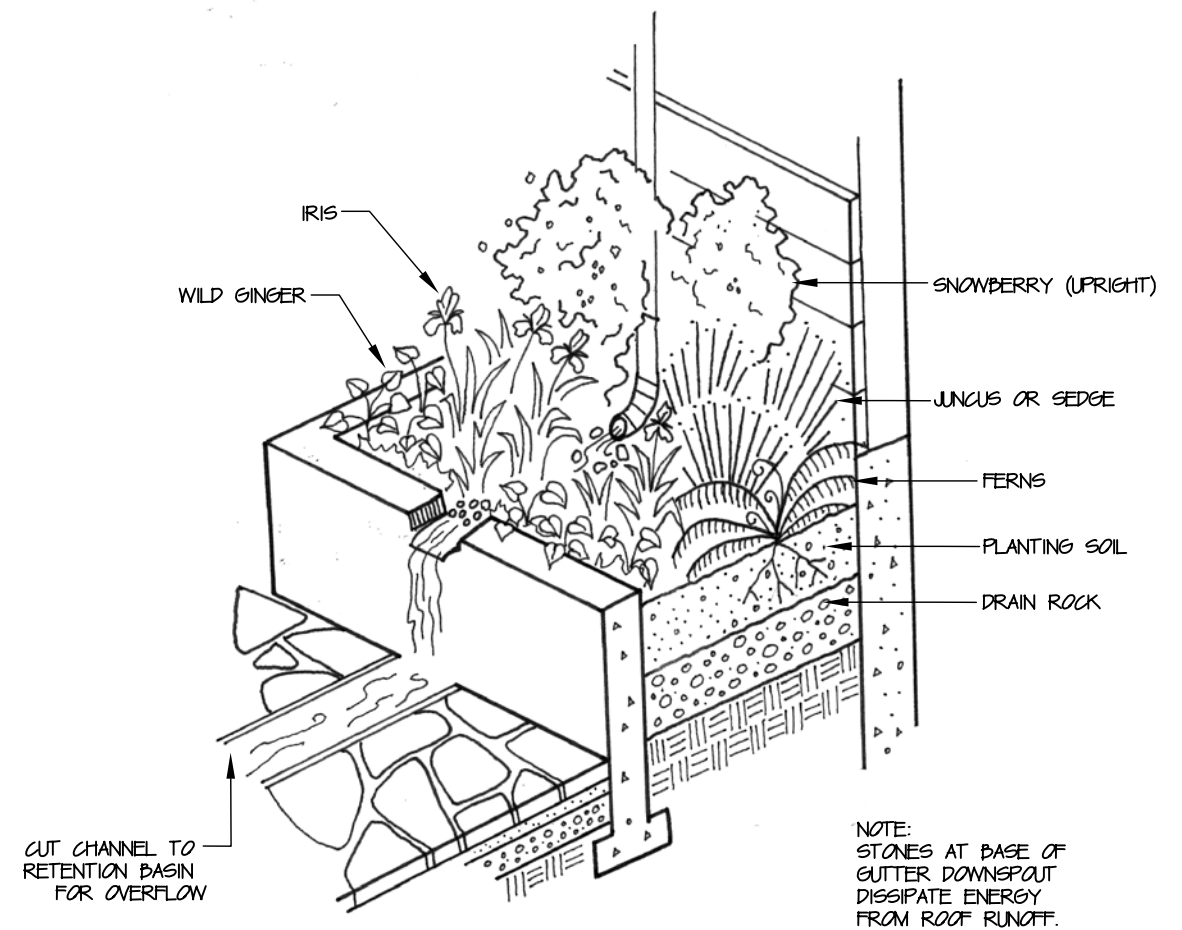
STORMWATER RETENTION PLAN



RAINWATER STORAGE TANK



SECTION A - RETENTION BASIN



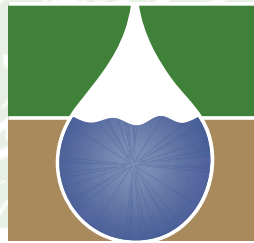
INFILTRATION PLANTER

NOTE:
 STONES AT BASE OF GUTTER DOWNSPOUT DISSIPATE ENERGY FROM ROOF RUNOFF.

Slow it. Spread it. Sink it!

A Homeowner's & Landowner's Guide to Beneficial Stormwater Management

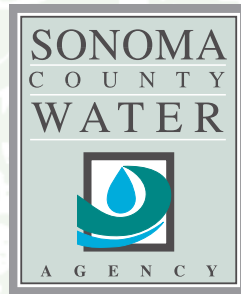




Sonoma Valley Groundwater Management Program



Southern Sonoma
County Resource
Conservation District
Caring for the Land



WATER
INSTITUTE
OCCIDENTAL ARTS &
ECOLOGY CENTER

Slow it. Spread it. Sink it!

A Homeowner and Landowner's Guide to Beneficial Stormwater Management

Practical and Eco-Friendly Ways to Protect Your Property and the Environment from the Effects of Stormwater Runoff

First Edition July 2010

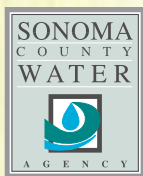
Compiled and Written by: Southern Sonoma County Resource Conservation District and The Resource Conservation District of Santa Cruz County
Guide Design & Layout: Blue Heron Design Group
Illustrations By: Ritch Waldron, Wildways Illustrated
Page Gruys

Copies of this guide can be obtained from:



Southern Sonoma County Resource Conservation District

1301 Redwood Way, Suite 170. Petaluma, CA 94954
(707) 794-1242 extension 5
www.sscr.cd.org



STATEMENT OF PURPOSE

This manual has been developed for educational purposes by the Southern Sonoma County Resource Conservation District and the Resource Conservation District of Santa Cruz County. The storm water runoff improvement practices included in this guide are meant to be used as general guidelines and are not to be used as professional engineered specifications. Prior to implementation of ANY practices, seek technical assistance from a licensed professional engineer or landscape architect, and/or certified professionals in erosion and sediment control for specifications for these practices. Site-specific designs that address each individual site's needs and constraints are essential.

WHO WE ARE

The Southern Sonoma County Resource Conservation District (SSCRCD) is a special district organized under state law. The RCD is also a public resource agency with no enforcement or regulatory functions. We work closely with the Natural Resources Conservation Service (NRCS) through a mutual agreement in responding to the soil and water management needs of Sonoma County landowners and users.

The NRCS, formerly the Soil Conservation Service (SCS), is a non-regulatory, federal agency of the U.S. Department of Agriculture (USDA) created to lead a national effort to prevent erosion and protect the nation's soils and water resources. NRCS provides free technical assistance through a variety of voluntary programs aimed at helping landowners protect, enhance, and wisely use our nation's soil, water, and other natural resources.

Together, through this local-federal partnership, landowners receive many services including free on-site resource evaluations, workshops and trainings related to beneficial stormwater runoff, cost-share and permitting assistance for qualified projects, and more.

ACKNOWLEDGEMENTS

Many individuals and organizations contributed to the development of this guide including:

- Sonoma Valley Groundwater Management Program Basin Advisory Panel and Technical Advisory Committee
- Resource Conservation District of Santa Cruz County
- Sonoma County Water Agency
- Southern Sonoma County Resource Conservation District
- Sonoma County Permit & Resource Management Department
- Sonoma County Department of Environmental Health
- Sonoma-Marin Vector Control District
- County of Sonoma
- City of Sonoma
- City of Santa Rosa
- Sonoma County Agricultural Preservation and Open Space District
- Sonoma Valley County Sanitation District
- Valley of the Moon Water District
- AP Rainwater Harvesting
- The Occidental Arts and Ecology Center/The Water Institute
- City of Petaluma
- North Bay Watershed Association

We would especially like to thank the RCD of Santa Cruz County who generously granted the use of their original source version of this guidebook to be adapted to address the unique conditions and natural resource challenges of Sonoma County. The authors would also like to thank Brock Dolman of the Occidental Arts & Ecology Center's Water Institute for use of the phrase "Slow it. Spread it. Sink it!" in the title. The Sonoma Valley Groundwater Management Program Basin Advisory Panel and Technical Advisory Committee provided valuable feedback and technical direction. The Sonoma County Water Agency, City of Petaluma, North Bay Watershed Association, and the Southern Sonoma County Resource Conservation District provided funding support and leadership for the development and production of the manual. This guide was also made possible with Proposition 50 Coastal Nonpoint Source Pollution Control Program funds administered by the State of California Water Resources Control Board.

IMPORTANT NOTE: Federal, state, and local regulations in California pertain to many of the subjects presented in this guide. Regulations change quickly, as do the technical methods and standards for environmental protection. Be sure to follow applicable regulations covering private land maintenance and related activities for your area. See the Resources Guide on page 61 for a list of contacts.

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DID YOU KNOW?

Something as simple as water from a downspout contributes to a number of unwanted consequences. Roofs and other impervious surfaces alter natural hydrology, increasing the volume and velocity of stormwater runoff. This has a variety of impacts including streambank erosion and degraded wildlife habitat. Other unintended outcomes associated with accelerated stormwater runoff are potholes, damage to structures, beach closures, and in severe cases, land and mud slides. Fortunately there are simple low-cost things that we all can do to help decrease the volume of, and minimize the pollutants in, the runoff leaving our properties. And many have the added benefit of beautifying our

DID YOU KNOW THAT THIS:

CAN CONTRIBUTE TO THIS:



SO WHY NOT TRY ONE OF THESE?

Here are just a few of the ideas you'll find in this guide to address stormwater runoff around your home.

Collect your roof water in a **RAIN BARREL**.



Cost: LOW
Installation difficulty: EASY
See page 29

Plant a **RAIN GARDEN** in your landscape.



Cost: LOW to MODERATE
Installation difficulty: EASY to INTERMEDIATE
See page 33

Install a **WATERBAR** on your driveway.



Cost: MODERATE
Installation difficulty: INTERMEDIATE
See page 43

Use **PERVIOUS PAVERS** when renovating your patio or driveway



Cost: MODERATE - HIGH
Installation difficulty: INTERMEDIATE
See page 38

Introduction

Before Sonoma County and its incorporated cities became the developed, unique communities they are today, the diverse collection of habitats including redwood forests, oak woodlands, native grasslands, riparian areas, coastal dunes, and wetlands were virtually undisturbed. Rivers and streams, capturing and conveying rainwater, flowed from upland areas through rivers and creeks to the Pacific Ocean and San Pablo Bay along sinuous unchanneled corridors. Intact wetlands functioned as natural filters and buffers from major storms. Under these pre-development conditions, as much as 50% of rainwater infiltrated (soaked into) the soil replenishing groundwater supplies, contributing to year-round stream flows, and sustaining ecosystem function. Another 40% was released into the atmosphere through evapotranspiration (evaporation of surface and ground water plus water loss from plants). Only about 10% contributed to stormwater runoff (rainwater that flows over the land surface). Our modern day urban centers and rural neighborhoods are made up of impervious surfaces (hardened surfaces that do not allow water to pass through) such as roofs, streets, and parking areas. When rain falls on these surfaces, it flows faster

and in greater amounts than it would have under pre-development conditions significantly increasing runoff and decreasing infiltration and evapotranspiration. Runoff is typically conveyed by pipes, driveways, streets, and storm drains to creeks and rivers, where it contributes to flooding, road damage, stream erosion, and landslides. Runoff also carries sediment and other pollutants to beaches and rivers, making them unsafe for recreation and wildlife. Though it starts as relatively clean rainwater, runoff collects pollutants as it flows over the landscape. For example, excess lawn fertilizers, pet waste, soap from car washing, oil and grease from leaking engines, zinc from tires, and copper from brakes are just some contaminants that have been found in runoff in the county. It is important to note that nearly ALL storm drains in Sonoma County empty into local waterways UNTREATED.

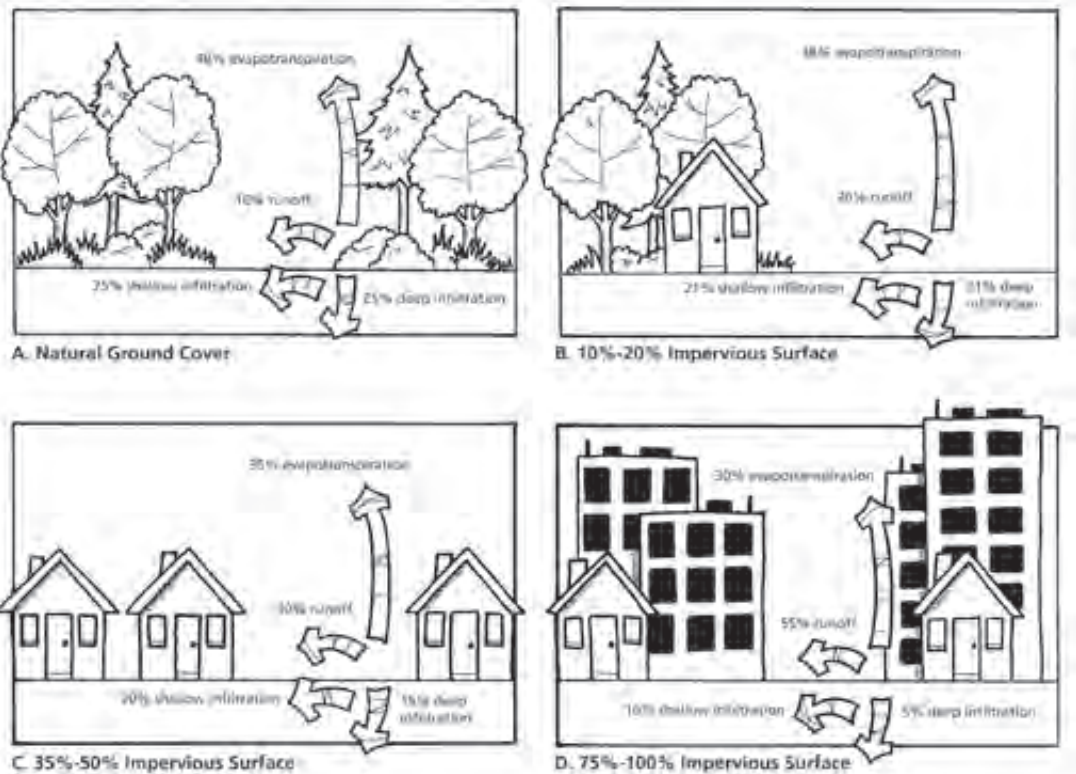


FIGURE 1: PERCENTAGE RUNOFF GENERATED FROM IMPERVIOUS SURFACES, ADAPTED FROM FISRWG 1998



RUNOFF FROM THE SURROUNDING HOMES AND STREETS FLOWS THROUGH THIS STORM DRAIN...



...AND CONTINUES DIRECTLY INTO LOCAL CREEKS AND RIVERS.



DID YOU KNOW?

Just as a city, county, state, or even our personal property has boundaries, so does a watershed. We define a watershed as the land that contributes water to a given area. Watersheds are normally named after the river, creek, or stream that they drain to. For instance, much of the the City of Sonoma is in the Sonoma Creek Watershed. If you live in Santa Rosa or Rohnert Park, you are in the Laguna de Santa Rosa Watershed. All of the rainfall and runoff from a home drains into the watershed where it is located, eventually replenishing critical groundwater resources ...or flowing to the Pacific Ocean.

SONOMA COUNTY

One way to help reduce the negative impacts of runoff and promoting sustainable groundwater use is by changing the way we approach new construction. However, since much of our county is already developed, a great benefit can be derived by addressing runoff from our existing homes. Just as with new construction, through good planning and design we can accomplish the following:

- Conserve and protect groundwater resources
- Clean up our creeks, streams, and the bay
- Create healthier homes
- Protect infrastructure and reduce flooding

In addition to the information provided in this guide, your local Resource Conservation District (RCD), in partnership with the USDA Natural Resources Conservation Service (NRCS) and other local organizations, offers free technical publications, educational workshops, and cost-share assistance for implementing stormwater Best Management Practices (BMPs). For more information contact your local RCD (see resources section on page 61).

MARIN COUNTY

Groundwater Management in Sonoma Valley A Success Story Begins



Groundwater resources have long played a significant role in the development, growth and sustainability of Sonoma County, with a significant portion of the water demand met by local groundwater resources. Sonoma County faces continued growth in population and demand for water. The Russian River and groundwater resources are the primary sources of that water. The challenge of increasing demand and other uncertainties necessitates thoughtful water management. With continuing and increasing demand on finite local groundwater supplies, overall groundwater storage has been and will continue to be depleted without appropriate actions in the near future.

In response to residents' concerns about future groundwater supplies, a collaborative group of twenty stakeholders, representing varied groundwater interests, has developed the Groundwater Management Program for Sonoma Valley. The group, called the Basin Advisory Panel, with public representatives from local agriculture, dairies, government, business, and environmental interests started meeting in August 2006. The Panel developed and recommended a non-regulatory Groundwater Management Plan (Plan) for adoption. The Sonoma County Water Agency, City of Sonoma, Valley of the Moon Water District, and the Sonoma Valley Sanitation District adopted the Plan in late 2007.

This Plan identifies a range of voluntary management actions to sustain groundwater resources for future generations. The primary goal of the Plan is to locally manage, protect, and enhance groundwater resources for all beneficial uses, in a sustainable, environmentally sound, economical, and equitable manner for generations to come.



Future Groundwater Management Planning in Sonoma County

The Sonoma County Strategic Plan outlines future groundwater management efforts through the Groundwater Basin Assessment and Management program. This program focuses on the most heavily populated groundwater basins in Sonoma County including: Alexander Valley, Santa Rosa Plain, and Petaluma Valley. Like the Sonoma Valley Program, the approach for each basin is to first conduct a scientific basin-wide study to provide a basis for the subsequent groundwater management planning activities, should stakeholders and the Sonoma County Water Agency's Board of Directors support the development of a groundwater management planning process. The Sonoma County Water Agency is currently investigating the feasibility of pursuing a groundwater management plan for the Santa Rosa Plain.

This guidebook empowers home and landowners to get directly involved in these critical efforts to protect and enhance our quality of life in Sonoma County today and for future generations. It provides straightforward best management practices that can help to protect and replenish groundwater resources, reduce erosion and pollution, while providing many other environmental benefits. Almost anyone can make a real and lasting difference that will help to improve and secure our quality of life. We encourage you to explore this resource guide and to "Slow it. Spread it. Sink it!"

CHAPTER 1

UNDERSTANDING AND EVALUATING STORMWATER RUNOFF AROUND YOUR HOME & PROPERTY

Most counties and cities in California are required by law to develop and submit a Stormwater Management Plan (SWMP) to the state. A SWMP must detail specific actions or practices, called Best Management Practices (BMPs) that will be implemented to minimize the effects of stormwater runoff. An example of a BMP is slowing runoff by temporarily storing it in a rain barrel or other containment system where it can be used to water plants or distributed out over the landscape once the rains have passed. Another example is allowing runoff to sink into the ground by directing it to landscape vegetation where sediment can be filtered out and contaminants reduced through bioremediation (use of plants and microorganisms to biologically break down and thereby remove pollutants). Low Impact Development (LID) is another common term normally referred to in larger scale developments that incorporate “green” stormwater management practices. Although new construction will soon be required to utilize BMPs and LID, many buildable areas of the county are already developed. It is essential that we each do our part to implement stormwater BMPs.

This guide will focus on BMPs that you can do at home. The BMPs are not complicated. They are geared toward residential homes or small developments and the underlying concepts behind them follow a simple mantra: Slow it. Spread it. Sink it!

- **Slow the runoff**
- **Spread it out in planters, gardens, or over other pervious surfaces - do not confine runoff to pipes**
- **Sink it back into the ground!**

This chapter divides your property into five major areas or “zones” that can contribute to runoff: 1) roofs, 2) elevated structure, 3) walkways and patios, 4) driveways and parking areas, and 5) bare soils and landscapes. It examines each zone for common problems related to runoff and suggests potential solutions. The end of the chapter provides instructions for a simple do-it-yourself evaluation of your property to assist you in choosing BMPs that suit your specific needs.



ROOFS

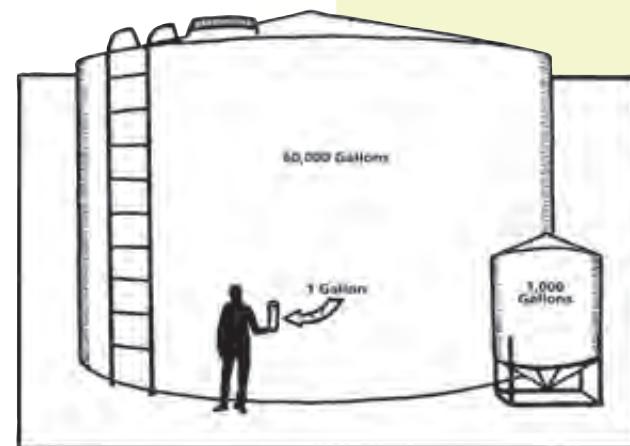
Your roof likely generates the most runoff from your home. While the majority of roofs are outfitted with gutters and downspouts, some are not, so protection measures for either possibility are discussed. Regardless of which system you use, all eaves and downspouts should be routed away from sensitive areas such as septic system leachfields, hillsides, and building foundations.

NON-GUTTERED ROOFS

If it is not possible to install gutters because of cost or other issues, you will need to protect the ground below the eaves which is referred to as the drip-line. Runoff from eaves can cause significant erosion and the resulting moisture can damage foundations and cause unhealthy mold to develop. A rain chain is an inexpensive option that can help direct water away from your foundation to an area where you can slow, spread and sink it.

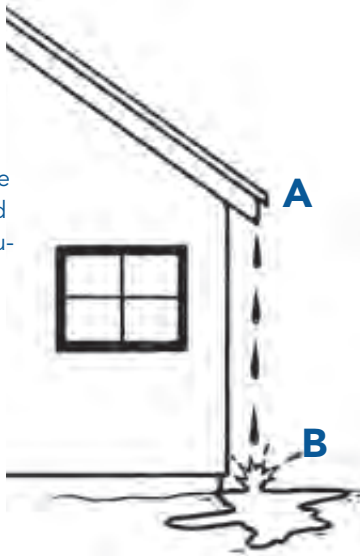

WHAT IS YOUR ROOF MADE OF?

