FINAL REPORT

EROSION AND SEDIMENT
CONTROL WITH
VEGETATIVE BARRIERS

Cooperative Agreement No. 96-7

Between

Texas State Soil and Water Conservation Board

and the

United States Department of Agriculture
Natural Resources Conservation Service

KIKA DE LA GARZA PLANT MATERILS CENTER
KINGSVILLE, TEXAS
2000

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PREFACE

This report contains the conclusions of a four-year field study to evaluate the use of vegetative barriers to stabilize and control erosion of waterways, gullies and sloping hillsides.

This project was coordinated and funded by the Texas State Soil and Water Conservation Board in conjunction with the U.S. Environmental Protection Agency.

Overall supervision of the field work and its supplementary analyses was provided by John Lloyd-Reilley, Manager, USDA, Natural Resources Conservation Service (NRCS), Kika de la Garza Plant Materials Center (PMC).

Field support was provided by Patrick Conner, Albert Quiroga and Raul David Hernandez of the USDA, NRCS, Kika de la Garza Plant Materials Center. George Farek, Research Assistant, Texas A&M University-Kingsville, Caesar Kleberg Wildlife Research Institute also provided valuable field support.

Successful culmination of the project is the result of the cooperative endeavor among a variety of agencies and organizations with a common interest in soil and water conservation. Appreciation is expressed to the following organizations and individuals:

- Flavio Garza and the NRCS field staff, the Webb County Soil and Water Conservation District, the Laredo National Bank and Brad Schwartz for their cooperation, coordination and assistance at the Laredo field site.
- James Hluchan and Merrill Schramm at the Bellville, NRCS field office, the Austin County Soil and Water Conservation District, Mr. and Mrs. Kott (landowners) and Mr. Myska and Mr. Koy (landowners) for their cooperation, coordination and assistance at the Austin County field sites.
- Fernando Garza and Allen Collins at the San Antonio, NRCS field office, the Bexar County Soil and Water Conservation District, Mrs. Agnes Stanush (landowner) and Mr. Alfred Rakowitz (landowner) for their cooperation, coordination and assistance at the Bexar County field sites.

EXECUTIVE SUMMARY

The Natural Resources Conservation Service (NRCS) has promoted the use of terraces for soil erosion control for over forty years. More recently the concept of using vegetative barriers or grass hedges as a vegetative alternative has been investigated. Vegetative barriers are narrow strips (1-3 feet wide) of stiff, erect densely growing plants, usually grasses, planted across the slope perpendicular to the dominant slope. These barriers function to slow water runoff, trap sediment and prevent gully development.

From 1996 to 2000 the United States Department of Agriculture (USDA), NRCS, Kika de la Garza Plant Materials Center (PMC) along with the Caesar Kleberg Wildlife Research Institute (CKWRI) of Texas A&M University-Kingsville, and cooperating NRCS field offices and Soil and Water Conservation Districts (SWCD) in Austin county, Bexar county, and Webb county established field demonstrations sites of vegetative barriers for the stabilization and control of waterways, gullies and other areas of erosive water-flow.

This study has documented that vegetative barriers can capture sediment and prevent erosion on erosive hillsides. At the Austin county field site, the vegetative barrier treatment prevented the erosion and downstream sediment deposition of over 1,190 cubic feet over a 27-month period. At the San Antonio cropland site the vegetative barriers are providing a flexible, vegetative terrace system that is saving over 5 tons of soil/acre/year on the 14-acre field. The PMC has written 3 articles for publication and conducted 4 presentations and field days to over 125 interested people. The PMC plans to continue to evaluate and promote the use of this promising low-cost erosion control technology.

INTRODUCTION

The Natural Resources Conservation Service (NRCS) has promoted the use of terraces for soil erosion control for over forty years. More recently the concept of using vegetative barriers or grass hedges as a vegetative alternative has been investigated (Kemper et al. 1992). Vegetative barriers are narrow strips (1-3 feet wide) of stiff, erect densely gr. owing plants, usually grasses, planted across the slope perpendicular to the dominant slope. These barriers function to slow water runoff, trap sediment and prevent gully development (Dabney et al. 1993). The barriers inhibit the flow of water because of their dense concentration of thick stems, thus slowing and ponding water and causing sediment to deposit in back of them (Meyers et al. 1994). Over time these deposits can develop into benched terraces (Aase and Pikul, 1995). These barriers function to diffuse and spread the water runoff so that it slowly flows through them without erosion. Vegetative barriers are resilient to failure because water passes over a broad area secured with perennial root reinforcement.

The vegetative barrier concept should not be confused with vegetative filter strips. Vegetative filter strips are a broad area of vegetation ranging from 15 to 30 feet wide whose purpose is to remove nutrients, pesticides and sediment from surface runoff. Vegetative barriers, on the other hand, are narrow strips of vegetation which are designed primarily to slow runoff, capture sediment and resist gully development. However, the two practices can be very complimentary. Research has reported that vegetated filter strips can be effective at nutrient removal and trapping sediment where water flows are shallow and uniform (Magette et al., 1989). Meyer et al., 1994 documented that stiff erect grasses such as vetiver [Vetiver zizanioides (L) Nash] and switchgrass (Panicum virgatum L.) can retard runoff and capture sediment from concentrated flow. Thus, as a vegetative barrier matures it reduces water velocities and establishes a broad uniform vegetative surface for the uptake of nutrients. Vegetative barriers have the potential to not only reduce erosion but can enhance vegetated filter strips in the uptake of nutrients.

Vegetative barriers could be a low-cost option for many farmers and ranchers to meet their conservation needs. It could be an alternative or complimentary practice with conventional terraces, waterways, and critical area stabilization. In many cases it does not require heavy machinery for installation, which eliminates the movement and compaction of the topsoil. It also takes less land out of production since it is only a narrow strip of grass.

In June 1996, the United States Department of Agriculture (USDA), NRCS, Kika de la Garza Plant Materials Center (PMC) along with the Caesar Kleberg Wildlife Research Institute (CKWRI) of Texas A&M University-Kingsville, and cooperating NRCS field offices and Soil and Water Conservation Districts (SWCD) in Austin county, Bexar county and Webb county established a three-year project to evaluate erosion control effectiveness of vegetative barriers. The objectives of this project are to 1) establish field demonstration sites of vegetative barriers for the stabilization and control of waterways, gullies or other areas of erosive water-flow; 2) validate criteria for the effective use of vegetative barriers including a) plant species (vetiver, switchgrass and big sacaton (Sporobolus wrightii Munro ex Scribn.), b) time of planting, c) barrier spacing, d) how to establish barriers; seeding, transplants, wattles, e) barrier density and width; and 3) document the effects of the vegetative barriers on water quality through determination of erosion and sediment patterns.

The Environmental Protection Agency (EPA) through the Texas State Soil and Water Conservation Board provided funding for this project.

METHODS:

PROJECT ORGANIZATION:

At each of the demonstration sites a project team was initially established to exchange ideas and coordinate duties to implement the demonstration project. The project coordinating teams involved the landowner, the local Soil and Water Conservation District, the Natural Resources Conservation Service field personnel, a representative of the Caesar Kleberg Wildlife Research Institute and the manager of the Kika de la Garza Plant Materials Center. This team interacted on a regular basis to ensure the implementation of the project.

STUDY SITES

Three locations were selected for this study. These three sites were picked because they all have threatened and/or impacted water supplies; the Rio Grande River in Webb county, the Mill Creek/ Brazos River in Austin county and Salado Creek/ Martinez Creek in Bexar county. Sediment and/or nutrients from suspected agricultural sources have been listed for the water bodies as a cause for inclusion in the assessment report on non-point source water pollution for the state of Texas. Successful vegetative barriers could effectively reduce sediment production from cropland and rangeland, thus improving the water quality within these stream segments.

These three sites were also selected because they will cover an area that is roughly 325 miles in distance. The sites selected will provide needed information on range of adaptability of vegetative barriers. Austin County has an average annual precipitation of 42 inches while Webb County has an average annual precipitation of only 17 inches. The soil types, topography and agricultural practices vary greatly among these three locations.

1. LAREDO-WEBB COUNTY STUDY SITE

INITIAL PLANTING

The farm selected in Webb County is located south of Laredo, near the Rio Bravo settlement, and is managed by the Laredo National Bank. The soils of the treatment site are a Lagloria silt loam with a 0-1 percent slope and a Copita fine sandy loam with a slope of 0-3 percent. The adjacent farm fields are normally planted to irrigated vegetables.

A baseline survey was conducted on August of 1996 on four vegetative barrier lines prior to planting. Surveying was done using a laser level recorded to a one-tenth of an inch in accordance with Natural Resources Conservation Service established guidelines. On 15 October 1996, Vetiver grass was planted at four barrier locations. The four barriers range in length from 80 feet to 180 feet. The distances between the barriers vary from 56 feet to 333 feet with a vertical index of 1.6 feet to 2.5 feet. Slopes range from 0.5 percent to 4.5 percent.

Vetiver was planted as a single row across the basin depth, which ranged from .8 feet to 1.8 feet in height. Bare-root vetiver clumps of 4 stems were planted end-to-end across the basin half- (½) depth. The outside ½ depth was planted with 4-stem clumps at three-inch (“) intervals. Vetiver was 9" tall with 4" roots.

A trencher was used to produce a 6-inch wide trench. A 13-13-13 fertilizer was sprinkled in the trench at approximately an 80#/acre rate of actual nitrogen. Plants were placed in the trench and then backfilled. Straw bundles from 5" to 9" thick were placed across the ½ basin depth locations to prevent dislodging of the plants. Water was added at the time of planting at 200 gallons/barrier.

A second survey of the site was performed on 16 October 1996 right after planting. The survey consisted of measurements at the ends of the barrier and at the ½ depth locations on either side of the barrier and in the middle. Measurements were taken not only at the barrier line but also at 4 feet upstream, 4 feet downstream and 20 feet upstream.

A second site (B) was planted on 1 April 1997. Big sacaton was planted at two barrier locations. Both barriers are 140 feet long. The barriers are 170 feet apart with a 2-foot vertical index and a 1.2- percent slope. Big sacaton was planted as a single row at a three-inch spacing the entire length of the barrier. A second row of Big sacaton was planted 9 inches uphill from the first row. The second row was at a 6-inch spacing and was planted only across the basin half-depth. The basin depths were approximately 1 foot. The plants were 5 months old with 1-13 stems at a 9" height and 6" roots. They were grown in paper plant bands. Plants in the first row at the half depth locations were grown in 3"x 3"x 6" bands while all the others were grown in 1" x 1" x 6" bands. A trencher was used to produce a 6-inch wide trench and then backfilled. The second row was planted using a narrow planting bar. No water was applied. Straw bundles were placed across the half basin depth locations. A second survey of the site was performed on 2 April 1997.

