Field Guide to Riparian Restoration, and Upland and Arroyo Erosion

for rural and natural lands owners, managers, and restoration practitioners

Trevor Hare Watershed Management Group December 2019

Introduction

We live in a unique part of the world, one of the world's most diverse and wet deserts. People settled in this region thousands of years ago because of one amazing thing –water in the desert! The water that attracted our predecessors in now mostly gone. The two reasons for that are over-pumping our groundwater and the degradation of our washes, creeks, wetlands and rivers.

This short guide has been developed to help landowners and managers, businesses and homeowners, and others interested in how to better manage stormwater to reduce erosion and benefit downstream riparian areas. The current state of our channels and their associated habitat is grim but we can get back some of what we have lost with relatively simple strategies.

The key action we can take to protect and restore our landscapes and downstream riparian forests and wetlands are to enhance infiltration through slowing, spreading and soaking in storm water flows as well as reducing our groundwater demands in critical shallow groundwater areas. Most of our restoration and erosion control strategies not only benefit the creeks and wetlands but also help to retain soil moisture for healthy upland vegetation.

Breaking Bad Cycles

		
Upland vegetative loss and sheet flow erosion	**Gully headcutting to downstream arroyo incision**	**Riparian system drying and incising**

Taking Steps to Restore Benefits

		
Upland landscape practices to slow and soak in rainfall	**Grade control structures to slow, soak, and re-establish vegetation**	**In-stream practices to restore riparian systems**

There are a variety of characteristics available to assess erosional areas, and to define priority sites including form and function of the erosion, rates of erosion and sediment movement, upland condition, infrastructure locations, spatial arrangement, proximity to critical resources such as wetlands and creeks, previous research and observations, and coordination with partners. Through coordination with partners the integration of these assessments and then the projects into other on-going/planned conservation projects will be achieved. Erosion control and riparian/upland restoration activities can easily integrate with on-going projects including shrub control, revegetation, and wildlife habitat and wetland protection and creation.

Get Started! *Don't just do something, stand there and <u>Read the Landscape</u>!!*

We need to look past the erosion, the symptom, and look for potential causes. Most ex-urban and rural landowners have keen eyes for what is happening in regards to their lands, water courses, vegetation, livestock and wildlife use, etc., and with just a few guidelines will quickly and easily pick up on landscape clues pointing toward erosional problems.

Tip 1. Check where you tread. Roads, paths, and infrastructure alignments have enormous impacts on the flow of water. Three main effects are usually seen, stream capture by road, sheetflow capture, and the creation of nick points where erosive headcuts can start. The flow of water on or along a road is also costly in terms of road maintenance.

Indicators of linear flow capture

		
Stream capture	**Sheet flow capture**	**Nick point**

Tip 2. Get down on the ground**.** Loss of ground cover leads to sheet erosion which carries soil and organic material down slope. Increased runoff volumes and velocities result in plant cover loss, soil disturbance, or the compaction and hardening of land surfaces. Sheet erosion also strips organic material which reduces the nutrient and moisture absorbing capacity from the soil leading to plant mortality which in turn, through the loss of roots holding the soil together, will cause greater soil loss.

Indicators of sheet erosion

	
Pedestalled plants	**Exposed roots**

As the depth of sheet flow increases it begins to concentrate into defined flow paths which increases the erosive potential. These erosive flow paths grow from shallow rills into larger gullies.

Tip 3. Follow the flow. Observe flow patterns during or immediately after rain storms that generate runoff. Gully erosion can begin after the loss of topsoil as above but also can start because of some aggravating event or structure. Natural channels can erode into deep, straight gullies, or can form in upland areas due to severe soil degradation or disturbance. The most common causes of accelerated erosion in our upland urban or rural areas is typically due to land clearing and soil disturbance, vegetation loss, animal trails, recreational vehicles, bulldozing, and flow concentration. These tend to modify flow paths, increase flow runoff, and reduce the opportunity to infiltrate runoff.

Deciding where to start

Most erosional issues can be addressed, but the cost and scope depend greatly on where we decide to tackle it. First, we must consider:

1. Can we treat the cause or only the symptom?
2. Are we able to coordinate or cooperate with others to fully address the cause?
3. Is the problem impacting valued natural or cultural resources?
4. Are there local and/or on-site materials we can use?
5. What is the scope and scale of the issue to be addressed? By human-labor or machine-labor?
6. Is the site accessible for hauling materials, machinery, hand labor, etc.?

In addition, the selection of an appropriate strategy may influence site selection. It may not be practical to address the instream site needs initially due to design skill, permitting, or cost requirements.

Here is a short list of helpful resources for assessment, design, and planning: Proper Functioning Condition (USDI. 2015), the Qualidad del Bosc de Ribera (Munné etal. 2003), Rapid Assessment-Riparian Assessment method (Stacey etal. 2006), WARSSS – Watershed Assessment of River Stability and Sediment. (Rosgen, D.L. 2007), Natural Channel Design: Fundamental Concepts, Assumptions, and Methods. (Rosgen, D.L. 2011) and those outlined in the book Let the Water do the Work: Induced Meandering, an Evolving Method for Restoring Incised Channels (Zeedyk and Clothier 2012).

Planning Next Steps
Each site should be visited by a restoration specialist and the land manager and/or owner and the areas of interest should be delineated on an aerial image, critical elevations should be recorded with a laser level (LiDAR data should be used where available), then through an iterative design exercise all available options should be carefully analyzed to develop a robust plan and design.

A final consideration is what happens to the water that has not soaked into your landscape, you must plan for safe downstream conveyance.

Selecting Your Strategy – The following considerations are critical for selecting the appropriate strategy or suite of strategies.

- Location – where in the landscape are you: top of a hill, middle (along the mid-slope), or bottom (near or in a channel); where is the erosion happening and is it upland sheet erosion or arroyo erosion?
- Contributing area and land use – how much water can you generally expect, how much developed land is above you? *The contributing area (watershed size) and the land use upstream will help you determine the amount of flow you can expect which indicates what rock size is required to use in your treatments. The larger the contributing area the greater the risk of failure and increased cost of installation.*
- Scale – how extensive is the issue? Do we take a broad-scale approach of smaller features applied across a larger area or an intensive effort applied to a smaller area?
- Slope – is the erosion in a steep, moderate or flat area? *The slope of the landscape area or channel is important to the spacing of treatment structures. The steeper the area the more structures that will need to be installed.*

Most low-tech and low-cost restoration practices will help to slow, spread and soak storm water flows from the upland to downstream practices (see Appendix A - *Quick Guide to Erosion Control Options*). Swale and basin systems and media lunas slows and spreads flows, Zuni bowls control headcuts, and one-rock dams slow and sink flows and act as grade control structures. In addition, induced meandering methods such as vanes, weirs, and baffles applied in creeks and rivers may be appropriate in certain circumstances. Remember, any work in a designated floodplain or channel will require review and permitting with your flood control agency and potentially with the Army Corps of Engineers if it is a designated “Waters of the United States” which in practice locally includes all sandy bottomed washes.

Planning Your Project

No matter the watershed size and land use, expected flows, the scale of the erosion, and the slope, you can begin to work on it. If you can only work on the symptoms because the cause is on another property then include them in the planning process, share your work with them, and show them the results. Maybe then they will realize how they can help to address the cause!

