Vetiver Grass Installation Guide

Prepared by

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This Vetiver Grass Installation Guide provides tips for farmers, landscapers and engineers thinking to install a soil conservation or slope stabilization project using vetiver.

BACKGROUND

Soil erosion in Hawaii is a serious problem due to intense rain storms, steep slopes and high volumes of runoff. While some level of soil erosion occurs naturally, accelerated soil erosion due to development and agricultural activities degrades the landscape and smothers coral reefs. Reducing soil erosion has long been a priority for Hawaii's farmers and people engaged in conservation. Conventional approaches to curbing soil erosion, which often involve land grading to construct earthen berms to detain or direct runoff , are expensive and reduce space available for production on Hawaii's many small farms. Vetiver grass is a relatively low cost erosion and sediment control technology with very high benefit/cost ratio. When used for water control for low and moderate intensity storms, its cost is about 1/20th of traditional engineered systems and designs. Vetiver's cost-effectiveness, along with the nature of maintenances for earthen berms, makes vetiver grass a promising alternative to conventionally constructed berms.

Figure 1. Mature vetiver hedges in Waimanalo reach a height of 8 feet. The plants produce a purple-colored inflorescence with non-fertile seeds.

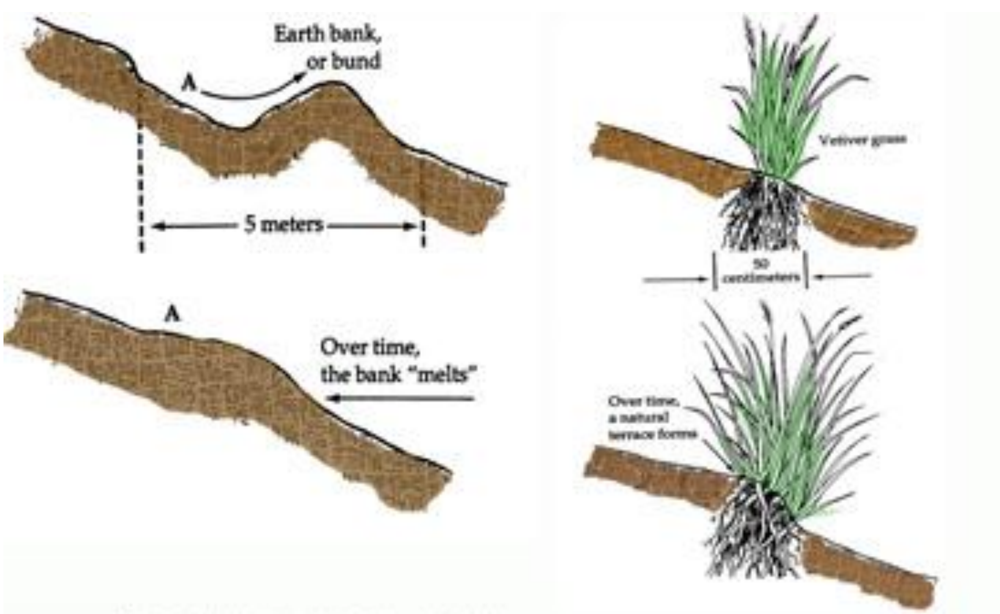

Figure 2. The image on the left shows a typical earthen embankment, and how its effectiveness is decreased overtime. The image on the right shows how vetiver supports diversions over time, eventually forming natural terraces.

Vetiver grass (*Chrysopogon zizanioides*, formerly known as *Vetiveria zizanioides*) is native to India. It has been used in many tropical countries, and has been shown to be a simple and economical method to conserve soil and stabilize slopes.

The only vetiver grass promoted for use in Hawaii is the 'Sunshine' genotype. Sunshine vetiver grass is sterile and is propagated only by splitting existing plants and planting the vegetative shoots. Using this variety will ensure that plants will not spread beyond where they are planted.