Vegetation analyses was conducted at each of the elevation survey sites along the barrier using a one square-foot frame. At each of the locations percent survival, stem density (numbers per square-foot), height (centimeters), and base width (centimeters) were recorded. Two, twenty-foot transect lines were evaluated at each barrier to determine gaps between plants (number of spaces greater than 15 centimeters apart) and the largest gap (centimeters).

2. AUSTIN COUNTY STUDY SITES

Two farms were selected in Austin County. One farm is owned by Mr. & Mrs. Kott and the other is owned by Mr. Koy who purchased it from Mr. Myska.

A) KOTT STUDY SITE

INITIAL PLANTING

Two critical area gully sites were selected for treatment on the Kott farm. The soil of the treatment site is a Frelsburg clay with a 3 to 10 percent slope. The sites had been shaped as an NRCS critical area in 1995. Surrounding areas are well-managed little bluestem pastures. Small head cuts were starting to reestablish at these sites in 1996.

A baseline survey was conducted in August 1996 on three vegetative barrier lines of site A prior to planting. On 7 October 1996 vetiver grass was planted at site A. The three barriers range in length from 55 to 195 feet. The distances between the barriers vary from 59 to 72 feet with a vertical index of 2.1 feet. Slopes range from 2.9 percent to 4.5 percent.

Vetiver was planted as a single row across the basin depth, which ranged from 1.1 to 2.0 feet in height. Bareroot vetiver clumps of 4 stems were planted end-to-end across the basin ½ depth. The outside ½ depth was planted with 4-stem clumps at a three-inch interval. Vetiver was 9" tall with 4" roots. A trencher was used to produce a 6-inch wide trench. A 13-13-13 fertilizer was sprinkled in the trench at approximately an 80#/acre rate of actual nitrogen. Plants were placed in the trench and then backfilled. Straw bundles from 5 inches to 9 inches thick were placed across the ½ basin depth locations to prevent dislodging of the plants. No water was applied.

A second survey of the site was performed on 9 October 1996 right after planting. The survey consisted of measurements at the ends of the barrier and at the ½ depth locations on either side of the barrier and in the middle. Measurements were taken not only at the barrier line but also at 4 feet upstream, 4 feet downstream and 20 feet upstream.

A second site (Site B) was planted on 15 April 1997. Big sacaton was planted at three barrier locations. The barriers range in length from 25 to 53 feet. The distances between the barriers vary from 24 to 31 feet with a vertical index of 1.5 to 2.4 feet. Slopes range from 3.6 percent to 10.8 percent.

Big sacaton was planted as a single row at a three-inch spacing the entire length of the barrier. The basin depths varied from 1.0 to 2.1 feet. The plants were 5 months old with 1-13 stems at a 9" height and 6" roots. Plants at the ½ depth locations were grown in 3"x3"x 6" paper plant bands while all the others were grown in 1"x 1"x 6" bands. A trencher was used to produce a 6-inch wide trench. A 13-13-13 slow release fertilizer was sprinkled in the trench at approximately a 280#/acre rate of actual nitrogen. Plants were placed in the trench and then backfilled. No water was applied. Straw bundles were placed across the 1/2-basin depth locations. A survey of the site was performed on 15 April 1997.

The results of the vegetation survey conducted on 12 May 1997 revealed virtually a 100% mortality for the vetiver grass. Therefore, a second row of plants (big sacaton) was planted 18 inches uphill from the vetiver plants at site A on 15 April 1997. Big sacaton was planted at a 3-inch interval at the basin ½ depth locations and at a 6-inch interval at the outside locations. Plants were 5 months old with 1-13 stems at 9" height and 6" roots. All plants were grown in 1" x 1" x 6" paper plants bands. A trencher was used for planting. A 13-13-13 slow release fertilizer was added at a 280#/acre rate of actual nitrogen. No water was applied. Fences were constructed upon completion of planting to prevent cattle grazing.

Vegetation analyses was conducted at each of the elevational survey sites along the barrier using a one square-foot frame. At each of the locations percent survival, stem density, height and base widths were recorded. Two, ten-foot transect lines were evaluated at each barrier to determine gaps between plants.

MYSKA/KOY STUDY SITE

INITIAL PLANTING

Two critical area gully sites were selected for treatment on the Myska/Koy farm. The soils of the treatment site are a Frelsburg clay at 1 to 8 percent slope and a Latium clay at 2 to 12 percent slope. The sites were crudely shaped to eliminate the head cuts in September 1996. Surrounding areas are severely overgrazed pasture.

A baseline survey was conducted in August 1996 on 14 barrier lines at site A and three barrier lines at site B. On 16 September 1997, vetiver grass was planted at both locations. The barriers range in length from 25 feet to 100 feet. The distance between the barriers varies from 13 feet to 74 feet with a vertical index from 1.7 feet to 2.5 feet. Slopes range from 2.8 percent to 16 percent.

Vetiver was planted as a single row across the basin depth, which ranged from 1.4 feet to 5.0 feet in height. Bareroot vetiver clumps of 4 stems were planted end-to-end across the basin ½ depth. The outside ½ depth was planted with 4 stem clumps at a three-inch interval. Vetiver was 9” tall with 4” roots. A trencher was used to produce a 6-inch wide trench. A 13-13-13 fertilizer was sprinkled in the trench at approximately an 80#/acre rate of actual nitrogen. Plants were placed in the trench and then backfilled. Straw bundles from 5 inches to 9 inches thick were placed across the ½ basin depth locations to prevent dislodging of the plants. No water was applied.

A second survey of the site was performed on 16 September 1997 right after planting. The survey consisted of measurements at the ends of the barrier and at the ½ depth locations on either side of the barrier and in the middle. Measurements were taken not only at the barrier line but also at 4 feet upstream, 4 feet downstream and 20 feet upstream.

A second row of plants (big sacaton) was planted 9 inches uphill from the vetiver plants at both sites on 17 April 1997. Big sacaton was planted at a 3-inch interval at the basin ½ depth locations and at a 6-inch interval at the outside locations. Plants were 2 months old with 1-4 stems at a 6-inch height and 6 inch roots. All plants were grown in 1” x 1” x 6” paper plant bands. Vetiver grass was spot planted on 13 May 1997 at a 6-inch interval at the basin ½ depth locations. All plants were planted with narrow planting bars. No water or fertilizer was used. Fences were constructed upon completion of initial plantings to prevent cattle grazing.

Vegetative analyses were conducted at each of the elevational survey sites along the barriers using a one square-foot frame. At each of the locations percent survival, stem density, height and base widths were recorded. Two, ten foot transects lines were evaluated at each barrier to determine gaps between plants. Velocities (feet per second-ft/sec) and volume of surface runoff (cubic feet per second-cfs) were determined using the Natural Resources Conservation Service WWCALC engineering software program.

3. BEXAR COUNTY STUDY SITE

Two farms were selected in Bexar County. One farm is owned by Mrs. Agnes Stanush and the other by Mr. Alfred Rakowitz. The Zigmond study site was terminated because of poor cooperator support.

STANUSH STUDY SITE

INITIAL PLANTING

A ninety-acre field was selected for treatment at this site. The soil of the treatment site is a Houston clay with a 1 to 5 percent slope. The field is planted to wheat. We treated the waterway in March 1997. On 25 March 1997, switchgrass was either seeded or transplanted on eight barrier lines of the waterway. The barriers were approximately 40 feet long. The distance between the barriers varied from 60 feet to 180 feet with a vertical index from 1.6 feet to 2.9 feet. Slopes range from 1.3 percent to 2.5 percent.

Switchgrass transplants were planted as a single row across the basin depth, which was approximately 1.0 feet in height. The plants were 1 year old with 5 to 10 stems at a 9-inch height and 6-inch roots. All plants were grown in 3” x 3” x 6” paper plant bands. Switchgrass transplants were planted end-to-end across the basin. A trencher was used to produce a 6-inch wide trench. A 13-13-13 slow release fertilizer was sprinkled in the trench at approximately a 280#/acre rate of actual nitrogen. Plants without straw bundles were planted at barriers 1 and 6. Plants with straw bundles were planted at barriers 2 and 3. At barriers 4, 5, 7 and 8 no transplants were used. Seed was broadcast on these sites at a rate of 100 pounds per acre of pure live seed. At barrier 5, a North American Green C-350 turf reinforcement mat was placed over the seeding. At barrier 7, a straw bundle was placed directly downstream of the seeding.

A survey of the site was performed on 27 March 1997 right after planting. The survey consisted of measurements at the ends of the barrier and at the 1/2-depth locations on either side of the barrier and in the middle. Measurements were taken not only at the barrier line but also at 4 feet upstream, 4 feet downstream and 20 feet upstream.

RAKOWITZ STUDY SITE

INITIAL PLANTING

A fourteen-acre field was selected for treatment at this site. The soil of the treatment site is primarily a Houston-Sumter clay with a 5 to 10 percent slope. The field is normally planted to grain sorghum. We seeded switchgrass on three nine hundred foot terraces at a 13 pounds of pure live seed per acre (#pls. /ac) rate with a Tye no-till drill into disked sorghum residue on October 20, 1997. The distances between the barriers are 90 feet with a vertical index from 2.1 to 3.3 feet. Slopes range from 2.4 percent to 5.8 percent.

At five of the concentrated runoff sites additional treatments were used. At all sites, the first row was planted with switchgrass transplants that were two and a half months old, 9 inches tall and with 6-inch roots. These transplants were grown in 3” x 3” x 6” paper plant bands. A trencher was used to produce a 6-inch wide trench. A 13-13-13 slow release fertilizer was sprinkled in the trench at approximately a 280#/acre rate of actual nitrogen. Plants were placed in the trench end-to-end and then backfilled. No water was applied. Six-inch straw bundles were placed, staked and tied down approximately 30’ across the channel width at each transplant location. At row 1 of terrace 2 and 3 we planted with a planter bar 1” x 3” switchgrass transplants at a 6-inch spacing as a second row. At row 2 of terrace 2 we planted with a planter bar 1” x 6” switchgrass transplants at a 6-inch spacing as a second row.

