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16. ABSTRACT

This report presents an investigation into the use of discarded tires for use as shoulder reinforcement and channel slope protection in areas where serious erosion has occurred. It also investigated the use of discarded tires for windbreaks for the temporary control of blowing sand. Guidelines for shoulder reinforcement and channel slope protection are included in this report.

Three separate projects were initiated to explore the use of discarded tires in highway maintenance. The first one was the installation of discarded truck tires in an embankment to control shoulder erosion. The second was the installation of discarded truck tires in a low velocity drainage channel with highly erodible soil to control slope erosion. The third, was the construction of discarded automobile tire barriers which provided temporary windbreaks for establishing tamarisk trees.

The results of this research have indicated the construction of shoulder reinforcement and channel slope protection with discarded tires provide an immediate and economical solution for minor contracts and projects initiated by maintenance personnel. The use of discarded tires for windbreaks provided temporary protection for the trees and the roadway. It also provided for the disposal of large quantities of tires. However, it is not cost-effective as the result of being extremely labor-intensive and the availability of other lower cost materials.

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November 2005, Division of Research and Innovation

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
OFFICE OF TRANSPORTATION LABORATORY

GUIDELINES FOR USING RECYCLED TIRE CARCASSES IN HIGHWAY MAINTENANCE

FINAL REPORT # FHWA/CA/TL-87/07

CALTRANS STUDY # R81TL08

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CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quality	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2) square feet (ft^2) acres	6.432×10^{-4} .09290 .4047	square metres (m^2) square metres (m^2) hectares (ha)
Volume	gallons (gal) cubic feet (ft^3) cubic years (yd^3)	3.785 .02832 .7646	litre (1) cubic metres (m^3) cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s	28.317	litres per second 1/s)
	gallons per minute (gal/min)	.06309	litres per second (1/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph) feet per second (fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity (G) (ft/s^2)	9.807	metres per second squared (m/s^2)
Density	(lb/ft^3)	16.02	kilograms per cubic metre (kg/m^3)
Force	pounds (lbs) (1000 lbs) kips	4.448 4448	newtons (N) newtons (N)
Thermal Energy	British termal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds (in-lbs) foot-pounds (ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi) pounds per square foot (psf)	6895 47.88	pascals (Pa) pascals (Pa)
Stress Intensity	kips per square inch square root inch ($ksi\sqrt{in}$)	1.0988	mega pascals$\sqrt{metre}$ ($MPa\sqrt{m}$)
	pounds per square inch square root inch ($psi\sqrt{in}$)	1.0988	kilo pascals$\sqrt{metre}$ ($KPa\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{+F - 32}{1.8} = +C$	degrees celsius (°C)

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Richard Howell	Headquarters, Hazardous Waste
Albert Lee	District 04, Materials.

The authors wish to thank members of the Transportation Laboratory staff and others who were associated with the discarded tire research project.

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DISTRICT 02
Gene Stark - Maintenance Supervisor
Jim Bouge - Maintenance Foreman

DISTRICT 06
Cap Akers - Maintenance Superintendent
Ray Vinson - Maintenance Foreman

DISTRICT 08
Bill Gartman - Maintenance Superintendent
Mario Savala - Design Engineer
Bishop Dowden - Design Engineer
Tim Kirkley - Design Engineer

Particular acknowledgement is extended to Dale Tenbroeck, District 2 Regional Maintenance Superintendent who initiated the concept of shoulder reinforcement with discarded tires and Virgle Ray, District 06 maintenance superintendent who initiated the use of discarded tires for channel slope protection.

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1. INTRODUCTION

It is estimated that more than 200 million automobile tires and 40 million truck tires are discarded each year in the United States. Over 20 million tires are discarded each year in California. The magnitude of this problem prompted the 1973 California Legislature to request that Caltrans study the problem of abandoned tires and develop possible solutions for the disposal and recycling of used tires. The subsequent 1975 report (1) indicated that discarded tires have been used for numerous purposes, such as retaining walls (Photos 1.1 and 1.2), rubberized asphalt, artificial reefs, breakwaters, and as a source of energy. Caltrans has been instrumental in studying the use of discarded tires in the reinforcement of earth structures and pavement structural sections.

The high cost of new construction materials which provide temporary protection for erosion control can delay construction on projects. The availability of discarded tires at low cost makes this waste product extremely attractive as an alternative construction product for erosion control. Standards for used tires as a substitute material to control slope erosion, stabilize drainage channels and control blowing sand are lacking. Before a large investment is made utilizing discarded tires on various highway projects, research is necessary to evaluate the uses for discarded tires and to develop guidelines to insure successful cost effective installations.

In addition to the above uses three Caltran districts began exploring the use of tires on three different projects located throughout California (Figure 1.1).

Photo 1.1 - Retaining Wall On Private Property

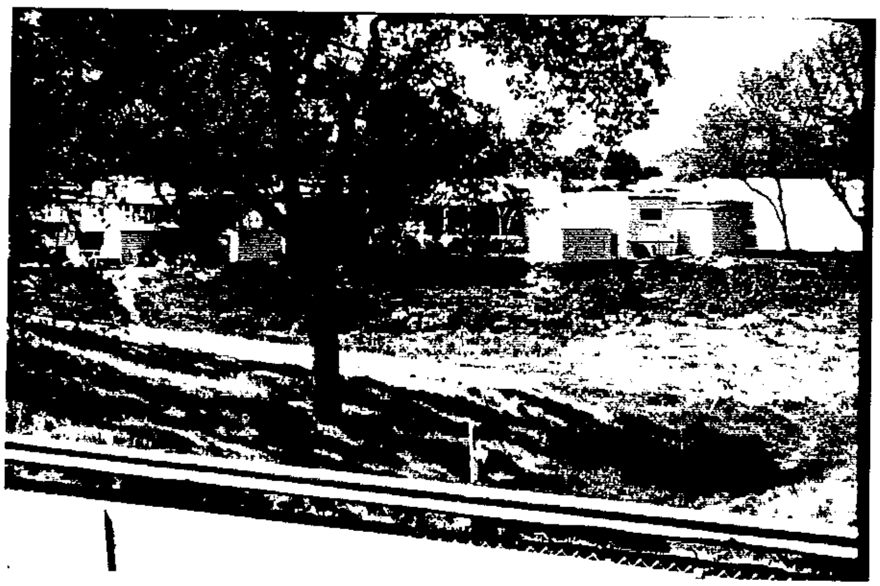


Photo 1.2 - Retaining Wall On Private Property

LOCATION MAP

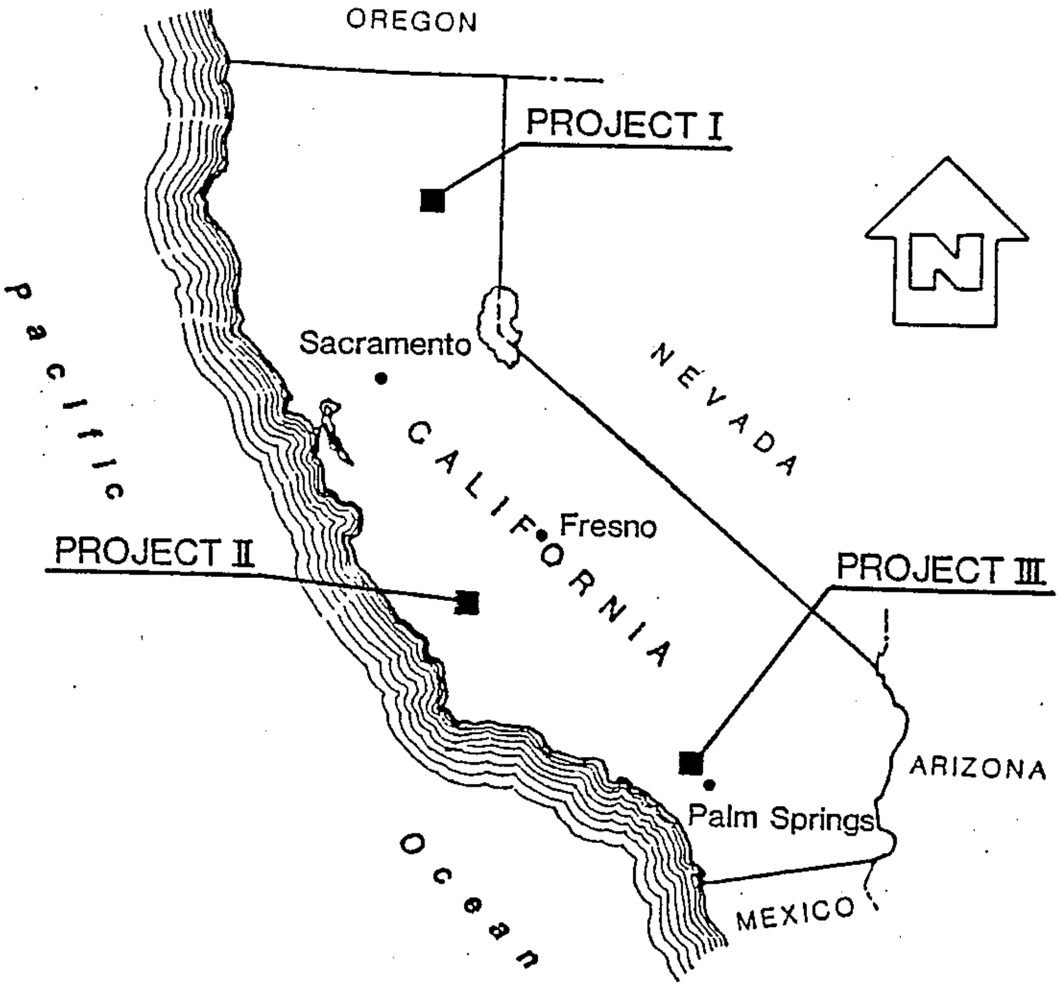


FIGURE 1.1

PROJECT I (State Route 32 - Tehama County) Installed discarded tires in an embankment along a narrow portion of Route 32 in Tehama County near Mount Lassen Volcanic National Park to control shoulder erosion.

PROJECT II (Interstate Route 5 - Fresno County) Installed discarded tires in a drainage channel along I-5 in Fresno County near Kettleman City to control channel slope erosion.

PROJECT III (State Route 111 - Riverside County) Construction of temporary tire barriers which protect a row of T. aphylla (tamarisk) trees being established as a windbreak from blowing sand on Route 111 in Riverside County near Palm Springs.

The concepts of the utilization of discarded tires were initiated by district maintenance personnel in each of the three districts in 1981. The three research projects were consolidated under a federally funded research project entitled, "Guidelines for Using Recycled Tire Carcasses in Highway Maintenance". In October 1982 FHWA approved a 5 year research project to study these three projects. The Translab assisted the districts in the research to further develop the concepts behind the projects, evaluate the aesthetics and prepare engineering guidelines for these projects. Since the project concepts originated with people in the field, it resulted in the research being readily implemented.

2. OBJECTIVES

PROJECT I: Develop engineering guidelines for the use of discarded truck tires and recycled materials as a mechanical means of stabilizing highway shoulder erosion problem at various locations along a mountainous highway.

PROJECT II: Determine if discarded truck tires and recycled materials would be feasible for channel slope protection. Also to investigate configurations and interlocking procedures and develop solutions for the use of discarded tires for bank protection.

PROJECT III: Evaluate the effectiveness of discarded automobile tires in various configurations as tire barriers to protect tamarisk tree seedlings planted within an existing tree row from blowing sand.

3. CONCLUSIONS

PROJECT I (Reinforced Shoulder)

With the exception of some minor erosion, the tires remained stable and maintained their integrity including the clips and steel posts that retained the tires in the mats. This installation has provided an economical solution to an increasing problem occurring on many low volume, narrow mountain highways throughout California.

PROJECT II (Bank protection)

If installed properly in low velocity sheet flow drainage facilities, discarded tires can provide immediate and economical mitigation solutions Discarded tires can for many bank erosion problems.

PROJECT III (Protective barriers)

The discarded tire barrier for protecting plants and cuttings was satisfactory for both the protection of the tree row and some of the young plants. It prevented the buildup of sand on the roadway and used a large number of discarded automobile tires. However, it remains labor-intensive.

The installation of snow fence or fences constructed of polyethylene type material mounted on metal posts is more economical for impounding sand.

The tire barriers resulted in an additional benefit during the research period by serving as a diversion groin for diverting storm waters from eroding the highway embankment.

The cost of discarded tire for reinforced shoulders and channel slope protection from erosion is less than half the cost of the next acceptable solution for this purpose.

Summary Of Observations And Findings

- Construction of the shoulder reinforcement and the slope protection concepts by Maintenance personnel are simple and economical.

- The availability of discarded tires is unlimited at this time. In some instances they may be provided free by vendors.

- Selection and grading of all material (tires, post, backfill etc.,) is required in order to provide uniformity and a desirable finished product.

- Where possible, discarded tire projects should be constructed out of sight of the traveling motorist. However, treatment by planting woody plants and grasses or painting the tires to conform to surrounding terrain can provide an aesthetically pleasing project.

- The reduction of injury and fatal accidents with the improvement of the shoulders of narrow mountainous highways.

- Substantial savings can be made in lower maintenance cost for rebuilding eroded highway drainage facilities and the elimination of potential claims from adjoining private property owners.

- With the large numbers of tires being discarded annually and the accelerated rate of registering vehicles, an additional disposal method will mitigate the discarded tire problem. The use of tires in highway construction or maintenance projects such as shoulder reinforcement or slope protection, will provide both design and maintenance personnel with immediate solutions. The availability, combined with the low cost of acquiring and installing discarded tires, makes tires the ideal solution for many emergency problems which occur on California highways.

- Using readily available, low cost, discarded tires in lieu of more expensive new materials can provide substantial cost savings. In addition, part of the tire disposal problem will be eliminated by additional alternative uses of discarded tires.

- During the course of the project the use of truck tire sidewalls or treads only was suggested (similar to the reinforced earth concept) to facilitate easier compaction in the reinforced shoulder concept. This proposal may have some feasibility. However, truck tires appear to be quite difficult and expensive to split and could be difficult to incorporate in a stable installation. The concept was dropped early in the research period.

4. RECOMMENDATIONS

Implement the shoulder reinforcement and channel slope protection concepts. It is recommended that tires be acquired by donation or purchase and delivered to the site when quantities justify it. As suppliers are finding it harder to dispose of tires this makes the discarded tire projects especially advantageous.

Hydraulic analysis should be conducted prior to considering any application to a channel problem as discarded tires may not always be the best solution.

When tire projects are being undertaken adequate safety measures must be undertaken to assure the safe working environment required by CAL-OSHA.

This report along with standard plans could be used as a design guideline for installation of discarded tires for maintenance purposes. Effort should be made to utilize salvaged materials for slope and erosion mitigation throughout California. The availability of the tires is unlimited and usually free. With the exception of minor amounts of additional material, labor and equipment are the primary costs of the tire installations. Standard plans would serve as adequate guidelines for the design of discarded tire shoulder stabilization and channel bank protection.

The discarded tire projects were constructed of truck and automobile tires and salvaged steel posts, Installations of discarded tires are especially economical for small projects constructed by district maintenance personnel.

5. IMPLEMENTATION (Projects I, II and III)

The construction of similar reinforced shoulder projects at various locations such as minor contract projects, a channel weir and shoulder reinforcement on Routes 10 & 247 in Riverside County (Photo 5.1 & 5.2) and other maintenance constructed projects using automobile tires on Route 70 in Plumas County (Photo 5.3) indicates a general acceptance of discarded tires for shoulder reinforcement.

Included in this report are guidelines for the use of discarded tires for controlling erosion on embankments (Figure 7.6) and controlling erosion on channel banks (Figure 8.8). These guidelines are plans which will allow designers to develop discarded tire projects. They will also provide maintenance personnel with an immediate solution for an erosion problem until more permanent measures can be undertaken. These guidelines also provide various aesthetic measures to consider during the project development stage.

This report will be distributed to Caltrans Districts and Headquarters offices, FHWA and will be available to other interested parties upon request.

The proper installation procedures for tires is very important. The slope protection projects shown in Photos 5.4 & 5.5 reflect a lack proper engineering practices for installations.

This information could be presented at various meetings held by Caltrans engineers and maintenance Personnel. A slide program is available for interested individuals, district maintenance and design personnel.

TransLab is available to assist the districts with any future site evaluations, design and installation assistance for the development of discarded tire projects.

Photo 5.1 - 11-Riv-10 - Channel Weir - Minor Project

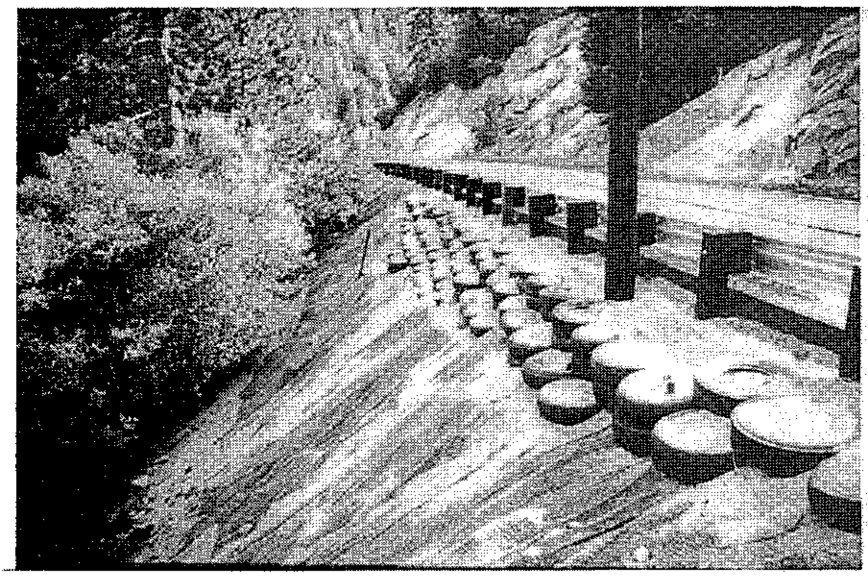


Photo 5.2 - 08-Riv-247 - Minor Contract

Photo 5.3 - 02-Plu-70
Installed By Maintenance Forces

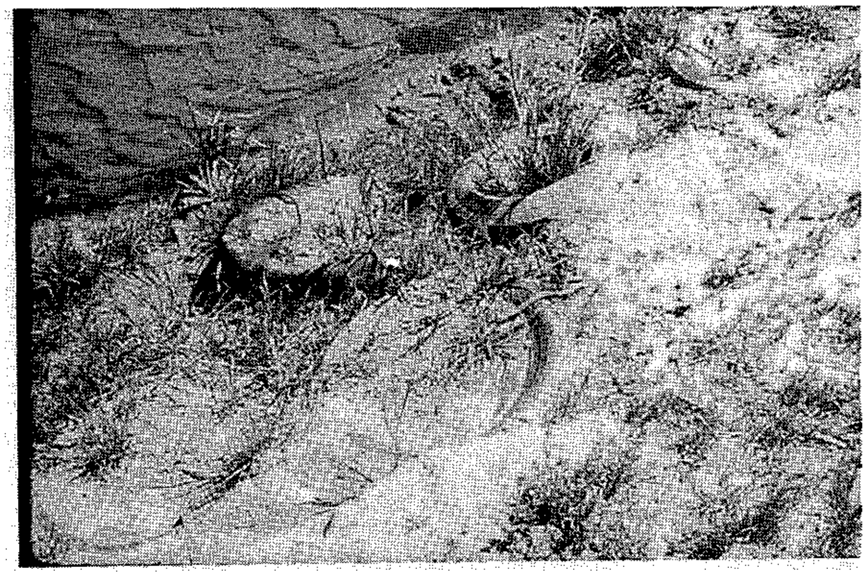


Photo 5.4 - Slope Protection In San Luis Obispo Co.

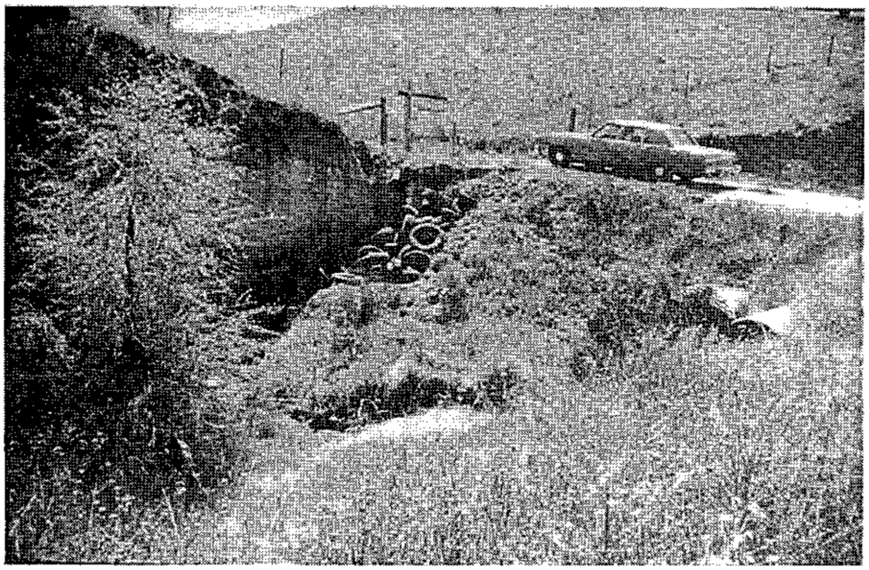


Photo 5.5 - Fresno County - 06-Fre-46

6. BENEFITS

- USE FOR DISCARDED TIRES - The use of discarded tires in highway construction and maintenance projects such as shoulder reinforcement or channel bank protection will assist both departments with immediate solutions.

- IMMEDIATE IMPLEMENTATION - The availability combined with the low cost of acquiring and installing discarded tires makes tires the ideal solution for many emergency problems which occur on California highways.

- LOW COST MAINTENANCE SOLUTIONS - The use of discarded tires for shoulder reinforcement and channel linings is considerably more economical than many alternative materials.

- SAFER HIGHWAY - Shoulder reinforcement will provide a wider road-way section, which will make a safer traveled way.

7. PROJECT I - SHOULDER STABILIZATION WITH RECYCLED TIRES

7.1 Introduction

Highway embankments in mountainous terrain are highly susceptible to severe soil erosion. In some locations the shoulders are eroded all the way to the edge of the pavement. It is this situation that this phase of the research project will address. The process investigated is the mechanical stabilization of the shoulders utilizing discarded tires.

7.2 Background

Route 32 is a narrow winding mountain roadway whose shoulders were being eroded by both rainfall and snowmelt. The water was overtopping the embankments and causing erosion so severe that, in some locations, embankments had eroded back to the pavement edge (Photo 7.1).

The District had previously installed several discarded tire shoulder reinforcement units on Route 32 in Tehama County. Therefore, it was decided that two additional sites in this vicinity would provide the opportunity to monitor the earlier installations as well as the new research project (Figure 7.1 & 7.2). In December of 1981 the decision was made to install discarded tire shoulder reinforcement units "A" & "B" utilizing modifications recommended by the Translab (Photos 7.2 & 7.3).

7.3 Design Description

In this project entire truck tires were used to reinforce the road shoulder. Engineering fabric was utilized in one

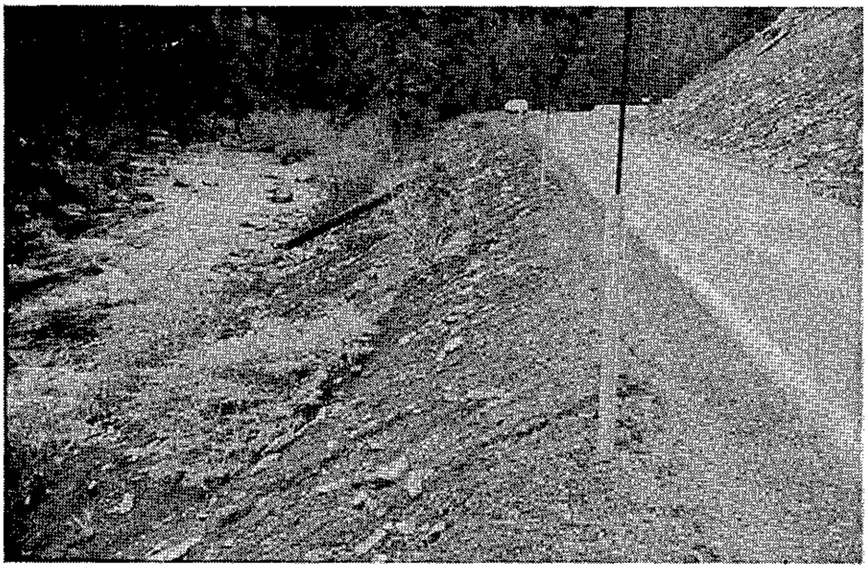


Photo 7.1 - Site Before Installation Of Tires

TIRE PROJECT I

LOCATION MAP

02-TEH-32 P.M. 22.8
SHOULDER STABILIZATION WITH RECYCLED TIRES

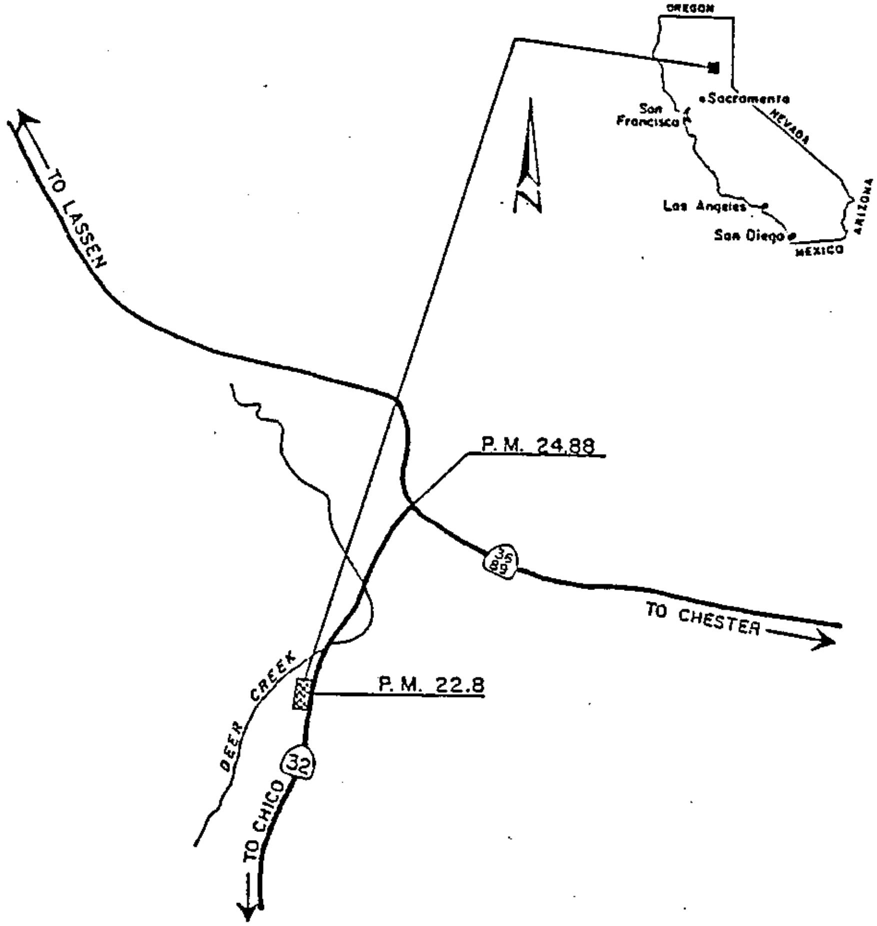


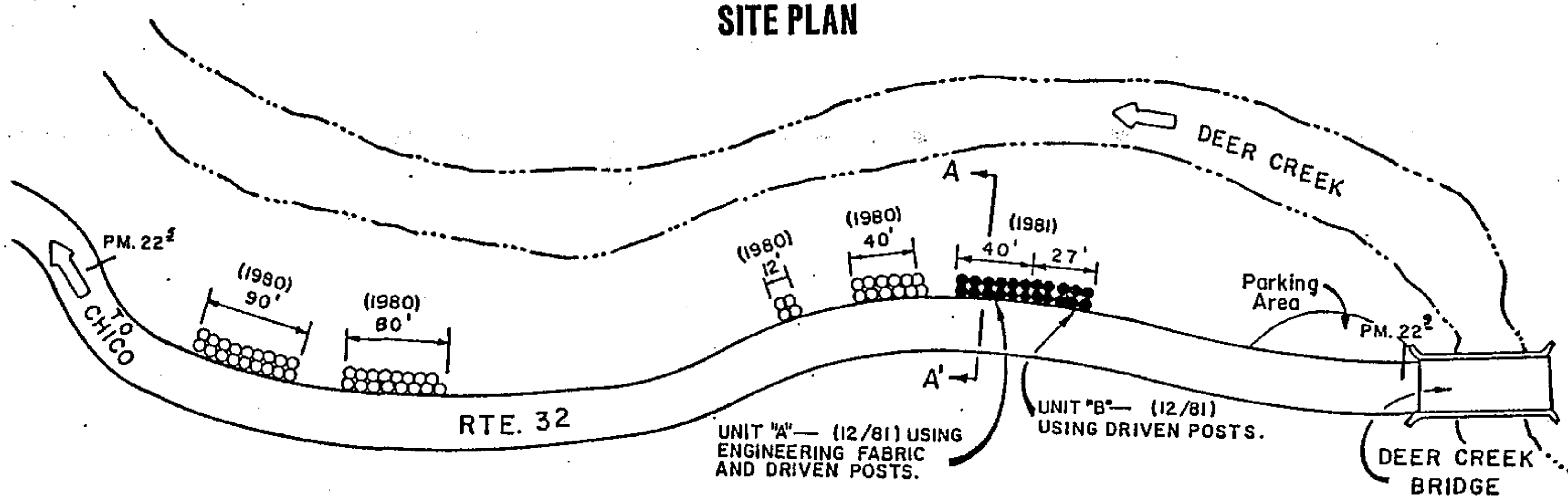
FIGURE 7.1

TIRE PROJECT I

SHOULDER STABILIZATION UTILIZING DISCARDED TIRES

02-Teh-32 P.M. 22.5-22.8

SITE PLAN

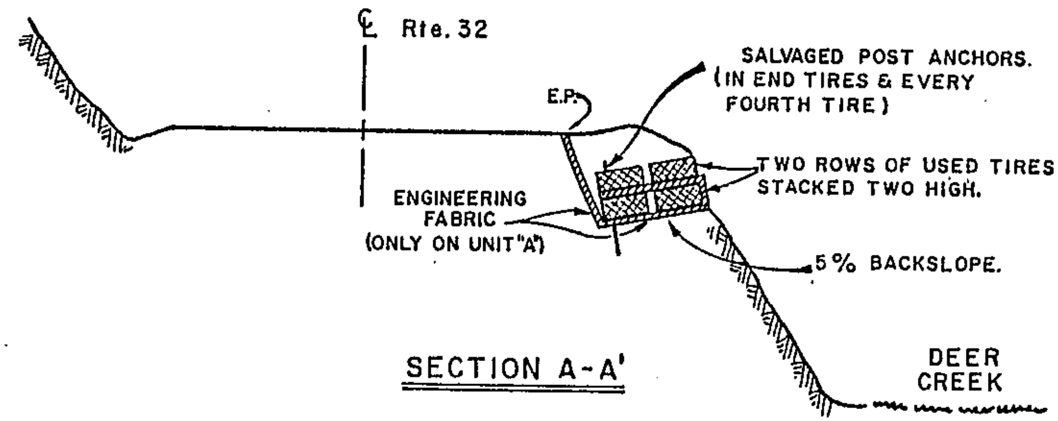


NOTE

Four tire installations, installed in November 1980

Two tire installations, installed in December 1981

NOT TO SCALE



SECTION A-A'

