https://www.ecologyartisans.com/

Erosion Control Treatment Training Packet

How-to Guides for Erosion Control Restoration Treatments in Drylands

***Note**: What follows is a suite of individual treatment techniques and options. Each treatment type has a set of appropriate settings for application. All treatments should be custom fit to the specific landform and context in which they are applied. Treatment types can be applied in unison and are often more effective when combined across a larger area of the landscape. Impacts of grazing and other land management practices not included here should be considered when selecting and implementing any of these treatments.*

***Credit**: The Treatment techniques included here were not created by Ecology Artisans. Where we have drawn directly from other resources we have noted this with credit to original sources. Where we have summarized, adapted, and/or expanded on other resources and techniques we have attempted to reference any informative resources. If you find an unlisted original source for material presented here, please contact us so we can update this document appropriately.*

Compiled by: Neil Bertrando and Tigre Pickett, Ecology Artisans, November 2016

Key/Legend

Treatment Type/Name
graphic/photo example

Treatment Summary
Short description

Materials
Materials list

Site Selection
Guidelines for determine where to apply each technique

Indicators
Bullet point list of observable phenomena that suggest application of treatment

Alternative Treatments (Alt. Treatments)
List of other treatment options

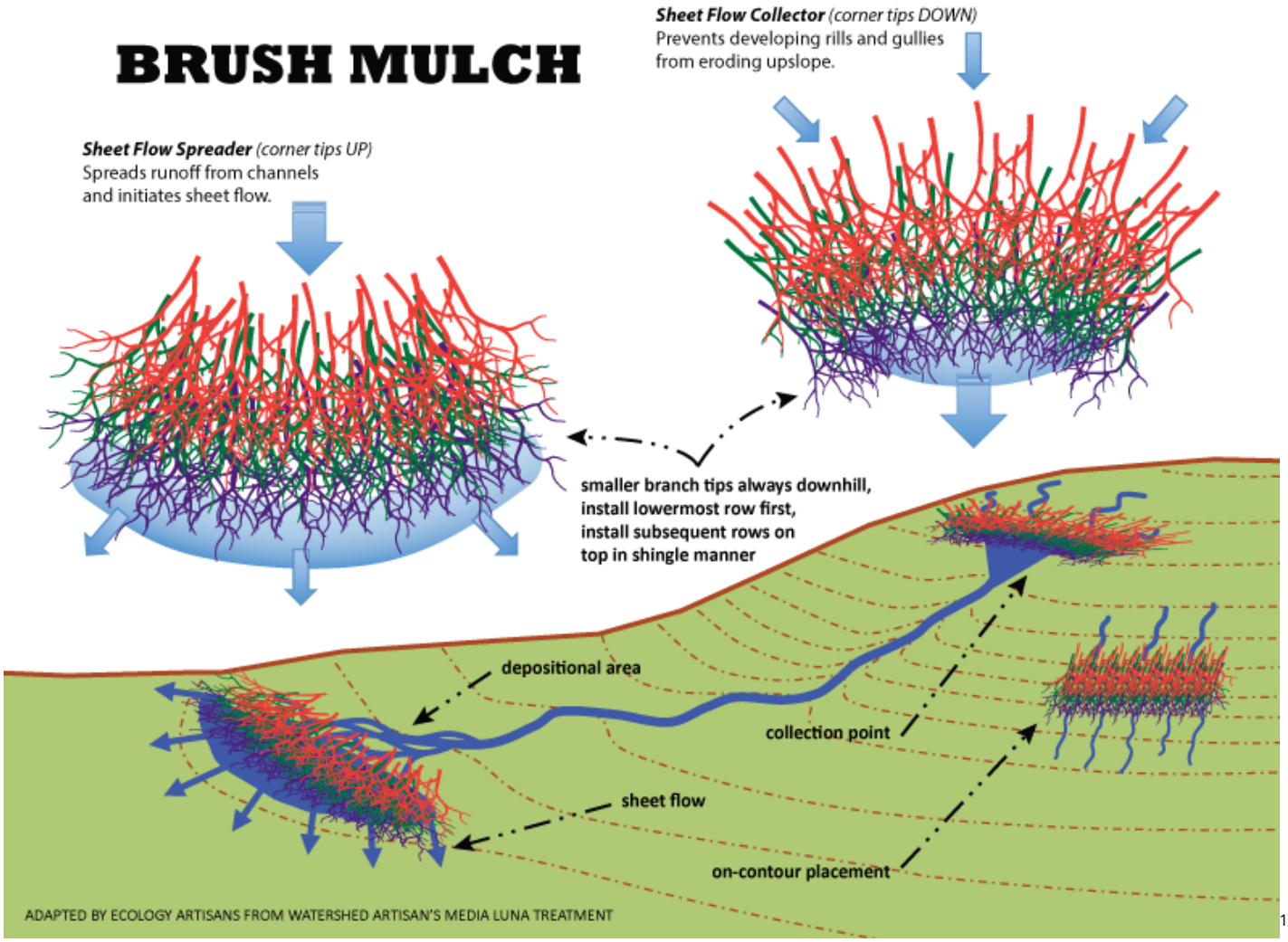
Installation
Step by step construction method

Inspection Quality Control
Checklist to look for during and after construction

Maintenance / Follow-up
Post-construction action points

Table of Contents

Brush Mulch



[1]

Treatment Summary

Brush mulch is a treatment for low-energy settings applied to maintain sheet flow and mitigate sheet and rill erosion. It can be applied in strips on contour, in Media Lunas, and in small low-energy gullies. Brush is applied in 3-6' wide bands with cut butt ends facing uphill and spreading branches facing downhill. Brush/branches can be a range of sizes and be freshly cut with leaves/needles attached or old dead branches. For best results, seed area before applying brush mulch and pin mulch down with twine and stakes to ensure good soil contact and resistance to movement by flowing water. Successful brush mulch collects sediment, organic matter and seeds carried by wind and water erosion resulting in a structure that vegetates and self buries over time.

[1] Modified & adapted from Sponholtz, C., et al.; "Media Luna"; "Erosion Control Field Guide"; Quivira Coalition & Watershed Artisans

Brush Mulch (con't)

Materials

- Brush/branches (ideally 2-6' long): Enough to cover area with good overlap (50%+)
- Seeds and mycorrhizal inoculant (optional)
- Rake (if seeding)
- Untreated heavy duty Jute twine (or bailing twine (return to remove if not biodegradable)
- 12-18" Stakes (can be made from 1-3" diameter branch trimmings; length depends on soil and erosional energy)
- Hammer
- Pruners, loppers, pruning saw
- Pocket knife

Site Selection

Low energy settings (non-channel) are best for this technique. It can be applied on steeper slopes (up to 30%) and is most effective on slopes <8%. Ideal locations are areas where sheet erosion is starting to concentrate into rill erosion (sheet flow starts channelizing) and areas just above where rills and gullies begin depositing sediment in small alluvial features. Low energy gullies and headcuts (low slope, shallow and wide), which are stabilizing (deposition, revegetation and litter accumulation are occurring). A nearby supply of brush/branches is ideal. If brush is imported from off-site make sure materials are screened for seed/propagules of undesirable species.

Indicators

- Point of initiation of rill erosion
- Point of initiation of deposition at mouth of gully or rill
- Sheet erosion: lack of litter / bare ground with coarse sediments

Alternative Treatments

- Compost
- Fish Scale Straw Mulch
- Jute Mesh
- Media Luna
- Micro-Basins: Net and Pan / Fish Scale / Chevron
- Rock Mulch
- Seeding
- Soil Crete
- Soil Pitting
- Straw Flake Filter Dam
- Surface Mulch
- Vertical Mulch
- Wattles/Socks

Brush Mulch (con't)

Installation

1. Select appropriate site: state why selected based on selection criteria
2. Gather and stockpile brush near site
3. Measure and flag contour of site and mark off extent of brush mulch structure (~3-6' long downslope, as wide as appropriate to treatment site)
4. Spread and rake seed
5. Place branches starting from the bottom of the structure in rows across the slope with the spreading branch ends facing downhill and cut butt ends facing uphill
    a. In general, align branching ends on bottom row of structure and but ends on top row.
6. Overlap branches both side to side and in ascending rows to create a shingled effect
7. Lightly Key in top row of branch butts: dig a small notch and cover the butt end.
8. Once all rows are placed, pin down structure (structures only need to be pinned down if they are in higher flow environments (i.e. at the mouth of a gully or used in gullies as Brush Dam)
    a. Create stakes from branch cuttings or use prefabricated stakes
    b. Cut small notch in stakes 3-4" down from top
    c. Position stakes at each end of the structure and at 6-10' intervals if structure is wide.
    d. Tie two lengths of Jute twine taut between each pair of stakes (can tie straight and at angles) (can use extra lengths of twine if branches are resistant)
    e. Pound in stakes as much as possible to secure structure. Try to get twine close to ground level
9. Cover uphill/but ends with soil or mulch with the goal to maintain sheetflow

Inspection / Quality Control

- Appropriate site selection
- Good soil contact with brush
- Taut strings holding structure down
- Good overlap of brush both side to side and uphill-downhill
- Spreading ends facing downhill
- Uphill ends covered or mulched
- All branches used or cleaned up

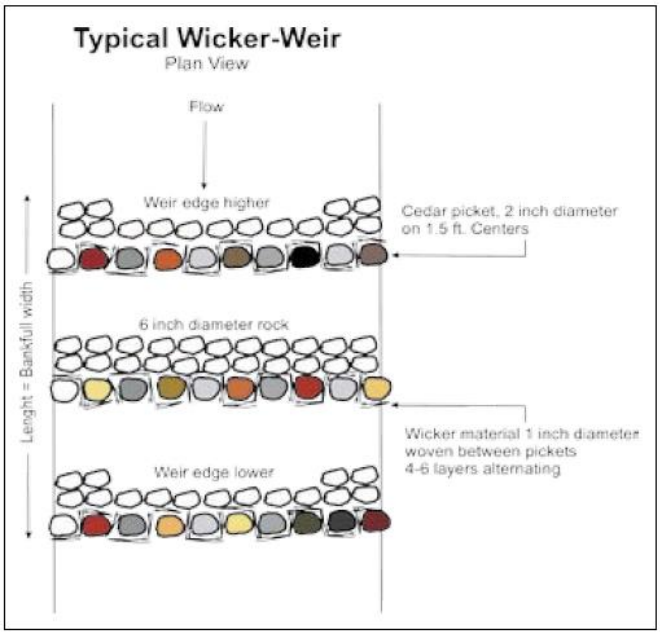
Maintenance / Follow-up

Visit annually and/or after storm events

- If rills continue to propagate, add additional structure uphill (consider Fish scale straw mulch, wattle/sock, rock mulch, or jute netting)
- If butt ends have been lifted, stomp down or tie down more securely
- If weeds are growing remove before seed set
- If poor vegetation recruitment, re-seed
- If structure is working well and completely filled in with sediment and vegetation, add additional brush mulch structure with bottom row overlapping top of previous structure

Brush/Wicker Weirs and Brush Dams

[2]



[3]

Treatment Summary

"**Wicker-Weirs**: Small dams across a creek or gully built by driving sharpened stakes or pickets into the channel bed and then weaving saplings, tree limbs, or willow cuttings between the stakes perpendicular to the flow. They are designed to control streambed elevation, channel slope, and pool depth while enabling free passage of water.

Brush Dams: Built of loosely piled brush or tree branches piled in gully bottom. These can be wired together or strength and increased stability. Keep them loose and low in height in order to stimulate plant growth. Tall, thick brush dams smother new plant growth." [2]

[2] Source: http://quiviracoalition.org/images/pdfs/1025-Leaving_It_Better_Presentation-Zeedyk.pdf

[3] Zeedyk, B. and Jansens, J. 2006. An Introduction to Erosion Control. 2nd Ed. Earth Works Institute, The Quivira Coalition, and Zeedyk Ecological Consulting

Brush/Wicker Weirs and Brush Dams (con't)

Materials

- 1.5-3" diameter stakes 2-4' long made from local branches (willow, eucalyptus, juniper, oak, etc)
- Smaller diameter branches (greenwood) to weave between posts
- Rocks or rubble
- Hammer
- Pruners, loppers, pruning saw, hatchet

Site Selection

Select Gullies which are 2' wide or wider. Position in flatter areas for increased effect. Can also be used as in channel grade control treatments. In this case use longer posts and position in cross-over/riffle sections. In both settings, treatment effectiveness is improved by building weir structures in sets of 2-3 approximately 2-6' apart (total length of set ~equal to width of gully/channel). Closer together for smaller gullies, wider spacing in arroyos and larger gullies (where water flow is higher). Brush dams can be build like One Rock Dams where lengths along channel are 4-6'.

Installation

1. Select a site: gully or cross-over/riffle and bring materials to site
2. Mark location of weirs or brush dams with pin flags. Line up weir perpendicular to gully / channel (flow of water).
3. For Brush Dam, build like Brush Mulch starting at downstream end with branch spreading pointed downstream and overlap building upstream in shingled rows from bottom row. Make sure brush is well stomped down with good ground contact. Can secure with posts and twine as in Brush Mulch if desired. Make sure dish shape is maintained in channel with lowest point in center of channel.
4. For Brush/Wicker Weir, sharpen post ends with hatchet, etc. and pound in on 1.5' centers (or closer in smaller gullies) and leave 4-8" sticking up above ground (on steeper gullies leave 4", flatter leave 8", err on the side of shorter rather than taller). Make sure that the tops of all the posts are lower than the gully or floodplain.
    a. Make sure to leave a dish shape in the tops of the posts with the lowest point being in the center of the channel. (if you cannot pound them to the appropriate heights, pull a line and mark the posts, then trim the tops with a saw/loppers).
5. Weave green branches/saplings between posts all the way from ground level to top of post
6. Backfill behind posts with rubble or ~6" rock (1-2 rows of rock) or in low energy (non-channel) settings, brush. Rocks should be lower profile than posts and weir.

Alternative Treatments

- One Rock Dam

Brush/Wicker Weirs and Brush Dams (con't)

Inspection Quality Control

- Wicker/brush is woven all the way to ground contact at all points along each weir, and no large gaps occur in wicker
- Post tops maintain a dish shape across the gully/channel with the lowest post in the center of flow
- Tops of all posts are below the elevation of the floodplain or gully edges
- Rocks are lower profile than weir and maintain dish shape across gully/channel

Maintenance / Follow-up

Visit annually and/or after storm events

- Widen weirs or brush dams if channel or gully widens and flow goes around structure
- Repair any breaks or holes in weirs
- If sediment fills in completely, create second set.

Compost

Treatment Summary

Compost application as a top-dressing or mulch is used to facilitate vegetative growth, increase infiltration, maintain sheetflow, and protect soil surface from compaction and erosion due to rainfall. Compost feeds the soil microbes when vegetation is dormant. Compost is usually applied in combination with seeding and spread at a depth of ¼-½" (sometimes as thick as 1"). It can be applied to cover a whole area or in contour strips (often ~4-8' wide with gaps 5-10' or more between strips). **We highly recommend applying in contour based strips to extend the available coverage over the site**.

Proper compost is a living medium. Exposure to sun, heat and wind will reduce its benefits significantly. It's best applied directly to the soil or within potting holes and then covered with appropriate mulch. If applied alone, after desiccation by sun/wind, compost can easily be blown away from the application site.

Compost (con't)

Materials

- Compost
- Wheelbarrow
- Shovels
- Rakes
- Mulch (optional)

Site Selection

Compost application can be used to jumpstart revegetation. Ideal sites are grade changes and lower gradient slopes (<15%, though steeper slopes can be treated) with high % of bare ground or low % cover/litter. Anywhere where topsoil has eroded away exposing subsoil. Areas where sheet and rill erosion are occurring and sites where runoff from the proposed treatment area is contributing to erosion downslope.

Indicators

- High % bare ground
- Small rills or sheet erosion
- Low % litter or plant cover

Alt. Treatments

- Jute Mesh
- Seeding
- Surface Mulch

Installation

1. Select appropriate site and measure area to get appropriate volume of compost.
2. Mark out strips when applicable.
3. Deliver compost as close to application site as possible.
4. If site is subsoil or has cemented surface crust, loosen surface with rakes or harrow.
5. Seed if desired.
6. Spread compost at desired thickness with wheelbarrows and rakes (or by machine).
7. Cover compost with Surface Mulch to improve effectiveness of compost and reduce drying out or wind distribution.