Metal and tile roofs are preferred catchment surfaces. Composite roofs require the installation of a downspout diverter to filter the asphalt and contaminants out so that the water can be clean enough for irrigating edible garden crops.



DID YOU KNOW?

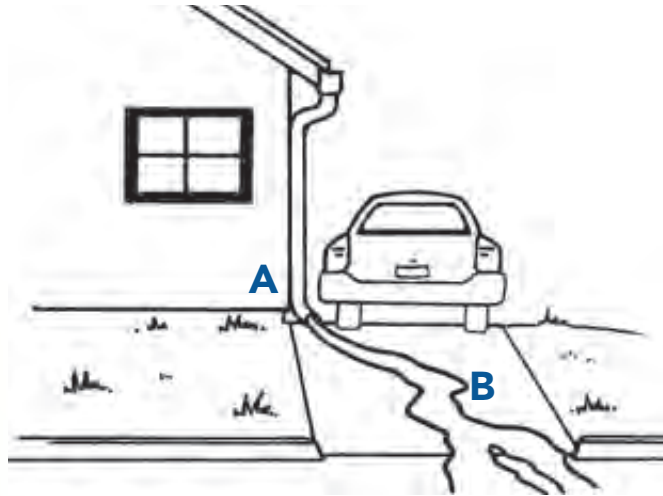
It takes only one inch of rain falling on a typical 1500-square-foot roof to generate approximately 1,000 gallons of runoff. Annual rainfall in Sonoma County typically ranges from 20 to 60 inches depending on where you live (residents at higher elevations generally receive higher amounts of rainfall). This means that in one winter, your roof alone could shed between 20,000 and 60,000 gallons of water as runoff!

POTENTIAL PROBLEMS	BMP SOLUTIONS
<p>A Non-guttered roofs can cause problems along the drip-line of your home</p> <p>B Water from a non-guttered roof can cause erosion, damage structures and foundations, and contribute to downstream pollution. Ponding near foundations can also cause unhealthy mold to develop.</p>  <p><i>Repairing mold and water damage</i></p>	<p>A Adding gutters and downspouts works to direct water to a safe location away from bare soil and buildings (see page 25).</p> <p>B Vegetated or rock drip-line protection SLOWS runoff thus reducing erosion and promoting Infiltration. It is also designed so that the ground slopes away from the home's foundation (see page 27)</p> 

GUTTERED ROOFS

Gutters and downspouts are excellent choices for handling roof runoff; however, they must be properly sized, managed, and maintained to prevent damage to property and the environment. Undersized gutters clog and overflow more frequently, which can damage foundations. Directing downspout runoff toward impervious surfaces like driveways is common but can contribute to downstream flooding, surface water pollution, potholes and other issues. ALWAYS avoid sending runoff toward hillsides, septic system leachfields, and buildings where they could cause significant damage to your property.

POTENTIAL PROBLEMS



A The downspout is directed toward an impervious (concrete) driveway that drains to the street. The resultant runoff may damage roads, exacerbate downstream flooding, or carry pollutants to nearby waterways.

B This driveway is constructed of impervious materials (concrete), and all of the runoff is directed toward the street. As above, the unconstrained runoff may result in detrimental effects to infrastructure and the environment.



Runoff from residential homes can carry pollutants to local streams that can be harmful to wildlife.

BMP SOLUTIONS

A Rain barrels, downspout diverters, and rain gardens are all potential solutions for treating downspout runoff by SLOWING water down and SPREADING it out (pages 29, 32, 33).

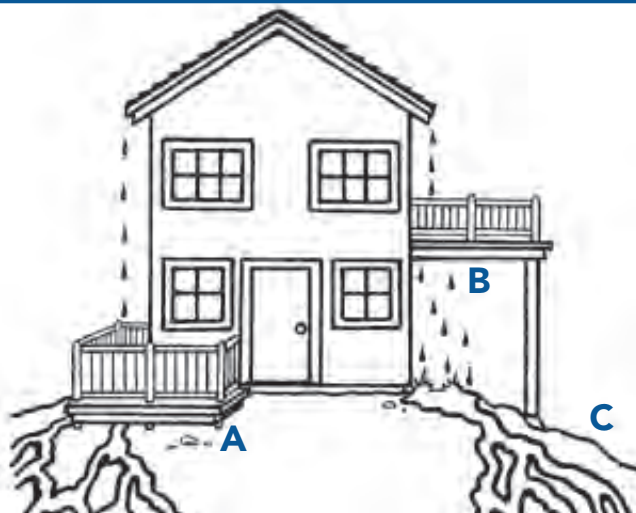


B See Driveways and Parking Areas (page 17).

ELEVATED STRUCTURES

The area underneath decks, outdoor stairs, and other elevated structures where water impacts the ground is called the drip-line. Significant soil loss, damage to supporting structures, or worse can occur if this area is not adequately protected. Where signs of erosion are present such as soil loss or uneven ground from water flow, it is important to take protection measures. Locations with over a 50% slope are particularly vulnerable and may require treatments designed and installed by a qualified licensed professional.

POTENTIAL PROBLEMS



A Low decks may prohibit the addition of protective ground cover, leaving bare soil to erode.

B The runoff from high decks impacts the soil with greater force than low decks. It can cause structural damage to supports and contribute to sediment and other pollutants entering nearby storm drains and streams.



Visible erosion under a deck is common.

C Runoff on steep slopes with bare soils can cause significant erosion and even landslides. Ground covers such as rock and mulch are hard to keep in place and can easily wash away.

BMP SOLUTIONS



A Adding drain rock or vegetation to the perimeter SLOWS and SPREADS water limiting the transport of sediment (pages 27-28)



B Adding drain rock SLOWS runoff and safeguards the drip-line area under elevated surfaces. Mulch around the perimeter adds extra protection to the surrounding bare soil (pages 27-28).



C Terracing or retaining walls may be added to sloped areas to keep rock or other mulch in place and protect hillsides (pages 44-45)

DID YOU KNOW?

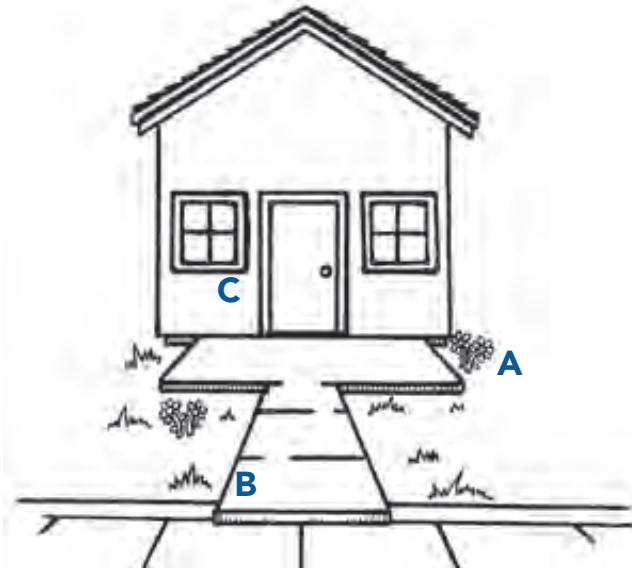
It's important to scoop your poop! Roundworms, *E. coli*, and *Giardia* are just a few of the many harmful microorganisms that can be transmitted from pet waste to humans. Some can last in your yard for as long as four years if not cleaned up. Children who play outside and adults who garden are at greatest risk of infection. Pet waste is also one of the causes of bacterial contamination of creeks in Sonoma County. The American Pet Products Manufacturers Association claims four in 10 U.S. households have at least one dog. That equates to over 186,000 dogs within Sonoma county and incorporated cities! Holy pooch! That's a lot of poop. Let's work to keep our families healthy and waterways clean. The solution is safe and easy: 1. Scoop the poop;



2. Put it in a bag (recycled or biodegradable bags are the best option);
3. Place it in the trash; and
4. Wash your hands.

WALKWAYS AND PATIOS

Walkways and patio areas often become conduits for runoff. For existing paved paths or patios look for areas of standing water or visible signs of erosion where the path or patio surface meets the soil. Does your walkway drain to the street or toward your house? When constructing a new walkway or patio always consider where it will drain. Angle it toward a vegetated area or try one of the new porous materials that reduce runoff and promote infiltration.

POTENTIAL PROBLEMS

A Foot traffic, even in low use areas, can inhibit plant growth and leave bare soil to erode.

B Walkways or other hard surfaces that drain to the street increase runoff causing problems downstream.

C Hard durable surfaces such as patios are often constructed of concrete or other impervious materials that don't allow runoff to infiltrate.



Residential runoff that drains to the street contributes to localized flooding.

BMP SOLUTIONS

A Mulch, gravel, or wood chips work well in low-traffic areas and allow for more runoff to SINK into the ground (page 40).



B Turf block works well for allowing water to SINK into the soil in medium-traffic areas or driveways with separate parking areas (pages 39).



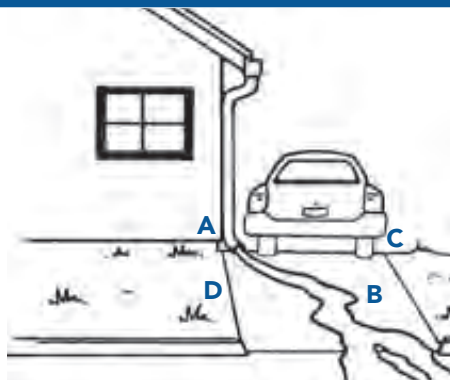
C Use paver stones for high-traffic areas and patios. For areas with excess runoff, use plant borders to allow more water to SINK into the ground (pages 38).

DRIVEWAYS AND PARKING AREAS

Traditionally driveways have been constructed to divert runoff directly to the street. That runoff can carry with it a variety of pollutants, such as oil and grease, soaps from car washing, leaked antifreeze and more. Your driveway also acts as a conduit for large volumes of roof runoff. Concentrating large volumes of water that outlet to the street increases the chances of potholes, flooding, erosion, adverse affects to wildlife and habitat degradation. Check to see where your driveway water goes and locate the nearest storm drain. There are now many alternatives available to replace impervious concrete and a variety of BMPs for addressing runoff on your driveway or parking areas. Mendocino and Santa Cruz RCD's publish useful guides on the design and maintenance of private residential and ranch roads. These publications can be found and or ordered online at: www.rcdsantacruz.org, and <http://www.mrcrd.org>. Your local Sonoma County RCD's also carry or publish related materials. Refer to the Resources Guide section on locating the RCD that services your watershed.

POTENTIAL PROBLEMS

A The downspout is directed toward an impervious (concrete) driveway that drains to the street. The resultant runoff may damage roads, exacerbate downstream flooding, or carry pollutants to nearby waterways.



B This driveway slopes toward the street and creates runoff potentially contributing to flooding, erosion, and pollutants in nearby storm drains and streams.

C This driveway is constructed of impervious materials (concrete), and all of the runoff is directed toward the street. The resultant runoff may damage roads, exacerbate downstream flooding, or carry pollutants to nearby waterways.



D Driveways that do direct water runoff away from the street can still contribute to erosion if the area collecting the runoff is not properly protected or maintained.

Driveways can act as conduits for excess amounts of runoff that can damage roads.

BMP SOLUTIONS

A See Guttered Roofs on page 25.



B A small speed bump known as a waterbar can be added to existing driveways to SLOW and SPREAD runoff to vegetated or rocked infiltration areas (page 43).



C Pervious concrete (pictured) or other materials such as paver stones or turf block, allow water to SINK into the soil decreasing runoff (pages 38-39).



D A rocky or vegetated swale lining the edge of a road or driveway reduces erosion potential by SLOWING runoff and then SINKING it back into the soil or directing it to a safer outlet (pages 34-35).

DID YOU KNOW?

We have all heard that cars contribute to air pollution. But, did you know they can also play a part in water contamination? Soap from car washing, oil and grease from leaking engines, zinc from tires, and copper from brakes can all end up in the water where we play, fish, live, and even drink! Keeping cars properly maintained, using only commercial car washes, that contain and recycle wastewater, recycling oil and antifreeze, recycling used batteries, keeping tires properly inflated, and simply driving less will all contribute to cleaner water for everyone!



BARE SOILS AND LANDSCAPES

Bare soils and sloped areas are the parts of any landscape which are most vulnerable to the impacts of runoff. Without a protective cover of vegetation, duff (decaying leaves and needles), or mulch (wood chips, etc.), these areas erode and increase runoff. Erosion reduces soil fertility, can compromise support structures for decks and buildings, and in extreme cases leads to catastrophic events such as landslides. Erosion on bare soils can be identified by uneven soil surfaces, depressions in the soils that create small gullies, and any sign that indicates soil loss. If water is flowing across bare soil anywhere on your property, at least some soil is being carried away (eroding). Since vegetation plays an important role in preventing soil loss, it is important to use plants adapted to your site. Some plants such as certain kinds of ivy or ice plant can actually hinder the stability of sloped areas due to poor root structure or added weight, and provide habitat for rats.

POTENTIAL PROBLEMS



A Bare soils are highly susceptible to erosion.

B In steeply sloped or hilly areas soil erosion is not only harmful to the environment, but can pose a serious threat to life and limb when land movement occurs.

C Moderately sloped areas are also prone to erosion and can cause damage to surrounding structures if they become unstable.



Bare soils are susceptible to erosion and increase runoff that delivers sediments and other pollutants to streets and storm drains and eventually to local waterways.

BMP SOLUTIONS



A Mulch protects soil from direct rain impact and SLOWS runoff across bare soils (page 40).



B Retaining walls help hold sloped areas in place and SLOW runoff. They also add beauty to a landscape and can double as benches and planter boxes (page 44).



C Using carefully chosen vegetation can help SLOW and SPREAD runoff in order to prevent soil erosion on hillsides. Ceanothus (pictured) is one example of a shrub that does well in areas with full sun and requires little to no summer water once established (page 27).

DO-IT-YOURSELF STORMWATER RUNOFF EVALUATION

To discover where you can implement BMPs that draw on the fundamentals of “slow it, spread it, sink it,” we recommend that you conduct a simple do-it-yourself evaluation of your property. The evaluation consists of a walk around your property on a rainy day to record observations of the 5 zones (see page 12) and how runoff is currently handled, where runoff is going, and where there might be potential for installing BMPs. The kids can even don their rubber boots and join you!

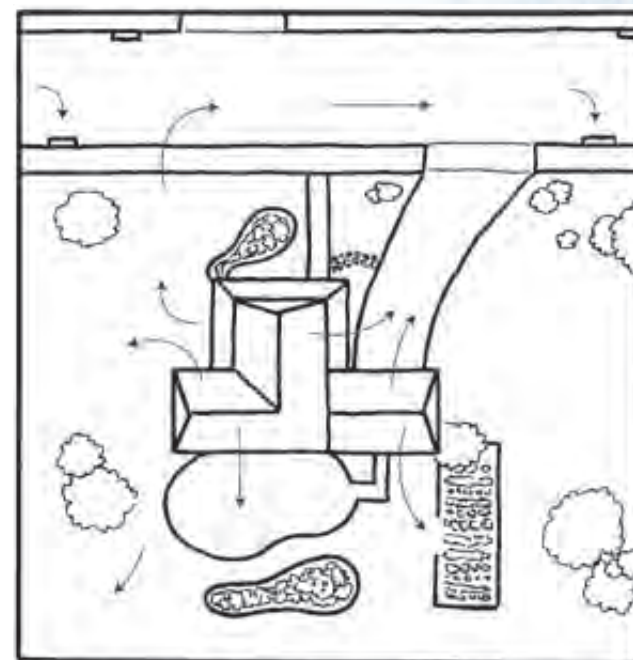
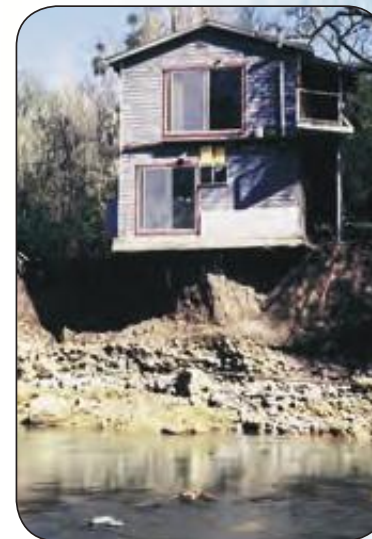
1) TOOLS. Below is a list of items you will need:

- rain gear
- a clipboard with scratch paper
- a simple sketch of your property
- a pencil (ink may run if it gets wet)
- an umbrella (to keep the paper dry)
- camera

2) SKETCH YOUR PROPERTY. Your sketch will be used to record observations about where the runoff comes from and flows to. The sketch can be very simple. It should include property boundaries, an outline of your house and foundation, outbuildings, driveways, areas of bare soil and any major vegetation (trees, lawns, etc.). Also note how close you are to the nearest stream, storm drain, or ditch that carries water away from your property. If you aren’t sure, see if you can find it on your walk! If you need assistance, it is always good to take photographs when water is flowing! You can then schedule an appointment with a local RCD staff member (see Resources Guide section) to help you evaluate your runoff using your recorded observations and photographs.

3) WALK YOUR PROPERTY. Once you’ve gathered all of the tools and completed an initial property sketch, head outside on a rainy day for the stormwater evaluation walk. For the most accurate results, do not choose the first storm of the season or go out during the first few minutes of rain. Wait until there have been at least one or two good rain events (more than a ½ inch). Go out during a subsequent storm once you see water flowing on your property. During the walk, you can record stormwater runoff observations by drawing arrows that follow the direction of water movement on your property (see sample drawing). You can also record potential locations where you might apply the BMPs listed in chapter 2. For example, if you have a downspout that currently drains to a driveway, look around and note locations where you might direct the runoff to a rain garden or hook up a rain barrel.

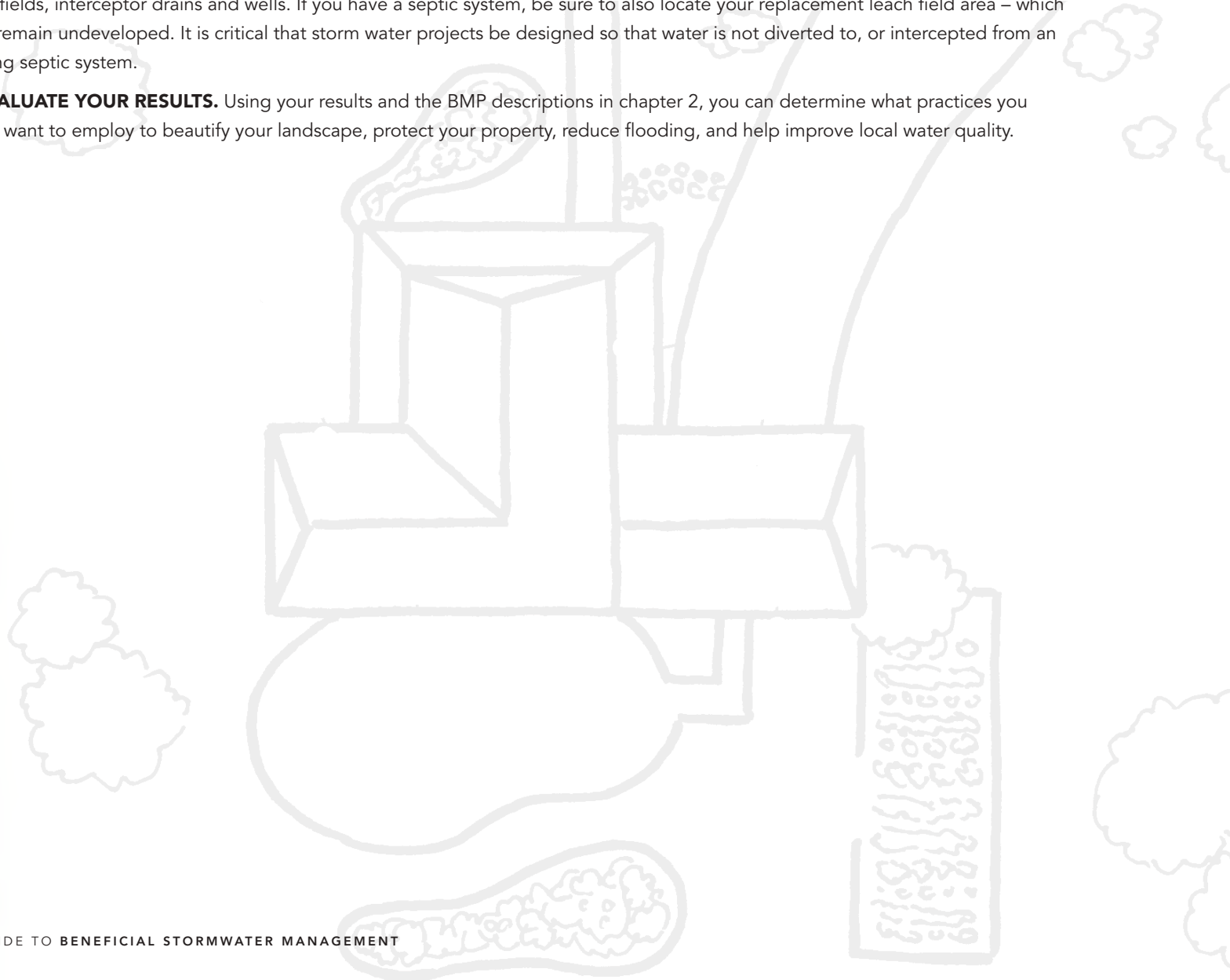
4) KNOW YOUR SOILS AND RAINFALL RATES! This is one of the most critical pieces of information you need. Soil maps are available through the local RCD and NRCS offices and online at <http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>. However, it is highly recommended that you consult a professional for an evaluation of the soils at your location. Soils with poor infiltration rates are NOT RECOMMENDED for many of the BMPs described in this guide. A rainfall map is also available through your local RCD and NRCS offices.