Vetiver grass does not have stolons ; instead, new shoots develop as a clump above its roots. Its roots are massive, finely structured, and grow very fast and very deep. Rooting depths have been reported to reach 10-12 feet (3-4 m) in the first year. Engineers compare the vetiver root to a "Living Soil Nail" with an average tensile strength of 1/6 mild steel. This deep root system makes vetiver extremely drought tolerant, difficult to dislodge, and an important tool for managing runoff. Vetiver has stiff and erect stems which grow tightly in a line and can stand up against water flows or depths of one foot. Vetiver grass is resistant to fire, trampling and moderate grazing because new shoots develop underground from the crown. These new shoots have the ability to emerge through several inches of sediment, enhancing its performance as a sediment trap.

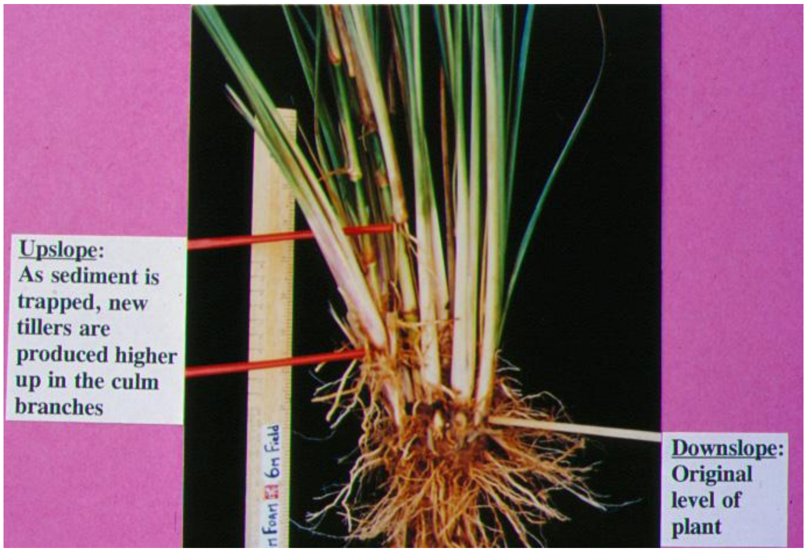

Figure 3. This photo from Malaysia shows how new roots are formed from stem nodes when sediment levels around the plant are raised. The plant is thus able to grow with deepening soils and is not killed as happens with many plants. Photos courtesy of The Vetiver Network International.

BASIC ESTABLISHMENT AND MAINTENANCE

Much information is available on the use and establishment of vetiver grass, including its agronomic requirements and propagation techniques. It is not necessary to mention all of these items here. For information relevant to Hawaii on the establishment of vetiver grass, including its agronomic requirements and propagation techniques, refer to the USDA Natural Resources Conservation Service's "Sunshine Vetiver Grass Plant Guide," available on the internet at http://www.plant-materials.nrcs.usda.gov/pub/hipmspg9015.pdf or contact your local NRCS

Field Office. In addition, information on vetiver's applications around the world can be obtained through The Vetiver Network International (www.vetiver.org) and its many partner members.

Vetiver grass is not shade tolerant and needs to be planted in areas with full sun. It is established vegetatively as bare-root slips (small clumps of vetiver that have been separated out and had the tops and roots trimmed). The best way to ensure a healthy vetiver plant is to start out with a healthy young plant with a good root system. A good root system on the young plants will almost guarantee survival because, once established, vetiver grass isn't affected to any significant extent by pests.

To ensure successful establishment of vetiver, it is essential to provide adequate moisture and control weeds for the first three months. When weed competition is likely, install weed barrier before planting. As the vetiver fills out, cut a line in the weed barrier between the plants. Once established, vetiver grass requires little maintenance. To keep hedges of vetiver grass from getting rough and ragged, periodically trim. A rough cutting every year or two is sufficient to remove the old growth and stimulate new shoots. Simply cut back the tops with a machete, weed eater or sickle mower, leaving at least 15" of plant growth. Trimmed material can be used as mulch. If the planting gets wider than two inches, tilling along the barrier will prevent excessive lateal growth by the vetiver.

