ENGINEERING
AND PLANNING REPORT

MASTER ROADWAY AND DRAINAGE PLAN for TAHITIAN VILLAGE SUBDIVISION BASTROP, TEXAS

PRELIMINARY

Prepared for:
BCWCID NO. 2
P.O. Box 708
Bastrop, Texas 78602

Revised: December, 1994

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EXECUTIVE SUMMARY

The Bastrop County Water Control Improvement District No. 2 (BCWCID No. 2) Roadway Authority has been determined to encompass approximately 63.1 miles of existing roadways. Of this total, approximately 5.5 miles are within the existing City Limits of Bastrop and the remaining 57.6 miles are within the County of Bastrop.

A "Road Condition Survey and Improvement Program" study was previously performed by Bastrop County concerning the BCWCID No. 2 Road Authority Project Area. Excerpts from the study have been utilized in performing this Roadway Master Plan.

The project consists of verifying the adequacy of the previous study and development of a master plan which complies with House Bill 2902.

In order to determine recommended roadway improvements, scheduling of proposed construction and a financial management plan, the project was divided into Chapter discussions of major topics of consideration.

The recommended roadway master plan is a composite of BCWCID No. 2 Board, City of Bastrop and County of Bastrop suggestions. See comment letters from City and County, Attachment No. 12 and 13 respectively. Cost estimates were developed using current best available data.

The total estimated cost of improvements is approximately $ 5,500,000. Revenue projections for the 20-year plan range from $ 100,000 to $ 800,000 per year, depending on amount of assessment fee and collection rate. Projected annual revenue for the plan is $275,000 per year.

It is anticipated that with minor changes, the proposed master plan will be implemented for future project planning.

INTRODUCTION

In October of 1991, the Bastrop County Water Control Improvement District No. 2 (the District) awarded to Fisher, Hagood & Hejl the task of researching and performing a roadway master plan to service the District. IN DECEMBER OF 1994, THE DISTRICT AUTHORIZED FISHER HAGOOD, INC. TO AMEND AND UPDATE THIS MASTER PLAN TO REFLECT MODIFICATIONS NECESSARY TO REFLECT HISTORICAL PERFORMANCE AND CHANGING PRIORITIES.

The BCWCID No. 2 was granted extended road utility district authority through House Bill 2902 (H.B.) effective June 10, 1991 until September 01, 1995. (see Attachment No. 1) H.B. 2902 requires the District to perform a roadway master plan. This project is a response to the above. The District currently has CONSTRUCTED OR IS IN PROCESS OF CONSTRUCTING APPROXIMATELY $780,000 WORTH OF ROADWAY REPAIRS.

The District made available to Fisher, Hagood & Hejl copies of "Road Condition Survey and Improvement Program" prepared by Bastrop County. The report presents data concerning existing roadway conditions, recommended roadway construction, cost estimates and other considerations.

The Roadway Master Plan is presented in the following chapters.

1. PROJECT AREA - Discussion of the project area limits and characteristics.
2. EXISTING ROADWAY AND DRAINAGE CONDITIONS - Assessment and Classification of proposed roadway and drainage improvements.
3. PROPOSED ROADWAY AND DRAINAGE IMPROVEMENTS - Assessment and Classification of proposed roadway and drainage improvements.
4. COST ESTIMATES - Cost estimates to improve road and drainage conditions.
5. PRIORITIZATION OF ROADWAY IMPROVEMENTS - Discussion and ranking of priority of performing improvements.
6. FINANCING ALTERNATIVES - Analysis of revenues, expenditures and a present worth cost analysis concerning bond issues.
7. PROPOSED MASTER PLAN AND SCHEDULE OF IMPROVEMENTS - Proposed master plan and project summary with schedule.

The final chapter accompanied with the Exhibits will present to the District a master plan to serve the BCWCID No. 2 service area.

CHAPTER 1

PROJECT AREA

The area considered for this project is within the BCWCID No. 2 service area. Exhibit No. 1 defines the approximate 5,000 acre Project Area.

The topography of the Project Area is comprised of mild to severely sloping land. Ground elevations in the area range from approximately 500 feet Mean Surface Level (MSL) at the upper end to approximately 320 feet MSL where the District borders the Colorado River. Slopes in the project area are generally greater than five percent with some slopes approaching thirteen to fifteen percent. The natural vegetation consists of native trees and grasses. A majority of the trees are pines with some oak, cedar and pecan. Vegetation is dense and typically perennial throughout most of the area.

Due to the hilly terrain and severe sloping land, the floodplain for the area is well defined. Exhibit No. 1 illustrates the floodplain presented by the Flood Insurance Rate Map (FIRM) published by the Federal Emergency Management Association. At this time, the FEMA map and historical witness accounts are the most comprehensive analysis of the floodplain.

The soils encountered within the Project Area are presented on Exhibit No. 20. The predominate geologic formations in the area exhibit various degrees of suitability concerning roadway construction. Attachment No. 2 is a copy of soils report performed in November, 1990 concerning borings taken at several roadways within the District. Field observations verify the above soil findings where typically sandy, sandy-clay and silty sand soils dominate soil groups encountered in the project area.

Existing utilities in the Project Area were evaluated from available information provided by contacting the utility companies/agencies listed in Attachment No. 3. The existing utilities include electrical, water, telephone and cable TV. The Project Area contains 7267 lots. There are approximately 461 water customers with 143 of this total located within the City Limits of Bastrop. Development in the area will be primarily single family residences. There are limited planned areas of commercial, industrial or dense dwelling units. Due to the fact that no centralized wastewater system exists and that soil conditions are not well suited to facilitate high density on-site wastewater disposal, it is anticipated that the primarily low density residential Project Area will remain that way.