5) ASSESS POTENTIAL POLLUTANTS. Determine what your roof is made of: Asphalt shingles, metal, etc. Do you live in an area with significant air quality concerns such as heavy industry or high traffic volume? Do your automobiles leak oil and or antifreeze in your driveway? Both are highly toxic to pets and the environment. Identify these potential sources of pollution, mitigate wherever possible and then determine areas that need to be protected from pollutants and erosion.

6) LOCATE SEPTIC SYSTEMS AND WELL, IF APPLICABLE. Determine required local, county or state setbacks from septic tanks, leach fields, interceptor drains and wells. If you have a septic system, be sure to also locate your replacement leach field area – which must remain undeveloped. It is critical that storm water projects be designed so that water is not diverted to, or intercepted from an existing septic system.

7) EVALUATE YOUR RESULTS. Using your results and the BMP descriptions in chapter 2, you can determine what practices you might want to employ to beautify your landscape, protect your property, reduce flooding, and help improve local water quality.

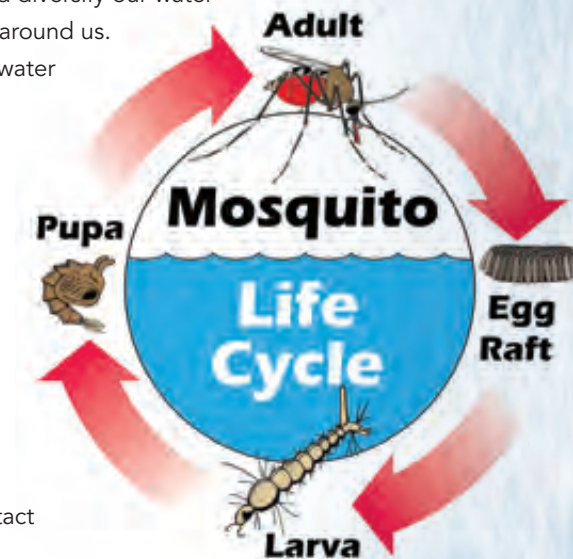


A WORD ON STORMWATER MANAGEMENT AND MOSQUITO CONTROL

Mosquitoes need standing water to reproduce. When open water is left to stagnate, mosquito populations can soar. In addition to the nuisance of an itchy bite, mosquitoes also have the capability to transmit disease. While we strive to conserve, protect and diversify our water supplies it is also our responsibility to maintain a healthy environment that does not harm or affect the health of those around us. To prevent unwanted mosquito breeding, please remember to follow these mosquito-proofing tips for standard stormwater management and water conservation practices:

FOR RAINWATER COLLECTION SYSTEMS:

- Use barrels with a mosquito-proof screen (fine mesh - 1/16th of an inch) under the lid and covering the overflow hole
- Keep your rain barrel lid and all connectors in the system sealed
- If possible, place your barrel on a surface that will soak up or promptly drain water that has overflowed
- Keep your barrel free of organic materials such as leaves and debris
- Remove water that may have pooled on the top of the barrel at least 1 to 2 times a week or use a barrel with a self-draining lid
- Use a downspout diverter to direct water into the barrel
- Inspect the system on a regular basis to be sure there are no cracks or leaks and that all seals and fittings remain intact
- Keep gutters and downspouts clean and free of debris



FOR LARGE WATER TANKS/CISTERNS:

- Cisterns (above and below ground) should be completely enclosed with no openings to the outside environment
- Tightly seal cistern lids and connections
- Cover all inlets, outlets, and vents with mosquito-proof screening (fine mesh -1/16 of an inch)
- Inspect on a regular basis to be sure there are no cracks or leaks and that all seals and fittings remain intact
- The area surrounding cisterns should be designed to either divert or absorb excess water from overflow
- The inside of the cistern must be accessible for periodic maintenance as well as inspection by mosquito control personnel

BEST MANAGEMENT PRACTICES (BMPs) FOR MOSQUITO CONTROL IN SWALES, RAIN GARDENS, AND INFILTRATION SYSTEMS:

It is important that stormwater treatment, storage, infiltration structures and systems are designed and properly maintained. Correct design and maintenance minimizes the potential for mosquito production, repeated mosquito larvicide applications, mosquito-borne disease transmission, and other public health issues.

Stormwater treatment features such as rock-lined swales, rain gardens, and retention basins should not contain standing water in excess of 48-72 hours.

The following list provides examples of how to minimize mosquito production when implementing Stormwater BMPs

PLANNING

- Select and maintain proper grade for water conveyance (e.g. swales, retention features, cross drains)
- Systems should completely de-water (drain) within 72 hours to prevent mosquito breeding
- Avoid loose-fitting rock or rip rap that may trap water, creating an ideal environment for mosquito production
- Systems should be easily accessible
- Use caution when installing any type catchment system that holds 18 or more inches of water as this poses a potential drowning hazard

VEGETATION

- Choose appropriate vegetation for the specific project
- Native, low-growing vegetation is preferred to minimize the potential for mosquito production in stormwater treatment systems and allow for efficient mosquito control, if necessary
- Do not plant cattails or other aquatic plant species that can become invasive such as creeping water primrose (*Ludwigia* species), water hyacinth (*Eichhornia*), and parrot feather (*Myriophyllum* species)
- Do not surround rain gardens, swales, or retention features with dense vegetation that could hinder access

MAINTENANCE

- Develop and adhere to a maintenance plan and schedule
- Periodic sediment removal may be necessary to minimize mosquito habitat (e.g. swales, retention features, cross drains) and maintain proper function
- Aggressively manage unwanted vegetation
- Mow or thin out vegetation regularly to avoid overgrowth, ensure proper system function, and facilitate access
- Keep inlets and outlets serviceable and free of debris

*If you are experiencing a mosquito problem or would like more information about controlling mosquitoes, contact the Marin/Sonoma Mosquito and Vector Control District.

Marin/Sonoma Mosquito & Vector Control District
 595 Helman Lane
 Cotati, Ca 94931
 1-800-231-3236 or 707-285-2200
www.msquito.com



CALL BEFORE YOU DIG!

Underground Service Alert (USA) is a FREE service available to anyone planning a project that entails digging. It is simple and easy to use. Before calling USA, outline your digging location with white chalk paint or another medium clear enough to enable USA underground facility members to determine the area of digging. Two working days BEFORE you start your project, call 811 or 1-800-227-2600. USA will contact the appropriate agencies to come and mark any utilities that may interfere with your project location. For more detailed information, visit USA North online at www.usanorth.org.

CHAPTER 2

BEST MANAGEMENT PRACTICES FOR STORMWATER RUNOFF AROUND YOUR HOME

Disclaimer: The Best Management Practices (BMPs) described in this guide are provided exclusively for general educational and information purposes. The guide is intended to help landowners consider their current management practices and to identify concerns and potential solutions. Any BMP should be installed with the consultation of an experienced professional who can address specific site conditions. This chapter outlines a number of well-established practices along with recently introduced options for managing stormwater runoff.

Managing stormwater on your property is not a new idea. Most residential homes were constructed using the runoff methods of the era in which they were built. For the past 50 years, that approach has been to direct runoff away from the property as quickly as possible using pipes and pavement. While largely effective, we now recognize that this approach only shifted problems downstream. We are now experiencing the consequences of those methods in a variety of ways including increased potential for flooding, damage to public and private property, stress on our water supplies, and degradation of our local waterways and habitats. The **Best Management Practices or BMPs** (practices thought to be the most practical and cost-effective) recommended in this guide move away from the old “pipe it and pave it” model and toward the slow it, spread it, sink it approach: slow the water down, spread the water out, and sink the water into the land. This notion is at the heart of these practices and is a simple mantra you can use to address the runoff on your own property. The following chapter includes information on a variety of BMPs. Find the one that best fits your needs, your pocketbook, and your unique site conditions. Following this chapter is a must-read section on difficult locations and site constraints. While this guide presents great ideas, it is critical to recognize when and where they are NOT appropriate.









Before embarking on any new project please remember:

1. In many cases a simple **change in management** of your current system may be all that is needed to minimize negative impacts of stormwater runoff. Each BMP includes details on maintenance. It is important to recognize that each BMP requires ongoing maintenance to remain effective, and to factor this maintenance into your plans. If you already use one of the listed BMPs, please review the maintenance section for tips on getting the most out of your existing features.
2. **Vegetation** plays several important roles in the function of BMPs, which may include:
 - Slowing down water and physically removing sediments
 - Helping to stabilize slopes through their root structure and reduction of rain impact on the soil
 - Biological removal of nutrients and other pollutants (bioremediation)
 - Improving soil infiltration
3. **Structural practices** are usually more expensive to install and maintain while placing a greater strain on resources and the environment. Structural practices should only be used when management changes or vegetation is not an option.
4. **ALWAYS check with applicable regulatory agencies to determine if a permit is necessary for any project.** Examples of projects for which a permit may be required include building a retaining wall, installing a large cistern, sending runoff to a creek or stream, and directing water to a neighboring property. For a list of resource agency contacts see page 61.
5. **CALL BEFORE YOU DIG!** Call 811 or 1-800-227-2600 for assistance from Underground Service Alert (USA). See expanded information to the left.



6. Important BMP Considerations for Properties with Septic Systems: In Sonoma County there are an estimated 45,000 homes served by onsite sewage disposal systems (aka septic systems). Not only do these systems have subsurface leach fields where the household sewage is treated and disposed of, but many also have subsurface drains (interceptor drains) associated with their design. It is imperative that any planned storm water BMP be designed to not intercept subsurface sewage or interfere with the functioning of a septic system or interceptor drain. When you are in the stormwater BMP design phase, always check with your local jurisdiction first for the location of your septic system and leach field replacement area. If there are no records available, consult with a qualified individual to locate your system and its replacement area prior to design of the BMP's. Septic systems also have statutory setback requirements that you will need to consider when planning storm water BMPs.

BENEFITS OF STORMWATER MANAGEMENT

	BENEFITS
	Conserves water
	Promotes groundwater recharge
	Enhances & creates wildlife habitat
	Improves landscape aesthetics
	Reduces peak flows or runoff timing
	Reduces erosion
	Protects infrastructure
\$	COST
\$\$	Low cost
\$\$\$	Medium cost
\$\$\$	High cost
E	INSTALLATION DIFFICULTY
M	Easy
C	Moderate
	Complex

The **Best Management Practices (BMPs)** described in this chapter include general information on the benefits of each practice, an estimated cost range of low to high, and a level of difficulty for installation by the homeowner. It is additionally noted where using a qualified licensed professional is highly recommended. Potential benefits include the following:

Conserves water: Potable water use for irrigation can be offset by capturing rainwater, using plants with low water needs OR directing runoff water to areas where it can be stored in the soil for later use by plants.

Promotes groundwater recharge: Allowing more water to sink into the soil helps to protect our aquifers by enhancing recharge.

Enhances and creates wildlife habitat: When installing BMPs that use vegetation, choosing appropriate plants can create habitat for local wildlife and act as natural pest control.

Improves landscape aesthetics: Many of the BMPs in this guide can actually beautify your landscape

Reduces peak flows or facilitates runoff timing: Peak flows occur when runoff reaches its highest point. By changing the timing of our residential runoff, we can reduce peak flows and mitigate flooding and erosion potential.

Reduces erosion: Practices that reduce erosion limit the loss of top soil and reduce the volume of sediments entering local streams.

Protects infrastructure & increases property value: These practices help reduce runoff that could damage structures, foundations, or public infrastructure such as roads. Sound stormwater BMPs will also increase the value of almost any property.



Gutters and Downspouts

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USES: ROOF RUNOFF

Sonoma County and the incorporated cities may have specific requirements for installing gutters and downspouts. Since requirements often change, we have provided general guidelines, but you should contact your respective planning/building department for more detailed information. See the resources section on page 61 for agency contact information.

NEW INSTALLATIONS OR RETROFITS

Properly sized gutters and downspouts are crucial for proper performance. While installation is fairly simple, calculating the correct size system for your roof can prove more difficult. You will need to know your roof area and pitch or slope and your location's annual rainfall. We recommend contacting a local qualified professional to assist with calculating correct gutter and downspout sizes.

Also consider where your downspouts drain. Wherever possible and safe, divert downspouts AWAY from impervious surfaces such as concrete driveways, walkways, or compacted soils and instead direct them to well vegetated areas of your property to allow runoff to SINK into the soil. This decreases water volume on streets and in storm drains and reduces the potential for downstream flooding while promoting infiltration.

General guidelines for selecting and installing gutters and downspouts or improving capacity:

GUTTERS

Select gutters at least 5 inches wide. Use materials made from galvanized steel (29 gauge minimum) or aluminum (.025 inch minimum). To enhance flow, slope gutters according to the manufacturer's recommendations (commonly 1/16 inch to 1/8 inch per 1 foot of sectional gutter; or 1/16 to 1/8 inch per 10 feet of seamless gutters). Tilt the gutter forward keeping the front 1/2 inch lower than the back. For straight runs exceeding 40 feet, use expansion joints at connections. Select elbows with 45, 60, 75 or 90 degree angles, as needed.



GUTTER PROFILES



Half Round



Ogee

Gutters not only come in different sizes, they come in different shapes too. It's important to understand that the shape of your gutter determines the amount of water it can handle from your roof during a storm. Ogee shaped gutters, for example, can handle more water than rounded gutters. However the ogee gutter's sharp edges and corners can collect sediment and debris.

DID YOU KNOW?

A RAIN CHAIN can be used instead of a downspout.

Rain chains ('kusari dio' in Japanese) have been used for hundreds of years in Japan. Not only are they visually appealing, they also provide some runoff reduction through evaporation and spillage. When installing rain chains, make sure to take the same precautions for outlet protections as you would with standard downspouts. For more information visit a local retailer or www.rainchains.com.

**DOWNSPOUTS**

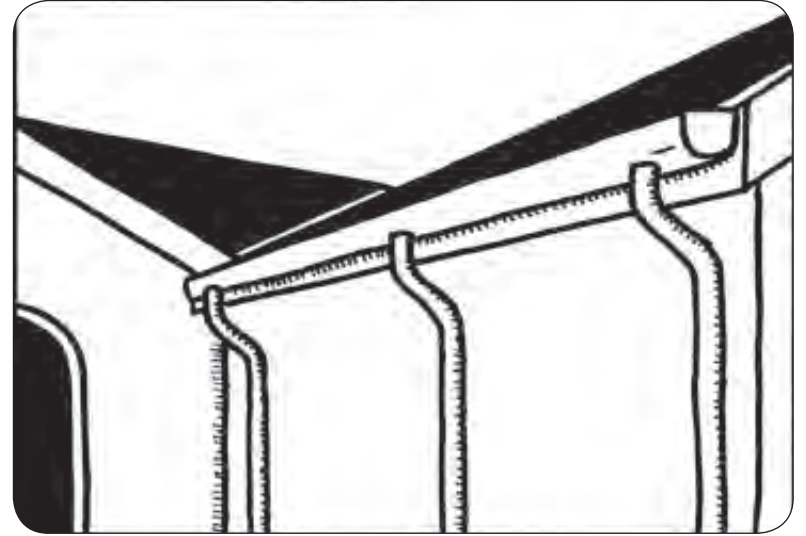
Space downspouts from 20 to 50 feet apart. Adding additional downspouts can increase capacity where necessary and help SLOW water down and SPREAD it out. Do not exceed 45-degree angle bends. Where needed use 4-inch-diameter extensions (flexible or rigid) to convey water to infiltration areas such as rain gardens and swales or to other safe outlets away from structures and steep slopes. All downspouts and pipes that outlet onto surfaces without substantial vegetation cover should use one of the outlet protection BMPs described on page 32. Do not direct downspout outlets to driveways or other impervious surfaces unless there are no safe alternatives. Instead, route them to vegetated areas. When harvesting water from your roof, loose asphalt, leaves and twigs can be prevented from entering storage tanks by installing a downspout diverter.

MAINTENANCE: Setting up a maintenance schedule is one of the easiest and most cost-effective solutions to many roof runoff issues. Clean your gutters at the beginning of each rainy season and as needed throughout the winter. In areas with dense trees or vegetation, trim trees and vines away from gutters to maintain a minimum 24-inch clearance zone. Add gutter guards to reduce debris buildup. You can also add a drip-line treatment (page 27-28) below gutters that clog often. Check your system for leaks, damaged parts, rust, and evidence of past erosion. Make sure to check hidden outlets under decks or staircases that might be forgotten. Also see page 21 for information on how to prevent mosquito breeding.

Always check and clean gutters after severe storms.

DO

- Direct runoff to a rain garden or swale.
- Collect runoff in a rain barrel or cistern.
- Check and clean gutters after severe storms.
- Install downspout diverters when harvesting water from your roof.



Adding an additional downspout helps reduce the volume and velocity of runoff at any given point reducing the potential for erosion.

DON'T

- Release water onto bare soil.
- Direct runoff to steep slopes or foundations.
- Send runoff onto a neighbor's property.
- Promote standing water.

Drip-Line Protection



USES: BELOW ROOF EAVES, UNDER DECKS OR ELEVATED STRUCTURES

A drip-line is the area below any elevated surface that receives runoff. For roofs it is the ground below eaves that do not have gutters installed. For decks and other elevated surfaces it is the area underneath where water drips through (e.g., the area between and below the deck boards). Drip-line BMPs create a barrier to protect exposed soil and reduce erosion. The protective cover also SLOWS runoff and allows it to SINK back into the soil. This is critical in areas where runoff-induced erosion could reduce the effectiveness of support structures and footings. Drip-line protection is also a great addition where gutters frequently overflow due to large amounts of debris.

VEGETATION PROTECTION FOR DRIP-LINES

Roof drip-lines: Homeowners can establish and maintain mature vegetation below their roof drip-lines. If there is existing vegetation (such as turf or a bordered planter bed), simply maintain these areas. Examples of adequate drip-line vegetation include the following:

- Healthy grass or turf that has been established directly up to the foundation of your home
- Plants, shrubs, or flower beds that are completely bordered by wood, rock, or turf with mulch between vegetation covering any bare soil

Contact the RCD, the local native plant society (NPS), native plant nursery, or a qualified professional for assistance with plants well-adapted to your specific location. See page 61 for contact information.

Deck/stair drip-lines: Where adequate sunlight is available, planting hardy ground cover, grasses, or other low growing vegetation is a good low-cost option for protecting soil from erosion beneath decks and stairs. Use drought tolerant plants that do not require supplemental watering, once established, to prevent additional runoff or water near a structure. If you have structures on your property that are low to the ground and are inaccessible underneath, try planting around the perimeter.

MAINTENANCE: Periodic mowing, pruning, and replacement of plants is needed. Inspect the foundation to ensure water is not saturating or eroding the structure or foundation. Keep fertilization to a minimum as it can contribute to excess nutrients in runoff. If you do fertilize, always follow the manufacturer's instructions and never apply in excess or prior to forecasted rain.



DO

- Use California natives or drought tolerant plants.
- Keep plants well pruned to allow adequate ventilation.
- Keep soil a minimum of 6 inches below siding.
- Minimize fertilization to prevent water contamination.
- Try organic fertilizers and pest controls.

DON'T

- Plant invasive species such as periwinkle (Vinca Major) or ivy.
- Plant highly flammable vegetation.
- Allow irrigation water to drain to your driveway, the street, or onto bare soil.

HARDSCAPE PROTECTION FOR DRIP-LINES

Roof drip-lines: Wood chips, mulch, or gravel can be used to protect soil from erosion and promote infiltration into soils with high permeability (sandy soils). Install gravel or mulch under the drip-line at a minimum depth of 3 inches. This treatment must extend 6 inches inside the eave and a minimum of 12 inches beyond the eaves of a single-story roof, 18 inches beyond the eaves of a two-story roof, and 24 inches beyond the eaves of a three-story roof. This treatment prevents erosion and allows runoff to infiltrate. Three-quarter inch to one and a half inch washed drain rock is an adequate size to prevent the rock from being moved by rainfall; however, you can use any kind of rock you would like to achieve desired aesthetic effects on your property. Installing non-woven geotextile fabric beneath the rock and then bordering the rock with wood or other material will reduce maintenance and increase effectiveness. You also need to

ensure that the ground slopes a minimum of 5% AWAY from the foundation for a minimum of 10 feet.



Deck/stair drip-lines: To protect the soil under elevated decks, stairs, and walkways from erosion, install a three-inch layer of drain rock under the entire footprint of the structure and extend one foot past its edge. If you have structures on your property that are low to the ground and are inaccessible underneath, install a three-inch layer of rock or other mulch approximately twelve inches wide around the outside perimeter of the structures. This treatment will slow runoff velocity and reduce erosion potential. It is only necessary to install drain rock under and around these structures if there is not adequate vegetation established. Installing non-woven geotextile fabric beneath the rock and then bordering the rock with wood or other material will reduce maintenance, help control weeds, and increase effectiveness. You also want to ensure that the ground slopes a minimum of 5% AWAY from the foundation for a minimum of 10 feet.

MAINTENANCE: Periodic replacement of gravel or mulch will be needed. Inspect the foundation to ensure that water is not saturating or eroding either the structure or the foundation.

DO

- Use existing rock or mulch from your property.
- Use rock from a local quarry.
- Make sure rock is washed.

DON'T

- Use rock under three-quarter inch in size.
- Allow runoff to flow TOWARD the house or structure.