Inspection Quality Control

- Compost is spread at desired thickness across entire desired treatment area

Maintenance / Follow-up

- Monitor results from various application thicknesses and use results to inform future application rates

Diversion Ditches / Worm Ditch

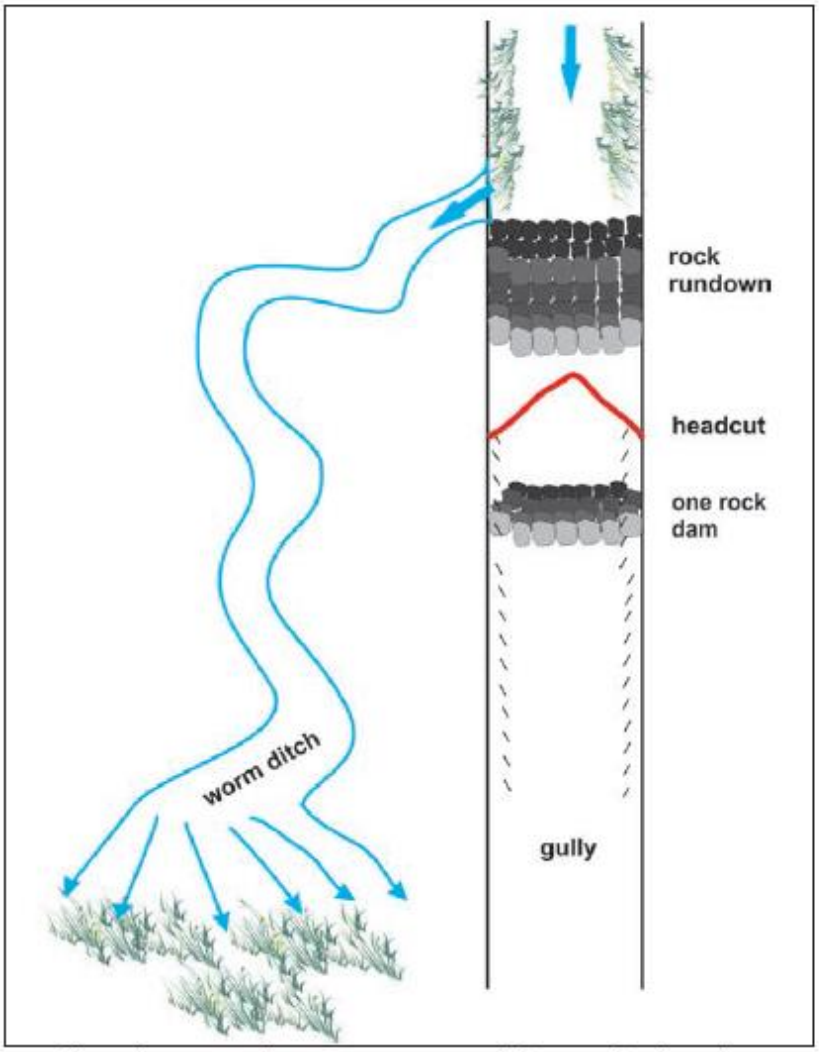


Figure 60. The photograph shows a worm ditch constructed by volunteers in the Springwagon Creek slope wetlands in the Comanche Creek Watershed. The schematic shows how to use a worm ditch in conjunction with other treatment structures to divert water out of an incised channel or gully.

Treatment Summary

One way to stop a headcut is to starve it for water. A worm ditch or diversion ditch is used to divert water away from a headcut or downcut channel and spill it onto a flatter spreading feature in the landscape to re-establish sheetflow. Accomplish this by digging a bypass ditch around the headcut. A media luna of rock or brush may be needed at the outlet to prevent erosion. Care must be taken if the runoff flow may re-enter a gully to armor the point of re-entry with a Rock Mulch Rundown to prevent further gully erosion.

Diversion Ditches/Worm Ditch (con't)

Materials

- Bunyip or laser level
- Pin flags
- Shovels

Site Selection

Ideal sites are locations where active headcuts are causing gully erosion to move upslope and dewater a landscape. Additionally sites need to be low slope (<15%) and have a flatter (0-8%), spreading feature where the water can be diverted to and re-establish sheet flow or infiltration.

Indicators

- Active headcut with angular cut and not revegetating
- Flat ridge shaped landform nearby (within 100') ideally with growing vegetation, good litter cover, and/or signs of deposition

Alt. Treatments

- Fish Scale Straw Mulch (as diversion)
- Rock Mulch Rundown (to treat headcut)
- Wattle/Sock (as diversion)

Installation

1. Select an appropriate site and identify source of water pouring over headcut and spreading feature in landscape where worm ditch outlet will drain.
2. Locate a point 3+' uphill from the headcut and put a pin flag in the center of water flow path.
3. Select a gradient for the ditch 0.25-4% (usually 1-2%) and mark off a line at this gradient to the spreading feature and to the other side of the headcut to ensure all water feeding the headcut is diverted away to the spreading feature.
4. Dig a ditch 4-8" deep and 12-24" wide at a constant depth along the marked line and make a gentle berm on the downhill side of the ditch.
    a. Make sure the edges of the ditch have as gentle a slope as possible to avoid creating more erosion
5. Feather the end of the ditch back up to grade at the outlet and build a media luna of rock or brush if needed (can also create with fish scale straw mulch).
6. Seed if desired.

Worm Ditch Installed by Restoration Ecology

Diversion Ditches/Worm Ditch (con't)

Inspection Quality Control

- Make sure the gradient of the ditch is < 4%.
- Make sure any runoff that could feed the headcut is diverted away.
- Make sure the edges of the ditch are gently sloped, not abrupt/steep cuts.
- Make sure the outlet is at a flat, spreading feature in the landscape (signs of deposition, good litter cover, and/or good vegetation) and that a structure is built at the outlet if needed.

Maintenance / Follow-up

Visit annually and/or after storm events

- Decrease grade or add brush or small rocks in ditch if erosion occurs in ditch,
- Check that headcut has stopped moving, if not, consider treating with Rock Mulch Rundown or identify source of water and extend ditch to divert it.
- Make sure ditch is not causing erosion at another point in the landscape. If so, treat this with mulch, media luna or other appropriate treatment.

Exclosures

Source: http://greatbasinenvironment alprogram.org/results/ts-ranch/

Treatment Summary

Exclosures are small, fenced areas which excludes livestock, wildlife, and/or other treatments such as mowing. They create a monitorable area to improve understanding of how a system responds to being rested. They are often used in grazing operations to monitor the effects of grazing and rest, and they are also used to exclude wildlife to allow vegetation recruitment and growth.

Materials

- T-posts
- Hog wire panels or wire fence and clips or tie wire
- Post pounder
- Tape measure or string

Site Selection

Exclosure sites are either representative of a general land area or protect a specific resource (such as a wetland or river corridor). Ideally they are not located near or on trails and are positioned not to interfere with general site operations. Exclosures are only used as part of an overall monitoring or management plan and should not be built randomly in the landscape, but rather with a clear objective for gaining information about the site or to protect a critical area from herbivory and allow vegetation recruitment and response.

Exclosures (con't)

Installation

For Meadowview Open Space, exclosures would be used to compare the effects of grazing vs. rest on an area that is being grazed for management. Exclosures should be set up before the grazing animals arrive and built to keep that specific class of animal out. For sheep, hog wire panels cut to 8' sections are a good choice and make an 8'x8' exclosure with 4 t-posts. Until grazing is being used as a management tool, exclosures should not be considered as a treatment option

1. Determine a monitoring or management plan and select exclosure sites to match this plan
2. Measure off a square of the desired size
3. Pound in posts
4. Attach wire to posts

Set up photopoint and collect any baseline monitoring data from within and without exclosure

Inspection Quality Control

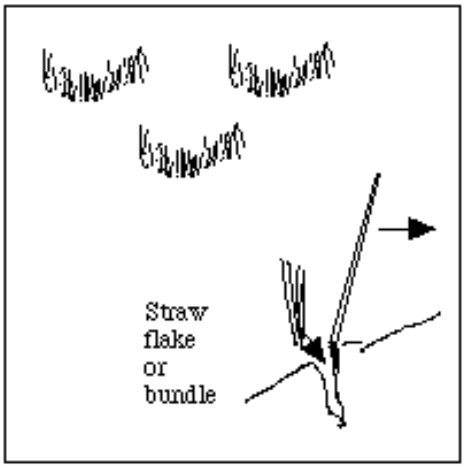
- Posts are solid in ground
- Wire is securely fastened and does not wobble or give. If it does add more posts and clips/tie wire. If this doesn't work, you may need to add bracing. The value of hog wire is that it provides this bracing/structure.

Maintenance / Follow-up

- Collect monitoring data on schedule based on monitoring plan
- Take down exclosure when not needed anymore
- Make sure exclosure is still sound before animals return
- Check on exclosure when animals arrive to see if they have damaged it or gotten inside

Fish Scale Straw Mulch


[4]



[5]

Treatment Summary

Weed-free wheat or rice straw fish-scale rows on contour are inexpensive and easy to install. These strips of vertical mulch help slow erosion, maintain sheetflow, infiltrate runoff, and allow sediment to be caught by the vertical straw fish scale mulch. Combined in an alternating offset pattern on or near contour, these are easy to install using low-skilled or volunteer labor and resource needs are minimal. Strips of fish scale straw mulch can be applied on contour at intervals up a hill at spacing ranging from 10-100' getting closer as the site gets steeper. Hard, compacted ground is not conducive for this treatment; use a digging bar and do Vertical Mulch instead or other treatment.

Materials

- Weed-free straw bales
- Shovel (Pick if shovels don't work)
- Seeds and mycorrhizae if desired

Site Selection

Areas where sheet and rill erosion are occurring leading to bare ground, low litter amounts, low vegetative growth and poor infiltration.

Indicators

- High % Bare ground
- Low litter cover
- Rill erosion

Alt. Treatments

- Brush mulch
- Compost
- Jute netting
- Rock mulch
- Seeding
- Soil Pitting
- Surface Mulch
- Vertical Mulch

[4] Source: Bainbridge, DA. 2007
[5] Source: http://www.sci.sdsu.edu/SERG/ techniques/erosion.html

Fish Scale Mulch (con't)

Installation

1. Select site and bring materials and labor.
2. Along contour/perpendicular to the flow of water, from uphill side dig one slot with shovel, stomp and stand on shovel and have one person slide and press a bundle of straw vertically into the slot as the shovel is removed.
    a. Do not crimp or bend the straw. Place ends into hole.
    b. Smaller bundles work best. Don't try to insert large bundles.
3. Pack the dirt to hold the straw in place.
4. Dig a slot adjacent to the first and repeat along a contour line (or close to) across the slope.
5. Stagger additional slots up and down slope to add surface area, coverage, and effectiveness to the overall treatment.
6. *Optional*:
    a. Seed with native seeds and mycorrhizae to help establish revegetation during flake installation.
    b. Combine with mulch, bark or seed-free compost.

Inspection Quality Control

- Make sure straw is placed vertically in slots and not bent halfway and jammed into slot.
- Check that soil is compacted and straw is secured in place.

Maintenance / Follow-up

Visit annually and/or after storm events

- If sediment is collected and vegetation is being recruited well, consider adding more rows on hillside staggered between previous treatments.

Jute Mesh

 [6]

Treatment Summary

Jute mesh is an open weave textile (OWT) that naturally degrades over time. Pinned flat along sloped surfaces from 4H:1V to 2H:1V, it provides immediate erosion control protection. The open weave allows for application of revegetation seed before or after the mesh is laid down. Mesh helps retain soil moisture and seed germination for vegetation establishment. Slopes exceeding 2:1 should use Rolled Erosion Control Products (Netting) made of coconut (coir) fiber.

Materials

- Jute mesh (Rolled Erosion Control Product (Netting) for steeper slopes or longer durability)
- Landscape staples
- Broadcast Seed, Machine or Hydroseed Materials
- Compost and/or Mulch

Site Selection

Areas where sheet and rill erosion are occurring leading to bare ground, low litter amounts, low vegetative growth and poor infiltration. Jute mesh is most appropriate for erosion control on slopes of 25-50% (4H:1V to 2H:1V).

Indicators

- High % Bare ground
- Low litter cover
- Rill erosion

Alt. Treatments

- Mulch or Bark
- Rolled Erosion Control Product (Netting)
- Brush Mulch

[6] Photo Courtesy: CalTrans

Jute Mesh (con't)

Installation

1. Purchase desired square footage of mesh taking into account a minimum of 12" (6" either side) overlap between adjacent strips.
2. Bring tools and materials to job site.
3. Remove any rocks, debris or objects on the site that will lift or interfere with the mesh.
4. Unroll and secure mesh with landscaping staples ensuring that the fabric is in good contract with the soil.
5. Overlap adjacent mesh rolls by 6" each side, stapling every 1-2'.
6. Apply any seed over top the jute mesh, or, if preferred, before Step 4.
7. *Optional:* Apply light compost layer over jute mesh to aesthetics or to aid in soil moisture production.

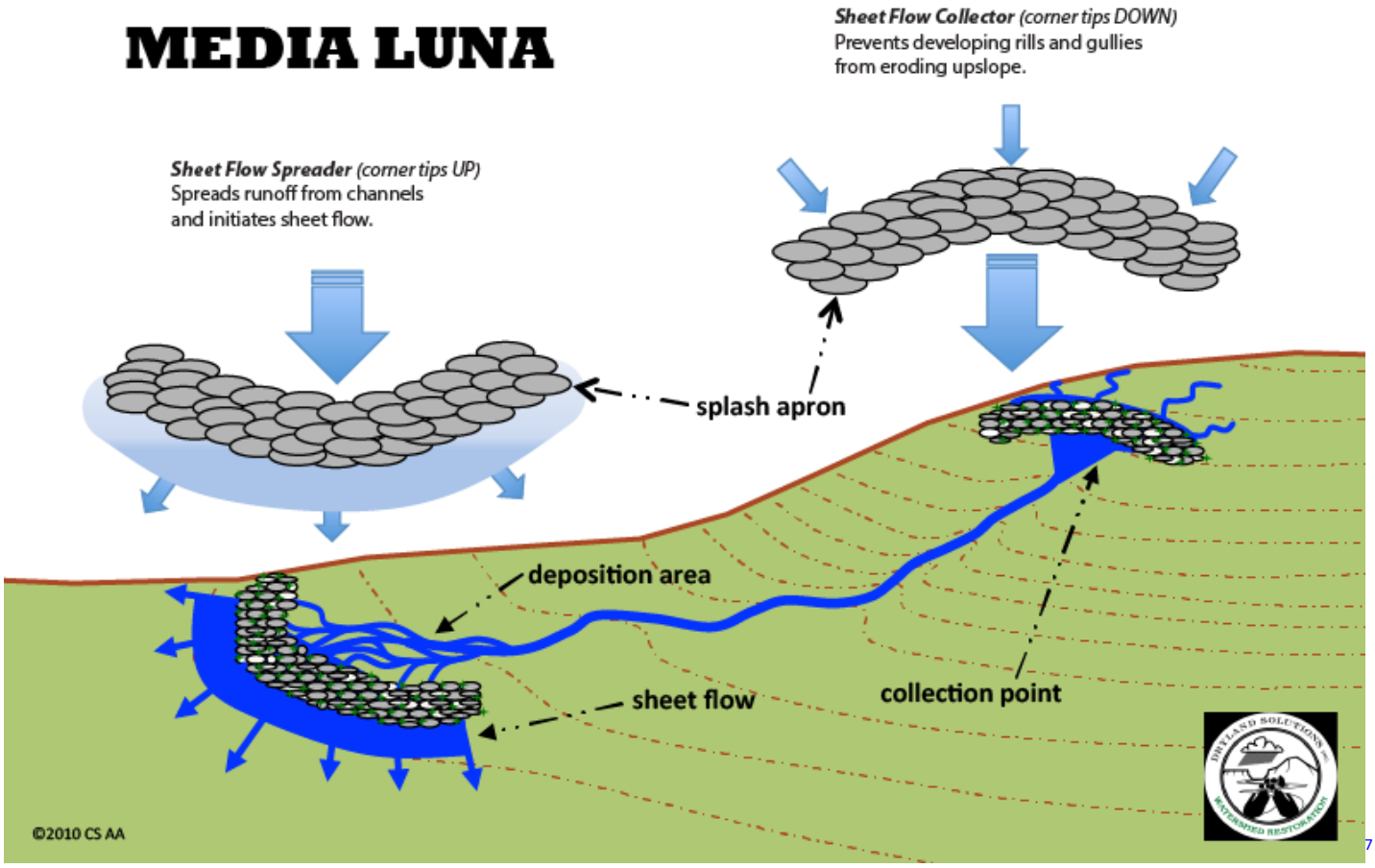
Inspection Quality Control

- Periodic maintenance visits to ensure mesh hasn't come loose or is no longer covering treatment area.
- Repair pulled staples, rips, or damage to mesh.
- If trying to establish vegetation through supplemental irrigation, test for soil moisture and system performance to ensure successful establishment.