FIGURE 7.2

Photo 7.2 - Unit "A" Installation

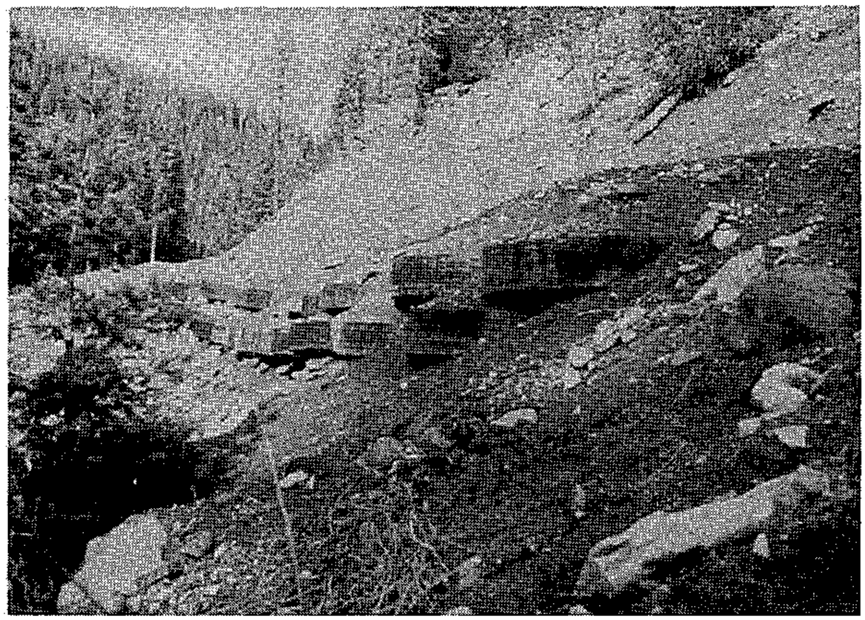


Photo 7.3 - Unit "B" Installation

of the installations for controlling erosion. Clips made of 1/2 inch steel reinforcing bars were used to hold the tires in point contact thereby forming a continuous mat (Figure 7.3). Salvaged anchor posts were used to secure the tire assembly to the embankment.

Figure 7.2 shows the location of the six discarded tire shoulder reinforcement units. Four of the units were placed by the District in 1980 and the other two units were placed in 1981 as part of this research project. The research project units were located north of the existing discarded tire units on Route 32 at Post Mile 22.7. Subsequent to these six installations district maintenance forces have installed several discarded tire shoulder reinforcement units along Route 32.

Two modifications to the original method were introduced in the installation of the two 1981 research projects. The modifications to the 1980 installations were the addition of anchor posts and engineering fabric.

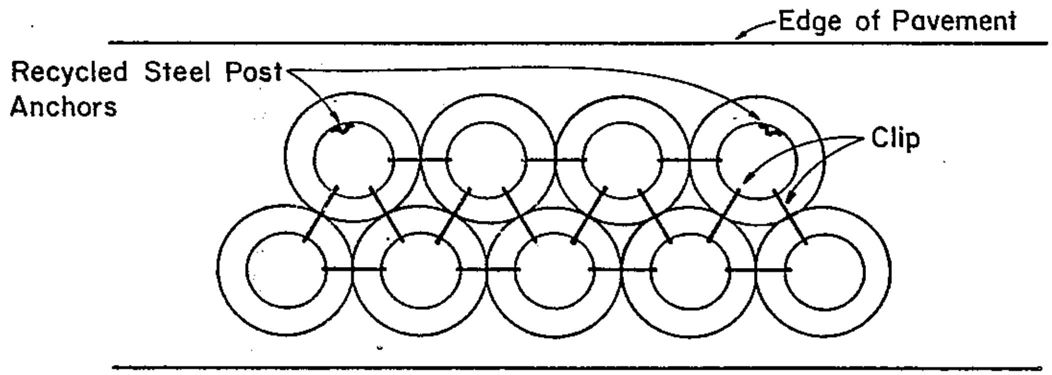
7.4 Installation Procedure

A bench was cut about five feet below the top of the pavement (Photo 7.4) and sloped slightly (-5%) towards the traveled way. The width of the cut was the width of the truck tire mat plus a minimum of six inches. This extra width was to prevent undercutting of the tire unit by erosion. On Unit "A" engineering fabric was placed behind, under and over the tires to prevent soil from eroding (Photo 7.5 & Figure 7.2). As a comparison (control section) fabric was not used in Unit "B".

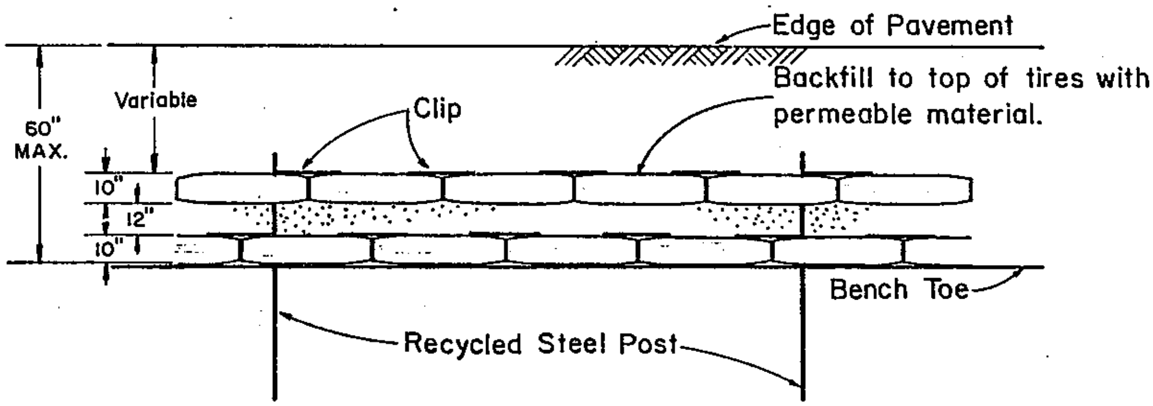
The tires were connected using clips which were made from 1/2 inch steel reinforcing bar. Salvaged snow poles were

TIRE PROJECT I

RECYCLED TIRE INSTALLATION FOR UNIT "A" & "B"



PLAN



ELEVATION

NOTE:

Tires horizontally secured by 1/2" rebar clips.

Engineering fabric, see Figure 7.2 .

FIGURE 7.3

Photo 7.4 - Bench Excavation - Unit "A"

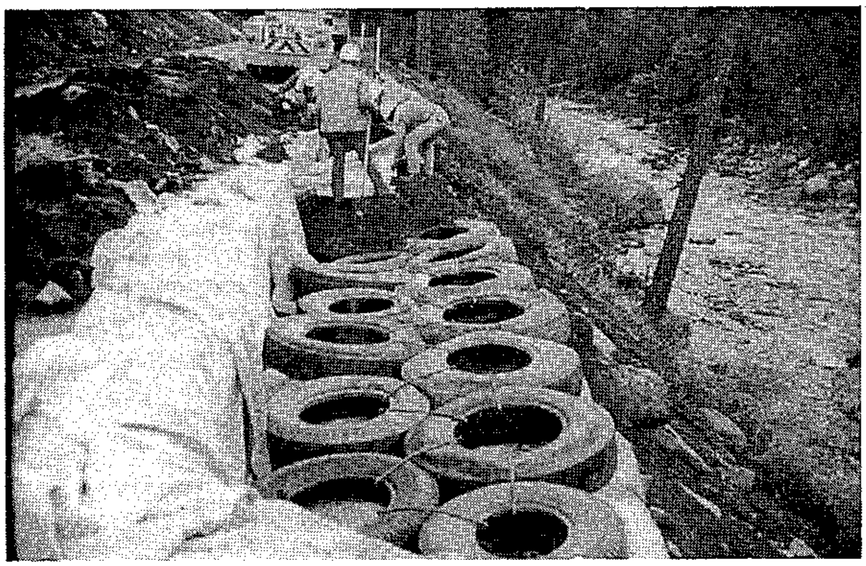


Photo 7.5 - Tire Placement With Engineering Fabric
Unit "A"

driven through the hole of every fourth tire in the inside row (Photos 7.6 & 7.7 and Figure 7.3). The top of the pole was driven flush with the top of the second layer of tires. The tires were placed in parallel rows and backfilled with imported permeable material (Photo 7.6). A 12 inch layer of permeable material was placed on top of the first layer of tires. Then the second layer of tires was placed and backfilled. To provide an unpaved shoulder an 18 inch layer of native soil was placed on top of the tires and compacted.

7.5 Components

7.5.1 Tires

Truck tires were used extensively for this project. They were obtained from local tire shops at no cost and stockpiled at the Chester Maintenance Station. As the two projects developed, additional tires were obtained and transported to the project. The truck tires varied in outside diameter from 40 inches to 42 inches. This variation in size tended to create some difficulty in developing a uniform installation. However, most of the irregularities can be overcome by adjusting the tire clips (Photos 7.8 and 7.9) to obtain the desired configuration of the tire mat.

The condition of the tire carcass is important in the construction of the mat. Tires with weak tread or sidewalls, tended to create stacking and alignment problems.

New truck tires weigh between 90 and 200 pounds (2) and light truck tires weigh between 30 and 60 pounds. Weight loss as the result of wear is estimated to be approximately fifteen percent. The average weight for used truck tires is estimated to be 85 pounds. They are easily managed by

Photo 7.6 - Backfilling With Permeable Backfill

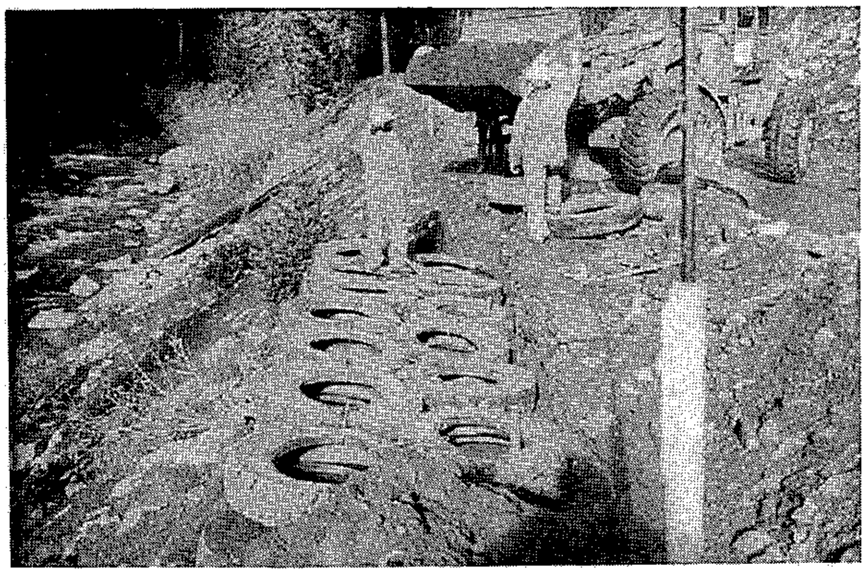


Photo 7.7 - Unit "B" Without Engineering Fabric

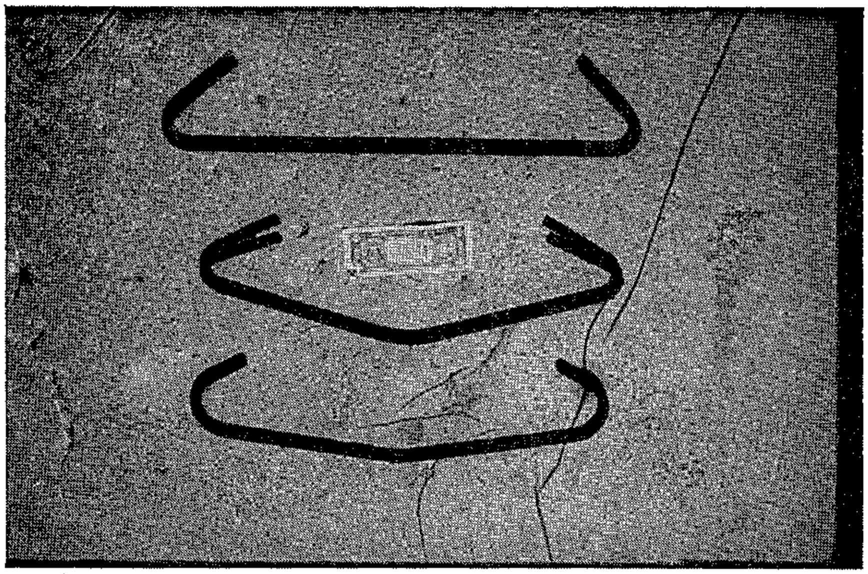


Photo 7.8 - 1/2" Rebar Tire Clips

Photo 7.9 - Assembling Truck Tire Mat

two people. Used automobile tires weigh between 15 and 30 pounds, averaging 22 pounds. Careful selection was necessary to insure that the stability would remain in its manufactured form after installation in the embankment.

Unit "A" (Figure 7.2) was installed with engineering fabric and required the use of 40 tires for the mats. Unit "B" (Figure 7.2) required the use of 30 tires and was constructed without the engineering fabric.

7.5.2 Engineering Fabric

As a result of a soil erosion problem on the previously installed shoulder reinforcement projects, it was decided to investigate the use of engineering fabrics. In order to evaluate the performance of the fabric it was installed on only one of the two research sites. The fabric was placed around the tires in Unit "A" as depicted in (Photo 7.5 and Figure 7.3). Unit "A" with the engineering fabric did much better in retaining material than Unit "B" (without the fabric). Some fabrics, if exposed to sunlight, deteriorate quickly from the ultraviolet rays. It is recommended that engineering fabrics that have been treated to resist ultraviolet degradation be used.

7.5.3 Tire Clips

Originally, the use of heavy duty commercial staples was considered as a method for connecting the tires in the mats. However, as part of a previous research project (3), it was found that the staples failed to develop sufficient resisting force to mobilize the inherent tensile strength of the tire sidewalls. The method chosen for connecting the tires was the use of 1/2 inch steel reinforcing bar bent into the form of a clip (Photo 7.8). These clips provide a strong connection and a longer corrosion life.

The effect of corrosion on the tire clips was considered in determining the size of the rebar required. The Translab estimates soil corrosivity by combining the relative influences of the hydrogen-ion concentration (pH) and the minimum resistivity of the soil. Samples of soil scheduled for an embankment were tested for potential corrosivity. The material was found to have a pH of 5.5 and an average min imum resistivity of 2400 ohm centimeters. This data indicated that the metal loss would be approximately 10 mils per year. This was interpreted as a weight loss of about 0.8 ounces per year. Based on this information, a 3/8 inch rebar was estimated to have an effective life of over 40 years. Therefore, the decision to use 1/2 inch rebar clips was made in order to provide an extra safety factor. Photo 7.9 shows the formation of a tire mat by using clips on the truck tires.

<u>7.5.4 Backfill</u>

Backfill for units "A" and "B" was imported permeable material from the local area. It was determined that the material taken from the excavation was not suitable for the project backfill due to its low permeability. However, existing excavation material should be used as backfill whenever possible. Backfill material should have some cohesive quality and be free-draining. If possible, all voids in the tire should be filled (spreading the sidewall during backfilling) to prevent excessive settlement. If compaction is less than 90 percent, it should not pose a problem, as this portion of the roadway section is not intended to support wheel loads. Some minor settlement of the backfill occurred subsequent to the completion of the installation.

7.5.5 Salvaged Anchor Posts

The posts selected for anchoring the tire mats to the fill were salvaged 10 foot snow poles. It was originally planned to use metal fence posts but they were not available. The anchorage device is not limited to any specific type of post providing it is adequate to secure the tire mats.

7.5.6 Revegetation

In the spring of 1982 after this project was completed, maintenance personnel planted two rows of (approximately fifty) western redbud (Cercis occidentalis) on the slope below the tire installations. This was done to accelerate the reestablishment of vegetation. The plants were spaced from 3.5 feet to 4.5 feet apart and were not watered at the time of planting. The Western Redbud is native to California and found in the Sierra foothills and Coastal Ranges at elevations between 1000 and 4500 feet.

In the fall of 1983, 38 woody plants were planted in a 15 by 25 foot test plot below the tire installations as shown in Figure 7.4. This planting consisted of the following:

18 - 1-gallon	Manzanita (Arctostaphylos) (Photo 7.10)
15 - liners	Deer brush (Ceanothus integerrimus) (Photo 7.11)
5 - 1-gallon	Deer brush (Ceanothus integerrimus)

TIRE PROJECT I
FALL AND SPRING PLANTINGS

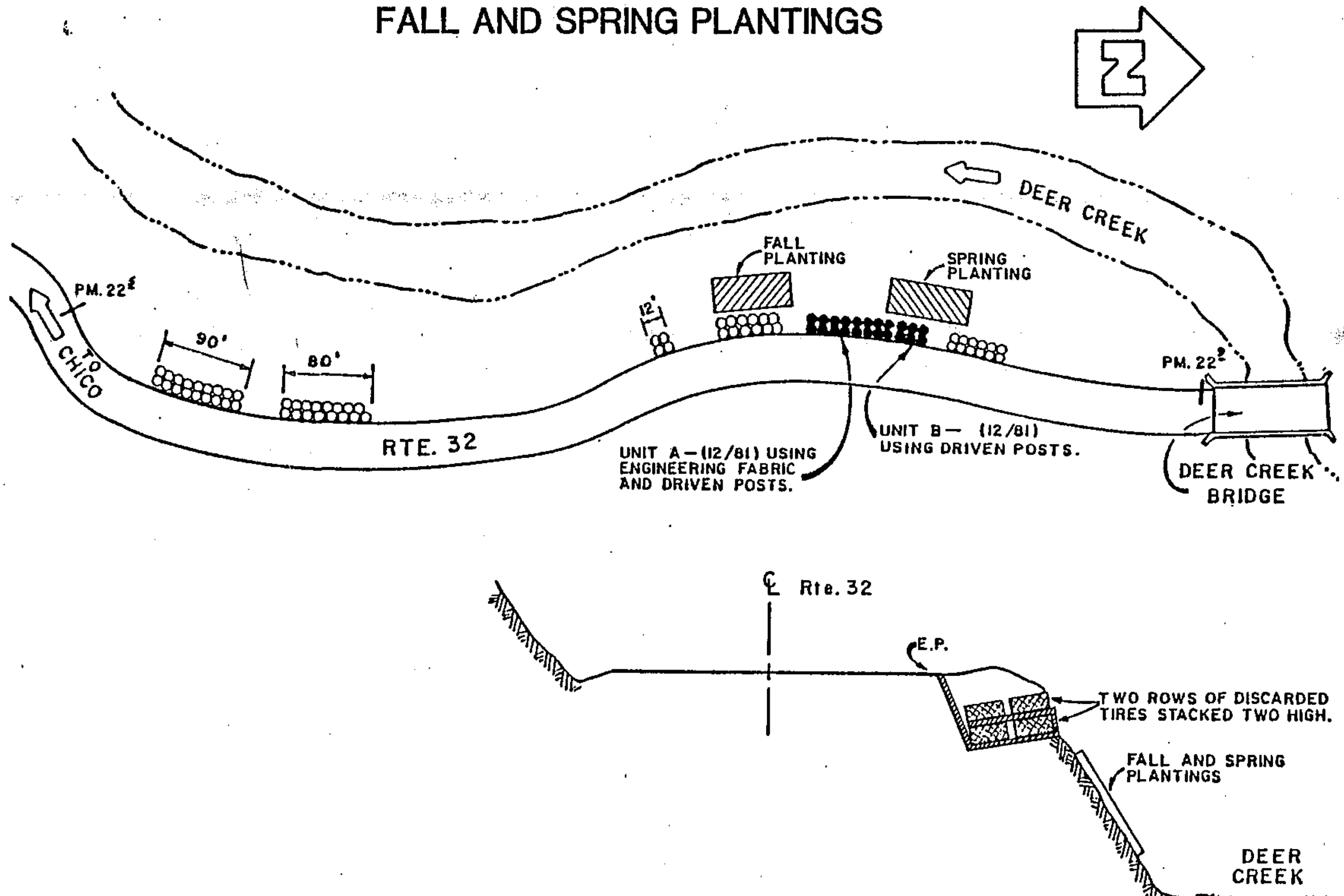


FIGURE 7.4

Photo 7.10 - Manzanita (Arctostaphylos)

Photo 7.11 - Deer Brush (Ceanothus Integerrimus)

In the spring of 1984, 35 woody plants were planted in a 15 by 25 foot test plot below the tire installation as shown in Figure 7.4. This planting consisted of the following:

19 - 1-gallon	Manzanita (Arctostaphylos)
16 - liners	Deer brush (Ceanothus integerrimus)

The selection of these plants was the result of an earlier investigation to determine the varieties of native plants growing on the site.

An additional measure taken during the spring planting was the installation of metal cages to protect the plants from foraging animals and provide the plant some protection from erosion. The planting plot was separated into two sections. One section included the metal cages and the other did not. After 13 months 50 percent of the manzanita and 29 percent of the deer brush survived where the metal cages were used. During the same period and where no cages were used only 17 percent of the plants remained. It is reasonable to assume that the metal cages did help protect the seedlings from animals and from erosion covering the small plants.

The plants for the fall and spring plantings were obtained from the California Conservation Corps Native Plant Nursery in Napa, California. The manzanita was from 4 to 6 inches in height and the deer brush was from 2 to 3 inches in height. Leaf color and foliage on both varieties were good. The plants were hardened at the Chester Maintenance Station for 20 days prior to planting. At the time of planting, the soil two inches below the ground surface was moist. Plants were watered when planted, but there was no supplemental watering. No nutrient additives were used during the planting, as the intent was to establish the plants in the native soil only. Plants were spaced

2.5 feet apart in a mixed selection on the slope. Included in the test plots were eight of the western rosebuds planted in 1982 by maintenance forces.

The lower slope used for vegetation test plots consisted of slopes ranging from 1:1 to 2:1, 30 feet high and west-facing at an elevation 4500 feet. The surface of the slopes was a rocky, brown, silty sand (Photo 7.12). The slope was slightly rilled with very little vegetation present.

7.6 Personnel, Equipment And Materials

The installation of the 40 foot tire Unit "A" and the 27 foot tire Unit "B" took 16 hours each. The following personnel, equipment and materials were used on the project.

Personnel: 1 - Foreman
3 - Maintenance Workers

Equipment: 1 - Dump Truck
1 - Pickup
1 - Backhoe and Loader

Material: Engineering Fabric - 80 square yards
Tires - Unit "A"-40 and Unit "B"-32
Clips - 180
Backfill Material - 18 cubic yards
Recycled anchor posts - 10

7.7 Installation Costs

Cost for Unit "A" and Unit "B" combined was as follows:

Cost of Material	$ 100
Cost of Labor	$ 2,774
Cost of Equipment	$ 1,245
Total 67ft - 5 feet high	$ 4,119* ($60 per linear foot)

* 1986 cost

Photo 7.12 - Project Site Material

An estimate from the Caltrans Bridge Department for a comparable reinforced concrete type retaining wall would be $250 per lineal foot for a five foot high wall.

7.8 Cost Comparison For Alternative Reinforcing Systems

The following cost comparison is the cost per lineal foot based on a wall height of five feet. These costs include all labor, materials and equipment for excavation, erection and backfilling.

Discarded Tire Wall	$ 60.00
Gabion Wall	$ 125.00
Concrete Crib Wall	$ 175.00
Reinforced Concrete	$ 250.00

The cost comparisons were taken from Caltrans Report FHWA/CA /TL-84/16, "Field Performance of Experimental Tire Anchor Timber Walls"(4). The cost for the Discarded Tire Wall is for a wall installed by Caltrans maintenance personnel. Gabion wall cost was derived from 1986 statewide averages. The alternative walls are contractor-installed costs. A contractor-installed discarded tire wall would exceed the maintenance unit cost as the result of smaller projects, and move-in and move-out costs at remote locations.

7.9 Monitoring

The project work plan for monitoring the project consisted of the following:

- The overall project and the stability of the horizontal rows of tires was determined by visual inspection and photographic log.

- Undermining of the slope by erosion was monitored visually.

7.9.1 Instrumentation

Survey points were established by driving masonry nails into the sidewalls of the tires at their outside edge. The nails were placed approximately every ten feet along the tire installation to document vertical and lateral movement. Elevation reference points were placed along the centerline of the traveled way, on the edge of pavement and on the tires. They were monitored to detect vertical displacement during the study. During the initial monitoring, a string line was used to measure the offset resulting from vertical or horizontal movements. String line and elevations (Photo 7.13) taken during and at the conclusion of the study indicated there had been neither significant settlement nor horizontal movement.