Knowing which permits are needed is imperative to the success of any restoration project. There are Federal, State, County and City permits to acquire depending on the jurisdiction and scope of the project. Work on private land with no federal funding is generally exempt from Federal and State permitting but may need a local jurisdictional permit if working in a designated floodplain. Any work with federal funding or on public land will need a series of clearances and permits.

- State Historic Preservation Office (SHPO) clearance is needed for any Federal or State funded projects.
- Federal Clean Water Act (CWA) Section 404 permits are issued by the Army Corps of Engineers and cover activities in sandy bottom washes and creeks, wetlands and rivers.
- The State administers CWA Section 401 which covers the discharge of pollutants in waterways.
- The National Environmental Protection Act (NEPA) covers activities on public lands.
- The Endangered Species Act (ESA) must be followed for any activities needing CWA 404/401 or NEPA permits.
- In addition counties and municipalities have various riparian protection, erosion hazard and floodplain ordinances that must be followed.

Partnerships – because of the costs of and expertise needed in the assessment, design, planning, permitting and implementation of restoration projects partnerships can be very important. Erosion control projects can be as simple as building a one-rock dam in a small gully to a large 800 acre watershed treatment. Leveraging additional resources (knowledge, skill, permitting, equipment, materials, monitoring, etc) through partnerships can help to reduce the direct cost burden of a restoration project.

Budgeting – Project costs scale with the scope of the project. Small erosion control projects can cost as little as $1,000-$2,000 for labor and materials, arroyo restoration can be up to $25,000 per mile of treatment, and creek and wetland restoration projects can cost upward of $50,000 per mile or 100 acres of treatment area.

Materials – Rocks are the most common material needed for erosion and restoration structures. Rock may be collected on site or purchased and delivered. Rock collected on site should be removed from areas that are flat and well away from water flow paths. Purchased rock should be sourced from a quarry/material company as close to the work site as possible. Rock should be angular not round (No river rock!) and some of the easiest rock to stack is blast rock from mining operations, however this rock is usually trucked in from distant areas and may not be similar in color to the local landscape.

Another source of material for structures is urbanite (re-purposed concrete chunks), again this material is not native to the local landscape but is a good use of material that otherwise gets hauled to the dump. Other materials used to build structures are brush and logs (see the references below).

Equipment – Depending on project scale equipment needs may range from a shovel and pick, to a loader to move rock to structure sites, to a backhoe with a thumb to place boulders. When using any equipment ensure the operator is experienced and aware of surroundings including other crew members in the area. Secondly, when using any type of motorized or hydraulic equipment (loaders and backhoes are both) having a spill kit is critical in case there is a diesel or hydraulic fluid spill, in addition a safe place to refuel away from the drainage or any water is also very important. Be sure to also define and plan equipment access routes and restoration of those routes when completing the project. Lastly, maintaining clean equipment is important to avoid transfer of invasive species or pollutants.

Labor – Erosion and restoration work is hard! Finding experienced labor can be even more difficult. Many organizations and businesses are beginning to offer expert rock crews, restoration services, and more. Check with local organizations and government agencies who often provide or contract restoration services. In addition, many landscaping and construction companies, water harvesting and permaculture practitioners are entering the restoration business.

Monitoring and Maintenance

The structures and the methods of installing them are designed to be robust and long-lasting and needing very little maintenance. However in our experience some of the structures will need re-working after the first big flow event or after the first monsoon season. This is an expected and normal outcome and you should consider the site you are working in as an interactive landscape –watching water flow across your site and interact with the structures can tell you a lot about the land and how the treatment will interact with it.

When using grant funding to plan and implement a restoration treatment there is often no funding allocated to long-term monitoring and management, however there are simple things you can do to help you monitor and assess the work.

Monitoring:

Photo-points –the most cost effective way to monitor erosion control and restoration projects. The most common method is to monument (mark with a rebar post or rock cairn) and geo-locate a point that you can easily find again, we would suggest three photo points per structure, one looking downstream, one up and one from the side. Some important points in photo-monitoring is that it is hard to represent three-dimensional structures in a 2-D photograph, so lighting and angle are important. Shooting in morning or late afternoon light lets you use shadows and softer lighting to capture more detail and we would suggest shooting from multiple angles the first time and then choosing and using only one for each photo-point. Second if you are using erosion pins (see below) having those installed and in the photo is very important. Third we suggest shooting photo-points before the start of installation, during installation and then after, and as frequently thereafter as funding allows. Lastly always try to use the same camera and setting and take prints of each photo into the field with you so you can align your next shot with the baseline photo.

Erosion pins –erosion pins can be metal stakes, rebar or any other steel rod which you hammer into place in an area to be influenced by a structure or where you want to monitor loss or aggradation of sediment and soil. Pins should be geo-located and measured to record length above ground level.

Vegetation –there are many methods for monitoring vegetation response to erosion control and restoration and it is beyond the scope of this chapter to outline them, please see *Effectiveness monitoring for streams and riparian areas: sampling protocol for vegetation parameters* linked in the References.

Laser Level survey –depending on the scale of your work site a survey can be an easy to use and effective monitoring tool. Ideally a laser-level survey was conducted in the assessment phase and the longitudinal profile and series of cross-sections can act as a baseline so that changes in the creek, arroyo or other site landform characteristics can be assessed as the work matures.

Maintenance:
Grant funding will rarely pay for long-term monitoring let alone maintenance, however asking for two years of maintenance at approximately 10% of the total is not unreasonable to ensure that the project is a success. We recommend the two years of maintenance funding to account for changes that could happen in the first two monsoon seasons. The structures and the methods of installing them are designed to be robust and long-lasting and needing very little maintenance, however in our experience some of the structures will need re-working after the first big flow event or after the first monsoon season.

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Glossary

Thanks to the following authors:
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Rainwater Harvesting for Drylands and Beyond, Vol. 2: Waterharvesting and Earthworks, by Brad Lancaster, Rainsource Press: 2008.

Aggradation: the accumulation of sediment in rivers and nearby landforms.

Alluvium: deposit of sediment by a stream usually in a valley bottom.

Avulsion: a rapid change in channel direction when a stream suddenly breaks through its banks, typically bisecting an overextended meander arc (oxbow cutoff).

Aspect: refers to the orientation or the direction a landform slopes, whether northerly or southerly. In the Northern hemisphere, a south slope faces the noon sun and dries more quickly, as well as is warmer than a north slope.

Aquifer: subterranean layers of sedimentary particles (sand, gravel, and rocks) laid down over geologic time, in which water fill the tiny spaces between the particles.

Arroyo: a water-carved gully or channel in arid lands, usually somewhat small with steep banks, and dry most of the time due to infrequent rainfall and the shallowness of the cut which does not penetrate below the level of permanent ground water.

Baffle: a structure designed to wedge stream flow toward the opposite bank and to be easily overtopped by flood events. An efficient baffle has the shape of a 30/60 degree triangle, and the right angle of the triangle is footed on the streambank, extending outward towards the middle of the stream channel.

Bank Height Ratio: the ratio of bank height to bankfull height.

Bankfull: the incipient elevation on the bank where flooding begins. In many stream systems, the bankfull stage is associated with the flow that just fills the channel to the top of its banks and at a point where the water begins to overflow onto a floodplain.

Baseflow: sustained or dry-weather runoff. It included water draining from natural storage in groundwater bodies, lakes, or swamps, and delayed subsurface runoff.

Bedload: the visible particles (silt, sand, gravel, cobble, and boulders) that are periodically rolled, or dragged along the stream channel by the current, each at rates according to flow energy, and size, shape, density, and interaction with other particles.