A survey of the site was performed on October 23, 1997 right after planting. The survey consisted of measurements at seven to nine locations on each terrace. Measurements were taken not only at the terrace barrier line but also at 4 feet upstream, 4 feet downstream and 20 feet upstream.

RESULTS AND DISCUSSION

LAREDO – WEBB COUNTY

Both vetiver grass and big sacaton had good survival throughout 1997. The established vetiver plants grew tall and vigorous (Table 1). By March of 1998, there were virtually no gaps between plants except where there was tractor damage. The big sacaton plants survived well but did not grow as robust as the vetiver grass. (Table 2) There were many small gaps between plants despite a better than average rainfall year in 1997 (Table 3).

On March 3, 1998, we replanted damaged sections of site A with vetiver and planted at each terrace a second row of vetiver in the concentrated flow zone. We also spot-planted big sacaton and extended the second row on terrace 1 of site B.

There was 100% mortality for the newly planted vetiver and big sacaton plants outside of the concentrated flow zone by November 1998. The severe drought of 1998 prevented plants from becoming established in 1998, despite 3 separate waterings. Furthermore, established vetiver plants went from a mean 98% coverage to 59% and big sacaton went from 92% to 79%. Survival of both species was restricted to the middle of the concentrated flow zone.

Results of the topographic surveys are presented in Tables 4 and 5. The elevations have not changed significantly since the initial planting survey. The largest increase in sediment has been at station 3 on terrace 2 of the vetiver barrier. Five inches of sediment have been captured at this site and surveys have indicated that it has caught this much sediment as far as 20 feet upstream. Terrace 2 was the only terrace with significant soil disturbances upstream. There was a road that was actively used between terrace 1 and terrace 2. The interspaces between the other terraces were left undisturbed. The small amount of rain along with gentle slopes, good soil infiltration and undisturbed surfaces prevented any soil movement at the other terraces.

It appears that established vegetative barriers will capture sediment and prevent erosion in areas of concentrated water flow. However, the dependability of plant survival and growth in such an arid area as Laredo suggests that nonvegetated practices for erosion control be utilized unless there is an assurance of timely irrigation.

TABLE 1

Vegetation Results from October 1996 Planting of Vetiver grass (Site A) in Laredo, Texas.

Barrier	Percent Survival				Stem Density (#/ft^2)				Height (cm)			
	4/97	10/97	3/98	11/98	4/97	10/97	3/98	11/98	4/97	10/97	3/98	11/98
1	70	94	100	80	5	23	3	0	48	74	88	84
2	94	90	90	71	13	26	9	4	69	80	88	100
3	88	95	100	63	9	25	14	3	65	73	91	99
4	60	65	100	20	9	12	13	1	54	51	76	91

	Base Width (cm)				Gaps (# spaces > 15 cm)				Largest Gap (cm)			
	4/97	10/97	3/98	11/98	4/97	10/97	3/98	11/98	4/97	10/97	3/98	11/98
1	3	6	8	9	19	5	2	7	111	27	25	122**
2	3	9	10	13	6	6	6	2	66	66*	63	549**
3	2	8	9	11	0	2	3	3	9	35*	122**	274**
4	2	5	11	5	9	6	4	10	23	71*	69	307**

* Tractor damage
**Outside concentrated flow zone

TABLE 2

Vegetation Results from April 1997 Planting of Big Sacaton (Site B) in Laredo, Texas

Barrier	Percent Survival			Stem Density (#/ft^2)			Height (cm)		
	10/97	3/98	11/98	10/97	3/98	11/98	10/97	3/98	11/98
1	84	100	78	10	9	3	61	52	52
2	100	100	81	13	14	6	65	65	50

	Base Width (cm)			Gaps (# spaces > 15 cm)			Largest Gap (cm)		
	10/97	3/98	11/98	10/97	3/98	11/98	10/97	3/98	11/98
1	4	4	8	3	0	9	25	13	91*
2	4	4	6	3	0	7	27	13	91*

*Tractor damage

TABLE 3:

Monthly Rainfall Totals and High and Low Temperatures at Laredo, TX.

MONTH	TEMPERATURE (°F) HIGH			TEMPERATURE (°F) LOW			RAINFALL (INCHES)		
	1996	1997	1998	1996	1997	1998	1996	1997	1998
January		64	84		26	32		.11	.08
February		90	94		34	37		.99	.89
March		96	102		44	34		3.08	1.12
April		102	104		44	49		2	.04
May		103	109		54	60		2.61	.00
June		106	114		54	60		2.57	.04
July		108	113		71	73	6.94	1.10	.21
August		110	110		73	72	5.47	Trace	.96
September		106	104		61	72	3.42	1.07	2.83
October	96	100	100	40	42	49	1.26	5.46	2.71
November	94	85	86	34	41	49	1.07	1.56	1.42
December	86	83	86	17	23	32	0.28	.25	.12
						TOTAL	18.44	21.05	10.42

TABLE 4:

Elevation in Feet at the Vetiver Vegetative Barriers at Laredo, Texas

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TERRACE **DATE** **STATIONS**

		1	2	3	4	5
1	10/16/96	96.7	96.0	95.4	96.1	96.3
	4/2/97	96.6	95.9	95.3	96.0	96.2
	7/8/97	96.7	95.9	95.4	96.0	96.3
	2/19/98	96.7	95.9	95.3	96.0	96.3
	6/16/98	96.7	96.0	95.4	96.0	96.3
	1/20/99	96.8		95.5	96.1	96.4
2	10/16/96	95.5	94.3	92.9	93.9	94.7
	4/2/97	95.4	94.2	92.8	93.8	94.6
	7/8/97		94.2	93.0	93.8	94.7
	2/19/98		94.2	93.1	93.8	94.7
	6/16/98		94.2	93.1	93.8	94.7
	1/20/99		94.3	93.3	93.9	94.8
3	10/16/96	92.7	91.9	91.3	91.9	92.5
	7/8/97	92.6	92.0	91.3	92.0	92.6
	2/19/98	92.6	91.9	91.3	91.9	92.6
	6/16/98	92.7	92.0	91.3	91.9	92.5
	1/20/99	92.6	92.0	91.4	92.0	
4	10/16/96	90.5	90.5	89.7	90.1	90.4
	7/8/97	90.6	90.5	89.6	90.2	90.4
	2/19/98		90.5	89.6	90.2	90.5
	6/16/98	90.6	90.5	89.5	90.2	90.4
	1/20/99	90.6	90.5	89.7	90.2	90.6

TABLE 5:

Elevation in Feet at the Big Sacaton Vegetative Barriers at Laredo, Texas

TERRACE DATE STATIONS

		1	2	3	4	5
1	4/2/97	99.6	99.7	99.2	99.6	99.5
	7/8/97	99.7	99.8	99.2	99.6	99.6
	2/19/98	99.7	99.8	99.2	99.6	99.5
	6/16/98	99.7	99.7	99.2	99.5	99.4
	1/20/99	99.7	99.7	99.2	99.6	99.5
2	4/2/97	98.4	97.6	97.0	97.8	98.3
	7/8/97	98.5	97.7	97.1	97.9	98.4
	2/19/98	98.4	97.7	97.1	97.9	98.4
	6/16/98	98.5	97.7	97.1	97.9	98.4
	1/20/99	98.6	97.8	97.1	98.0	98.5

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KENNEY-AUSTIN COUNTY

KOTT STUDY SITE

The results of the vegetation survey conducted on 12 May 1997 revealed virtually 100% mortality for the vetiver grass. The reasons for the plant mortality are speculative. Cold weather may have been a contributing factor to vetiver mortality. There were several days of well below freezing temperatures (Table 6). However, it is felt that cool-season competition from plants such as bur clover may have been the main reason for the death loss. At the Koy/Myska farm in Kenney, Texas, vetiver survival was 61 percent for the same year. The soils are poor at the Koy/Myska study site and there is very little vegetative cover. The lack of cover provides less insulating protection but also less competition. Therefore, cold weather maybe a reason for vetiver mortality but cool-season plant competition maybe an even greater cause.

Big sacaton survival and growth has been very good at this site (Table 7 and 8). In the concentrated flow zone the plants have grown especially large and dense with very little gaps between plants. This site has a gentle slope with very fertile soil and has received good rainfall throughout the study period. Minor plant damage did occur occasionally due to harvester ant and fire ant colonies as well as armadillo digging, which required periodic maintenance.

Results of the topographic surveys are presented in table 9. The elevations have not changed significantly since the initial planting survey. The largest increase in sediment has been for Terrace 2 at site B. Approximately 3 inches of sediment have been captured at this site. Following the initial shaping and planting of this critical area, there has been little soil disturbance and good vegetative cover within the drainage area. This probably accounts for the minimal soil movement and capture at the vegetative barriers.

MYSKA/KOY STUDY SITE

Results of the vegetation surveys are presented in tables 10 and 11. Total survival of vetiver grass for the winter of 1996 at Site A averaged 61 percent. Numerous gaps between plants exceeded the 15-centimeters/6 inches threshold established by the Kika de la Garza Plant Materials Center. Previous research at the PMC revealed that it took from 1-2 years for plants planted 15 centimeters apart to close the gap and become a solid hedge (Texas Natural Resources Conservation Service Technote 1996). Subsequent investigations indicate that a gap as wide as 30 centimeters maybe acceptable where an extensive root system binds together and prevents downcutting.

Following spot planting in April 1997 and March 1998, vetiver grass produced a summer survival rate of 93% in 1997 and 97% in 1998. By November of 1998, the vetiver grass at site A had produced very large plants that averaged 117 centimeters tall with a base width of 14 centimeters. Furthermore, there were very few gaps with the largest being 36 centimeters and these gaps were on the outside edge of the barriers.

Vetiver grass performed better when planted in the spring versus the fall at this site. Competition from cool-season vegetation and freezing temperatures had a detrimental impact on vetiver survival. Vetiver appears to prefer planting in the spring at a time when it is starting its period of rapid growth. Planting at this time also helps it avoid mortality from sediment burial. It is remarkable that we were able to establish a solid vegetative barrier at this site since it is a crudely shaped gully with very poor, hard clay subsoil. We had to fight high velocities at some barriers and dry subsoil on the outer slopes during the summer.