7.9.2 Settlement And Stability Of The Tires

The survey points on the tires indicated the movement was undetectable during the research period. Elevation reference points on pavement indicated settlement of less than .04 of a foot. There were 2 inches of initial settlement of backfill material at the location immediately after installation of the project.

7.9.3 Shoulder Cracks

Several small cracks developed immediately after installation of the tires in Unit "A". Subsequent to patching by maintenance forces no further cracking or significant movement in the tires or pavement in either the test sites "A" and "B" occurred (Photo 7.14).

Photo 7.13 - String line And Elevations On Tires

Photo 7.14 - Shoulder Cracking

7.9.4 Erosion

Erosion was monitored visually as well as by string line stretched across the area below the tires. There was considerable undermining due to erosion at the outside edge of the bottom row of tires on both sections. However, the tire-earth system remained stable during the entire study. Engineering fabric was placed under and behind the tires in Unit "A". This was done to prevent soil erosion from behind the tires and in the event that the tires were severely undermined it would prevent the backfill material from washing out. There was less erosion and undermining in Unit "A" with the engineering fabric than with Unit "B" without engineering fabric (Photos 7.15 & 7.16).

7.9.5 Revegetation - Survival And Growth

Sixteen months after the fall 1983 planting there were 5(28%) 1-gal manzanita and 1 deer brush remaining. This heavy loss of plants in the fall plant was the result of debris from snow removal operation covering the young seedlings before they became established.

In the spring 1984 Planting, 32% of the manzanita remained and 25% of the deer brush. Initially in the spring planting half of the plants were protected from animals by the installation of plastic cages (later these were replaced with metal cages). Although there is fauna in the area, there was no browsing during the course of the study. The plant cages primarily protected the plants from erosion.

Evaluation of the fall 1983 and spring 1984 plantings indicated marginal success. This lack of success is believed to be the result of winter roadway cleanup debris overtopping the plants.

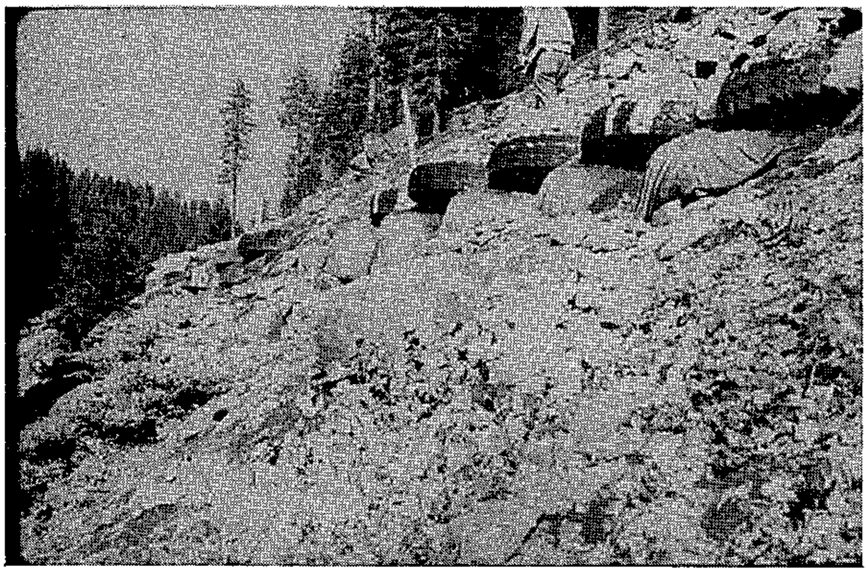


Photo 7.15 - Unit "A" Site (1983)

Photo 7.16 - Unit "B" Site (1983)

At the conclusion of the study in mid-1985, 5 (10%) of the western redbud plants remained of the original 50 that maintenance had planted in the project area.

In summary, at the conclusion of this research (Photos 7.17 & 7.18), manzanita from the one gallon containers that were protected from animals and erosion by wire cages showed the best survival rate. The study period was 19 months for the fall plant and 13 months for the spring plants. This is a relative short duration for obtaining conclusive data for revegetation research. A larger, more extensive planting project, extending over a longer period of time would provide more conclusive results.

7.9.6 Precipitation

The amount of rainfall and snow cover was recorded to assist in the analysis of erosion. In October 1982, three rain gauges were installed on the project (Photos 7.19). Due to vandalism, snow and freeze-thaw conditions, readings were unreliable. Weather information from the stations within the area shown on Table 7.1 were determined to be sufficient for necessary weather data.

Precipitation for the area was estimated from data recorded at the National Oceanic and Atmospheric Administration (NOAA) Weather Station located in Mineral (Photo 7.20), 17 miles west of the project and the U.S. Forest Service Weather Station at Chester (Photo 7.21), 12 miles east of the project. The average annual rainfall in this portion of Tehama County varies from approximately 33 inches at Chester Weather Station, to 53 inches at the Mineral Weather Station. The reason for less rainfall in the Chester area is that Chester lies within the rain shadow of an eastern slope, and thus, receives less rainfall from

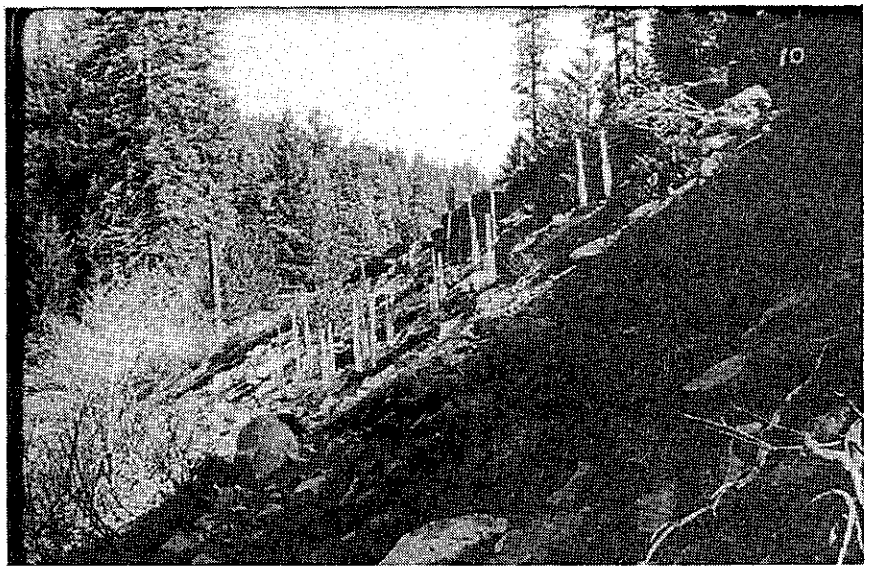


Photo 7.17 - Fall Plant (1983) - Plastic Cages

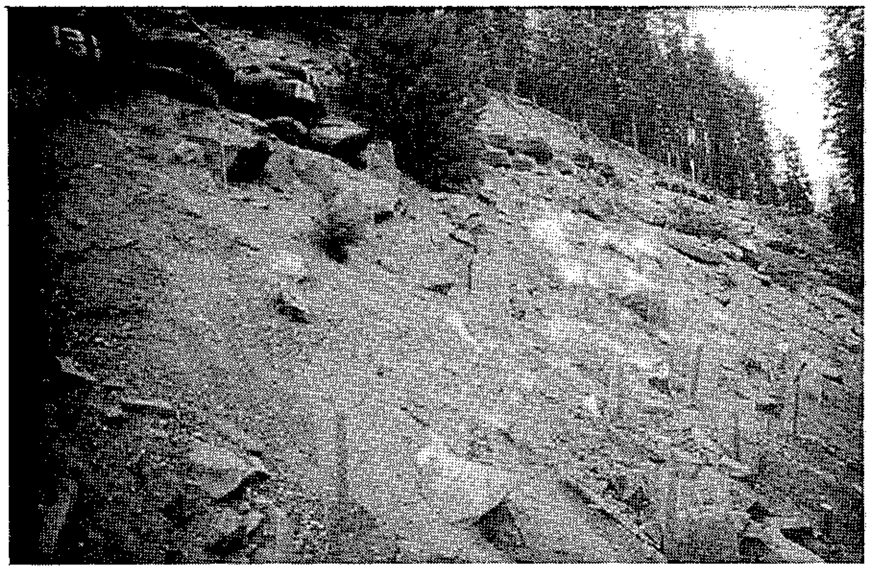


Photo 7.18 - Spring Plant (1984) - Metal Cages

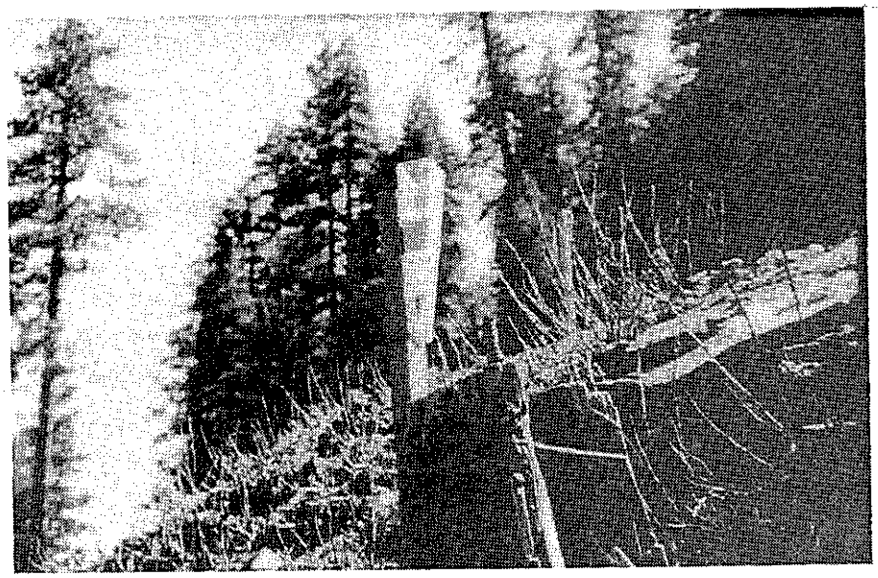


Photo 7.19 - Rain Gauge

TABLE 7.1

PRECIPITATION SUMMARY

TOTAL RAINFALL (inches)

(July 1 - June 30)

YEAR	CHESTER	MINERAL
	*(33.09)	*(53.45)
82-83	57.20	101.72
83-84	36.48	67.42
84-85	21.43	34.81
85-86	27.89	50.66

*Normal Annual Rainfall

LOCATIONS OF WEATHER STATIONS

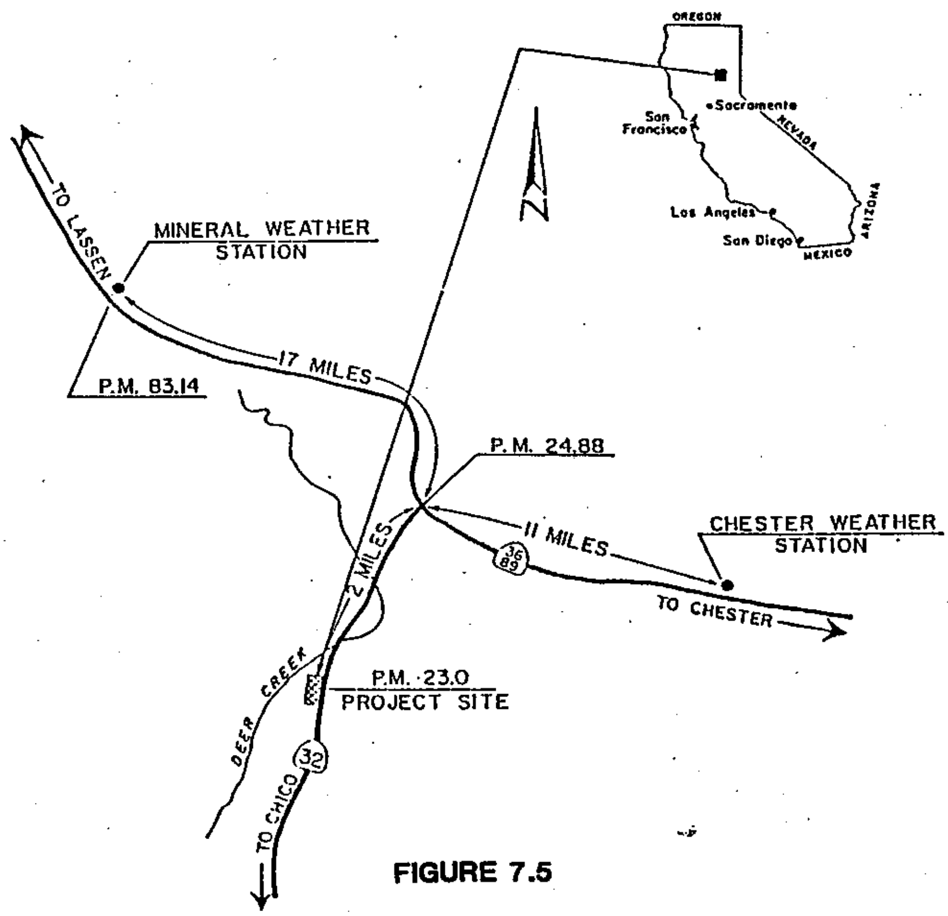


FIGURE 7.5

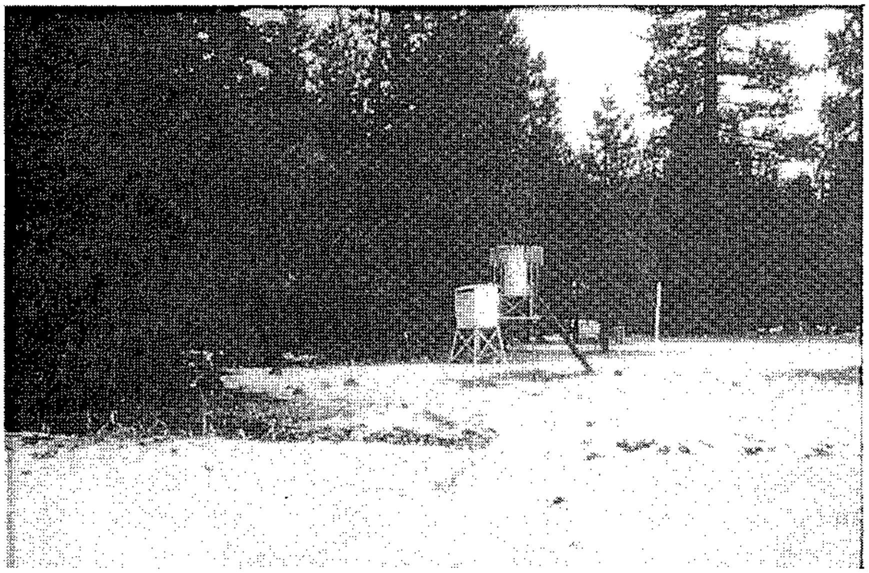


Photo 7.20 - Weather Station (Mineral)

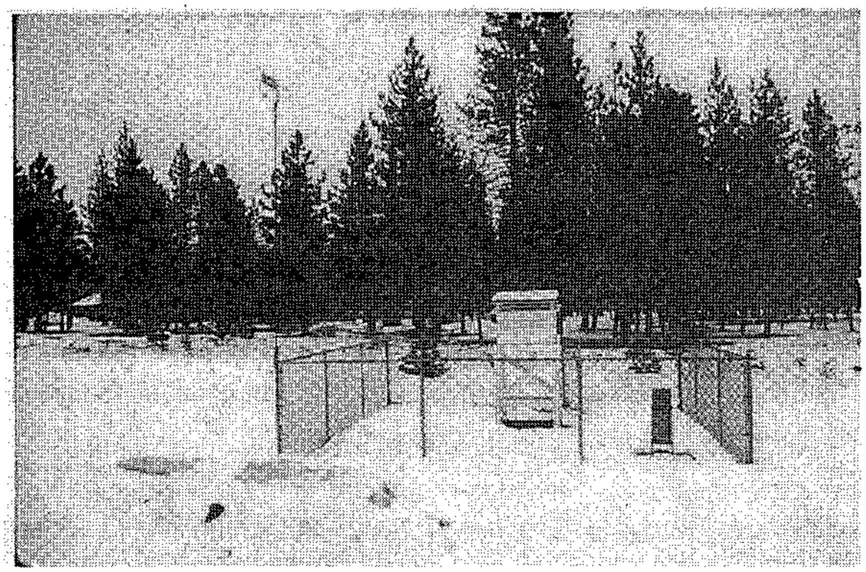


Photo 7.21 - Weather Station (Chester)

winter storms. Rainfall in the project area (Table 7.1) was above normal with the exception of FY 84/85. In Table 7.2 monthly rainfall data are listed for both stations between July 1982 and June 1986.

There was approximately 12 to 30 inches of snow cover between December and February 1983 at the project (Photo 7.22). Average snow depths ranged form 12 to 48 inches on the project site during the winter months.

7.10 Aesthetics

Aesthetically, the tire carcasses were embedded under the shoulder and were generally not visible from the roadway. Planted and native growth tend to camouflage the assemblages and blend the installation with the surrounding terrain.

The District Landscape Architect made visual observations of the slope during the research study to determine if the installation presents any negative visual effect. It was felt tires used on the lower slope in areas of low visibility would be acceptable.

7.11 Appendix: Guidelines.

Figure 7.6 contains the guidelines for shoulder stabilization using recycled tires.

Table 7.2

PROJECT I

MONTHLY PRECIPITATION DATA (inches)

FISCAL YEAR	MONTH	CHESTER	MINERAL	FISCAL YEAR	MONTH	CHESTER	MINERAL
82-83	7	0.41	2.23	84-85	7	0.05	0.00
	8	0.31	0.28		8	1.53	1.52
	9	1.23	2.24		9	0.98	0.27
	10	5.68	10.80		10	2.40	5.96
	11	6.44	9.47		11	8.46	13.88
	12	7.31	11.66		12	0.92	2.45
	1	8.54	14.20		1	0.79	1.27
	2	11.43	15.68		2	2.16	3.68
	3	10.70	24.23		3	3.37	4.56
	4	4.12	5.96		4	0.40	0.52
	5	0.21	3.11		5	0.33	0.55
	6	0.82	1.90		6	0.04	0.13
82-83	TOTALS	57.20	101.76	84-85	TOTALS	21.43	34.81
83-84	7	0.03	0.30	85-86	7	0.00	0.00
	8	0.43	0.51		8	0.12	0.10
	9	0.90	1.87		9	2.43	5.60
	10	2.07	2.52		10	1.34	2.20
	11	11.19	20.81		11	5.25	6.88
	12	11.65	22.01		12	2.58	4.82
	1	0.23	0.55		1	6.26	10.89
	2	2.72	5.69		2	1.26	2.16
	3	3.33	5.60		3	3.91	11.63
	4	1.68	4.04		4	1.68	2.19
	5	0.97	1.22		5	2.19	4.01
	6	1.28	2.30		6	0.87	0.18
83-84	TOTALS	67.42	36.48	85-86	TOTALS	27.89	50.66

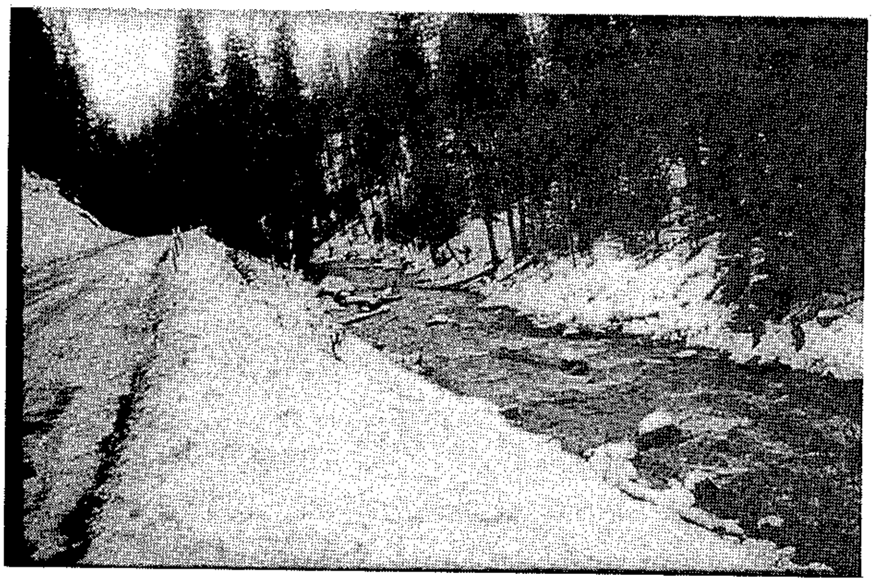
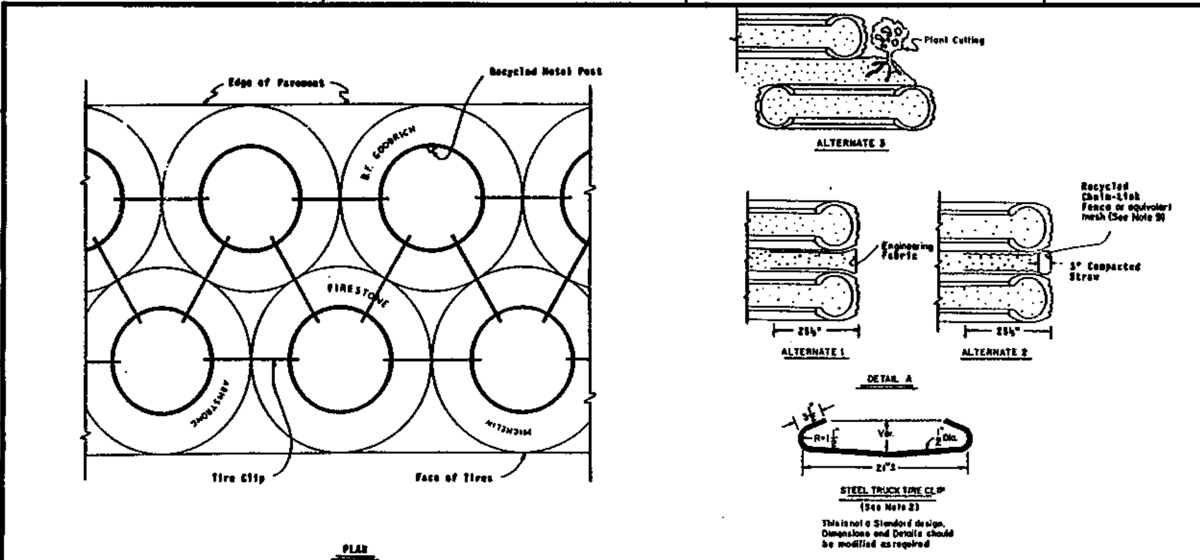
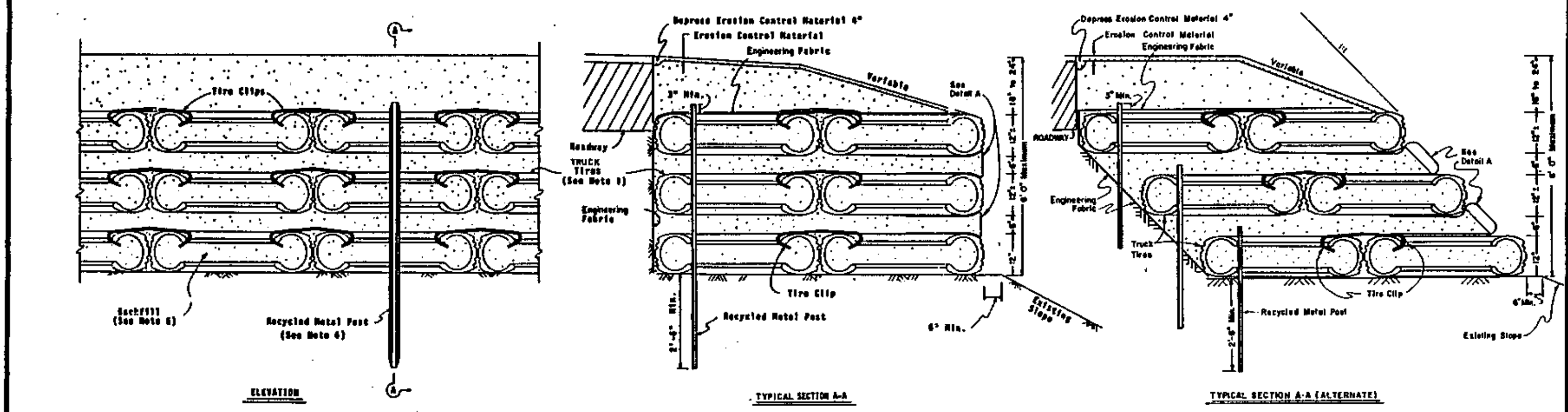


Photo 7.22 - Site In Winter



Notes:

1. Scrap tires will be in such condition as they will retain original manufactured shape when stacked.
2. Steel tire clip is to be made of "cold rolled" 1/2" diameter steel. All measurements, except bend radius, are to center of bar, bend radius is inside diameter.
3. All posts shall be recycled metal posts in good condition.
4. Post shall be secured tightly against bead on inner row of tires, placed at a minimum of every other tire and at ends of tire mats.
5. Excavated material may be accepted for backfill provided it will be readily consolidated with the use of hand held vibratory compactors.
6. Ponding and jetting may be permitted if it will not damage foundation material, will not develop hydrostatic pressure on the tire unit, and if the backfill material is free-draining.
7. Sidewalls of tires should be spread during backfilling operations to facilitate adequate compaction.
8. Salvaged materials shall be state furnished, if available.
9. Ends of mesh shall be lapped 6" and secured with hog rings or 14-guage wire.
10. Tires shall be used on lower slopes and in locations not visable to the motorist.
11. Painting the tires to blend with the surrounding terrain will improve the aesthetics of the installations



TRANSPORTATION LABORATORY
State of
CALIFORNIA
DEPARTMENT OF TRANSPORTATION

SHOULDER STABILIZATION WITH RECYCLED TIRES

SCALE NONE

FIGURE 7.6

8. PROJECT II - CHANNEL SLOPE PROTECTION WITH RECYCLED TIRES

8.1 Introduction

Considerable scour occurs in drainage channels on many of the highway right-of-ways throughout the San Joaquin Valley. This scour is due to the highly erodible nature of the non-cohesive soils found in this area. Project II addresses this erosion problem through the use of discarded tires as a means for shielding the channel banks from storm water runoff. The site chosen for this project is located in Fresno County, on Route 5 at post mile 0.43, the Lassen Avenue Overcrossing interchange (Figure 8.1).

8.2 Background

In 1978, Caltrans District 06 maintenance forces installed discarded tires to provide channel bank protection at the Lassen Avenue Overcrossing interchange. The channel banks in this area had severely eroded up to the adjacent private property (Photos 8.1 & 8.2). Maintenance installed two discarded tire units (Figure 8.2, Units "A" & "B") along the lower portions of the drainageway. These installations were necessary to restore the channel banks downstream from a 66 inch reinforced concrete pipe culvert. The waterway before the discarded tires were installed consisted of a 275 foot length of channel 20 feet wide with approximately 2:1 side slopes. At this point the channel widens to an undetermined width until it reaches a 54 inch culvert at Lassen Avenue approximately 500 feet downstream.