Berm 'n basin: a water-harvesting earthwork laying perpendicular to land slope, consisting of an excavated basin and a raised berm located just downslope of the basin.

Bioengineering: the use of living plants to stabilize soil. Restoration and stabilization techniques that use plants to prevent erosion, stabilize slopes or streambanks, or to mimic other natural functions and benefits. Preferably uses native species.

Boomerang berm: semicircular berm open to, and harvesting, incoming runoff from upslope.

Break line: the dividing "line" in a landscape where a slope changes from a gentle grade where sediments settle out of slow-moving runoff, to steep grades where sediments are picked up and carried off by faster-moving runoff.

Capillary action: the attraction of water molecules to the small voids between soil particles. Capillary action is responsible for moving water from wet areas of the soil to dry areas, and it is powerful enough to move water upwards against the flow of gravity, up to 40 inches in clay soils.

Channel: (1) A perceptible natural or artificial waterway which periodically or continuously contains moving water or which forms a connecting link between two bodies of water. It has a definite bed and banks which confine the water. (2) The deep portion of a river or waterway where the main current flows. (3) The part of a body of water deep enough to be used for navigation through an area otherwise too shallow for navigation.

Channelization: constricting and straightening water flow by sealing and smoothing the banks and sometimes the bed of a waterway, often with concrete. It can be compared to a shotgun barrel for water. Channelization increases the velocity of water flow, and can reduce infiltration of water into the soil and deepen the channel downstream.

Colluvium: loose earth material that has accumulated at the base of a hill, through the action of gravity, as piles of talus, avalanche debris, and sheets of detrius moved by soil creep and frost action.

Competence: the ability of a stream to move a given size particle.

Contour berm: a berm 'n basin constructed on a contour.

Cross section: cut-away view of one slice of the stream channel as seen in the downstream direction.

Crossover: the length of the channel between adjacent bends in the channel.

Cutbank: the bank where erosion is concentrated.

Cross-vane: A rock vane structure that extends fully across the stream channel's width, and is built at a height that does not exceed the assessed bankfull level for the stream. Cross-vanes are treatments for streambank erosion and downcutting.

Diversion swale: a gently sloping drainage way that moves water slowly downslope across a landscape, while simultaneously allowing some of the water to infiltrate into the soil.

Downcutting: a geological process that deepens the channel of a stream or valley by removing material from the stream's bed or the valley's floor; also called erosion downcutting or downward erosion or vertical erosion.

Effective discharge: geomorphic concept representing the flow, or range of flows, that transports the most sediment over the long term.

Ephemeral: a stream or portion of a stream which flows briefly in direct response to precipitation in the immediate vicinity and whose channel is at all times above the water table elevation.

Evapotranspiration: the combined measurement of water loss to evaporation and transpiration through the pores of vegetation.

Flood stage: the stage beyond bankfull stage when overflow from the channel spills onto the floodplain.

Floodplain: flat or nearly flat land adjacent to a stream or river that experiences occasional or periodic flooding. It includes the floodway, which consists of the stream channel and adjacent areas that carry flood flows, and the flood fringe, which are areas covered by the flood, but which do not experience a strong current.

Fluvial: used in geography and earth science to refer to the deposits and landforms created by the action of rivers and streams and the processes associated with them.

Flow splitter: a "double L" or "Y" pipe fitting that splits or "branches" greywater flow in two for wider passive distribution within a landscape.

Geo-locate: pinpoint a location via a GPS unit in either lat/long or UTM.

Glide: begins where the pool ends, where the bed has an adverse slope and starts to become shallow. There is upwelling of the flow here that ends at the top of the next riffle where the water surface becomes steep again.

Grade control: structures installed to maintain a desired streambed elevation; used either to raise the streambed (i.e. to reverse channel incision), or to maintain the present elevation to prevent channel incision.

Groundwater: water that has naturally infiltrated into and is stored within an underground aquifer.

Gully: a small, elongated, usually eroded depression in the land surface, usually dry except after a rainstorm; a channel or miniature valley, formed by a concentrated runoff, through which water commonly flows only during and immediately after heavy rains or during the melting of snow. The distinction between ravine, gully, and rill is one of size, a gully being smaller than a ravine, larger than a rill. A gully is sufficiently deep that it would not be obliterated by normal ploughing operations, whereas a rill is of lesser depth and would be smoothed by ploughing.

Gully plug: structure constructed with rock to form a weir in the gully channel to keep the flow of water in the center of the gully. They are placed in a stair-step method so the elevation of the top of one gully plug is level with the toe of the plug above it. Eventually the once-deep gully will fill with silt and form a stair-step down the slope.

Headcut: a sudden change in elevation or nickpoint at the leading edge of a gully. Headcuts can range from less than an inch to several feet in height, depending on several factors, including: streambed widening, increased water velocity, loss of streamside vegetation from bank erosion and sloughing, increased sedimentation, and deteriorating water quality.

Heel-to-toe: stable placement of check dams where the toe of the level terrace of accumulating soil and sediment behind a downstream dam extends to the heel of the downstream-facing base of the next upstream dam.

Incised: a condition that occurs when a river or stream has cut downward through its bed and no longer has access to its floodplain.

Induced Meandering: a stream restoration method for incised channels that uses artificial (though naturally sourced) in-stream structures, manipulation of stream bank vegetation, and the power of running water to expedite channel evolution and floodplain development. Key components of induced meandering are the proper sizing and spacing of structures and the selective introduction of streambank vegetation.

Infiltration: the movement of water from the land's surface into the soil.

Invert: pour-over of a culvert outlet or rock grade control structure.

Lateral bar: forms in the crossover and is an indication of sediment overload.

Living sponge: a natural mix of fertile soil, soil organisms, organic surface mulch, and vegetation that quickly infiltrates water into the soil and pumps some of it back out through the vegetation to produce additional resources such as food, shelter, wildlife habitat, and beauty.

Longitudinal profile: a means of illustrating how the stream bed loses elevation as it proceeds down valley. The thalweg, one of the features surveyed for a longitudinal profile, is used to identify and measure bed features such as rifles, runs, pools, and glides.

Meander length or Wavelength: comparable to wavelength, the distance between corresponding parts of the consecutive waves in a wave train. A stream's meander length is the valley distance used to form a "S" curve in the streambed. Meander wavelengths are 10-18 times the bankfull channel width.

Media Luna: A half-moon shaped one-rock dam whose curvature custom fits the stream channel's elevation and width. A media luna is designed to slow a stream's velocity, disperse sediments, and increase elevation in an incised channel for the streambed's overall stability.

Net-and-pan system: a modified series of boomerang berms connected directly to one another, concentrating harvested runoff water at multiple points in the landscape. A completed system looks like a "net" of berms draped over a hillside with "pans" or basins inside each segment of the "net."

Nitrogen-fixing: the ability of microorganisms to fix or convert atmospheric nitrogen gas to a chemically combined form—ammonia—which is essential to plant growth.

Non-point Source Pollution (NPS): pollution that occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into groundwater.

One-rock-dams (ORD): are used to raise channel bed elevation and control or modify slope gradient. ORDs are best suited to rock channels, especially ephemeral or intermittent streams and arroyos.

Ordinary High Water Mark (OHWM): that line of the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of liter or debris, etc. Applies to jurisdictional determinations for non-tidal waters under Section 404 of the Clean Water Act and under Sections 9 and 10 of the Rivers and Harbors Act of 1899.