Maintenance / Follow-up

- Observing and documenting improved erosion control and/or vegetative establishment.
- Ideally, jute mesh is absorbed into landscape as vegetation improves. Depending on impact of erosion and mitigation, apply addition mesh or consider Rolled Erosion Control Products (Netting).

Media Luna



Treatment Summary

There are two types of Media Luna structures – both used to manage sheet flow and prevent erosion. "Sheet flow collectors" (tips DOWN) prevent erosion (small headcuts) at the head of rills and gullies by creating a stable transition from sheet flow to channel flow at the collection point. "Sheet flow spreaders" (tips UP) are used to create a depositional area on relatively flat ground by dispersing erosive channelized flow and reestablishing sheet flow where it once occurred. Original concept developed by Van Clothier, and expanded upon by Craig Sponholtz.

They are most commonly made out of rock mulch, but can also be made from Soil Crete, brush, and prickly pear cactus pads. Other materials may work as well. Media Lunas are laid out on contour to define their shape and are positioned either at the apex of an alluvial fan / deposition zone where channelized flow slows down and spreads out or at the location where channelized flow begins to concentrate. Ideally, seed are spread prior to laying down erosion control materials.

[7] Sponholtz, C., et al.; "Media Luna"; "Erosion Control Field Guide"; Quivira Coalition & Watershed Artisans

Media Luna (con't)

Materials

- Bunyip or laser level
- Pin flags
- Sufficient rock, Soil Crete and burlap sand bags, or prickly pear pads to fill area
- Seed and mycorrhizae
- Shovels

Site Selection

Locations where sheet flow converges into rills and gullies and the slope begins to steepen, or flat areas where rills or gullies can be re-dispersed into sheetflow. These flat areas are often near or above the apex of an alluvial fan.

Indicators

- Point of initiation of Rill or small gully erosion
- Point of initiation of deposition from rill or gully
- Apex of alluvial fan at base of erosion gully or rill complex

Alt. Treatments

- Brush Mulch
- Fish Scale Straw Mulch
- Jute Mesh
- Seeding
- Wattles/Sock

Installation[8]

1. Identify which type of Media Luna ("tips UP" or "tips DOWN") is appropriate for the treatment site.
2. If the treatment site is at the collection point of a network of rills (< 6 in/15cm deep) or small channels (< 1 n/30cm deep) then use a sheet flow collector (tips DOWN). First lay out the down-slope edge of the structure by selecting two points on the banks of the main channel immediately down slope from where the rills enter. Using a leveling tool, lay out a level arc from bank to bank so that the tips point down slope, and the arc spans all of the rills that you aim to treat.
3. If the treatment site is located where runoff from rills or a shallow channel can easily be spread across relatively flat ground, then use a sheet flow spreader (Hps UP). First lay out the down-slope edge of the structure by creating a level arc across the flat area with the tips on a slightly higher contour. The tips should be far enough up slope that they prevent water from running around the ends of the structure.
4. Layout the up-slope edge of both types of Media Lunas by tracing a level arc parallel to the down-slope edge to create a band that is at least 3 ft / 1m wide. Media Lunas composed of wider bands of rock mulch offer more protection from erosion, improved infiltration and increased plant recruitment.
5. Scatter native grass and wildflower seeds in the area where the Media Luna is to be built.
6. To construct the splash apron, start by digging a shallow trench from tip to tip along the down-slope edge. Fill the trench with one to two rows of rock, so that no rock protrudes more than 2 in / 5cm above ground level.
7. For both types of Media Lunas, continue construction on the down-slope edge (by the splash apron) and work up slope covering the ground with a single layer of rock mulch to form a band at least 3 ft / 1m wide. The tops of the rocks need to be level to ensure proper function of the structure.

[8] Sponholtz, C., et al.; "Media Luna"; "Erosion Control Field Guide"; Quivira Coalition & Watershed Artisans

Media Luna (con't)

Inspection Quality Control

- Ensure rocks are stabilized and no excessive water flow or physical force has dislodged rocks and compromises structure.
- Inspect and repair any side cutting of the media luna and ensure water is flowing through the structure and NOT around it.

Maintenance / Follow-up

- Press or broadcast additional seed if first seeding didn't not have successful germination.

Micro-Basins: Net and Pan / Fish Scale / Chevron

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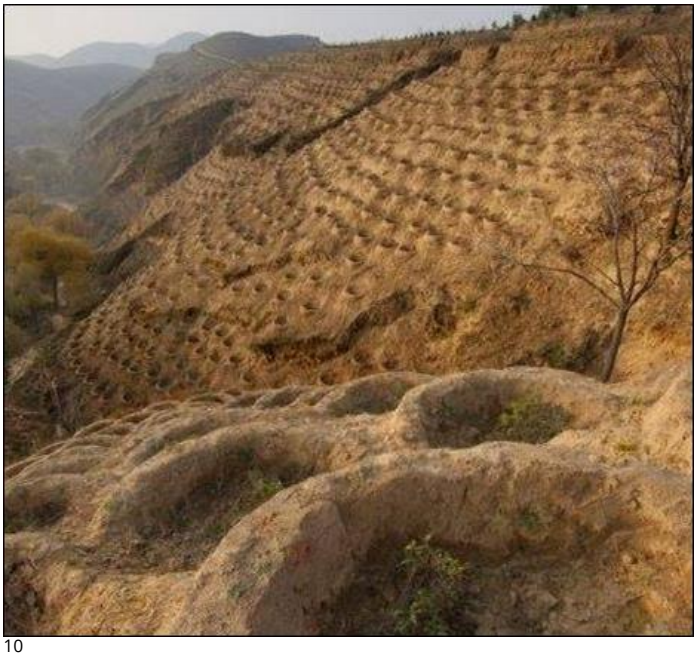

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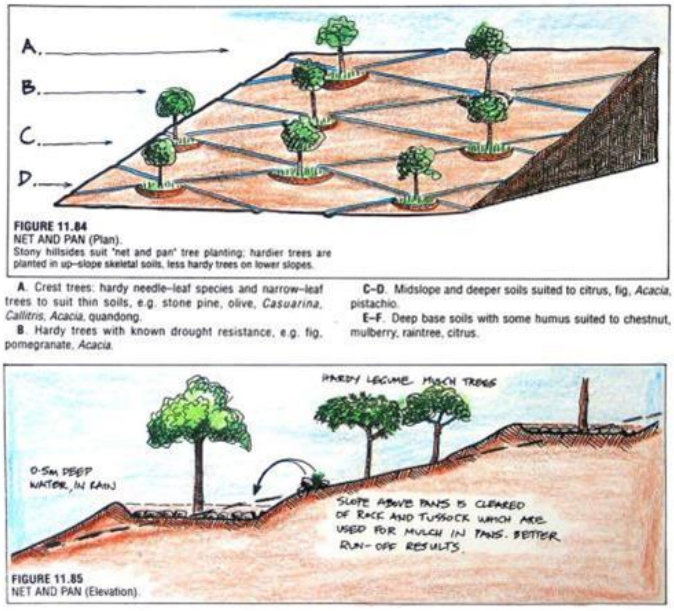


11

Treatment Summary

Micro basin/catchment sites using dammed or embanked earth, generally non-compacted berms. Seeds, silt and moisture is more easily intercepted by the bermed pits allowing for the conditions of first successional vegetative establishment. Larger plant specimens will link basin overflow in a netted series of basins to direct water flow to down slope plants. In highly erodible soils, take care to maintain a low gradient on the uphill cut slope when digging

[9] Source: http://www.fao.org/docrep/006/y4690e/y4690e09.htm

[10] Source: https://www.youtube.com/watch?v=8QUSIJ80n50

[11] Source: Permaculture A Designers Manual

basins. micro-basins can be dug individually or in a variety of patterns, most often as offset rows. Spacing within and between rows varies based on desired effects on runoff and water needs of desired plant species. In general for larger plant species with higher water needs basins are larger and more widely spaced. To make basins larger, it is usually better to make them wider and longer rather than deeper, especially in areas where erosion is a concern.

Materials

- Spade/Shovels/Picks
- Water (for shaping and molding earth to retain berm)

Site Selection

Almost any site can use micro-basins (as seen in the photos above). Net-pan is more specific to tree plantings and it is not recommended to establish trees currently on site. Micro-basin placement is best in low slopes (<8%) and can be used to stabilize steep slopes if used cautiously, particularly to interrupt the downhill flow of water.

Indicators

- High % Bare ground
- Low litter cover
- Rill erosion
- Excessive overland flow or rapid runoff

Alt. Treatments

- Imprinting
- Soil pitting
- Fish scale straw mulch

Installation

1. Select an appropriate site and define the pattern and size of your micro-basins (generally small pits (2’ wide x 1’ long x 0.5’ deep) unless growing trees in net and pan basins).
2. Layout the micro-basins if needed using a tape measure, pin flags and laser level or bunyip. It is ideal to layout basin rows across the slope along contour lines or with a gentle fall towards ridges.
3. Dig basins being careful to dig shallowly and at a low grade. Pile the spoil material downhill in a crescent or chevron shape.
4. If soil is compacted or sealed by digging, knick those areas with the shovel tip to promote infiltration and safe sites for seed-soil contact and establishment
5. Plant trees if appropriate
6. Spread seed and mycorrhizae if desired
7. Mulch lightly if possible

Micro-Basins: Net and Pan / Fish Scale / Chevron (con't)

Inspection Quality Control

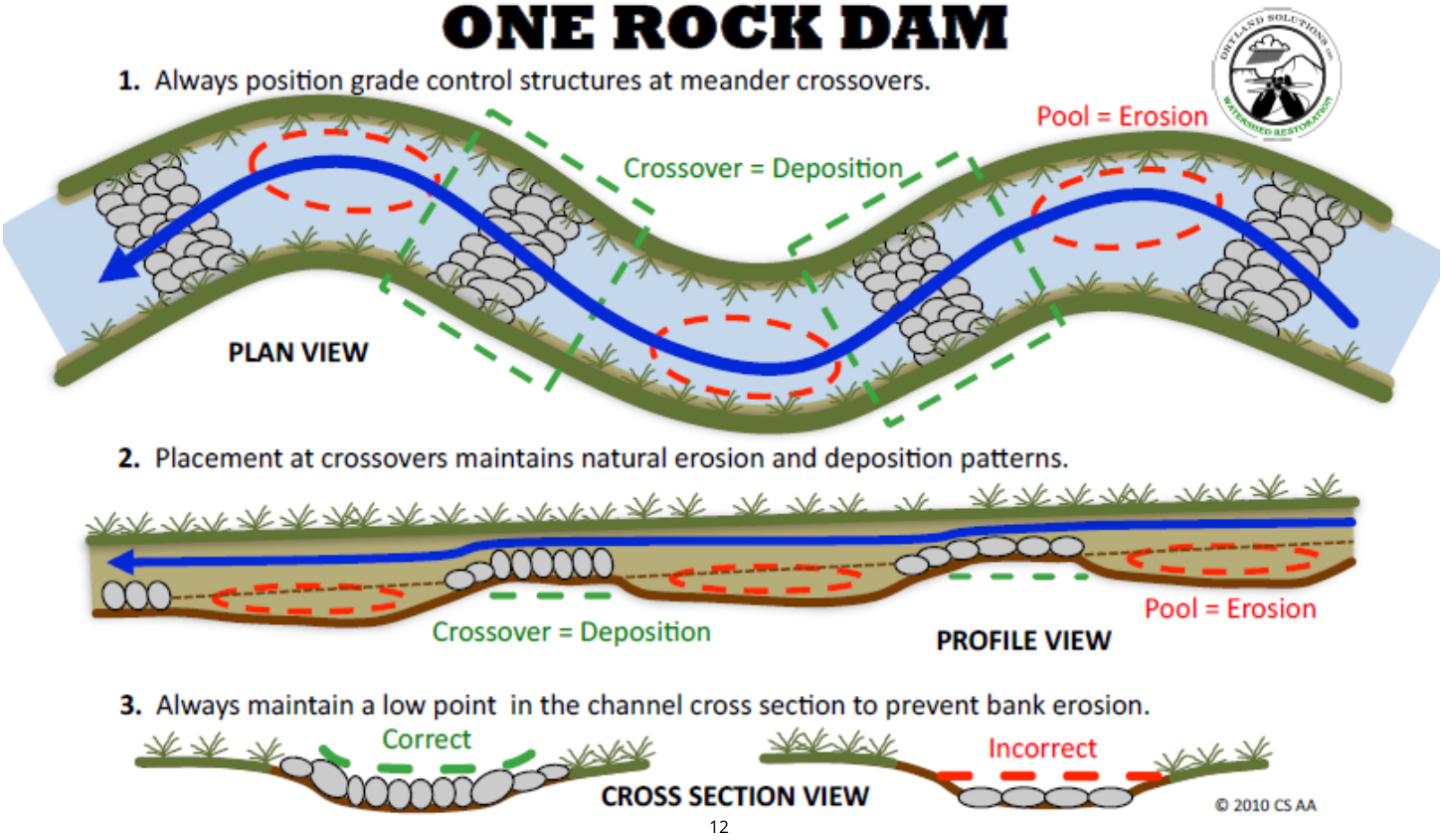
- Make sure cut-slopes (batters) are not steep.
- Check that basins aren't too deep.
- Check that the basin array will interrupt overland flow and segment runoff paths into short distances downslope (1-20' depending on design) before encountering a basin.

Maintenance / Follow-up

Visit annually and/or after storm events

- Monitor for erosion: if erosion is occurring identify cause (flow path length, steepness of batter, etc) and address with mulch, re-grading of basin, diggin additional basins, etc.
- Consider applying compost, seeding and/or mulching if revegetation efforts are unsuccessful.

One Rock Dam (ORD)



[12]

Illustration and Text Source: Watershed Artisans

Treatment Summary

A short grade control structure built with a single layer of rock on the crossover bed of the channel. One Rock Dams (ORDs) stabilize the bed of the channel by slowing the flow of water, increasing roughness, recruiting vegetation, capturing sediment, and gradually raising the bed level over time. ORDs are also passive water harvesting structures. The single layer of rock is an effective rock mulch that increases soil moisture, infiltration, and plant growth. Original concept developed by Bill Zeedyk.

[13]

[12] Sponholtz, C., et al.; "One Rock Dam"; "Erosion Control Field Guide"; Quivira Coalition & Watershed Artisans

[13] Source: Genius Loci Foundation

One Rock Dam (ORD) (con't)

Materials

- Rocks or Soil Crete
- Shovel/Rake/Picks
- Digging Bar
- Wheelbarrow
- Back brace
- Seeds (only if ephemeral channels)

Site Selection*

For use in streams or other eroding gullies or valley drainage lines. Also can be used to stabilize trails crossing valley drainage lines. Locate at crossover in meandering channels. In gullies locate where flow can be slowed and maximum sediment and water can be harvested with a single structure.