SOIL CONSERVATION

Vetiver grass can be used alone or in combination with other conservation measures to control runoff and stabilize soil. Applications of vetiver grass include vegetative barriers, diversions, outlet and bank stabilizations, sediment basins, field borders and general water management. Initially, vetiver was introduced for use as a vegetative barrier to mitigate changes in surface runoff that occur with land use changes. Vegetative barriers are permanent strips of stiff, dense vegetation along the general contour of slopes or across concentrated flow areas.

Vegetative barriers, when installed properly in conjunction with other conservation practices as part of a conservation management system, can effectively:

- Reduce sheet and rill erosion
- Reduce ephemeral gully erosion
- Manage water flow
- Stabilize steep slopes
- Trap sediment

Secondary benefits that can sometimes be realized:

- Entraps sediment-borne and soluble contaminants and facilitate their transformations.
- Reduces offsite removal eroded sediment.
- Facilitates benching of sloping topography.
- Provides valuable wildlife habitat.

HOW VETIVER WORKS

Vetiver can reduce sheet and rill erosion by interrupting surface runoff sufficiently to reduce the length of slope. Vetiver manages runoff flow by reducing the amount of runoff through infiltration and diversion, lengthening the time of concentration of flow, and interrupting momentum by detaining and slowly releasing runoff.

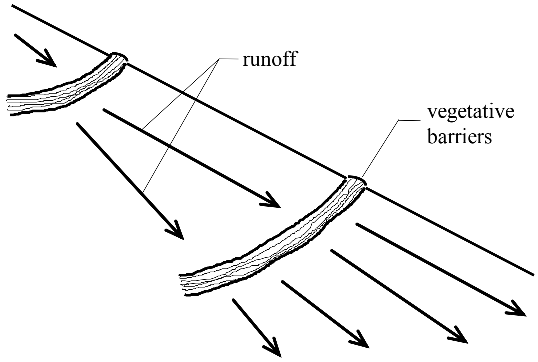

Figure 4. The basic technique for soil stabilization involves planting multiple hedgerows on the contour.

Failure in the use of vetiver in most cases is due to lack of understanding or incorrect applications rather than to the Vetiver System itself. Therefore, it is essential that planners and installers be aware of how water moves around and through vetiver barriers, which happens in four ways:

1. **Infiltration upslope and along roots.**
Some of the water flowing or ponded behind a line of vetiver will infiltrate and flow into the soil along the roots of the vetiver. The amount of runoff reduced due to infiltration is related to the permeability of the soil and duration of wetting. Vetiver roots are very strong and can break compacted layers in the soil which impede infiltration. The longer water is in contact with the soil behind the barrier (standing or flowing), the more water will infiltrate. Increased infiltration will improve soil moisture conditions, but may also move pollutants into the ground to ground water. Fortunately, vetiver roots have been found to uptake nutrients and metal in runoff.

2. **Through erect stems.**
Vetiver's stiff, erect stems both physically filter out sediment and create roughness that slows flow and results in deposition of sediment. Additional removal of sediment is possible through deposition if runoff water is retained behind the vetiver barrier for an adequate period of time (rule of thumb: 3 minutes of retention will generally remove soil particles greater than .425 mm, material retained on the #40 sieve). Vetiver's large stems (up to ¾ inch diameter) and compact growth habits result in a high Vegetation Stiffness Index, indicating that plants remain upright during runoff events when the height of water behind the vetiver does not exceed one foot. Table 1 lists Stem Diameter and Minimum Stem Density Values for Vegetation Stiffness Index (VSI) Values of 0.05 and 0.10.