Overflow: the planned and stabilized exit route for excess water from a water-harvesting earthwork or tank.

Oxbow cutoff: a crescent-shaped pool formed near a flat-valley river when one of its meanders becomes pinched off and isolated.

Plug 'n Pond: A restoration technique of gully plugs that create ponding and direct overflow to appropriate places in the landscape. This technique is suitable for restoring gullied wet meadows in small watersheds with a low sediment supply.

Point bar: a bedload deposit formed on the inside bend by the flowing water of a meandering river.

Pool: where a stream's water slows and stagnates in a stream channel, usually following a sequence of a riffle, which slows the water initially. Pools are essential for aquatic habitat, as well as for the maintenance of good water quality in a riparian zone.

Pond: an open earthen holding area for water. Ponds can be appropriate in drylands if filled with runoff harvested on site to provide a backup water supply in the dry season, but are inappropriate if groundwater or off-site water is consumed or pumped into the pond to keep it full.

Proper Functioning Condition (PFC): the ability of a stream, river, wetland, or lake, and its riparian area, to withstand: normal peak flood events without experiencing accelerated soil loss, channel or bank movement, filter runoff, and store and safely release water.

Regional curves: plots that show how bankfull channel dimensions increase as the size of the watershed increases. Regional curves are plots of bankfull width, depth, and cross-sectional area as a function of watershed area.

Riffle: A stream rapid, where the water surface at base flow is flowing quickly.

Rill: a tiny erosive drainage where loose soil has washed away. It is very common on eroding slopes where roadways have been cut into hillsides or on bare dire driveways and roads that run downslope.

Riparian: of, pertaining to, or situated on the bank of a river or other body of water.

River Left: left bank of a river when facing downstream.

River Right: right bank of a river when facing downstream.

Run: the steepest facet slope of a stream bed.

Sheer stress: a tangential force per unit area acting on a surface. Fluids flow in the presence of a sheer stress; for example, a puddle of water will be disturbed if a wind exerts a tangential stress on the water surface.

Sedimentation: when excessive sediment (soil, sand, rocks, and minerals) washes from land into water or lower reaches of land after a rain. Sedimentation can destroy aquatic habitat by impairing water quality, as well as create hazards on roads, paths, etc. in urban zones.

Sheet flow: the relatively even distribution of runoff water over the land surface, following the slope of the land downward but not focused into distinct channels. Sheet flow has most likely occurred after a large rainfall if you don't see distinct channels in an area of sloping bare dirt.

Sinuosity: ratio of stream length to valley length.

Stormwater: rainwater once it has landed on a surface.

Sub-watershed: a smaller watershed within, and making up part of a larger watershed.

Surface runoff: (1) that portion of the runoff of a drainage basin that has not passed beneath the surface after deposition. (2) The water that reaches a stream by traveling over the soil surface or falls directly into the stream channels, including not only the large permanent streams but also the tiny rills and rivulets. (3) Water that remains after infiltration, interception, and surface storage have been deducted from precipitation.

Terrace: fragment of a former valley floor that now stands well above the level of the present floodplain.

Thalweg: the deepest part of the channel.

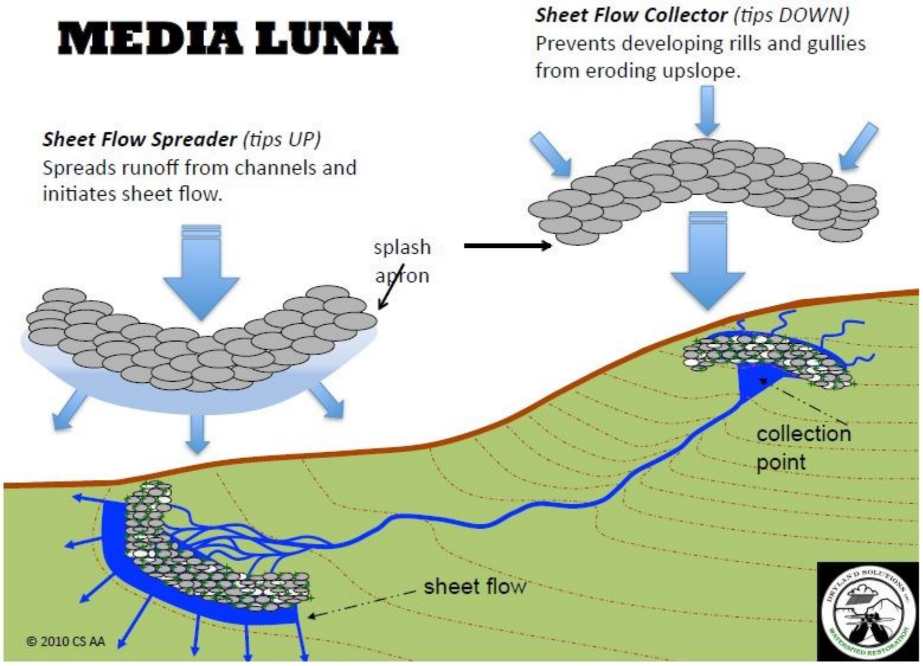
Transmission loss: when an advancing flood pulse encounters porous alluvium on the dry channel bottom of an ephemeral stream. The floodwater takes away a significant amount of soil/alluvium from the stream channel and moves it downstream quickly.

Transpiration: the loss of moisture from plants to the air via the stomata within their leaves.

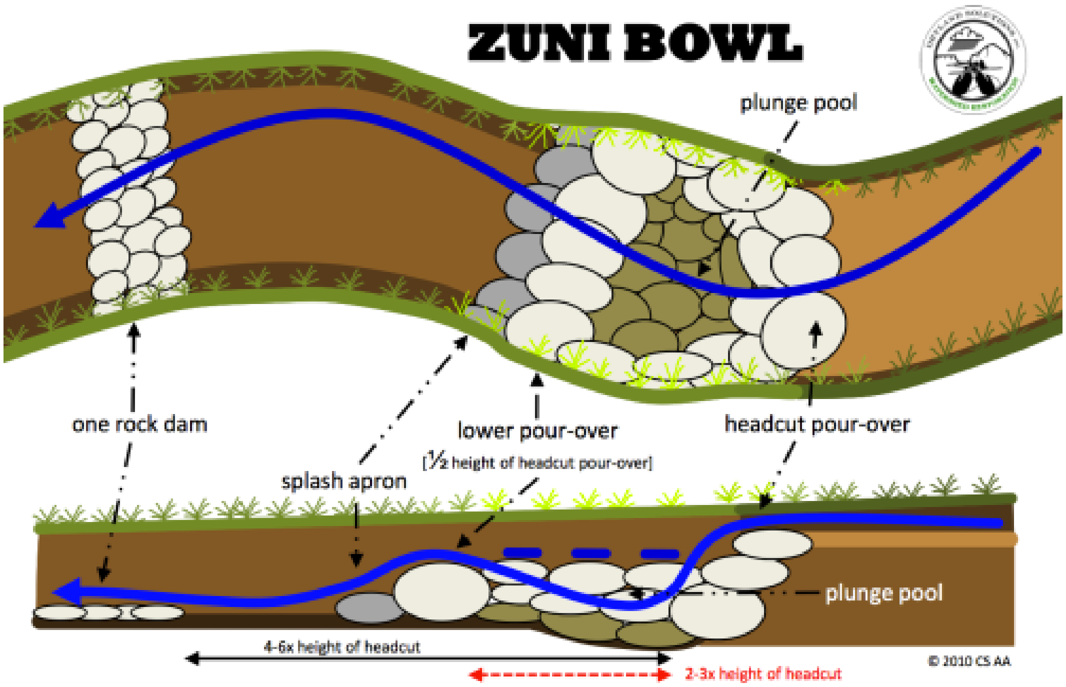
Vane: a straight-edged structure protruding from the streambank into the oncoming current at an angle from the streambank not to exceed 30 degrees. The top edge of the van dips downward at a 15 degree angel from horizontal, beginning at bankfull level of the stream bank to streambed elevation at mid-channel. It is important that the base of the vane, where it is embedded in the streambed, does not extend above the bankfull level. Vanes can be built of rock, boulders, logs, or posts.

