EXPERIMENTAL PROJECT
USE OF SHREDDED TIRES
FOR LIGHTWEIGHT FILL

FHWA Experimental Project No. 1
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Post-Construction Report

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16. Abstract
Shredded rubber tires have been used as lightweight fill in repair of a landslide tha occurred under a highway embankment in mountainous terrain on Highway US 42 (Orego State route #35). The force driving the slide was decreased by removing the soi embankment and replacing it with a lighter weight embankment constructed with shredde tire chips. The tire embankment has a three-foot-thick compacted soil cap on the to and side-slopes and supports a conventional aggregate base and asphalt pavement. 580 tons of shredded tires were used - approximately 580,000 tires. Cost of the tires delivered to the site was $30/ton reduced by a $20/ton reimbursement from Oregon DEQ; net $10/ton ($7/yd^3). Cost of placing and compacting the tires was $8.33/ton ($5.85/yd^3). Total cost of the tire fill at final in-place density was $18.33/ton ($12.87/yd^3). Surface monuments, settlement plates, and slope inclinometers have been installed to monitor the performance of the embankment.

Shredded tire chips were transported to the project site in "live-bottom" trailers from vendors located 150 to 200 miles from the project. The trailers each carried 28 tons of tires. The tire chips were placed and compacted in three-foot lifts using a D-8 dozer. Density (unit weight) of the tire chips was on the order of 30 pcf when "loose" in the haul vehicle, 45 pcf compacted in-place, and 52 pcf when compressed under the soil cap and pavement. The 12.5-foot-thick section of compacted tire embankment compressed 20 inches (13.4%) under the capping load. Few construction problems were encountered. Exposed wires in the tire chips caused tire punctures on dump trucks.

Pavement surface deflections were measured using a falling weight deflectometer. Deflections were twice as great as would be expected of the same pavement over an earth embankment. Vibrations similar to those felt when standing on a bridge can be felt by a person standing on the embankment when a heavy truck crosses it.

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DISCLAIMER

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Abstract

Shredded rubber tires have been used as lightweight fill in correction of a landslide that occurred under a highway embankment in mountainous terrain on Highway US 42 (Oregon State route #35). The force driving the slide was decreased by removing the soil embankment and replacing it with a lighter weight embankment constructed with shredded tire chips. The tire embankment has a three-foot-thick compacted soil cap on the top and side-slopes and supports a conventional aggregate base and asphalt pavement. 5800 tons of shredded tires were used - approximately 580,000 tires. Cost of the tires delivered to the site was $30/ton reduced by a $20/ton reimbursement from Oregon DEQ; net $10/ton ($7/yd^3). Cost of placing and compacting the tires was $8.33/ton ($5.85/yd^3). Total cost of the tire fill at final in-place density was $18.33/ton ($12.87/yd^3). Surface monuments, settlement plates, and slope inclinometers have been installed to monitor the performance of the embankment.

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Pavement surface deflections were measured using a falling weight deflectometer. Deflections were twice as great as would be expected of the same pavement over an earth embankment. It may be that the larger deflections have larger-than-normal radii. Vibrations similar to those felt when standing on a bridge can be felt by a person standing on the embankment when a heavy truck crosses it.

EXPERIMENTAL PROJECT

USE OF SHREDDED TIRES FOR LIGHTWEIGHT FILL

INTRODUCTION

The use of shredded tires for lightweight fill represents a very new technology. There are many questions to be answered regarding the construction and performance of this type of structure. The objective of this experimental evaluation was to provide information to help answer the following questions:

1. Is lightweight fill constructed of shredded tires effective in stabilizing a landslide or soft ground problem?
2. What special construction problems are associated with shredded tire embankments?
3. Can construction methods (details) be improved?
4. What is the density of the shredded tire chips:
   a. during haul ("loose density")?
   b. following compaction in an embankment?
   c. following loading with "capping embankment" and pavement?
5. Will shredded tires in embankments undergo continuing long-term compression?
6. Will pavement over shredded tire embankments be subject to abnormal distress?
7. Are shredded tire fills cost-effective?

BACKGROUND

The United States has an estimated 2 billion scrap tires stockpiled around the country. Another 240 million tires are discarded each year. Disposal of waste tires is one of the country's most pressing environmental problems.

Beginning in 1986, the Minnesota Department of Forestry has demonstrated the feasibility of using shredded tires as lightweight fill in embankment construction over soft ground. Use of shredded tires as lightweight fill also has application on landslide correction projects.

The use of shredded tires for lightweight fill (or as "standard" fill) provides the significant benefit of utilizing a troublesome waste product (scrap tires) in a beneficial highway engineering application. Further, the present commercial uses for scrap tires utilize only a small portion of the amount stockpiled and generated annually in the U.S. The use of shredded tires in embankments offers the potential benefit of disposing of large volumes of tires in short sections of highway. For example, the use of an asphalt-rubber pavement overlay utilizes only about 3600 tires per mile of 2-lane road while a mile of 2-lane embankment 20-feet high would utilize about 5 million tires (one tire equals approximately one cubic foot loose bulk density before compaction).