Rainwater Collection Systems

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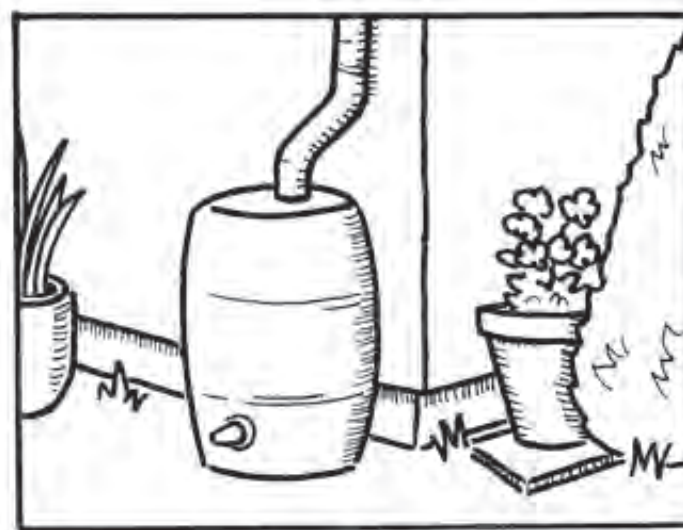
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USES: COLLECT AND STORE WATER FROM ROOFS

Rain tanks and cisterns can be placed outside buildings to store water collected from roof downspouts. The stored water can then be used for irrigation. Collecting and storing water from roofs is an excellent way to SLOW water down by temporarily storing it. Captured water can be reused for irrigation or other non-potable options or metered off slowly after storm events to allow for infiltration and reduced flooding.

RAIN BARRELS are small- to medium-sized containers placed outside buildings and connected to roof downspouts to collect runoff for later use in non-potable applications. Rain barrels have many advantages in urban settings. They take up very little space, are inexpensive, and easy to install. Rain barrels conserve water and reduce the volume of runoff moving off-site.



MAINTENANCE: Rain barrels require regular draining after rainstorms and removal of leaves and debris collected on screens. Always check that the overflow is clear and directed to an appropriate location. Fine mesh screens should be used to seal lids and vents. A hole as small as 1/16 of an inch can allow mosquito access and result in significant larvae production.

DID YOU KNOW?

Sediment and debris that collect in the corners and edges of gutters support the growth of bacteria, mosquitoes and other organisms that could contaminate rainwater and spread disease. Because rounded gutter systems have fewer edges than their square-cornered counterparts, they provide cleaner water for rainwater catchment systems.



DO

- Use water regularly.
- Use gravity to your advantage.
- Use multiple barrels where possible.
- Keep barrels sealed and maintained to eliminate debris and mosquito breeding.

DON'T

- Allow access for mosquitos, rodents, children, pets, or debris.
- Use for drinking.
- Capture water from roofs with excessive debris (e.g., leaves, pine needles, or bird droppings.)

WATER TANKS (CISTERNS) are manufactured water storage containers for non-potable use in residential, commercial, or industrial applications. Water tanks can be installed both above and below ground. Some tanks come as sectional pieces that can be put together to fit different space constraints. Tanks can be used with most guttered roofs to collect runoff and reduce runoff volume. Both water tanks and rain barrels can be used without pumping devices, instead relying on gravity flow. However, depending on the desired use for the water, a pump may be necessary for best performance.

Larger tanks can be designed to also function as privacy screens, fences, or small retaining walls. Tanks can also be hidden under decks or serve as the foundation for play structures or other landscape features. Get creative!

Underground tanks are excellent options for areas with limited space. However, do not install underground systems beneath the path of vehicles or heavy machinery traffic unless they have been engineered for that purpose. Extra precautions may be needed when placing tanks in locations with high water tables or saturated clay soils. Contact an experienced licensed professional for tank installations under these conditions.

Basic components of a rainwater collection system:

■ Catchment surface

This is normally a roof, but there are other options.

■ Gutters and downspouts

Round gutters are recommended because they are less likely to collect sediment in corners and edges. This sediment can then support bacteria growth.

■ Screening of tanks or barrels and downspout openings

■ First-flush device/Downspout Diverter

■ Water tanks

There are various options including manufacturing on-site.

■ Water tank vent

■ Overflow device

This should be equal to or larger in diameter than the inflow pipe to avoid backup.

■ Faucet and valve

■ Filters and pumps (optional)



Underground systems can be customized to fit various shapes and sizes using these modular RainBoxes.

MAINTENANCE: Remove accumulated sediment and debris annually and inspect all components such as gutters and downspouts regularly. The inside of the tank must also be inspected. Look for system leaks and cracks. Check all connections and hoses for wear and all screens or mesh for debris accumulation and holes. Make sure overflow is clear and directed to an appropriate location. Inspect all seams for leaks. Follow all manufacturers' recommended maintenance for any storage device.

DO

- Obtain necessary permits for tanks over 500 gallons.
- Secure tanks with straps for protection from earth movement.
- Use gravity to your advantage wherever possible.
- Keep underground tanks a minimum of ¼ full at all times to prevent collapsing of certain tank types.
- Place tank in an accessible location

DON'T

- Place tanks on steep hillsides.
- Place water tanks below ground unless they are approved for this use.
- Collect water from cedar or highly degraded roofs.
- Collect roof water from areas prone to large amounts of debris (leaf litter, etc.)
- Use or install older type cisterns with open tops or sides

Outlet Protection

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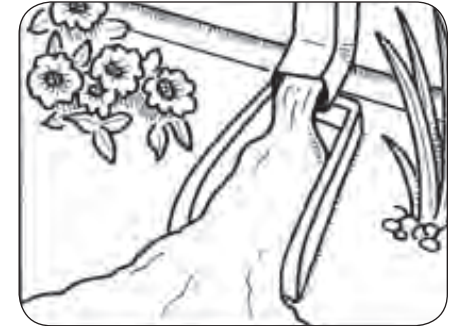
USES: DOWNSPOUT, PIPE, OR CULVERT OUTLETS

One of the most overlooked parts of a drainage system is the outlet of downspouts and pipes. Outlets should not release water onto bare soil or to an area prone to erosion. On the other hand, discharging water onto hardened impervious surface eliminates infiltration and increases the velocity of water that is directed to streets and streams creating a new set of challenges. All outlets that drain onto soils or other erodible surfaces should have some type of outlet protection. The BMPs below work to SLOW water down and/or SPREAD it out so it can SINK back into the soil.



SPLASH GUARDS are simple devices that reduce the initial force of the water at the outlets and allow it to SPREAD out into an area of vegetation or an appropriate infiltration area and SINK back in to the soil.

A HOSE ADAPTER is a neat option (Drought Buster East Connect is pictured) that allows a standard garden hose to connect directly to a downspout. The hose can then be moved to different locations of your yard when it rains. It is perfect for watering trees or keeping any one area from becoming too saturated by allowing the water to SPREAD out through the landscape.



ROCK DISSIPATORS are placed at outlets to SLOW runoff by reducing the initial impact of concentrated, high velocity runoff. For downspout outlets there are several easy creative options like filling a large plant container (it must have drain holes) with pebbles or placing rock on the ground surrounded by a wood border (similar to a rock drip-line). Large containers (1/2 wine barrels are an inexpensive option) with established plants and a thick layer of mulch (wood chips or gravel) also work well. Make sure that the drainage from under the pots flows away from your foundation.



For culverts or outlets with drain pipes over 8 inches in diameter, rock must be properly sized to prevent movement and placed with filter fabric underneath. Angular rock is typically recommended for high velocity flows because it locks in place and has a greater capacity to slow the water than rounded rock or broken concrete which tends to have some smooth edges. Rock should be carefully laid by hand forming an evenly lined depression or basin with no spaces between the rocks. It is highly advisable to contact a licensed qualified professional for design assistance. Generally speaking, work done at any outlets that drain directly into a waterway will need a permit. Contact your local RCD for permitting assistance or see page 61 for a list of agencies.

DO

- Direct downspouts to vegetated areas or rock dissipators.
- Protect ALL outlets on your property.

DON'T

- Allow water to pond near foundations.
- Direct water to driveways or other impervious surface that drain directly to the street.
- Allow large spaces between rocks that can hold stagnant water

Rain Gardens

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USES: ROOF, WALKWAY, DRIVEWAY, OR PARKING AREA RUNOFF

A **rain garden** is a specialized landscape design that captures stormwater runoff from roofs, driveways, or other impervious surfaces and allows water to SINK back into the ground. It uses plants to remove pollutants and improve infiltration allowing water to soak back into the ground. In soils with low permeability this system may be used to temporarily store water (not completely infiltrate) and remove pollutants before they enter a waterway.

A rain garden design can be as simple as a shallow depression filled with plants that can flourish in both moist and dry conditions. The required size, shape, and depth of the garden depend on how much water you are trying to capture. For large amounts of runoff or areas with insufficient infiltration, there are a full spectrum of engineered features, such as specialized soil mixtures, an aggregate base, and subsurface drains that can be added. These more complex designs are often referred to as bioretention cells.

Plant the center of the garden with species that tolerate wet conditions, such as native sedges and rushes. Around these, put plants suited to occasional standing water, like Yellow Monkeyflower (*Mimulus guttatus*) or California Aster (*Aster chilensis*). At the furthest edges there are a variety of native evergreen and deciduous shrubs that prefer drier soil. Contact your local RCD (page 61) or a local plant nursery knowledgeable in native and drought tolerant species for more suggestions. Rain gardens should be located at least 10 feet from your house and at least 40 feet from a septic system or steep slope. They should also be designed to drain within 48 hours to reduce the risk of standing water and mosquito breeding (see page 21 for more info). Rain gardens are a beautiful way to protect your property from erosion and protect the water quality of local creeks. They can enhance the aesthetic value of a site; be used on small parcels of land, easements, and right-of-ways; and are easily incorporated into existing landscapes or open space.

MAINTENANCE: Routine maintenance is required and can be performed as part of the regular site landscaping program. Weeding and irrigation are essential in the first couple of months while plants become established. Annual pruning and mulching are recommended. Additional irrigation may be necessary during drought years. The use of native, site-appropriate vegetation reduces the need for fertilizers, pesticides, excessive water, and overall maintenance.

DO

- Use California native or drought tolerant plants as appropriate.
- Minimize fertilization to prevent water contamination and try organic options.

DON'T

- Site in soils with high water tables or clay soils without an overflow device.
- Place too close to your home's foundation.





Swales

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USES: ROOF, WALKWAY, DRIVEWAY, OR PARKING AREA RUNOFF; LOW TO MODERATELY SLOPED HILLSIDES

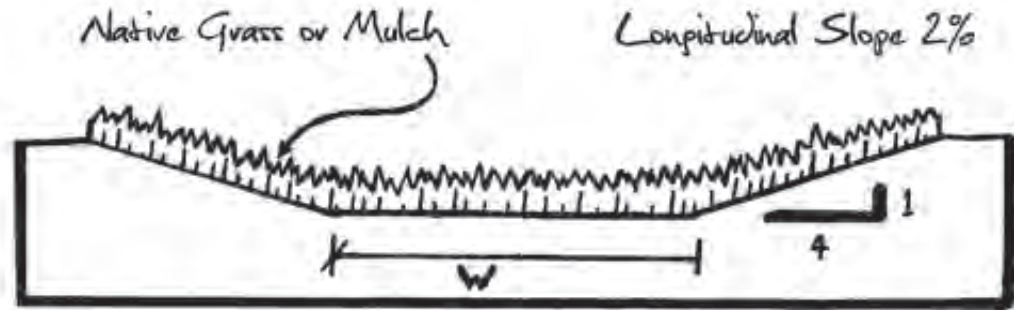
Swales are shallow channels designed to SLOW water down, SPREAD it out and allow it to SINK into the soil during low flows. Once saturated, they convey water to a safe outlet such as a rain garden (page 33) or other infiltration areas. They can be formed to fit almost all site conditions and landowner objectives. Depending on the existing landscape and available space, swales can have a meandering or nearly straight alignment. An advantage to a meandering swale is that its geometry maximizes the time water spends in the swale thus aiding the trapping of pollutants and sediments while promoting infiltration. There are two types of swale systems: vegetated or rock-lined (sometimes called dry creek beds).

VEGETATED SWALES

Grassed swales are vegetated with native perennial grass species along the bottom and sides of the channel. The vegetation in the channel slows runoff, allows sediments to filter out, and can help remove nutrients. Bioswales are vegetated swales that use engineered media (usually a designed soil mix consisting of sand, loam soil and hardwood mulch) beneath the swale to improve water quality, reduce runoff volume, and control peak runoff rates. Although their functions are similar to grassed swales, bioswales have a greater capacity for water retention, nutrient removal, and pollutant removal. Adding gravel or other permeable material below the soil mixture further enhances infiltration.

When installing a swale, use a minimum 2% slope from beginning to end (longitudinal slope) to ensure that water is conveyed away from any structures and to a desired destination. Vegetation in the swale should be established before the first winter storms, so plant accordingly. Once saturated, swales function as conveyance structures carrying runoff to a rain garden, wetland, infiltration area, or other safe location. Swales are not recommended for areas that receive large amounts of sediment that can prematurely fill the swale and impede its functionality.

MAINTENANCE: Routine maintenance is required. Before a planted swale is densely vegetated, it is extremely vulnerable to erosion and must be protected with straw matting and other erosion control materials. Maintenance of a dense, healthy vegetated cover consists of periodic mowing (keep grass 2-4 inches high), weed control, reseeding of bare areas, and clearing of debris and accumulated sediment. The swales should be regularly inspected for pools of water, formation of gullies, and for uniformity in cross section width and longitudinal slope. When the uniformity is compromised it should be corrected quickly.



DO

- Use California native plants or drought tolerant plants.
- Use fertilizer and pesticides only when necessary.

DON'T

- Walk or drive machinery directly in the swale as this will cause soil compaction.
- Place too close to your home's foundation.
- Allow water to stand or stagnate

ROCK-LINED SWALES (DRY CREEK BEDS)

A rock-lined swale (or dry creek bed) uses rock instead of grass or other vegetation to safely infiltrate and convey runoff. Most are designed with rounded rock for an aesthetically pleasing landscape feature that mimics a creek bed.

When installing a swale use a minimum 2% slope from beginning to end (longitudinal slope) to ensure that water is conveyed away from any structures and to a desired destination. Non-woven geotextile fabric can be used underneath the rock.

MAINTENANCE: Periodically remove leaves and replace rocks moved by surface flow.

DO

- Use existing rock from your property if available.
- Use washed rock from a local quarry.
- Make sure the outlet does not cause erosion or clog.
- Use non-woven geotextile fabric beneath the rock.

DON'T

- Install in soils with high water tables or saturated clay soils without an overflow device.
- Place too close to your home's foundation.
- Allow leaf litter to accumulate.



INFILTRATION STRUCTURES



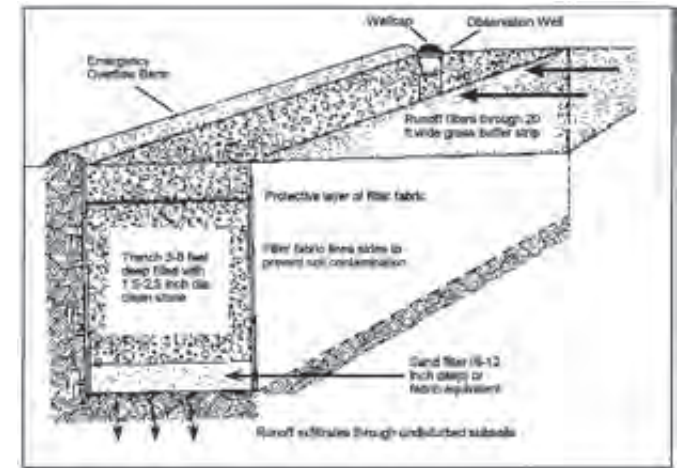
USES: ROOF, WALKWAYS OR OTHER HARDSCAPES, VEGETATED AND/OR UNDEVELOPED AREA RUNOFF; LOW TO MODERATELY SLOPED AREAS



INTRODUCTION: Infiltration structures are typically underground storage chambers designed to collect stormwater and allow it to infiltrate into the surrounding soil for groundwater recharge. They go by many names including; infiltration gallery, seepage pit, drainage well, dry well etc. In addition to promoting groundwater recharge, they can also help to enhance base flows in nearby creeks, reduce runoff volume, and can improve water quality by removing sediment and pollutants. Downspout diverted water is often the best source for an infiltration structure as it typically does not have pollutant and sediment filtration requirements. Infiltration BMPs are advanced techniques and should only be undertaken with sufficient planning and professional assistance. Your local RCD can assist you in the early planning and permitting stages and provide referral assistance with public agencies and private consultants.

GROUNDWATER PROTECTION: A discussion of infiltration BMPs would be incomplete without a word on groundwater protection. In some areas, the water table may be shallow (“perched”) or have seasonal variation. Soil types and ground disturbance also varies by site location. The BMP relies on proper design, appropriate soil types and a minimum depth of underlying soil (above the water table) to filter pollutants before stormwater reaches the aquifer so groundwater contamination does not occur. Therefore, extreme care must be undertaken to ensure that the BMP is properly sited, designed, constructed, and maintained.

INFILTRATION TRENCHES: Infiltration trenches are fabric-lined, rock-filled trenches or shallow rock-filled pits that receive and infiltrate stormwater runoff. They are designed to capture runoff and SINK it into the soil, helping to restore infiltration function, replenish groundwater supplies and restore base flows in nearby creeks. Infiltration trenches also help to filter runoff pollutants and alleviate the negative environmental impacts of peak storm flows such as erosion. The potential property and environmental benefits of installing an infiltration trench are considerable, but the design and installation of an infiltration trench should only be undertaken in consultation with a qualified professional. Proper site conditions are critical to avoid groundwater contamination and possible failure of the BMP. In addition, infiltration trenches often need to be used in conjunction with other BMPs that pre-treat the stormwater. Pre-treatment BMPs are important because they remove suspended solids before they enter the trench to prevent clogging and possible failure.



Source: Schwab et al. 1992

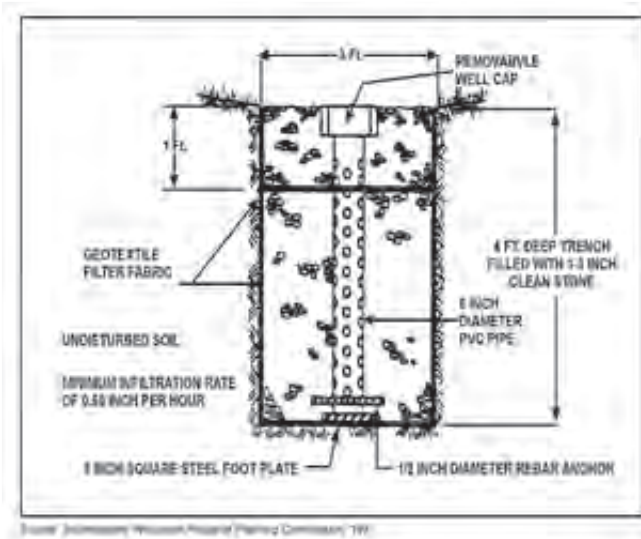


FIGURE 1 TYPICAL INFILTRATION TRENCH

INFILTRATION PITS: An infiltration pit is nearly identical in principal and design to a trench but is typically smaller and vertically aligned. Like a trench, they have similar design, pre-construction site evaluation and analysis requirements. The advantage is that they can be installed with minimal space requirements. Note that infiltration pits also have setback and site requirements that must be considered.

SITE AND DESIGN REQUIREMENTS: Consideration of an infiltration trench must start with a thorough, professionally performed site analysis. This site analysis should carefully examine if soil types, percolation rates, required setbacks from roads, wells and septic systems, and depth to groundwater table are appropriate and possible. Infiltration trenches are not for all sites and only a professionally performed site analysis can determine if your property is suitable. The analysis should also consider runoff water quality, quantity and whether or not pre-treatment BMPs will be required to remove suspended solids. If the analysis indicates that the site is appropriate, the

trench should be designed and installed by a qualified professional. You should also be sure to notify the appropriate building or planning agency before the site analysis to determine if there are any special permitting requirements, site limitations, or restrictions.

MAINTENANCE: Regular maintenance is required for the proper operation of an infiltration BMP. However, maintenance requirements for properly designed and constructed infiltration BMPs are reasonable. Future planning should also take into account maintenance requirements for any associated BMPs that pre-treat the stormwater and include a specific inspection and maintenance schedule as well as acceptable performance guidelines. General guidelines recommend that in the first year, the BMP should be inspected during and after several major precipitation events to confirm that it is functioning properly. After the first year, it should be inspected at least twice a year. Trash and plant debris should be removed from the surface on a regular basis to ensure optimal function and prevent clogging. A properly functioning infiltration structure should dewater within 72 hours. Even a partially clogged trench can lead to standing water which is conducive to mosquito breeding. If inspection indicates that the BMP is partially or completely clogged, consult a professional immediately to identify the problem and repair requirements. The probability of failure for an improperly sited, designed or maintained infiltration BMP is nearly 100%.

DO

- Consult a professional before considering installation
- Perform a thorough site analysis before building
- Have the BMP professionally designed and constructed
- Plan on regular maintenance

DON'T

- Attempt to install without a site analysis
- Build an infiltration BMP in an area with high sediment input or excessive slopes
- Install a trench or pit that is greater than 3' deep

Pervious Hardscapes

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M-C



USES: WALKWAYS, PATIOS, PARKING AREAS AND DRIVEWAYS

There are many new types of pervious materials that allow runoff to pass through and SINK back into the soil. Some popular choices are paver stones, turf block and permeable asphalts and pavements. There are now pervious options for almost any application. Since the variety of options is growing rapidly, we will only discuss them generally. For specifics on installation and use, contact your local retailer or product manufacturer.



PAVER STONES/FLAG STONES

Paver stones are normally made of pre-cast brick, concrete, stone or other material and installed over a sand base. They come in various shapes and normally interlock and can form different shapes and patterns. Pervious pavers are designed to allow more runoff to SINK into the ground than traditional pavers. Each paver has a spacer that ensures the ideal distance between placed stones for maximum infiltration. Each piece is placed with gaps between to allow the infiltration of water. Flag stones are larger and may be placed directly on the soil. A low-growing ground cover may be planted between flag stones to allow for greater infiltration. Pavers can be used in high use area such as parking lots, patios and walkways.

MAINTENANCE: Keep the area clear of sediment to prevent clogging. Annual vacuum sweeping with a shop vac helps maintain permeability. The gaps between pavers may require occasional weeding or scorching and sand or gravel replenishment. Because pervious pavers are easily lifted and reset, they are easy to repair or replace.