In conclusion, the Project Area has many characteristics which were considered in selecting proposed roadway improvements. Soil conditions, terrain, existing occupied structures, existing utilities, school bus routes, most utilized roadways, emergency 911 traffic routing and access to County Road and State Highway 71 were all considered in developing the Master Plan.

CHAPTER 2

EXISTING ROADWAY AND DRAINAGE CONDITIONS

The existing roadway and drainage conditions in the Project Area were determined by field observation and verification of previous classifications provided in the Bastrop County "Road Condition Survey and Improvement Program" study. As per the study, roadways were classified into the following categories:

1. Approaching City/County Standards
2. Weathered Asphalt with failures
3. Heavily weathered with overgrowth
4. Disintegrated asphalt or gravel only
5. Undeveloped, not in use.

Exhibit No.s 2 through 10 present roadways and their respective classifications. The Project Area has approximately 63.1 miles of roadways. Approximately 5.5 miles of roadway are located within the City Limits of Bastrop with the remaining 57.6 miles located within the County of Bastrop. Attachment No. 4 presents existing roadway and drainage classifications by classification type, linear feet and approximate miles. The attachment delineates City and County totals.

In general, existing roadway and drainage conditions within the city limits of Bastrop are better than those encountered throughout the Project Area. The above can be attributed to the proximity of City property to the entrance of the Project Area with quick access to State Highway 71. Over 30% of the occupied structures (143 out of 461) are located in the City Limits while the percentage of City roadway is approximately 9% (5.5 miles out of 63.1 miles) of the total roadway in the Project Area.

The existing roadways have primarily been maintained by the BCWCID No. 2. WITH THE COMPLETION OF PHASE I AND II CONSTRUCTION AND THE CURRENT PHASE III CONSTRUCTION IN PROGRESS, THE DISTRICT HAS TRANSFERRED THE MAINTENANCE RESPONSIBILITY OF THOSE INVOLVED STREETS TO EITHER THE CITY OF BASTROP OR BASTROP COUNTY CURRENTLY, THE CITY OF BASTROP HAS ACCEPTED APPROXIMATELY 3/4 MILE (3,040 LF) OF ROADWAY AND BASTROP COUNTY HAS ACCEPTED OR ANTICIPATES ACCEPTING APPROXIMATELY 5.1 MILES OF ROADWAY.

Existing roadway and drainage conditions are hindered by extreme slopes within the Project Area. Typical slopes range from 2 to 15 percent. Although the slopes facilitate rapid removal of storm water, they also contribute to difficult roadway construction, flash flooding events, severe cut/fill situations, sight distance problems and lot accessibility considerations.

Existing soil conditions exhibit various degrees of roadway construction suitability. The Axtell and Jedd soil series are poor road fill materials. The Patilo and Vernia soil series are good road fill materials. All of these soil classes are encountered in the Project Area.

CHAPTER 3

PROPOSED ROADWAY AND DRAINAGE IMPROVEMENTS

The proposed roadway and drainage improvements in the Project Area were determined by thorough analysis of existing conditions, a minimum five to ten year improvement life expectancy, recommendations from meetings with City of Bastrop, County of Bastrop and the BCWCID No. 2 Board, consultant's experience with best practical design technology for the project area and financial limitations for performing improvements.

Roadways were classified into four categories:

R	Residential
C	Collector
A	Arterial
MA	Major Arterial

Residential roadway and drainage areas make up approximately 62% (38 miles out of 63 miles) of the total classifications with 11% Collector, 18% Arterial and 9% Major Arterial.

Attachment No. 5 provides a breakdown of proposed roadway and drainage classifications. Exhibit No.s 11 through 19 present the proposed classifications for each roadway within the Project Area.

The proposed roadway sections are presented on Attachment No. 6. Roadway improvements are proposed to be minimum 20 foot widths with stabilized shoulders and topping. The intent is to develop uniform base thickness throughout the roadway construction so that as the Project Area population and traffic loadings increase, future street maintenance costs will be minimized. The proposed sections facilitate drainage by channelization. Subsurface drainage as in development of curb and gutter sections with inlets and storm sewer pipes have been determined to be too expensive for further consideration.

Other considerations in classifying streets were the school bus route, 911 emergency traffic route, density of existing structures and future development potential within the Project Area.

The proposed roadway sections do not meet current regulations for the City and County. The District, by HB 2902 is not required to met these regulations. However, the proposed sections do exceed roadway construction standards established in 1972 when the Tahitian Village Subdivision was originally created. This is important as the District is required only to meet standards which were in place at the time the Subdivision was created. The District has chosen to propose roadway and drainage improvements which provide a balance of good product versus available funding capacity.

CHAPTER 4

COST ESTIMATES

The construction cost estimates developed for the master plan were based on the proposed roadway and drainage improvement sections, existing roadway and drainage condition, discussions with roadway contractors and consultant's knowledge of current cost estimating practices. Attachment No. 7 provides construction cost estimates to improve the four proposed roadway and drainage sections based on existing classifications. The roadway sections with the lowest class rating (5 on a scale of 1 to 5) will cost the most to improve to their respective classification. Cost estimates were developed per linear foot for ease in calculating totals.

The total estimated construction cost of roadway and drainage improvements is $5,057,890. This cost does not include engineering, soils testing, acquisition, legal or any other contingency costs. These additional non-construction costs will average approximately 10% of the total construction cost. Therefore, the total estimated cost of the roadway improvements is approximately $5,500,000.

The District may consider using and compensating City and/or County forces to perform roadway and drainage improvements in order to reduce costs. The District will contact the State Department of Highways and Public Transportation for any potential assistance with necessary bridge improvements along Wahane Lane and Kaaawa.