THE OREGON SLIDE CORRECTION PROJECT

The slide that ODOT corrected is at mile point 59.3 on Highway U.S. 42 (Oregon Hwy. 35, Coos Bay - Roseburg), approximately 25 miles west of Roseburg, Oregon as indicated on Figure 1. The slide occurred in a newly-constructed 15-foot-high highway embankment and the slide block extends approximately 150 feet beyond the toe of the embankment to a small creek (Shields Creek) running parallel to the highway.

The first indications of a possible landslide problem were pavement cracks which appeared in September, 1989, shortly after construction of new embankment that raised the previous highway embankment 4 feet and widened it about 20 feet. More definite slide symptoms, as shown in Figures 2 and 3, appeared early in 1990. The original ground underneath the embankment is gently sloping. The slide is a block slide riding on an old slip plane of an ancient slide. Although the old slip plane had "healed" and had enough strength to support the original 11-foot-high embankment, the additional load of the new construction was sufficient to activate the portion of the ancient slide between the highway and the creek. The head scarp of the new slide is at approximately the centerline of the highway. Figure 4 is a plan drawing of the slide.

DESIGN OF SLIDE CORRECTION

Geotechnical analyses indicated that an effective correction scheme would be removal of some of the embankment weight by replacement with shredded tires and use of the excavated embankment soil to construct a counterbalance berm between the embankment toe and the creek. The weight of the counterbalance acts as a force resisting the movement of the landslide.

The design called for removal of 8,500 cubic yards of earth embankment to be replaced with shredded tires. (Final tire volume was 8,260 cubic yards.) The weight of soil removed was approximately 12,800 tons compared to 5,800 tons of shredded tires used as replacement. An estimated 580,000 tires were used. Details of the design are shown on Figures 5, 6 and 7.

A drainage blanket consisting of 12 inches of free-draining rock between two layers of geotextile was placed beneath the shredded tire embankment and beneath the counterbalance in order to prevent the groundwater table from rising into the embankment. Three 10-foot-deep french drains which outlet into Shields Creek were located beneath the blanket to enhance the subsurface drainage. The tire chips would have served as a good drainage medium without the rock blanket, but the Oregon DEQ required the rock blanket so the tire chips would not be submerged.

ENVIRONMENTAL (GROUNDWATER) CONSIDERATIONS

A laboratory study has been completed for the Minnesota Pollution Control Agency (MPCA) "to evaluate the compounds which are produced by exposure of tires to different leachate environments." One of the recommendations in the report of that study (2) is "that the use of waste tires be limited to the unsaturated zone in a roadway ..." The Oregon DEQ used the recommendations in the report as a basis for evaluating and approving the slide correction design. That is why a rock drainage blanket was required below the tire fill.

At this time there are differences of opinion regarding the need for controlling contact between tires and groundwater. Some question the conclusions and recommendations of the MPCA report and believe that the threat to the environment due to tire leachate is virtually nil. Much of the data in the MPCA report could be used to support such an opinion.

Geisler, et. al. (1) describe the use of shredded tire fill in submerged applications in Minnesota. They used a lightweight shredded tire embankment to successfully cross soft organic wetland soils that had failed under the load of an earth embankment. They also used shredded tires to cross a peat swamp. They single out wetlands applications as being a particularly suitable for shredded tire applications. The extremely low buoyant weight of rubber makes it especially beneficial as lightweight fill when submerged.

We recommend that additional research be conducted regarding the chemical stability of shredded tires in submerged conditions. Monitoring of groundwater quality in the vicinity of full-scale embankments would be particularly valuable.

CONSTRUCTION WITH SHREDDED TIRES

The embankment construction was completed in two stages to allow traffic on one half of the embankment while the other half was under construction. The construction steps are listed briefly on Figure 7 and more completely in Attachment A. Figures 8, 9, and 10 show the embankment under construction.

TRANSPORTING TIRE CHIPS TO THE PROJECT

Shredded tires were brought to the site from four different vendors, located 150 to 250 miles from the project: one in Salem, Oregon, two in the Portland Oregon area, and one in Winlock, Washington. They were transported in trailers capable of carrying 28 tons of tires; approximately 80 cubic yards "loose weight." The tires would "shake down" or "pack" to about 60 cubic yards during the trip to the project site. The trailers were "live-bottom" trailers capable of "self-unloading" at a stockpile near the project. Some tilt trailers were also used (Figures 11 and 12).

The cost of transportation from vendor to stockpile was $10-per-ton which is equivalent to approximately $7-per-cubic-yard at final in-place density.

The shredded tire suppliers were:

1) Western Recovery
   1650 Industrial Drive, Salem, OR 97303

2) RMAC PO Box 301008
   12245 NE Whitaker Way, Portland, OR 97230

3) Tire Recyclers Inc.
   583 N. Military Road, Winlock, WA 98596

4) Waste Recovery Inc.
   8501 N. Borthwick, Portland, OR 97217

PLACEMENT AND COMPACTION

After a sufficient stockpile was accumulated, shredded tires were brought from the stockpile to the construction site in 10-yard dump trucks and dumped at one end of the 350-foot-long correction excavation. It was not practical to drive the dump trucks over the in-place shredded tires because exposed wires sticking out of the shredded tire "chips" punctured the tires of the hauling vehicles.