Watershed: a geomorphic area of land and water within the confines of a drainage divide. The total area above a given point on a stream that contributes flow at that point.

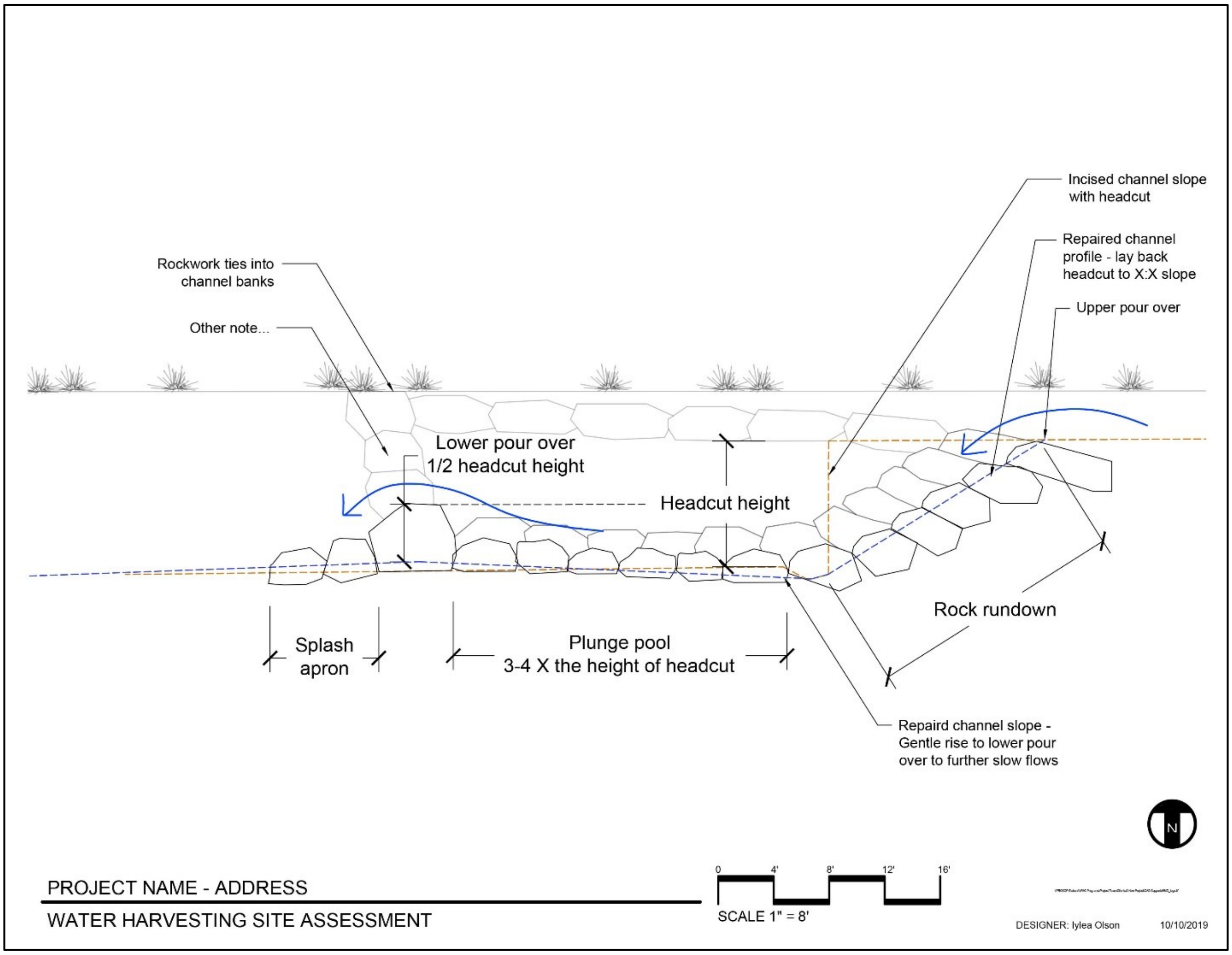
Wicker weirs: are small dams across a creek made from wooden stakes and rocks and are designed to control streambed elevation, channel slope, and pool depth while enabling free passage of bedload. Stakes can be made from local vegetation, such as willow, juniper, salt cedar, and Russian olive. Wicker weirs can be reinforced with the use of wicker materials (such as willow branches) woven between the stakes and installed midway between baffles at an angle that anticipates water flow.



Media Luna structures are used to manage sheet flow and prevent erosion. These “sheet flow spreaders” are used on relatively flat ground to disperse erosive channelized flow and reestablish sheet flow where it once occurred. They are made with appropriately sized rocks, generally 4-10”, and are one rock tall with the bottom row acting as a footer, dug in, and subsequent rows offsetting the previous row to get good a good locking structure that will capture sediment and provide germination sites for native plants.



Zuni bowls are a headcut control structure composed of rock lined stepfalls and plunge pools that prevent headcuts from continuing to migrate upstream. Zuni Bowls stabilize actively eroding headcuts by dissipating the energy of falling water at the headcut pour over and the bed of the channel. The structure converts the single cascade of an eroding headcut into a series of smaller step falls. Zuni Bowls also serve to maintain soil moisture on the face of the headcut, encouraging the establishment of protective vegetation.

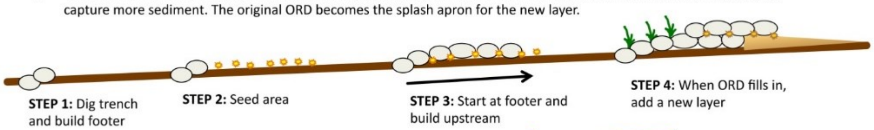

Incised channel slope with headcut
Repaired channel profile - lay back headcut to X:X slope
Upper pour over
Rockwork ties into channel banks
Other note...
Lower pour over 1/2 headcut height
Headcut height
Rock rundown
Splash apron
Plunge pool 3-4 X the height of headcut
Repaird channel slope - Gentle rise to lower pour over to further slow flows
N
PROJECT NAME - ADDRESS
WATER HARVESTING SITE ASSESSMENT
0
4'
8'
12'
16'
SCALE 1" = 8'
DESIGNER: Iylea Olson
10/10/2019

ONE ROCK DAM "ORD"

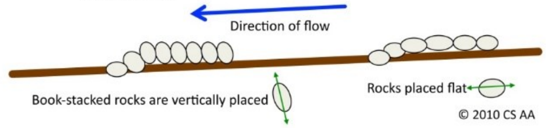
A low grade control structure built with a single layer of rock on the bed of the channel. ORDs stabilize the bed of the channel by slowing the flow of water, increasing roughness, recruiting vegetation, capturing sediment, and ***gradually*** *raising the bed level over time. ORDs are also passive water 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.*