The estimates per linear foot provided for in this plan are subject to verification at the time work is actually designed, bid and performed. It is logical to assume that if the District performed more volume of roadway improvements at one time, the unit cost per linear foot would be reduced. Likewise, if a limited scope of work is performed, the cost per linear foot would be higher.

CHAPTER 5

PRIORITIZATION OF ROADWAY IMPROVEMENTS

The prioritization of roadway improvements were based on road classification, density of existing structures, school bus route, existing traffic patterns and contiguous development of improvements.

The District proposes to initially improve the major arterials of Tahitian, Riverside, Akaloa, AND Kannapali ~~Kaneho and Moku Manu~~ roadways. After improvement of these major arterials, the District proposes to improve arterial and residential roadways contiguous to the major arterials.

By improving the major arterials first, the District accomplishes several critical goals: Goal No. 1 - These roadways have historically been the most used roads, therefore it is logical to improve them first. Goal No. 2 - These roadways provide access for school bus routes. This is very important to the families with school age children who reside in the Project Area. Goal No. 3 - These roadways facilitate 911 vehicular traffic for access to the most populated areas within the District Goal No. 4 - These roadways offer contiguous development. This is important to both city and county forces for ease in identifying and accessing roadways to be maintained. Goal No. 5 - These roadways provide a looped traffic system which allows for systematic improvements of both arterial and residential roadways contiguous to the major arterials.

Exhibit No. 21 presents a 2, 5, 10 and 20 year roadway and drainage improvement master plan and schedule. This exhibit illustrates the logic in improving the major arterials first.

A major concern associated with this development scenario is that in improving the major arterials first, the roadways will be utilized excessively for access by heavy vehicles used to construct future roadway improvements thereby resulting in premature deterioration. This concern, though well intended, does not adequately justify changing improvement priorities.

The District is exercising common sense in performing roadway and drainage improvements to the areas most frequently used. The proposed prioritization allows for contiguous development of roadway improvements. This item is very important to not only the District, but the City and County as well. These improvements will be the most noticeable and benefit a greater number of residents within the Project Area. A secondary impact of improving the major arterials will be the potential for growth. Growth within the area will add tax dollars to the City and County.

It is anticipated that the improvements to the major arterials would be performed within the first two years of the master plan. After successful implementation of these improvements, the District will concentrate on improving roadways contiguous to the major arterials which directly benefit the most people living in the Project Area. The roadways located within the City Limits are planned to be improved within the five year master plan.

Priorities are subject to review annually, however the District proposes to closely follow the proposed two year implementation plan to initially improve major arterial roadways.

CHAPTER 6

FINANCING ALTERNATIVES

The District has the authority to assess lot owners a fee not to exceed $10.00 per month for roadway and drainage improvements. HB 2902 specifies that 90% of this fee be allocated to fund capital improvement projects. The remaining funds (10%) are allocated to finance administrative costs associated with accounting, collection of fees, management of funds, etc. Attachment No.s 8 and 9 present revenue projections based on $5.00 and $10.00/month assessment fee and varying collection rate percentages. The current assessment fee is $5.00/month. There are 7,267 existing lots. Potential revenue at 100% collection rate is $436,020. Actual collection percentage per previous years has been 59% ($258,681) FOR 1991, 58% ($256,458) FOR 1992, AND 54% ($234,346) FOR 1993.. For this master plan, annual revenue of $275,000 is projected.

Assuming the above annual revenue, 90% or approximately $250,000 would be available for capital improvement projects. During the 20 year master plan period, a total estimated revenue of $5,000,000 would be available to fund projects.

The District could fund a project equivalent to approximately $250,000 per year. Based on an estimated $5,500,000 total cost to perform the 63.1 miles of roadway improvements, 22 years would be required to complete the project. However, several factors such as inflation, variance in collection rate, actual maintenance expenses, construction costs, etc. play critical roles in the future successful financing of District projects over this time period.

Bonds are an alternative to performing greater amounts of work by financing capital improvement projects over a set time frame. It is recommended that the term of bond be limited to ten years. The District could issue bonds on the open market or finance through the USDA Farmer's Home Administration. Current bond rates at the USDA FmHA are 6.75%. Terms are recommended to be set at the anticipated design life of the project. Assuming the District desires to finance a bond issue for a ten year term, and assuming 6.75% interest rate with annual payment of $250,000, the amount of potential bond funds would be approximately $1,776,000. This bond issue would hypothetically improve approximately one-third of the total roadways within the Project Area. The advantage to this financing alternative is the expected lower per unit construction cost associated with the economies of scale. In other terms, because the District is buying in greater volume, the unit cost should be lower. The primary disadvantage of this financing alternative is bonded indebtedness the District occurs for a ten-year period.

A present worth economic analysis has been included as Attachment No. 10. This analysis compares two financing alternatives. Alternative No. 1 finances projects annually as funds are available over a ten-year period. Alternative No. 2 finances a larger project by bond issue with payback through annual revenues collected. The present worth economic analysis assumes inflation at 6% and 8%, discount rate at 6.75%, 10-year term and no salvage value. The analysis indicates that at an annual inflation rate of 6% or less Financing Alternative No. 1 would be the preferred method of financing improvements. An annual inflation rate of 8% or more indicates that Financing Alternative No. 2 would be the preferred method of financing. Historical data indicates annual inflation rates of 3 to 4%.

CHAPTER 7

PROPOSED MASTER PLAN AND SCHEDULE OF IMPROVEMENTS

The proposed master plan and schedule of improvements for years 2, 5, 10 and 20 are presented on Exhibit No. 21. The plan was developed by a priority assessment, anticipated revenues, estimated costs of constructing proposed improvements and discussions with the District Board, City of Bastrop and County of Bastrop. The plan and schedule are based on alternative no. 1 financing method.