The tire chips were spread and compacted by a D-8 dozer. At least 3 "full-coverage" compaction passes were specified for each

3-foot lift of tires. (A full coverage pass is a pass during which at least one track of the dozer passes over every portion of the lift surface being compacted.) Attempts to compact the tires with a D-6 Dozer were observed to be less effective than compaction by the D-8.

The specified compaction method was selected based on successful results achieved during similar construction in Minnesota using the same method (1).

The most effective method of compaction with the dozer proved to be the use of a "grid" coverage pattern with the dozer making a full-coverage pass while travelling back and forth the length of the lift followed by a full-coverage pass while travelling back and forth the width of the lift and continuing to alternate the travel direction on successive passes.

During compaction by the D-8, the shredded tire material tended to "push-out" or "bulge-out" on the sides of the embankment under construction. Due to the staging scheme of the construction, one side of the embankment under construction was always confined against the other half of the highway embankment which was in-place and carrying traffic. This was advantageous in that dressing of the slope was only necessary on the unconfined side.

An attempt was made to compact the material by "squirming" the dozer, that is, turning the dozer in-place with the tracks turning in opposite directions and then reversing the turn direction in an alternating pattern. This technique was not effective, tending to loosen the fill rather than compacting it.

A VERTICAL CUT

During the Phase-2 construction of the north half of the embankment, a vertical cut was made in the shredded-tire portion of the Phase-1 embankment. This vertical cut, with a maximum height of approximately 8 feet, stood under traffic without any observable distress during the 28 days required to build the Phase-2 embankment. The fact that this vertical cut through the tire chips was able to stand unsupported for several days illustrates the high internal shear strength of the compacted tire chips due to friction and interlock. Close up photographs of the vertical cut are show in Figure 13.

SLOPE CONSTRUCTION

Final trimming of the 2:1 slope of the shredded tire embankment could not be effectively accomplished with a dozer. A dozer attempting to trim the slope surface would loosen the material on the surface resulting in a rough, uncompacted slope.

The desired embankment slope was achieved by over-building the slope approximately 1 foot horizontally and then trimming it back with a Cat 235 excavator sitting on top of the tire embankment. The excavator trimmed the slope with a bucket that had a "thumb" on it. (The excavator could be observed "rocking" considerably on the flexible embankment as its center-of-gravity shifted during the boom moves associated with the trimming operation.)

SOIL CAP CONSTRUCTION

A three-foot-thick soil cap (vertical thickness) was specified for both the top and the south slope of the embankment. A separation geotextile was placed between the shredded tires and the soil.

The south (right) slope of the embankment had a height of approximately 10 feet above the embankment toe berm. On this slope, the soil cap was placed and compacted in horizontal lifts with a horizontal width of approximately 10 feet resulting in a vertical thickness of about 5 feet. Four feet of the width was temporary widening to provide sufficient width for the Stage-2 traffic, and it was removed after completion of Stage 2. The tire fill along the north (left) boundary of the embankment was quite thin and the edge of the fill was constructed with a very shallow slope. The soil cap on this side was constructed as an extension of the soil cap on the top of the tire fill.

The soil cap over the top of the shredded-tire fill was placed in a conventional manner using standard lift thicknesses of no more than 8 inches and compaction to 95 percent of maximum density as determined by "Standard Proctor," except for the first lift which was compacted to 90 percent as specified for that lift. In general, the contractor did not experience difficulty in obtaining the specified compaction using an Ingersoll-Rand LD 150 compactor on the native clayey silt soil.

During compaction of the first 8-inch lift of soil over the top of the tire fill, the earth cap was deflecting ("bouncing") significantly, but 90 percent compaction was achieved with normal compactive effort. With each additional lift of capping soil, aggregate base, or asphalt, the deflections became progressively smaller.

Due to the flexibility of the surface of the shredded-tire fill, the joints between panels of the geotextile placed on top of the tires had a greater-than-normal tendency to separate as the first lift of soil cap was placed. In order to overcome this tendency, brass "hog-ring" clips were used to pin the joints together. The panel edges were overlapped 12 inches as normally specified and then the clips were added at 6-foot intervals along the joints. This method was very effective in preventing joint separation.

TEMPORARY SURFACING

In order to allow for compression of the tire fill under traffic loads, permanent asphalt pavement was not placed on the project for several weeks following completion of the embankment. Temporary surfacing was constructed on the top of the aggregate base of the Phase 1 embankment during construction of Phase 2 and also on the Phase 2 surface for a specified three-week-minimum waiting period and while waiting for suitable weather to allow placement of permanent pavement. An asphalt prime coat surface was placed on the Phase 1 aggregate base surface on September 14, and with weekly maintenance, performed reasonably well for the two months prior to permanent paving. A temporary surface of compacted asphalt pavement grindings placed on the Phase 2 half of the embankment in October required daily maintenance. The pavement grindings may have performed better if they had been exposed to warmer weather to soften them and facilitate binding.