Design & Construction

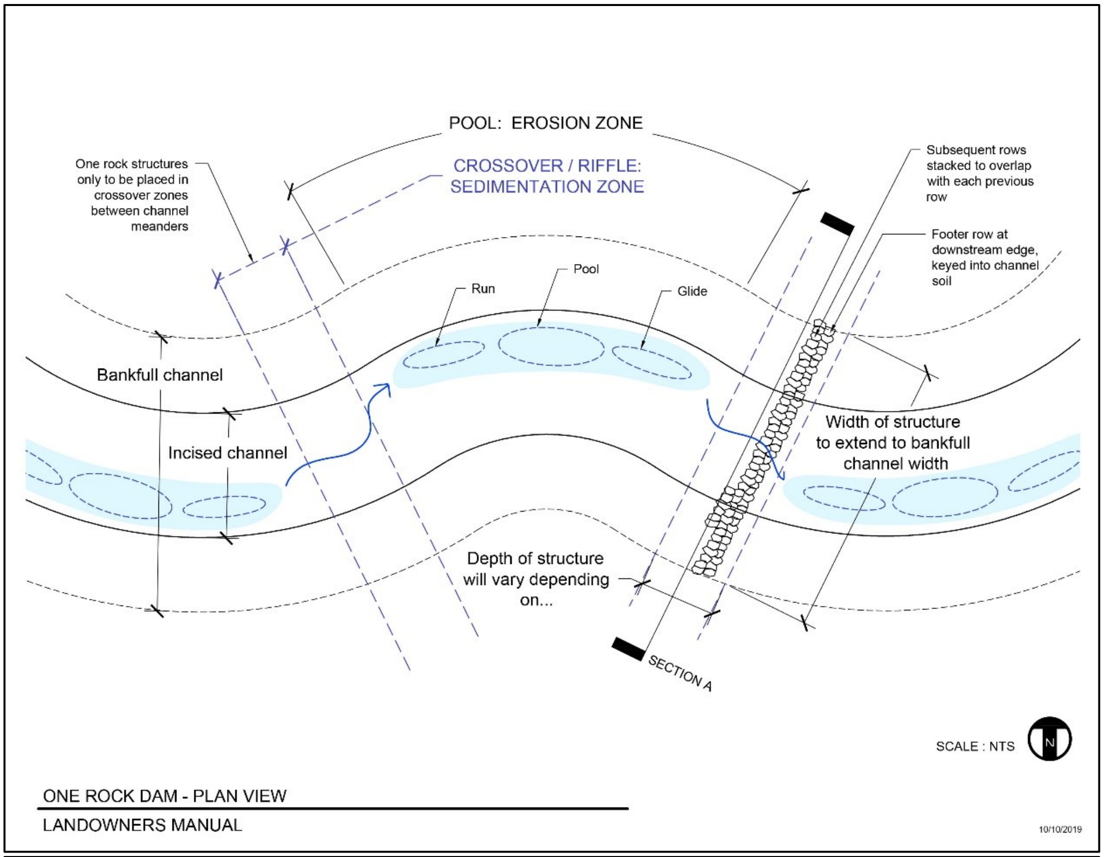
1. Select area to build the ORD; dig a shallow footer trench and fill with one or two rows of rock, so that no rock protrudes more than 2 in/5cm above the bed of the channel. This will serve as the ***splash apron*** for the ORD.
2. Scatter native grass and wildflower seeds in the area where the ORD is to be built.
3. Start building at the footer and continue upstream, laying down one layer of rock horizontally, as if you were building a rock wall.
4. Once the ORD is completely filled with sediment, another layer can be added to further raise the bed of the channel and capture more sediment. The original ORD becomes the splash apron for the new layer.

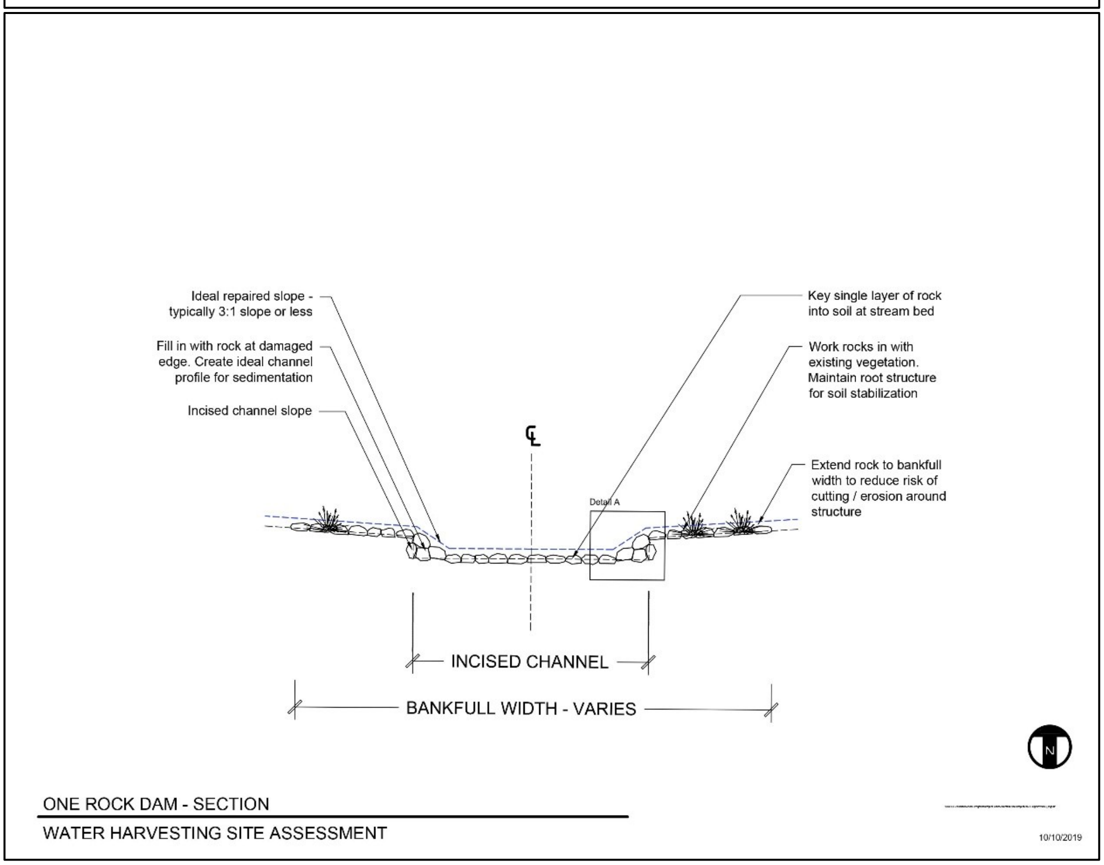


Orientation of Rocks: Placing rocks vertically is called book-stacking, this makes a very strong structure, especially when using small rocks. It is also a good way to make a slightly higher structure.