The District intends to annually evaluate and update the master plan but anticipates that the initial 2-year plan will not change from that presented.

The District has implemented the development of standards for roadway utility cuts and alternatives to routing heavy vehicular traffic through less traveled roadways within the Project Area. These efforts are being made to maintain integrity of the street conditions.

The BCWCID No. 2 Roadway and Drainage Master Plan encompasses many meetings between the Board, the City of Bastrop and the County of Bastrop. Acknowledgements are presented as Attachment No. 11. Without the cooperation and assistance of these groups, the success of this master plan would not have been possible.

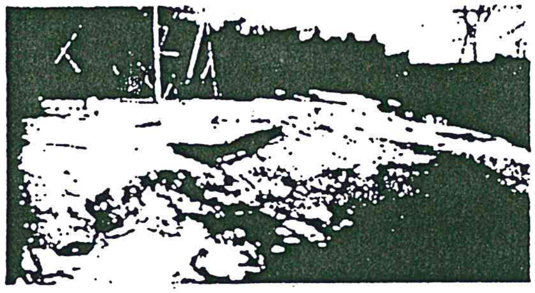
A P P E N D I X

Soil Bioengineering at Raccoon Creek

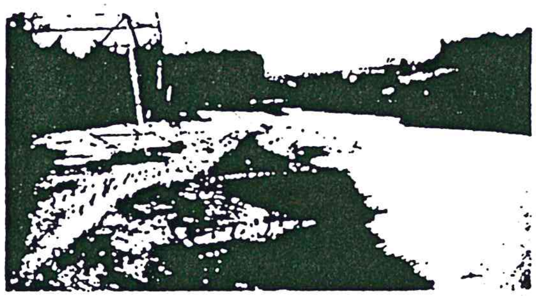
ASE STUDY: Georgia Power Company Transmission Tower Raccoon Creek, Paulding County, Georgia
Drainage Area: approx. 30 sq. Miles
Average Flow: 45 cubic feet per second

oil bioengineering work at Raccoon Creek focused on stabilizing a transission tower foundation threatened y bank erosion due to frequent floods with flows 10 to 15 feet above ırmal. Previous measures, including ..eet piling, riprap and stream realignment, had not been effective; eir failure had deposited more than 00 cubic yards of fill and rock into ıe stream.

Working with a hydrologist/engineer .indt McDuff Assoc.), we designed system of brushmattresses, live cribwalls, and crib booms (or dikes) to ıbilize the bank and divert water to .e center of the stream. Within 30 miles of the site, we located black illow and red twigged dogwood, hich the adjacent landowners gave permission to harvest for no cost. We ovided daily supervision for the cal contractor, who used unskilled orkmen to harvest the live material and install the systems. First, un-:ated timbers were used to construct ıe cribbing, which was filled with ayers of live brush. Brush mattresses ere then secured above the cribs ith live fascine bundles. The live


ROBBIN B. SOTIR

Sheet piling and riprap fail to prevent scour at the base of a 500 kv transmission tower. Raccoon Creek, Paulding County, Ga.


ROBBIN B. SOTIR

Crib deflectors, cribwalls, brush packing and brush mattresses shortly after installation on the same site.


ROBBIN B. SOTIR

A dense thicket of willow effectively protect the tower from bank failure.

stakes were tamped in above the mattress to give the system deep rooting and consolidation into the parent slope.

A week after construction, the site flooded with no damage to the installation. In fact, flood water, rather than further destroying the bank, now deposits silt into the brush. This rebuilds the bank. The design takes advantage of the live qualities of the land. It will sustain itself as it continues to move, to change, and to grow. This project clearly demonstrates the enormous potential in this country for the soil bioengineering/biotechnical techniques already established in Europe. This distinctive approach can help solve many problems associated with moisture and shallow mass wasting of soils. These systems are compatible with classical engineering, but on sites where engineering solutions do not function well, are uneconomical, or are visually incompatible with the surrounding environment, my knowledge and experience with these techniques have provided an exciting, responsible and naturally beautiful approach to land stabilization.

Robbin B. Sotir is President of Soil Bioengineering Corporation International and Biotechnical Land Stabilization Limited, Inc., in Marietta, Georgia. Robbin has a 1974 degree in landscape architecture from the University of Guelph, and credits much of her knowledge, interest, and commitment to the subject to Dr. Hugo Schiechtl of Innsbruck, Austria.

A CUMBERLAND GAP TUNNEL PROJECT HIGHLIGHT:

Controlled Testing of New Construction Technologies

Workers on the Cumberland Gap Tunnel Project site place live fascines (bundles of living plant material) on the live boom, a soil bio-engineering project which is being constructed to redirect the stream of Little Yellow Creek. Alton Simms, (left, background), Vice President of the Soil Bio Engineering Corp., and Barry Carnes, field inspector with Vaughn & Melton, oversee the work.

SOIL BIO ENGINEERING

The Cumberland Gap Tunnel project is one of the first applications of soil bio-engineering in federal highway construction, and it is also the first project in a national park. The methods used in soil bio-engineering have been used for centuries in Europe, according to Alton Simms, Vice President of the Bio Engineering Corporation of Marietta, GA. Simms stated that three-quarters of the European country, Holland, is land reclaimed out of the North Sea. "This is how they did it," said Simms. He added that these methods were also used in the U.S. in the early 30's by the Soil Conservation Service, but were abandoned, mostly because of the "high tech" solutions that had started to come about since World War II. Now, this old way of stabilizing land using natural materials is again gaining recognition as the technology has been further developed and refined in the U.S.

The methods of bio-engineering use native plant materials cut in the vicinity of the project. The cuttings must be capable of rooting themselves, and work must be done during the plant's dormant season. After the system takes hold, it requires very low to no maintenance, and is capable of self repair. The systems used are site specific, according to Simms.