Big sacaton plantings in the spring of 1997 and 1998 produced a summer survival rate of 86% in 1997 and 94% in 1998. However, the plants did not grow very tall or robust. The big sacaton plants were planted about 23 centimeters away from the established vetiver plants and thus had to compete with the vetiver for light and moisture. Since the big sacaton plants were only about 23 centimeters tall versus the 91 centimeters tall vetiver plants, they were at an extreme disadvantage. The competition plus the nature of the poor clay subsoil made it hard for these plants to grow very big. This subsequently resulted in numerous small gaps of 10 centimeters in width between plants.

Results of the topographic surveys are presented in table 12 and table 13. At site A terraces 1, 4, 5, 7, 11 and 12 all accumulated significant amounts of sediment, ranging from 5 inches to 8 inches both at the barrier and four feet upstream. The other terraces either revealed slight sediment accumulations or little change. However, where vegetative barriers had steep, bare, side slopes, like barriers 5 and 11, soil was redistributed across the basin. Figure 1 shows sediment gains or losses at selected vegetative barriers.

In general, the vegetative barriers have helped to keep this gully stable and noneroding whereas an adjacent gully has substantially eroded. Initial measurements on October 7, 1996 of this untreated gully had measurements of its two gully heads of 73 feet and 100 feet from an established benchmark. On January 5, 1999, the measurements were 66 feet and 90 feet from the benchmark. At approximately 7 feet deep by ten feet wide, there was a loss at this gully of approximately 1,190 cubic feet of sediment over a 27-month period.

This treatment site provided us with a great deal of insight on the parameters necessary for establishing a vegetative barrier. Immediately after planting on September 18, 1996, an estimated ten-year rainfall event (3.5'" in 6 hrs) occurred that washed out several of the vegetative barriers. Severe runoff broke the straw bundles and dislodged the plants. At high velocities, straw bundles staked through the middle will not stay secured. They must be staked and woven down with baling string. We resecured all the bundles on September 19, 1996, and they have remained secure throughout the study.

Vegetative barriers 4,5,6,7 and 10 developed plunge pools because of the high velocity of the surface runoff (Table 14). This forced us to add concrete cylinders at these locations. We were afraid that the deep plunge pools would threaten the stability of the entire gully treatment.

Vegetative barriers 8 and 14 had velocities greater than vegetative barriers 4 and 7, which failed. The difference between these barriers and the ones that failed were the length and steepness of upstream conditions and narrowness of the channel downstream of the vegetative barrier.

Vegetative barrier 3 stayed stable with a barrier length of 30 feet and a slope greater than 10% for 60 feet upstream. Vegetative barrier 4 failed with an average slope greater than

10% for 80 feet upstream. The channel width for barrier number 4 was only 20 feet and narrowed to 15 feet directly below the barrier. The velocity as it approached vegetative barrier 5 was 7.7 feet per second (ft./sec.). This velocity on the bare soil below barrier 4 is what caused the plunge pool, which required remedial treatment.

Vegetative barrier number 10 failed with a slope of 9% for 30 feet upstream. Vegetative barrier 10 had a channel width of only 15 feet that narrowed to five feet directly below the barrier. Again, the velocity below the barrier was well over 7 ft./sec. and caused the plunge pool that nearly undermined the vegetative barrier.

Vegetative barrier 8 stayed stable despite a velocity of 6 ft./sec. and a channel width that was 15 feet both at the barrier and downstream of the barrier. The slope averaged less than 6% for over 80 feet upstream and the downstream barrier had a velocity of only 5.2 ft./sec. Vegetative barrier 14 also stayed stable with a velocity of approximately 6 ft./sec. The slope was roughly 7.5% and the channel width was 20 feet. Thirty feet upstream the slope was less than 4% and the velocity was less than 4 ft./sec., while downstream the slope flattened out and the velocity was less than 6 ft./sec.

It appears at our site that vegetative barriers will be stable when constructed appropriately for velocities at 4 ft./sec. and volume less than 50 cubic ft./sec. Vegetative barriers will probably be stable at higher velocities up to 6 ft./sec. when the channel width is constructed and maintained at a consistent width at the barrier and downstream of the barriers. Optimum channel width for the grass hedges at our site was between twenty and thirty feet wide. Vegetative barrier length should be based on the width determined by the grass waterway calculation and should extend a minimum of 1 ½ to 2 feet in vertical height. Extending the height up to 2 feet allows for increased sediment capacity and helps prevent water flow around the barrier ends. Side slopes should be a minimum of 10:1 or gentler to prevent erosion on these slopes. It is recommended that any treatment gully be designed as a waterway in the shape of a trapezoid with a consistent flat bottom (figure 2). The limiting factor on velocity should be the soil velocity relationship. “Permissible velocities for channels lined with vegetation” and “Permissible velocity for vegetated spillways” in the SCS-TP-61 handbook provides a useful guide for this relationship (Table 15) and (Table 16). At our site, which had erosion resistant soils and slopes between 5-10%, the suggested permissible velocity would be 3.5 ft/sec. This is the permissible velocity suggested for native grass mixtures, and the suggested value for the bare soil, native plant composition that existed at our test site. At this time, we would not recommend exceeding the velocities established for specified seed mixtures for newly constructed sites. As a repair or secondary treatment for existing vegetated sites or grass waterways we might be able to use vegetative barriers at increased velocities of 1 to 2 ft./sec. above these levels.

TABLE 6:

Monthly Rainfall Totals and High and Low Temperatures at Kenney/Bellville TX

MONTH	TEMPERATURE (°F) HIGH		LOW		RAINFALL (INCHES)	
	1997	1998	1997	1998		
January	80	78	25	36	4.81	2.48
February	82	79	34	35	6.10	6.23
March	88	86	40	30	5.95	2.61
April	88	90	41	46	5.03	2.02
May	94	102	57	61	6.24	0.03
June	95	107	63	66	4.85	0.09
July	103	108	73	75	1.69	.073
August	104	108	69	74	3.22	6.68
September	102	104	60	72	3.57	11.26
October	95	94	42	48	8.29	15.67
November	89	84	39	44	6.16	11.51
December	78	81	27	22	5.25	2.86
				TOTAL	61.16	62.98

TABLE 7:

Vegetation Results from April 1997 Planting of Big Sacaton at the Kott Study Site in Kenney, TX.

SITE A

BARRIER	PERCENT SURVIVAL			STEM DENSITY (#/ft^2)			HEIGHT (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	100	100	100	2	2	2	54	54	69
2	100	100	94	3	3	6	67	67	80
3	100	100	100	6	6	7	61	61	82

BARRIER	BASE WIDTH (cm)			GAPS (# spaces > 15cm)			LARGEST GAP (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	4	4	8	1	1	1	19	19	20
2	4	4	8	2	2	2	16	16	25
3	4	4	8	0	0	1	12	12	18

TABLE 8:

Vegetation Results from April 1997 Planting of Big Sacaton at the Kott Study Site in Kenney, TX.

SITE B

BARRIER	PERCENT SURVIVAL			STEM DENSITY (#/ft ^{2})			HEIGHT (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	100	100	100	14	14	9	56	56	77
2	100	100	100	10	10	14	59	59	85
3	100	100	100	6	6	6	66	66	80

BARRIER	BASE WIDTH (cm)			GAPS (#spaces > 15cm)			LARGEST GAP (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	4	4	15	0	0	0	9	9	0
2	4	4	13	0	0	0	10	10	0
3	5	5	8	0	0	0	8	8	0

TABLE 9:

Elevation in Feet at the Vegetative Barrier at the Kott Study Site in Kenney, Texas.

SITE A

TERRACE | **DATE** | **STATIONS**

TERRACE	DATE	1	2	3	4	5
1	7/29/97	96.2	95.5	95.1	95.4	96.4
	2/12/98	96.2	95.7	95.1	95.6	96.5
	6/23/98	96.2	95.7	95.1	95.6	96.5
	1/5/99	96.2	95.6	95.1	95.6	96.5
2	7/29/97	94.8	93.3	93.0	93.4	93.5
	2/12/98	94.9	93.4	93.0	93.5	93.6
	6/23/98	94.9	93.5	93.0	93.5	93.6
	1/5/99	94.9	93.5	93.0	93.5	93.5
3	7/29/97	92.3	91.5	90.9	91.9	92.8
	2/12/98	92.4	91.6	91.0	92.0	92.9
	6/23/98	92.2	91.7	91.0	92.0	93.0
	1/5/99	92.4	91.6	91.0	92.1	92.9

SITE B

TERRACE | **DATE** | **STATIONS**

TERRACE	DATE	1	2	3	4	5
1	4/15/97	95.2	94.6	94.2	95.0	95.5
	7/29/97	95.2	94.5	94.2	95.0	95.4
	2/12/98	95.4	94.7	94.3	95.1	95.6
	6/23/98	95.3	94.7	94.4	95.1	95.5
	1/5/99	95.3	94.7	94.4	95.1	95.5
2	4/15/97	93.5	93.2	92.6	93.2	94.2
	7/29/97	93.5	93.2	92.7	93.3	94.2
	2/12/98	93.6	93.4	92.8	93.4	94.3
	6/23/98	93.7	93.3	92.8	93.4	94.3
	1/5/99	93.7	93.3	92.8	93.4	94.3
3	4/15/97			90.0.	91.5	
	7/29/97		92.0	90.1	91.2	
	2/12/98			90.2	91.3	
	6/23/98		92.2	90.2	91.7	
	1/5/99		92.2	90.2	91.7	

TABLE 10:

Vegetation Results from Planting of Vetiver Grass at the Myska/Koy Study Site in Kenney, TX.

SITE A

BARRIER	PERCENT SURVIVAL				STEM DENSITY ($\#/ft^2$)				HEIGHT (cm)			
	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98
1	50	89	60	100	5	0		13	64	70		122
2	67	89	87	100	3	3		8	53	79		111
3	60	100	90	100	5	6		17	63	89		136
4	22	83	86	100	3	8		10	64	84		119
5	58	93	100	95	4	8		12	51	87		124
6	39	100	100	95	4	12		11	63	91		115
7	58	80	100	95	6	3		3	54	82		105
8	50	100	100	92	3	3		9	47	91		123
9	58	100	100	92	8	15		18	48	91		138
10	80	100	100	100	7	9		10	62	91		126
11	93	92	100	100	9	4		1	61	87		93
12	70	100	100	100	6	3		6	52	89		119
13	71	86	100	95	5	2		2	54	84		103
14	93	86	100	100	8	1		4	56	86		108

SITE B

BARRIER	PERCENT SURVIVAL				STEM DENSITY ($\#/ft^2$)				HEIGHT (cm)			
	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98	2/97	9/97	3/98	11/98
1	58	83	100	100	5	9		4	73	86		120
2	55	80	83	93	6	9		11	57	85		126
3	50	100	100	100	11	4		17	58	77		143

TABLE 10: Continued

Vegetation Results from Planting of Vetiver Grass at the Myska/Koy Study Site in Kenney, TX.