PERMANENT ASPHALT SURFACING

The pavement design is 8 inches of asphalt concrete over 21 inches of aggregate base. Due to compression of the tire fill during construction of the pavement, it is estimated that 23 inches of aggregate base were placed in order to reach design grade.

To date, 6 inches of asphalt have been placed. The final 2 inches will be placed in the summer of 1991.

COMPRESSION UNDER SOIL AND PAVEMENT CAP

The shredded tire fill was constructed to a elevation 12 inches above the design elevation for top-of-tire-fill in anticipation of "compression" of the tire fill during placement of the overlying soil cap and pavement. This anticipation of compression was based on the 10 percent compression observed in a similar embankment (9 feet of tire fill under 4 feet of soil cap) constructed in Minnesota and reported by Geisler, Cody, and Niemi (1).

Data from the settlement plates and from monuments on the surface of the pavement indicate that the thickest portion of the shredded-tire fill (approximately 12.5 feet thick) compressed 13.4 percent during construction as follows:

1. 16 inches during placement of 3 feet of soil cap,

2. 2 inches during placement of 23 inches of aggregate base, and

3. 2 inches during 3 months of traffic and placement of 6 inches of asphalt concrete.

CONSTRUCTION CHALLENGES

SHREDDED TIRE CHIPS QUALITY CONTROL

The nature of the tire chips varied among the four vendors supplying material. Attachment B is a "specification" (with commentary) for the shredded tire material. Some of the material delivered to the site departed from the specifications with:

1. excessive exposed wire (from cords and belts),

2. tire chips with both sidewalls attached,

3. tire chips that exceeded the maximum size of 24 inches, and

4. occasional extraneous material including: tires which had not been through the shredder, wheel rims, and miscellaneous debris.

However, less than 25 cubic yards of material was judged unsuitable and sorted out of the 17,000 cubic yards (loose measure) delivered to the site. Typical examples of tire chips delivered are shown in Figures 13 and 14.

The oversized tire chips were used in the embankment. Visual inspection revealed that virtually all of the tire chips which were too large or had both sidewalls attached had multiple holes through the body of the chip and were, in effect, "porous". It is estimated that less than 2 percent of the chips were in these two categories. These oversize chips caused no problems during placement and compaction.

Apparently the shredding machine of the first vendor had dull cutters and tended to expose more than the specified maximum allowable amount of wire in approximately 5 percent of the chips. These chips were also used in the embankment since the exposed wire was not considered detrimental to the function of the chips as fill, and the drainage blanket beneath the fill protects against contact of the groundwater table with any corrosion developed on the exposed wire. Examples of these "poorly shredded" tire chips are shown in Figure 14.

Control of the material quality was difficult without an inspector at the source location (at the vendor). The deliveries were made by independent truckers, often in the middle of the night. Had a significant portion of the material been unsuitable for use in the embankment, an inspector at the source would have been necessary.

PUNCTURING OF DUMP TRUCK TIRES

Because of the quantity of tire chips with relatively long wires exposed on the edges, it was not possible to route rubber-tired vehicles such as dump trucks over the tire fill without chip wires penetrating the vehicle tires and sometimes puncturing them. Chips in the stockpile area punctured a few tires, and even the chips that fell off the trucks along the haul route caused a minor problem. Tighter quality control of the chip material might reduce, or possibly eliminate, this problem.

MISCELLANEOUS

The dump trucks with tail gates had some difficulty in dumping the tire chips. The chips tended to hang up on the tail gate during dumping.

Some people have expressed concern that a shredded tire embankment is subject to destruction by fire. Once the shredded tires are in place and covered with the earth cap, there is no danger of combustion. During construction, normal caution should be used to avoid starting any fires in the stockpiled tires or in embanked tires that have not yet been capped with soil.

UNIT WEIGHT OF SHREDDED TIRE FILL

Measurements were taken to facilitate computation of the density (unit weight) of the shredded tire material in several different conditions: as-loaded in the haul vehicles at time of loading and after a long haul, as-compacted prior to placement of a soil cap, immediately following placement of a soil cap, and after a "settlement" period of 3 months with a soil cap, aggregate base, and a temporary surfacing in place and carrying traffic.

LOOSE DENSITY

The average loose density (unit weight) in the haul vehicles was determined by weighing three trucks empty and loaded and physically measuring the load volume by profiling the top of the load relative to the bottom of the trailer. Two trucks were measured immediately after the loading operation and one truck was measured after a 40-mile haul. One truck was measured from each of three different vendors.

The loose density of the shredded-tire material varied with the nature of the shredded product, how "coarse" the shred was, and also changed due to "packing" of the material during hauling. The following loose unit weights were measured:

1. <u>24 pcf</u> Coarse material with many large chips as-loaded at Vendor #1. This material was apparently produced by a shredder with dull knives.

2. <u>30 pcf</u> Material from vendor #2 with fewer large chips than material #1. This material was apparently produced by a shredder with sharper knives.

3. <u>33 pcf</u> Material from vendor #3, similar to material #2, following a 40-mile haul. According to one of the drivers, this amount of "packing" was less than could be expected for the 150-mile haul.