Unit "A" (Figure 8.2) was a 200 foot section of truck tires which were placed against the north bank. The tires were stacked side by side, seven to eight tires high. To secure

TIRE PROJECT II

LOCATION MAP

06-Fre-5 P.M. 0.4
RECYCLED TIRES IN DRAINAGE CHANNEL

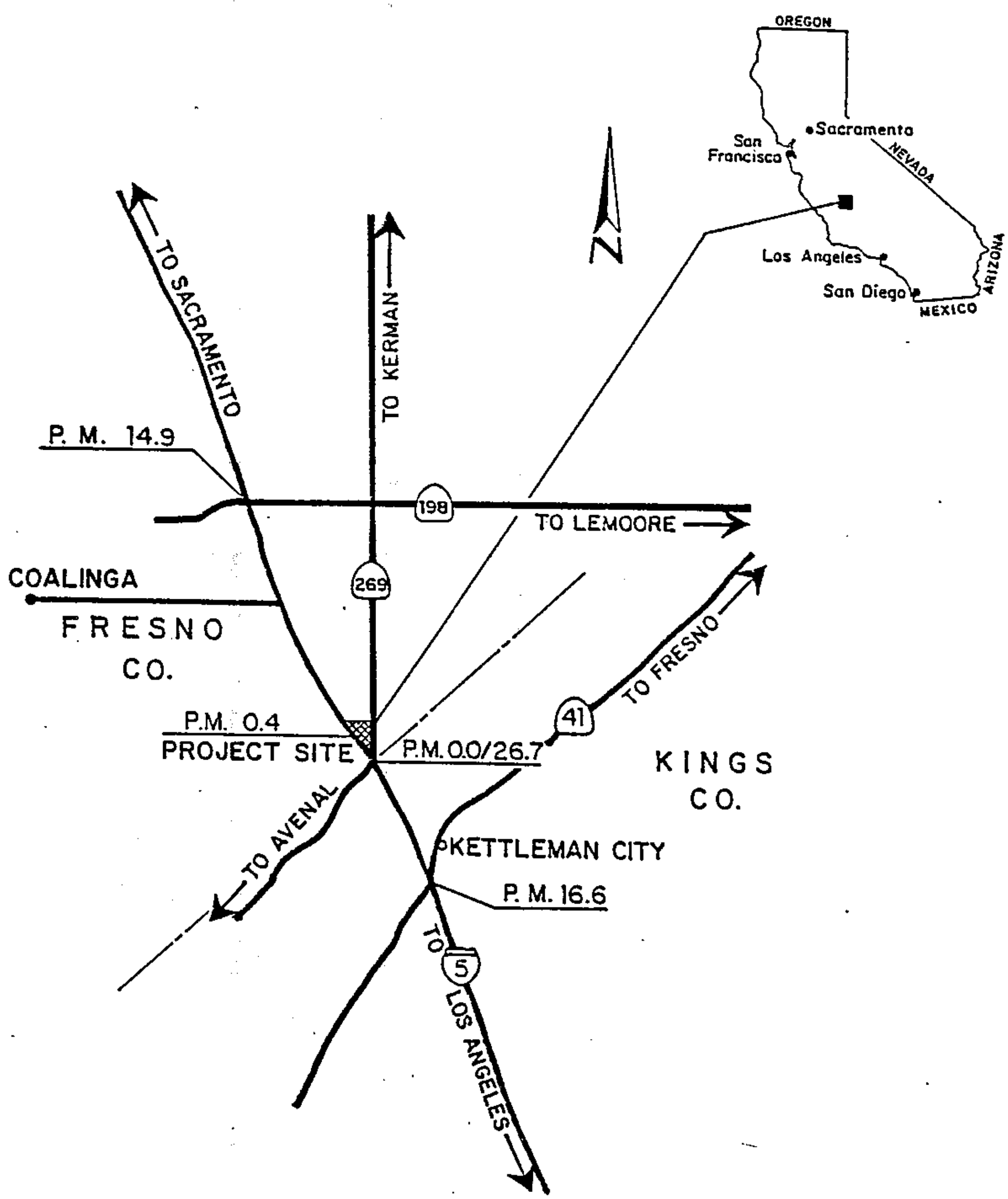


FIGURE 8.1

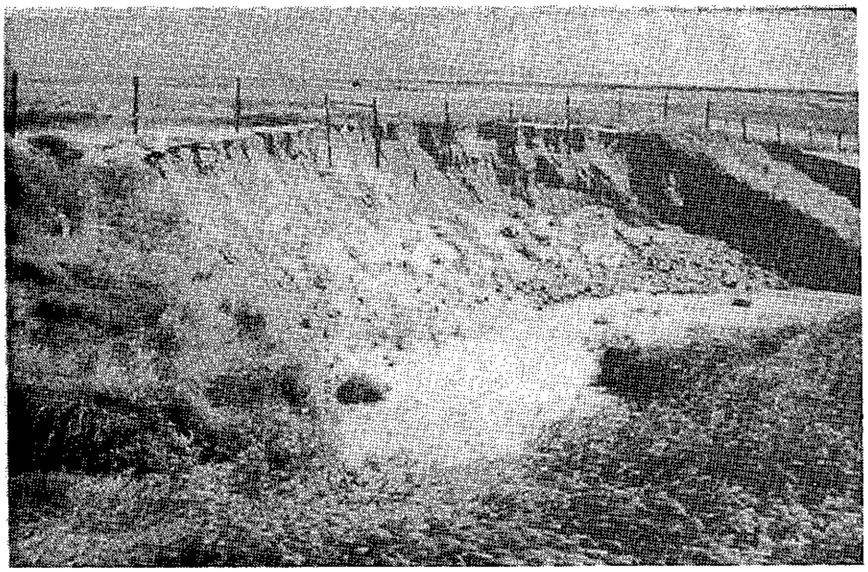


Photo 8.1 - Unit "A" - Eroded Channel Slope (1978)

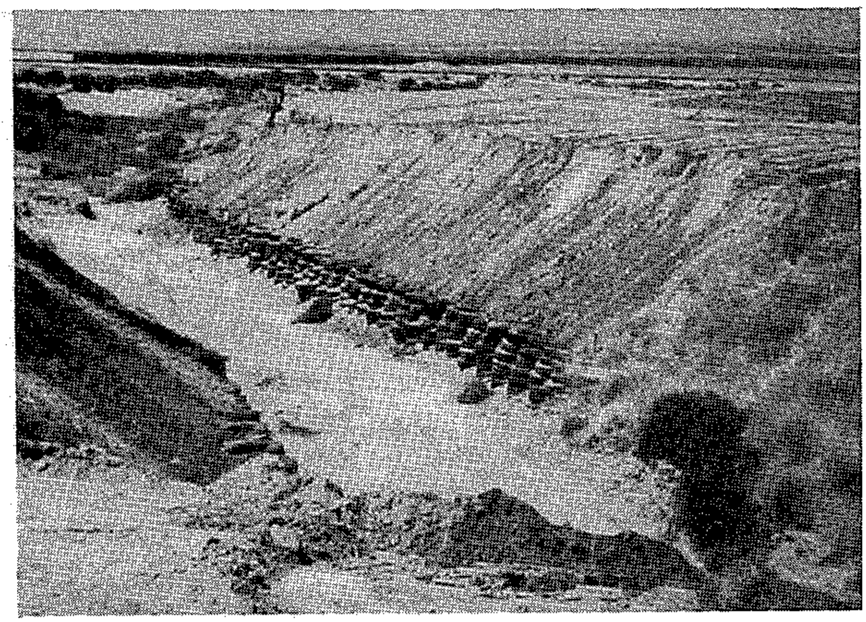


Photo 8.2 - Unit "A" - Channel After Tire Installation (1978)

TIRE PROJECT II

SITE PLAN

RECYCLED TIRES IN DRAINAGE CHANNEL

06-Fre-5 P.M. 0.43

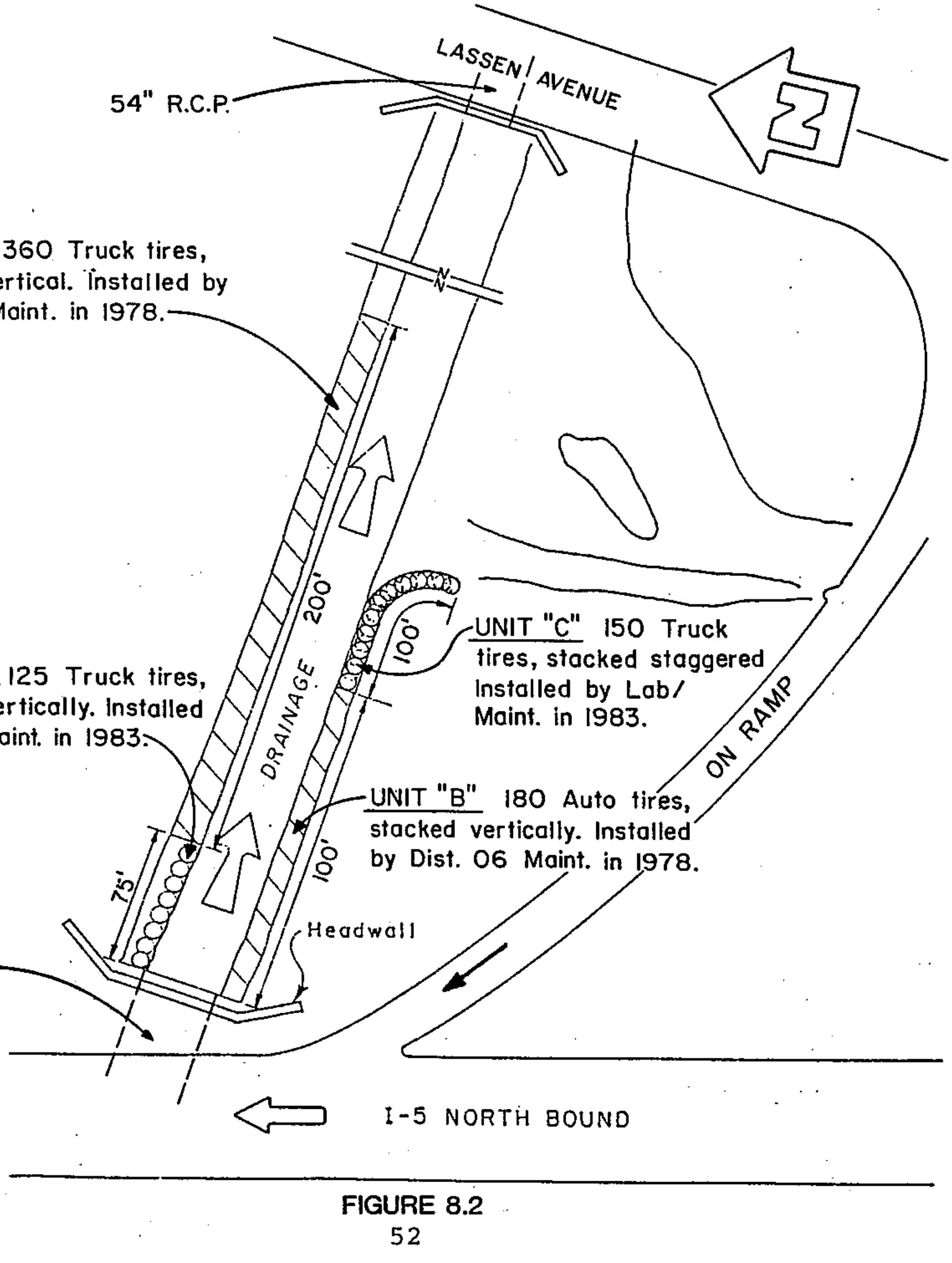


FIGURE 8.2

the tires in place, posts were driven at each end of the unit with #8 gauge wire strung horizontally between them. Wire was then laced through each stack of tires and secured to the horizontal wires. Tires were backfilled with the native excavated material. Unit "B" (Figure 8.2) was composed of discarded automobile tires. This unit, 100 feet in length was placed on the south bank of the channel and constructed in the same fashion as Unit "A".

The installations were very successful in mitigating the scour problem and subsequently, the channel banks were revegetated (Photo 8.3). In subsequent years several additional sections (locations Unit "C" & "D")of the channel had eroded and it was decided to study the use of discarded tires through a research project. The research project would investigate the configurations and interlocking procedures needed and develop guidelines for the use of discarded tires for scour control.

Due to the continuing channel bank erosion it was decided to extend the existing bank protection. Unit "C" would be an extension of Unit "B" and Unit "D" would be an extension of Unit "A" (Figure 8.2).

8.3 Design Description

As part of the research project two sections of channel bank protection were evaluated. In February 1983, the two research units "C" & "D" were installed. Unit "C" consisted of 150 discarded truck tires. The unit measured approximately 100 feet long and was placed against the south bank (Figure 8.2). Unit "D" consisted of 125 discarded truck tires placed along the north side (Figure 8.2) and measured 75 feet long. All preliminary work,

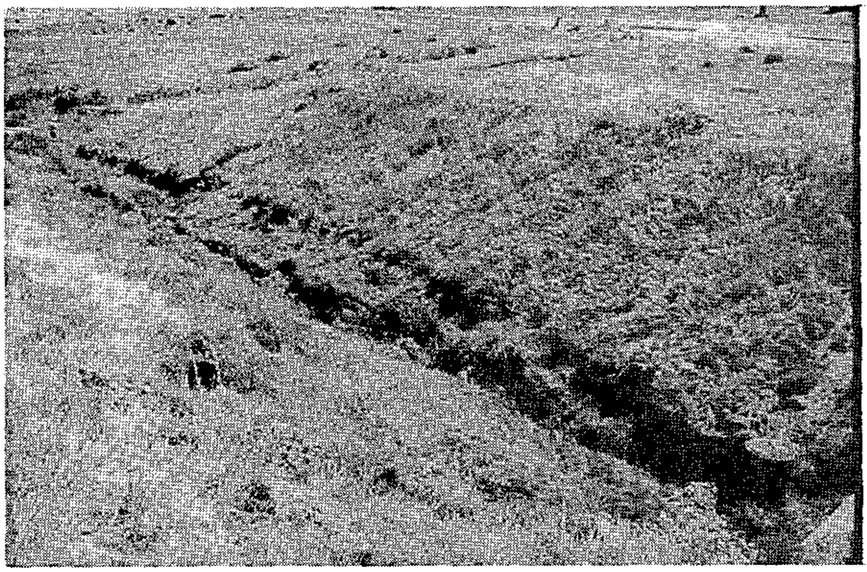


Photo 8.3 - Units "A" & "B" Revegetated Slopes (1983)

including material, transportation and site excavation was performed by District 06 maintenance personnel.

8.4 Installation Procedure

For both discarded tire research units a foundation of one tire in depth was dug in order to provide a stable footing (Figure 8.3). The channel banks were excavated and sloped to a slight batter of approximately one in twenty to insure the stability of the tire wall. Engineering fabric was placed under and behind the tires as shown in (Photo 8.4 and Figure 8.3).

In Unit "C" truck tires were placed in a staggered configuration similar to construction of a brick wall (Figure 8.4). The bottom five layers of tires were banded together and the top four layers were banded together with and overlapped into the bottom five layers as shown in Figure 8.4. The south end of Unit "C" was turned into the slope to prevent water from flowing behind the tires and causing soil to erode. At the west end of Unit "C", a staggered tire configuration meets with Unit "B", a vertically stacked configuration. With the two dissimilar configurations, keying Unit "C" into the channel bank, as shown in Figure 8.4, prevented water from getting behind the tires and further eroding the slope.

For Unit "D" the truck tires were stacked eight high in straight columns (Figure 8.5). Unit "D" was not keyed into the channel bank due to abutting a headwall at one end and "Unit "A" with a similar stacking configuration at the other. The tires were then strapped together both horizontally and vertically using 1/2 inch wide polypropylene strapping.

PROJECT II

TYPICAL CROSS SECTION FOR UNITS "C" & "D"

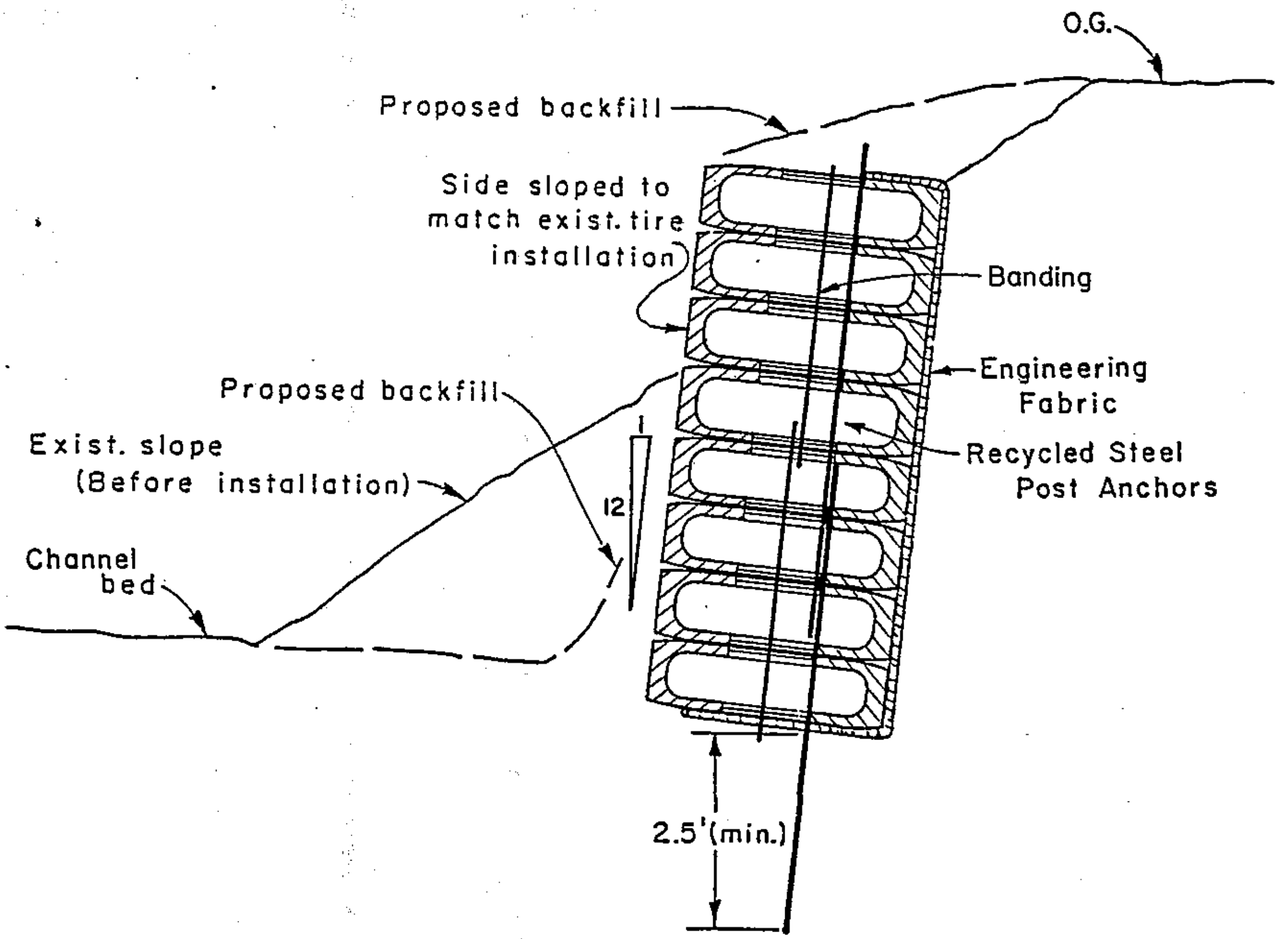
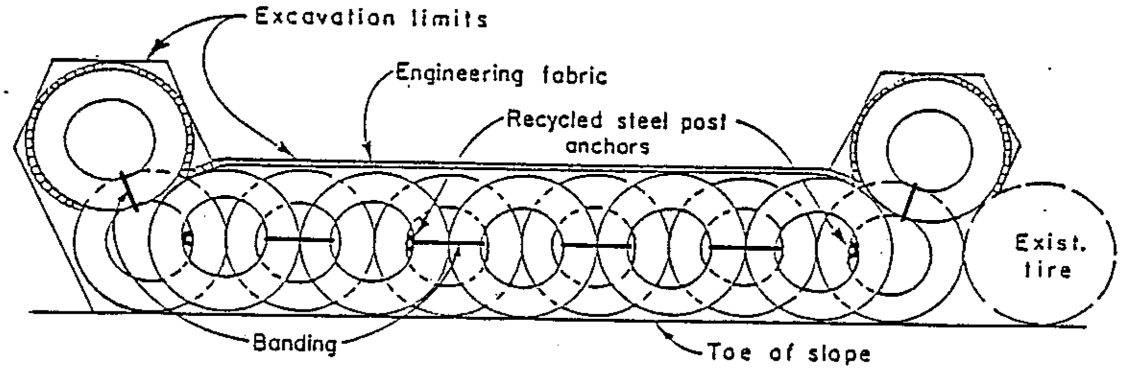


FIGURE 8.3

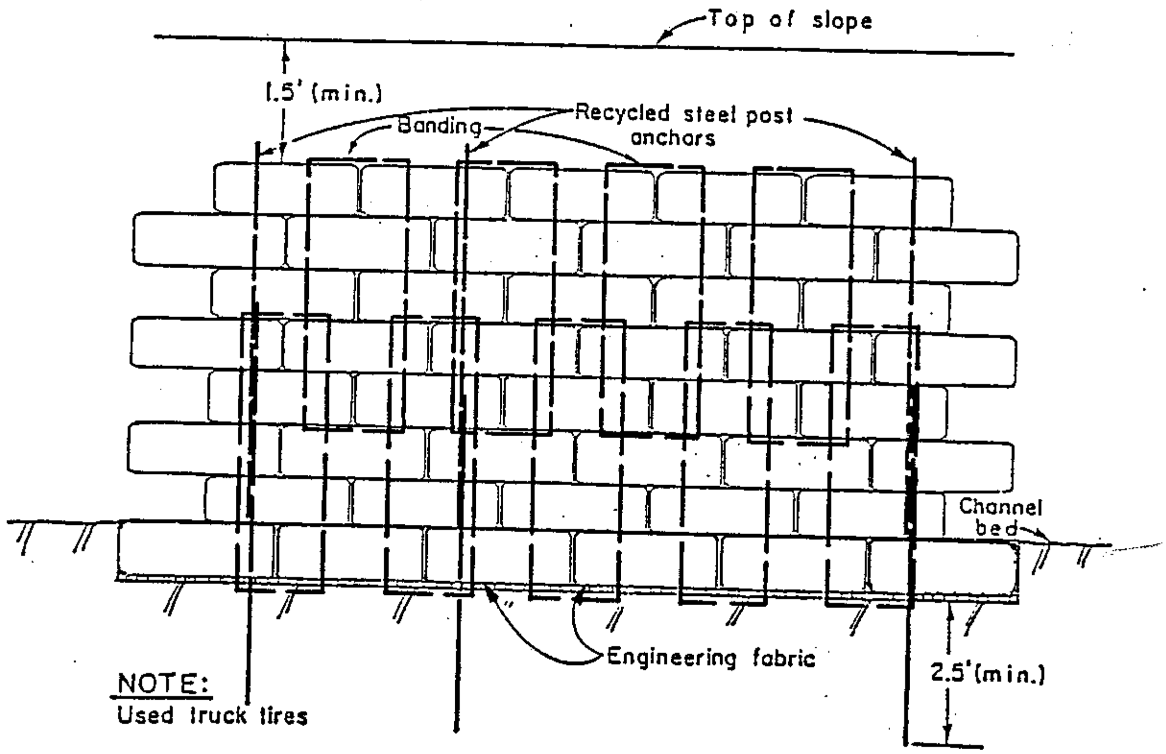
Photo 8.4 - Unit "C" Engineering Fabric Placement

TIRE PROJECT II

RECYCLED TIRE INSTALLATION FOR UNIT "C" (STACKED STAGGERED)



PLAN

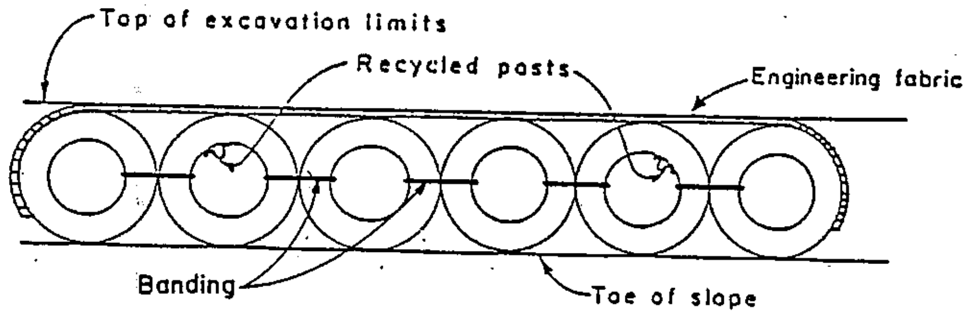


ELEVATION

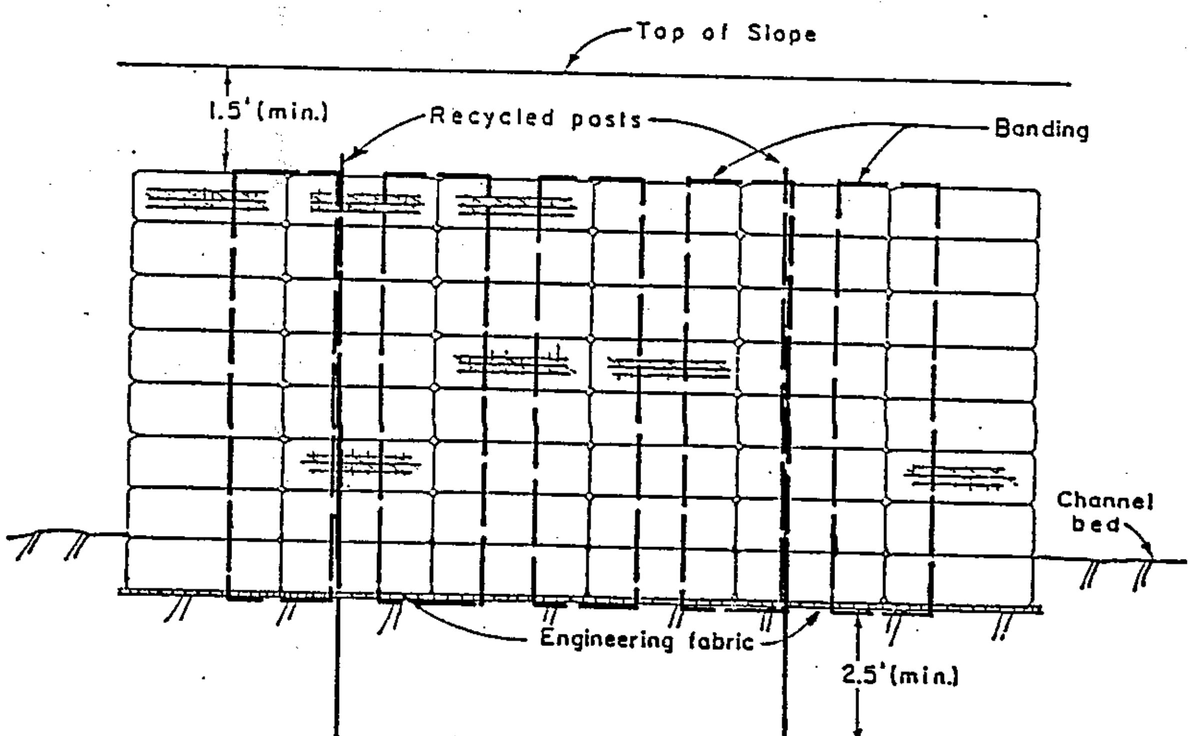
FIGURE 8.4

TIRE PROJECT II

RECYCLED TIRE INSTALLATION FOR UNIT "D" (STACKED VERTICALLY)



PLAN



ELEVATION

FIGURE 8.5

The tires in both units were backfilled with the excavated material and compacted by ponding and jetting, and using a vibratory compactor. Metal posts then were driven through the center hole of every fourth tire. The area above the tire units was then revegetated.

8.5 Components

8.5.1 Tires

Two hundred seventy five truck tires were used in the construction of the two research units. The tires were acquired from a local tire shop in Kettleman City near the project site. The tires were transported on a flatbed trailer (Photo 8.5) to the site and stockpiled by maintenance personnel. The majority of the tires selected were in fairly good condition with the exception of those that had been run flat, thus developing a weak carcass. The tires were segregated in order to accomplish an orderly staggered stacking of the tires. It was determined from a trial stacking of the tires that if they are stacked in a random fashion without regard to size that serious problems could occur. For example, when the tire sizes are grossly mismatched, the vertical poles cannot be positioned properly. Also, horizontal bending of the wall occurs because the tires do not remain on a level plane.

On the research sites problems occurred due to different thickness of tires and weak carcasses. On Unit "D" the problem was the tilting outward of the tires. Another was the loss of the staggered layered pattern, on Unit "C", as the tires progressed toward the end of the section due to the variation in sizes of tires.