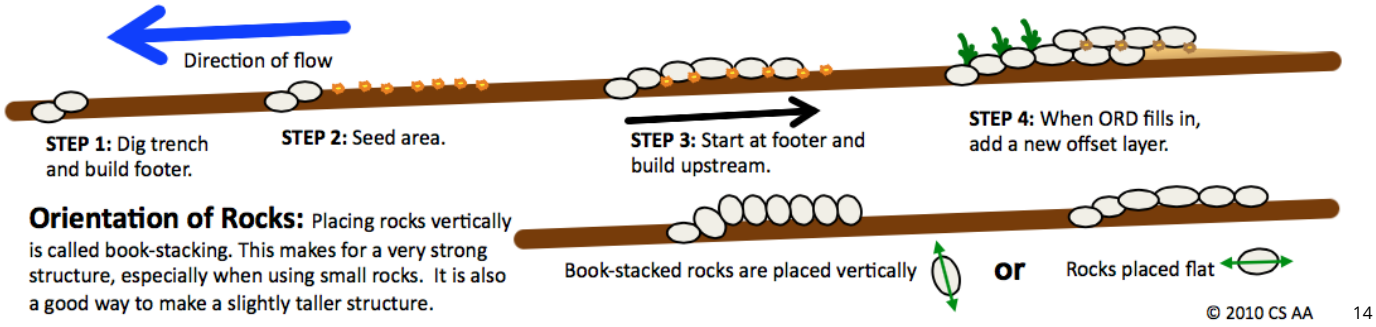
Indicators

- Erosion of sidewalls of channel
- Lowering of channel bed
- Gully erosion
- Trail crossings of valley drainage line (non-channel)

Alt. Treatments

- Rock Mulch Rundown

** Streams with bed-and-bank are subject to US Fish and Wildlife or other Agency control.*



Installation[15]

1. Select area to build the ORD. Dig a shallow footer trench and fill with one or two rows of rock, so that no rock protrudes more than 2 in / 5 cm above the bed of the channel. This will serve as the splash apron for the ORD.
2. Scatter native grass and wildflower seeds in the area where the ORD is to be built.
3. Start building at the footer and continue upstream, laying down one layer of rock, as if you were building a horizontal wall on the bed of the channel. For the first row, overlap the splash apron ~4".
4. Make sure to maintain a channel shape with the low point of the ORD at the low point of the channel, and to feather the ORD into the banks or floodplain, so the water does not go around the structure.
5. Over time, the ORD will fill with sediment. Once completely filled, another offset layer can be added to the ORD to further raise the bed of the channel and capture more sediment. The original ORD becomes the splash apron for the new layer.

[14] Sponholtz, C., et al.; "One Rock Dam"; "Erosion Control Field Guide"; Quivira Coalition & Watershed Artisans
[15] Sponholtz, C., et al.; "One Rock Dam"; "Erosion Control Field Guide"; Quivira Coalition & Watershed Artisans

Inspection Quality Control

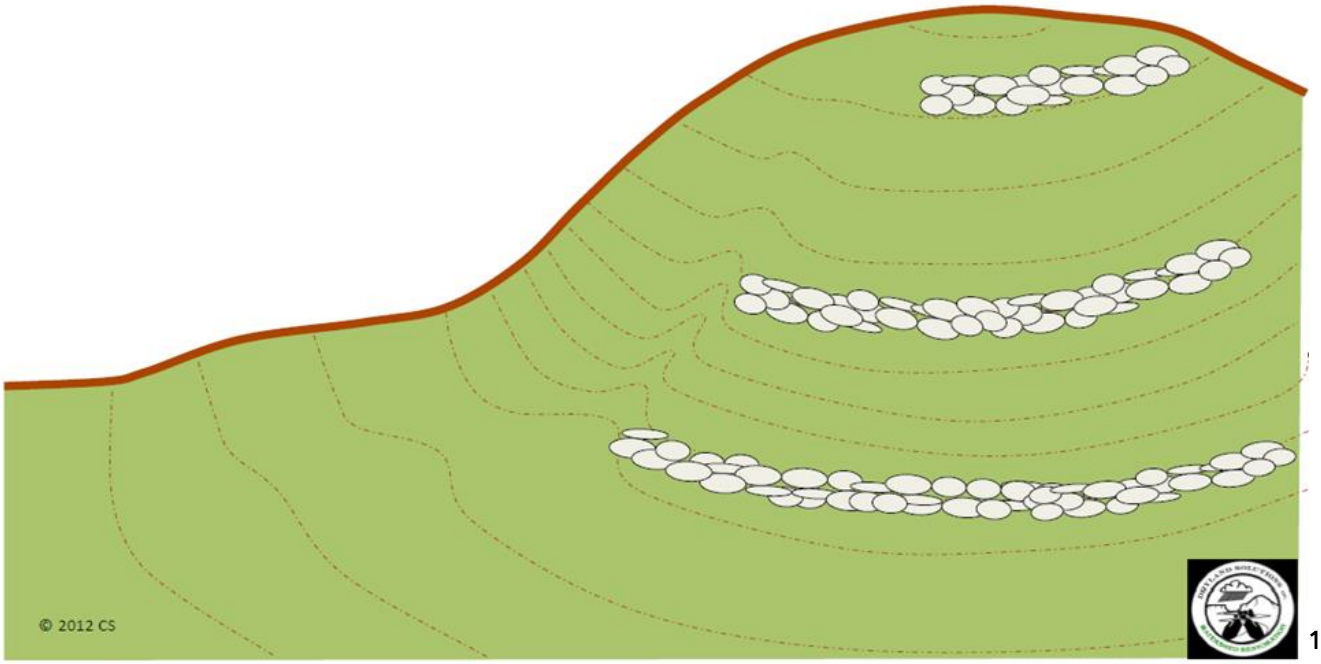
- Check that there are not large gaps between the rocks: fill gaps with gravel or small rocks
- Check that the ORD has a slight dish shape with the low point at the low point of the channel/drainage
- Make sure the splash apron is dug in and next layer of rock slightly overlaps
- Make sure the rocks along the bank edges or floodplains taper down to ground level so water flows over the structure and not around

Maintenance / Follow-up

Visit annually and/or after storm events

- If channel has widened or water flows around the structure, add rocks to widen it.
- If downcutting / scour is happening at the downstream end of the structure, rebuild with an new, longer splash apron
- When the structure has been covered in sediment, add another layer, using the top row from the previous structure as the splash apron of the new structure.

Rock Mulch on Contour



[16]

Treatment Summary

Low-grade erosion control structures built of rock or other durable material set out on contour. Structures catch sheet flow and sediment erosion by slowing water and helping to deconcentrate rills and gullies back into sheet flow. Structure also acts as a good seedbed for revegetation.

Materials

- Shovel/Rake/Pick
- Rocks or concrete rubble
- Seeds

Site Selection

For use in streams* or other eroding water channels.

Indicators

- Sheet erosion and lack of litter/cover
- Beginning rill erosion

Alt. Treatments

- Brush mulch
- Compost strips
- Fish Scale Mulch
- Jute Netting
- Seeding
- Soil Pitting
- Straw Flake Filter Dam
- Surface Mulch
- Wattle/Sock

[16] Illustration and Text Source: Watershed Artisans

Rock Mulch on Contour (con't)

Installation

1. Select Site and Mark out contour lines at desired spacing (~10-100' apart depending on slope)
2. Measure 4-5' up from contour and flag out top of structure, tip both ends slightly uphill to prevent water from running around the structure
3. Calculate size of structure and bring materials to site
4. Dig in row of splash apron rock leaving 1-2" above ground
5. Scatter seed where rock mulch will be placed
6. Build up in rows with next row overlapping the splash aprons slightly with tight spacing between rocks
    a. Use rocks that maintain a low profile (3-6" height of structure)
7. Keep the height of the structure consistent, especially on the top row, to maintain sheet flow

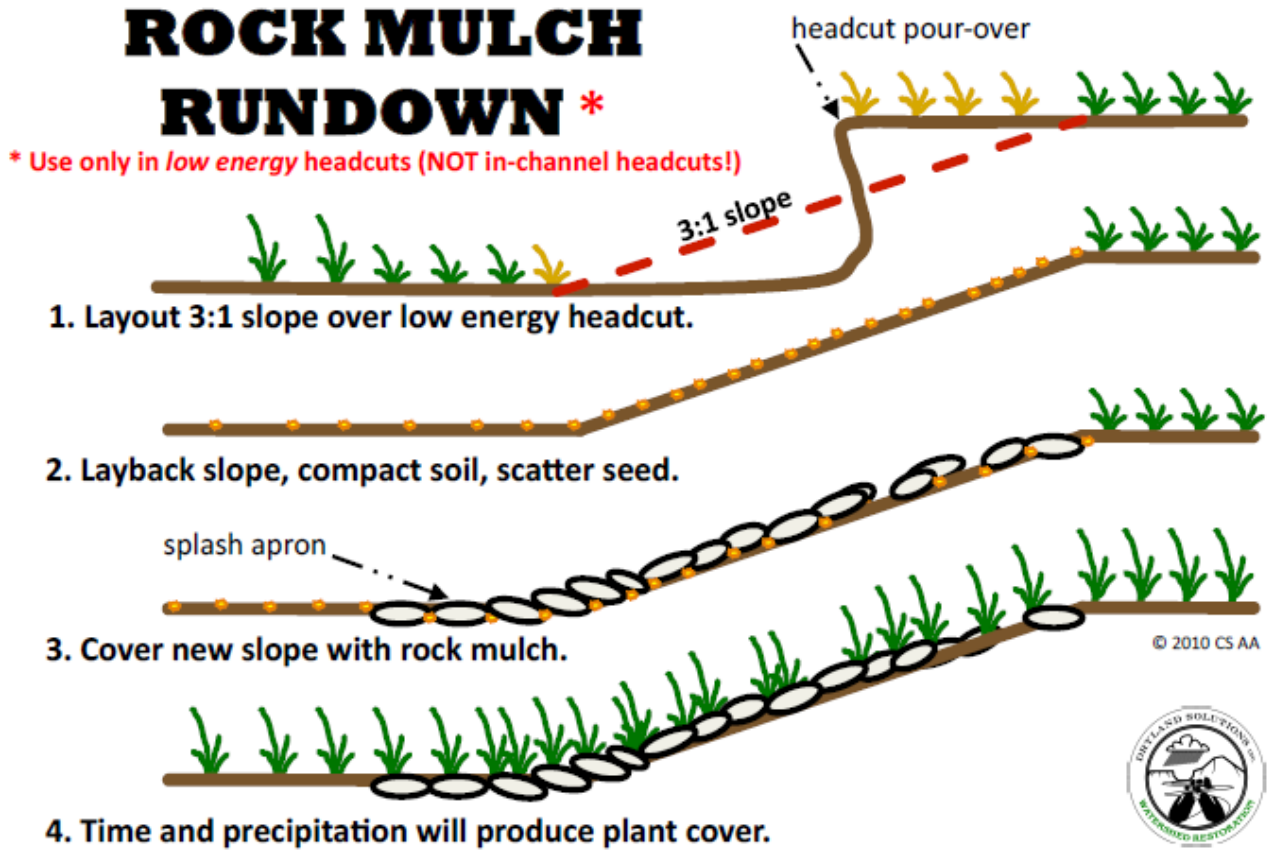
Inspection Quality Control

- Check for big gaps between rocks and fill with smaller rocks and gravel
- Check that the splash apron is dug in enough and next row overlaps slightly
- Make sure that height of rocks stays consistent

Maintenance / Follow-up

- Make sure that water is not flowing around structure and getting channelized: if so add rocks at end to prevent flanking
- Check for scour or erosion on the downhill side and fix any splash apron areas where this occurs

Rock Mulch Rundown (RMD)



[17]

Treatment Summary

Stabilizing low-energy headcuts using a 3:1 slope and armoring with rock mulch and seeding for stabilization. This structure reshapes the headcut by taking cut and filling to achieve a gentle slope to transition the elevation change. Rock mulch ensures stability during flow periods while creating suitable conditions for revegetation from seeding. Not to be used in high-energy channels with large catchments. *Original concept by Craig Sponholtz.*

Materials

- Shovel/Rake/Pick
- Rocks or concrete rubble
- Seeds

Site Selection

Low-energy headcuts with low drops.

Indicators

- Migrating headcut pour over or culvert daylighting
- Lowering of gully bed
- Top of Gully erosion

Alt. Treatments

- Rock Mulch Rundown
- Diversion Ditch

[17] Sponholtz, C., et al.; "Rock Mulch Rundown"; "Erosion Control Field Guide"; Quivira Coalition & Watershed Artisans

Rock Mulch Rundown (RMD) (con't)

Installation[18]

1. Select a low energy headcut for treatment.
2. Determine the extent of the 3:1 slope. Take care to balance the cutting required to achieve a 3:1 slope vs. the potential disturbance to existing vegetation.
3. Layback the headcut by cutting away soil from the top of the face, and then use the cut material to fill the base of the headcut. Where possible, the Rundown should be the entire width of the channel below the headcut. Narrow headcuts may need to be widened to accommodate the rock work. Adjacent headcuts, separated by uneroded fingers of earth, but leading to the same channel, can be combined into a single Rundown structure. Knock down the uneroded earth between the headcuts, and use it as fill.
4. Compact the fill.
5. Scatter native grass and wildflower seed and rake the surface of the Rundown.
6. Dig a shallow trench on the down slope side of the Rundown and fill with one to two rows of rock, so that no rock protrudes more than 2in/5cm above the bed of the channel. This will serve as the splash apron for the Rundown.
7. Cover the entire surface of the Rundown with a single layer of rock mulch. The center of the Rundown should be the lowest point in the structure so that water will not run around the edges.
8. Continue to lay rock on the surface of the Rundown until you reach the height of the headcut pour-over. No rocks should protrude above this level to allow water to flow freely over the structure. It is very important to avoid gaps in the rock work because gaps cause weak points in the structure. Fill gaps with small gravel if needed. To improve durability, you can use a biodegradable geotextile mesh to line the surface of the Rundown prior to laying down rocks. In this case, skip seeding.

Inspection Quality Control

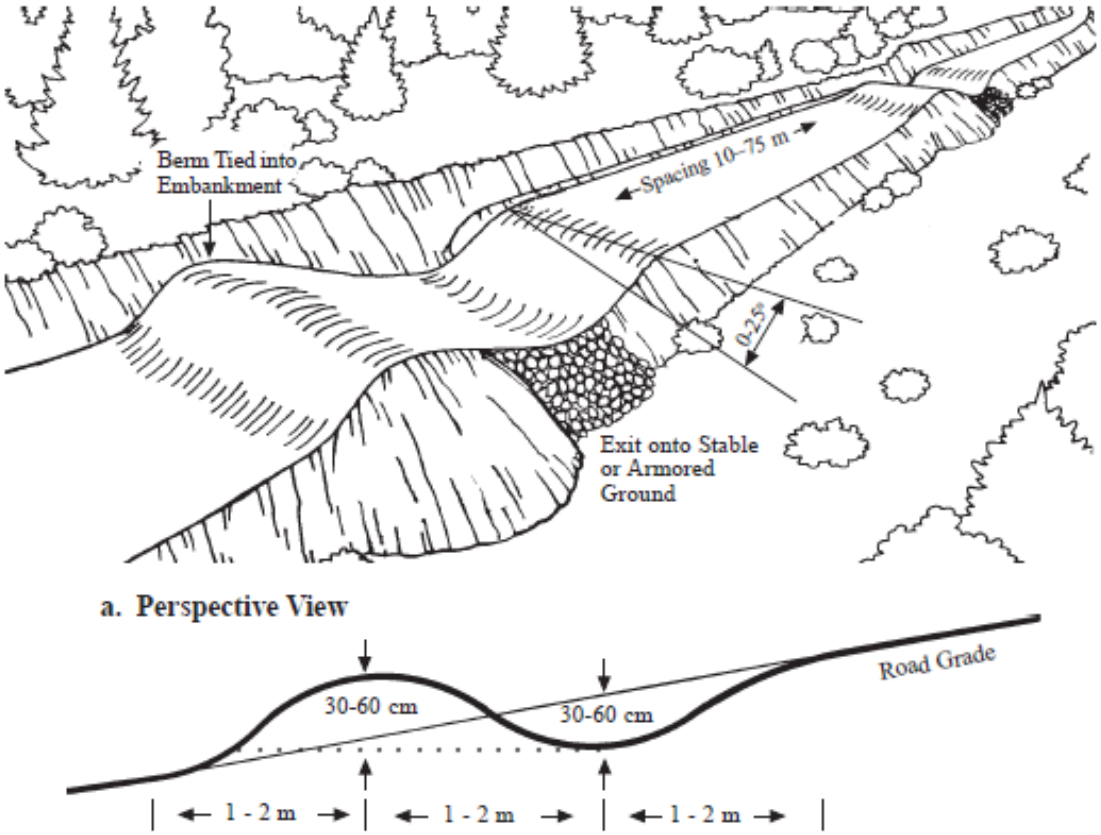
- Ensuring width of structure prevents chance for flow side cutting and compromising it.
- Maintaining a 3H:1V or lower slope to reduce energy of flow.
- Shunting excess flow using additional structures like a Worm Ditch to starve the headcut.
- Ensure only one layer of rock is being used.