The material that weighed 30 pcf at the time of loading is representative of the material intended by the material specification. It was produced by a shredding machine with reasonably sharp cutters. Our computations based on estimates by Geisler (1) of density and volume shrinkage during compaction indicate that the loose density of material used on a Minnesota project was 29 pcf. The 24 pcf density of "coarse" material should not be considered typical, but can occur in cases of marginal shredding machines. In computing the weight of tire chips that could be carried in a haul vehicle of a given volume, 24 pcf would be the lowest reasonable density to assume.

COMPACTED DENSITY

The compacted density (unit weight) was **45 pcf** prior to loading with the soil and pavement cap.

The unit weight of the compacted tire fill was determined by dividing the entire weight of tires incorporated in the embankment by the total volume occupied by the tires at the end of compaction. The volume of tire fill was determined by cross-sections on 50-foot centers before and after tire placement and compaction. The settlement of the original ground under the weight of the tire fill was negligible, so no volume correction was necessary to compensate for settlement. This settlement was measured by two settlement plates under the thickest portion of the tire fill.

DENSITY UNDER LOAD OF SOIL AND PAVEMENT CAP

The density (unit weight) was 52 pcf following loading with approximately 3 feet of soil, 23 inches of aggregate base, and 6 inches of asphalt and after 3 months under traffic (ADT of 3750 with 20 percent trucks).

This unit weight was determined by adjusting the volume of compacted tires to compensate for the compression of the tire fill. The compression of the tire fill was estimated by using data from four settlement plates, two located on the top surface of the thickest portion of the tire fill and two directly below them at the base of the fill. The settlement was estimated to be directly proportional to the tire-fill thickness. The 20 inches of compression measured for the 12.5-foot thickness of fill established a compression ratio of 1.6 inches per foot of thickness or 13.4 percent.

Based on measurements of temporary surface monuments, we estimate that two inches of the settlement occurred during the first four weeks under traffic with the temporary pavement surface in place. Less than an inch of settlement occurred during the next two months.

ADDITIONAL DENSITY MONITORING

The settlement plates and surface monuments will continue to be monitored until December of 1991. A final report at that time will report any additional "compression" of the tire fill.

PERFORMANCE OF THE EMBANKMENT

In addition to the short-term "compression" or "settlement" performance reported above, we have made some qualitative observations of the embankment performance. We have also made dynamic deflection measurements on the pavement surface.

QUALITATIVE OBSERVATIONS

When a heavy truck travels over the shredded-tire embankment, there is a perceptible vibration. During Phase 2 construction, while traffic was carried by the temporary surfacing on the south half of the embankment (the thick half), an observer standing on the embankment during passage of a loaded log truck could note a vibration sensation similar to what one would feel standing in the middle of a long-span bridge. Following construction of the north half of the embankment, that vibration was noticeably reduced, but still easily perceptible.

A visible indication of vibration was also apparent during Phase 2 construction. Following excavation for Phase 2, the shredded tires in the south half of the embankment (constructed in Phase 1) formed an 8-foot-high, near-vertical face below the soil and base-rock cap (Figures 10 and 13). Some of the larger tire chips protruding from this face could be seen oscillating in response to the vibrations generated by the passage of a loaded log truck. Although actual measurements of this movement were not made, the magnitude was on the order of one inch or less for a chip protruding eight inches, and the frequency of the oscillation was on the order of five to ten cycles per second.

DEFLECTION TESTING

Deflection testing was conducted on January 7, 1991, 4 months after completion of the Stage 1 soil cap and aggregate base construction. Testing was done using ODOT's Falling Weight Deflectometer (FWD). The FWD is a non-destructive testing device which measures the pavement deflection under an impact load that simulates actual truck traffic loading. A 12-inch-diameter plate was used to apply the impact load to the pavement surface. Deflections were measured at three load levels ranging from 3,000 to 12,000 lbs. with sensors located at 0, 12, 24, 36, and 58 inches from the point of the load. The measured deflections were normalized to a standard 9,000 lb. load by linear interpolation.

The asphalt was cored and measured to be 6¼ inches thick at the time of the deflection testing.

The average deflection of the pavement over the rubber tire fill was approximately 0.020 inch compared to a typical deflection of 0.010 inch normally measured for a similar asphalt-and-aggregate-base pavement constructed over a conventional soil subgrade. The standard pavement overlay design method used by the Oregon Highway Division would call for an overlay of 5 inches of asphalt for an existing pavement with deflections of 0.020 inches. However, there is some question whether the standard overlay design procedure would be appropriate for the unusual subgrade condition of a shredded tire embankment. It is expected that, since the increase in dynamic deflection is apparently due to a deep layer (the tires), the deflection increase may have a large radius and cause less stress in the pavement than similar magnitudes of dynamic deflection with conventional embankment underlying the pavement.

The pavement design for this project calls for a total of 8 inches of asphalt. The top 2-inch lift of asphalt pavement is scheduled for construction in fall of 1991. Additional deflection readings will be taken following construction of the top lift, and results will be given in our final report.