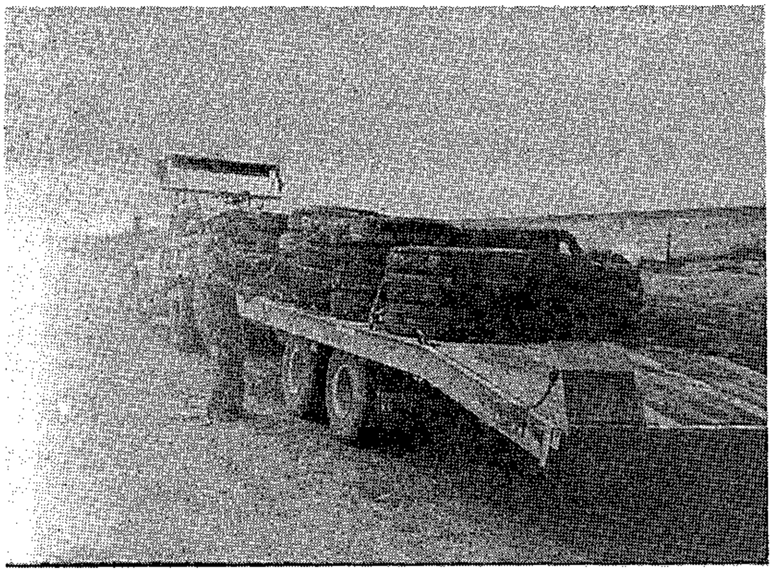


Photo 8.5 - Transport Vehicle

8.5.2 Engineering Fabric

Engineering fabric was placed behind the tires in both units. The fabric was used to prevent the backfill material from being washed through tires in the event that moving water got behind the tire installations.

8.5.3 Strapping

Strapping was used to bind the tires together to form a continuous channel protection unit. Half inch polypropylene strapping was used due to its strength and resistance to corrosion. The tires were strapped together as shown in Figure 8.4. Due to the flexing of the tires it was difficult to secure tight banding.

8.5.4 Backfill

After placement of the tire assemblages, backfill material was dumped into the tires (Photos 8.6 & 8.7) and compacted. The excavated material was selected for backfill as it was felt that the sandy loam would readily fill the space inside the tires and easily compact. The first row of tires was placed and backfilled. This was done to provide a stable and level base to build upon. Difficulty was encountered in the backfilling operation in that the soil did not easily flow into the tires thus leaving large voids. A vibratory compactor was used in an attempt to assist the movement of the soil into the voids. This procedure proved to be ineffective. Ponding and jetting was then tried and this method proved to be somewhat successful. The backfill material had a tendency to flow out of the interstices in the installation. This backfilling difficulty occurred most often when the tires were stacked when the staggered fashion.

Photo 8.6 - Unit "C" Backfilling With Excavated Material

Photo 8.7 - Unit "D" Backfilling With Excavated Material

It is felt that, with the assistance of a vibrator, of a more granular backfill material would flow into the tires more readily.

8.5.5 Anchor Posts

Metal posts were driven through the center hole of every fourth tire. Some difficulty was encountered when driving the posts through the staggered configuration due to misalignment of the tires. Recycled steel posts 8 to 10 feet in length were driven with sledge hammers. For larger projects pneumatic hammers would be more applicable.

8.5.6 Revegetation

The area above Units "C" & "D" were revegetated following the installation of the discarded tires. The slopes were seeded with a grass seed mixture of blando brome (10%) and Belford barley (90%). Within one month after planting and fertilizing there was significant growth. Within three months excellent stands of vegetation had grown and had effectively stabilized the upper slopes.

8.6 Personnel, Equipment And Materials

The following personnel, equipment and materials were used on these two units:

Personnel:	1 - Foreman
	3 - Maintenance workers
Equipment:	2 - Pickups
	1 - Dump Truck
	1 - Loader
	1 - Water Truck
	1 - Water Tank
	1 - Flatbed Trailer
Material:	Tires - Unit "C" 150
	Unit "D" 125
	Engineering Fabric - 500 square yards
	Recycled Anchor Posts - 20
	Strapping - 1 coil

8.7 Installation Costs

The following costs are for both Units "C" & "D":

Personnel	$ 4,625
Equipment	$ 1,858
Materials	$ 593
	* $ 7,076

* 1986 cost

The final cost per linear foot was $40.

8.8 Cost Comparison For Alternative Channel Slope Protection

The following cost comparison is the cost per linear foot based on a wall height of five feet. These costs include all labor, materials and equipment.

Recycled Tires	$ 40.00
Rock Slope Protection	$ 95.00
Broken Concrete Slope Protection	$ 115.00
Gabion Wall	$ 125.00
Reinforced Concrete	$ 250.00

The cost for the recycled tire channel slope protection is for recycled tire wall installed by Caltrans maintenance. The alternating walls are contractor-installed costs. The cost for a contractor to install recycled tires for slope protection would exceed the maintenance unit cost as the result of being a small project.

8.9 Monitoring

The project work plan proposal for monitoring the project consisted of the following:

- The overall project and the stability of the tire installation were determined by visual inspection and photographic log.
- Channel condition was monitored visually.

8.9.1 Settlement and Stability

Visual inspections and a photographic log were the methods used to evaluate settlement. For stability, the alignment of the tire units was checked for overturning and sliding.

Although some settlement occurred on both Unit "C" and "D", the settlement was not enough to cause concern (Photos 8.8 & 8.9). There were no stability problems on either unit.

8.9.2 Control Sections

Portion of the channel downstream from the tire installations were selected as control sections (Photos 8.10 & 8.11). Prior to and during the course of the project some bank slope erosion occurred on the control sections.

8.9.3 Scour

During the course of the study, photographs were taken at predetermined locations for monitoring scour of the channel bed. There was no scour observed at the project site

8.9.4 Erosion

Due to the low rainfall in 1984 and 1985 the water flows in the channel were low. Even with these low flows, comparison of the protected banks with the control sections shows a marked difference. The only place any erosion occurred on the test sections is where Unit "D" meets with Unit "A". In this area the soil eroded from between the two Units. And at that it was only minor. However, erosion of the channel banks continued to occur in the control sections.

The channel was cross-sectioned to determine if any erosion was occurring. During the course of the study, the flow level was less than 4.5 inches and no erosion was noted in the test section. On the slopes above the discarded tires erosion was kept to a minimum by timely revegetation.

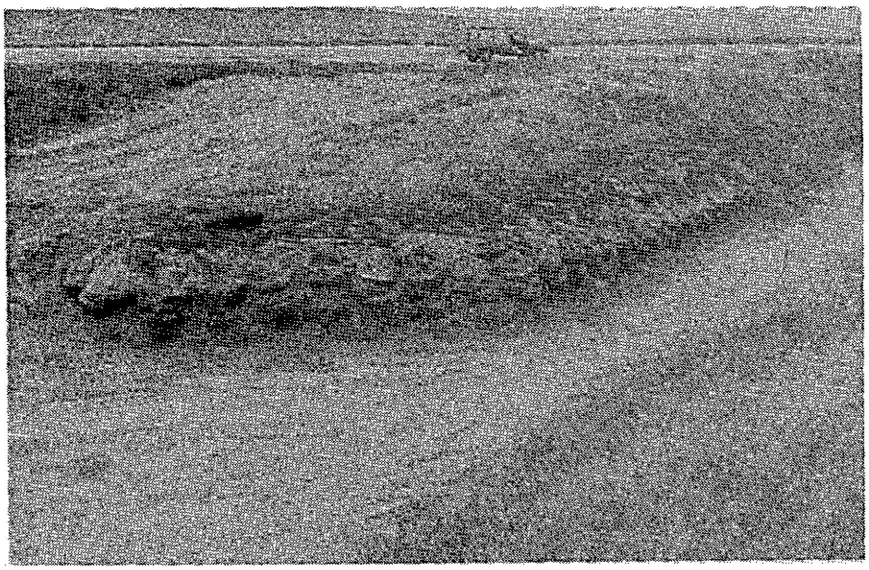


Photo 8.8 - Settlement - Unit "C"

Photo 8.9 - Settlement - Unit "D"

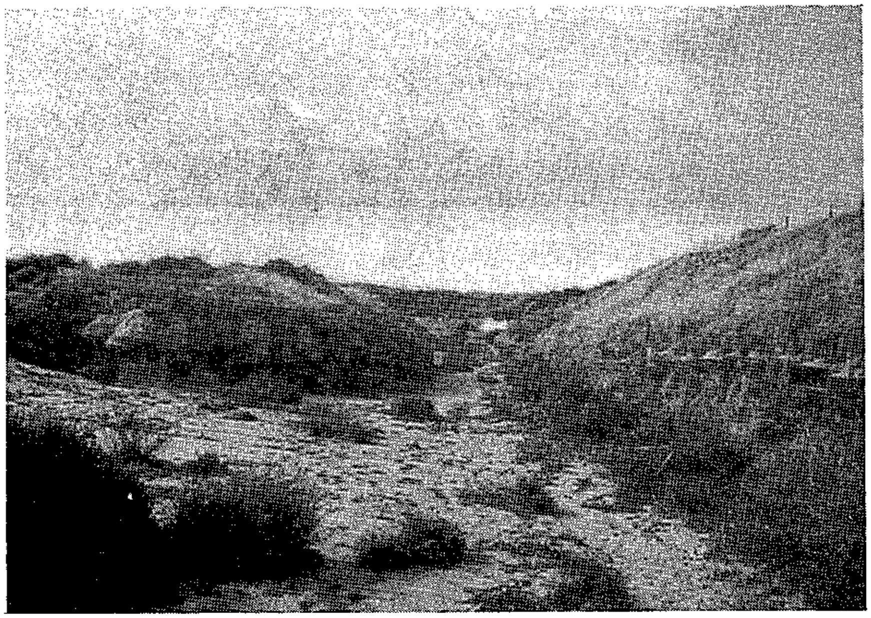


Photo 8.10 Control Section - Channel East Of Unit "C"

Photo 8.11 Control Section - South Of Lassen Avenue

8.9.5 Revegetation Analysis

The grass growth, percent of cover, density, and type of plant were evaluated on the two sites (Table 8.1). The growth was determined by measuring the height of the grasses, percent cover was estimated, density and plant type were determined by selection of one square foot of the representative area for a grass count. Fertilizer was applied to both units at a rate of 450 pounds per acre. There was no watering at the time of planting or thereafter.

Table 8.1 Plant Growth

Unit	Growth	Percent Cover	Plant Density	Type
				(Between)
"C"	1" - 2.5"	50 - 55	$600/ft^2$	10% - 20% BB*
				80% - 90% B**
"D"	5" - 6"	55 - 60	$650/ft^2$	5% - 15% BB*
				85% - 95% B**

* BB - Blando brome

** B - Barley

8.9.6 Precipitation

The average annual rainfall in this portion of Fresno County varies from 6.1 inches at Kettleman City to 7.8 inches at Coalinga (Table 8.2). These locations are 10 miles southeast and 15 miles west of the project site respectively (Figure 8.6). There is also a weather station at PG&E's Kettleman Compressor Station 1 mile south of the project (Photo 8.12). At the beginning of the project the

TABLE 8.2

PRECIPITATION SUMMARY

FY	COALINGA	KETTLEMAN	PG&E FACILITY
	*(7.83)	*(6.12)	-
82-83	13.62	12.20	13.74
83-84	4.56	4.45	4.68
84-85	5.14	3.98	3.99
85-86	9.93	8.47	-

*Normal annual rainfall

LOCATIONS OF WEATHER STATIONS

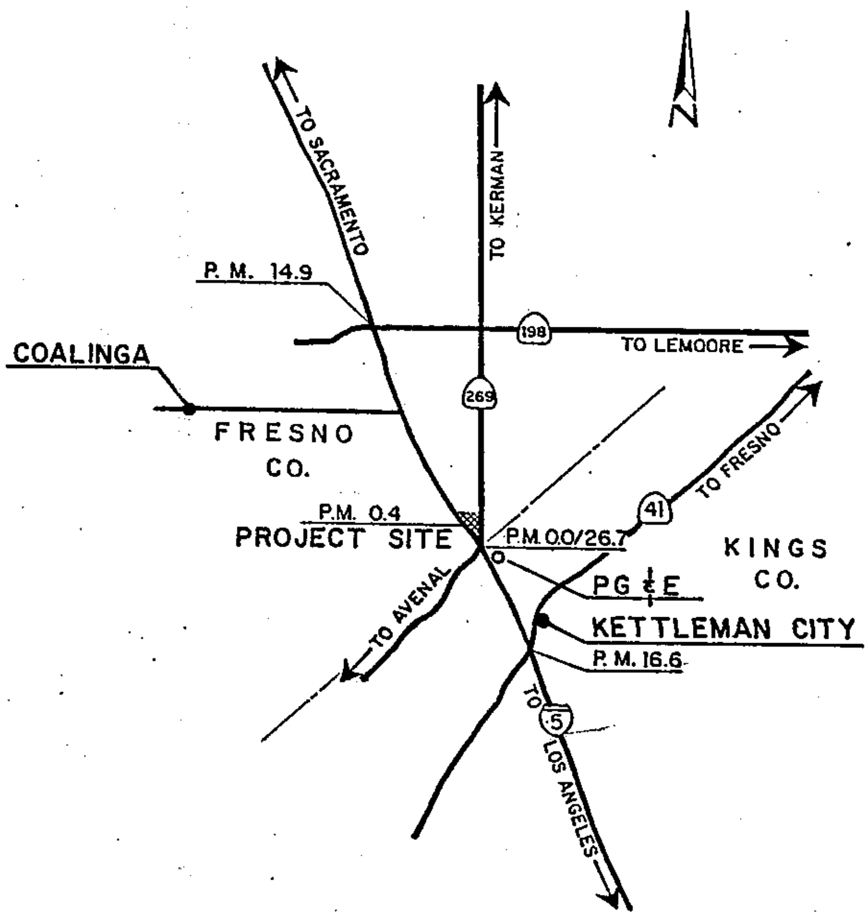


FIGURE 8.6

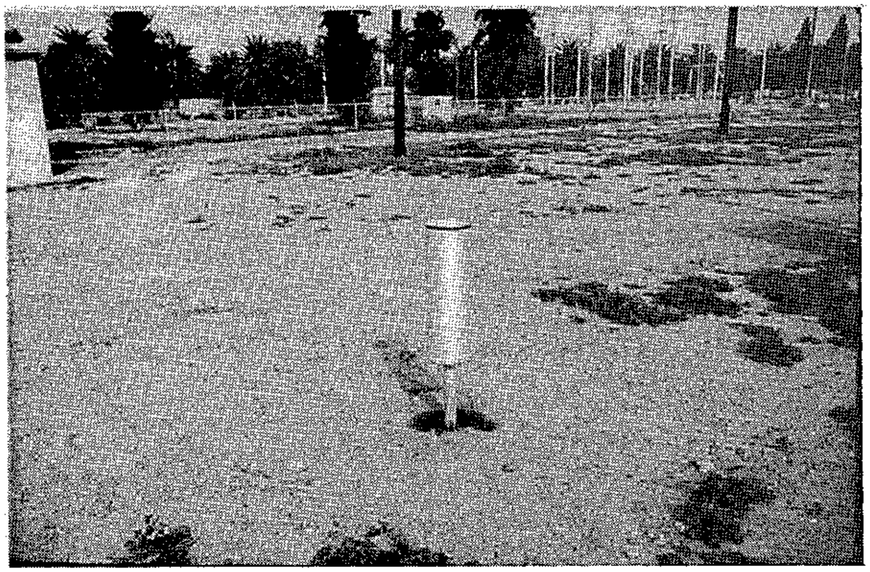


Photo 8.12 - PG&E's Weather Station

rainfall for 1982-83 was well above normal. However, in the following two years, the rainfall dropped well below normal and, in FY 1985-86, the rainfall was slightly above normal. In Table 8.3 monthly, rainfall data are listed for both stations between July 1, 1982 and June 30, 1986.

Investigation of the upstream watershed during the monitoring period indicated a restricted water source feeding this channel. It would have required a significant storm to obtain sufficient flow to adequately test the tire installation. As indicated on the Precipitation Summary (Table 8.2), the rainfall during the last two years of the study period was below normal so that the project lacked the storm intensity to fully evaluate the discarded tire installations.

8.9.7 Channel Flow Level

A crest gauge, to monitor flow levels, was installed on the site in October 1983. The gauge was set on a 2.5 inch steel pipe placed 4.5 inches above the channel bottom (Photo 8.13).

The crest gauge consists of a length of two inch pipe capped at both ends and mounted vertically on a steel post (Figure 8.7). The gauge contains a removable wood measuring shaft with the bottom set at a fixed elevation. The gauge unit is charged with regranulated cork for recording the water surface elevation on the measuring shaft. The intake is positioned facing downstream.

The gauge recorded a maximum flow level of less than five inches during the course of the study.

TABLE 8.3

PROJECT II

MONTHLY PRECIPITATION DATA (inches)

F.Y.	MONTH	COAL-INGA	KETTLE-MAN	PG&E FAC.	F.Y.	MONTH	COAL-INGA	KETTLE-MAN	PG&E FAC.
82-83	7	0.00	0.00	0.00	84-85	7	0.00	0.00	0.00
	8	0.00	0.00	0.00		8	0.02	0.00	0.00
	9	0.00	1.00	0.40		9	0.00	0.00	0.00
	10	0.70	0.59	0.61		10	0.35	0.00	0.00
	11	2.40	1.52	2.10		11	1.20	1.13	1.14
	12	1.00	0.61	0.80		12	1.76	1.58	1.58
	1	3.24	2.24	3.45		1	0.25	0.80	0.35
	2	2.58	2.01	2.01		2	0.05	0.07	0.05
	3	2.52	3.30	3.45		3	1.27	0.17	0.80
	4	1.15	0.79	0.92		4	0.24	0.06	0.04
	5	0.03	0.14	0.00		5	0.00	0.17	0.03
	6	0.00	0.00	0.00		6	0.00	0.00	0.00
82-83 TOTALS		13.62	12.20	13.74	84-85 TOTALS		5.14	3.98	3.99
83-84	7	0.00	0.00	0.00	85-86	7	0.00	0.00	-
	8	0.37	0.36	0.23		8	0.23	0.00	-
	9	0.58	2.15	2.15		9	0.40	1.14	-
	10	0.82	0.46	0.46		10	0.35	0.00	-
	11	0.53	0.00	0.52		11	1.42	1.56	-
	12	1.81	1.35	1.25		12	0.68	0.49	-
	1	0.18	0.07	0.07		1	1.79	1.70	-
	2	0.14	0.06	0.00		2	2.75	1.95	-
	3	0.06	0.00	0.00		3	1.99	1.61	-
	4	0.07	0.00	0.00		4	0.32	0.00	-
	5	0.00	0.00	0.00		5	0.00	0.02	-
	6	0.00	0.00	0.00		6	0.00	0.00	-
83-84 TOTALS		4.56	4.45	4.68	85-86 TOTALS		9.93	8.47	-

Photo 8.13 - Crest Gauge

TIRE PROJECT II

CREST GAGE

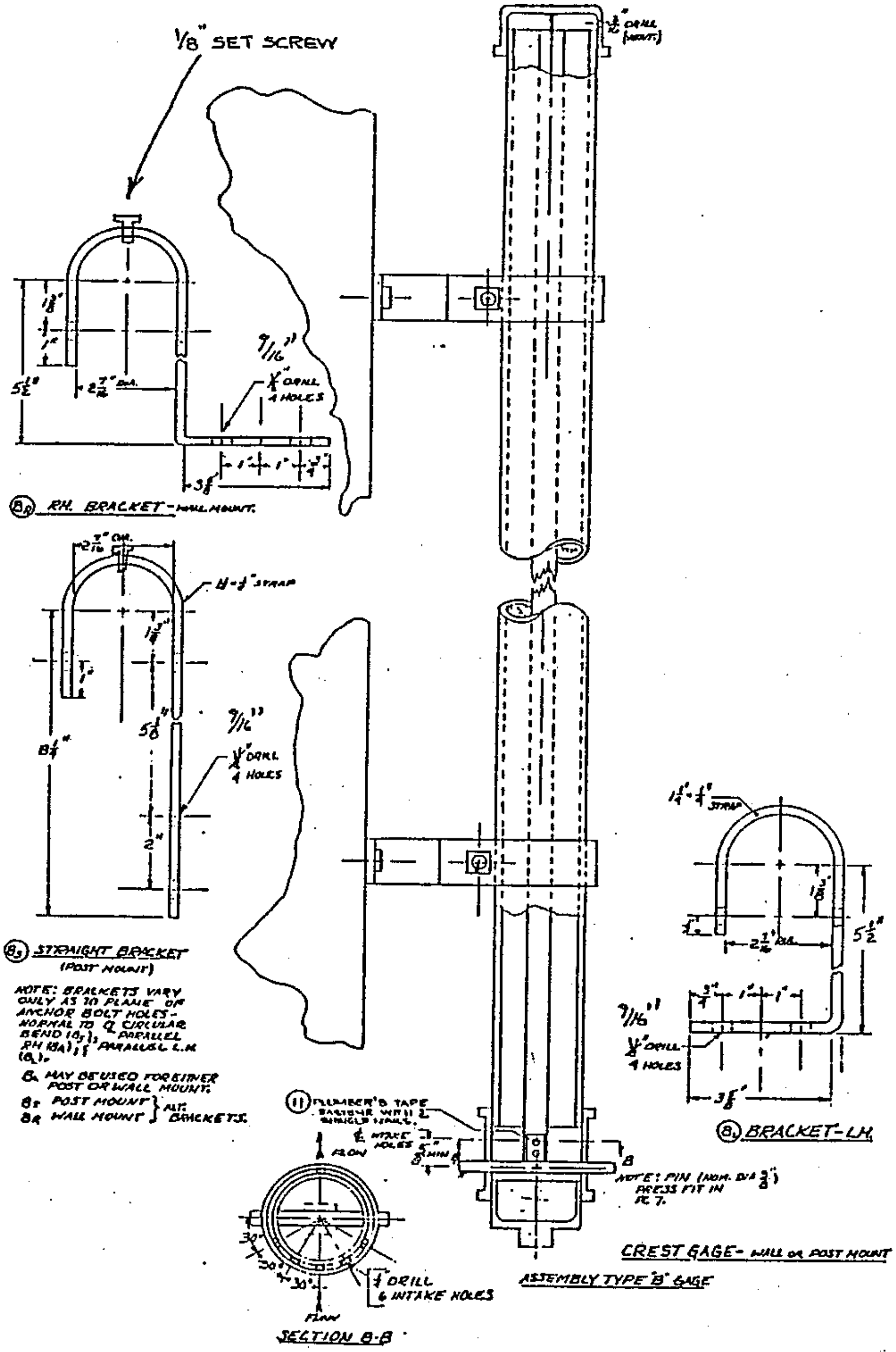


FIGURE 8.7

8.10 Aesthetics

The channel slopes were seeded with native grasses and the growth photographed to determine the time required to erase any negative visual impact. Previous experience at the site demonstrated that the tires can be successfully screened by the natural sloughing of the soil combined with the growth of native grasses (Photos 8.14 & 8.15). It took six weeks to develop this growth. Depending on the time of year, it can take from one to four months to develop a significant vegetative cover.

8.11 Appendix: Guidelines

Figure 8.8 contains the guidelines for slope protection using recycled tires.

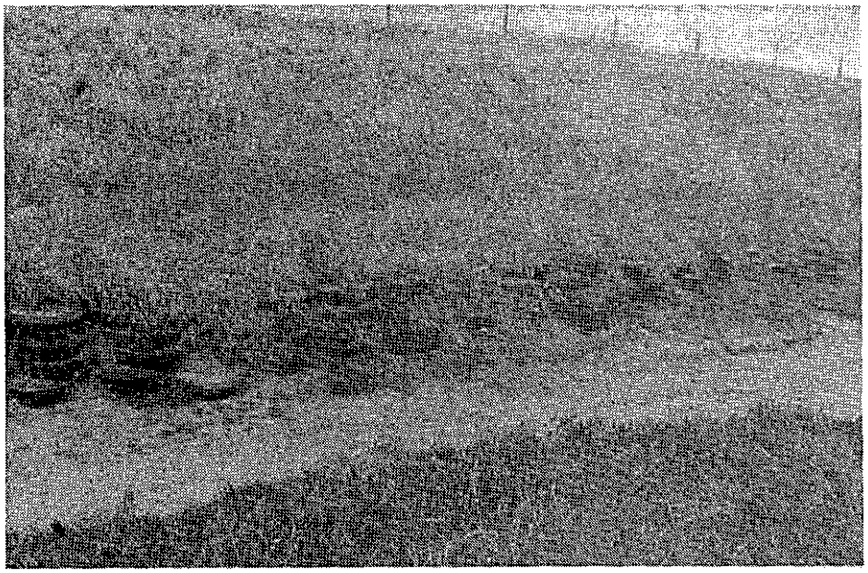
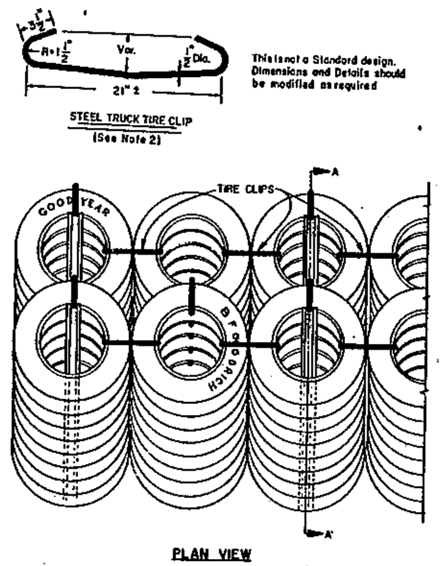
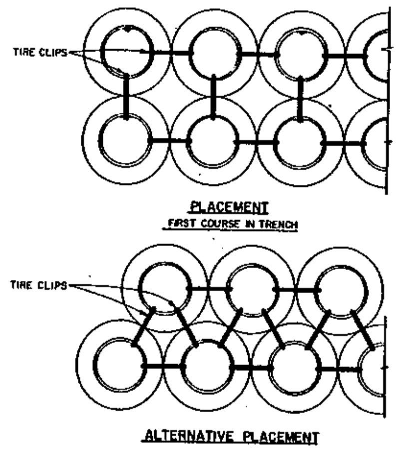


Photo 8.14 - Unit "A" - Vegetation (1984)

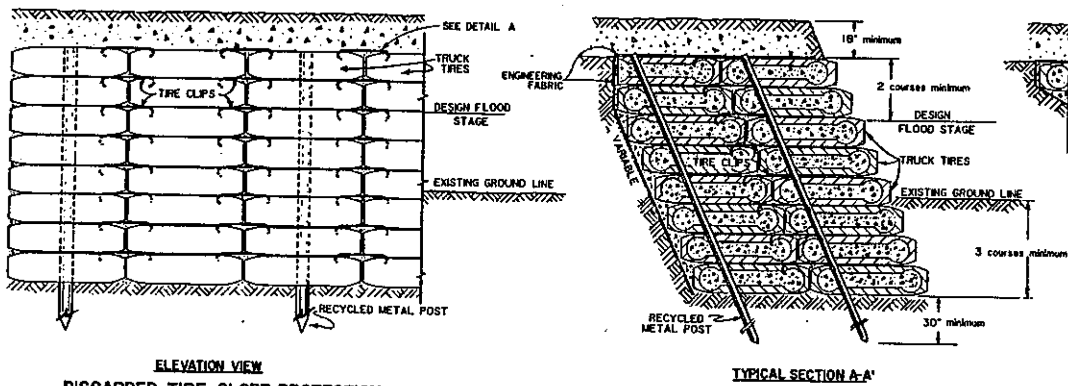
Photo 8.15 - Unit "D" - One Month After Seeding

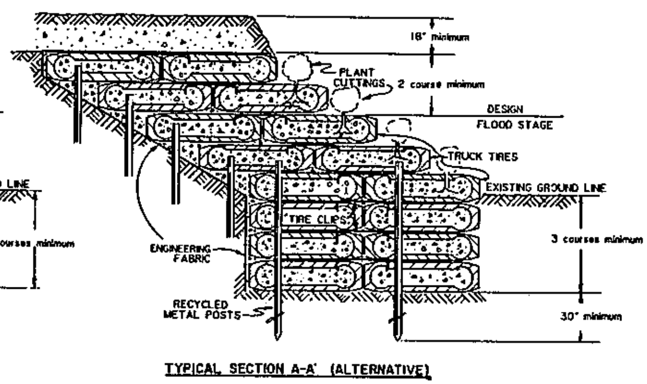




Notes:

1. Scrap tires will be in such condition as they will retain original manufactured shape when stacked.
2. Steel tire clip is to be made of "cold rolled" 1/2" diameter steel. All measurements, except bend radius, are to center of bar, bend radius is inside diameter.
3. All posts shall be recycled metal posts in good condition.
4. Post shall be secured tightly against bead on inner row of tires, placed at a minimum of every other tire and at ends of tire mats.
5. Excavated material may be accepted for backfill provided it will be readily consolidated with the use of hand held vibratory compactors.
6. Backfill material may consist of suitable native material, imported backfill which will readily compact and is free-draining or low yield concrete.
7. Ponding and jetting may be permitted if it will not damage foundation material, will not develop hydrostatic pressure on the tire unit, and if the backfill material is free-draining.
8. Sidewalls of tires should be spread during backfilling operations to facilitate adequate compaction.
9. Salvaged materials shall be state furnished, if available.
10. Tires shall be used on lower slopes and in locations not visable to the motorist.
11. Painting the tires to blend with the surrounding terrain will improve the aesthetics of the installations





DISCARDED TIRE SLOPE PROTECTION

ENVIRO-CHEMICAL BRANCH

DRAWN BY: JKD 12/85

TRANSPORTATION LABORATORY
State of
CALIFORNIA
DEPARTMENT OF TRANSPORTATION

SLOPE PROTECTION WITH RECYCLED TIRES

SCALE NONE

FIGURE 8.8

9. PROJECT III - PROTECTIVE BARRIERS FOR SEEDLINGS AGAINST BLOWING SAND

9.1 Introduction

This project studied the alternative of using tires to effectively eliminate damage to newly planted tamarisk trees in gaps in an existing row of tamarisk trees. Impounding the blowsand upwind of the existing tree row permits early tree development which, in turn, provides long-term protection for the vehicles and the highway.