Table 1. Stem Diameter and Minimum Stem Density Values for Vegetation Stiffness Index (VSI) Values of 0.05 and 0.10

Stem Diameter (inch)	Concentrated Flow Areas Stem Density per square foot at VSI=0.10	Other Purposes Stem Density per square foot at VSI=0.05
0.10	1000	500
0.15	200	100
0.20	60	30
0.25	30	15
0.50	20	10
=/> 1.00	1.0	1.0

3. Along or around the vetiver barrier.

Water flow along or around the barrier should occur by design only. If barriers are installed on the contour, the ends should curl upslope at least 1.5 feet in elevation to allow for containment of water, and provisions should be made for release of water when its depth exceeds 1 foot (detailed in next paragraph). The slope of barriers placed on grade will depend on the amount of flow the barrier is being designed to handle. While considerations for alignment will influence the ultimate decision, they should not be the sole basis of deciding the barrier placement. Ideally, barriers are installed on as flat a slope as possible without exceeding a flow depth of one. Perform hydrologic calculations to determine the design runoff for the barrier and determine the minimum slope that will be needed so that flow depth does not exceed one foot.

4. Over the barrier during overflow.

Flow over vetiver should occur only under controlled conditions, and overflow locations should be carefully selected and designed. Flow of this nature will occur when the water depth behind the barrier reaches around 1.5 feet. Excessive depths will push over the less rigid vetiver leaves and result in water falling onto the ground below the barrier. If unprotected, the force of the falling water may erode and possibly undercut the barrier, or result in gullying. Installation of an energy dissipating structure such as rock riprap below overflow locations will help protect against erosion. If rock riprap is used, it should be angular rock underlain by a filter (graded gravel or geotextile with gravel bedding). Length of protection needed and the size of the rock used will depend on the expected flows.

TO REDUCE SHEET AND RILL EROSION

Sheet and rill erosion is the product of rainfall, soil, slope, cover and cultivation practices. While the best way to prevent soil erosion is to reduce soil disturbances and increase cover, vetiver can be used to reduce sheet and rill erosion. Vetiver rows planted at intervals can reduce slope length and, to a degree, reduce slope. Interval planting is effective when the alignment results in cross slope or contour farming. In order to be effective, it is essential that no gaps between plants exist. Gaps created by dead plants must be quickly re-planted.

Erosion reduction is achieved when vetiver interrupts runoff flow. Slopes along the barrier should be between 0.2 and 1.0 percent, except where the vegetative barrier crosses concentrated flow areas. Slopes entering a concentrated flow area may be up to 1.5 percent for 100 feet.

A single line of vetiver, sometimes called a hedgerow, is often not sufficient to adequately prevent soil erosion. The number needed and distance between hedgerows will depend on the slope, soil conditions, and the severity of the problem. As a general rule of thumb, the vertical interval, or change in elevation, between two hedgerows should not exceed six vertical feet when used to reduce sheet and rill erosion.

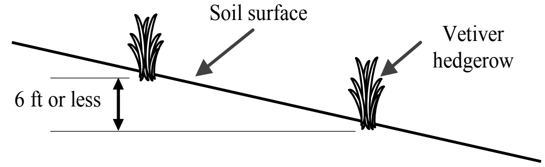

Figure 5. Vertical interval (elevation change) between vegetative barrier hedgerows should not exceed 6 feet when used to reduce sheet and rill erosion.

A hedgerow will stay where it is planted and the sediment that is spread out behind the hedgerow will gradually accumulate to form a long lasting terrace with vetiver protection.

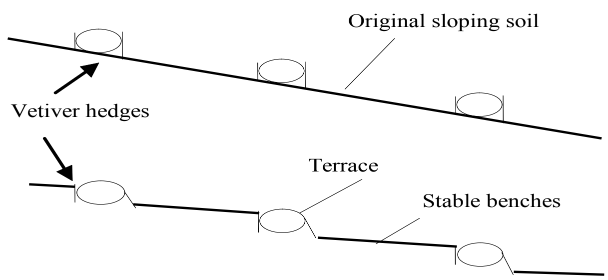

Figure 6. Over time, soil deposits up-slope of the vetiver hedges form terraces and stable, less sloping benches. The vetiver helps support and protect the terraces.