"You can't really take any one of these things and put it someplace else without considering where you're putting it and why, and what you're trying to achieve," he stated. Some of the bio-engineering systems being used on the Cumberland Gap Tunnel Project are: live stakes, live fascines, brush mattressing, joint plantings and a live boom. Live stakes are sticks that have been cut and pruned from living plant material. Live fascines are bundles of live cut branches grouped together in a sausage like structure with the growing tips all oriented in the same direction. A brushmattress is a construction of living branches placed close together to form a mattress-like cover over the ground. Joint plantings are live stakes tamped in between riprap rocks. A live boom is a dyke or groin-like structure which is built of cut living plant material. It is used to divert and/or control water flow.

The way these bio-engineering systems work is really quite simple. In the case of the joint plantings, the live stakes root themselves, making a live root network that functions to consolidate the soil underneath the rock and transpire the moisture out of it. In cases of an overwash, the stream bank that has been prepared with joint planting will dry out much faster than a natural bank would. The root system of the native willow used in the Cumberland Gap project are much deeper than a grass, legume or weed, and they will grow into bushes, eventually covering the rock. Within two to three years a natural stabilization of the soil as well as a natural ground cover should be established.

A live boom was constructed at the project site for the purpose of redirecting Little Yellow Creek. The live boom is made of many layers of live fascines placed at right angles to each other and staked down. Riprap rock was hand placed on the face of it, which will take the brunt of the force of the stream. Although living material is used throughout the structure, the material below the stream bed is intended to rot, promoting life for that which is above.

The live boom is intended to function as a living structure. According to Simms, one major limitation of these systems is that they are vulnerable to damage initially because they have not yet developed roots. Soil bio-engineering is also very labor-intensive work, but its benefits are lasting. "once it starts to take root and grow, there's no stopping it," stated Simms.

CREEK CURRENTS

NEWSLETTER OF THE URBAN CREEKS COUNCIL

OLUME 2, NO. 3 AUTUMN ISSUE, 1987

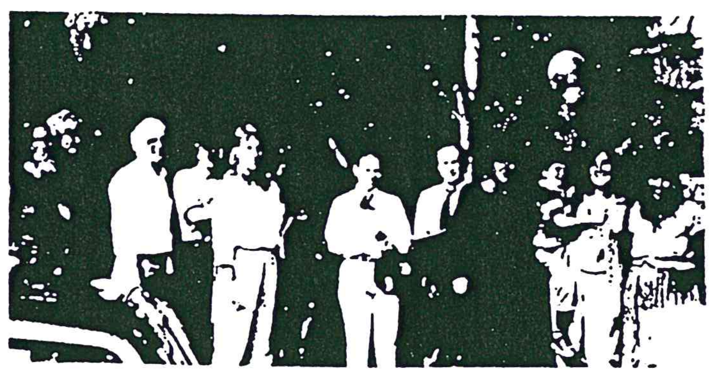
SOIL BIOENGINEERING, AN ALTERNATIVE TO THE USE OF CONCRETE AND RIPRAP ON DIFFICULT STREAM BANK PROBLEMS

obbin Sotir, president of Soil Bioengineering Corporation, nta, Georgia, presented a slide show in Oakland this fall to embers of the Urban Creeks Council, staff of the East Bay egional Parks District, visitors from the University of California, keley, and the Alameda County Flood Control District. Ms. r was brought to Oakland at the request of the Urban reeks Council by the California Departments of Water sources, and Parks and Recreation to introduce the methods stream restoration by soil bioengineering techniques and scribe a restoration plan for Sausal Creek. Robbin did some eliminary evaluation of some erosion and unstable bank blems in a portion of Sausal Creek. Ms. Sotir studied in tria with Hans Schiechtl, an internationally known expert in osion control. Schiechtl has synthesized and developed chniques of the system referred to as "Bioengineering." In trast to conventional engineering "hard-fix" solutions that ose upon natural processes, bioengineering uses natural ocesses to allow problem situations to repair themselves. By ilizing a combination of living plants and inert materials, a amic self-repairing system can be constructed.

Ms. Sotir presented a slide show illustrating some of the tech- ues devised by Schiechtl and now used by Sotir in her inter- onal consulting business. She illustrated the re-establishment creek bank vegetation using live stakes of plants (such as illow) that easily root. Some bank restoration designs use od or rock as a temporary structure for the purpose of sup- ting the bank until the vegetation matures and provides the ng term stability. Illustrations were presented of slope re- etation using brush layering and live fascine methods. Brush ering involves laying live brush branches in terraced trenches ong a slope. By using species that readily root, the new plants ill eventually produce a root network that will hold the soil. ally, the cuttings slow water and soil movement down pe. In areas where soil water saturation has the potential to use landslides, the planting of water-loving plants with this ethod can reduce the excess load of water through the rapid po-transpiration typical of these plants.

Live fascine, commonly referred to as wattling in the U.S., uses bundles of live branches which are partially buried in trenches. These perform similar functions to the brush layering technique. Bioengineering techniques are generally more labor-intensive as opposed to capital-intensive concrete and riprap solutions more typically used. In many cases it is the best solution where access is difficult, and environmental, aesthetic considerations and economy are important. Ms. Sotir has been promoting her "soft-fix" solutions to stream bank and slope problems for a number of years and has gained an international reputation. Her clients include Georgia Power and Light and several districts of the Army Corps of Engineers.

Submitted by Michael Marangio



Members of the Urban Creeks Council, staff of the East Bay Regional Parks District, visitors from the University of California, Berkeley, and the Alameda County Flood Control District meet with Soil Bioengineer, Robbin Sotir at Sausal Creek, Oakland.