9.2 Background

This project involved the continuous blowing sand problem which occurs in low rainfall desert regions. Irrigated vegetative windbreaks are commonly used and have proved to be quite successful. However, there remain some problems with achieving total success in starting seedlings where blowing sand destroys the plants before they mature. Consequently, gaps exist in the tree rows (Photo 9.1) which allow wind-driven sand to collect on the roadway (Photo 9.2). The blowsand is abrasive. It damages vehicles, reduces visibility and is hazardous to motorists. Removal of the deposited sand constitutes an appreciable annual maintenance cost. Such an area existed on State Route 111 south of I-10 in Riverside County near Palm Springs (Figure 9.1).

In May 1975, Caltrans established a special protective screen in the area of the Whitewater overflow where severe damage to vehicles was occurring and district maintenance personnel were unable to establish tamarisk tree plantings. The problem was mitigated by the installation of a temporary protective fence fashioned from salvaged overhead

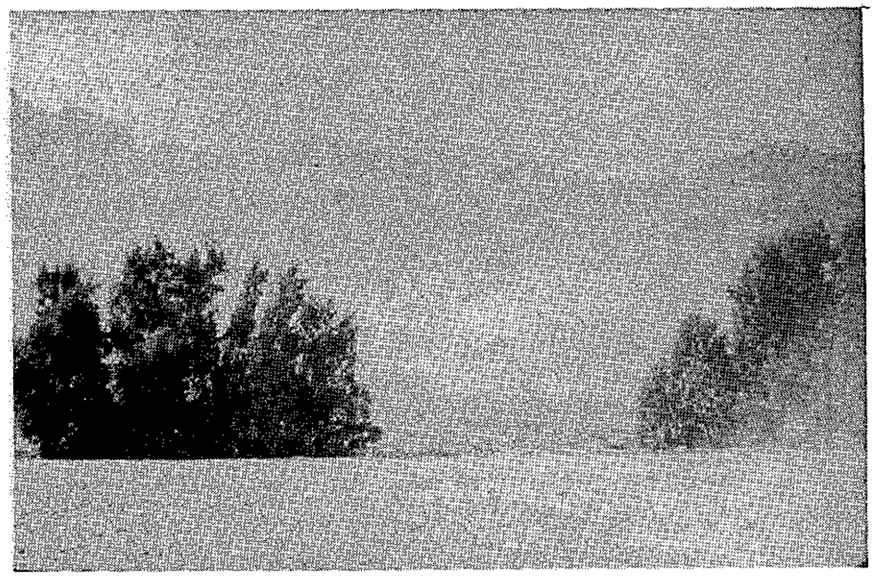
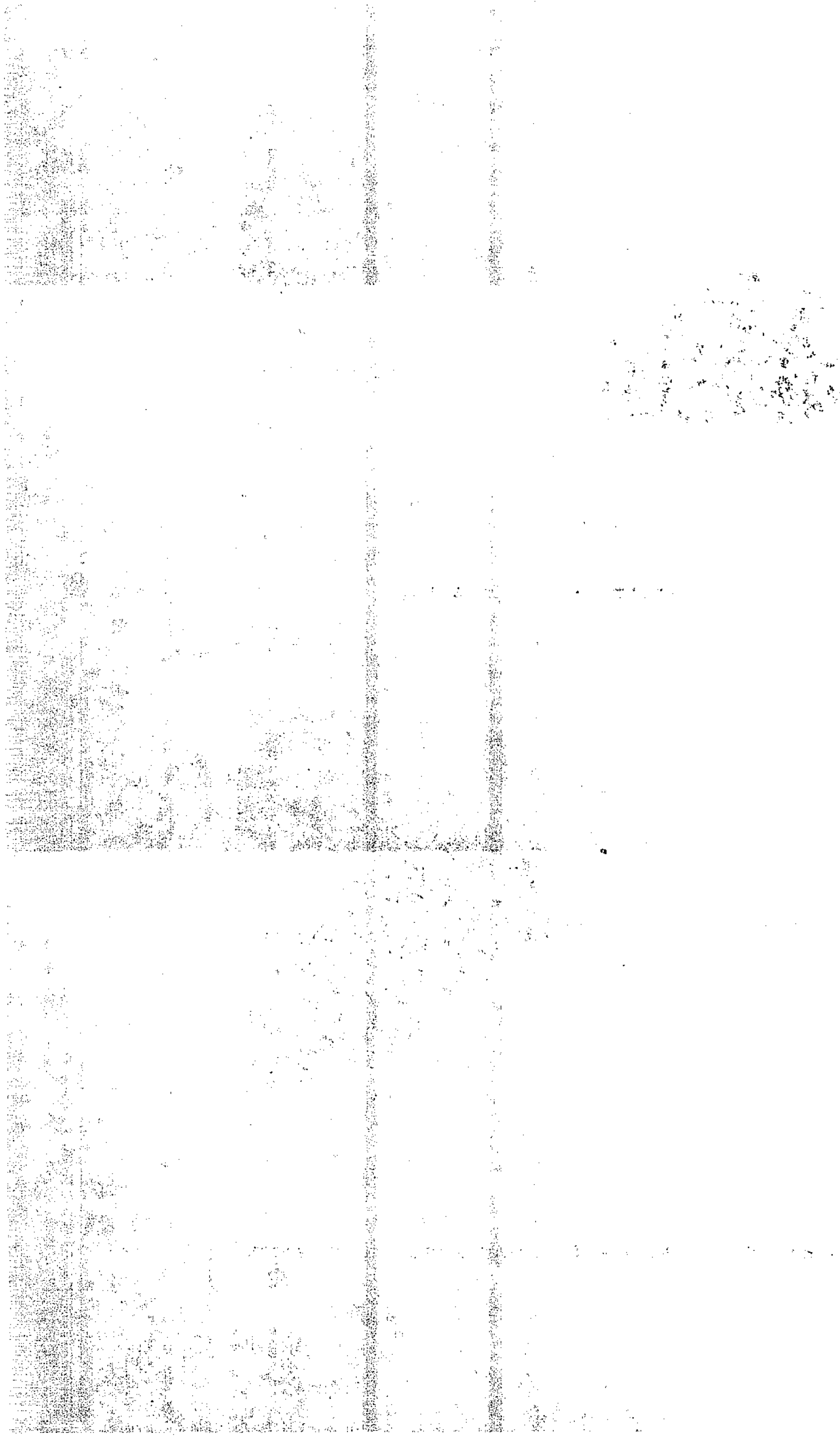


Photo 9.1 - Tree Gap

Photo 9.2 - Blowsand Impoundment On Pavement



TIRE PROJECT III

LOCATION MAP

08-Riv-111 P.M. 62
PROTECTIVE BARRIER FROM RECYCLED TIRES

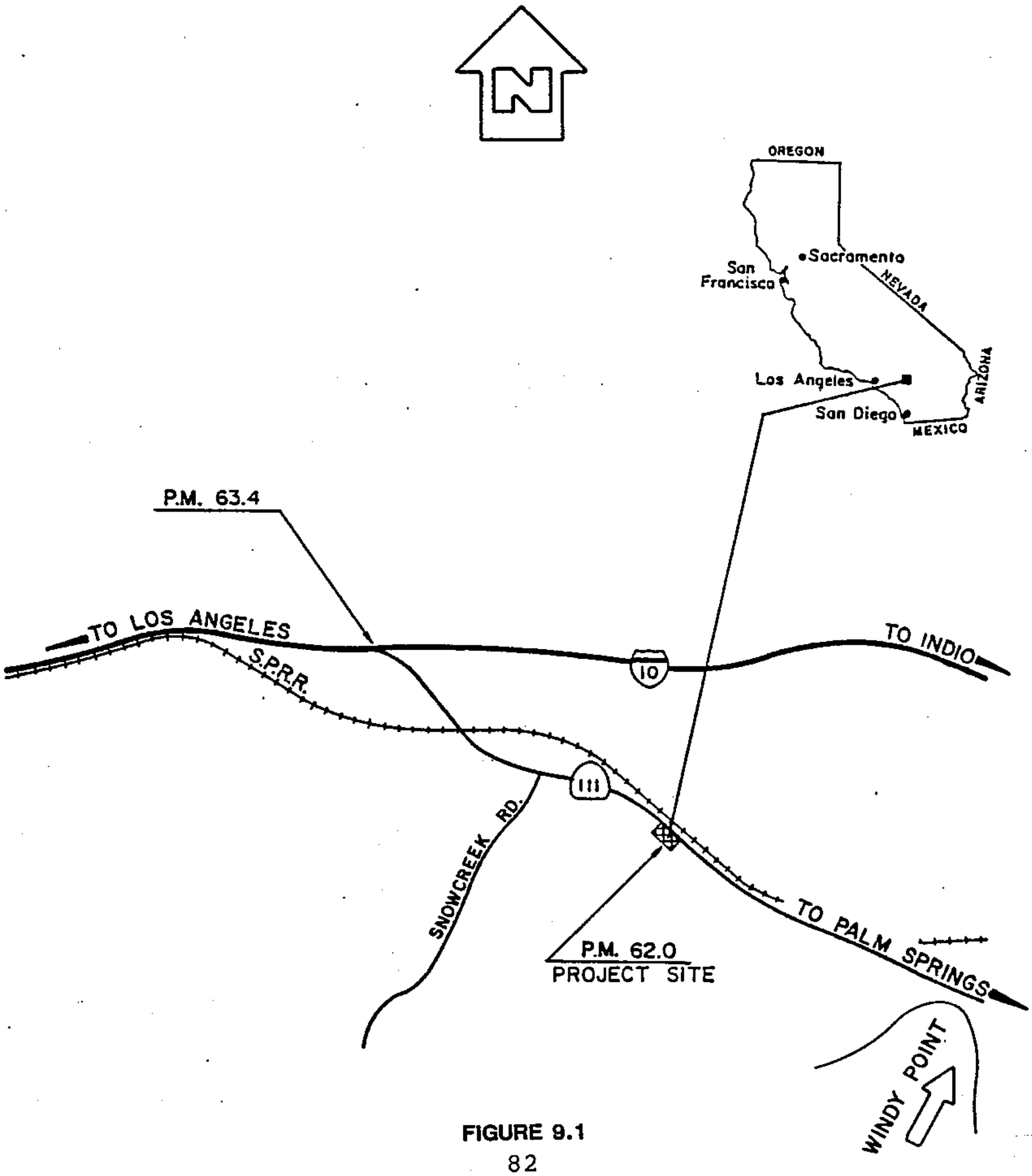


FIGURE 9.1

signs and recycled glare screens (Photo 9.3). This screening protected the new plantings from severe sandblasting, thus promoting the ultimate development of the tree row.

In the early 1980's due to the shortage of salvaged overhead signs or glare screening, it was necessary to develop some other means of providing protection against blowing sand at additional locations along this tamarisk tree row.

9.3 Design Description

The original proposal provided for three wind path protection areas 150 feet wide. These three wind path areas were designated "A","B" & "C" (Figure 9.2)

1. "A" consisted of a tire mat.
2. "B" consisted of three tire barriers
3. "C" consisted of three tire barriers

Due to design changes and prior to the construction of the installation of the project the designations "A" "B" and "C" were changed to :

1. Location "A" became tire Unit 6.
2. Location "B" became tire Units 3,4 and a portion of Unit 5.
3. Location "C" became tire Units 1,2 and a portion of Unit 5.

Unit 5 is a composite of portions of the tire barriers and the tire mat in Units "A" "B" & "C".

There were six tree gaps. All but one had a single tire barrier across the gap. The sixth gap was left open in order to provide access though the tree row during the project.

Two basic methods of impounding wind transported sand with discarded tires were proposed for this project. One is the

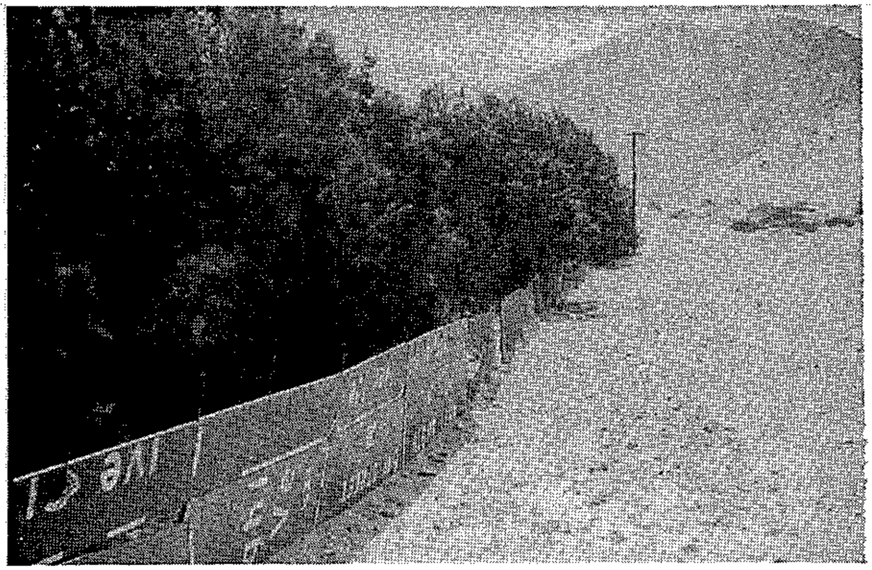


Photo 9.3 - Protection With Salvaged Signs And Glare Screen

TIRE PROJECT III

SITE MAP AS BUILT

PROTECTIVE BARRIERS FROM RECYCLED TIRES

08-Riv-111 P.M. 61.4-61.9

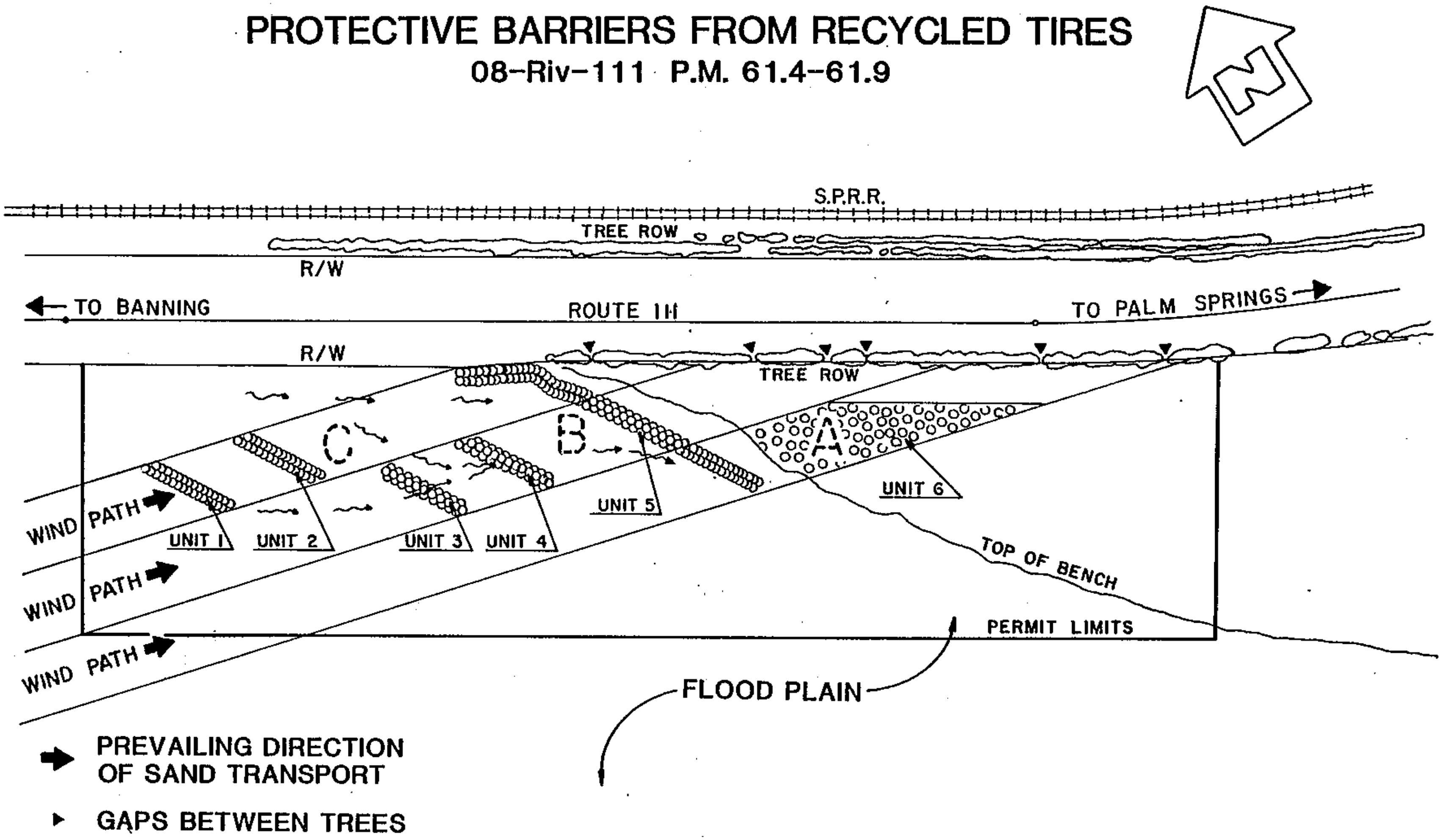


FIGURE 9.2

laying out of a mat of tires, and the other, is the creation of barrier walls perpendicular to the direction of the sand movement. The direction of sand movement was extremely stable at the project site, rarely varying more than a few degrees in the oncoming direction.

The automobile tire mat provided an impounding capacity of approximately 90% of the volume of the overall mat dimensions. Each tire commands a space of approximately 6 cubic feet (average), with about 0.75 cubic feet already having been excluded for material volume and trapped airspace. Minor drawdown occurs between tires at the top level of the mat. This mat method is extremely tire-intensive. Approximately twice as many tires can be employed as with the barrier method, with essentially the same effectiveness. The mat contained approximately 16,000 discarded tires.

Barriers constitute a more effective use of tires for protection, if disposal of quantities of tires is not an objective. Units 1 through 5 constituted the use of approximately 13,000 discarded tires.

There were also weaved tire walls constructed at each of the 5 gaps in the tree row. The addition of these barrier walls was to provide immediate protection for the planting. A sixth opening was left without planting to permit access for maintenance forces. The District is to close this opening utilizing a mechanical barrier later.

Barrier walls in the five gap closures used approximately 2,000 tires. The total project including the tire blanket to cap off the barriers utilized a total of approximately 31,000 tires.

9.3.1 Site Selection

Unless protection against blowing sand is provided, severe abrasion damage occurs to vehicles traveling westbound near Palm Springs on State Highway 111, between Snow Creek Road and Windy Point during strong windstorms (Figure 9.1). Caltrans has also encountered a considerable buildup of blowsand on the eastbound shoulder and through lanes which represents a potential hazard for motorists. Removal of this material constituted an appreciable annual maintenance cost. Of the several locations in the Coachella Valley where blowing sand damages vehicles, this is probably the most severe.

The selection of this site was aided by the fact that it provided an ideal location to formulate a project that would study the alternative use of discarded tires to effectively eliminate damage to newly planted tamarisk trees by impounding blowsand upwind of the tree row, thus permitting early tree development. An additional benefit from this site selection was the long-term protection for vehicles and the highway that would be provided by a completely solid tree row upon conclusion of the research project.

9.3.2 Cross Section And Geometrics

The original proposal was to examine three different configurations of tire assemblages. The test area for each was proposed to be 100 feet wide by 500 feet. Location A (Figure 9.2) consisted of a tire mat placed over an area of approximately one acre. The initial planned installation was a single layer mat comprised of approximately 5,500 tires. It was anticipated to add additional layers to impound the amount of sand received over a 3 year period.

This method was extremely tire-intensive and it should be noted that twice as many tires could be employed to achieve the same effectiveness as barrier methods. If the primary objective were to dispose of tires this method could be used.

Also, in the original proposal locations B and C constituted the development of six discarded tire retention walls, utilizing between 2,000 and 3,000 tires. The plan consisted of three walls at each location, spaced approximately 170 feet apart.

Cabling of the tires in large groups was proposed to prevent their being washed away by potential flooding within the floodplain area. Experiments with the cabling process indicated that lacing the tires would be cumbersome and that it would be difficult to hold an entire installation in a uniform manner if subjected to substantial storm water flows. Prior to installation the decision was made to enclose the tire walls in a containment fence similar to rock groins (Photo 9.4 & Figure 9.3), for retaining the tires placed in the floodplain area.

The concept of vertical placement at Location C (Figure 9.4) was dropped in the initial installations as it was difficult to stack and hold tires in a vertical position even by cabling the units together. A weaved configuration (Figure 9.5) resulted in a much more stable and satisfactory installation.

In order to obtain a positive barrier, the third units downwind in each wind path were combined into one continuous unit designated as Unit 5 (Figure 9.2). The overall modification to the proposal resulted in constructing Units 1 and 2 into a weave configuration. Units 3 and 4

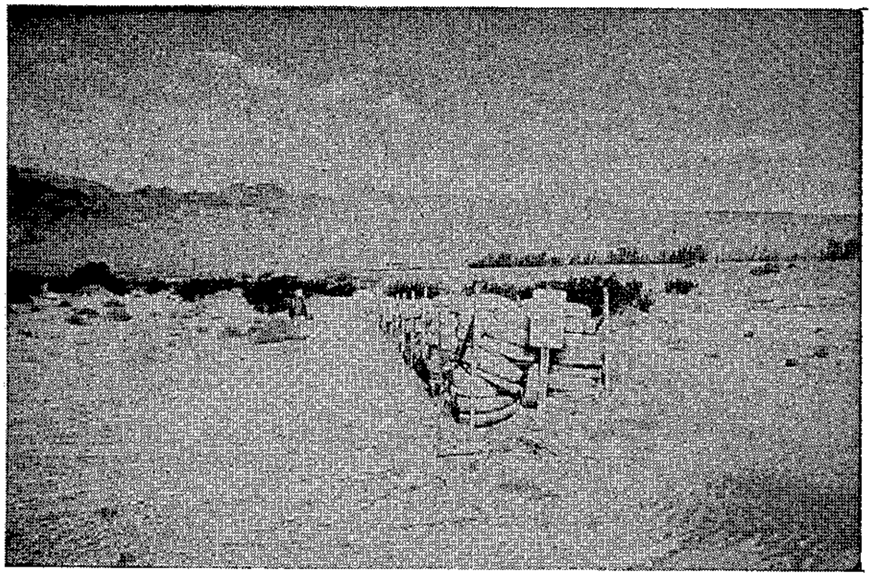
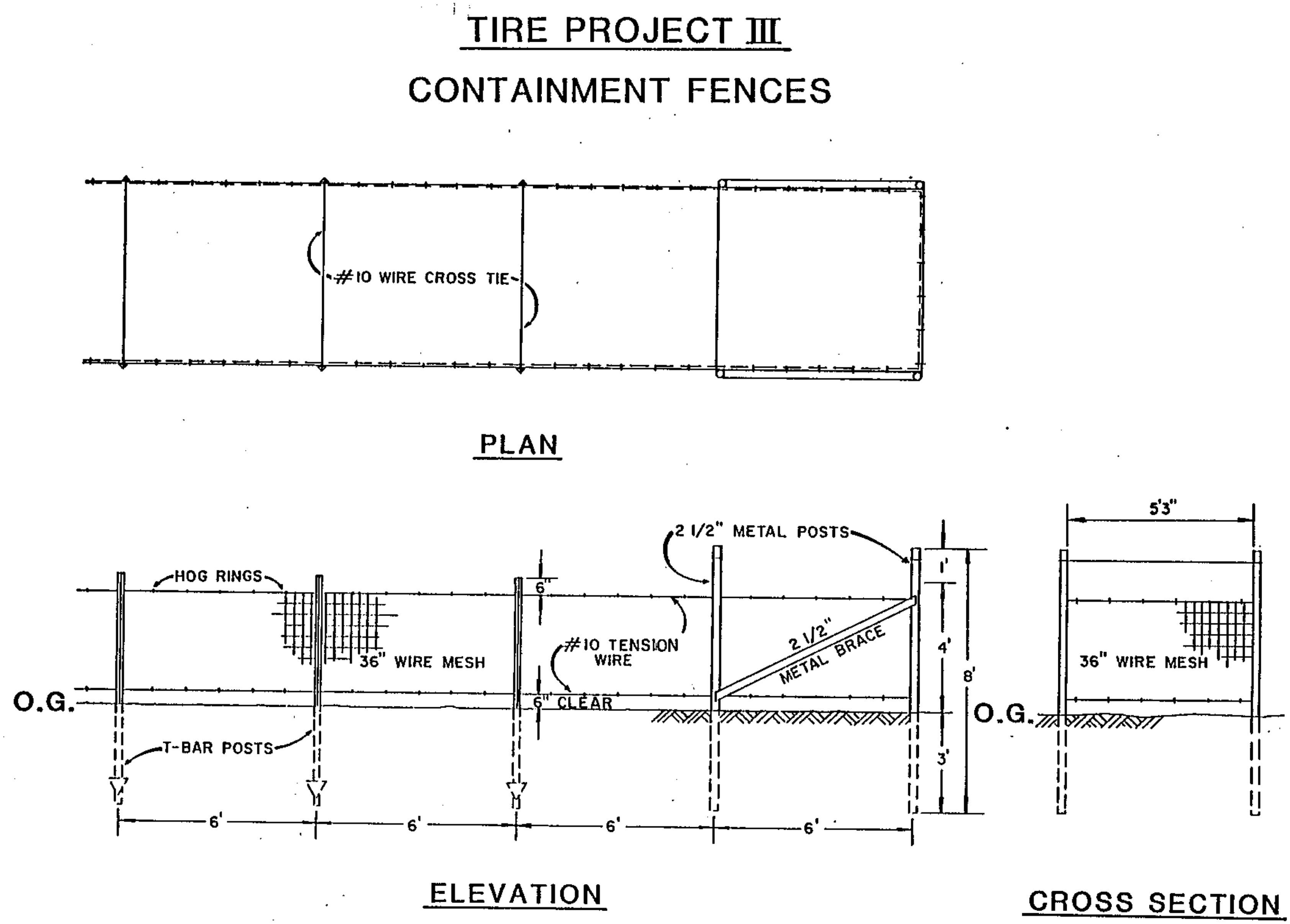