DO

- Use only in gravelly sand, loamy sand or other pervious native soils.
- Plant vegetation in between or around pavers.

DON'T

- Use in areas with high sediment loads that can clog porous areas.

TURF BLOCK

Turf block (concrete blocks with holes) and similar products can be filled with sand or planted. They provide soil stability for driveways and walkways. Sometimes the pores are filled with gravel or cobble. They are not ideal for everyday parking, because of irrigation and maintenance demands, and if they are planted, long term parking inhibits sunlight required for plant growth.

MAINTENANCE: Planted turf block may require regular mowing (depending on plant choices) as well as irrigation, fertilization and weeding.

DO

- Choose low water grasses such as native fescues.
- Use only in gravelly sand, loamy sand or other pervious soils.

DON'T

- Use in high traffic areas or permanent parking areas.
- Aerate.



PERVIOUS PAVEMENT

Pervious pavements contain pore spaces that allow infiltration of runoff. The water seeps through the material to a rock base layer underneath and is naturally filtered through the underlying soil where pollutants are removed. There are different types of pervious (or porous) pavements including porous asphalt and pervious concrete. Soil must have permeability between 0.5 and 3.0 inches per hour to be considered for pervious concrete installations. The bottom of the rock base/reservoir should be completely flat so that runoff will be able to infiltrate through the entire surface. Pervious pavement should be located a minimum of 2 to 5 feet above the seasonally high groundwater table and at least 100 feet away from drinking water wells. Ideal uses include walkways, residential parking areas, and driveways.

Although installation is becoming an easier and more cost-effective alternative to traditional paving methods, appropriate construction techniques are necessary to ensure the effective performance of pervious pavements. Hiring a licensed contractor experienced in these materials is highly recommended and may even be required depending on the application.

MAINTENANCE: Keep clear of soil, rocks, leaves, and other debris. Vacuuming annually, using a shop vac or specialized vacuum for larger areas, may be necessary to remove debris from the surface of the pavements. Other cleaning options may include power blowing and pressure washing. Always follow the manufacturer's maintenance recommendations.

DO

- Consult a professional to recommend a design customized to your site.
- Treat surrounding bare soil areas by planting or mulching.

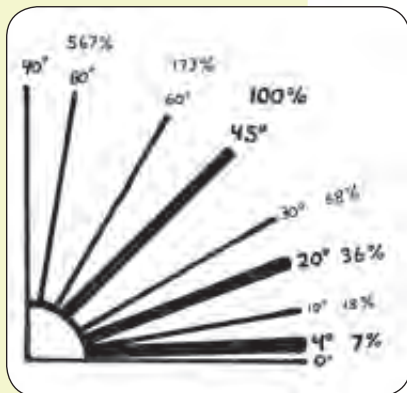
DON'T

- Use in areas where there is a possibility of sand drifts.
- Seal or repave with non-porous materials.



DID YOU KNOW?

There is much confusion when referring to the “steepness” of slope. We sometimes find a slope measured in degrees and other times as a percentage such as a 20% slope. To figure out the percentage slope, you would use the rise over run formula. For instance a distance of one foot horizontally with a one foot rise over that distance would give you the formula 1/1 or 100% slope. The equivalent angle or degree would be a 45° angle. The chart below is an easy conversion table to calculate the equivalent % grade to degree of slope.



SLOPE GRADIENT CONVERSION TABLE

Ground Covers



USES: TEMPORARY AND PERMANENT SOIL COVER, LOW USE WALKWAYS, AND SLOPE PROTECTION



Using mulches or vegetation to cover bare soil is a key ingredient to SLOWING down and thus preserving valuable top soil, preventing sediment from being carried downstream, and reducing the potential for erosion. Ground cover varieties include vegetation, wood chip, gravel, or other mulches. Mulches are a good choice for areas with LESS THAN a 33% slope. Vegetation works well on areas with LESS THAN a 50% slope.

MULCH (ROCK, WOOD CHIPS, OR OTHER MATERIALS)

Mulching is a simple and beneficial conservation practice you can use in your yard. Mulch is simply a protective layer of material that is spread on top of the soil. Mulches can be organic -- such as grass clippings, straw, bark chips, and similar materials -- or inorganic -- such as stones, brick chips, and recycled glass. Mulching has many benefits such as protecting soil from erosion, reducing compaction from the impact of heavy rains, conserving soil moisture, maintaining an even soil temperature, and preventing weed growth. It is also useful as temporary ground cover until supplemental vegetation becomes established.

MAINTENANCE: Organic mulch may need to be replaced annually. Removal of old mulch and plant debris each fall prevents growth of fungus and other unwanted pests and diseases. Keep any organic materials at least 6 inches from building siding. Gravel or rock should be raked regularly to prevent the buildup of organic materials.

DO

- Use recycled material whenever possible.
- Keep rock free of organic materials.

DON'T

- Use wood chips from diseased trees.
- Use straw mulch near stream channels.

VEGETATION/PLANTING

Plants cover and protect the soil. Once established, plants provide excellent long-term erosion control. Their roots knit together to hold the soil in place. Their leaves, needles and twigs reduce the impact of rain, and the organic matter they add to the soil improves water infiltration. A drip irrigation system provides slow delivery of water to plants, so water infiltrates with little or no runoff.

When selecting plants for a landscape, it is important to understand the site conditions. While most property owners select plant materials for their form and color, it is essential to know their solar, soil, and moisture requirements. Plants that do well in specific microclimates on a site are termed “site appropriate.” For the purpose of improving stormwater runoff choose plants that improve infiltration, decrease runoff, filter pollutants, and help stabilize slopes. Contact the Sonoma Agricultural Commissioner’s Office or UC Cooperative Extension (page 61) or a local plant nursery knowledgeable in native and drought tolerant species best suited for these functions.

Native plants (vegetation that grows naturally in particular climates or regions) are a great choice because of their performance, site enhancement, and life cycle cost benefits. Native plants typically are more cost-effective in the long run because they require less water and fertilizer, and they are more resistant to local pests and diseases than nonnative ornamentals. Costs are also reduced due to lower maintenance and replanting requirements. Additionally, native plants provide habitat for local/regional wildlife. If you choose nonnative plants, care should be taken to not plant invasive species as they tend to crowd out the native species. Contact the Sonoma County Agricultural Commissioner’s Office or UC Cooperative Extension (see page 61) for a complete list of plants that should be avoided.

MAINTENANCE: Routine maintenance is required and can be performed as part of the regular site landscaping program. Weeding and irrigation are essential in the first couple of months while plants become established. Annual pruning and mulching are recommended. Additional irrigation may be necessary during drought years. The use of native, site-appropriate vegetation reduces the need for fertilizers, pesticides, excessive water, and overall maintenance requirements.



DO

- Use California natives or drought tolerant plants that can endure periods of saturation.
- Keep plants well pruned near foundations and siding to allow adequate ventilation.
- Minimize fertilization or try organic options to prevent water contamination.

DON'T

- Plant invasive species such as periwinkle (Vinca) or certain ivys.
- Plant highly flammable vegetation near buildings.
- Allow irrigation water to drain to your driveway, the street, or bare soils.

Erosion Control Blankets (ECBs)

\$-\$

E-M



USES: BARE SOIL COVER AND SLOPE PROTECTION WHILE ESTABLISHING VEGETATION

Erosion control blankets are a good tool to improve the success rate of new plantings and can quickly add a layer of protection to bare soils. Some of the benefits of ECBs include reducing seed and soil loss, decreasing runoff volume and velocity, reducing top soil disturbance and loss, encouraging plant root developments and suppressing weeds.

It's important to choose the correct ECB for the site conditions (slope, runoff velocity, and purpose). Ask your local retailer or contact the RCD for assistance (see page 61) in choosing the correct blanket. We have included basic installation instructions, but ALWAYS follow the manufacturer's recommendations. Before laying the blanket, prepare the soil surface making sure it is smooth to maximize soil-blanket contact. At the top of the slope, at least 2 feet from the crest, dig a 6 inch minimum ditch (called an anchor ditch). Line the ditch with the top of the ECB leaving enough to roll back over once the ditch is filled. Now fill the ditch back in over the ECB and wrap the extra over the top and secure with staples. Next, carefully roll the ECB vertically down the slope in the same direction as the water flows. Overlap the side edges of the contiguous blankets used by at least 4 inches and overlap the top and bottom edges of the blankets by at least 3 inches. The uphill roll should overlie the downhill roll. Stake the blanket, at a minimum, horizontally every 2 feet and vertically every 3 feet. Stake at least every foot where an uphill and downhill blanket overlap. If the ground is soft, staples can be used to hold the blanket down. Otherwise, 4 inch nails and a washer should be used.



MAINTENANCE: Monitor for erosion until vegetation becomes established.

Check for proper placement that could be disturbed by animals or a large storm event. Ensure that overlaps remain in place and correct as necessary.

DO

- Make sure to choose the appropriate ECB for the desired use and conditions.
- Use decomposable netting.

DON'T

- Walk on the ECB after it is in place.
- Allow gaps between the blanket and the soil.
- Let concentrated runoff flow onto the ECB from above.

Cross Drains



USES: DRIVEWAYS, PRIVATE ROADS

Cross drains are used to SLOW water down by breaking up the impervious surface area into smaller sections. Smaller sections help divert the water to a point where it can SINK in to help combat the ill effects of driveway and road runoff. The BMPs described here can be installed on existing driveways and roads, both paved and unpaved. If you are constructing or reconstructing a road, other techniques such as outsloping can be used but are beyond the scope of this guide. Contact the Mendocino County RCD for a copy of a road maintenance guide and for more information on alternative techniques. See page 61 for contact information.

WATERBARS

Waterbars are used to break up runoff into small units so that it does not have enough energy to erode soils. They also divert water away from streets and allow it to infiltrate. On unpaved roads, an earthen waterbar, also known as a water break, consists of a shallow trench with a parallel berm or ridge on the downslope side which is angled down across the road. On these surfaces they can be constructed by hand, with a backhoe, or with a blade-equipped tractor. Optimal size of an earthen waterbar is 12 inches above the road surface and 6 inches below the road surface. Asphalt or cement waterbars can be smaller in size (6 inches) and thereby provide greater ease of access. Water bars should be installed at a 30 to 45 degree angle and in most cases the outlet of waterbars should be protected with rock dissipaters.

MAINTENANCE: Keep the outlets clear of debris and sediment so water drains freely. Inspect annually and make necessary repairs to earthen berms that break down over time and ensure there is no erosion.

SLOTTED CHANNEL DRAIN

A slotted drain installed across the width of your driveway is another option to address surface runoff. It consists of a metal-grated conveyance structure that transports water to a safe location. Decorative varieties are also available. Slotted channel drains are installed flush with the driveway surface, a feature that makes these conveyance devices more appealing for aesthetic reasons. The drain should be sloped no less than a ½ inch per foot of length to prevent clogging from sediment and debris. It should also be angled at 30-45 degrees. Although slotted channel drains may be installed on any driveway, they are recommended for driveways with slopes greater than five percent.



MAINTENANCE: Ensure that the grate is open before and during storm events (not covered by leaf litter). Check that the outlet is protected, non-eroding, and clear of debris and sediment so water drains freely.



DO

- Install energy dissipators at all outlets.
- Install at 30 to 45 degree angles.

DON'T

- Direct runoff to erodible surfaces.
- Outlet water onto steep slopes.
- Direct water to a neighbor's property.

DO

- Ensure the drain is large enough so that the majority of water enters the drain and doesn't flow over.
- Install energy dissipators at all outlets.
- Install at 30 to 45 degree angles.

DON'T

- Install channel drains in areas with large amounts of leaf debris.
- Outlet water onto steep slopes.
- Direct water to a neighbor's property.
- Allow drain to clog and trap water.

Retaining Walls and Terracing

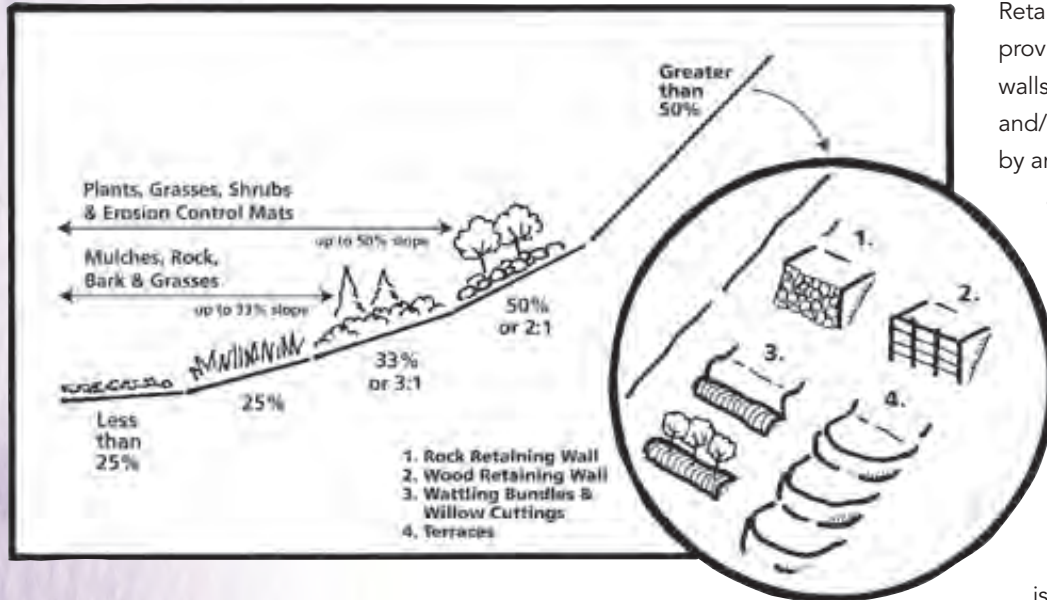
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M-C



USES: SLOPED AREAS

Protecting steep slopes is very serious! Improperly installed systems can pose a serious threat to life and property. We recommend that ALL retaining wall and terraced areas be designed and installed by a licensed qualified professional. In addition, always check with Sonoma County PRMD or your city building department before embarking on terracing projects to determine compliance and permitting requirements.



Retaining walls and terraces are used to reduce the gradient or slope and provide level or gently sloping areas for establishing vegetation. Retaining walls and terrace walls are constructed with boulders, treated timber, bricks and/or interlocking concrete blocks. (Walls over 3 feet high must be designed by an engineer). There are MANY different types of retaining walls, each with a different purpose, so always check with a qualified professional before embarking on any wall project for soil retention. A building permit and engineering expertise are required to build many retaining walls. Always check with your local planning department to determine if a permit is necessary for your project. Contact information can be found on page 61.

RETAINING WALLS

Rock retaining walls are an alternative to wood retaining walls and are often used next to a roadway or drainage way. They are freestanding walls built from rock 10 inches to 2 feet in diameter. A footing trench is dug along the toe of the slope, and the largest boulders are placed in the trench. Subsequent rocks are laid with at least three bearing points on previously laid rocks. The external face of the wall should incline slightly uphill, though the wall itself is freestanding and does not lean. As the wall is built, fill material is placed around and behind the rocks and packed in. Since the finished slope behind the wall will be flatter than before treatment, possibly a level terrace, it should be easier to establish all-important perennial plants on and above the wall.

Wood retaining walls can be used on slopes steeper than 50 percent and are often located between the base of a slope and an adjacent road, driveway or drainage way. Lumber and posts should be treated with an approved wood preservative (not creosote). Ensure proper drainage methods behind the wall are utilized. As always, vegetation should be established on the slope above the wall.

WILLOW CUTTINGS

Willow cuttings are used under very specific site conditions and are normally recommended only through the guidance of a qualified professional. Contact your local RCD for assistance (see page 61 for contact information).

TERRACES

Many materials are available for building terraces. Treated wood is easy to work with, blends well with plants, and is often less expensive than other materials. Interlocking concrete blocks are made specifically for walls and terraces and are more easily installed by a homeowner than other materials, such as fieldstone and brick. The steepness of the slope dictates wall height. Make the terraces in your yard high enough so the land between them is close to level. This soil surface should be carefully revegetated. Be sure the terrace material is strong and anchored well to stay in place through cycles of freezing, thawing, and heavy rainstorms. Large terraces should be tied back into the slope and properly drained. This takes expertise and equipment, so you may want to restrict the terraces you build to a foot or two in height. Get help from a professional to make sure higher walls stand up to the forces of gravity and water pressure in the soil.

MAINTENANCE: Always check retaining walls to make sure they are not leaning or failing. Ensure there is adequate drainage behind walls and the drains remain functional.

DO

- Provide adequate drainage behind retaining walls.
- Use a qualified professional to design your wall.

DON'T

- Install without checking on permit requirements.
- Use creosote-treated wood.



Check Dams

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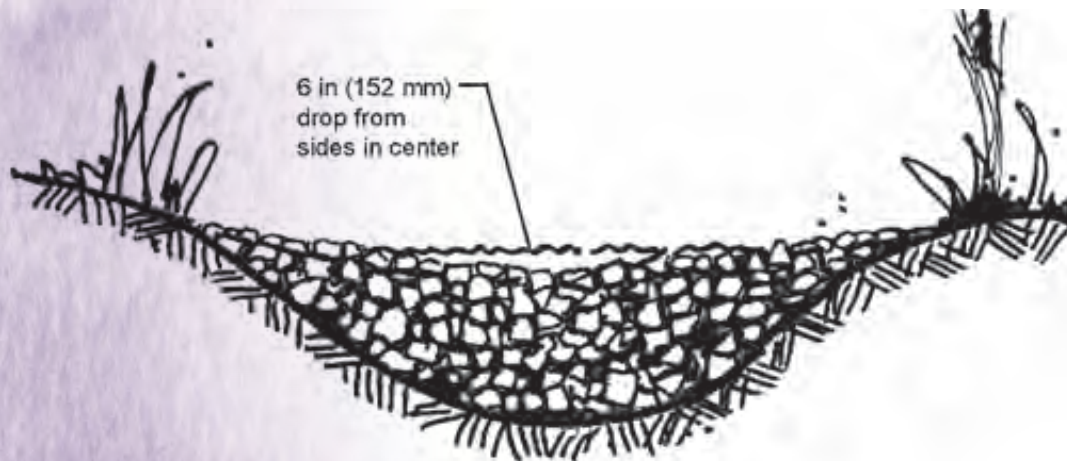
USES: IN ROCK-LINED DRAINAGE CHANNELS; VEGETATED DITCHES AND SWALES; LOW TO MODERATELY SLOPED AREAS



A check dam is a small structure constructed of rock, gravel bags, logs or sandbags generally used in vegetated swales, constructed channels or drainage ditches to lower the speed of stormwater flows. They reduce flow velocity by temporarily ponding water and decreasing the effective slope. Stormwater enters a swale or rock-lined channel and is ponded behind the check dam which allows sediment and other pollutants to settle out. Check dams can help to SLOW and SINK stormwater by reducing peak flows and runoff timing. In certain situations they can provide other benefits such as limited sediment trapping, erosion control and partial removal of other pollutants. They are relatively inexpensive and easy to install depending on the site conditions.

Multiple check dams are often used in succession to further reduce velocity and increase effectiveness. They can also be useful for establishing vegetation and preventing erosion in newly constructed swales. It is important to note that check dams must not be used in creeks, streams, or any other type of natural watercourse or wetlands. Consult with a professional (see resources guide on page 61) during the planning stages to ensure proper design and site suitability.

GENERAL INFORMATION: Proper site selection, maintenance and installation of check dams is crucial for successful implementation. Size of the drainage area, construction materials, spacing, and water quality are some of the important issues that must be addressed prior to installation.

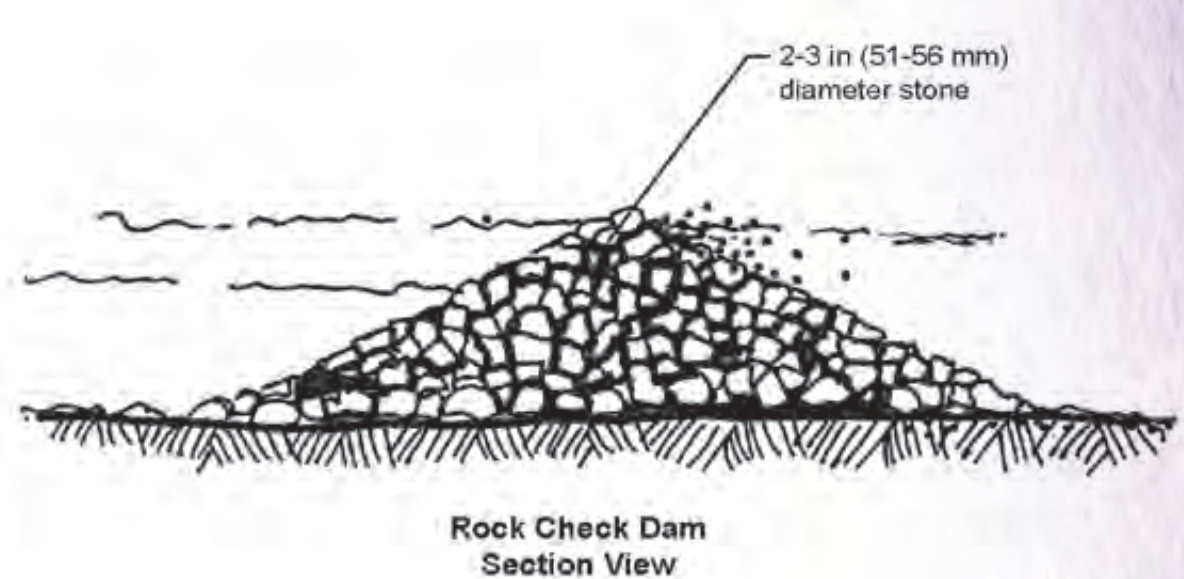


**Rock Check Dam
Section View**

Check dams should only be used in small open channels in areas that drain less than ten acres. They must not be installed or substantially alter flows in a natural watercourse. When installing in drainage channels or swales with established vegetation, it is important to make sure that measures are taken to prevent erosion if vegetated areas are disturbed during the installation process. Conversely, small check dams are particularly useful when installed at the same time of a vegetated swale to help establish vegetation. They are carefully removed once sufficient vegetation is established. They may also be useful in rock-lined drainage channels for slowing water down to manage peak flows. Erosion control blankets are typically installed under and around a check dam to prevent unwanted erosion. A local professional can assist you with site analysis, design, possible permitting requirements and installation.