SITE A

BARRIER	BASE WIDTH (cm)				GAPS (# spaces > 15cm)				LARGEST GAP (cm)			
	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98
1	2	4.3		13	12	6		2	74	25		18
2	1	8		12	24	6		0	103	91		0
3	2	8		20	17	4		2	115	91		36
4	2	8		13	9	2		1	72	144		30
5	2	8		17	8	2		0	136	37		0
6	2	10		14	7	2		1	91	23		20
7	2	7		13	3	0		0	305	0		0
8	1	7		13	9	3		0	89	30		0
9	1	11		22	7	2		0	198	47		0
10	1	8		13	5	6		0	137	49		0
11	2	7		10	1	0		0	19	0		0
12	1	6		13	5	1		0	33	27		0
13	2	7		12	9	0		0	61	0		0
14	2	8		10	2	0		0	19	0		0

SITE B

BARRIER	BASE WIDTH (cm)				GAPS (#spaces > 15cm)				LARGEST GAP (cm)			
	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98	5/97	9/97	3/98	11/98
1	2	7		12	7	3		0	86	24		0
2	1	14		14	8	6		0	67	80		63
3	2	5		16	8	1		2	91	33		30

TABLE 11

Vegetation Results from Planting of Big Sacaton at the Myska/Koy Study site in Kenney Texas

SITE A

BARRIER	PERCENT SURVIVAL			STEM DENSITY (#/ft^2)			HEIGHT (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	50	93	100	0		1	7.5		41
2	83	82	100	0		1	11		23
3	100	83	80	1		0	29		17
4	78	75	100	0		1	16		29
5	100	86	80	0		0	12		19
6	89	100	100	0		0	25		24
7	100	60	100	0		0	23		19
8	50	89	100	0		0	18		13
9	100	100	100	0		0	23		25
10	100	100	62	0		0	22		20
11	72	100	50	0		0	21		15
12	89	100	83	1		0	16		21
13	100	89	83	0		0	12		19
14	86	100	75	1		0	16		18

SITE B

BARRIER	PERCENT SURVIVAL			STEM DENSITY (#/ft^2)			HEIGHT (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	100	89	83	0		0	12		27
2	100	89	60	0		1	19		45
3	89	89	75	0		0	27		16

TABLE 11 Continued

Vegetation Results from Planting of Big Sacaton at the Myska/Koy Study site in Kenney Texas

BARRIER	BASE WIDTH (cm)			GAPS (# spaces > 15cm)			LARGEST GAP (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	1		5			1			30
2	1		5			2			30
3	1		3			8			76
4	1		5			1			46
5	1		3			3			66
6	2		5			4			20
7	1		5			5			30
8	1		3			4			53
9	2		3			5			30
10	2		3			2			23
11	2		3			5			56
12	3		4			5			46
13	1		5			8			91
14	2		4			5			122

SITE B

BARRIER	BASE WIDTH (cm)			GAPS (# spaces > 15cm)			LARGEST GAP (cm)		
	9/97	3/98	11/98	9/97	3/98	11/98	9/97	3/98	11/98
1	1		3			6			48
2	2		3			5			30
3	2		3			4			30

TABLE 12

Elevation in feet at the vegetative barrier site at the Myska/Koy study site in Kenney, Texas

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SITE A

TERRACE	DATE	STATIONS 1	2	3	4	5
1	7/30/97	115.6		115.2		115.5
	2/11/98	115.6		115.6		115.6
	3/28/98	115.6	115.7	115.3	115.1	115.5
	6/24/98	115.5	115.4	115.3	115.1	115.5
	1/699	115.8	115.7	115.6	115.0	115.5
2	7/30/97	111.9	111.2	110.9		112.3
	2/11/98	111.8	111.2	110.9		112.2
	6/24/98	111.7	111.2	110.8		112.2
	1/6/99	111.7	111.1	110.9		112.1
3	9/19/96	111.3	109.0	108.5	109.1	110.4
	4/18/97	111.1	108.9	108.5	109.1	110.4
	7/30/97	111.2	109.1	108.7	109.3	110.5
	2/11/98	111.1	108.9	108.5	109.2	110.4
	6/24/98	111.2	108.8	108.6	109.2	110.5
	1/6/99	111.1	108.9	108.4	109.1	110.4
4	9/19/96	108.5	107.3	106.5	107.4	108.5
	4/18/97	108.4	107.2	106.7	107.3	108.3
	7/30/97	108.5	1075	106.9	106.7	108.4
	2/11/98	108.4	107.4	106.9	107.5	108.4
	6/24/98	108.5	107.4	106.9	107.5	108.4
	1/6/99	108.3	107.4	106.1	107.4	108.2
5	9/19/96	107.3	105.6	104.5	105.4	107.6
	4/18/97	107.2	105.6	104.7	105.5	107.4
	7/30/97	107.3	105.7	104.9	105.5	107.6
	2/11/98	107.1	105.6	104.9	105.4	107.4
	6/24/98	107.2	105.6	105.0	105.5	107.5
	1/6/99	107.1	105.7	105.2	105.5	107.3

TABLE 12 Continued

Elevation in feet at the vegetative barrier site at the Myska/Koy study site in Kenney, Texas

SITE A

TERRACE **DATE** **STATIONS**

TERRACE	DATE	1	2	3	4	5
6	9/19/96	106.0	103.1	102.7	102.9	105.4
	4/18/97	106.0	103.4	102.5	102.9	105.5
	7/30/97	106.1	103.5	102.7	103.1	105.6
	2/11/98	105.9	103.4	102.7	103.0	105.4
	6/24/98	106.0	103.4	102.7	103.0	105.4
	1/24/99	105.8	103.4	102.9	103.5	105.3
7	9/16/96	103.7	101.6	100.6	101.2	102.9
	4/18/97	103.7	101.6	100.8	101.3	102.8
	7/30/97	103.9	101.8	100.9	101.4	103.0
	2/11/98	103.7	101.8	100.9	101.4	102.9
	6/24/98	103.9	101.7	101.0	101.4	103.0
	1/6/99	103.7	101.7	101.0	101.4	102.9
8	7/30/97	101.0	99.5	98.8	98.9	101.3
	2/11/98	100.8	99.5	98.7	98.8	101.1
	6/24/98	100.6	99.5	98.7	98.8	101.2
	1/6/99	100.8	99.5	98.9	98.9	101.1
9	9/16/96	98.9	97.6	96.9	97.1	99.8
	4/18/97	98.9	97.5	96.7	97.2	99.9
	7/30/97	98.9	97.5	96.8	97.2	99.9
	2/11/98	98.9	97.5	96.7	97.2	99.8
	6/24/98	98.9	97.5	96.6	97.2	99.8
	1/6/99	98.9	97.5	97.1	97.2	99.8
10	9/16/96	97.5	95.0	94.6	95.8	97.5
	4/18/97	96.2	95.0	94.1	95.8	96.9
	7/30/97	96.4	94.9	94.5	95.8	96.9
	2/11/98	96.4	94.9	94.4	95.7	96.7
	6/24/98	96.4	94.9	94.2	95.7	96.8
	1/6/99	96.4	95.0	94.8	95.8	96.8

TABLE 12 Continued

Elevation in feet at the vegetative barrier site at the Myska/Koy study site in Kenney, Texas

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SITE A

TERRACE	DATE	STATIONS 1	2	3	4	5
11	9/19/96	95.1	92.3	91.3	92.4	95.5
	4/18/97	93.9	92.5	91.4	92.3	94.4
	7/30/97	94.2	92.5	91.5	92.4	94.5
	2/11/98	94.0	92.4	91.6	92.3	94.4
	6/24/98	94.1	92.6	91.5	92.4	94.4
	1/6/99	94.0	92.5	91.7	92.4	94.4
12	7/30/97	92.0	90.0	89.6	89.9	92.4
	2/11/98	91.8	90.0	89.9	89.8	92.4
	6/24/98	92.0	90.1	90.1	90.0	92.6
	1/6/99	92.0	90.1	90.1	90.1	92.5
13	7/30/97	90.2	88.8	88.1	88.8	90.8
	2/11/98	90.2	88.7	88.0	88.7	90.7
	6/24/98	90.4	88.8	88.0	88.8	90.8
	1/6/99	90.2	88.7	88.0	88.7	90.9
14	7/30/97	88.1	86.7	85.4	87.1	88.8
	2/11/98	88.2	86.6	85.2	87.0	88.7
	6/24/98	88.3	86.7	85.4	87.0	88.8
	1/6/99	88.2	86.6	85.5	87.1	88.8

TABLE 13

Elevation in Feet at the Vegetative Barriers at the Myska/Koy Study Site in Kenney, Texas