Photo 9.4 - Containment Fences

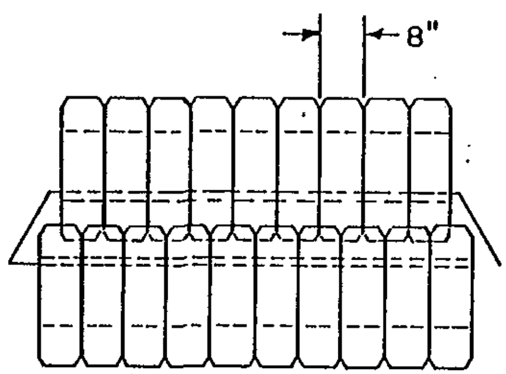


TIRE PROJECT III
CONTAINMENT FENCES
#10 WIRE CROSS TIE
PLAN
HOG RINGS
36" WIRE MESH
O.G.
T-BAR POSTS
6"
#10 TENSION WIRE
6" CLEAR
2 1/2" METAL POSTS
2 1/2" METAL BRACE
1'
4'
8'
3'
6'
6'
6'
6'
ELEVATION
5'3"
36" WIRE MESH
O.G.
CROSS SECTION

FIGURE 9.3

TIRE PROJECT III

LOCATION "C"
VERTICAL TIRE BARRIER (NOT USED)



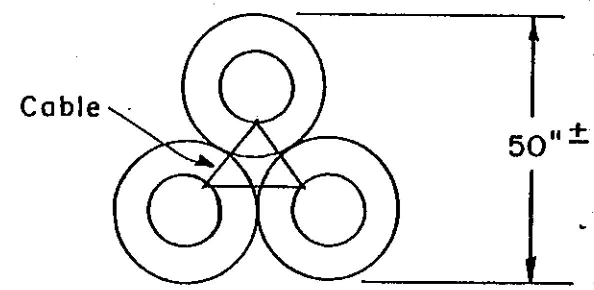


FIGURE 9.4

TIRE PROJECT III
WEAVED TIRE BARRIER

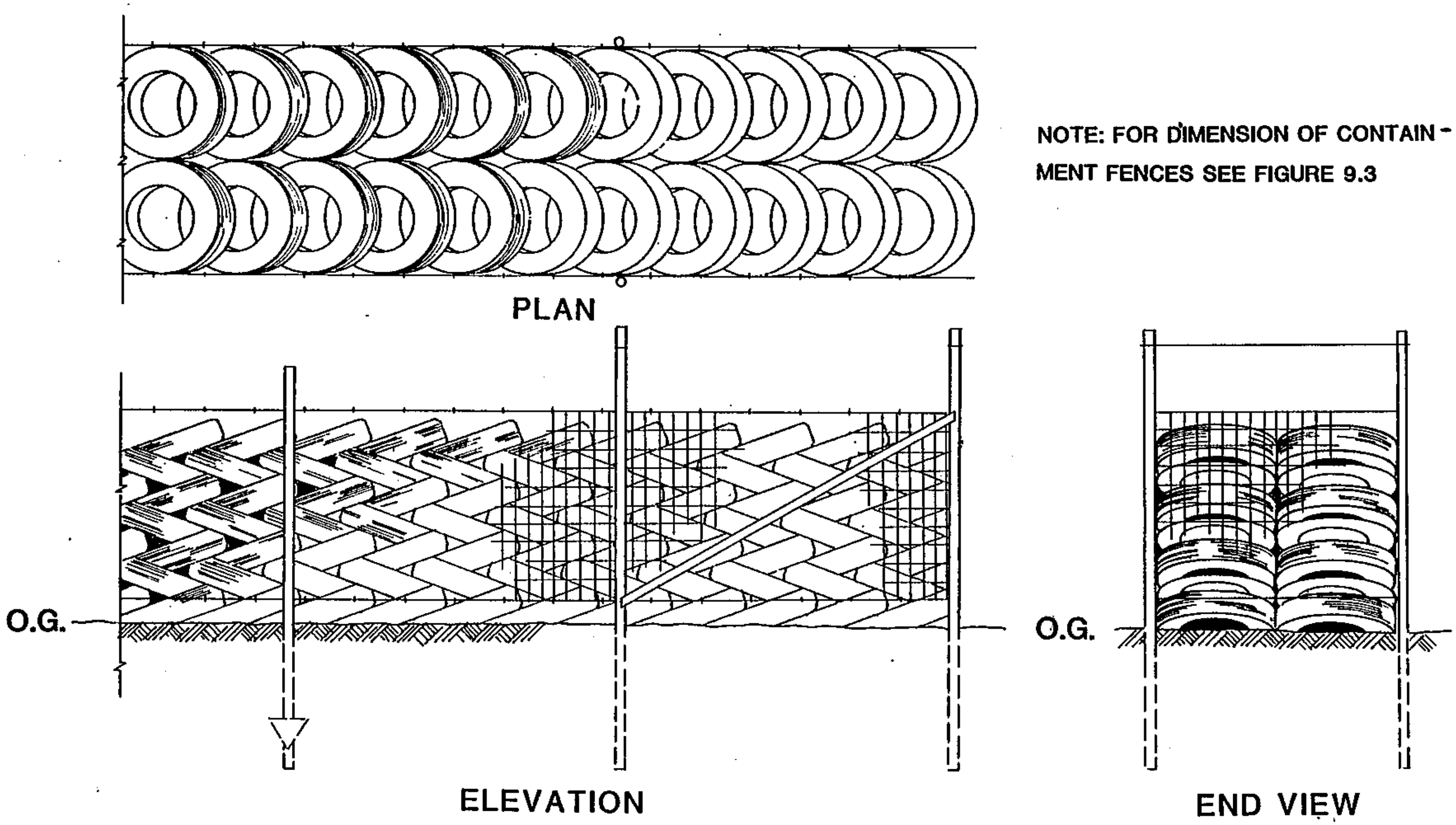


FIGURE 9.5

consisted of stacked configuration (Figure 9.6). Unit 5 consisted of weaved and stacked configurations. The intent of the overall modified plan was to provide the same configuration within the 150 foot wind path for each of the barriers. The tire mat configuration remained as designed (Unit 6).

Units 1 through 5 lie within a floodplain area and were enclosed within the containment fences.

9.4 Installation Procedure

9.4.1 Description

At the beginning of the research project 21,000 tires were delivered to the site for the installations. The tires for this project were obtained from recapping companies and tire outlets in the San Bernardino/Riverside area. They consisted primarily of discarded automobile tires. Tires ranged in sizes from compact to pickup and 4-wheel drive vehicle tires. They were available at no cost, with most being picked up at the tire companies' facilities. The tires were transported to the site in 24 foot vans (Photo 9.5). Each van load held between 450 and 500 discarded tires. The total one-way haul distance averaged approximately 60 miles. To load, haul and unload took approximately four hours for a round trip. From 2,700 to 3,000 tires were hauled per day. The trucks were loaded and unloaded manually. Toward the end of the project, one vendor delivered several loads to the site free of charge.

The installation of Unit 6 (Photo 9.6), was a single layer mat comprised of approximately 11,000 tires. The area covered by the unit did not require any grading prior to placement of tires. The tires were hauled from the stock-

TIRE PROJECT III
STACKED TIRE BARRIER

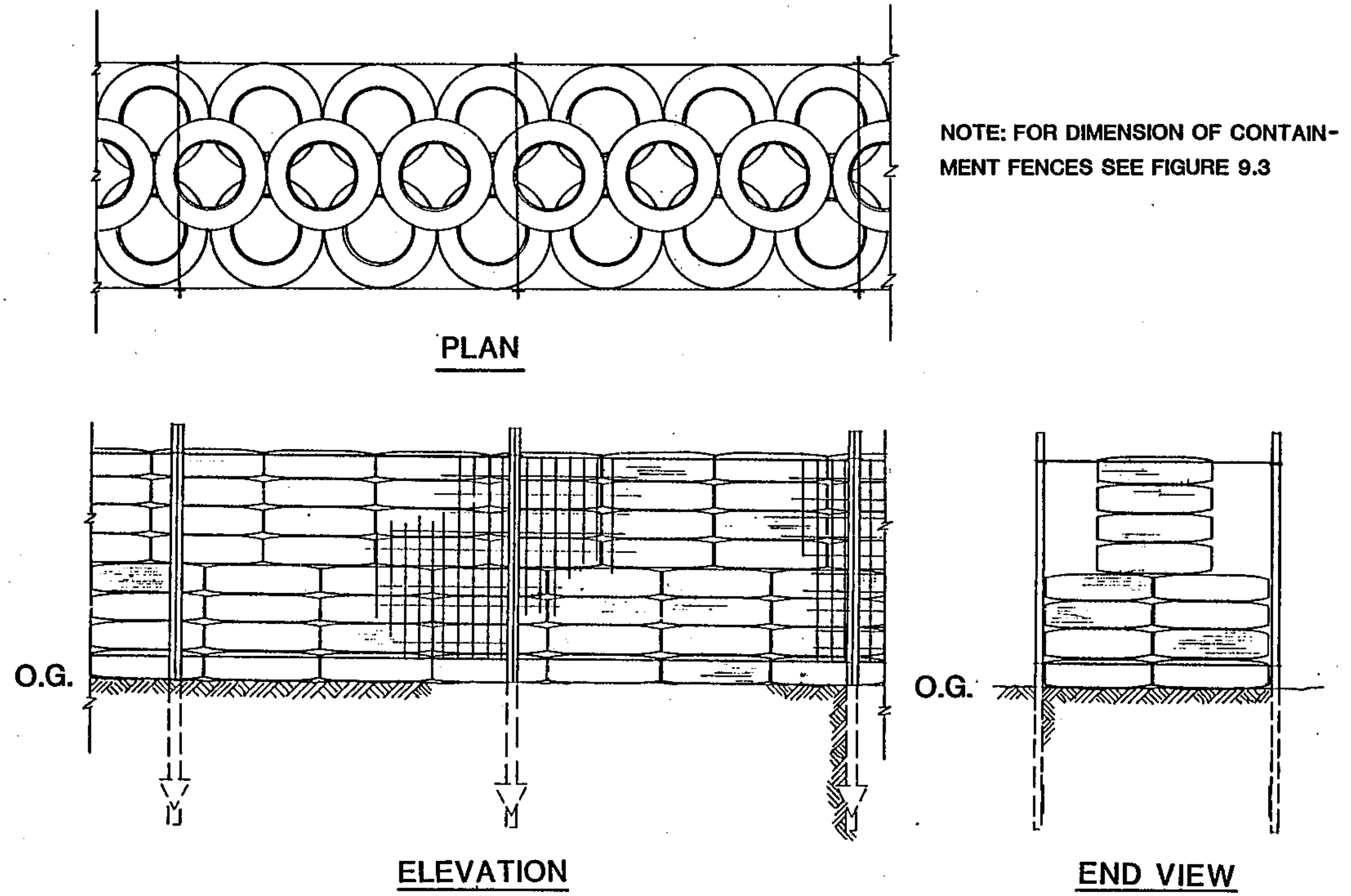


FIGURE 9.6

Photo 9.5 - Transport Vehicles

Photo 9.6 - Tire Mat

pile and hand placed. Care was taken to place the tires around the existing native plants. It was originally intended to cable the tires together into one unit. However, due to the weight of the tires and the fact that they immediately began filling with blowsand, cabling was not required. The mat was not visible from the roadway and was not given the aesthetic paint treatment.

At the Units 1 through 5 sites, the containment fences were erected and then stacked with tires in the various configurations. The top of the tire units were laced together with number 10 wire longitudinally and across the unit every 12 feet. Both Units 1 and 2 and Units 3 and 4 were spaced approximately 115 feet apart. Each barrier wall was 5.3 feet wide and between 200 and 230 feet long. Each wall protected a wind path approximately 150 feet wide. Units 1 thru 5 initially contained 10,000 tires and the tree gaps 1000 tires. Unit 5 (Photo 9.7) utilized approximately 5200 of the 10,000 tires. As the sand impoundment covered the initial tires, additional tires were added to each installation to maintain maximum impounding capability.

Enclosures to retain tires were constructed of 1.5 inch diameter by 8 foot long posts at end of fences and 7 foot T-bar posts spaced on 6 foot centers for the remaining portion of fence. The entire containment fence was comprised of 36" wide property fence material strung on tension wires. The tires were then placed in the containment enclosures. These retention enclosures prevented the tires from floating away during flooding periods or from being easily vandalized.

Two methods were used to place the tires in the retention walls. For Units 1 and 2, the weaving pattern was used in the same wind path as the weaving pattern in Unit 5. For

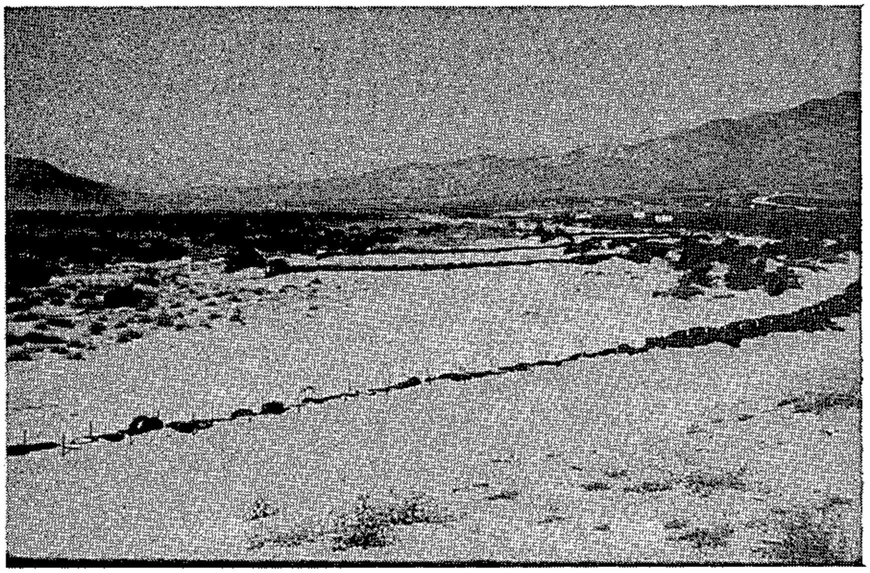


Photo 9.7 - Units 1 Through 5 (5 In Foreground)

Units 3 and 4, the stacking pattern was used. Unit 5 consisted of both the weaving pattern and stacking pattern in combination to form one continuous wall covering a total 450 foot wind path.

The posts, wire and hardware to construct the retention units were state furnished material. Drivers for the vans and workers for the total project were California Conservation Corps (CCC) personnel, contracted out of the San Bernardino Office. The CCC personnel used on the project started work at approximately 8:00 AM in the San Bernardino/Riverside area and returned at approximately 4:30 PM. A work day for each workman was approximately six hours due to the 2 hours travel time to and from the project.

Due to the terrain being covered with loose blowsand it was not possible to drive the vans onto the test site. The tires were unloaded along the edge of traveled way and transported to the test unit locations by a loader and trailer (Photo 9.8).

9.5 Components

9.5.1 Tires, And Materials, Handling And Sorting

The tires were hand loaded into the vans used for hauling tires during the installation period. There were three CCC workers with each vehicle. The tires were loaded by placing them in a weave fashion starting at the front of the vehicle proceeding toward the rear. At the project site, a crew unloaded the vehicle and stockpiled the tires (Photo 9.9). At the supplier's facilities all tires in a collapsed condition and large truck tires were rejected. It is difficult to obtain an acceptable installation if the

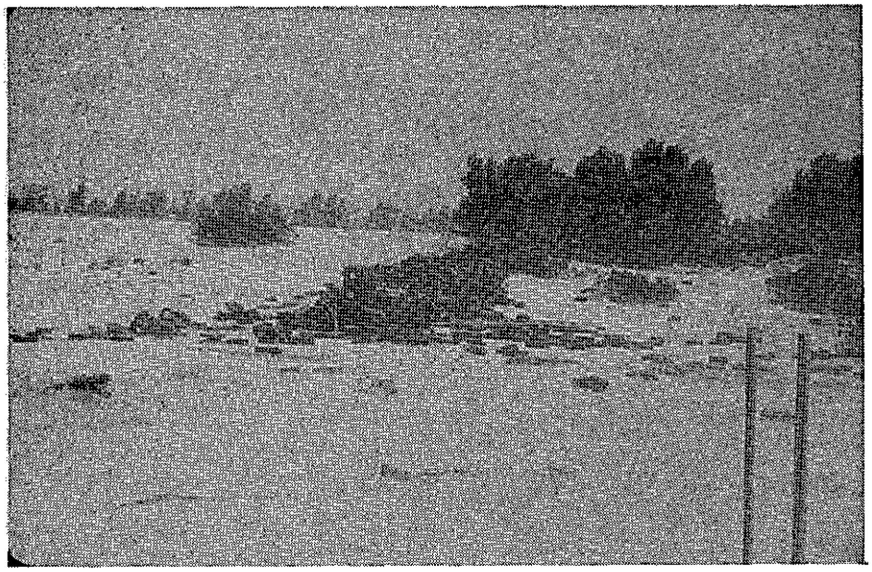


Photo 9.8 - Transporting Tires To Sites

Photo 9.9 - Handling And Sorting Tires

tires do not have a reasonable consistency as to size and shape. It may be necessary to accept some of the undesirable units after they are delivered free of charge to the site.

9.5.2 Tire Volumes And Disposal Cost

Currently the disposal of waste in landfills in the western United States averages approximately $10.00 per ton. Some tipping fees for waste are as much as $36.00 per ton in San Francisco and $37.00 in Cleveland, Ohio (4). Additional charges are imposed by landfills for accepting discarded tires. The main reason for the tipping fees being so high is because the tires are bulky and undesirable for incorporation into landfills. The cost for disposing of 31,000 tires in the sand retention project exceeded $480.00 per ton (90 tires per ton) Disposal of tires by this method is economically impractical. The tires used on the project are summarized below:

Location		Size of Tire Unit 6.5'high	No. of Tires Originally	No. of Tires Added	Tire Total
Unit 1(C)	Weaved wall	230 L.F.	1,000	1,300	2,300
Unit 2(C)	Weaved wall	200 L.F.	1,000	1,000	2,000
Unit 3(B)	Column	230 L.F.	1,400	400	1,800
Unit 4(B)	Column	200 L.F.	1,400	300	1,700
Unit 5(B,C)	Combined	500 L.F.	5,200	-	5,200
Gaps in Tree Row		350 L.F.	1,000	1,000	2,000
Unit 6(A)	Tire mat	1 acre	11,000	5,000	16,000
		Total	22,000	9,000	31,000

Letters in parenthesis are the original proposal designation and were changed early in project to unit number designations.

9.5.3 - Maintenance Problems

After completion of the initial installation of the units there were five specific maintenance activities required to retain the overall project.

- At the point where the units were no longer effective at impounding sand, it was necessary to raise the height of the units in order to impound additional material reaching the barrier. This required importing tires and stacking them on top of the previously placed tires. The original containment enclosures, in most situations, were adequate to accommodate the additional tires. Number 10 wire was laced through the top row of tires and crosstied every 12 feet (Photo 9.10). This secured the tires sufficiently to prevent displacement or removal.

- It was necessary to occasionally pick up tires that had been scattered by vandals (explained later in this report). It was also necessary to replace many of the sand collection test devices that were flooded, broken or destroyed by vandals.

- During the project several warning signs were stolen and several as shown in (Photo 9.11) were used as targets by gun enthusiasts.

- Replacement of plantings was a constant maintenance problem due to the lack of water caused by the irrigation system being destroyed by off-road vehicle activity. Irrigation for this project was obtained from the system that waters the main tree row. The main tree row has been developed for approximately ten years and did not require water as frequently as the cuttings. Interruptions to the irrigation system had a significant impact on the plantings.

Photo 9.10 - Installing Longitudinal And Crosstie Wires

Photo 9.11 - Damaged Sign

The existing water system consists of PVC pipe placed on top of the ground due to the problem of the line being constantly being buried in the rising blowsand within the tree row. The PVC line was constantly broken by off-road vehicles.

9.5.4 Vegetation In Tree Gaps

The original intent of this project was to interplant either tamarisk cuttings or plants to fill in the gaps in the tamarisk tree row on the project. Planting was not undertaken until the majority of the tire barrier walls were in place.

9.5.4.1 Type Of Plants

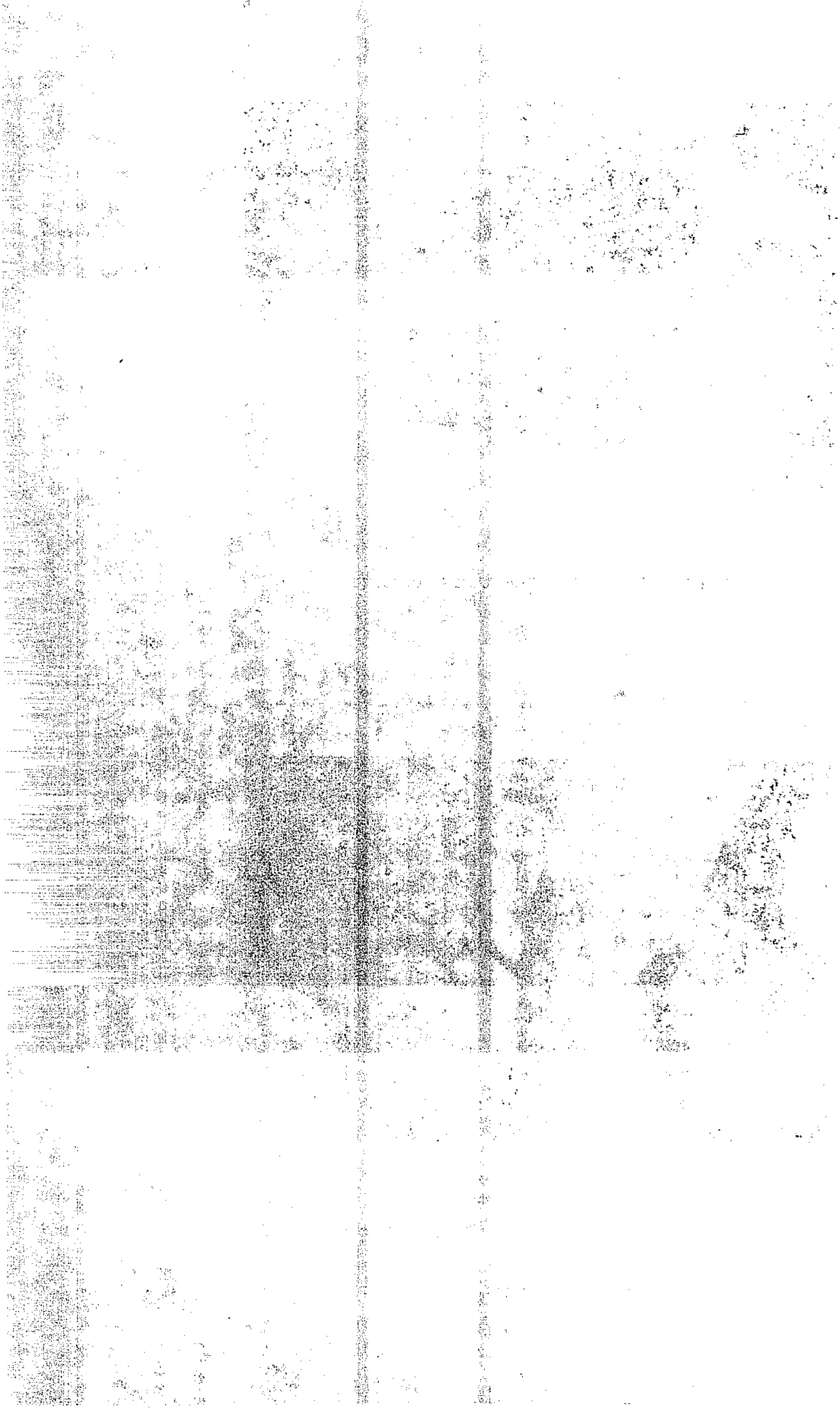
The first plantings used on the project were 33 tamarisk (T. aphylla) cuttings. Nineteen tamarisk cuttings were propagated at Sacramento TransLab and 14 plants were started from cuttings obtained from the site and propagated at the Palm Springs Maintenance Station (Photos 9.12 & 9.13). The site was planted in February 1984. By December 1984 they had all died or been destroyed by dune buggies and motorcycles. Signs were erected to discourage vandalism. In December 1984, thirty 1-gal and four 5-gal Arizona cypress (Cupressus glabra) were interplanted in the gaps within the tamarisk tree row. Additional cuttings of tamarisk from the tree row were planted at the same time.

9.5.4.2 Materials Source

The plants were obtained from three sources. Cuttings obtained from tamarisk trees on the project and propagated at the Caltrans maintenance station near the project.

Photo 9.12 - Tamarisk Plants

Photo 9.13 - Tamarisk Cuttings



Another was the propagation of tamarisk cuttings at the Translab in Sacramento and returned to the project as one gallon plants.

The 34 Arizona cypress were purchased from a nursery in Palm Springs. The local water agency has established a plant test plot near their facility in Palm Desert to evaluate different plants that would be environmentally acceptable and more water tolerant than the tamarisk. The Arizona cypress appeared to meet those criteria and, in cooperation with the water agency, the Arizona cypress plants were included in the project.

9.5.4.3 Survival And Growth

In February 1984, when the tamarisk cuttings propagated at the Palm Springs Maintenance Station and tamarisk trees propagated in Sacramento were planted on the project they had a very poor survival rate. The primary reasons were the lack of water and the gaps in the tree rows being used by the public for access to the desert area upwind of the trees. This activity tended to destroy the plants, tire walls and water system.

Although the survival rate was poor, the remaining plants appeared to be assisting the existing tree growth close the gaps. See Photos 9.14 & 9.15 for comparison.

9.5.4.4 Floor Growth

Prior to this research project, the terrain within the test area lacked any significant ground cover growth with the exception of sporadic clumps of grease wood. The Unit 6 (tire mat) generated considerable growth compared to the area

Photo 9.14 - Gap Before Project

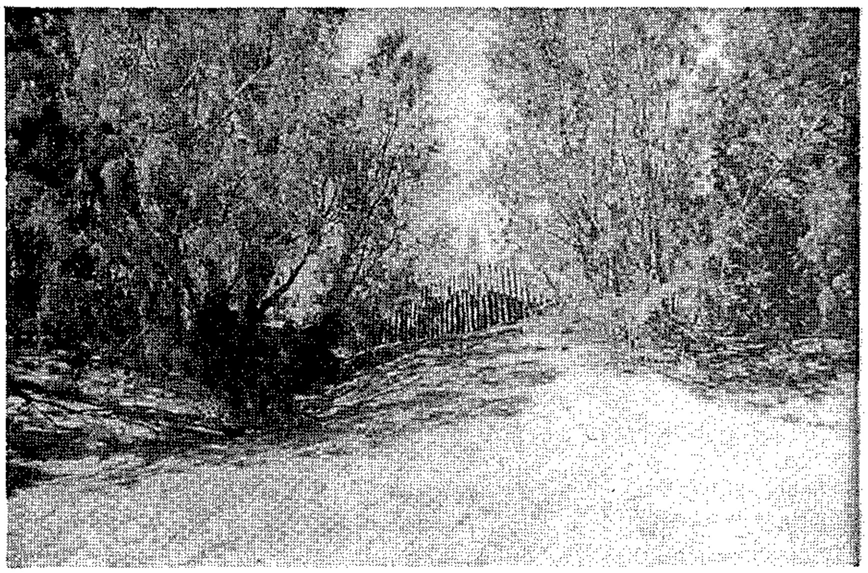


Photo 9.15 - Gap After Project

immediately adjacent to the unit (Photo 9.16). The tire barriers tended to provide protection in the downwind areas, thus encouraging growth (Photo 9.17).

9.6 Personnel, Equipment, Material And Cost

The following cost estimate for this project was used to determine the cost-benefit ratio for using discarded tires versus alternative materials to construct sand barriers. Although the CCC personnel were not a direct cost to the project, they were included in this estimate to derive the cost for constructing this type of project. The $68.00 per lineal foot cost for a 78" high tire barrier, greatly exceeds the comparable cost for alternative materials.