LONG-TERM PERFORMANCE

Subsequent reports will address the topics of long-term compression of the tire fill, success in stabilization of the landslide, and performance of the pavement over the embankment. The following instrumentation has been placed to monitor the long-term performance of the embankment.

INSTRUMENTATION

As mentioned above, four settlement plates have been installed. The plates are located in two pairs under the outside edge of pavement with one pair approximately 100 feet in from each end of the slide. Each pair has a plate at the bottom of the tire fill and a plate at the top of the tire fill. The plates are being used to measure any foundation settlement below the tires and any additional compression of the tire fill.

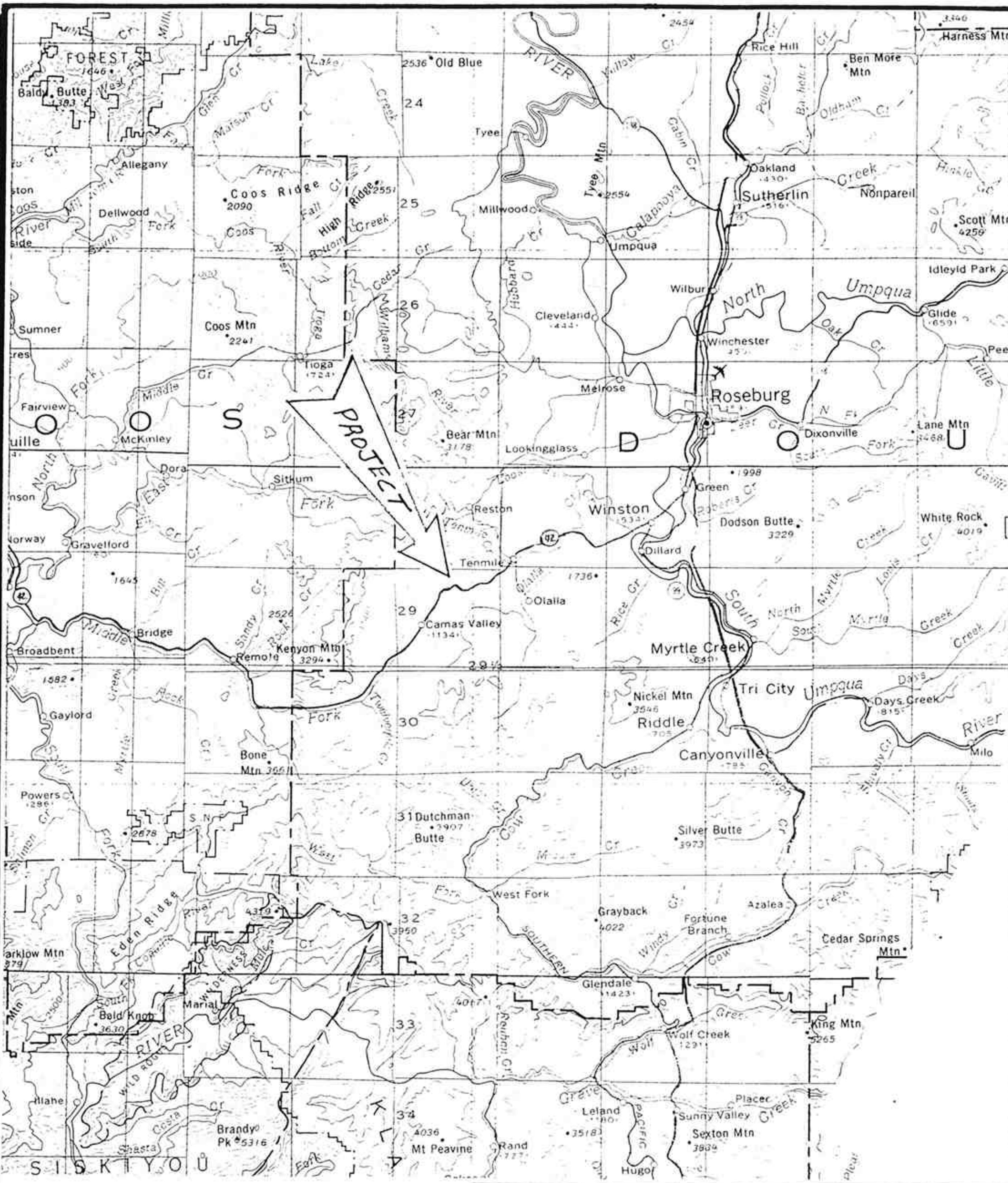
The settlement plate standpipes were temporarily buried in September following construction of the Phase-1 soil cap since they were in the detour path. They were re-exposed in November at the time of the asphalt paving construction.

Three lines of survey monuments have been installed running parallel to the centerline of the highway: one on the centerline, one on the shoulder, and one at the toe of the embankment. The monuments are installed on 50-foot spacing and extend to at least 50-feet beyond each end of the slide correction. The monuments are being used for monitoring of both horizontal and vertical movements.

Two plastic slope inclinometer tubes have been installed to measure the lateral stability of the embankment: one at the embankment toe, and one at 75 feet from the toe, toward the creek. The inclinometer tubes are located along the center cross-section of the slide and installed to a depth of 35 feet below the pre-construction ground surface. The inclinometer tubes are slotted to serve as observation wells for determination of groundwater level.