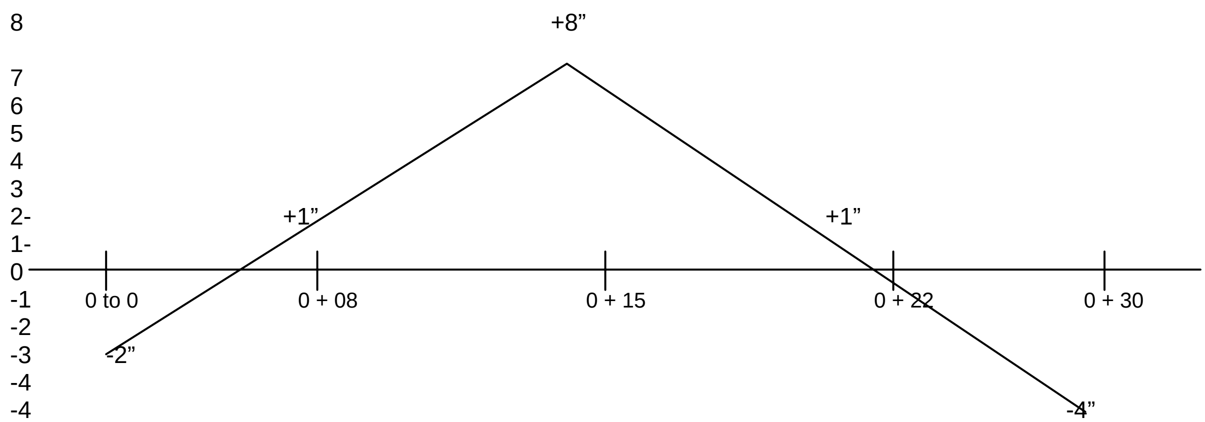
SITE B

TERRACE	DATE	STATIONS 1	2	3	4	5
1	9/16/96	102.9	102.2	101.3	101.8	102.9
	7/30/97	102.8	102.2	101.3	101.8	103.0
	2/11/98	102.9	102.2	101.4	101.8	103.0
	6/23/98	102.9	102.2	101.3	101.7	103.0
	1/5/99	102.8	102.2	101.8	101.8	103.0
2	9/19/96	101.4	100.1	99.4	99.9	100.8
	10/10/96	101.4	100.1	99.4	99.7	100.9
	4/18/97	101.4	100.0	99.3	99.5	100.9
	7/30/97	101.4	100.1	99.4	99.5	100.9
	2/11/98	101.3	100.0	99.3	99.6	100.9
	6/23/98	101.3	100.1	99.4	99.6	100.9
	1/2/99	101.3	100.0	99.3	99.6	100.9
3	10/10/96	99.3	97.9	96.9	97.8	99.6
	4/18/97	99.2	97.9	96.7	97.9	99.6
	7/30/97	99.2	97.9	96.7	98.0	99.6
	2/11/98	99.2	97.9	96.7	97.8	99.6
	6/23/98	99.2	97.9	96.7	97.8	99.6
	1/5/99	99.2	97.9	96.8	97.8	99.6

FIGURE 1

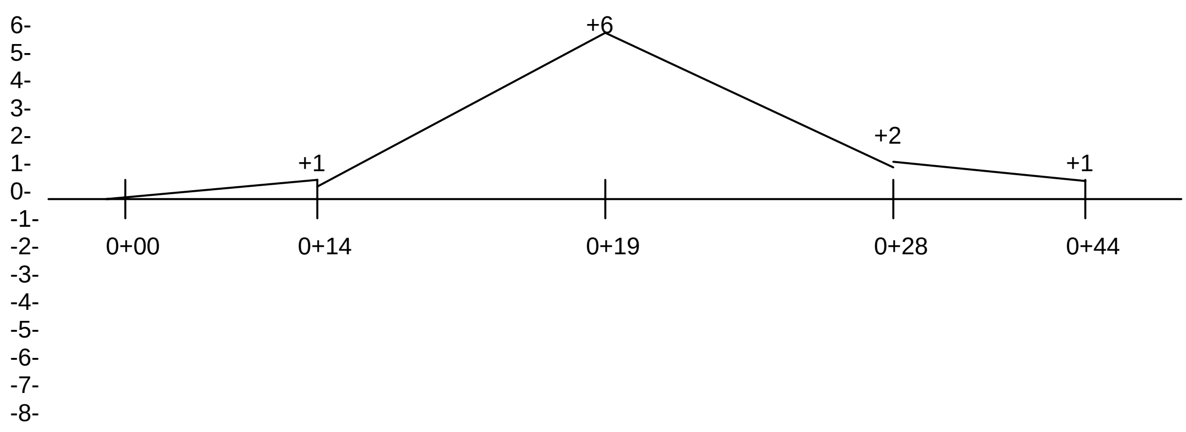
Sediment Gains or Losses (in inches) at selected Vegetative Barriers at the Myska/Koy Study Site A in Kenney, Texas

TERRACE 5



(Distance)

TERRACE 12

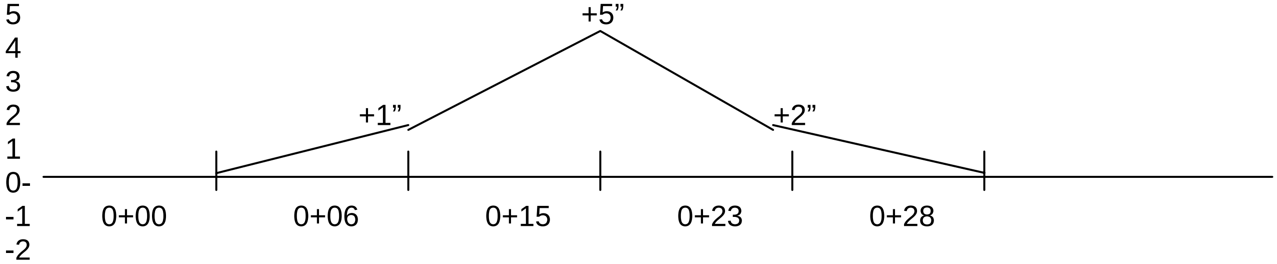


(Distance)

FIGURE 1 CONTINUED

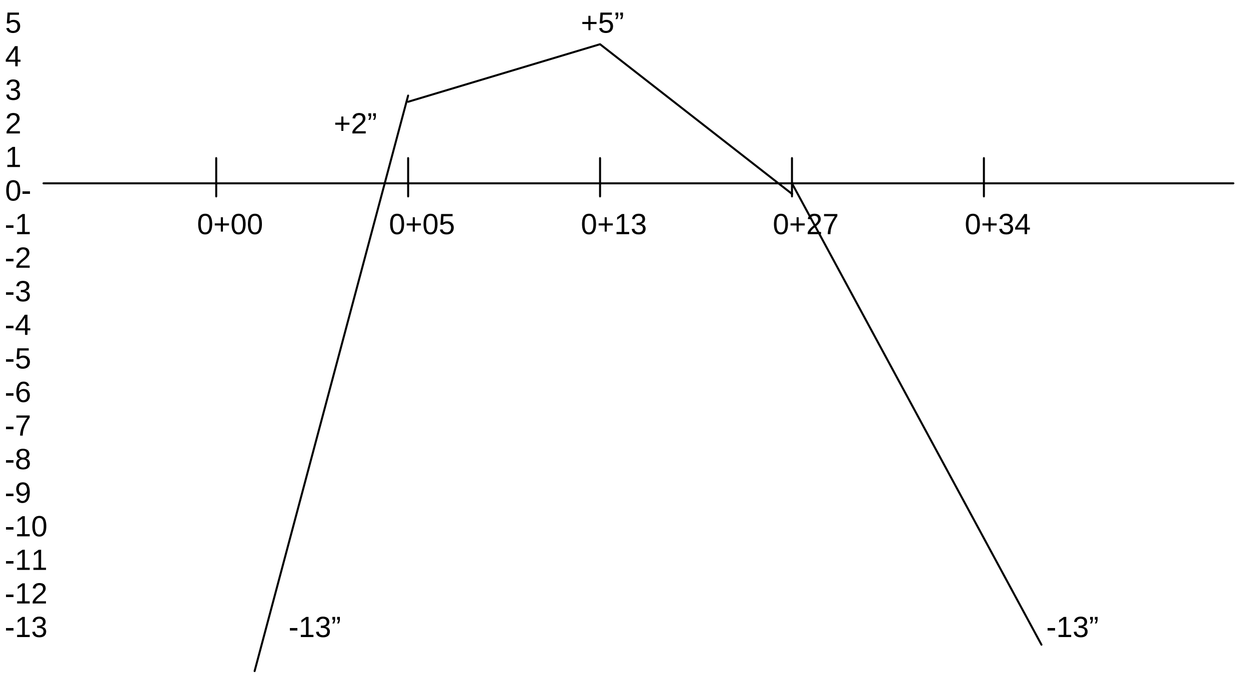
Sediment Gains or Losses (in inches) at selected Vegetative Barriers at the Study Site in Kenney, Texas

TERRACE 7



(Distance)

TERRANCE 11



(Distance)

FIGURE 2

Trapezoidal design of a vegetative barrier.

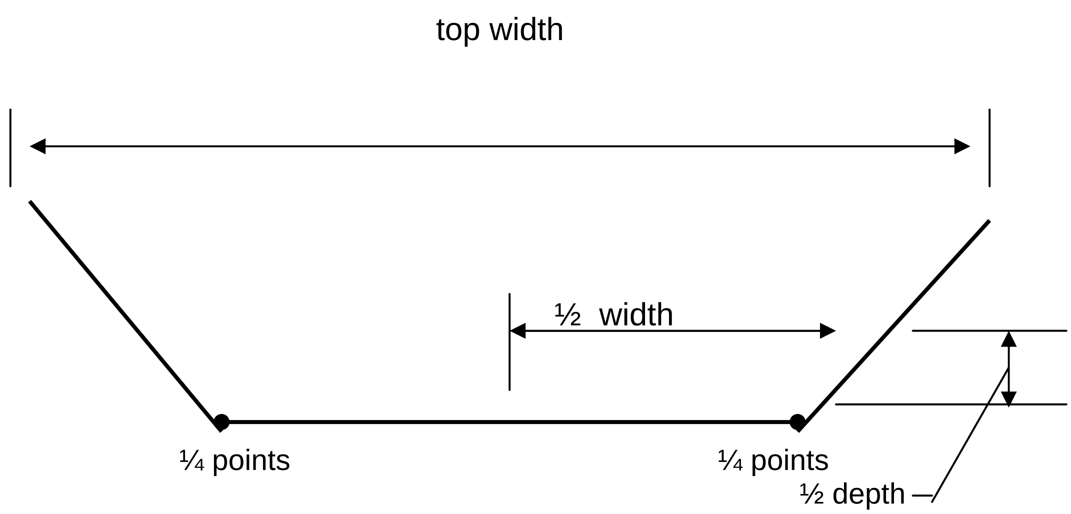


TABLE 14

Velocity and Discharge of Surface Runoff at the Vegetative Barriers at the Mysksa/ Koy Study Site in Kenney, Texas

SITE A

BARRIER	DISCHARGE (CFS)	VELOCITY (FT./SEC)	PLUNGE POOL (FT)
1	27	2.7	
2	27	2.5	
3	27	3.8	
4	35	4.9	2
5	40	7.7	1.7
6	40	9.6	2.1
7	40	5.4	2.0
8	47	6.1	
9	47	5.2	
10	47	7.0	1.8
11	47	4.5	
12	52	3.5	
13	52	3.5	
14	52	6.0	

SITE B

BARRIER	DISCHARGE (cfs)	VELOCITY (ft./sec)	PLUNGE POOL (ft)
1	34	2.93	
2	34	6.70	2.5
3	34	6.70	2.4

TABLE 15

Permissible velocities for channels lined with vegetation[1]. The values apply to average, uniform stands of each type of cover

COVER SOILS	SLOPE RANGE[2]	PERMISSIBLE VELOCITY EROSION RESISTANT SOILS	 EASILY ERODED SOILS
	Percent	Ft. per. sec.	Ft. per. sec.
Bermudagrass }………	0-5	8	6
	5-10	7	5
	over 10	6	4
Buffalograss	0-5	7	5
Kentucky bluegrass	5-10	6	4
Smooth brome }………	over 10	5	3
Blue grama			
Grass mixture }………	[2]0-5	5	4
	5-10	4	3
Lespedeza sericea			
Weeping lovegrass			
Yellow bluestem			
Kudzu }………	[3]0-5	3.5	2.5
Alfalfa			
Crabgrass			
Common lespedeza[4] }…………	[5]0-5	3.5	2.5
Sudamgrass[2]			

[1]Use velocities exceeding 5 feet per second only where good covers and proper maintenance can be obtained.
[2]Do not use on slopes steeper than 10 percent, except for side slopes in a combination channel.
[3]Do not use on slopes steeper than 5 percent, except for side slopes in a combination channel.
[4]Annuals—used on mild slopes or as temporary protection until permanent covers are established
[5]Use on slopes steeper than 5 percent is not recommended.