Tire Barrier Installations

Material:		
25,700 Tires (no cost)		$ 0
Post and Fence		5,600
Hardware		700
	Subtotal	$ 6,300
Equipment:		
1 - Passenger Van		$ 3,600
3 - 14 Foot Vans		1,100
1 - Loader and Trailer		6,300
2 - Pickups		7,200
	Subtotal	$ 18,200
Labor:		
10 - Laborers		$ 81,400
1 - Foreman		8,900
1 - Operator		2,100
	Subtotal	$ 92,400
	Total	$116,900

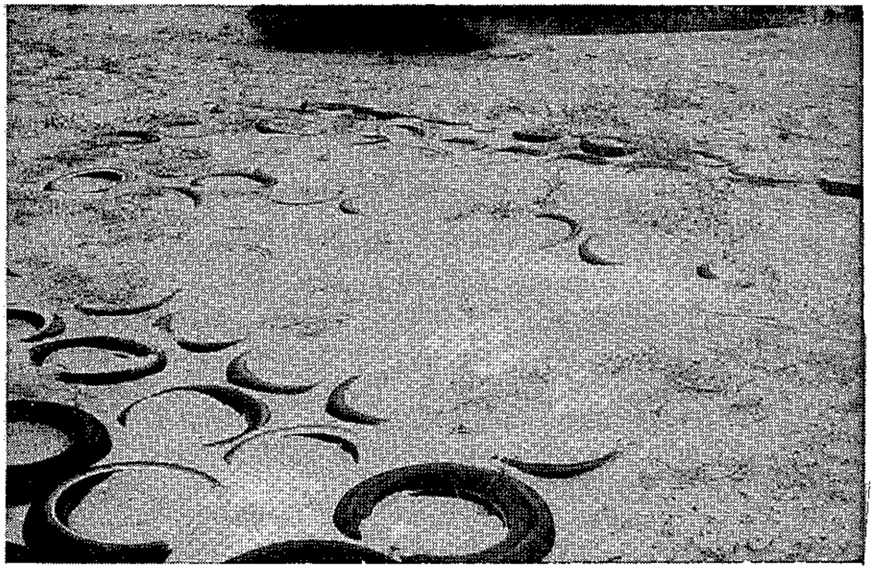


Photo 9.16 - Plants Within Tire Mat

Photo 9.17 - Plants Downwind Of Unit 4

Tire Blanket Installation

Material:		
5,000 Tires (no cost)		$ 0
Tire Clips		13,000
	Subtotal	$ 13,000
Equipment:		
1 - Passenger Van		$ 1,000
2 - 14 Foot Vans		300
1 - Loader and Trailer		1,800
2 - Pickups		2,000
	Subtotal	$ 5,100
Labor:		
10 - Labors (CCC)		$ 22,600
1 - Foreman (CCC)		2,500
1 - Operator		1,100
	Subtotal	$ 26,200
	Total	$ 44,300

Paint Tires

Material:		
Paint	Subtotal	$ 1,800
Equipment:		
5000 Watt Generator		300
Wagner 1200 Airless Paint Sprayer		300
Pickup Truck		400
	Subtotal	$ 1,000
Labor:		
2 - Painters	Subtotal	$ 2,000
	Total	$ 4,800

Plants

Material:			
30 - 1-Gal Arizona Cypress Tree		$	110
4 - 5-Gal Arizona Cypress Tree			60
24 - 1-Gal Tamarisk			60
Planting Mix			10
	Subtotal	$	240
Labor:			
2 - Laborers	Subtotal	$	360
	Total	$	600

Snow Fencing And Sand Collection Devices

Material:			
400 Lineal Feet		$	500
Sand Collection Devices			100
	Subtotal	$	600
Equipment:			
Pickup	Subtotal	$	100
Labor:			
4 - Laborers		$	700
1 - Foreman			200
	Subtotal	$	900
	Total	$	1,600

COST SUMMARY

(Cost in 1986 dollars)

Tire Barrier Installations	$116,900
Tire Blanket	44,300
Paint Tires	4,800
Plantings	600
Snow Fencing and Sand Collection Devices	1,600
Total Project Cost	$168,200

Tire Barriers (78" high)	$68.00 Lineal Foot
Tire Mat	$ 1.02 Square Foot

9.7 Alternative Barrier Material

There are other types of material that can be used to build a barrier wall to impound blowing sand.

There is a polyethylene material on the market that is installed similarly to snow fence. It is very resistant to ultraviolet radiation light and has an extremely high tensile strength.

There are also the applications of salvaged roadway signs and glare screens which have been used on earlier protective wall projects. Again, the project life of these materials is limited but in comparison to tire walls, they are much more economical to install and less labor-intensive.

9.7.1 Snow Fence

Snow fencing has been used for many years by highway maintenance forces in areas where snow or blowing sand tended to deposit next to or upon the traveled way or to otherwise jeopardize motorist safety by impairing visibility. Snow fence tends to disintegrate in the desert areas in a few years. However, it can provide for interim protection from blowing sand for up to two or three years depending upon the severity of wind conditions, the quantities of sand intercepted, and other site specific conditions.

9.7.2 Snow Fence Screening

As the result of concern for aesthetics by the local agency during the project, five short lengths (20 to 30 feet each) of snow fence were used to provide a screening effect to mask off the tire walls along the tree gaps. The only problem encountered was the destruction of the fence by off-road vehicle users attempting to remove them to gain access to the area behind the trees.

9.7.3 Polyethylene Fence

Polyethylene fencing which has appeared on the market in recent years (although not used on this particular project) may prove to be more durable. Either type is relatively inexpensive and more easily installed than discarded tire installations which are labor-intensive.

9.7.4 Cost Comparison

The following is a cost comparison for the sand barriers of several materials now in use.

48" high fence	Cost per Lineal Ft
Tire barrier	$42.00
Polyethylene	3.25
Snow Fence	3.25

9.8 Monitoring

The project work plan proposal for monitoring the project consisted of the following:

9.8.1 Cross Section Surveys Of The Project

The test facility was monitored continually to determine the amount of material retained and the degree of protection afforded. Three types of monitoring were conducted. Cross section surveys were made of the test sites before the test period. Each tire unit was surveyed for continuing impoundment of sand. At completion of the project the site was surveyed for the total amount of sand retention.

9.8.2 Maintained Visual Inspection And Photographic Log

A photographic log was maintained of the overall project. Photographs were taken of the gaps before the project began and after completion of the research. Photographs were also taken during the study of the change in flora (Photos 9.14 and 9.15).

9.8.3 Monitor Plants And Growth

The progress of the tamarisk seedlings and surrounding desert flora was monitored and evaluated during the course of the research.

9.8.4 Sampling

Sampling consisted of recovering samples from specially designed collection containers. Sand collection containers were installed throughout the project. The samples were extracted from these units after each significant sand storm. However, results were sketchy due to vandalism and flooding. Ten containers were installed; one container upwind and one downwind of each tire unit. Those containers located in the floodplain, were susceptible to flash flooding and all containers were susceptible to vandalism and the off-road vehicle traffic.

9.8.5 Sand Collection Devices

The sand collection devices (Figure 9.7) were fashioned from 5 gallon plastic containers. The device has 12.5 inches of 1 inch PVC pipe extending upwards from the top. The stack consists of an entrance inlet and the vent exhaust port. The entrance inlet pipe is 1/2 inch inside diameter x 2 1/2 inch long galvanized pipe. The reason for the galvanized pipe was to with stand any distortion to the entrance from sandblasting. The entrance was installed at 6 1/2 inches above the ground level. The exhaust stack extended 6 inches above the entrance pipe. These characteristics were arrived at through field testing to minimize back pressure or suction at the orifice during normal sandstorm conditions and relieve any back pressure developing in the bucket.

TIRE PROJECT III

SAND COLLECTION DEVICE

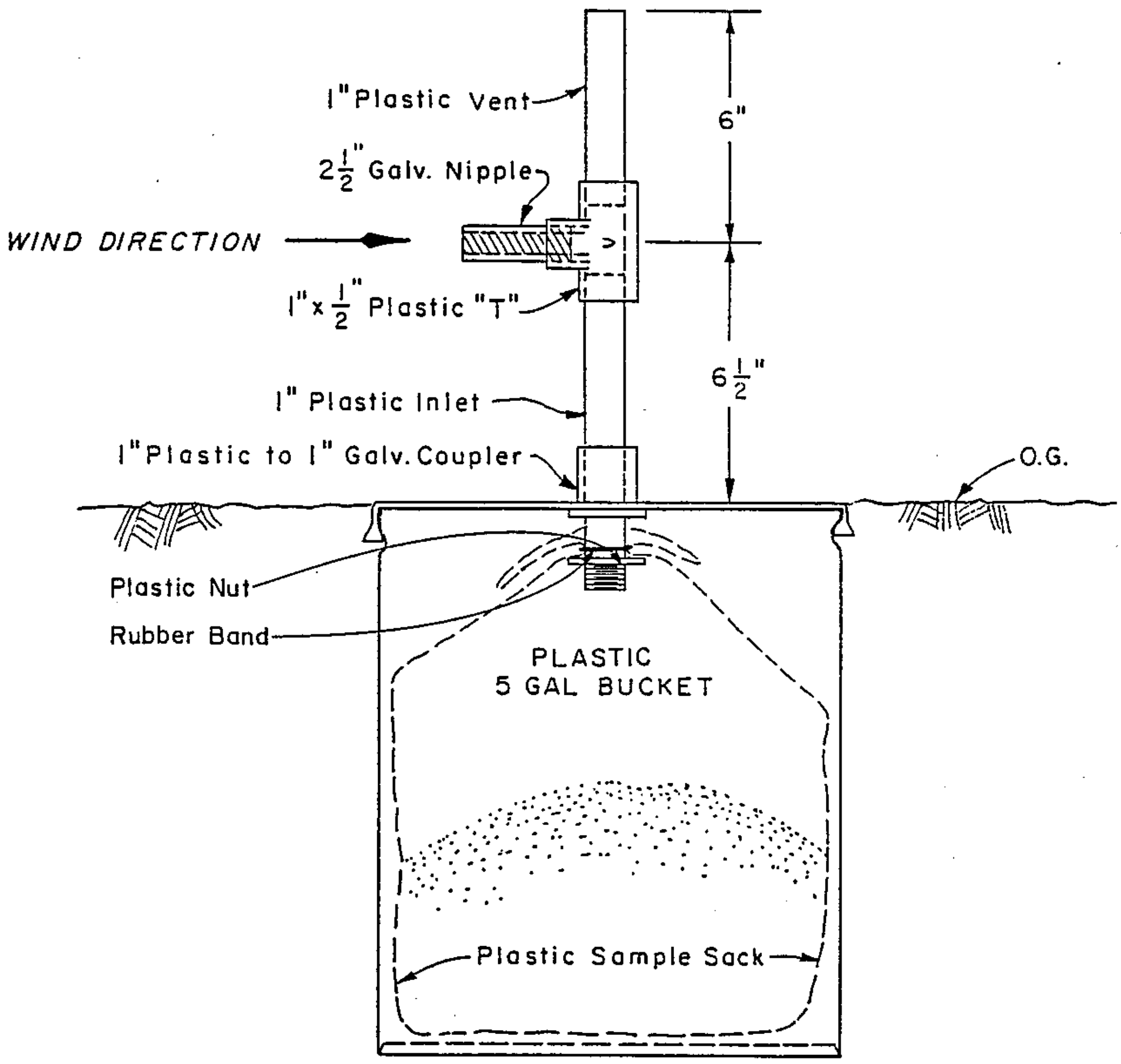


FIGURE 9.7

The monitoring devices were placed upwind and downwind of each tire unit. The devices upwind of the tire unit were to detect the amount of sand approaching the unit and those downwind were to indicate the amount of sand which escaped entrapment.

The plastic sample sacks were affixed to the inlet pipe by rubber fasteners. This provided easy extraction of the sample from the container. The top of the plastic containers were pressure fit lids and were installed at ground level (Photo 9.18).

9.8.6 Monitoring Tires

9.8.6.1 Sand Retention

At completion, the project had impounded approximately 6,100 cubic yards of sand on units 1 thru 5, 4,000 cubic yards in the tire blanket and 1,000 cubic yards of sand in the tree gap.

Unit		Impounded Sand-CY'S
1		1,030
2		550
3		1,030
4		790
5		2,670
Tire mat		4,000
Tree gaps		1,000
	Total cubic yards	11,070

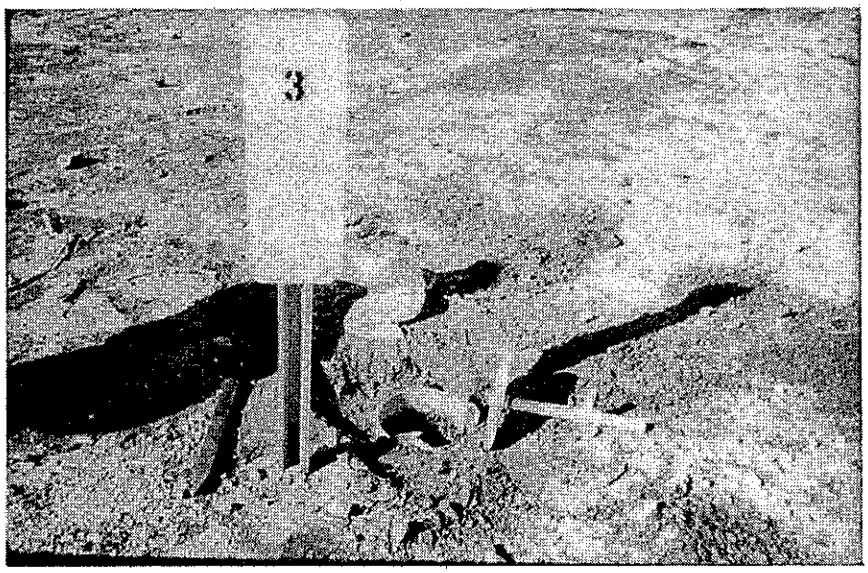


Photo 9.18 - Sand Collection Device

9.8.6.2 Stability Of Barriers

Stability of the barriers was very good. A section of Unit 2 experienced some erosion early in the project. Flooding washed away the sand from the front of the barrier wall and undermined a portion of the tire row. This was mitigated by the installation of an additional containment fence and depressing the tires below grade.

The weave pattern appeared to provide the best stability of the three different methods. During installation of the tires, the weave method provided the easiest means of incorporating different size tires into the barrier walls. The weave results in a form of interlocking of the tires which creates a single unit effect.

The stacked installations required tying the units together on top of the installation to prevent tires from falling over and vandals removing tires from the barriers. Once the tires became filled with blowsand, instability or removal was no longer a problem. It is extremely difficult for one person to dislodge a single impounded tire without a shovel or mechanical equipment.

9.8.6.3 Vandalism Plants, Irrigation System, Sand Collection Devices And Signs

About the time this project started, the test area began to be used extensively by people with off-road vehicles. A trade magazine advertised the area as one of the best locations in Southern California available for off-road vehicles.

Problems that occurred during the project consisted of removing tires from the various tire units and using them in configurations to maneuver their vehicles and motorcycles through. Other problems experienced were the destruction of plants, irrigation lines, sampling units and signs used on the project.

Because of the remoteness, one main concern at the beginning of the project was the possibility of vandals attempting to ignite the tires. However, this did not occur. It would have been possible to remove tires from the installations and burn then when they were initially installed; however, as the blowsand filled and covered the majority of the installations, the possibility of igniting the tires became near zero.

9.8.6.4 Erosion And Rainfall

During the course of the study there were storm periods where storm water sheet flowed through the project. This sheet flow resulted in some erosion to Unit 2, which required maintenance. It also flooded the collection devices and voided the sample material collected.

One indirect benefit provided by the contained tire installation was the protection of the highway embankment by tire Unit 5. Photo 9.19 shows the Unit 5 site before the installation and the force of the sheet flow eroding the protective slope. Photo 9.20 shows the area three months after the installation of the tire barrier. The impoundment of sand has replaced the material removed by erosion before installation of Unit 5. The unit now protects the slope from further erosion as well as impounding sand before it reaches the tree row.

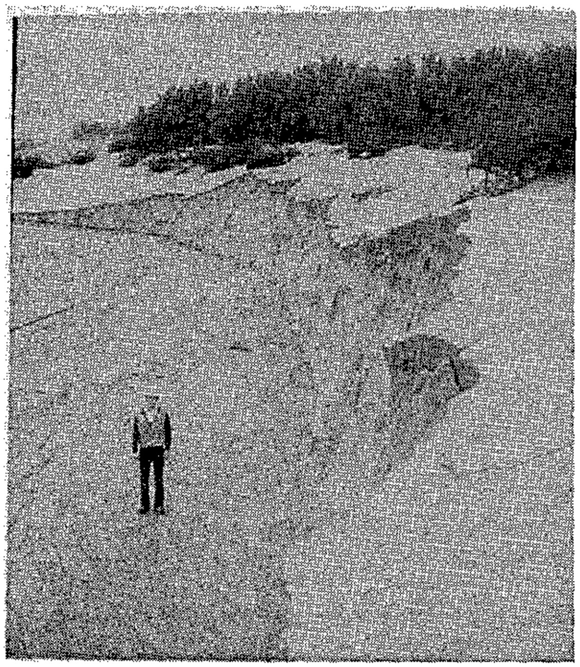


Photo 9.19 - Before Unit 5 Was Installed

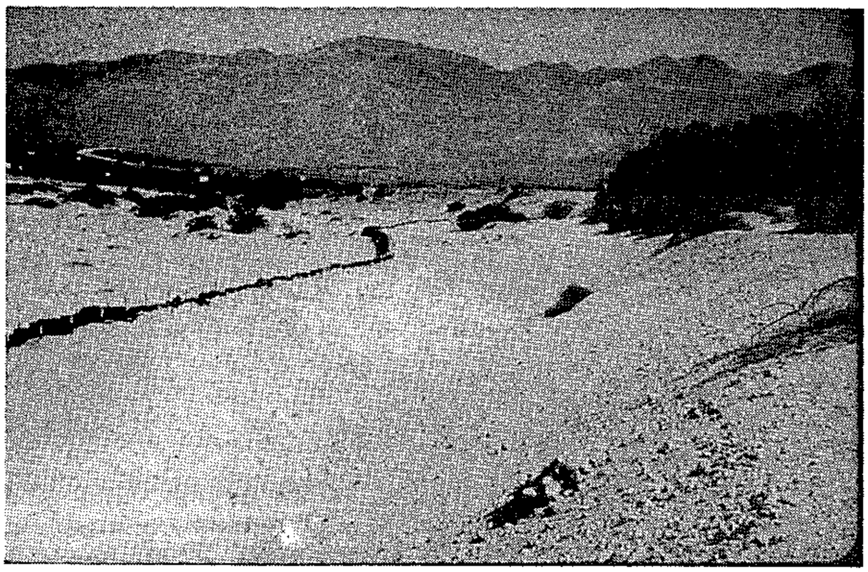


Photo 9.20 - After Unit 5 was installed

9.9 Aesthetics

Because of the visibility of the tire barriers from the highway, the district was concerned with the compatibility of the test installation with the desert environment. Therefore, the various tire installations were evaluated by an aesthetics committee set up by the district. This project was declared categorically exempt by the District Environmental Branch in 1982.

Prior to installation of the tire units, care was taken in the selection of each unit site to insure that none of the existing flora was disturbed during the construction of the tire units or throughout the study.

During initial installation, aesthetic concern was raised by the city of Palm Springs. However, a brief presentation and discussion resulted in the City Planning Commission acknowledging the benefits of the project and endorsing its implementation. In return, Caltrans agreed to paint the completed installations to better blend with the desert surroundings.

Because this project is proximate to the environmentally sensitive community of Palm Springs, utmost care Photo 9.20 in planning, installation and maintenance was required. At the completion of the tire installation the tires in units 1 thru 5 were painted to conform with the color of the surrounding terrain.

Throughout the project the tire installations provided an excellent habitat for endangered species, the Coachella Valley fringe-toed lizard (Uma inornata), and other small animals indigenous to the area.

9.9.1 Progress

Early in the project a concern was also expressed that the tire walls installed at the gaps in the tree row, close to the highway and visible through the gaps were unsightly. In addition to painting these, tires they were also screened with snow fencing.

As the project developed, between severe wind storms, native desert flora tended to grow and cover the downwind areas which were protected by the tire walls. The combination the painted surfaces and the native growth tended to mitigate the negative visual impact of the tires.

9.9.2 Mitigation - Painting Tires

In August 1983 one of the tire walls in a tree gap was selected as an experimental test panel for specially tinted paint. Three different coatings were sprayed onto the test panels (Photo 9.21). One was a solid pattern, the second, a dusted-on pattern and the third, a camouflage pattern which consisted of green and the specially tinted paint. The purpose of these on-site test panels was to develop an aesthetic screening for the tire walls. After determining the dusted on pattern would be the most acceptable, it was applied to Units 1 through 5 (Photo 9.22).

The paint selected for the tires was Pittsburgh acrylic outdoor flat (Product code 72-150, Color M-609 smokey beige 8010-009-1017-7). This paint was acquired under the state contract for $6.05 per gallon. The paint was pretested by applying it to aluminum plates and subjecting them to accelerated weathering with ultra violet light according to test method ASTM G53. No significant change was noticed on the sample after 300 hours of exposure.

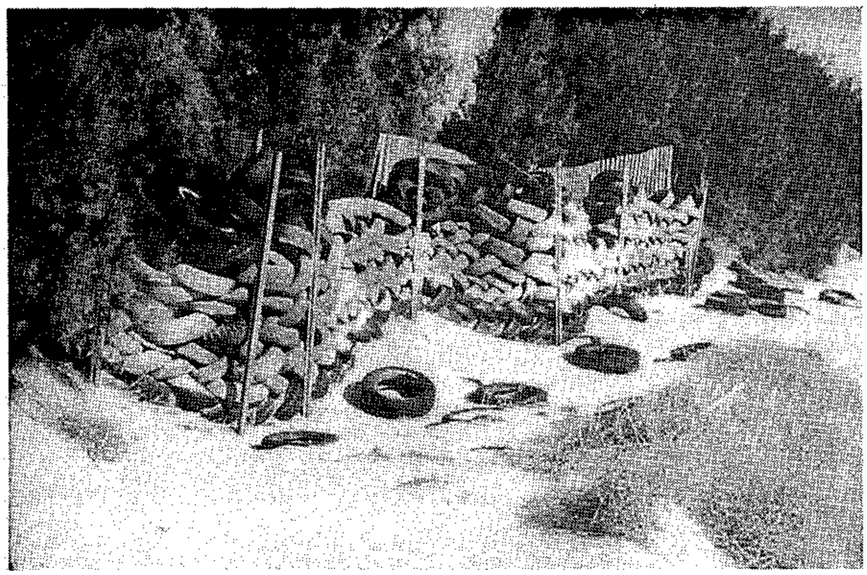


Photo 9.21 - Test Panels

Photo 9.22 - Unit 1 Thru 5

A simulation test was also performed in the laboratory by applying the smokey beige paint and a more expensive paint to two automobile tires. These tires were allowed to completely dry and then were submitted to sand blasting similar to that which would occur in a severe sandstorm. They were then shipped to the project site for color matching. The smokey biege was selected for application on the project.

The original paint test sections withstood the sandblasting without any appreciable removal of paint from the surface of the tires. The five tire walls which sustained significant sand blasting over a period of 30 months did not show any significant indications of paint removal. The acrylic paint was the most economical on the market at that time. The smokey beige color was close to the sand color on the project site, making the tires blend well with the terrain.

9.10 Aesthetic Guidelines

The main aesthetic mitigation for the tire barriers is the application of paint to blend with the surrounding terrain and limited screening with snow fence if required. These applications are suitable for temporary installations and not intended to become a permanent mitigating solution.

9.11 Tire Blanket

Upon completion of the project the District desired to retain the tire installations and the impounded material by covering each of the tire barrier Units 1 thru 5 with a tire blanket as detailed in (Figure 9.8). This blanket will retain the impounded sand and prevent any erosion of the installation by sheet flow flooding of the channel. The blanket is clipped together with cold rolled 3/8" diameter

PROJECT III

RECYCLED TIRE BLANKET

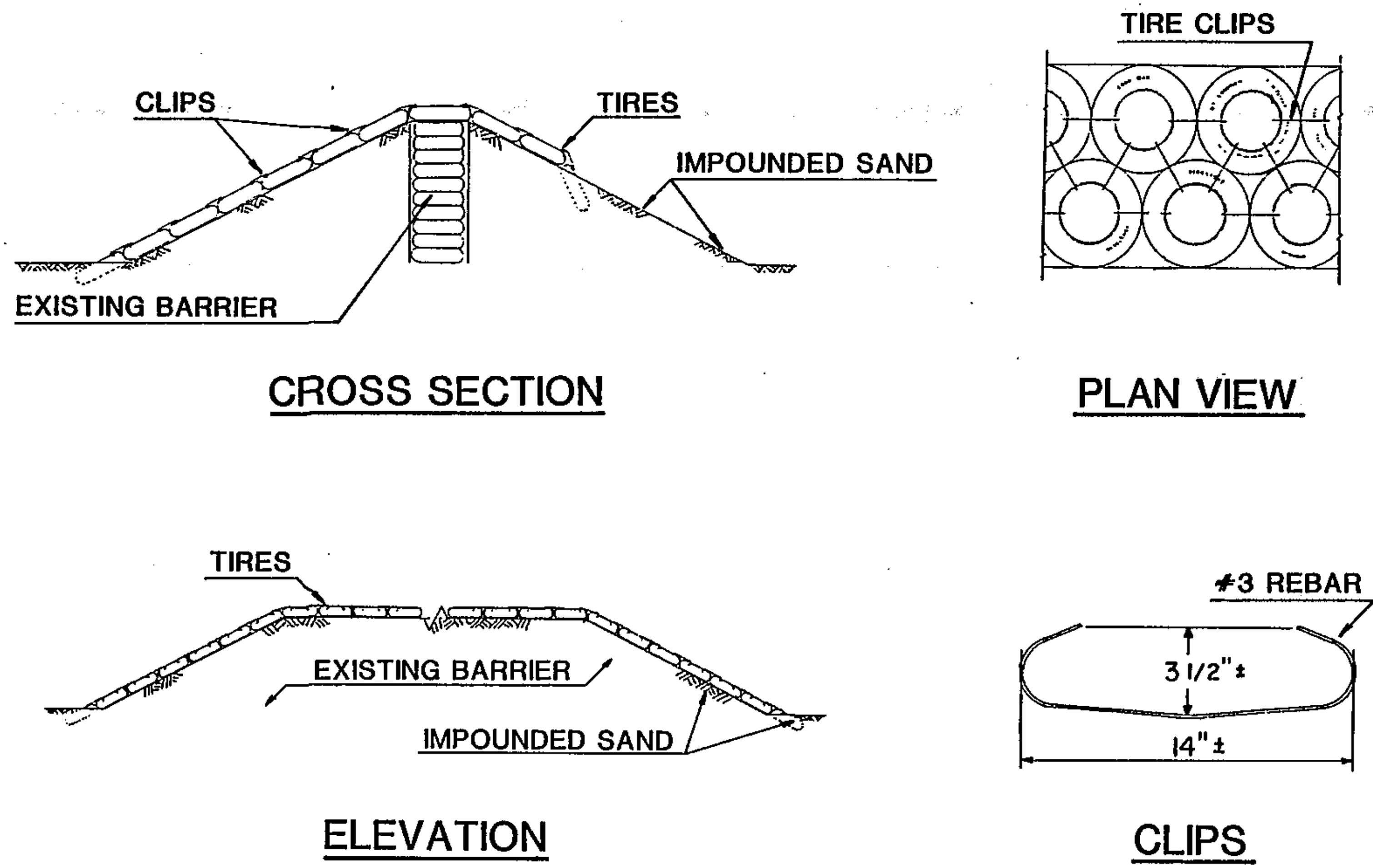


FIGURE 9.8

steel and the tires aesthetically treated to satisfy the environmental concerns of the region.

9.12 Coordination With Other Agencies

There was considerable support for this project due to the blowing sand problem along this portion of State Route 111.

During the course of the research, meetings were held with representatives of various agencies to keep them abreast of the progress of our research in the area. The area around the project is administered by the city of Palm Springs, Riverside County and various federal agencies, as well as the Southern Pacific Land Company (S.P.L.Co.).

The S.P.L.Co. is the owner of the property on which this research project has been conducted. The S.P.L.Co. had a significant interest in the project as protection of our tree row also provides protection for their railroad facilities.

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