TO TRAP SEDIMENT AND POLLUTANTS

Vetiver can be used to reduce offsite transport of sediment and thus suspended solids in runoff when planted at the ends of fields. Vetiver, with its ability to break up and pond water, functions as a sediment basin when planted in a manner that holds water for extended periods of time, allowing deposition. Planting C-shaped cups of vetiver across the slope, with ends elevated 1.5 feet above the lowest point, provides space for water to pond for at least three minutes and deposit sediment.

Vetiver will continue growing new shoots above the sediment deposits, reducing the need to remove sediment inherent with typical sediment basins.

Additionally, vetiver allows water to flow slowly through its stems, providing a natural spillway.

TO REDUCE GULLY EROSION AND PROVIDE GRADE STABILIZATION

In concentrated flow areas plant vegetative barriers perpendicular to the direction of water flow. Higher plant densities are needed to withstand hydrologic forces in concentrated flow areas; therefore it is recommended to plant vetiver slips in double rows with six inches between slips and six inches between rows. Gaps created by dead plants must be quickly re-planted.

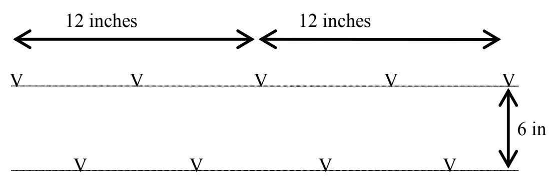

Figure 7. Single rows of vetiver are adequate for basic applications. For areas with concentrated flow, or those warranting extra protection, vetiver slips are planted in two rows with 6 inches between the rows and 6 inches between plants within the row. Rows are slightly offset, resulting in four plants per linear foot.

Spacing between multiple vegetative barriers in a gully will be based on a vertical interval of 1.5 feet for conditions where no tillage is performed between the barriers, and 3 feet for all other conditions where sediment deposition and bench development is anticipated.

When water ponds between the barriers, it dissipates the energy of water flowing over them. Sediment deposits out of the ponded water providing a flatter, more stable channel. Start planting vetiver at a stable downstream location—at the bottom of a gully where the slope of the flow line flattens out, or above a hardened point in a channel. Continue planting to upslope of the top of the gully or section of channel to be stabilized.

Each strip should extend far enough to provide at least 1.5 feet of elevation from the center of the flow area to the end of the vegetative barrier (see Figure 8). Because vetiver will grow on accumulated sediment, the overflow level at the center will rise over time. Extending the vetiver to greater than 1.5 feet above the center elevation will increase the life of the barrier and ensure that water will not flow around the sides of the barrier.

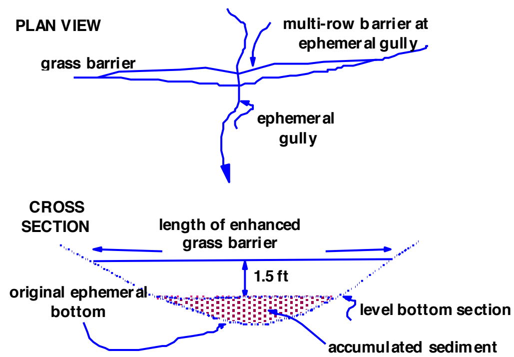

Figure 8. Vegetative barriers in concentrated flow areas must extend at least 1.5 feet in elevation to avoid bypass around the ends at high flow.

Grade stabilization is often needed in steep forming channels to establish a non-erosive channel grade. The most common sign that grade stabilization is needed in a channel is the presence of head cutting.

Components of grade stabilization include structures that pond water in the flow channel, each with a controlled overflow and energy dissipation. Structures provide vertical intervals of 1.5 feet, and are placed to create a stable channel slope. Structures in steep channels, while placed closer together than ones in flatter channels, will have backwater from one structure extending up to the base of the next structure which will help to dissipate energy and reduce the requirements for energy dissipation. Without backwater, it will be necessary to install an energy dissipating basin. Typically, this involves the shaping of a basin and installation of geotextile, gravel bedding and rock riprap.