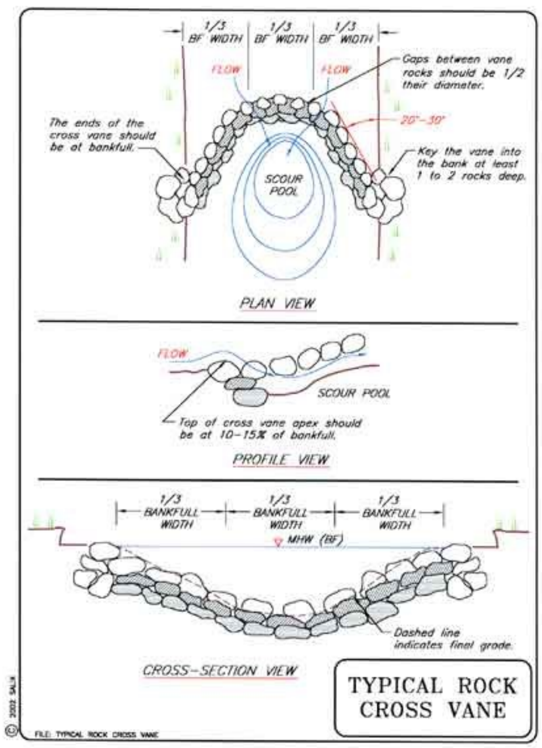


One-rock dams are small grade control and flow slowing structures that are only one rock high. The dams should be built with several rows of rock across from the up-stream to the downstream edge. They should not be taller than 1/3 bankfull depth of the channel. Stones are selected, sized, and placed so that the completed structure ends up relatively level from bank to bank and flat from the upstream edge to the downstream edge. This is accomplished by placing larger rocks in the deepest part of the channel and as a footer row, and then smaller ones to either side. Flood flows will pack smaller-sized bedload particles between the rocks, gradually strengthening the structure over time as new vegetation begins to develop at the site.


POOL: EROSION ZONE
CROSSOVER / RIFFLE: SEDIMENTATION ZONE
One rock structures only to be placed in crossover zones between channel meanders
Subsequent rows stacked to overlap with each previous row
Footer row at downstream edge, keyed into channel soil
Run
Pool
Glide
Bankfull channel
Incised channel
Width of structure to extend to bankfull channel width
Depth of structure will vary depending on...
SECTION A
SCALE : NTS
N
ONE ROCK DAM - PLAN VIEW
LANDOWNERS MANUAL
10/10/2019


Ideal repaired slope - typically 3:1 slope or less
Fill in with rock at damaged edge. Create ideal channel profile for sedimentation
Incised channel slope
Key single layer of rock into soil at stream bed
Work rocks in with existing vegetation. Maintain root structure for soil stabilization
Extend rock to bankfull width to reduce risk of cutting / erosion around structure
CL
Detail A
INCISED CHANNEL
BANKFULL WIDTH - VARIES
N
ONE ROCK DAM - SECTION
WATER HARVESTING SITE ASSESSMENT
10/10/2019

Cross Vane

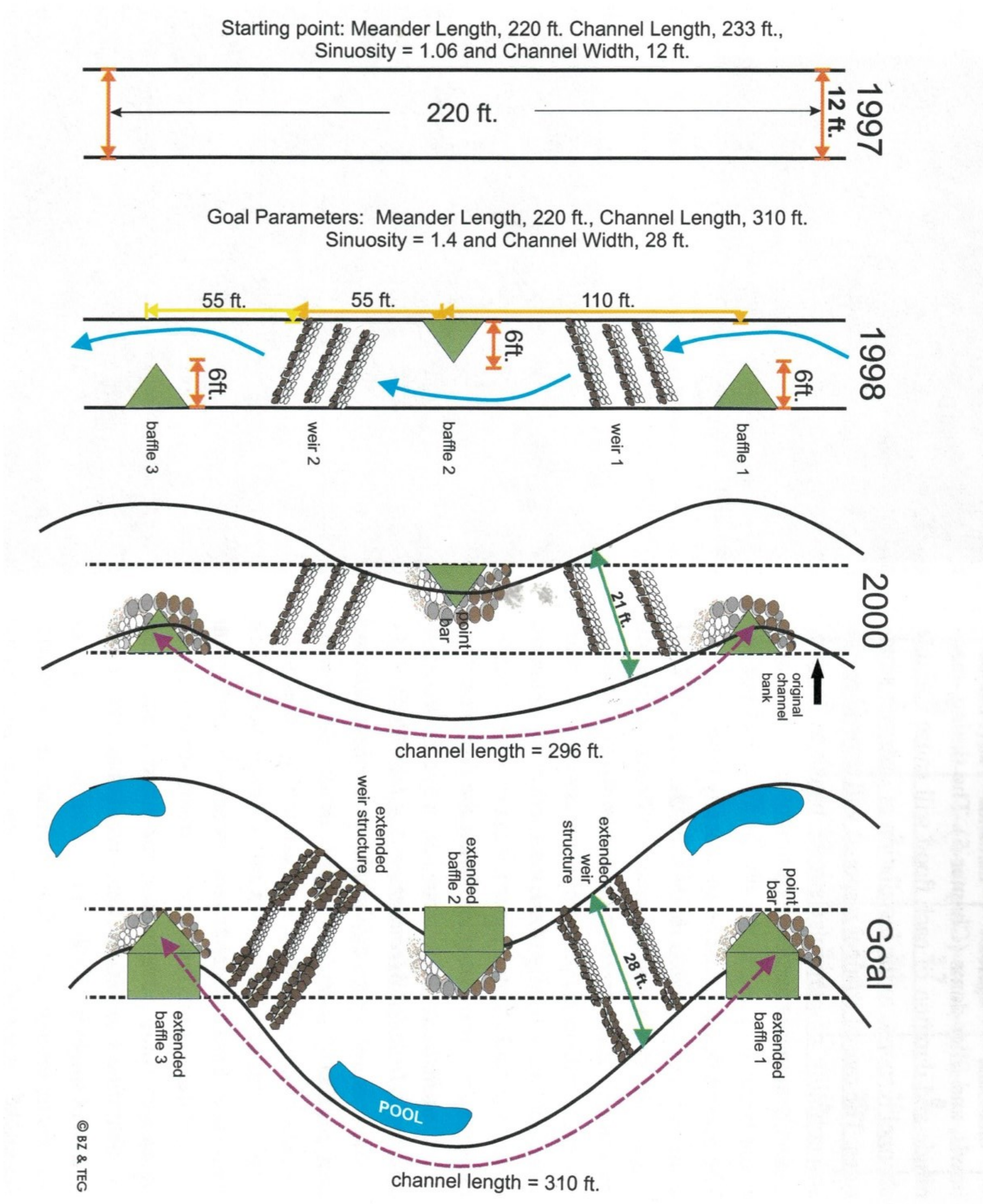


A cross vane is a grade control structure that decreases near-bank stress and focuses stream power toward the center of the channel. The structure will establish grade-control, reduce bank erosion, create a stable width to depth ratio, and maintain channel capacity and sediment transport capacity. Cross vanes are built with 18-24 inch rock and are supported by footers dug into the stream channel and both banks.

Swale and Basin

Swales, berms, and basins networks help to slow, spread, and infiltrate excess runoff from rooftops, driveways, roads, and more. Construct features in areas already disturbed or degraded to facilitate native plant restoration and infiltration of stormwater.

Induced Meandering



Induced meandering can build floodplains in incised gullies and promote plant growth soil stabilization.