E&S Bulletin

Number 24 | Virginia Erosion & Sediment Control Program | Fall–Winter, 1984–85

"Soil Bioengineering" gaining steam

Have you ever noticed that no matter how hard you try to ignore a good idea, it simply won't go away?

In a national sense, that seems to be what is happening in the U.S. regarding "soil bioengineering." At the turn of the 20th century this country almost completely abandoned this science in favor of hi-tech, concrete and stone structural alternatives. Now this pesky little good idea is back and gaining steam daily.

In short, soil bioengineering is the practice of combining live plant materials (usually woody) with "dead" structural measures in order to stabilize a slope or a bank. The dead material (wood, brush, stone, etc.) is usually installed to support the live materials during establishment. Often the dead material is designed to rot away. The live parts, of course, are meant to reinforce soil, block its movement and slow water velocity.

While soil bioengineering is not new (Europeans were using it in the 16th century), its modern methods are sophisticated. Native plant cuttings are criss-cross layered and anchored in a way that they take root and grow. The living material, once established, forms an almost indestructible network that protects steep slopes and banks from erosion.

Living Advantages

A biotechnical erosion control system has many advantages over structural measures. First of all, no matter how well earth is sealed, it still moves. A living stabilization system can also move and will absorb the movement of soil. Conventional structural systems must eventually break up as the natural surface beneath changes.

Robbin Sotir, president of Soil Bioengineering Corporation put it this way: "Land is alive. It is always moving so it makes sense to use a live, dynamic system to protect it."

A live system also is normally self repairing whereas a structural system degrades with time. Rather than falling apart, a live system expands and becomes more structurally sound with time. In this way, live systems are actually more permanent than conventional structures.

"Land is alive. It is always moving so it makes sense to use a live, dynamic system to protect it."

Live, vegetative structures exhibit another engineering advantage over conventional systems. Because vegetation transpires, water is absorbed from the soil by roots and is pumped back into the atmosphere. This removal of soil moisture reduces the weight of the soil mass thereby lessening the chance of slope failure.

Besides Engineering

European countries have been sold on the concept of soil bioengineering for centuries. Reasons for this vary but they are not always based on pure, logical engineering advantages. In fact, one of the major reasons living materials are preferred to static, structural measures is that they just plain look better. In many European projects, banks are actually lined with flowering plants, such as the Iris.

The live system improves water quality and provides cover and food for fish and wildlife. On banks, biotechnical systems serve as filters which catch eroded soil from upstream and this actually

- continued p. 2

Biotechnical "a more responsible" way?

- continued

builds a stronger, expanding bank rather than simply a static one.

Costs for live systems seem to be very competitive. On an erosion control project in Atwood Water Park, Monticello, Ga., an estimate of $275,000 was given for conventional structures. The cost using soil bioengineering techniques was less than one-third that figure and, although evaluation of the site is ongoing, success is predicted.

Most of the costs involved in soil bioengineering are tied up in unskilled labor and management. Little or no heavy equipment is required and energy costs are correspondingly low. Since cuttings of native plants are used, they are obtained nearby so transportation costs are very low. The plants also are usually obtained at no cost.

Sotir said her company has never paid for a single cutting. She said, "People are often happy to have you take cuttings from their lands because their vegetation improves the next year." She also said that they seldom use fertilizers on their projects.

Disadvantages

Of course, live systems have disadvantages. Soil bioengeering requires good management and is labor intensive. Biotechnical elements with names like fascines, wattles, brush mattresses and live soft gabions must be installed in precisely the right place and position. Live systems also can only be installed during the dormant season, from January through March.

"I am not offering this as a panacea," said Sotir, adding, "In fact, it doesn't work everywhere. It works in so many places that I think it's a shame we're not using it more."

The biggest obstacle facing biotechnical stabilization may not be any of those listed above. Perhaps the greatest disadvantage it faces here is that it is "new." While the systems have been used here before and have been applied successfully elsewhere for some time, the concept is practically new in America and minds will have to accept it before its potential can be achieved.

"....More Responsible"

Sotir said that aside from her belief that soil bioengineering is more permanent and "environmentally aesthetic, it is possibly a more responsible way to protect land." After all, the erosion-controlling system eventually leaves the land in a natural state and nature very seldom behaves irresponsibly.

Hugo Schiechtl, one of the world's most experienced bioengineers, was once asked how he knew when a biotechnical project was done. He said, "A bioengineering project can be regarded as complete only when it is no longer obviously man-made, but appears rather to be a work of nature."