Maintenance / Follow-up

- Replace or repair any dislodged rocks.
- Expand areas where side cutting is occurring or threatens to occur.
- Remove any excess sediment accumulation.

[18] Sponholtz, C., et al.; "Rock Mulch Rundown"; "Erosion Control Field Guide"; Quivira Coalition & Watershed Artisans

Rolling Dips



[19]

Treatment Summary

Rolling Dips (aka Grade Dips/Cross Drains) gently convey surface flow on unpaved roads and trails and direct it off in a controlled, low-energy manner. The goals of Rolling Dips are two-fold: design the structure to direct water off the access and to build it long enough for the intended traffic to barely notice it.

Unfinished roads and access paths need proper drainage to ensure long useful life without excessive maintenance or repair input. Rolling Dips are scaleable, depending on the largest vehicle transiting them. Foot and/or bicycle trail Rolling Dips can be quite short, depending on the volume of traffic and slope. Vehicle trails and roads require significant road length to avoid being a nuisance to drivers, especially access that handles trailers or low-clearance vehicles.

Note: Some may describe these as Waterbars. We consider waterbars to be simple ditches or semi-buried logs across a trail or path.

Installation is done best in straight, or slightly curved sections; they are not intended to be used in corners. The ideal time for installation is when the access is being constructed, but can be installed, post construction, at a higher cost.

[19] Weaver. 2015.

Rolling Dips (con't)

Materials

- Shovel
- Iron rake
- Pick and/or Mattock
- Bulldozer for larger
- Water for compaction
- Tamper
- Dissipator materials (rock, concrete rubble, RMDs, etc.)
- Seed for dissipator

Site Selection

All unpaved roads and paths can benefit from Rolling Dips. Designing for the length and height/depth of the structure is critical, as is locating where water is directed. Avoid directing water back towards the road/trail and aim for immediate infiltration of water in other treatments like mulched basins, swales, etc.

Indicators

- Rills and gullying of roadways
- Washboarding
- Erosion of roadbed
- Depletion of soil surface

Alt. Treatments

- Cross Slopes - in-slope and outslope.
- Ditches, Lead Offs, and Sumps
- Waterbars

Installation

"The rolling dip consists of a lead-in section, a flat bottom section where water is conveyed off the trail, and a lead-out section. The lead-in and lead-out sections are steeper than the original trail.

The flat bottom section is turned at an angle to the trail (preferably 45 degrees or less) and sloped outward to get the water off the trail and onto the forest floor. A flat-bottom section is preferable to a v-shaped bottom because it allows water to slow down, spread out, and drop sediment on the trail.

Of all the techniques, rolling dips are the easiest to maintain, and they are the preferred method of getting water off existing trails. Rolling dips require more technical skills to build than water bars but are much more effective at removing water from the trail and require less maintenance."[20]

Note: Due to the complexity of Rolling Dips, we only recommend design and installation by trained and qualified equipment operator or grading contractor. Drainage profiles, slope percentages and proper construction methods are critical to their success and reduced maintenance input, if built well.

Maintenance / Follow Up requires less expertise, but it is advisable to consult with a professional before any major work is undertaken.

[20] "Rolling Dips"; http://www.fs.fed.us/t-d/atv_trails_site/build/keeping-water-off-the-trail/rolling-dips.html; Sustainable ATV Trails; US Forest Service, EPA

Rolling Dips (con't)

Inspection Quality Control [21]

"The key to good maintenance is identification of maintenance needs through frequent inspections. Road inspections should focus on identifying areas where problems may occur in future storms. All parts of the road including the road surface and cut-and-fill slopes should be inspected, as well as drainage structures such as culverts, bridges, and water bars. Ideally, inspections should be done in time to allow for repairs before the rainy season."

- Make sure the berm is high enough and well compacted. It will settle over time so build it higher than desired final grade
- Make sure drain is at least 1% to lead out ditch
- Make sure lead out ditch edges are smoothed and battered to a 3:1 or lower slope
- Add rock to end of end out ditch if on steep or highly erodible slope

Maintenance / Follow-up [20]

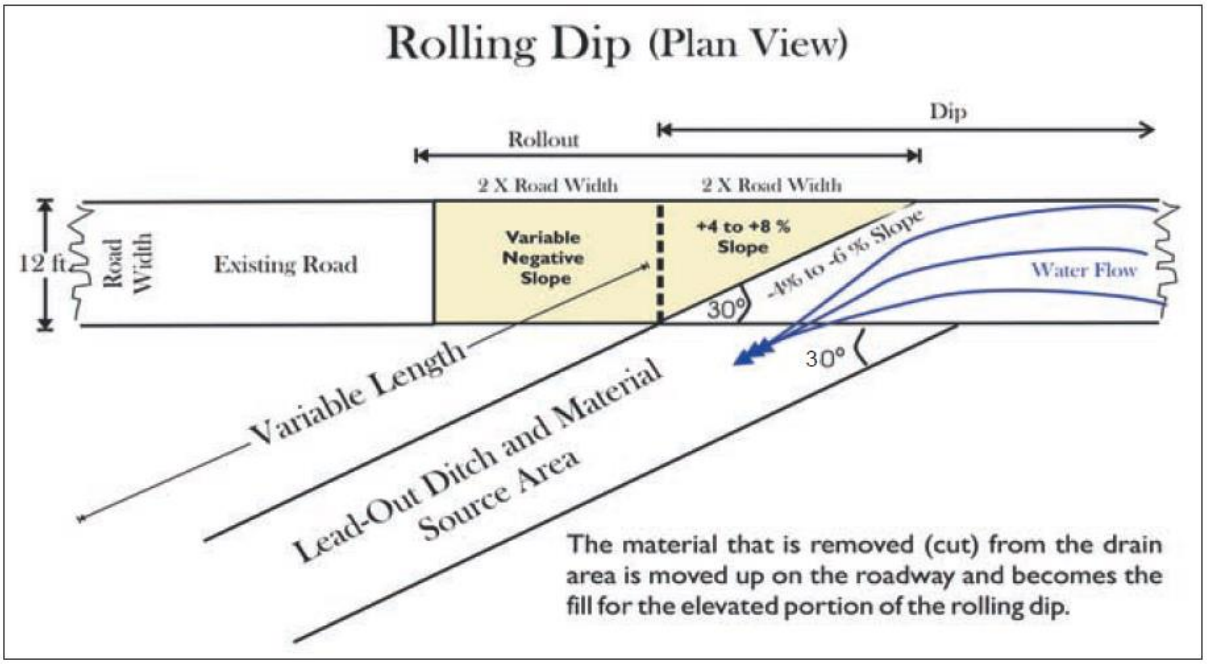
Quality record keeping is essential for good road and trail maintenance.

- Inspect roads regularly, especially before the winter season and following heavy rains
- Keep ditches and culverts free from debris.
- Remove slide material from the road or ditches where it blocks normal drainage.
- Regrade and shape the road surface periodically to maintain proper surface drainage.
    - Keep rolling dips shaped and graded.
    - Keep the downhill side of the road free of berms unless they are intentionally placed to control water or traffic.
    - As necessary, apply surfacing such as aggregate or pavement to protect the roadbed.
- Avoid disturbing soil and vegetation in ditches, shoulders, and on cut-and-fill slopes.
- Maintain an erosion-resistant surfacing such as grass or rock in ditches.
- Close the road during very wet conditions.
- Carry a shovel in your vehicle during the rainy season to clean out ditches, redirect water off the road surface, etc.

Video: Maintaining Rolling Drips/Cross Drains (YouTube)

[21] Kocher, S., et al. "Rural Roads: A Construction and Maintenance Guide for California Landowners". UC Davis, Pub. 8262. http://anrcatalog.ucanr.edu/pdf/8262.pdf

Rolling Dips (con't)



[22]

Table 1. Rolling dip and ditch relief culvert recommendations[23]

Road Grade (%)	Soil Erodibility	
	Low to non-erosive soils (ft)	Erosive soils (ft)
0-3	400	250
4-6	300	160
7-9	250	130
10-12	200	115
12+	160	100

[22] Zeedyk, B.; "A Good Road Lies Easy on the Land"; Quivira Coallition; 2006; http://quiviracoalition.org/images/pdfs/1888-A_Good_Road_Lies_Easy_on_the_Land.pdf

[23] Source: Adapted from Keller and Sherar, 2003

Seeding

 [24]

Treatment Summary

Seeding is used to establish a vegetative cover to reduce the volatile impact of raindrops and erosion due to surface flow and wind erosion. Vegetation's roots also increases infiltration rates and water holding capacity of the soils, further reducing the potential for erosion.

Delivery methods include: hand broadcasting, drill seeding, and hydroseeding. Success is dependent on adequate rainfall or irrigation and benefits from installation at the beginning of the locations rainy season. Seeding can benefit from compost and mulch application at time of seeding to retain soil moisture and reduce soil temperatures. Temporary or permanent supplemental irrigation may be required and always increases the success rate.

[24] Brink, Inc. Environmental Solutions; "Erosion Control Seeding and Mulching"; http://www.brinkinc.biz/photos/cafos/dscn4179/

Seeding (con't)

Materials

Materials will vary depending upon treatment application.

- Seeds
- Application method (broadcasting, drill seeding, hydroseeding, etc.)
- Compost
- Mulch
- Inoculant (mycorrhizae)
- Water

Site Selection

Site and seed selection will be dictated by many factors. Most bare and exposed soil can benefit from seeding. Considerations to review are seeding mix, mature dimensions of seeds, application rate, slope, intended use, animal pressure, aspect, water availability, and soil conditions (to name a few).

Indicators

- Exposed and/or eroded soils
- Declining health of existing vegetation
- Opportunistic plants overtaking desired plant populations

Alt. Treatments

- Soil Imprinting
- Mulch
- Compost
- Rock Mulch

Overviews of Seeding Applications

Due to each application method being different, we recommend erosion control specialists for observing and selecting the most appropriate method for the site in question.

Drill Seeding

As a general rule, drill seeding is used for "positive placement and uniform dispersion of seed at a regulated depth into the soil where levels of moisture are more consistent and the actions of wind and water will not remove the seed from the treated area."[25] Seedlings are not placed on top of the soil to root down into it, like broadcasting, but are placed into the soil. Mix granular mycorrhizae inoculant into the hopper with the seed mix at a rate of 60 lbs/acre.

Very steep slopes and rocky soils can prevent effective drill seeding. Slopes under 3H:1V will fare better without excess seed rate or supplemental water, when using regionally appropriate/native seed mixes.

In highly erodible areas, it is important to drill seed along the contour of the slope rather than up and down slope.

[25] Brammer, R.; "Drill Seeding Steep Slopes for Establishment or Interseeding; 1981; http://archive.lib.msu.edu/tic/wetrt/article/1981jun30.pdf

Seeding (con't)

Broadcasting

Hand or mechanical scatter of seed across a surface. Simple and doesn't require expensive machinery for small applications, but wastes seed and produces uneven results. Animal predation, wind, and drying out are factors in low germination and success rates. Using mulch to cover the seed after broadcasting can help, but care must be taken with depth, application method, and type. Supplemental irrigation is crucial for higher success rates in xeric or low-rainfall zones. Hand seeding rates are usually 2x drill seeding rates (use 60 lbs/acre for mycorrhizae). Mulch applied at 90% cover is ideal which allows small gaps for plants to establish through. Mulch can be applied by hand or with hydromulcher which secures it with a tackifier.

Hydroseeding

Hydroseeding is the application of seed via pressurized water mixed with mulch, binder agents and possibly compost and/or inoculant. Binder agents help hydroseed application to remain in place, thus improving the distribution irregularities of Broadcasting.

Hydroseeding is useful for areas that a drill seeder cannot reach or operate on. Limitations are cost, water access, higher seed costs, additional materials, requires specialized equipment and operators.

Inspection Quality Control

Adequate application rates for the site conditions are important to verify and cross-check. Too little seed and you will need to reapply. Irrigation for establishment is crucial if using non-native seed or rainy season weather patterns are highly irregular.

Maintenance / Follow-up

It is critical to monitor the seedlings frequently post install. Depending on factors, this oversight and observation can be as frequent as every day. Irrigation cycles may need to be 3-6x per day depending on seed mix and site conditions. Seeding prior to wet season then irrigating during dry spells for establishment the first year can greatly increase effectiveness. Weed control is also very important to reduce competition with the desired plants.

Soil Crete Burlap Sandbags [26]

 [27]

NOTE: *Only use untreated burlap bags*

Treatment Summary

Soil Crete is the mixture of portland cement with native soils to create concrete. Placing it in burlap sandbags allows one to create rocks of various shapes and sizes for use in erosion control where no rock resource exists particularly in remote locations. It works best in sandy soils, though can be applied in a wide range of sand to sandy loam and silt soils. Soil to cement ratios vary from 5-10:1 and should be trialed in small test batches before large scale applications. Soil Crete Sandbags can be used to construct Media Lunas, ORDs, Rock Mulch Rundowns, Zuni Bowls, and other rock based structures.

[26] Credit to Craig Sponholtz for adapting this method to many alternative erosion control and restoration treatments

[27] Source: http://socalsandbags.com/SWPPP%20Installation.htm

Soil Crete Burlap Sandbags (con't)

Materials

- Untreated burlap sandbags
- Portland cement
- Sisal or jute string/twine
- Shovels
- Tamper
- Wheelbarrow or concrete mixer
- 5 gallon bucket marked with lines (1 to 5 parts) for consistent measurements
- *Optional*: Seeds

Site Selection

Soil Crete Sandbags are used when rocks are not available on-site or too costly to import. Excess coarse textured soil must be available to mix with cement. Sites for Soil Crete Sandbags should be selected based on Criteria outlined for the structure to be built. Ideally a source of soil is available nearby such as a cutbank or gully wall.

Indicators

- No rocks
- Sandy textured soil
- Low labor costs / volunteers
- See Indicators for structure to be built

Alt. Treatments

- Use of rock, log, brush, or other materials

Installation

1. Select appropriate site and treatment structure; bring materials to site.
2. Layout desired structure and select source of soil that will not cause further degradation or erosion.
    a. Ideal sources are gully walls downstream from the structure which can be widened and battered back to a 3H:1V slope or lower.
    b. Prior to day of construction, trial small batches of soil and cement mixes at ratios from 5:1 - 10:1 to find ones which are the strongest with least cracking/brittleness.
3. Source soil from site. Rake away organic matter and deposit out of channel or upstream of structure. **Take care not dig down into channel bottom except for splash apron ditch or other needed shaping to fit structure/treatment**. Soil source options:
    a. Eroding banks of gully to widen channel at a slope. Cut vertical banks at a gentle slope when possible.
    b. Outside of channel sourced from spoils of nearby or other erosion control structures.
4. Measure out appropriate ratio of soil and cement and mix in a wheelbarrow or cement mixer. **Do not mix organic matter with soil crete mix.**
5. Fill bags and tie shut.
6. Build structure as described for treatment selected. Place tied end down to hide and clean aesthetic. Tamp bags well and place tightly together. Alternate edges as in brick masonry to prevent water from channeling through. Fill any gaps with gravel/small rocks.
7. If possible spray wet sandbags with a hose when complete to begin the curing process. If not, wait for rain.