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Available for free download at
http://streamdynamics.us/sites/default/files/resource-docs/an-introduction-to-erosion-control-bill-zeedyk.pdf

An Introduction to Induced Meandering - A Method for Restoring Stability to Incised Stream Channels, Bill Zeedyk and Van Clothier. Available for free download at
http://streamdynamics.us/sites/default/files/resource-docs/induced-meandering-field-guide.pdf

A Good Road Lies Easy on the Land - Water Harvesting from Low-Standard Roads,
Bill Zeedyk. Available for free download at
http://streamdynamics.us/sites/default/files/resource-docs/a-good-road-lies-easy-on-the-land-water-harvesting-from-rural-roads.pdf

Let the Water do the Work: Induced Meandering, an Evolving Method for Restoring Incised Channels, Bill Zeedyk and Van Clothier. Available for purchase at
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Quick Guide to Erosion Control Options

	Strategy	Topographic Position			Erosion Goal					
		Top of hill, low slope	Mid Slope; moderate to steep grades	Bottom of Slope; transition to low slope	Spread flow & Initiate sheet flow	Enhance infiltration	Concentrate flow	Stop headcut	Prevent rills from eroding upslope	Develop new floodplain within incised channel
Upland Strategies	Rock berm		X		X	X				
Upland Strategies	Soil berm-n-basin	X		X		X				
Upland Strategies	Diversion swale	X		X	Depends	X				
Upland Strategies	Media Luna (horns up)			X	X	X				
Upland Strategies	Media Luna (horns down)	X	X				X		X	
Channel Strategies	Zuni Bowls					X		X		
Channel Strategies	One rock dams					X				
Channel Strategies	Induce Meandering					X				X

Focus Area Characteristic	**Practitioner's Rule of Thumb**
Contributing Area	
Small (< 10 acre)	use 3-6" rock
Medium (25 acres)	use 12-18" rock
Large (> 50 acres)	use 18-36" rock
Slope	
Low (<5%)	space features every ~20ft
Moderate (5-10%)	space features every ~10ft
Steep (>10%)	space features every ~5ft

Erosion Control and Riparian Restoration Site Knowledge Sheet

Authors Name(s): Todays Date:

Contact Info (for follow up):

Site Name (Optional, but helpful for future reference):

Location (as specific as possible because this is used to truth the model, match the site with other sources of information. Consider using the map grid for lat/long):

Site Description: In your own words, what is the issue that you think may need to be addressed in this particular location?

Site Characteristics (natural): What is the natural setting of the area? (e.g. is it in a stream, floodplain, upland? Are there notable vegetation, geology, or soil features?)

Site Characteristics (human): What human values are at stake? What is known about land ownership, infrastructure, or nearby land uses that might affect this area?

Treatment Considerations: When planning treatments to fix the problems and to benefit the resources described above, what should we consider to inform our choices?

Other Important Insights you can Offer: including feedback on the process or this scoring sheet

Author Name:		**Site Name:**			**Date:**
Personal Overall Knowledge of Site:	*Somewhat familiar*				*Very familiar*
A. Problem description:					
Type of problem:	*Headcut*	*NickPoint*	*Sheet Erosion*	*Other:*	
Size of problem area:	*very isolated*				*Expansive*
Level of Degradation :	*Low*		*Medium*		*High*
Has this site been the location of previous restoration efforts :	*No*	*Yes*	*Anticipated/Planning Already Begun*		
Trajectory of problem :	*getting better*		*aparently stable*		*worsening*
B. Site characteristics, natural					
Surface Water immediately at risk?	*Active Channel*	*Spring(s)*	*Wetlands*	*No*	*Unk*
Wetlands immediately at risk?	*Yes*	*No*	*Unk*		
Other Values at Risk	*Floodplain*	*Swale*	*Grassland*	*Other:*	
TE/Sensitive Species affected?	*Yes*	*No*	*Maybe - Suitable Habitat Present*		
Invasive species issues?	*Yes*	*No*	*Species?*		*Unk*
Cultural Sensitivity Level?	*Unknown*	*High Site Potential*			*Low Site Potential*
C. Site characteristics, human (land use, jurisdiction, etc.)					
Jurisdiction?	*County:*	*State*	*Federal: (which agency?)*	*Private*	*Is the land owner interested in working with us? Yes / No*
Infrastructure at Risk of Damage if Problem Persists?	*Road*	*Structures - Modern*	*Structures - historic*	*Fence Lines*	*Other*
Potential Causes identified?	*Unknown / Other:*	*Road, Including GasPipieline*	*High human Use*	*Concentrated Cattle Use - example water tank, or high traffic area*	*De-Vegetation*
Visibility?	*Not visible*		*Somewhat visible*		*Site highly visible to public*

D. Treatment considerations

Suitable types of treatment:	*Upland Structures*	*Channel Structures*	*Road Repair/Re-Drainage Actions*	*Other:*	*Unknown:*
Size of upland treatments recommended:	*point location: <1 acre;*	*small: >1-10 acres;*	*med: 10-99 acres*	*large: >100 acres*	
Size of channel treatments recommended :	*(1: point location, work by hand;*	*2: several structures, work by hand;*	*3: some engineering. heavy machinery for <1 week;*	*4: large structures, complex engineering, heavy machinery for >2 weeks)*	
Permitting	*Planned (3-5 years)*	*Planned (1-2 years)*	*Yes w/ DNA*	*N/A (Private Land or..)*	
Accessibility	*Very Accessible - next to a road*	*Within a short distance (<1 mi) from road*	*>1 mile from road*		
Post-Restoration Monitoring	*Often Visited Site*	*Easily Accessible Site*	*Nearby well to track groundwater results*	*Other posibilities:*	
Expertise/preparation needed to make treatments effective & prevent harm	*Rank 1 - 5; 1 - acheivable with basic training or supervision (example, revegetation or one rock dams*				
	5 - requires extensive training and environmental awareness to avoid additional damage (ex in-stream headcut				
Will this site potentially impact a Long Term Study Site?	*No*	*Unk*	*Yes - please describe*		
Expected Benefits from Treatment? Circle all that apply:	*Stabilize channel*	*Reduce sediment load*	*Hold soil in place*	*Improve plant productivity*	*Enhance groundwater recharge*
	Improve wildlife habitat	*Protect infrastructure*	*Other:*		
Expected Time Frame for Results	*Long term*				*Short term*

This page is designed to inform the modeling process: These scores will help weight some information more than others within the model by giving some factors additional weight. For example, if any of these consistently score highly, then the related data may be amplified

In Generalized Conditions - all else equal,

A) Rank these in terms of **Contribution of Erosion Risk**, which biophysical factors are a large factor:

	Less		*More*	*Notes:*
Steepness of Slope	1	2	3	
Soil Erodability Score (K Factor)	1	2	3	
Underlying Geology	1	2	3	
Dropping Water Table	1	2	3	
Distance to Sinks (depression points in the landscape, where water and sediment accumulate)	1	2	3	
Low Vegetation Cover - root structure	1	2	3	
Low Vegetation cover - canopy	1	2	3	
Bare Ground	3	2	1	
Roads, other channelization	1	2	3	
Sediment Load (In balance)	1	2	3	
Other Factors:				

B) Rank In order of **Valued Resources or Attributes,** what should be protected first:

	Less		*More*	*Notes:*
Infrastructure	1	2	3	
Wildlife, Crucial Habitat	1	2	3	
Veg Communities (Sacaton, Cottonwood/Willow, etc)	1	2	3	
Watershed Position (low to high)	1	2	3	
Publicly Visible Sites	1	2	3	
Recreation Potential	1	2	3	
Cultural Sites/Potential	1	2	3	
Surface Water	1	2	3	
Recharge Potential	1	2	3	
Other Values:				