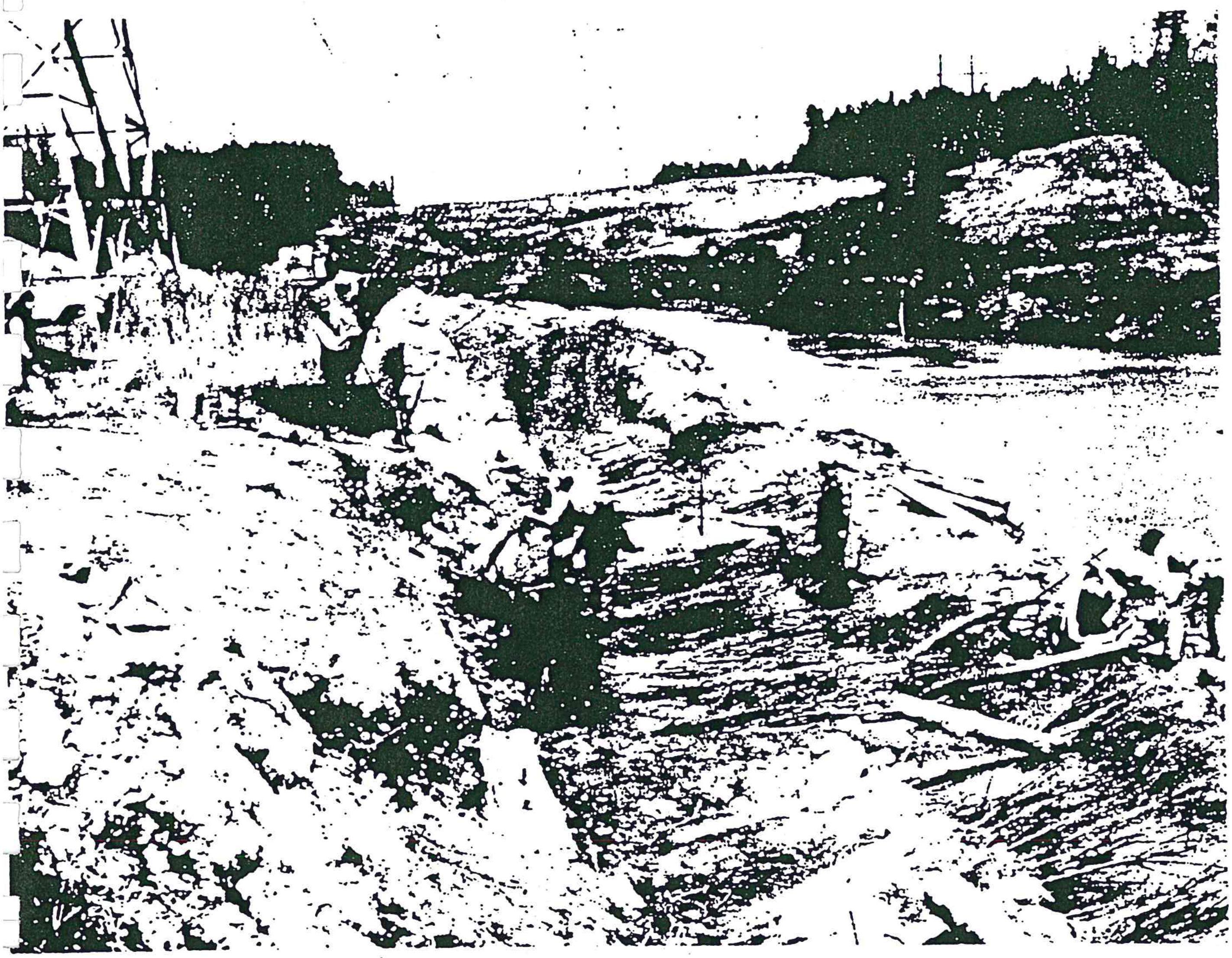
This may take three or four years, of course, but maybe it's worth the wait.

IECA REPORT

Dedicated to protecting, reclaiming and restoring land disturbed by man

Bulletin of international erosion control association

Vol. 18, No. 3 Fall 1986



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An Introduction to . . .
Soil Bioengineering

Robbin B. Sotir

Soil Bioengineering/biotechnical Land Stabilization is an applied science which combines biological, engineering and ecological concepts to construct living structures. It is a highly developed and distinctively different technology that offers an alternative to solving many shallow mass waste erosion and sedimentation problems, often with more immediacy and permanence than conventional stabilization methods. It is a wonderful, exciting method of land stabilization. In addition, these live systems work well with classical conventional engineering, often providing a more permanent, aesthetic, and environmentally responsible product.

The term, "biological engineering," was first formulated at the end of the 1930's and since then has come to be used to cover aspects of classical works which emphasize techniques based on the science of biology, particularly using the knowledge gained through biological and ecological studies of landscapes in the securing of unstable lands. Characteristic of these measures is that plants or parts of plants are utilized as living construction materials which, in the course of growing together with earth, rock and groundwater, afford the greatest contribution to the permanent protection and preservation of the whole.

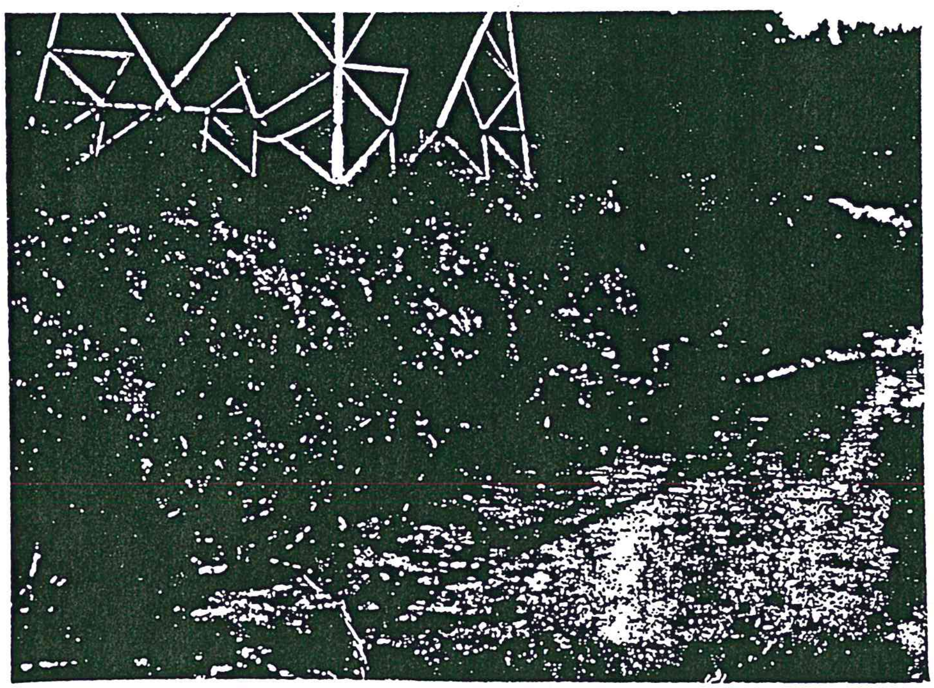
Soil Bioengineering may be used in a wide range of situations including the revegetation in the repair of highway roadsides, cut and fill slopes, dredge disposal sites, streambanks, floodplains, dams, transmission line right-of-ways, gullies, shorelines, bluffs, earthslides, slumps, stream bank erosion, and streambed degradation. These systems may be used on mining, transportation and transmission corridors, recreation, forestry, commercial, agricultural, wildlife, and wetlands habitats.