Soil Crete Burlap Sandbags (con't)

Inspection Quality Control

- Use fresh/new Portland Cement
- Make sure cement and soil are thoroughly and evenly mixed
- Ensure that sandbags are tied shut and well tamped/compacted
- Inspect appropriately based on structure built

Maintenance / Follow-up

Maintain or follow-up as described for treatment structure being built.

Soil Pitting

 [28]

Treatment Summary

Soil pitting is a low-cost mechanical modification of soil surfaces to increase micro-ponding and water harvesting features. Hand or mechanical methods disturb the soil to create pits or indentations that reduce the capacity for concentrated erosion to form, collect water, and act as deposition basins for wind born seed and sediment. Infiltration rates increase, germination rates improve, erosion and water runoff is reduced and improved vegetative growth are results of effective Soil Pitting.

"The low value of most desert land commonly makes treating the entire area uneconomic. But, treating only 10 to 20 percent of an area with contour oriented pitting strips may be enough to dramatically improve establishment and trigger recovery. Soil pitting should be done before the best seed establishment period if possible. In the low desert of California this would probably be in late fall to early spring.

Pitting is not easily adapted to rocky soils and brushy sites. It may not work very well on high clay soils unless they are ripped first and may not be needed on sands with high infiltration rates. It can be very effective on most other soil types, and is particularly well suited for crusted, degraded soils. Machine pitting is often confined to flat and gentle slopes and should be done on the contour if possible. Hand pitting can be done on much steeper slopes."[29]

[28] Bainbridge, DA. 2007

[29] Bainbridge, D.; "Soil pitting to Improve arid land revegetation"; 1996; http://www.sustainabilityleader.org/Sustainability_Leader/Soil_treatment_files/1996%20Soil%20pitting.pdf

Soil Pitting (con't)

Materials

Mechanical Pitting

- Specific Pitter (Camel*/ Disc, Tine, Spike-Tooth, Blading/Scraping)
- Seed

Hand Pitting

- McLeod's Tool
- Hoe
- Seed

**Best for clay/loam soils*

Site Selection

Flat lands with large acreage are well suited to Mechanical Pitting. Implement type will depend on soil type and obstructions. Steeper slopes or sites lacking vehicle access can use Hand Pitting (which is useful for low-skilled or volunteer labor. If irregular patterns are desired, Hand Pitting is best.

Indicators

- Exposed and/or eroded soils
- Declining health of existing vegetation
- Opportunistic plants overtaking desired plant populations

Alt. Treatments

- Compost
- Brush Mulch
- Fish Scale Straw Mulch
- Seeding
- Soil Imprinting
- Surface Mulch
- Vertical Mulch

Installation

Mechanical methods have varying installation requirements. Of the Mechanical Pitting methods, the Tine and Spike-Tooth are the best recommendations for Meadowview Open Space. **Not appropriate for slopes greater than 3H:1V, and avoid deep holes as this is a shallow surface treatment.**

Hand Pitting

1. Select site for pitting based on site selection requirements
2. Using a team for faster coverage, move in a unified direction. Tools:
    a. **Shovels**: 1 scoop, dig from uphill side at a shallow angle to minimize chances of further erosion
    b. **McLeod's or Hoes**: 1 strike/pull at shallow angle from downhill side.
3. Stagger pits closer together on steeper soils. Aim for a random pattern with some pits being closer, even touching with others farther apart.
4. Allow excavated soil to rest near the hole. Often directly downhill or to fill nearby rills.
5. *Optional*: Hand broadcast desired seed over pits and possibly top dress with a light layer of mulch to help cover seeds.

Mechanical Pitting

Follow device/tool instructions.

Soil Pitting (con't)

Inspection Quality Control

Mechanical Pitting should result in even coverage of the treatment area. Ensure depth of pitting isn't too deep which can lead to excess soil moisture loss.

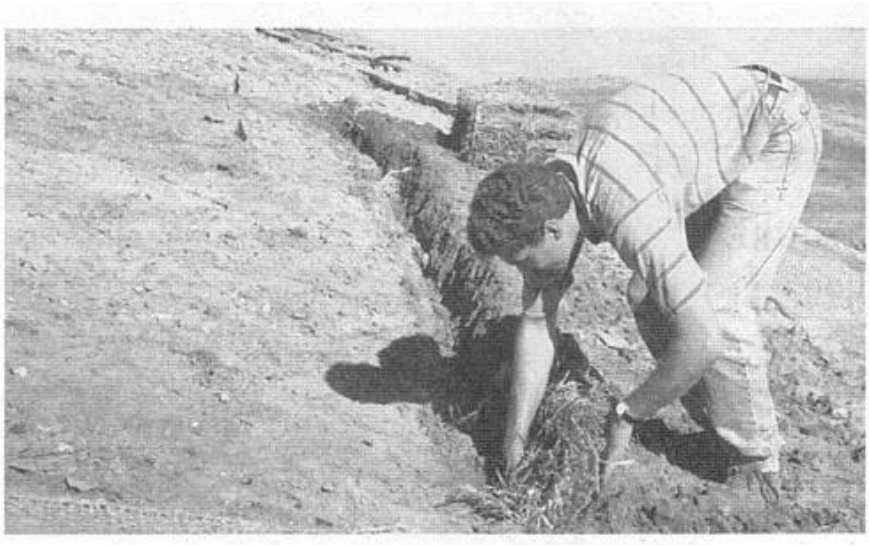
Hand Pitting quality control consists of roughly identical pitting style, shape and depth. Large variations in execution will lead to a pattern effect when viewed from afar and on broad scale. Randomness is good, but ideal if distributed over the area and not in patchwork fashion.

Make sure pits do not have a steep angle on the uphill side of the cut, and be careful on steeper slopes. Always cut from the uphill side.

Maintenance / Follow-up

Documentation of results is important to compare how the treatment fairs compared to other treatments or locations. After a season or two have passed, then a follow-up treatment application may be appropriate if another treatment hasn't shown better success and falls within budget. If soil pits fill in with debris or sediment quickly, another round of treatment may need application, or that site may be ill suited for this treatment.

Straw Flake Filter Dam



[30]

Treatment Summary

Straw bale flakes are placed in on contour vertical slots in the soil, backfilled, and act as a surface runoff control point catching sediment, slowing water, slowing erosion and trapping seed.

This treatment is an ideal, low-cost solution for decommissioning old trails/roads or where substantial water flow is occurring. Installation is easy, requires low skill and is effective. Combined with mulch and/or compost, these treatments offer effective erosion control.

Materials

- Shovel or Spade
- Weed-free Straw Bales

Site Selection

- Eroded or bare soils, or where surface drainage is occurring.
- Decommissioned roads or trails.

Indicators

- Eroded soils with substantial water flow

Alt. Treatments

- Brush Mulch
- Compost
- Fish Scale Straw Mulch
- Jute Netting
- Micro Basins
- Rock Mulch
- Surface Mulch
- Vertical Mulch
- Wattle/Sock

[30] Bainbridge, DA. 2007

Straw Flake Filter Dam (con't)

Installation [31]

1. ID site for installation.
2. Survey contour lines using Water Level, A-Frame or Laser Level. Flag line.
3. Using shovel/spade, dig along line a 3-4" wide slot 6-10" deep across slope.
4. Pull of flakes of straw from the bale 2-4" thick.
5. Place flakes with strands oriented vertically into slot (straw should protrude out of the slot).
6. *Optional*: Sow desired seed mix into slot.
7. Backfill soil and compact well around the straw "fence".
8. Apply mulch, bark or compost to reduce erosion potential and increase performance.

Inspection Quality Control

- Ensure trench lines are correctly sited along contour.
- Observe installation method for new labor over a period of 10 feet installed to ensure proper technique.
- Adjust and experiment with flake thickness depending on steepness of slope, water runoff amount, and material availability.
- Make Sure soil is compacted along uphill and downhill edges of straw flakes

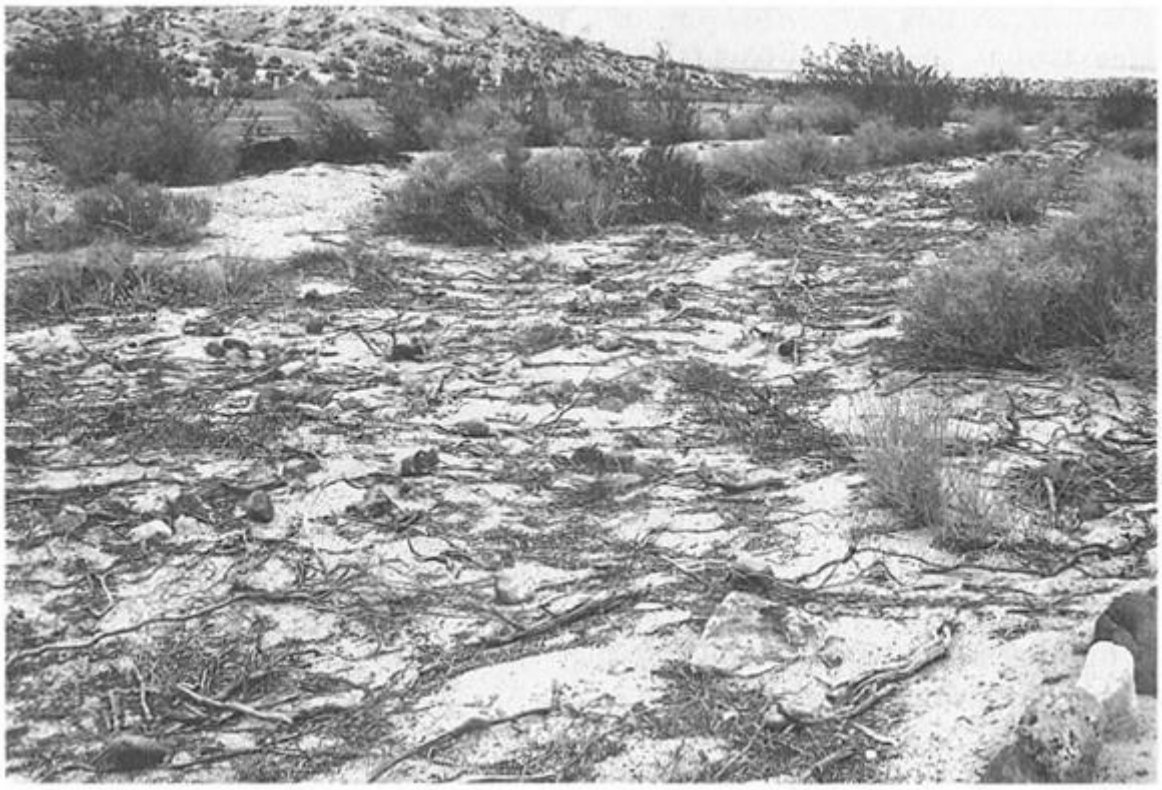
Maintenance / Follow-up

Very little maintenance is needed outside of documentation and observation. Potentially add more if benefits are noticed. If straw is gone or if sections are damaged, replace with new straw to ensure performance.

- Watch for any erosion cutting uphill or downhill from the structure and take appropriate action to maintain sheetflow

[31] Bainbridge, DA. A Guide for Desert and Dryland Restoration. Island Press. 2007. Pg. 151.

Surface Mulch



[32]

Treatment Summary

The simple spreading of brush across denuded or bare soil sites greatly decreases soil loss due to wind and surface flow. Debris also acts as a net, catching wind or water borne sediment and seeds. By spreading brush and debris and ensuring contact with the soil, woody material can begin to fully decompose and help build soil.

Materials

- Local, native dead or excess brush trimmings
- Seed

Site Selection

Wind swept, flat (0-2% slope low litter surfaces subject to erosion.

Indicators

- Eroded soils
- Soils exposed to wind
- Low-surface water flow events

Alt. Treatments

- Brush Mulch
- Compost
- Fish Scale Straw Mulch
- Jute Netting
- Rock Mulch
- Wind Fence
- Vertical Mulch

[32] Bainbridge, DA. A Guide for Desert and Dryland Restoration. Island Press. 2007. Pg. 93.

Surface Mulch (con't)

Installation

1. Using local Brush: Collect and gather native brush and distribute across site.
    a. Trample and walk on debris to ensure good contact with soil surface. Apply at a density of 50-70% soil cover.
2. Imported Woodchips or straw: can be spread manually or mechanically, and applied at density of 50-90% soil cover depending on budget
    a. If using straw, it is ideal to crimp it into the soil with a crimping disc (different than roller crimper)
3. *Optional*: Hand broadcast seed, or seed drill prior to Step 1.

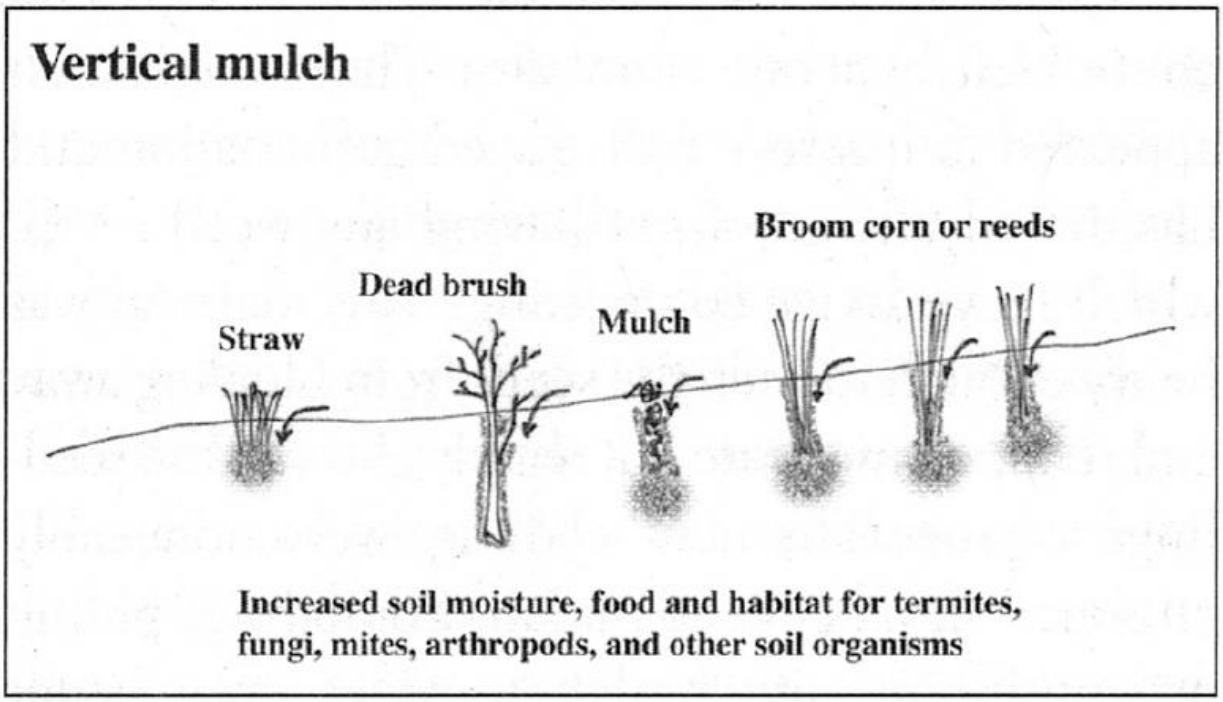
Inspection Quality Control

- Very low-skill task. Ensure that good uniform and random distribution of brush is accomplished.
- Ensure unwanted plants are not included in brush or are removed.
- Observe that slope is not too steep and does not have a large surface flow which can lead to the debris being moved down slope.

Maintenance / Follow-up

- Replenish brush in excessively exposed areas.
- Inoculate with beneficial microbiology during rainy season to aid in decomposition of brush.
- Document and capture effects of treatment.
- Broadcast more seed over area prior to rainy season.

Vertical Mulch



[33]

Treatment Summary

Sometimes a more effective method of erosion control compared to Surface or Sheet Mulch (laying mulch in layers across surface). Treatment involves planting plant material like straw, dead brush, mulch, reeds, stalks, native grass clipping bundles into holes dug in soil. Provides deeper water penetration, dust/seed collection, nursery sites for seeds to sprout and shade for seedlings.

Materials

- Dry organic matter like straw, dead brush, mulch, native grass clipping bundles, etc.
- Digging bar/shovel
- Trencher
- Seed
- Compost

Site Selection

Eroded or bare soils, or where surface drainage is occurring. Density of application determined by labor, material, and intention. Closed roads or trails are also good candidates.