DESIGN: The size and structure of a check dam will depend on the site but should be no greater than two feet in height and extend across the entire water conveyance channel. The center of the check dam must be at least 6 in (152 mm) lower than the outer edges. They may kill grass linings in channels if water stays high or sediment load is excessive.

MAINTENANCE: Be prepared for regular maintenance and repairs for the life of the BMP. Check dams should be inspected after rainfall events and repairs made immediately. Accumulated sediment and debris must also be removed when it reaches one half the original height of the structure. If this material is left in place, it can become re-suspended and released in a subsequent storm event – sometimes known as “fill and spill”. Erosion around the edges of check dams is a serious problem and must be avoided.



DO

- Consult a professional before considering installation
- Plan on regular maintenance for the life of the BMP
- Consider other options when channel stabilization is the primary objective

DON'T

- Install in drainage areas with excessive erosion or sediment input
- Alter natural drainages and water courses



ADVANCED SYSTEMS

INTRODUCTION: Several of the techniques in this guide can be enlarged or used in combination to address stormwater management goals for bigger parcels and in conjunction with a variety of land uses such as agricultural operations or livestock management. Large, integrated best management practice systems can yield substantial benefits. They also have the advantage of addressing multiple resource concerns including erosion control, environmental enhancement, and water quality/quantity attainment. However, project costs and maintenance requirements can be substantial, so careful consideration and planning is required when implementing large-scale systems. The landowner should first consider overall objectives and goals as well as ongoing maintenance obligations. Other important factors to consider

are site conditions, design and engineering requirements, location, water quality, and neighboring landowners. Consult a professional or a local resource agency when considering a large-scale, advanced stormwater management system.



Listing every available stormwater BMP and potential combination is well beyond the scope of this guidebook. Size and selection will largely be driven by site-specific conditions, management goals, costs, engineering limits, and regulatory compliance needs. Agricultural producers and some non-agricultural landowners with special needs may be eligible for financial assistance to implement stormwater BMPs. Your local Resource Conservation District and the Natural Resources Conservation Service (NRCS) can provide assistance and guidance for large or complex stormwater management systems (see resources section, page 61).

MULTIPLE, INTEGRATED BMPS AND SYSTEMS:

A multiple treatment system uses two or more BMPs in a series or in an integrated fashion. Directly connected BMPs are also known as a “treatment train”. Many of the BMPs in this manual can be

easily combined or integrated on a small or medium residential scale – so don't hesitate to identify a set of BMPs that can help you to SLOW-SPREAD-SINK, and harvest stormwater!

For example, a rainwater harvesting system can be combined with a rain garden/bioretention system, native vegetation drip line protection, and permeable pavers to simultaneously harvest, slow and sink stormwater. In this case, excess rainwater that exceeds storage capacity is slowed and infiltrated in a variety of ways. Most parcels offer considerable opportunities to integrate several techniques regardless of their size.

Remember that many advanced techniques may not be sufficient or appropriate for addressing significant water quality requirements when deployed independently – especially in medium to large-scale scenarios. In these cases, the system is designed from the ground up with a set of integrated BMPs that attain a set of specific objectives. Large-scale integrated systems can benefit the landowner and environment in many ways. They do, however, require careful planning and professional consultation before implementation.



LARGE SCALE PROJECTS

Many of the practices and basic principals in this guidebook can be scaled-up to yield greater benefits or to address multiple stormwater management goals (e.g. quality and volume). Small-scale projects can often be implemented without the need for designs or a permit. Medium to large-scale projects will often trigger the need for engineered designs and one or more permits. Sometimes, this can be as straightforward as obtaining a building permit. Reconfiguring the stormwater flow regime on a large parcel with substantial earth movement may require engineered designs, and multiple agency permits. Consult a local resource agency or professional engineer when considering a large-scale, integrated BMP system.

MAINTENANCE CONSIDERATIONS

Each BMP will require maintenance as indicated. For advanced techniques, maintenance of one BMP may affect the functioning of all others in the system. Be sure to identify your maintenance needs in the design phase of your project and if BMPs could have an effect on each other. Improper maintenance of one BMP can lead to failure and adversely affect others. In a small-scale residential environment, maintenance requirements are typically reasonable for most of the described techniques. For large-scale, complex systems, maintenance requirements will be greater.

CHAPTER 3

DIFFICULT SITES AND SITE CONSTRAINTS

There are a wide variety of soil types found in Sonoma County. When attempting to implement any BMP that increases the infiltration of water into the soil, it is critical that the soils have the capacity to handle the amount of water being directed to the area. Conducting a thorough analysis of your soils and ascertaining if a BMP will function in these soils is critical to the success of any project. In order to evaluate your soils check the Web Soil Survey at <http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>. Be sure to verify that the soil conditions noted on the website are accurate by observing your own soils or by contacting your local RCD or a qualified professional. Also make sure to look for areas of shallow parent material or infiltration limiting layers such as hardpans.

Frequently, site conditions make it difficult or impossible to implement certain home drainage practices on your property. For example, sites that are on steep slopes, located in a wet area with a high water table, or soil conditions that have poor infiltration rates can be problematic. Below is a list of primary site constraints that you should consider when evaluating drainage practices for your home. Although there are many opportunities to control runoff on site, it is important to consult a professional to ensure that all options are thoroughly considered and to avoid unforeseen consequences.

STEEP SLOPES

The severity of the slope plays a significant role in determining the practices that can be installed. Avoid installing practices on slopes that are greater than 50% without professional consultation. Use caution when installing practices on any steep slopes. By directing and infiltrating runoff to these sites you run the risk of saturating soils and promoting slumping and conditions that promote landslides. Out-letting drainage systems on steep slopes can also cause erosion that can lead to gully formation and even landslides. If your home is on or near steep slopes, please consult an expert before considering home drainage projects.



PREEXISTING EROSION PROBLEMS

In some cases, preexisting erosion problems may complicate the site and preclude the implementation of drainage practices. It is important to be aware of your current erosion issues and be sure that the drainage practices you implement will not make your drainage and erosion issues worse. Of particular importance is ensuring that you do not exacerbate current conditions by diverting flows into already dynamic systems. If your home has existing erosion problems, please consult an expert before considering home drainage projects.

GEOLOGICALLY HAZARDOUS SITES

Land uses vary in their sensitivity to geologic hazards. State law requires a geologic report for projects along known active faults. "Special Studies" zones have been designated along four faults in Sonoma County where surface movement has taken place during the past 11,000 years. The Sonoma County Permit & Resource Management Department website provides maps of seismically active areas at <http://www.sonoma-county.org/prmd/>. These maps should be consulted to identify if you home is located within a hazard area. If **your** home is in one of these areas, please consult an expert before considering home drainage projects.



COASTAL BLUFFS

Coastal bluffs are inherently geologically unstable and prone to erosion. You should avoid placing any additional drainage on these sites whenever possible. Careful management of site drainage is probably the most cost-effective approach to minimizing bluff hazards. Even where circumstances dictate significant structural stabilization efforts, such as shoreline bulk heading or re-grading of slopes, site drainage remains an essential component of the solution. Consult a drainage professional when designing drainage system for sites on coastal bluffs.



AREAS PRONE TO FLOODING

Under a widespread heavy rain scenario (accumulation of .30 inches of rain per hour or more), severe flooding is likely in low-lying areas within a basin. If you are unsure about the potential for flooding on your property, contact Sonoma PRMD or your City's building department (see page 61) for more information. If your home is within a flood prone area, consult an expert before considering home drainage projects.



LANDSLIDE ZONES

Areas of Sonoma County are susceptible to landslides due to the topography and geological soil characteristics. Installing complex drainage practices that promote infiltration may also promote landslide activity if hill slopes become saturated. Designing drainage practices on these sites requires special care. To determine if your home is in a landslide prone area, contact NRCS or Sonoma County PRMD (see page 61) to review potential landslide area maps. If your property is located in a landslide zone, consult an expert before considering home drainage projects.



CHAPTER 4

LOCAL PROJECTS

VEGETATED BIOSWALE AND DETENTION POND

Location: Frog Song Cohousing Community, Cotati, CA

Project Description: The bioswale is planted with low-water natives and other beneficial plants. It intercepts surface runoff from the cohousing community and helps to infiltrate water. Overflow is collected in a detention/percolation pond for controlled release. This system promotes groundwater recharge, and helps to reduce peak storm flows, non-point source pollution discharges, and erosion.

Photo Credit: Dave Ergo



LAWN REMOVAL, MULCH & LOW WATER LANDSCAPE INSTALLATION

Location: Sonoma Valley High School

Project Description: Taking advantage of City of Sonoma's "Cash for Grass" program, Sonoma Valley High School removed a large irrigated landscape program. They replaced over 13,900 square feet of turf and replaced it with mulch and other low-water landscape improvements. Removing turf and installing mulch helps to offset potable water use and infiltration while preventing erosion. 2009 Sonoma Valley Groundwater Management Program Conservation Award Winner

Photo Credit: Glenn Moll

PERVIOUS HARDSCAPE DRIVEWAY

Location: Sonoma, CA

Original concrete driveway was removed and replaced with pervious pavers and landscaped strips to further enhance infiltration. This improvement helps to reduce runoff volume, non-point source pollution and encourages infiltration and groundwater recharge.

Photo Credit: John Guardino



RAINWATER HARVESTING TANK FARM

Location: Santa Rosa, CA

Design & Installation: AP Rainwater Harvesting

Project Description: A 2,500 gallon rainwater harvesting system installed to offset potable city water usage for landscape and vegetable garden irrigation. This system employs a multiple tank system attached to a downspout. The downspout also has the proper diverter installed so first-flush rainwater can be properly released before collection begins. This system helps to control erosion, non-point source pollution, and reduces peak flows.

Photo Credit: David Ortiz





SOLAR POWERED WATER RECLAMATION AND RECYCLING SYSTEM

Location: Gundlach Bundschu Winery, Vineburg

Project Description: Reclamation and reuse system for over a million gallons of winery wastewater through a collection pond and integrated wetland system. BMPs include an acute deficit irrigation management program, water reclamation ponds, rainwater harvesting, sustainable winegrape production methods, and solar power. Total water used in the winery is collected from all drains, including rainwater, filtered and gravity flows to process ponds and wetland system. The water is then used for irrigating grape vines. Solar power provides 100% of the electricity needs for the reclamation system. 2009 Sonoma Valley Groundwater Management Program Conservation Award Winner



INTEGRATED WATER SUSTAINABILITY SYSTEM

Location: Salmon Creek Middle School, Occidental, CA

Project Description: The Salmon Creek Falls Environmental Center is a visionary project that fosters eco-sustainability and provides environmental education to the community. Salmon Creek Falls Environmental Center stormwater management techniques include a living roof, water efficient fixtures, low- water native landscapes, and a rainwater collection system. These BMPs help to offset potable groundwater consumption, reduce peak flows, erosion, and non-point source pollution.

Photo Credit: David Ortiz

INTEGRATED WATER CONSERVATION AND RE-USE PROJECT

Location: Sonoma County Administrative Complex - Santa Rosa, CA

Design: Sonoma County Permit & Resource Management Department

Installation: Broad collaborative effort of private and public entities

Project Description: This innovative demonstration project was a multi-agency collaborative effort to provide water quality treatment and storm water detention for 2-acres of parking lot via retrofit installation of storm water BMPs. The retrofit installation included eleven BMPs designed to treat storm water runoff as well as detain storm water to reduce peak runoff in nearby Paulin Creek. Some BMPs are public domain and some are proprietary but all act to either prevent rain water from coming in contact with pollutants, treating storm water runoff, detaining storm water, or a combination of treatment and detention. BMPs include:

1. Drop inlet filter inserts to catch trash
2. Unit pavers to allow infiltration
3. Pervious concrete to allow infiltration through a vehicle rated paving surface
4. Underground detention to reduce peak discharges
5. Bioretention pond to treat and detain water
6. Treepods biofilters to remove oil, grease, and other pollutants
7. Three vegetated swales to improve water quality and detain runoff
8. Erosion control fabric demonstration area with three types of fabric: jute, coconut, and wood product
9. Straw wattle demonstration area showing proper installation, embedding, and overlapping
10. Silt fence demonstration area showing proper installation, embedding, overlapping, and ending
11. Roof enclosure to prevent rain water from mixing with garbage and leaching onto the parking lot

This project is open to the public and can be viewed anytime during regular business hours.

Photo Credit: Sonoma County PRMD





SIMPLE RAINWATER COLLECTION SYSTEM

Location: Occidental Arts and Ecology Center, Occidental, CA

Design & Installation: Brock Dolman

Project Description: This simple rainwater collection system was installed on a goat feeding shed roof. The attached flexible gutter and pipe feeds into a 1000 gallon storage tank. Stored water will be gravity fed to livestock areas for watering milking goats and chickens. The roof area is 160 square feet which roughly yields 100 gallons of water per inch of rainfall into the storage tank. Sliced flexible drain pipe was fastened over the end of a corrugated roof. The leading edge of the gutter acts as an effective prefilter for coarse leaves and twigs (see photo). This system is easily cleaned and maintained. An onion sack acts as a simple debris filter wired to the end of the flexible gutter pipe that is placed in the storage tank. This system is inexpensive and easy to build, install and maintain.

Photo Credit: Brock Dolman



RURAL ROAD IMPROVEMENTS

Location: Occidental Arts and Ecology Center, Occidental, CA

Design & Installation: Pacific Watershed Associates, Gold Ridge Resource Conservation District, Brock Dolman

Project Description: This project integrates land and road management techniques to reduce erosion and sediment discharges into nearby streams. Sediment traps were installed above ditch relief culverts adjacent to a rural road to slow runoff and promote infiltration. The road surface was contoured with "rolling dips" to assist in reducing storm water flow velocity and removing fine sediment. Assistance for the design and installation of this project was made possible, in part, by a grant from the California Department of Fish and Game for sediment reduction in the Dutch Bill Creek Watershed.

Photo Credit: Brock Dolman

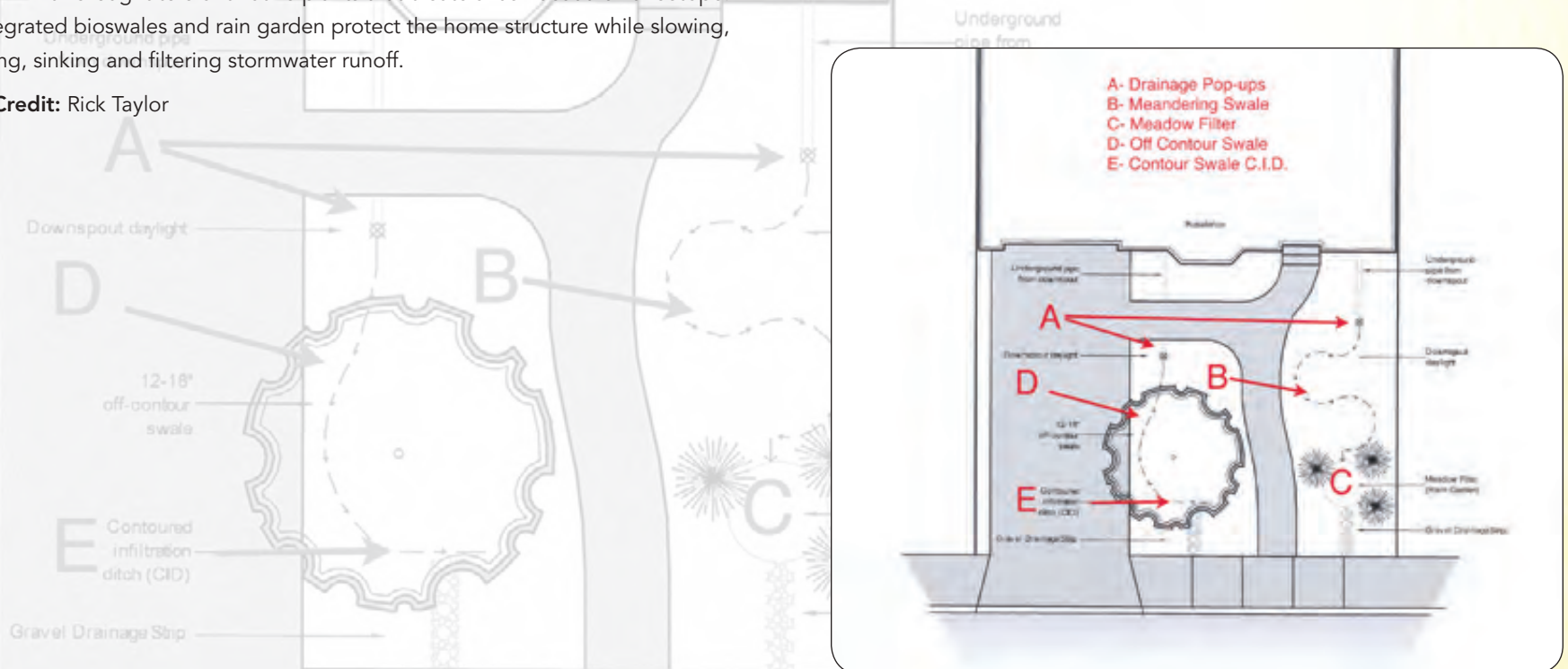
SUBURBAN INTEGRATED STORMWATER MANAGEMENT SYSTEM

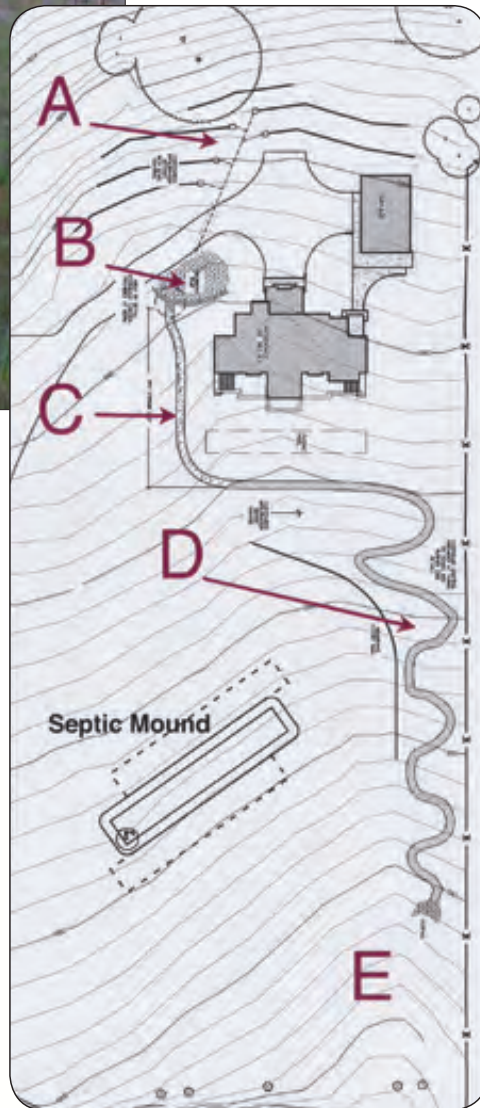
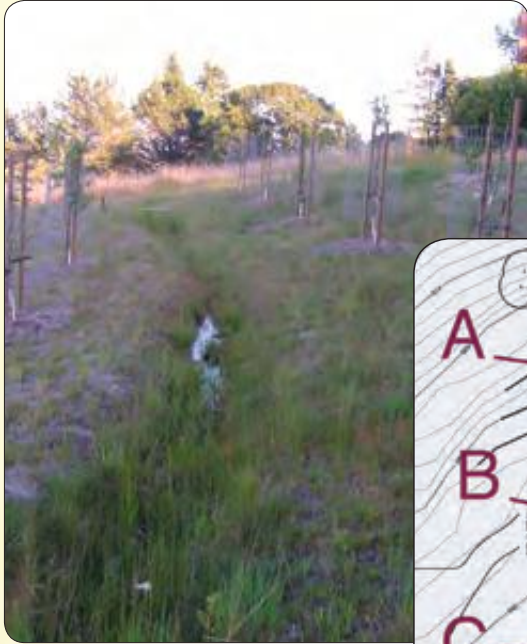
Location: Sebastopol, CA

Design and Installation: Rick Taylor, Elder Creek Landscapes

Project Description: This unique system replaced a lawn with a landscaped, integrated stormwater management system. The system integrates a rain garden, conveyance swales, diverse native plantings, and a completely revised drainage plan. Drainage downspouts were disconnected from a traditional system that diverted all roof runoff to the street. The roof water was diverted to bioswales to slow the water down, reduce suspended sediment and eventually drain into a specially designed rain garden with a diverse palette of native plants. The system slows and retains some water for the plants, and promotes infiltration. It also includes a gravel bed to accommodate significant storm events by allowing for overflow and providing another sediment filter. This project greatly reduces potable water use by replacing a lawn with drought tolerant native plants that create a lush beautiful landscape. The integrated bioswales and rain garden protect the home structure while slowing, spreading, sinking and filtering stormwater runoff.

Photo Credit: Rick Taylor





RURAL ORCHARD STORMWATER MANAGEMENT INTEGRATING MULTIPLE BMPS

Location: West Sonoma County, CA

Design and Installation: Rick Taylor, Elder Creek Landscapes

Project Description: This advanced case study project utilizes a Keyline approach while at the same time addressing the needs and guidelines of soils and civil engineering, septic field setbacks, and county permitting oversight. This approach provides multiple benefits, which include, responsible stormwater management, fertility development of upland soils, habitat creation/restoration, and food production with reduced water use, all while creating a beautiful space. Section A (see schematic) is an integrated system of engineered, contoured infiltration trenches that mitigate soil erosion and catch surface flow for percolation on a hillside orchard. Fruit trees are planted on the berm portion of the trenches. The infiltration trench system feeds into a lateral line that discharges into a sediment trap planted with native grasses and berries that can handle both inundation with water and long dry spells.