Instrumentation (slope inclinometers, settlement plates, and survey monuments) will be read on the following schedule by State personnel:

a. Initial readings immediately after installation.
b. Every 2-months for the first 6-months, i.e. @ 2, 4, and 6 months.
c. Every 3-months for the next 6-months, i.e. @ 9 and 12 months.



PROJECT LOCATION

N

VICINITY MAP

SCALE: 1" = 8 MILES APPROX.

0 1 2 4 8 16 MILES

GEOTECHNICAL GROUP
Oregon State Highway Division

FIGURE NO. 1

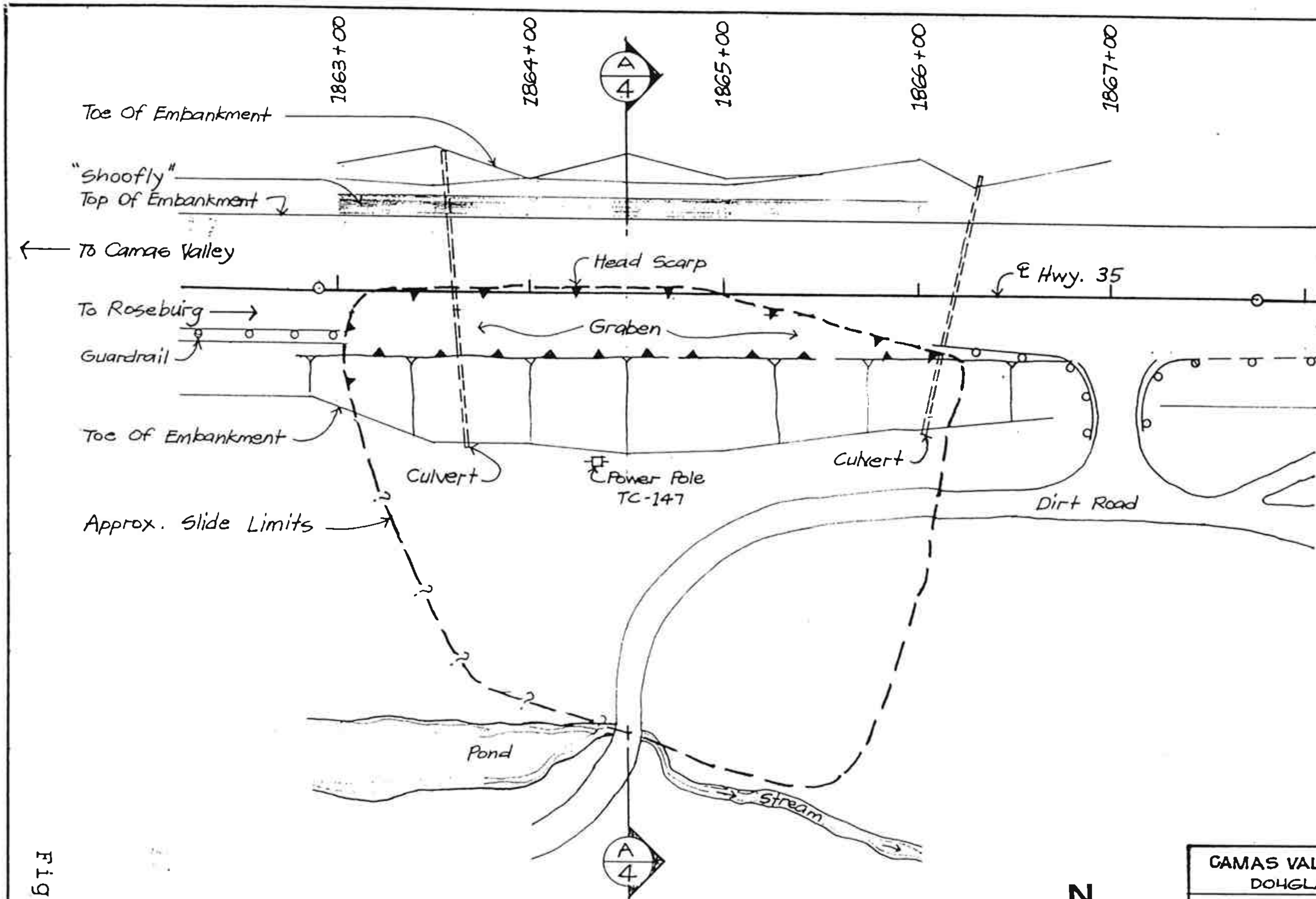
10.90

LANDSLIDE DISTRESS: FEBRUARY 6, 1990

Figure 2

LANDSLIDE DISTRESS: MARCH 14, 1990

Figure 3



N ↑

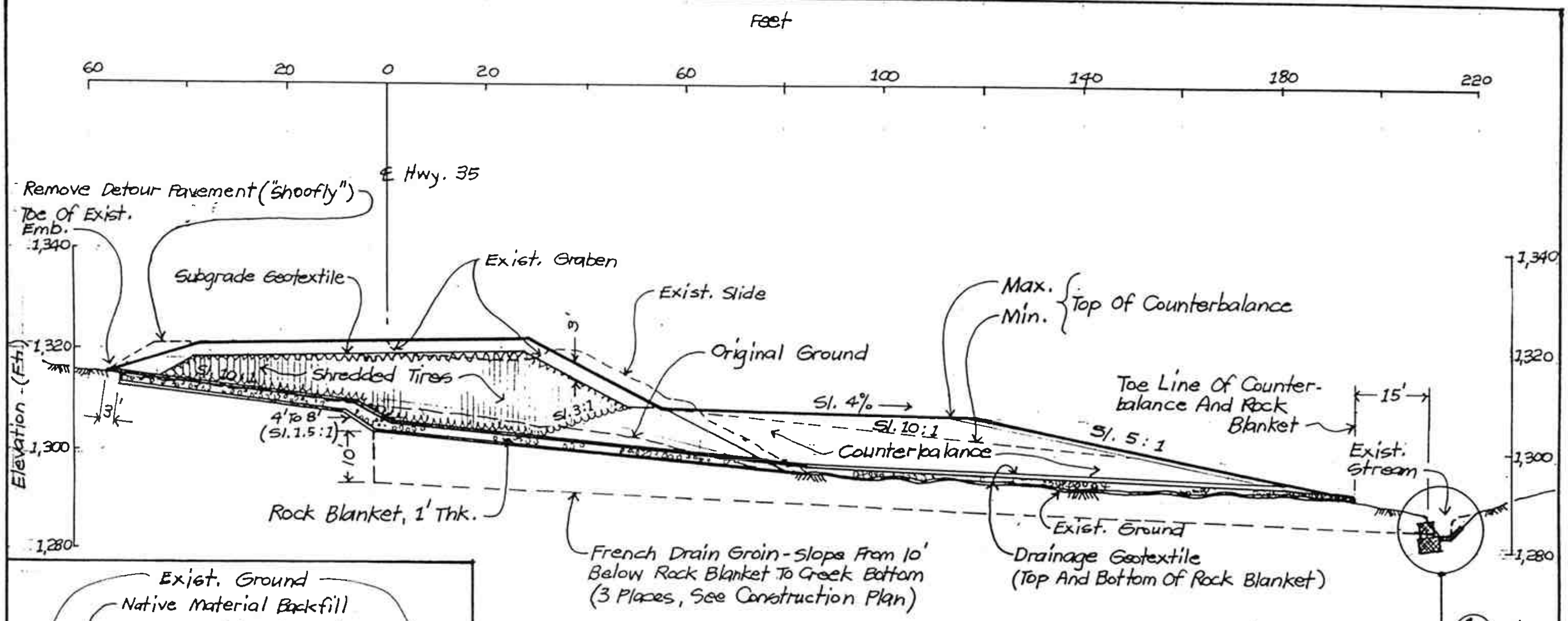
SLIDE PLAN (EXISTING)