Live systems, as is true of any system, are not usable for all land instability problems, but are very useful in areas where classical engineering may be uneconomical, unsuitable, or ineffective. Soil Bioengineering goes a step beyond classical engineering. It investigates the live qualities of land and addresses them with living structures. This is the central and perhaps the most important concept in understanding something about Soil Bioengineering. Land is always changing and moving, to different degrees of course, but it is always in some state of change or with that potential. The simplest example that can be cited is that of moisture. Moisture often represents one of the greatest land instability problems, whether this is associated with cut and fill sites or banks on river and stream systems. So it makes sense to respect that quality and respond to it with live dynamic, flexible, self-repairing, natural units, which are sensitive and work with the fragile balance of land and water.

Responding to the land's changing nature, biotechnical methods offer a live approach intended to restore land. Rather than creating an artificial static state by imposing rigid systems, soil bioengineering enables the land to recover to a natural state which will become as self-supporting and as self-maintaining as possible. Biotechnical methods follow the principles of nature by utilizing the inherent strengths of the site to protect itself, rather than addressing only the weaknesses in the site. Dr. Hugo Schiechtl, a prominent Austrian soil bioengineer, has said:

"Man must learn to protect himself and his environment by calling in nature as his working partner."

Soil Bioengineering uses largely native plants collected in the immediate vicinity. This



Three years after construction at Racoon Creek.

assures that the plant material will be well adapted to the specific site conditions. While a selected few species may be installed for immediate protection, the ultimate goal is the natural invasion of a diverse plant community. Typically, pioneer plants are installed. Herbaceous and (especially) woody pioneer species able to root from cuttings form the major portion of biotechnical systems. These are intended to meet the needs of the land and are intended to stabilize and improve the soils to prepare the site for natural invasion.

Intensive site assessment, careful species selection, exacting design and proper installation of these fragile live units are very important to the success of Soil Bioengineering projects. What may seem most unique to you, however, will be the methods of installation.

Soil Bioengineering uses plant parts as the major structural or engineering component. Unrooted live vegetation installed in various systems acts as structural members, which provide direct mechanical soil stabilization, covered soil protection and water velocity reducing units. In time, shoots and roots develop to form a permanent vegetative cover and root reinforcing matrix. Live plants excel in stabilizing soils. Top growth intercepts raindrops, filters sediments out of runoff, enriches the soil and increases infiltration. Roots mechanically reinforce and restrain soil by providing arching and buttressing structures.

Soil Bioengineering has been used worldwide for hundreds of years. Today it is used in over 30 countries in the world. Some of the first written works of this type of construction date back to the 1500's. It had some of its first beginnings in the mountain areas of Europe, where avalanche and mud slides were ever present, and on the mountain rivers which were used for navigation. This live system was used in the United States in the 1930's and 1940's by the Soil Conservation Service in an abbreviated form. After World War II, these systems were abandoned as high tech solutions were developed to solve problems. Today, with high energy costs, with depleting resources, with the recognition that all problems *can not* be solved using conventional methods alone and with the new environmental land ethic, Soil Bioengineering/Biotechnical Land Stabilization is experiencing a rebirth as a viable technology. The Europeans recognized the live qualities of land and water and continued to use and develop this technology. They recognized that many problems could not be solved with conventional engineering methods alone. Soil bioengineering, being a live system, investigates both the technical and the biological problems in the land and solves them in a more complete and permanent manner. Unlike inanimate parts, they are completely live dynamic systems capable of self-repair. Even under very stressful conditions, land can be kept self-supporting. This has been substantiated by research that has been done and is ongoing in Europe, Japan and the United States. Correctly chosen biotechnically capable plants can stabilize certain land instability problems through soil particle consolidation and can remove water through transpiration. Research has proven that the development of strong intensive and extensive root systems consolidates soils into unitary masses. The flexible root fibers are imbedded around the soil particles. Live roots will promote a friction transfer along their length which will serve to add strength to the soil system. Roots, by their very live nature, respond to the stress conditions at the site. These could be topographic or hydrologic. They respond to these stresses in a self-corrective manner. They have built-in bioadaptive processes. Root systems can reshape and reorientate. This capability further serves to increase the stability of the soil in the overall slope. Vegetative slopes can modify the moisture condition of the soil through transpiration.

It is a more complicated, sophisticated and complete approach which is sensitive and realistic in that *it follows the principles of Nature.*

This effective live system is labor-skill intensive rather than capital-energy intensive. It is a practical, cost effective, rapid recovery system that offers low long term maintenance and beautiful products.

Soil Bioengineering *works closely with nature to cause land to become its own self-supporting structure.* It is a responsible and sound approach to land stabilization, which *produces products that grow stronger and more beautiful with age.*

Robbin Sotir, the president of Soil Bioengineering Corporation, of Marietta, Georgia has successfully completed over 140 projects in North and Central America, Europe, and S.E. Asia. She has studied specialized European soil bioengineering techniques, and is probably the only European trained soil bioengineer practicing in the United States. She has developed comprehensive soil bioengineering/biotechnical construction specifications for the North American continent.