Section D consists of a series of short infiltration trenches connected by switchbacks that extend out beyond the 50' required septic setback. A subsurface, impermeable membrane was installed along the setback to further reduce the possibility of surface water contamination. For soil stabilization, a hydroseed of Native California, deep rooting, perennial grasses and wildflowers as well as plugs of native grasses were planted directly into the watercourse. Rock aprons were installed on the banks of the switchbacks. A rock diffuser was also required on the lowest trench where it is designed to breach in an overflow event. A pond is proposed in the area below the lowest trench to further slow and store stormwater. The system is also plumbed to allow diversion of road runoff through the infiltration switchbacks once vegetative cover matures. The lower portion of the water course attracts a diverse array of wildlife.

Photo Credit: Rick Taylor

THE MALONEY FAMILY MEMORIAL GARDEN

Location: The Sonoma Community Center- Sonoma, CA

Design and Installation: Community-wide effort with assistance from; City of Sonoma, Sonoma County Master Gardeners, Sonoma County Water Agency, Sonoma State University

Project Description: This water-wise demonstration garden replaces a grass lawn and showcases water conservation by integrating drought tolerant plants and rainwater collection systems. The site features a wide variety of demonstration gardens including a children's garden with scented plants, a Mediterranean garden to reflect our climate, a California native plant garden, a succulent garden and a rainwater garden. The rainwater collection system, developed by Sonoma State University, includes 3,000-gallon corrugated tanks with a filtration system that collects rain from the 16,000-square-foot roof of the center. The newly designed garden will use approximately 70 percent less water than the lawn it replaced. The rainwater collection system is expected to fulfill two-thirds of the garden's water needs greatly reducing dependence on drinking water for landscape irrigation.

Photo Credits: John Guardino





RESIDENTIAL LAWN REMOVAL AND REPLACEMENT WITH NATIVE, DROUGHT TOLERANT LANDSCAPING

Location: Rohnert Park, CA

Design and Installation: Homeowners

Project Description: Front and backyard lawns and landscaping features near the home were removed and replaced with drought tolerant native plants. Wood chip mulch was applied to provide ground cover, prevent erosion, conserve water and to provide aesthetic appeal. Native plantings near the home provide drip-line protection and erosion control by helping to slow stormwater runoff. The new landscape conserves thousands of gallons of drinking water per year, greatly reduces property maintenance requirements, creates beautiful outdoor spaces and provides habitat for a variety of native birds and beneficial insects. Reducing water use saves the homeowners hundreds of dollars per year on water bills and eliminates costs associated with mowing and fertilizing the lawn.

Photo Credits: Phillip Jehly

RESOURCES GUIDE

AGENCIES & NON-PROFITS

Gold Ridge Resource Conservation District

PO Box 1064,
Occidental, CA 95465
707-874-2907
www.goldridgercd.org

Laguna Foundation

900 Sanford Road
Santa Rosa, CA 95401
707- 527-9277
www.lagunafoundation.org

Low Impact Development Center California Branch Office

P.O. Box 747
San Luis Obispo, CA 93406-0747
805-540-9772
www.lowimpactdevelopment.org

Mendocino County Resource Conservation District

206 Mason St, Suite F, Ukiah CA 95482
707-462-3664
www.mcrcd.org

Occidental Arts & Ecology Center Water Institute

15290 Coleman Valley Road
Occidental, CA 95465
707-874-1557 x 206
waterinstitute@oaec.org

Russian River Watershed Association

707- 833-2553
www.rrwatershed.org

Sonoma County Energy Independence Program

404 Aviation Blvd.
Santa Rosa, CA 95403
707-521-6200
www.sonomacountyenergy.org

Sonoma Ecology Center

P.O. Box 1486
Eldridge, CA 95431
707- 996-0712
www.sonomaecologycenter.org

Sotoyome Resource Conservation District

2150 West College Ave.
Santa Rosa, CA 95401
707-569-1448
www.sotoyomercd.org
**Southern Sonoma County
Resource Conservation District**
1301 Redwood Way
Petaluma, CA 94954
707-794-1242 Ext. 5
www.sscr.cd.org

University of California Cooperative Extension, Sonoma County Office

133 Aviation Boulevard, Suite 109
Santa Rosa, CA 95403-2894
707-565-2621

USDA-Natural Resources Conservation Service (NRCS)

1301 Redwood Way
Petaluma, CA 94954
707-794-1242
www.ca.nrcs.usda.gov

LOCAL CITIES & WATER PURVEYORS

Many cities sponsor water conservation and efficiency programs, provide technical support materials, and offer rebates for water saving techniques, turf grass/lawn removal, water harvesting, low water landscaping, etc.

City of Cotati

201 West Sierra Ave.
Cotati, California 94931
707-792-4600
www.ci.cotati.ca.us

City of Cloverdale

124 N. Cloverdale Blvd.
Cloverdale, CA 95425
707-894-2521
www.cloverdale.net

City of Healdsburg

401 Grove Street
Healdsburg, CA 95448
707- 431-3317
www.ci.healdsburg.ca.us

City of Petaluma

Water Resources and Conservation Department
202 North McDowell Blvd.
Petaluma, CA 94954
707-778-4546
www.cityofpetaluma.net/wrcd

City of Rohnert Park

130 Avram Avenue
Rohnert Park, CA 94928
707-585-6750
www.rpcity.org

City of Santa Rosa Water Conservation Program

100 Santa Rosa Avenue
Santa Rosa, CA 95404
707-543-3985
www.ci.santa-rosa.ca.us

City of Sebastopol

7120 Bodega Avenue
Sebastopol, CA 95472
707-823-8597
www.ci.sebastopol.ca.us

City of Sonoma

No.1 The Plaza
Sonoma, CA 95476
707-938-3681
www.sonomacity.org

Sonoma County Water Agency

404 Aviation Boulevard
Santa Rosa, CA 95403-9019
(707) 526-5370
www.scwa.ca.gov

Town of Windsor

9291 Old Redwood Highway
Windsor, California 95492
707-838-1000
www.ci.windsor.ca.us

Valley of The Moon Water District

19039 Bay Street, P.O. Box 280
El Verano, CA 95433
707-996-1037
www.vomwd.com

PROFESSIONAL ASSOCIATIONS

American Rainwater Catchment Systems Association

919 Congress Ave., Ste. 460
Austin, TX 78701
www.arcsa.org

California Landscape Contractors Association

1491 River Park Drive, Suite 100
Sacramento, CA 95815
916-830-2780
www.clca.org

CLCA can help you find a qualified and licensed landscape professional to assist with your home drainage needs.

California Native Plant Society Milo Baker Chapter

55 Ridgway Ave
Santa Rosa, CA 95401-4771
707-578-0595
www.cnpsmb.org

California Stormwater Quality Association

P.O. Box 2105
Menlo Park, CA 94026-2105
650-366-1042
www.casqa.org

Certified Professionals in Erosion and Sediment Control, Inc. (CPESC)

49 State Street
Marion, NC 28752-4020
828- 655-1600
www.cpesc.org/cc-info/cc-dir-list.asp

Link to CPESC professionals in California who can assist you with erosion and drainage concerns

Ecological Landscape Association

1257 Worcester Road #262
Framingham, MA 01701
617-436-5838
California chapter web site
www.ecolandscaping.org/ela-CA.html
Contact the local ELA chapter for information on regional landscape professionals

RESOURCES GUIDE

San Francisco Public Utilities Commission

www.sfwater.org

Publishes excellent resource guides for rainwater harvesting and advanced stormwater design BMPs

Sonoma County Master Gardeners Program Santa Rosa

133 Aviation Blvd Ste 109,
707-565-2608

Sonoma: 19722 8th St E.

707-938-0127

www.groups.ucanr.org/sonomamg

REGULATORY AGENCIES

California Coastal Commission

North Central Coast District Office

45 Fremont Street, Suite 2000

San Francisco, CA 94105-2219

415-904-5260

www.coastal.ca.gov

California Department of Fish and Game (CDFG)

P.O. Box 47

Yountville, CA 94599

(707) 944-5500

www.dfg.ca.gov

**CDFG should be contacted for any work done within a stream or riparian corridor*

National Marine Fisheries Service

(NOAA Fisheries)

777 Sonoma Ave.

Santa Rosa, CA 95404

707-575-6050

www.nmfs.noaa.gov

NOAA must be consulted when steelhead or salmon are potentially affected by an activity

Regional Water Quality Control Boards

North Coast RWQCB (1)

5550 Skylane Blvd., Suite A

Santa Rosa, CA 95403

707-576-2220

www.waterboards.ca.gov/northcoast

San Francisco Bay RWQCB, Region 2

1515 Clay Street, Suite 1400

Oakland, CA 94612

510-622-2300

www.waterboards.ca.gov/sanfranciscobay

Sonoma County Agricultural Commissioner's Office

133 Aviation Blvd., Suite 110

Santa Rosa, CA 95403

707-565-2371

www.sonoma-county.org/agcomm

U.S Army Corps of Engineers (ACOE)

333 Market Street, 8th Floor

San Francisco, CA 94195

415-977-8462

www.usace.army.mil

ACOE regulates the discharge of dredged or fill materials in most creeks, rivers, and wetlands

US Fish and Wildlife Service

Region 8 – Covers Sonoma County

Sacramento Office

2800 Cottage Way, Room W-2605

Sacramento, California 95825

916-414-6600

www.fws.gov/sacramento

WEBSITES

Holy H2O

www.holyh2o.org

International Rainwater Catchment Systems Association

www.eng.warwick.ac.uk/ircsa

Oasis Design - Rainwater Harvesting/ Coliform Concerns

www.rainwaterharvesting.net

www.oasisdesign.net/water/quality/coliform.htm

Permacultura America Latina

www.permacultura.org

Penn State School of Forest Resources

– Water Facts #13 – Coliform Bacteria

www.pubs.cas.psu.edu/FreePubs/pdfs/XH0019.pdf

San Francisco Public Utilities Commission

– Rainwater Harvesting

www.sfwater.org/mto_main.cfm/MC_ID/14/

[MSC_ID/361/MTO_ID/559](http://www.sfwater.org/mto_main.cfm/MC_ID/14/MS_ID/361/MTO_ID/559)

The Rainwater Calculator

www.rain-barrel.net/rainwater-calculator.html

The Centre for Science and Environment -Rainwater Harvesting Technology and Systems www.rainwaterharvesting.org

CONTRACTORS/DESIGN CONSULTANTS

Allwest Construction - Steve Hardister

707-732-6011 in Sonoma CA

AP Rainwater Harvesting & Graywater Gardens - David Ortiz

707-874-9460 in Sebastopol, CA

www.aprainwaterharvesting.com

Artisans Ecological Landscapes and Farms

- Erik Ohlsen

707-332-8100 in Sebastopol, CA

www.permacultureartisans.com

Bill Wilson Environmental Planning

310-441-3861 in Mill Valley, CA

Design Ecology - Josiah Raison Cain

415-888-8515 in Petaluma, CA

www.designecology.com

Earth Craft Design - Bobby Markowitz

831-475-9355 in Soquel, CA

www.earthcraftdesign.com

Elder Creek Landscapes - Rick Taylor

707-529-3008 in Sebastopol CA

Prunuske Chatham, Inc. – Mike Jensen

707-824-4601 ext. 107 in Sebastopol, CA,

www.pcz.com

WaterSprout – John Russell

510-541-7278 in Oakland, CA

www.watersprout.org

Wonderwater - Dylan Coleman

530-926-5050 in Mt. Shasta, CA

www.wonderwater.net

SONOMA COUNTY EQUIPMENT SUPPLIERS

American Tank Co. Inc.

Windsor, CA

877-655-1100

www.watertanks.com

Harmony Farm Supply

Graton, CA

707-823-9125

www.harmonyfarm.com

Horizon Turf and Irrigation

Santa Rosa, CA

707-584-7272

www.horizononline.com

John Deere Green Tech - Tony Yarish (Sales Manager)

Santa Rosa, CA

888-438-7435

ayarish@johndeergreentech.com

National Storage Tank - Aaron Avila

Santa Rosa, CA

707-537-7433

Pioneer Tanks

Sonoma County distributor:

Frank 707-965-3600

www.pwtusa.com

Superior Tank Company

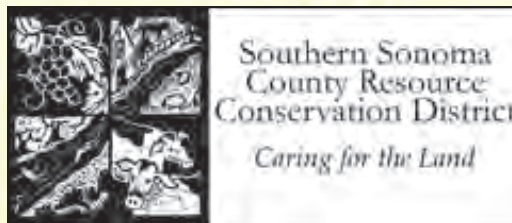
Bakersfield and Rancho Cucamonga, CA

800-221-TANK

www.superiortank.com

NOTES:





Southern Sonoma County Resource Conservation District

1301 Redwood Way, Suite 170 · Petaluma, CA 94954
(707) 794-1242 extension 5
www.sscr.cd.org



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Salmon Creek Water Conservation Program

Conservation Strategy No.5:
Roofwater Harvesting for
Coastal California
Communities





Overview

In many coastal communities, reliable access to fresh water is limited and watershed health is a concern. During summer months, when stream flows and groundwater supplies are lowest, human demand is highest and endangered fish populations are under extreme stress. Additionally, climate change forecasts indicate that greater seasonal variations in rainfall could affect water security.

Roofwater harvesting systems are a “low-tech” way to capture winter rains for use during dry periods. The following is a brief overview of design and construction considerations for roofwater harvesting systems.

Target community

Residents and businesses within all coastal California communities, especially those with water supplies directly linked to waterways supporting threatened or endangered salmon and steelhead fisheries.

Potential effect

A well-designed roofwater harvesting system can reduce or eliminate demand for surface and groundwater supplies, increase water security, improve fire protection, and result in more reliable instream flows for fish and other aquatic life during the dry season. In addition, capturing and infiltrating storage tank overflows onsite can recharge groundwater supplies while reducing erosion, flooding, and pollution during rains.

Implementation

Design elements common to both potable and non-potable systems are listed below, followed by those specific to potable water systems. Special considerations for residential, non-residential, and agricultural uses are addressed next, with a final section of additional web and print resources that offer in-depth analysis of the information in this Conservation Strategy. For a recent rainwater harvesting case study, see: www.oaecwater.org/education/roofwater-harvesting-booklet

First Steps in System Design

Conservation – Efficiency First

A roofwater harvesting system is not intended as supply augmentation for inefficient use, waste, or increase in demand. Roofwater harvesting in coastal California is one approach to seasonally offset demand for instream flows and groundwater with stored rainwater. In any water system design, conservation, and efficiency are always the first steps.

The following websites offer strategies that can significantly reduce a site’s water use. For residential conservation, see www.h2ouse.org or use the Salmon Creek Water Conservation Program’s Residential Self Survey Conservation Strategy at www.salmoncreekwater.org. Many businesses can also use the Salmon Creek Water Conservation Program’s Conservation in the Hospitality Industry Conservation Strategy also at www.salmoncreekwater.org Agricultural users visit www.pacinst.org

Regulations and Permitting

Before starting to design a system, research existing policies or ordinances in your area that regulate the use of rainwater, and be sure your intended system will be in compliance. In many counties, tanks over 5,000 gallons will need a building permit for their grading and installation. For more information visit your county's building department website.

Intended Use: Potable or Non-potable

Anyone who has their water supply impacted during the dry season or who uses water from a stream will benefit from installing a roofwater system. The type of system selected will depend on the intended use of the stored water.

Simple non-potable systems provide fire protection, irrigation, and livestock water supply independent of instream flows and groundwater. Potable systems need filtration, treatment, and possibly a backflow preventer. Consider these factors to determine which roofwater system is most appropriate:

- If irrigation or livestock water supplies are insufficient or unusable, or there are water needs in remote/inaccessible areas (even those currently served by stream diversion or pumping), consider a non-potable system.
- If the current potable water supply requires trucking in water, seasonal changes diminish well capacity or reliability, or there are concerns about water quality, then a potable water system may be worth developing.

Site Survey and Water Audit

To determine how much water will be needed during the summer, perform a water audit on the structures and surrounding landscape. A Residential Self Survey Conservation Strategy is available at www.salmoncreekwater.org, and will help in estimating storage capacity needed for the rainless months of the year. For help performing a water audit and designing systems for larger scale agricultural needs, contact your local Resource Conservation District (RCD). The Gold Ridge RCD also has information on roofwater systems for dairy operations. Their website is: www.goldridgercd.org.

RAINWATER CALCULATOR

A = (catchment area of building)

R = (inches of rain)

G = (total amount of collected rainwater)

$(A) \times (R) \times (600 \text{ gallons}) / 1000 = (G)$

Factors Common to Both Potable and Non-potable Systems

Roofwater harvesting systems range in complexity from rain barrels under downspouts to municipal-scale systems. All share the following elements discussed below.

Collection Capacity

To calculate the collection area of a structure's roof, measure the horizontal length and width of your roof line (not the sloped roof) and multiply the two measurements. Next, gather data on average annual rainfall for the area. On-site rain gauge data is optimal, but contacting the local weather service, agricultural extension agent, or public water agency will suffice.

Then, estimate the water quantity the structure's roof could harvest per year using the following formula: (Collection area square footage) x (Average annual inches of rainfall) x (600 gallons) / 1000 = Total gallons of rainfall harvested per year.

While average annual rainfall numbers are a good starting point, it is a valuable exercise to do this calculation for 25- and 50-year drought figures in order to plan for the worst- case scenario. A capacity calculator is available at www.oaec.water.org/calculators

Gutters and downspouts

24-hour storm intensity in the area will determine gutter and downspout size. Ideally, gutters should capture all the rain that falls during a storm without overflowing. In most coastal communities, a 6" gutter system will work for all but the most severe storms.

First flush diverter/pre-filter

During the dry season, debris will accumulate on the roof and in gutters. First flush diverters and pre-filters ensure that the first few minutes of runoff are rejected, allowing time for rain to clean the roof. As a rough estimate of the necessary diverter capacity, plan for 1 to 2 gallons diverted per 100 square feet of roof area.

Storage capacity

In medium to large systems, storage will be the largest expense and occupy the most space, and so needs to be carefully selected and sized. Based on your water audit, include storage for at least a six-month supply (or whatever it takes to get through our lengthy dry season). Remember this is a minimum number—current climate change projections are for worsening droughts and increasingly unpredictable storms. Increasingly, municipalities are offering incentives to offset part of the installation cost for roofwater harvesting systems. For additional information on storage options, see *Water Storage: Tanks, Cisterns, Aquifers and Ponds*, by Art Ludwig.



Overflow

Once the storage structure is full, the overflow water needs to be piped to an appropriate storm water management location like a rain garden or bioswale. For help with designing an overflow system, please read the Stormwater Conservation Strategy available at www.salmoncreekwater.org

Considerations Unique to Potable Water Systems

Potable water systems have more exacting design requirements than non-potable, and need careful consideration of the following elements:

Roofing

The more non-reactive the roof surface, the better. Many common materials add chemicals that are unsuitable for a potable water system, as do lead roof jacks. For some resources concerning roofing materials and water quality, visit: http://www.thecenterforrainwaterharvesting.org/2_roof_gutters2.htm

Gutters

Keeping your gutters clean of debris and leaves is critical for water quality. In fire-prone areas, gutters act as part of the "defensible space" strategy for your home. For best performance, gutters should be:

- Round-bottomed, smooth, durable, and supported every 30"
- Soldered with non-lead solder
- Protected from leaves and debris

Roof washer

For an additional level of filtration after the first-flush diverter, consider using a roof washer system—a device that mechanically removes finer levels of particulates and debris before it gets to the storage structure. Many different designs are available.

Storage

If a tank is employed, at a minimum it should be National Sanitation Foundation (NSF) certified. All storage vessels regardless of type need to be fully enclosed and screened at all inlets and outlets to prevent mosquito breeding. Also include a connection for Fire Department use and plumb for full drainage to allow cleaning. A complete guide to storage methods and materials can be found in *Water Storage: Tanks, Cisterns, Aquifers and Ponds*, by Art Ludwig.

Backflow prevention

In many cases, municipal water supply codes require a backflow prevention device to be installed. These devices require annual inspections by qualified inspectors. For more information regarding these regulations, call your municipal water supply agency.

Post-storage filtration

For potable water, a fine level of post-filtration for particulate matter is required prior to any disinfection treatment. Failure to filter particulates leaves microscopic sheltered sites where pathogenic bacteria and microbes can survive disinfection. Carbon filtration is the preferred technology. Sand filtration and other methods are sometimes used.



Post-storage treatment

Disinfection deals with bacteria, viruses or other pathogens that are small enough to pass through a particulate filter. The three most common options are:

- Chlorine: the primary biocide in many city water systems and has a long track record, but many people have health concerns with the by-products of chlorination.
- Ozone: can be used as a disinfectant. It is made on site by passing oxygen through ultraviolet light and adding it to the tank water by bubble contact. It requires electricity, has fewer potentially dangerous by-products and leaves no taste or odor.
- Ultra Violet (UV) light: a proven technology that kills unwanted microbes. Electricity is required to operate the UV bulb, which must be changed periodically, but it is effective and leaves no chemical residue in the water. Installing UV with carbon pre-filtration at points of use avoids the need for residual chemicals intended to disinfect storage and distribution systems.

Testing

Collect a sample of water at the tap and send it in to a local Environmental Laboratory Accreditation Program accredited laboratory for testing before drinking it. Consider sampling at the downspout, after the storage structure, and after treatment, for a complete system profile. For additional information, see: www.oasisdesign.net/water/quality/coliform.htm

Site Design

Storage structure placement design parameters are beyond the scope of this document and may require professional assistance. At a minimum, the location must be solid, seismically stable, and provide sufficient clearance below your lowest gutter to install the first-flush pre-filter and/or roof washer above the top of the installed tank. For underground installations, be sure to assess the water table before designing the site.