TABLE 16

Permissible velocity for vegetated spillways[1]

Vegetation	Permissible velocity[2] Erosion-resistant soils[3] Slope of exit Channel		Easily eroded soils[4] Slope of exit channel	
	pct 0-5	pct 5-10	pct 0-5	pct 5-10
	ft/s	ft/s	ft/s	ft/s
Bermudagrass Bahiagrass }………	8	7	6	5
Buffalograss Kentucky bluegrass Smooth brome Tall fescue Reed canarygrass }………	7	6	5	4
Sod-forming Grass-legume Mixtures }………	5	4	4	3
Lespedeza sericea Weeping lovegrass Yellow bluestem Native grass mixtures }………	3.5	3.5	2.5	2.5

[1]SCS-TP-61

[2]Increase values 10 percent when the anticipated average use if the spillway is not more frequent than once in 5 years, or 25 percent when the anticipated average use is not more frequent than once in 10 years.

[3]Those with a higher clay content and higher plasticity. Typical soil textures are silty clay, sandy clay, and clay.

[4]Those with a high content of fine sand or silt and lower plasticity, or non-plastic. Typical soil textures are fine sand, silt, sandy loam, and silty loam.

SAN ANTONIO – BEXAR COUNTY

Stanush Study Site

Table 17 shows the results of our vegetation surveys at the Stanush study site. Switchgrass transplants installed in March of 1997 survived and grew vigorous in the first year at barriers 1, 2, 3, and 6. At barriers 4A, 7A and 8A, no switchgrass plants became established from the switchgrass seeding at the 100 pounds per acre seeding rate. At barrier 5A, only a 33% stand of switchgrass was established from seeding and installation of a turf reinforcement mat.

Attempts at installing a seeded row of 1”x1”x6” switchgrass transplants next to the established rows of switchgrass in October 1997 were unsuccessful. The planting of a double row of vetiver grass and switchgrass at barriers 4B, 5B, 7B and 8B in April 1998 was also unsuccessful. However, we learned several things from these plantings. Switchgrass transplants can not compete in an established bermuda grass waterway. Established switchgrass also appears to be weakening and becoming thinner.

Vetivergrass grown in 3”x3”x6” paper bands had better survival rate than bare-root vetiver transplants in the dry year of 1998 (Table 18). The vetiver in paper bands had survival rates that ranged from 18% to 90% at barriers 4B, 5B, 7B and 8B, where as the bare-root transplants had survival rates of 5% to 18%. The vetivergrass also appears to compete better with bermudagrass than switchgrass.

In March of 1999, we replanted barriers 4 and 5. We installed a double row of vetivergrass and switchgrass. We sprayed a 20-foot area of bermudagrass with roundup one month prior to planting. After planting, we watered all the transplants. We had virtually a 100% survival from this planting on rows 4C and 5C. Adequate spring moisture secured establishment of this planting despite a very dry summer. The only mortality occurred where cows were allowed to graze and bed down on the barrier, which was evident in the gaps at row 5C.

Results of the topographic surveys are presented in Table 19. Barrier one is the only barrier that captured sediment. In the middle of the barrier as much as 5” was captured at the barrier, as well as 7” at 4 feet upstream and 4” at twenty feet upstream. Barrier one did not have a straw bundle but stayed stable at estimated 10-year storm velocities of 1.2 feet per second. The other three barriers either had no change or lost 1-2 inches of sediment. These barriers lost sediment primarily from the outside edges where the switchgrass was thinner from competing with bermudagrass under extremely droughty conditions. Although some soil was lost from this site, despite both vegetative barriers and a grass waterway, it is our feeling that even more soil would have been lost without them. The vegetative barriers have helped slow down the water in the waterway as well as spread out the water flows and sediment deposits. This was especially noticeable following the floods of October 1998. It is our recommendation that where vegetative barriers are to be employed on a bermudagrass waterway that vetiver be the species of choice.

Rakowitz Study Site

The October 1997 and the March 1998 seedings of switchgrass were complete failures. 1998 was an extremely dry year but the fall of 1997 had good soil moisture and moderate temperatures. It has been our experience at this location and other sites that seeding switchgrass on heavy clay soils has provided very poor grass stands. We recommend that switchgrass seedings be limited to the coarser textured loams and sandy soils.

We seeded eastern gamagrass in March 9, 1999 in two rows at a rate of 3-4 pure live seed per foot at 1-2 inch planting depth. We ended up in December 1999 with a 20% stand. Although the stand was better with eastern gamagrass than with switchgrass, it still was not adequate. We would like to evaluate another seeding of eastern gamagrass before completely disgarding it as a viable option for a vegetative barrier. Economically, seeding provides the most attractive method for establishing a vegetative barrier. However, in Texas it may be effective only for the coarser textured soil.

An alternative to seeding is the transplanting of small 1"x3" plants with a mechanical transplanter. In April, 1998 and in April 1999 we transplanted 1"x3" switchgrass plants as a double row at a 7-inch spacing. Table 20 shows the vegetative results of these transplants at the Rakowitz study site. Barrier A-4 and B-4 had only a 25% survival rate in the extremely dry year of 1998. But in 1999, the switchgrass transplants had a 100% survival rate. This method seems extremely practical for establishing vegetative barriers on heavy clay soil of cropland in South Central Texas.

Barriers A-1, A-2, A-3, and B-2 and B-3 averaged a winter survival rate of 80% from hand transplanting of switchgrass in October 1997. The 3"x6" container material had an 84% survival rate but the smaller material in the 1"x3" or 1"x6" containers had a 73% survival rate. It appeared that the main reason for mortality was that the small plants got bent over and buried by sediment in these concentrated flow zones especially at the straw bundles.

Spot planting was done in the spring of 1998. However, the extremely dry year of 1998 saw the average survival rate fall to 72% and by the spring of 1999, the average rate was at 68% and the second row of small transplants was at 38%. The established switchgrass survived the drought adequately but small transplants had a very difficult time. Furthermore, in October of 1998 when the drought finally broke a 100-year storm event scoured out many of the small plants.

Based on our experience at this site, we recommend that a double row of transplants be installed in the spring. Transplants should have at least 6" of top growth to prevent burial from spring rains. Spring planting is the time of rapid growth for the switchgrass plants and this should allow them to outgrow any sediment deposits. Furthermore, the landowner should be prepared to water the transplants in the concentrated flow zone both at planting and periodically during the summer if an extreme drought persists.

Table 20 shows the largest gaps for barriers A-2, A-3, B-2 and B-3 exceeding 30 centimeters in November, 1998. These large gaps were primarily caused by scouring around the edges of the vegetative barriers. The barriers extended in length to a vertical height of roughly .5 feet. It is our recommendation that the vegetative barrier extend in length to a vertical height of 1.5-2 feet. If this is not done, then sediment that is captured behind the barrier will flatten out the basin and cause water to try to flow around the outer edges.

The results of the topographic surveys are presented in Table 21. Sediment was either captured at these barriers or there was no change in elevation. Sediment deposits ranged from 2 inches to 5 inches. It is interesting to note that even without a solid vegetative stand these barriers maintained stability and captured sediment under a 100-year storm event in October of 1998.

Estimations using the Universal Soil Loss Equation (USLE) indicate that conventional tillage of sorghum at this site results in the loss of roughly 29 tons/acre of soil. Using the vegetative barriers, the soil loss was reduced by 5 tons/acre. When the vegetative barriers were incorporated with conservation tillage the soil loss was reduced to 11 tons/acre. If the farmer adjusts his crop sequence to include an alternating year of either hay grazer or wheat the soil loss is only 5 tons/acre which is the soil loss tolerance established by NRCS for this soil.