Indicators

- Eroded soils
- Soils exposed to wind
- Trail decommissioning

Alt. Treatments

- Brush Mulch
- Compost
- Fish Scale Straw Mulch
- Jute Netting
- Straw Flake Filter Dam
- Surface Mulch
- Wind Fence

[33] Bainbridge, DA. A Guide for Desert and Dryland Restoration. Island Press. 2007. Pg. 150.

Vertical Mulch (con't)

Installation

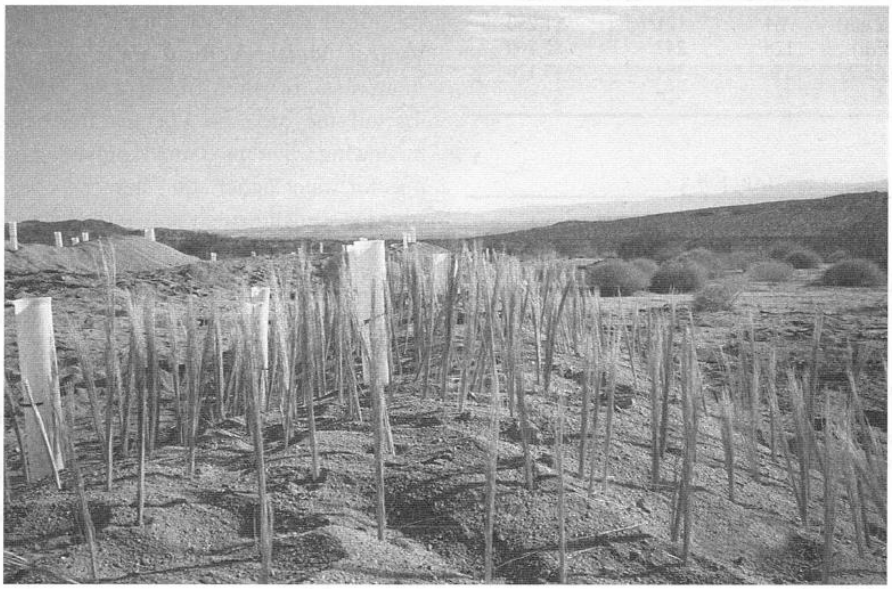
1. Collect material to be used. Ensure or limit unwanted weed seeds.
2. Dig holes 4-6" deep and relatively narrow, about 4-6" in diameter. Large holes require more brush and decrease the amount of area that can be covered.
3. Vertically insert material into hole. Add wanted seeds if doing so.
4. Backfill and compact hole.
5. *Optional*: Inoculate hole with Activated Compost Tea or other organic plant food spray.

Inspection Quality Control

- On flat sites, installation should be done in a random pattern and be consistent.
- Ensure material doesn't easily blow or get knocked out of holes. Properly packed in with soil
- Ensure material bundles aren't too thin which don't provide the intended benefits.
- Install larger, intact dead brush specimens in areas to mask unwanted trail creation or fill in visual gaps.
- Observe where small rills or gullies are starting to form, add additional Vertical Mulches to these areas and where potential future overflow may lead to reduce down slope water concentration.

Maintenance / Follow-up

- Observe results and document performance.
- Install more if results are good. Vary material, if possible, to test different responses.
- Add additional seed to mulches if first planting wasn't successful.



[34]

[34] Bainbridge, DA. A Guide for Desert and Dryland Restoration. Island Press. 2007. Pg. 150.

Vertical Mulch (con't)

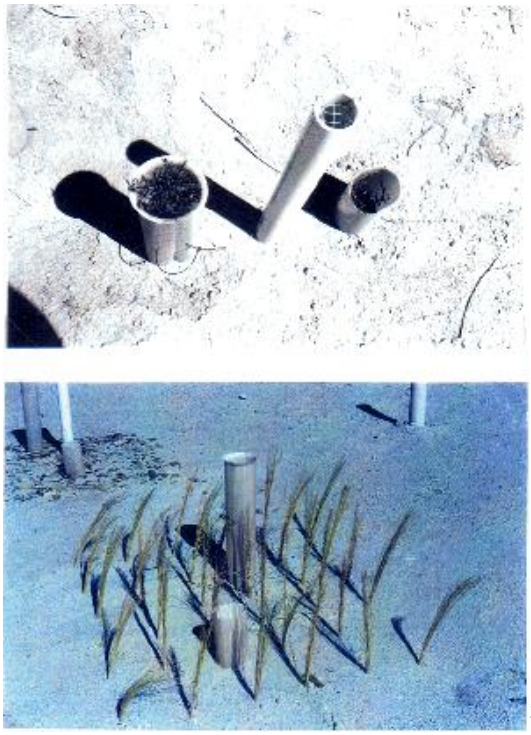

[35]

FIGURE 8.17. Planting dead bushes reduces visibility of trails, adds habitat value (perches and shelter), and reduces erosion.
[36]

[35] Source: http://www.sci.sdsu.edu/ SERG/techniques/mulch.html

[36] Bainbridge, DA. A Guide for Desert and Dryland Restoration. Island Press. 2007. Pg. 156.

Wattles / Socks / Fiber Rolls

[37]

Treatment Summary

Fiber or organic material filled mesh socks (aka Fiber Rolls) of varying lengths installed on contour for runoff and sediment control. When used as a diversion treatment to starve gully erosion, install at 1-2% grade away from the gully and spill at a spreading area or 2nd wattle section installed on contour Spacing of wattles or socks decreases as slopes increase in steepness. Proper installation is crucial for wattles to work effectively. Combined with mulch to improve moisture retention and reduce surface erosion which can lead to undercutting of the wattle.

Materials & Tools

- Wattles/Socks: 9-12" diameter tubes, 10-30' long
- Wood Stakes: 5 1x2 or 2x2 18-24" long per wattle, or #3/#4 rebar
- Hand Tools: Shovels, Pulaskis, & Stake Hammer (Small Machines for trenches on < 30% slopes)
- Flags and Contour Level Tools
- *Optional*: Seed & Mulch

Site Selection

Sloping eroded or bare soils, restoration project areas, recently disturbed construction sites, and revegetation work. Areas susceptible to runoff and sediment loss.

Indicators

- Eroded or bare soils
- Slopes
- Downhill gully or rill erosion

Alt. Treatments

- Brush Mulch
- Compost
- Diversion Ditch
- Fish Scale Straw Mulch
- Jute Netting
- Straw Flake Filter Dam
- Surface Mulch
- Vertical Mulch

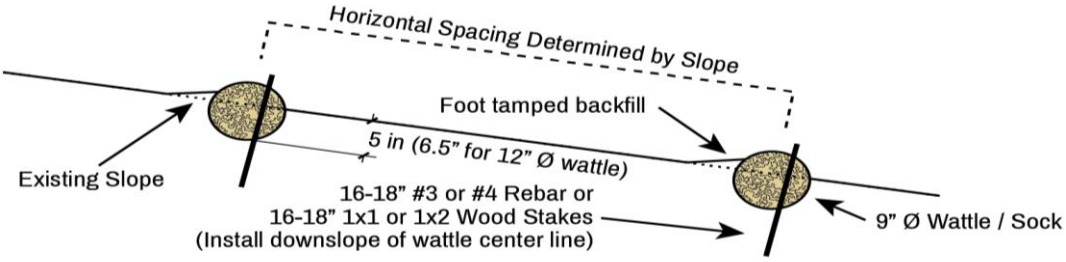
[37] Bainbridge, DA. 2007 p152

Wattles / Socks (con't)

Installation [38]

1. Layout a contour line on the slope with a hand level and wire flags. Space install lines according to Table 2.
    a. If uphill from gully headcut, layout similar to worm ditch with slight fall (1-2%) away from gully to divert water to side-hill and maintain sheet flow.
2. Dig a depression 5 inches deep (for 9" wattles, or 7" for 12" wattles) with spoils on uphill slope. Lay wattle, seam side down into it.
3. Drive a 1x2 or 2x2 wooden stake (or #3 or #4 rebar, depending on soil hardness) through the center of the wattle 6" inboard of each end at least 6 inches into the ground, stopping about two inches above the wattle.
4. Put 5 stakes in each wattle roughly 8' apart,
5. For multiple wattles in 1 row, install with 1' overlap (widen trench at overlap to keep wattles from sitting atop soil).
    a. Keep a smooth contour or grade at overlap and shingle to maintain flow of water along wattle towards ridge forms.
6. Seat the wattle with foot tamped backfill on the upstream side such that water flowing down the slope will not run under it. Backfill any gaps in downhill side as well.

STRAW WATTLE (9" DIA.) INSTALLATION - ELEVATION VIEW



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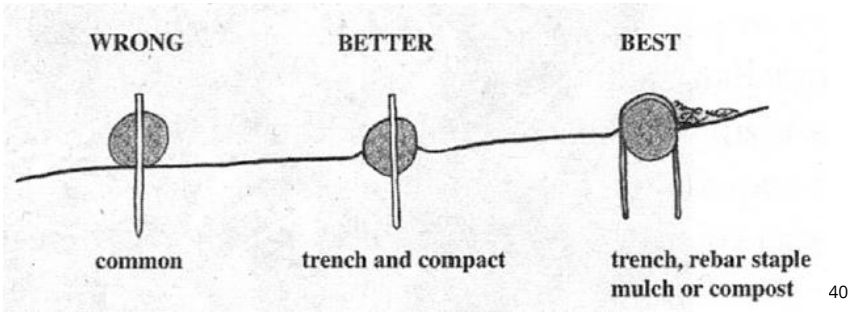

 [40]

Table 2: Recommended Spacing for Straw Wattles

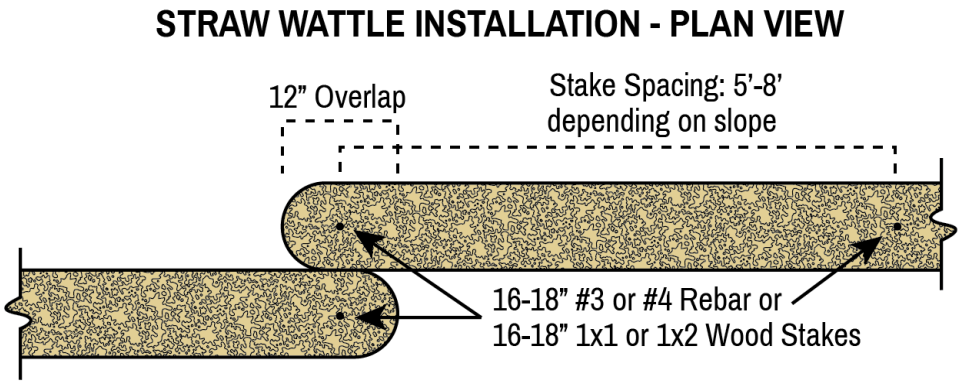
Land Slope (%)	Spacing (ft)	# Wattles (ft/acre)
10-20	60	726
20-50	30	1452
> 50	10	4356

[38] "Contour Straw Wattle Guide". NRCS Colorado. http://www.herefordnrcd.com/Straw_Wattles.pdf
[39] Adapted from https://www.nrcs.usda.gov/wps/portal/nrcs/detail/wy/technical/engineering/
[40] Bainbridge, DA. A Guide for Desert and Dryland Restoration. Island Press. 2007. Pg. 152.

Wattles / Socks (con't)

Inspection Quality Control

- Ensure trenches are not dug too shallow or too deep and are on contour or fall at the appropriate grade away from gullies.
- Verify that sufficient stakes are used and 1' of overlap on wattles is achieved. Ensure contour is maintained as step overlap occurs. Aim for contour line overlaps to "step" from valleys toward ridges.
- Sufficiently foot tamp the upstream backfill on the wattles to prevent undercutting.
- Clean up and remove any unused material.



Maintenance / Follow-up

- Repair or replace split, torn, unraveling, dislodged or slumping wattles.
    - Pay attention to any animal burrows that may be channeling water under wattles.
- Inspect wattles when rain is forecast, following rainfall events and once daily during prolonged rainfall. Perform maintenance as needed.
- Seed upstream/uphill sediment during rainy season to aid in establishment of vegetation
- Wattles are designed to be left in place. If wattles must be removed, remove all stakes and plastic debris and fill in trench or apply other treatment to control erosion.
- If water flows around wattle and creates rill or feeds gully erosion, extend with additional wattle, rock mulch, etc with slight uphill grade.

Zuni Bowl

 [41]

Treatment Summary

Zuni Bowls (aka Rock Lined Plunge Pools) help treat headcuts and prevent their expansion and upstream migration. Sizing of rocks used very important based on stream flows & intensity. Their main function is energy dissipation of falling water where the headcut pour-over scours the channel bed below. Instead of having one large, high energy fall, water "steps" down smaller, reinforced falls that do not allow direct contact with loose soil or channel bed. Moisture retention is also achieved to help vegetation establish. Original concept developed by the people of Zuni Pueblo and Bill Zeedyk.

Materials

- Rocks or Soil Crete Filled Sand Bags
- Geotextile Fabric (optional)
- Native Seed Mix
- Digging tools and tape measure

Site Selection

Actively eroding headcuts in channels.

Indicators

- Active headcuts in channels

Alt. Treatments

- Cross Vane
- Log Stepdown
- Rock Mulch Rundown (in low flow situations)
- Rock Filter Dam

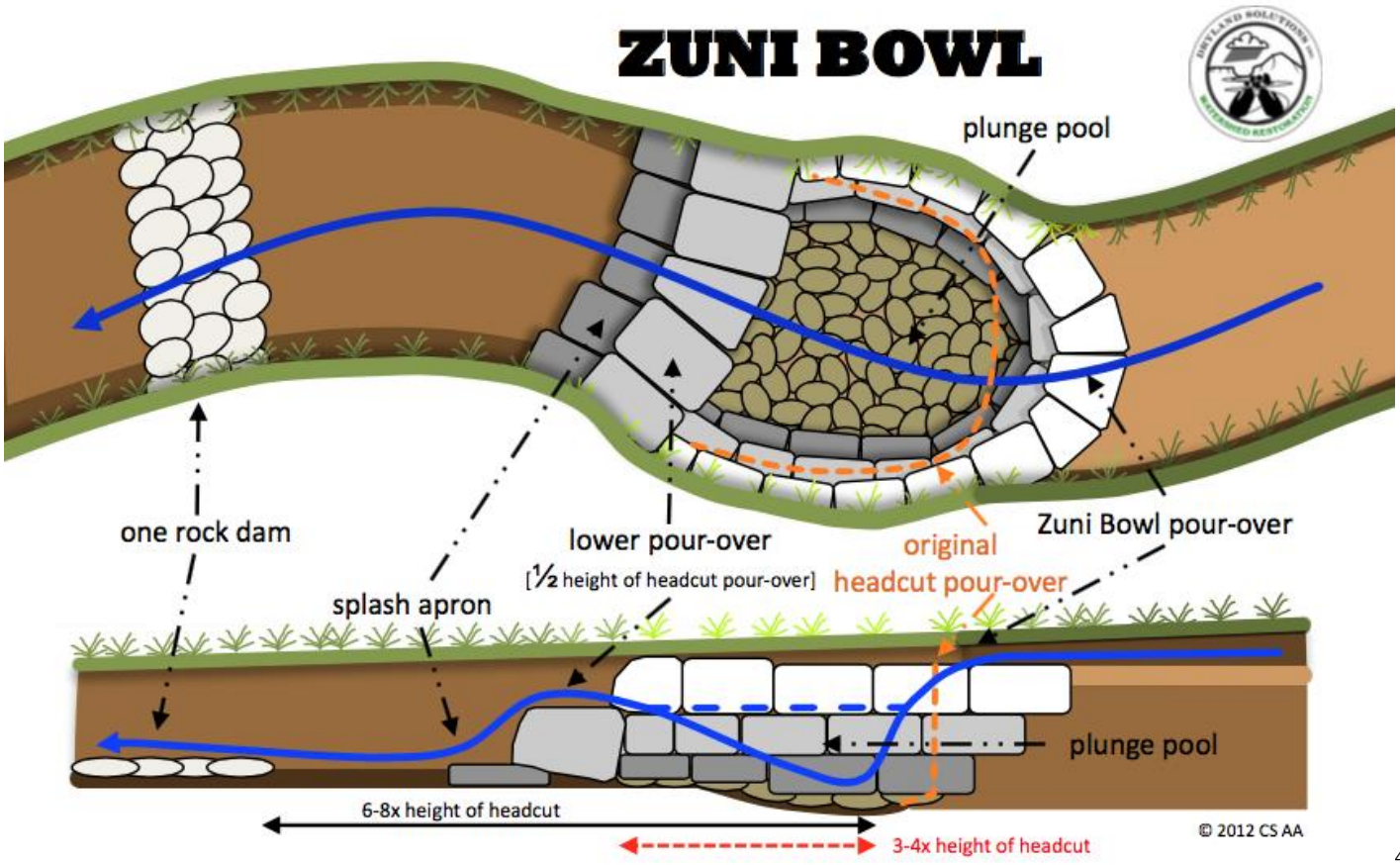
[41] Source: http://www.rainwaterpartnership.com/portfolio/watershed-assessment/