In channels that are wide and that have gradually sloping banks, vetiver can be used as a grade stabilization structure. Higher plant densities, and care to insure no gaps occur in the planting, will be needed in order for the vetiver to pond water and withstand concentrated flows over the planting. Plantings will need to extend up the sides of the channel to ensure that flows go over and not around the vetiver. To increase the weir length, angle the arms of the vetiver up the bank in a downstream direction to the required design depth, then outward perpendicular to the channel two more feet in vertical height.

TO MANAGE WATER FLOWS

Vetiver can manage water flows by interrupting and slowing runoff and by spreading runoff for infiltration or evaporation.

When using vetiver, it is best to create a furrow and install the vetiver plants on top of the down-slope bump. This optimizes vetiver's height and gives a place for water to flow if runoff occurs before the vetiver hedge is fully established. The recommended minimum berm height/channel depth is four inches.

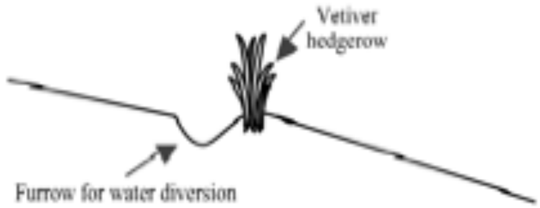

Figure 9. Create a small furrow and plant vetiver on top of the down-slope bump to help capture and divert runoff.

The cross sectional area of water flow behind the vetiver can be approximated as a triangle, with the side against the vetiver being vertical and the other side the slope of the ground.

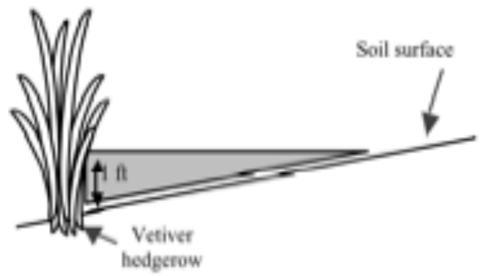

Figure 10. A triangle can be used to approximate the cross-sectional area of water contained by vetiver. In this diagram, water depth behind the vetiver is 1 foot.

If more flow area is needed, the area can be expanded by grading a level section upslope of the barrier. The resulting cross sectional area would be trapezoidal, with a bottom width equal to the width of the level section and a new upslope side slope no steeper than 2 horizontal: 1 vertical.

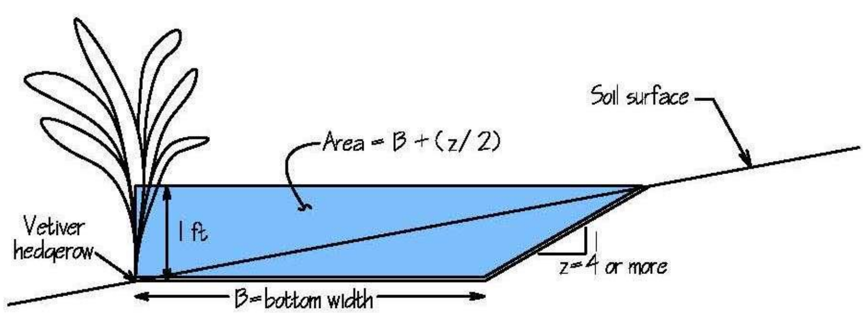

Figure 11. A trapezoid can be used to approximate the cross-sectional area of water contained by vetiver where a level section is used to increase the flow area behind the vetiver.

Slope along the barrier should not be steeper than that which would be stable for the soil. If allowable velocity based on soil erosion resistance for bare soil is not exceeded, scour of the vetiver roots upslope of the barrier should not be a problem. If allowable velocity for bare soil is exceeded and a rhizomatous grass can be established upslope of the vetiver, a higher velocity can be used.