TABLE 17

Vegetation Results from Plantings at Stanush Study Site in San Antonio, Texas

BARRIER	PERCENT SURVIVAL					STEM DENSITY(#/ft^2)				HEIGHT (cm)			
	10/97	4/98	11/98	4/99	12/99	10/97	11/98	4/99	12/99	10/97	11/98	4/99	12/99
1-Switchgrass transplants Row 2-Switchgrass	100	100 0	89 0	83	83	23	30	19	37	73	78	61	66
2-Switchgrass transplants and bundle Row 2-Switchgrass	100	100 50	100 0	93	100	20	15	18	22	67	70	67	65
3-Switchgrass transplants and bundle Row 2-Switchgrass	100	100 17	100 0	93	100	25	31	38	37	73	76	74	73
4A-Switchgrass Seed	0												
4B-Vetiver grass Row 2-Switchgrass		5/22 0											
4C-Vetiver Row 2-Switchgrass					100 100				5 11				77
5A-TRM and Seed	33					5				43			
5B-Vetiver Row 2-Switchgrass		5/18 0											
5C-Vetiver Row 2-Switchgrass					83 100				8 9				69 13
6-Switchgrass transplants Row 2-Switchgrass	100	100 33	100 0	100	100	26	49	75	59	77	83	82	77
7A-Seed and Bundle	0												
7B-Vetiver Row 2-Switchgrass				10/90 0	20/90 0				0/3				44/66
8A-Seed	0												
8B-Vetivergrass Row 2-Switchgrass			18/90 0		25/100				0/1				39/63

TABLE 17 CONTINUED

Vegetation Results from Plantings at Stanush Study Site in San Antonio, Texas

Barrier	Base Width (cm)				Gaps (# spaces > 15cm)				Largest Gap (cm)			
	10/97	**11/98**	**4/99**	**12/99**	**10/97**	**11/98**	**4/99**	**12/99**	**10/97**	**11/98**	**4/99**	**12/99**
1-Transplants	**7**	**11**	**11**	**14**	**0**	**1**	**5**	**4**	**13**	**33**	**30**	**30**
2-Transplant/bundle	**5**	**0**	**8**	**11**	**3**	**0**	**0**	**0**	**20**	**15**	**15**	**13**
3-Transplant/bundle	**5**	**15**	**13**	**13**	**0**	**1**	**3**	**4**	**10**	**43**	**20**	**48**
4C-Vetivergrass and Switchgrass				**10** **9**				**0** **0**				**13** **13**
5A-TRM and Seed	**3**								**3meters**			
5C-Vetiver and Switchgrass				**9** **7**				**1** **9**				**53** **76**
6-Transplants	**6**	**15**	**14**	**14**	**0**	**3**	**2**	**2**	**13**	**30**	**20**	**30**
7B-Vetivergrass				**6/10**				**3/5**				**183/38**
8B-Vetivergrass				**6/10**				**5/5**				**91/18**

TABLE 18

Monthly Rainfall Totals and High and Low Temperatures at San Antonio, Texas

MONTH	TEMPERATURE (°F) HIGH			LOW			RAINFALL (inches)		
	1997	1998	1999	1997	1998	1999	1997	1998	1999
January	84	81	82	24	35	23	0.70	1.33	0.23
February	82	81	89	31	35	29	3.35	2.52	0.0
March	88	87	91	40	32	32	2.73	1.46	0.20
April	91	88	89	40	40	37	4.28	0.12	1.32
May	97	100	93	52	58	53	4.29	0.0	2.78
June	98	107	95	52	64	69	10.21	0.0	3.37
July	98	103	99	66	73	69	0.03	0.0	1.97
August	101	103	104	68	69	71	0.36	6.74	2.11
September	100	94	99	60	70	49	0.32	2.62	0.22
October	94	93	93	38	45	41	6.60	13.20	0.87
November	80	81	84	32	45	31	1.68	2.70	0.09
December	77	80	83	25	23	25	2.23	0.04	0.22
						TOTAL	36.78	31.09	13.38

TABLE 19

Elevation in Feet at the Vegetative barriers at the Stanush Study Site in San Antonio, Texas

TERRACE	DATE	STATIONS 1	2	3	4	5
1	3/26/97	95.7		94.7		95.8
	7/15/97	95.6		94.5		95.7
	1/27/98	95.6		94.6		95.8
	6/30/98	95.6		94.9		95.8
	1/14/99	95.5		95.1		95.7
	7/27/99	95.5		95.1		95.7
	12/3/99	95.4		95.0		95.7
2	3/26/97	94.5	94.4	93.1	94.0	94.3
	7/15/97	94.5	94.3	93.0	93.9	94.3
	1/27/98	94.5	94.2	92.9	93.9	94.3
	6/30/98	94.4	94.2	92.9	93.9	94.2
	1/14/99	94.3	94.1	93.2	93.8	94.1
	7/27/99	94.3	94.1	93.1	93.8	94.2
	12/3/99	94.2	94.1	93.2	93.8	94.2
3	3/26/97	92.0	91.3	90.4	91.2	
	7/15/97	92.0	91.2	90.4	91.1	
	1/27/98	92.0	91.1	90.4	91.1	91.8
	6/30/98	91.9	91.1	90.3	91.0	91.8
	1/14/99	91.9	91.2	90.5	91.3	92.0
	7/27/99	91.8	91.2	90.4	91.3	92.0
	12/3/99	91.7	91.2	90.5	91.3	92.0
6	3/26/97	85.0		83.8		85.2
	7/15/97	85.0		83.7		85.1
	1/27/98	84.9		83.7		85.1
	6/30/98	84.9		83.7		85.0
	1/14/99	85.0		83.7		85.1
	7/27/99	84.8		83.7		85.1
	12/3/99	84.8		83.8		85.0

TABLE 20

Vegetation Results from Switchgrass Plantings at the Rakowitz Study Site in San Antonio, Texas

Barrier	PERCENT SURVIVAL				STEM DENSITY(#/ft^2)				HEIGHT (cm)			
	4/98	11/98	4/99	12/99	4/98	11/98	4/99	12/99	4/98	11/98	4/99	12/99
A-1					6	69	71	111	23	79	89	134
Row 1	97	99	100	100								
Row 2		69	10									
A-2												
Row 1	91	72	83	100	6	42	52	75	23	75	91	120
Row 2	88	57	57									
A-3												
Row 1	88	83	77	83	6	34	42	59	23	74	80	137
Row 2	71	56	48									
B-2												
Row 1	73	90	97	83	6	25	39	40	23	75	71	120
Row 2	60	57										
B-3												
Row 1	72	90	100	83	6	20	24	27	23	75	71	120
Row 2		50	37									
A-4												
Row 1		25		100				12				63
Row 2		25		100				6				46
B-4												
Row 1		25		100				14				73
Row 2		25		100				5				23

BARRIER	BASE WIDTH (CM)				GAPS (# SPACES>15CM)				LARGEST GAP (CM)			
	4/98	11/98	4/99	12/99	4/98	11/98	4/99	12/99	4/98	11/98	4/99	12/99
A-1												
Row 1		10	13	15		1	1	2	15	20	20	18
Row 2												
A-2												
Row 1		13	13	15		10	11	8	15	91	91	89
Row 2												
A-3												
Row 1		11	14	15		4	8	6	15	79	79	76
Row 2												
B-2												
Row 1		7	10	15		4	2	2	15	51	33	53
Row 2												
B-3												
Row 1		9	13	14		3	0	2	15	66	0	56
Row 2												
A-4												
Row 1				8				0				15
Row 2				10				0				15
B-4												
Row 1				8				0				15
Row 2				8				1				30

TABLE 21

Elevation in Feet at the Vegetative Barrier at the Rakowitz Study Site in San Antonio, Texas

TERRACE	DATE	STATIONS 1	2	3
A-1	10/23/97	90.7	90.4	90.7
	1/27/98	90.7	90.4	90.7
	6/30/98	90.6	90.3	90.7
	1/14/99	90.9	90.8	90.8
	7/27/99	90.8	90.8	90.7
	12/3/99	90.8	90.7	90.7
A-2	10/23/97	87.5	87.0	87.3
	1/27/98	87.5	87.0	87.3
	6/30/98	87.4	87.0	87.3
	1/14/99	87.6	87.5	87.5
	7/27/99	87.5	87.3	87.4
	12/3/99	87.4	87.3	87.4
A-3	10/23/97	84.4	83.9	84.2
	1/27/98	84.4	83.8	84.2
	6/30/98	84.3	84.1	84.2
	1/14/99	84.4	84.2	84.3
	7/27/99	84.3	84.1	84.3
	12/3/99	84.3	84.1	84.3
B-2	10/23/97	91.0	90.4	90.9
	1/27/98	91.0	90.4	91.0
	6/30/98	91.0	90.6	91.0
	1/14/99	91.1	90.7	91.1
	7/27/99	91.0	90.6	91.0
	12/3/99	91.1	90.5	90.9
B-3	10/23/97	86.8	86.4	86.6
	1/27/98	86.8	86.4	86.6
	6/30/98	86.8	86.6	86.6
	1/14/99	87.0	86.6	86.5
	7/27/99	86.9	86.6	86.6
	12/3/99	86.9	86.6	86.5

Conclusion and Recommendations

This study has documented that vegetative barriers can capture sediment and prevent erosion on erosive hillsides. However, vegetative barriers must be appropriately designed and constructed. Vegetative barriers for concentrated flow areas must be surveyed, designed and shaped similar to grass waterways. Velocities and volume of surface runoff must be carefully calculated. The barrier should be spaced as close to 2 feet in vertical height as possible to prevent excessive erosion between barriers and to assist in water velocity reduction and improve sediment deposition.

A double row of transplant makes a very effective barrier in the concentrated flow area. It is important that both rows be planted at the same time and at a minimum of 18 to 36 inches apart to avoid competition and ensure that both rows grow big and vigorous. Furthermore, the length of the barrier must extend to a vertical height of 1.5 to 2 feet to prevent scouring around the edges. In high velocity, concentrated flow sites a straw bundle or some other reinforcement will be required to stabilize the site and secure the transplants.

Vetiver and switchgrass have shown themselves to be good grasses for vegetative barrier establishment. These grasses perform better when planted in the spring with a good watering at planting time.

Seeding switchgrass on clay soils to achieve a vegetative barrier or terrace appears to be a high-risk endeavor. With the erratic rainfall that South Texas experiences, along with clay soils that quickly dry up and crust over, the chances for a switchgrass seeding are not good. We believe that small transplants established with the use of a mechanical transplanter may be a more effective alternative for vegetative terraces. Complete guidelines for the establishments of vegetative barriers are provided in the booklet “Vegetative Barriers for Erosion Control”.

There are numerous advantages to vegetative barriers. Vegetative barriers can capture sediment and reduce concentrated water velocities. They can provide an effective technique for constructing water and sediment control basins. They can revitalize and support waterways by capturing and spreading eroded sediment. They also can enhance nutrient uptake of filter areas. Furthermore, vegetative barriers can provide critical wildlife habitat when annual crops deteriorate.

However, there are several factors in Texas that must be resolved before vegetative barriers will reach full conservation use. Can vegetative barriers provide a proven cost effective and labor effective alternative to conventional methods of conservation? Will there be adequate contractor and landowner interest to apply this alternative practice? In order to answer these questions, government agencies will have to encourage and assist landowners over the next several years in the application of this practice. In this effort, the Plant Materials Center conducted four slide presentations and field days at Laredo, Austin, Bellville and San Antonio, Texas. Over 125 people attended these presentation and showed interest in the application of this practice. The PMC has also written 3 articles for publication in the Land & Water magazine, Texas Agri-News, and the Journal of the Soil and Water Conservation Society. Furthermore, the PMC will continue to evaluate and promote the use of this promising low-cost erosion control technology.

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