Deciding Who Will Build the System

As with any building project, it is important to ensure that your design is safe. Water is very heavy (over 8,000 pounds for a full thousand-gallon tank) and it is recommended to have professional review of your plans, even if you are building the system yourself. If you prefer to hire a contractor, a list of licensed regional contractors is available at: www.oaec.water.org/roofwater-suppliers



Special Considerations for Residential Applications

Residential lots tend to have limited space as well as setback requirements, making storage installed within the building envelope attractive. Consider a tank in the basement or under a deck. At a minimum, a rain barrel helps—they are cheap, simple, and have fewer design requirements.

Special Considerations for Non-residential Applications

Larger public and commercial buildings have significant collection capacity and opportunities for tank placement within the building envelope or under playing fields, golf courses and parking lots, yielding high storage capacity.

Special Considerations for Agricultural Applications

Large roof area and open spaces can make agricultural installations less prone to restrictions on tank size and siting, while offering much improved water security for crops and animals during drought years. In upland dry sites that are distant from existing plumbed infrastructure, consider placing a freestanding, self-filling tank. If additional capacity is needed, simple shed roofs built over roofwater storage structures can reduce demand for stream withdrawal and groundwater pumping. Collection and storage capacity of the structure must be sufficient to accommodate the stocking rate and duration of use.

Tools

Financial Incentives

For financial incentives and resources related to roofwater harvesting, Brad Lancaster's site is a good place to start: <http://www.harvestingrainwater.com/rainwater-harvesting-inforesources/water-harvesting-tax-credits/>

The Sonoma County Energy Independence Program offers financial incentives for "permanently installed rainwater cisterns". For more information, see: www.sonomacountyenergy.org

Some municipalities provide rebates on installation of rain barrels. For example, Santa Rosa rebates \$0.25 per gallon of storage. Check with your local water agency.

Books/Periodicals

A highly accessible book for the beginning do-it-yourselfer is *Rainwater Collection for the Mechanically Challenged* by Suzy Banks with Richard Heinichen. www.rainwatercollection.com/rainwater_collection_how.html

The definitive introductory book to all things rainwater is *Rainwater Harvesting for Drylands, Volume 1: Guiding Principles to Welcome Rain Into Your Life and Landscape*, by Brad Lancaster. www.Harvestingrainwater.com

Websites

For a list of Environmental Laboratory Accreditation Program accredited laboratories in California that can test drinking water quality, download: www.cdph.ca.gov/certlic/labs/Documents/ELAPLABLIST.xls

For information on restoring and protecting watersheds by utilizing a framework of regenerative water-use practices known as Conservation Hydrology, visit the Occidental Arts and Ecology Center (OAEC) WATER Institute website at: www.oaecwater.org/education/bor-publication and purchase "*Basins of Relations*." Proceeds benefit the WATER Institute.

For educational opportunities, rainwater harvesting seminars, conferences and a business directory, visit The American Rainwater Catchment Systems Association website at: www.arcsa.org



This conservation strategy was produced by Brock Dolman and Kate Lundquist, Occidental Arts and Ecology Center's WATER Institute and Kevin Swift, Swift Writing, for the Salmon Creek Water Conservation Program (SCWCP). The SCWCP is a multi-year, multi-stakeholder effort focused on developing alternative water supply solutions that support human needs while protecting and restoring instream flows for fish and wildlife.

Resources from OAEC WATER Institute publication, Roofwater Harvesting In California, 2011

BOOKS/PERIODICALS

Design For Water: Rainwater Harvesting, Stormwater Catchment and Alternative Water Reuse by Heather Kinkade-Levario. Publisher: New Society Publishers. ISBN: 9780865715806. (2007) www.newsociety.com/bookid/3954.

Rainwater Catchment Systems for Domestic Supply: Design, construction and implementation by John Gould & Erik Nissen-Petersen. Publisher: ITDG Publishing. ISBN:1853394564 (1999)

Rainwater Collection for the Mechanically Challenged by Suzy Banks with Richard Heinichen Publisher: Tank Town Publishing. ISBN: 0966417003 (1997)
<https://rainwatercollection.com/store/index.php?searchkey=book>

Rainwater Harvesting for Drylands, Volume 1: Guiding Principles to Welcome Rain Into Your Life and Landscape by Brad Lancaster. Publisher: Rainsource Press ISBN: 097724640X (2006) www.harvestingrainwater.com

Rainwater Harvesting for Drylands, Volume 2: Water Harvesting Earthworks by Brad Lancaster. Publisher: Rainsource Press ISBN: 0977246420 (2008)
www.harvestingrainwater.com

Water From The Sky by Michael Reynolds,
http://earthship.com/books?page=shop.product_details&flypage=flypage.tpl&product_id=21&category_id=6

Water Storage: Tanks, Cisterns, Aquifers and Ponds by Art Ludwig. Publisher: Oasis Design. ISBN: 0964343363 (2005) www.oasisdesign.net/water/storage

RELATED ORGANIZATIONS & WEBSITES

American Rainwater Catchment Systems Association
www.arcsa.org

Harvest H2O
<http://www.harvesth2o.com> http://www.harvesth2o.com/statues_regulations.shtml

International Rainwater Catchment Systems Association
www.eng.warwick.ac.uk/ircsa

Oasis Design - Rainwater Harvesting/Coliform
<http://oasisdesign.net/water/rainharvesting/index.htm>
www.oasisdesign.net/water/quality/coliform.htm

Occidental Arts and Ecology Center's WATER Institute
www.oaecwater.org

Penn State School of Forest Resources – Water Facts #13 – Coliform bacteria
<http://pubs.cas.psu.edu/FreePubs/pdfs/XH0019.pdf>

San Francisco Public Utilities Commission – Rainwater Harvesting
www.sfwater.org/mto_main.cfm/MC_ID/14/MSC_ID/361/MTO_ID/559

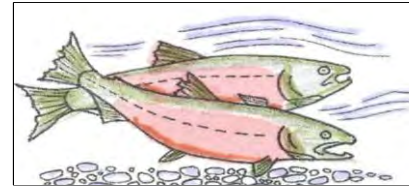
Salmon Protection and Watershed network (SPAWn)
www.spawnUSA.org

The Rainwater Calculator
www.rain-barrel.net/rainwater-calculator.html

The Centre for Science and Environment - Rainwater Harvesting technology and Systems
www.rainwaterharvesting.org

tree People
<http://www.treepeople.org/demonstrations-and-solutions>

Wholly H2O
www.whollyh2o.org



State and Federal Permits for Work in Creeks

AGENCY	PERMIT	AREA OF CONCERN
CA Department of Fish and Game (DFG) http://www.dfg.ca.gov/habcon/1600/	1600 Streambed Alteration Agreement	DFG must be notified of any activity that will: <ul style="list-style-type: none"> ▪ substantially divert or obstruct the natural flow of any river, stream or lake; ▪ substantially change or use any material from the bed, channel, or bank of, any river, stream, or lake; or ▪ deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake. If DFG determines that the activity may substantially adversely affect fish and wildlife resources, a Streambed Alteration Agreement is required.
US Army Corps of Engineers http://www.spn.usace.army.mil/	404 Permit, Section 10 consultation	Section 404 of the Clean Water Act requires Army Corps authorization for work that may result in a sediment discharge into a wetland or stream. Section 10 of the Rivers and Harbors Act requires Corps authorization for work or structures that affect navigable waters.
San Francisco Bay Regional Water Quality Control Board http://www.swrcb.ca.gov/rwqcb2/	401 Certification, Waiver of Waste Discharge Requirement	Section 401 of the Federal Clean Water Act requires certification that actions in or near stream channels do not increase the level of pollutants in streams—including sediment and temperature.
US Fish and Wildlife Service (USFWS) http://endangered.fws.gov/index.html .	Incidental Take Permit	USFWS must be consulted for projects that may result in "take" for species listed as either threatened or endangered under the Federal Endangered Species Act. Take means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" listed species. Incidental take means take of listed species while carrying out otherwise lawful activities.
NOAA Fisheries http://www.noaa.gov/fisheries.html	Incidental Take, or Sect. 10 of the ESA	NOAA must be consulted for projects that may affect anadromous fish, such as salmon and steelhead.

Modified from *Stewardship Guide for the Russian River Watershed*, Sotoyome Resource Conservation District.

Useful websites for Marin County regulations:

Look up your zoning:

<http://gis.marinpublic.com/ZoneGPllookup/default.master.aspx>

Marin County Code, Title 22. DEVELOPMENT CODE:

http://www.co.marin.ca.us/comdev/comdev/CURRENT/pdf/DevCode_1-24-2012_final_draft.pdf

Includes information on setbacks, allowable uses, and permit requirements based on zoning.

General information on the building permit process:

http://www.co.marin.ca.us/depts/cd/main/pdf/building_safety/General_Information.pdf

Includes a list of work exempt from a Building Permit.

Marin Countywide Plan:

http://www.co.marin.ca.us/depts/cd/main/fm/cwpcodes/CWP_CD2.pdf

Policies pertaining to Stream Conservation Areas start on page 2-28.

Marin County Code:

<http://library.municode.com/index.aspx?clientID=16476&stateID=5&statename=California>

Chapter 11.08, Watercourse Division or Obstruction describes activities that will need a creek permit. These include any actions that will block or alter streamflow, such as building retaining walls, installing bridge footings, reconstructing an inset floodplain, or depositing garbage, soil, or yard trimmings.



Information about the applicability of the SCA (Stream Conservation Area) and WCA (Wetland Conservation Area)

The Stream Conservation Area (SCA) and Wetland Conservation Area (WCA) policies of the Marin Countywide Plan establish buffer zones that prohibit development within 100 feet of creeks or wetland areas as measured from the top of bank of creek, edge of riparian habitat, and edge of wetlands. The SCA and WCA policies are applied to projects that require discretionary entitlements (also known as Planning Permits, such as Design Review). *In other words, if your project does not trigger the need for a discretionary entitlement (also known as a planning permit), then the SCA and WCA policies do not apply to your project.*

The Marin County Community Development Agency (CDA) Planning Division reviews all development applications in the San Geronimo Valley (Valley). The Valley is predominantly zoned R-1:B-2 and R-1:B-3, which are considered “conventional” single-family zoning districts that have established height, size, and setback requirements. Usually, if a project complies with the established standards no discretionary entitlements are required and although a building permit may be required to construct the project, the policies of the SCA and WCA would not be applied to the project.

Design Review is the most common discretionary entitlement required for development proposals that might require the application of SCA and WCA policies. Design Review can be required in the following instances:

- The project is for a new single-family residence on a vacant, substandard sized lot that contains less than 50% of the required minimum lot area pursuant to the zoning district or the lot-slope ordinance;
- The project is for a residence that exceeds a total building area of 4,000 square feet;
- The project is for a residence on a vacant lot with a slope of 25% or greater and exceeds 3,000 square feet of building area;
- The project involves the development of a “paper street;”
- The proposed building area following the construction would exceed 3,000 square feet and the size of the resulting residence is more than 100% greater than the existing building area as of January 1, 2008;
- The project exceeds a maximum building height in excess of 30 feet;
- The project is located within a Stream Conservation Area of a vacant lot; and,
- The project is located within a “planned” zoning district, such as ARP, RMP or RSP.

If a project involves a deviation from the established standards (e.g., setback encroachment) or is located in a “planned” zoning district, then a discretionary entitlement, such as a Variance, Use Permit, or Design Review may be required before a building permit is issued. In these instances, the policies of the SCA and WCA would be applied to a project (if applicable).

For more information, contact:

Curtis Havel, Senior Planner
County of Marin
Community Development Agency
3501 Civic Center Drive, Suite 308
San Rafael, CA 94903
415 473 2755 T
415 473 7880 F
chavel@marincounty.org



TREE REMOVAL PERMIT FACT SHEET

A Tree Removal Permit is required for the removal of trees in the following instances:

- More than two (2) "Protected Trees" are being removed from a developed lot in a 12-month period;
- The tree qualifies as a "Heritage Tree";
- The tree is a "Protected Tree" or "Heritage Tree" and is located in a Stream Conservation Area or a Wetland Conservation Area;
- Any removal of "Protected Trees" on a vacant lot; and,
- The trees proposed for removal do not qualify for an exemption under Section 22.62.040 of the Marin County Code (see below).

The Native Tree Protection and Preservation ordinance does not apply to properties located in the coastal zone, and a Coastal Permit may instead be required for the removal of trees and vegetation.

Exemptions

The removal of any protected or heritage tree on a lot is exempt from the requirements of Tree Removal Permit requirements if it meets at least one of the following criteria for removal:

- A. The general health of the tree is so poor due to disease, damage, or age that efforts to ensure its long-term health and survival are unlikely to be successful;
- B. The tree is infected by a pathogen or attacked by insects that threaten surrounding trees as determined by an arborist report or other qualified professional;
- C. The tree is a potential public health and safety hazard due to the risk of its falling and its structural instability cannot be remedied;
- D. The tree is a public nuisance by causing damage to improvements, such as building foundations, retaining walls, roadways/driveways, patios, sidewalks and decks, or interfering with the operation, repair, or maintenance of public utilities;
- E. The tree has been identified by a Fire Inspector as a fire hazard;
- F. The tree was planted for a commercial tree enterprise, such as Christmas tree farms or orchards;
- G. Prohibiting the removal of the tree will conflict with CC&R's which existed at the time this Chapter was adopted;

- H. The tree is located on land which is zoned for agriculture (A, ARP, APZ, C-ARP or C-APZ) and that is being used for commercial agricultural purposes. (This criterion is provided to recognize the agricultural property owner's need to manage these large properties and continue their efforts to be good stewards of the land.);
- I. The tree removal is by a public agency to provide for the routine management and maintenance of public land or to construct a fuel break;
- J. The tree removal is on a developed lot and: 1) does not exceed two protected trees within a one-year timeframe; 2) does not entail the removal of any heritage trees; and 3) does not entail the removal of any protected or heritage trees within a Stream Conservation Area or a Wetland Conservation Area.

It is recommended that a property owner obtain a report from a licensed arborist or verify the status of the tree with photographs to document the applicability of the criteria listed above to a tree which is considered for removal.

Permit Process

Assuming the application for a Tree Removal Permit is complete and there are no potentially significant environmental impacts, the timeframe to process a Tree Removal Permit is 8 to 10 weeks. Please refer to the "Zoning/Development Application Submittal Guide" (available in Room 308 of the Marin County Civic Center and online at www.marincounty.org) for more detailed information regarding the submittal requirements for a Tree Removal Permit.

An application for a Tree Removal Permit must include a landscaping/vegetation management plan that identifies the trees proposed for removal, and proposed replacement trees. As a standard practice to maintain consistency with the Marin Countywide Plan, the Landscaping Objectives identified in Section 22.26.040 of the Marin County Development Code, the Single Family Residential Design Guidelines, and the vegetation management requirements of the Marin County Fire Department or local Fire Protection District, the County may impose requirements including but not limited to the following:

- Replacement of trees at a ratio of two new, appropriately sized and installed trees for each tree designated to be removed;
- For large properties, a management plan which designates areas of the property for preservation of stands of trees or saplings and replacement plantings as required;
- Removal of invasive exotic species; and,
- Posting of a bond to cover the cost of an inspection to ensure success of measures described above.

In the event that tree planting on the site is not feasible or appropriate, the Director may require in lieu of planting on the specific property, the payment of money in the amount of \$500.00 per replacement tree to be deposited into the Tree Preservation Fund managed by the Marin County Parks and Open Space Department for planting, maintenance, and management of trees and other vegetation.

Protected Trees and Heritage Trees

The table below depicts tree types and sizes that qualify as Protected and Heritage Trees.

Common Name	Botanical Name	Protected Size <i>Diameter at Breast Height</i>	Heritage Size <i>Diameter at Breast Height</i>
Arroyo willow	<i>S. lasiolepis</i>	6 inches	18 inches
Big-leaf maple	<i>Acer macrophyllum</i>	10 inches	30 inches
Bishop pine	<i>Pinus muricata</i>	10 inches	30 inches
Blue oak	<i>Q. douglasii</i>	6 inches	18 inches
Box elder	<i>A. negundo var. californicum</i>	10 inches	30 inches
California bay	<i>Umbellularia californica</i>	10 inches	30 inches
California black oak	<i>Q. kelloggii</i>	6 inches	18 inches
California buckeye	<i>Aesculus californica</i>	10 inches	30 inches
California nutmeg	<i>Torreya californica</i>	10 inches	30 inches
Canyon live oak	<i>Q. chrysolepis</i>	6 inches	18 inches
Chaparral oak	<i>Q. wislizeni</i>	6 inches	18 inches
Coast live oak	<i>Quercus agrifolia</i>	6 inches	18 inches
Coast redwood	<i>Sequoia sempervirens</i>	10 inches	30 inches
Douglas-fir	<i>Pseudotsuga menziesii</i>	10 inches	30 inches
Giant Chinquapin	<i>Castanopsis chrysophylla</i>	10 inches	30 inches
Hawthorn	<i>Crataegus douglasii</i>	10 inches	30 inches
Mountain-mahogany	<i>Cercocarpus betuloides</i>	10 inches	30 inches
Narrow leaved willow	<i>Salix exigua</i>	6 inches	18 inches
Oak	<i>Q. parvula var. shrevei</i>	6 inches	18 inches
Oregon ash	<i>Fraxinus latifolia</i>	10 inches	30 inches
Oregon oak	<i>Q. garryana</i>	6 inches	18 inches
Pacific madrone	<i>Arbutus menziesii</i>	6 inches	18 inches
Pacific yew	<i>Taxus brevifolia</i>	10 inches	30 inches
Red alder	<i>A. rubra</i>	10 inches	30 inches
Red elderberry	<i>Sambucus callicarpa</i>	10 inches	30 inches
Red willow	<i>S. laevigata</i>	6 inches	18 inches
Sargent cypress	<i>Cupressus sargentii</i>	6 inches	18 inches
Scoulier's willow	<i>S. scouleriana</i>	6 inches	18 inches
Service-berry	<i>Amelanchier alnifolia</i>	10 inches	30 inches
Shining willow	<i>S. lucida ssp. lasiandra</i>	6 inches	18 inches
Silk tassel	<i>Garrya elliptica</i>	10 inches	30 inches
Sitka willow	<i>S sitchensis</i>	6 inches	18 inches
Tanbark oak	<i>Lithocarpus densiflorus</i>	10 inches	30 inches
Valley oak	<i>Q. lobata</i>	6 inches	18 inches
Wax myrtle	<i>Myrica californica</i>	10 inches	30 inches
White alder	<i>Alnus rhombifolia</i>	10 inches	30 inches

FREE CREEK PERMITTING ASSISTANCE



Marin Project Coordination Meetings

Marin County has monthly project coordination meetings to review and guide projects through the environmental and regulatory permit process. Landowners share their prospective creek projects for free input and constructive feedback from staff at the permitting agencies. These meetings are intended to provide a forum for interaction and input, not public comment or regulatory action. Input from regulators can help you design and implement projects that have minimal impacts to natural resources while achieving your goals.

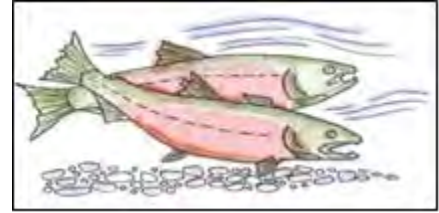
Meetings are held at the Civic Center on the 3rd Wednesday of each month from 11-2. Each project proponent has time on the agenda to share their project and receive feedback. Landowners or their representatives may present their projects (bring photos, sketches, or conceptual plans).

Schedule is based on availability of state, federal, and local staff. Agency staff can include: County of Marin, San Francisco Bay Regional Water Quality Control Board, California Department of Fish and Game, U.S. Army Corps of Engineers, and NOAA Fisheries.

For more information or to be placed on the agenda, contact:

Liz Lewis, Marin County Public Works: lizlewis@marincounty.org or 415.473.7226 or

Chris Choo: cchoo@marincounty.org or 415.473.7586



Internet Resources

General information for Marin County

http://www.marinwatersheds.org/landowner_help.html Extensive list of resources with links and downloads for all things creek-related. Other parts of the websites contain information on Marin County watersheds and announcements of events and meetings.

Native Plants for Landscaping and Wildlife:

Two local nurseries have excellent information on which plants to put where, and lists of plants for attracting pollinators:

<http://www.mostlynatives.com/>

<http://www.calfloranursery.com/>

Habitat gardening tips from California Native Plant Society. Plants for birds, bees, and other wildlife species.

<http://www.cnps.org/cnps/grownative/habitat/>

A fun website created by a conservation biologist to help homeowners:

<http://www.ecosystemgardening.com/>

Bay Area Landscape Guidelines

http://www.stopwaste.org/docs/bay-friendly_landscape_guidelines_-_all_chapters.pdf

Rainwater Harvesting

Resource lists and downloadable guides from the Occidental Arts & Ecology Center's Water Institute:

<http://www.oaecwater.org/education/roofwater-harvesting>

Rainwater catchment guru Brad Lancaster's site:

<http://www.harvestingrainwater.com/rainwater-harvesting-inforesources/>

Information-sharing site with many excellent resources and articles:

<http://www.harvesth2o.com/>

Salmon and Steelhead

A study guide for 6th grade students, but thorough explanation of coho salmon and steelhead life cycles and habitat needs:

[http://sns.ucdavis.edu/index.php/background_information#The Salmon and Steelhead Life Cycle](http://sns.ucdavis.edu/index.php/background_information#The_Salmon_and_Steelhead_Life_Cycle)

Clear description of all stages of coho, steelhead, and Chinook lifecycles:

<http://www.fishnet4c.org/pdf/Roads%20Manual%20PDFs%2007/Chapter%204%20Stream%20Habitat-%20Salmon%20Fisheries%20update%202-07.pdf>

Rainwater infiltration

Resources, plans and specifications, and general information on low impact stormwater development techniques such as bioswales, rain gardens, and green roofs:

<http://www.lid-stormwater.net/homedesign.htm>

Benefits and instructions for rain gardens:

<http://www.raingardennetwork.com/about.htm>