Table 2. Allowable water velocity by Soil Erosion Resistance Group.

Soil Erosion Resistance Group	Max Velocity Bare	Max Velocity Vegetated
I	5.5 fps	10 fps
II	4.5 fps	9 fps
III	3.5 fps	8 fps
IV	2.5 fps	6 fps

TO STABILIZE STEEP SLOPES AND STREAMBANKS

Vetiver can be used to stabilize steep slopes like roadsides, keeping in mind the difficulty of establishing vegetation on slopes that are steeper than 2 horizontal:1 vertical (50% slope). It is recommended to use vetiver in combination with critical area plantings, tree/shrub establishment, riparian forest buffers, filter strips, and conservation cover to maximize effectiveness. Where possible, eliminate concentrated flow channels by installing diversions or terraces to remove runoff from upslope of the site and periodically along the slope.

The barriers should be installed on the contour, at a horizontal spacing between barriers resulting in a vertical interval of no more than six feet. If overland flow is expected down the slope face, however, the barrier alignment may deviate from the contour up to a grade of 2% to divert water if the spacing is adjusted so the vertical interval between barriers is no greater than four feet.

Figure 12. Vetiver is used to stabilize roadsides in California (left) and Australia (right).

The same guidelines used for stabilizing steep slopes apply to streambank stabilization. Additionally, planting rows of vetiver perpendicular to the direction of flow or at 45 degrees to the direction of flow will help to increase channel surface roughness and prevent water from flowing behind the line of vetiver.

Figure 13. Vetiver planted on this streambank in Australia helps to stabilize it.

As a general rule of thumb, banks with slopes steeper than 2:1 cannot be stabilized just with vegetation. It may be necessary to decrease the slope by cutting back the banks in order to achieve a 2:1 slope. In the case of streams, this may increase the top width significantly. If stream conditions allow, vetiver can be planted at the bottom of the slope, whereby subsequent deposition causes a reduction in the bank slope.

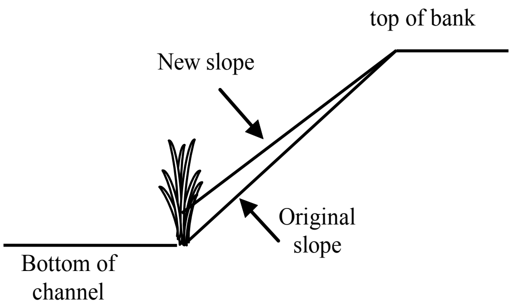

Figure 14. Vetiver can be planted at the bottom of the slope and capture deposition, resulting in reduced slopes.

CAUTION: It is essential to obtain permits when constructing a structure, making alterations or establishing vegetation on streams. Possible permits needed include: a 404 permit from the U.S. Army Corps of Engineers; a Stream Channel Alteration Permit from the Department of Land and Natural Resources; Clean Water Permit from Department of Health; and a Grading and Grubbing Permit from the appropriate county agency. Other permits may be required and it is highly recommended you work with an engineer experienced in streambank restoration.

INSTALLATION TIPS

It is important to decide carefully how and where to install vetiver. Closely observe the source and amount of water and sediment flow to ensure the plantings that will direct flow to a safe outlet. Improper installation will not solve sedimentation problems and can even exacerbate a problem.

- Use acceptable methods to determining the amount of runoff expected.
- Use a level to ensure accurate planting on the contour.
- Remove obstructions, such as trees and debris that can interfere with vegetative growth and maintenance, to improve vetiver establishment and alignment.
- After planting, if there is no rain, water daily for at least 3-4 weeks. Better yet, install irrigation before installing your planting to ensure water or your new planting.
- Control weeds around the hedge until established.

CAUTION: If incorrectly installed, vetiver will direct surface water flow to its lowest elevation and may accelerate erosion or result in flooding.

When used correctly, under the guidelines of the Vetiver System, this is a practical, inexpensive, low maintenance, and effective means for soil erosion and sediment controls, water conservation, land stabilization, and rehabilitation.