Zuni Bowl (con't)

Installation [42]

1. Select a headcut for treatment. Shape and layback the face of the headcut to create a uniform surface on which to build.
2. Determine the height of the headcut. Next measure and mark the location downstream from the face of the headcut that is three to four times (3-4x) the height of the headcut. At this location dig a shallow trench and fill with one to two rows of rock, so that no rock protrudes more than 2 in/5cm above the bed of the channel. This will serve as the splash apron for the Zuni Bowl.
3. Scatter native grass and wildflower seeds in the area where the Zuni Bowl is to be built.
4. Gather the largest rocks available, and place them in a row just upstream from, and in contact with, the splash apron. These rocks should sit at an elevation approximately ½ the total height of the headcut. This will serve as the lower pour-over of the Zuni Bowl. Use keystones on the pour-over whenever possible.
5. Armor the bottom of the plunge pool with a single layer of rocks. Place these rocks at a uniform height to create a stable foundation for the rest of the Zuni Bowl. Smaller rocks may be used for this part of the Zuni Bowl.
6. Starting just upstream from the lower pour-over, lay courses of rock around the face of the headcut. This will form the walls of the bowl.
7. Maintain contact with the shaped surface. The structure will have more integrity if built with layers of offset rocks that form a sloping wall inside of the headcut, as opposed to merely lining the face with rocks. Improve the durability of the structure by avoiding gaps in the rock work. As an extra precaution, you can use biodegradable geotextile fabric to line the face of the headcut prior to laying down rocks.
8. Continue to lay courses of rock on the face of the headcut until you reach the height of the original headcut pour-over. No rocks in the Zuni Bowl pour-over should protrude above this level to allow water to flow freely over the structure. Use keystones whenever possible.
9. Construct a ORD downstream from the Zuni Bowl. Place the upstream edge of the ORD approximately six to eight times (6-8x) the height of the headcut away from the Zuni Bowl pour-over.

[42] Sponholtz, C., et al.; "Zuni Bowl"; "Erosion Control Field Guide"; Quivira Coalition & Watershed Artisans



[43]

[44]

[43] Sponholtz, C., et al.; "Zuni Bowl"; "Erosion Control Field Guide"; Quivira Coalition & Watershed Artisans

[44] Source: http://streamdynamics.us/project/stormwater- harvesting-demonstration-project-arroyo-chamisos-city-santa-fe

Zuni Bowl (con't)

Inspection Quality Control

- Ensure solid, well constructed base to prevent structure collapse (splash apron, lower pour over, base layer of rock in plunge pool area).
- Make sure second pour over is ~½ height of total headcut
- Make sure top of structure is flush with grade in center so water flows over the structure and not around it.
- Be sure to seed before laying rock down to improve revegetation.
- Apply geotextile fabric under rocks if soils are easily erodible.
- Make sure ORD is built 6-8x height of drop downstream from structure

Maintenance / Follow-up

- Inspect during and following rainfall events (once daily during prolonged rainfall). Perform maintenance and/or repairs as needed.
- If structure is being flanked or soil piping occurs add rock to edges, lower center pour over rocks and fill in any gaps with well packed gravel

Appendix

Table 3 Soil and Revegetation Treatment Cost Scenarios

Treatment Type	Treatment Location(s)	Est. Cost/Acre or relative cost	Priority
Hand Crews, Volunteers, and Contractors			
Brush Mulch on Contour	Alluvial fans, gully mouths	Low - Med	Opportunistic
Brush mulch and weirs	Non-channel gullies/rills	Low - Med	Med
Diversion ditches	Above headcuts in uplands	Med	Med
Fish Scale Straw mulch	Legacy Disc scars and steep slopes	Low - Med	Med
Jute Mesh	Steep Slopes and highly eroded areas	Med	Med
Media Luna / Rock mulch on contour	Alluvial fans, gully mouths	Med	Opportunistic
Mulching: light coverage (50-90% cover, ¼-½" depth)	Areas treated w/ other erosion control actions, and as a stand alone treatment in bare areas	Low-Med	
Net and Pan / fish scale / chevron micro basins	Legacy Disc scars and steep slopes	Low	High
One Rock Dam	Non-channel gullies/rills	Med	Opportunistic
Rock Mulch Rundown	Non-channel headcuts	Med	Opportunistic
Seeding (Broadcast)	Areas treated w/ other erosion control actions	Low	High
Soil Pitting	Legacy Disc scars, steep slopes, Valley bottoms not accessible for drill seeding	Med	High
Straw, compost, or wood chip wattles	Above headcuts in uplands	Med	High
Straw flake filter dam (on contour)	Legacy Disc scars and steep slopes	Med	Med
Vertical Mulching	Trail decommissioning, downhill from existing trails	Med	Med

Treatment Type	Treatment Location(s)	Est. Cost/Acre or relative cost	Priority
Contractors Only			
Compost Blankets	Only steep road grades and high visibility areas	$5-8K/ac unseeded	Low-Med
Hydroseeding	Not recommended	Med	N/a
Hydromulching	Lightly sprayed over seeded areas	Med	Med
Imprinting	Slopes <8%: Ridgetops, valley bottoms	? hard to find tool ?	Low
Keyline pattern subsoiling	Slopes <15%: edge of foothills and valley bottoms, trial small area	~$150-200/ac includes cost of layout	Med
Rolling Dips	Trails	Med-High	High
Seeding (Drill) w/ mycorrhizae	Slopes <15%: Ridgetops, valley bottom, foothills, start w/ 10-20 acres to assess results (integrate w/mulch (i.e. straw crimping)	$800-1,500/ac	High
Zuni Bowls / Rock Lined plunge pools (volunteers w/ supervision)	In-channel headcuts	High	High

Table 4 Labor type recommendations by Treatment Type.

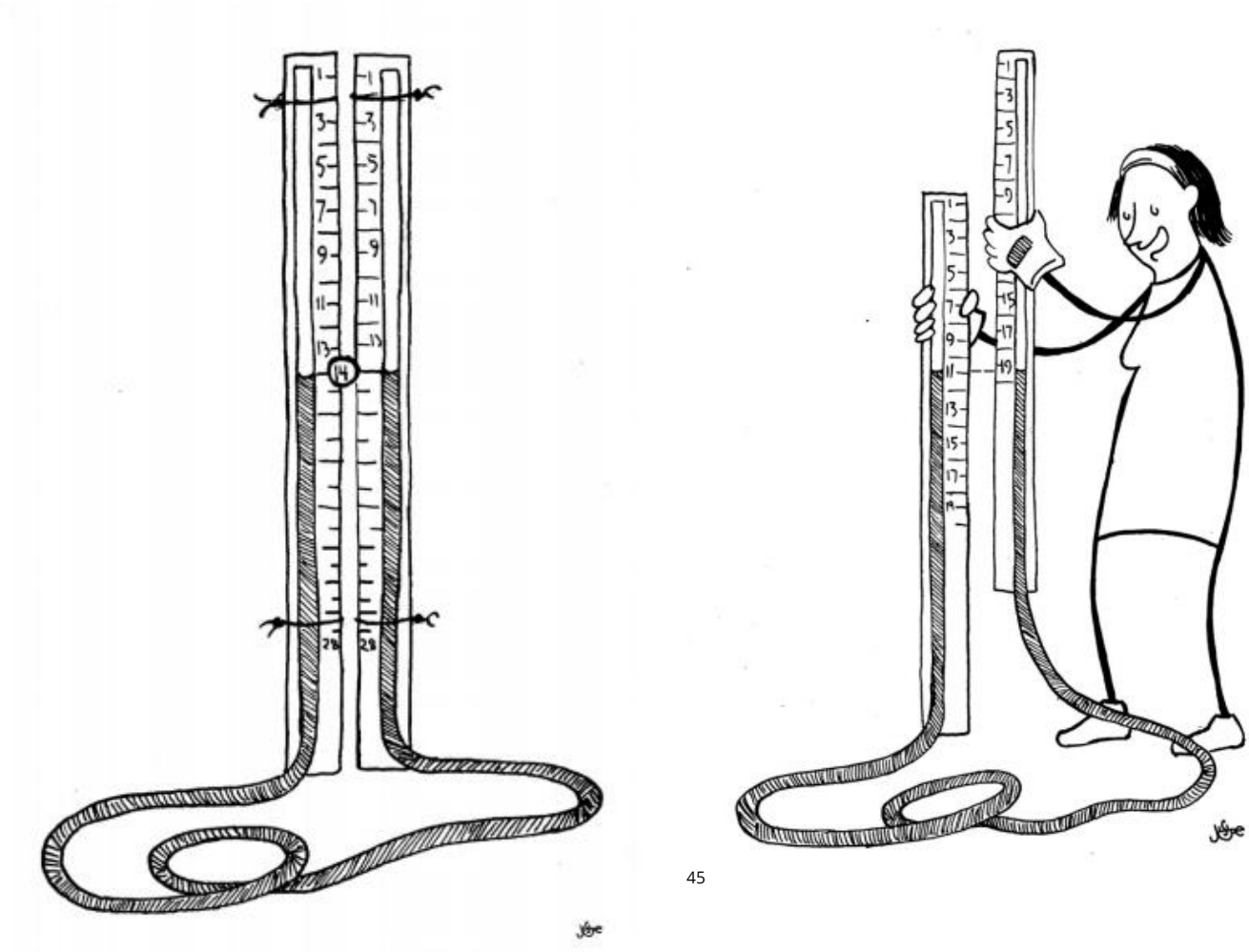
Treatment Type	Contractor	Volunteer	Hand	Mechanical
Brush Mulch on Contour		✓	✓	
Brush mulch and weirs in non-channel gullies and rills		✓	✓	
Compost Blankets	✓	✓		✓
Diversion ditches	✓	✓	✓	✓
Fish Scale Straw mulch		✓	✓	
Hydroseeding	✓			✓
Hydromulching	✓			✓
Imprinting	✓			✓
Jute Mesh	✓	✓	✓	✓
Keyline pattern subsoiling	✓			✓
Media Luna / Rock mulch on contour	✓	✓	✓	
Mulching: light, 50-90% cover, ¼-½" depth	✓	✓	✓	✓
Net and Pan / fish scale / chevron micro basins		✓	✓	
One Rock Dam	✓	✓	✓	
Rock Mulch Rundown	✓	✓	✓	
Rolling Dips	✓			✓
Seeding (Broadcast)		✓	✓	
Seeding (Drill) w/ mycorrhizae	✓			✓
Soil Pitting	✓	✓	✓	✓
Straw, compost, or wood chip wattles	✓	✓	✓	✓
Straw flake filter dam (on contour)		✓	✓	
Vertical Mulching	✓	✓	✓	
Zuni Bowls / Rock Lined plunge pools	✓			✓

How to Build a Bunyip (Water Level)

Bunyips (Water Levels) are simple tools for finding contour lines in a landscape. Consisting of 2 long sticks of exact same length with some form of standard measurement inscribed or attached along their length, a clear hose is attached to the sticks and filled with water.

Since water always finds its own level, you can find level points by moving one stick until the measurement reads equal on the ruler or measurement notches.

- Instruction Manual on Building Bunyip (Water Level): http://bit.ly/build-bunyip-water-level
- How to Video with Brad Lancaster: http://bit.ly/build-bunyip-video



[45]

[45] Source: Instruction Manual on Building Bunyip (Water Level) by Brad Lancaster: http://bit.ly/build-bunyip-water-level

BMPs Standards and Specifications

- San Diego County Stormwater Standards
- Caltrans Compost and Water Quality tech memo
- Caltrans specifying seed and plant species website
- Caltrans TransPLANT plant selection tool website
- CalTrans Callouts for EC treatments guide
- Riverside Flood Control Stormwater BMP design handbook

Revegetation and Seeding

- Drill Seeding CalTrans Info
- Drill Seeding NRCS info pdf
- Calibrating a Drill Seeder pdf
- Caltrans list of short shelf life seeds - not recommended for use on reveg seeding
- Caltrans list of plants ecozones
    - Cal eco unit 261Bj
        - Mixed lowland pioneers ss9
    - Cal eco unit M262Bl
        - Perennial Grassland ss6
    - Cal eco unit M262Bf
        - Mixed lowland pioneers ss12

Weed Abatement

- Jim Deguire Weed Abatement - 951-943-8827 or 951-741-4790

Erosion Control Contractors

- Inland Erosion Control, Inc.
- Summit Erosion Control
- Creative Hydroseeding – 800 973 3346
- Hydro-Plant Hydroseeding – 760 744 7360
- Hydrosprout, Inc – 760 432 8233

- So Cal Hydroseeding – 951 296 0650
- Quality Hydroseed - 760-789-8040

Erosion Control Suppliers and Resources

- **In-State**
  - Hedgerow Farms, Inc.: rents no-till drill, seed mix, etc. see services page
    - Near Sacramento
- **Local**
  - **Imperial Sprinkler Supply - Menifee**
    - Kent Gardner - Erosion Control Specialist @ ISS - 760-559-0078
    - Straw Wattle:
      - Regular - 8" x 25' - $14.95/ea
      - Biodegradable - 8" x 25' - $29.64/ea
    - Stakes:
      - 1x2x18 - $0.27/ea
      - 1x1x18 - $0.25/ea
    - Jute:
      - Net - 4' x 225' (900 ft²) - $57.54
  - Wholesale Erosion & Landscape Products
    - (951) 241-2589 | ramon@wholesaleerosion.com
    - 4000-4300 Rice Straw Wattles - Biodegradable - 8"x25' Burlap- 12 wattles/pallet
  - **Hay suppliers**
    - Weed Free straw and hay suppliers list from Cal-IPC
    - S&S Seed: native grass straw $12/bale + freight
    - Hay USA Fort Worth
    - So Cal Hay
    - R Hay and Grain
  - **Rock Materials Suppliers**
    - PTI Sand & Gravel - Corona, CA
    - West Coast Sand and Gravel -
    - Blue Rock - Murrieta, CA
  - **Equipment Rentals**

    - Pauley Equipment - 28374 Felix Valdez Ave, Temecula, CA 92590 - (951) 695-9080
    - RDO Equipment Co - 20 Iowa Ave, Riverside, CA 92507 - (951) 778-3700
    - Sunbelt Rentals - 3275 Columbia Ave, Riverside, CA 92501 - (951)-682-6823

- Out of State
    - AmericanTex
    - L&M Supply - Large options.
        - Ships from Georgia on 52' Van Pearson Truck
        - Jim Taylor - jim@landmsupplyco.com
        - 9" X 25' Jute Net Straw Logs @ $18.75 ea. plus frt. Sold 9/skid or pallet
            - *5,850 linear feet per truckload*
        - 9" X 25' Straw Wattles Poly @ $10.50 ea. plus frt. Sold 14/skid or pallet
            - *9,100 linear feet per truckload*
        - Truck Freight:
            - $3000/shipment. 4 week lead time, every day after that
            - 26 skids per 53' Dry Van
- GEI Works - Erosion Control Supplies
- Filtrexx sustainable technologies - soxx and mats Manufacturer
- L and M Supply Co - EC supplies
- Hanes Geo Components - logs, wattles, filter socks, jute mats, blankets