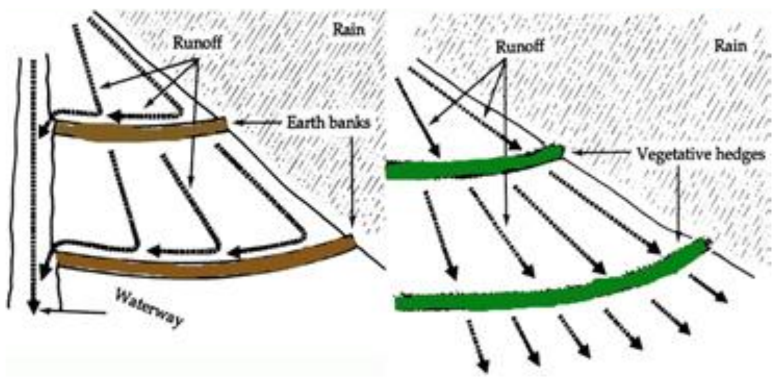

Figure 2. Earth banks used to divert water do not typically reduce the volume of runoff water or the amount of sediment moving off the slope. Vegetative barriers reduce the amount of run-off through infiltration, and provide for sediment deposition.

References :

Vetiver Grass Application Guide, Agriflora 312. Permission is granted to copy, distribute, and/or modify the document under the terms of the GNU Free Documentation License.

Adams, R. P. 2000. DNA Analysis of the Genetic Diversity of Vetiver and Future Selections for Use in Erosion Control. Second International Conference on Vetiver-ICV2, Thailand, January 2000. URL: http://www. vetiver. org/TVN_IVC2/PL-4. PDF

Carey, B. 2006. Monto Vetiver Grass for Soil and Water Conservation. Natural Resource Sciences, Queensland, Australia. Council of Scientific and Industrial Research (CSIR). 1976.
CRC for Australian Weed Management. URL: http://www.weedscrc.org.au/cropweeds/cropweedsv. html

Global Compendium of Weeds. URL: http://www. hear. org/gcw/species/vetiveria_zizanioides/
Greenfield, J. C. 1990. Vetiver Grass. The Hedge Against Erosion. 3rd ed. The World Bank, Washington, D. C.

Hawaii-Pacific Weed Risk Assessment. URL: http://www. botany. hawaii. edu/faculty/daehler/WRA/full_table. asp

National Research Council. 1993. Vetiver Grass: A Thin Green Line Against Erosion. National Academy Press, Washington, D. C.

Pacific Island Ecosystems at Risk (PIER). URL: **http://www. hear. org/pier/species/chrysopogon_zizanioides. htm**

Paquin, D. , R. Ogoshi, S. Campbell, and Q. X. Li. 2002. Bench-Scale Phytoremediation of Polycyclic Aromatic Hydrocarbon-Contaminated Marine Sediment with Tropical Plants, International Journal of Phytoremediation, 4:4, 297-313.

USDA, ARS, National Genetic Resources Program. *Germplasm Resources Information Network* – (GRIN) (Online Database). National Germplasm Resources Laboratory, Beltsville, Maryland. URL: **http://www. ars-grin. gov/cgi-bin/npgs/html/taxon. pl?424704** (20 March 2009)

USDA, NRCS. 2009. The PLANTS Database (**http://plants. usda. gov**, 17 March): National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Van den Berg, J. , C. Midega, L. J. Wadhams, and Z. R. Kahn. 2003. Can Vetiver Grass be Used to Manage Insect Pests on Crops? Third International Conference on Vetiver-ICV3, Guangzhou, China, October 2003. URL: **http://www. vetiver. org/ICV3-Proceedings/SA_stem%20borer. pdf**

Vetiveria. 1976. The Wealth of India, Vol. X. Publications and Information Directorate, CSIR, New Delhi, PP. 451-457.

Vetiver Network International. URL: **http://vetiver. org**