SCALE: 1" = 50'

CAMAS VALLEY-MUNS CREEK DOUGLAS COUNTY	
SITE PLAN (EXISTING)	
HWY. 35 (Coos Bay-Roseburg) M.P. 56.0-61.8	
E.A. NO. C10653 DATE Apr. '90	
GEOTECHNICAL GROUP Oregon State Highway Division	FIGURE 1 OF 4

Figure 4

4/89

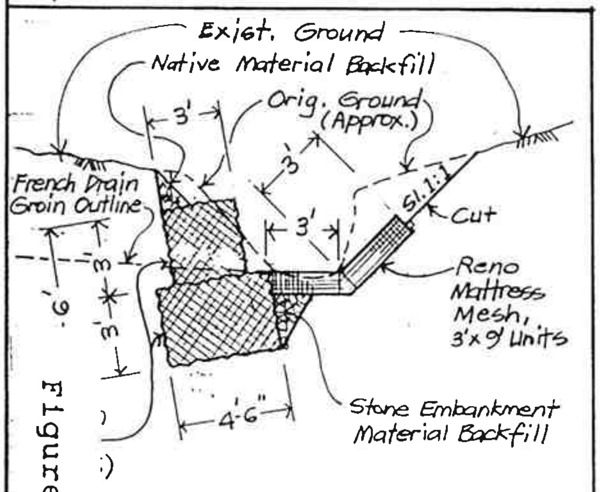


SECTION: STA. 1864 + 50 (A/4)

SCALE: 1" = 20' H & V

NOTE:

See Figure 2 for SUGGESTED CONSTRUCTION SEQUENCING AND STAGING.



PROTECTION DETAIL @ STREAM

SCALE: 1" = 50'

CAMAS VALLEY-MUNS CREEK DOUGLAS COUNTY	
SECTION: STA. 1864 + 50 and DETAIL	
HWY. 35 (Coos Bay-Roseburg) M.P. 56.0-61.8	
E.A. NO. C10653	DATE Apr. '90
GEOTECHNICAL GROUP Oregon State Highway Division	FIGURE 4 OF 4

4/89

Figure 5

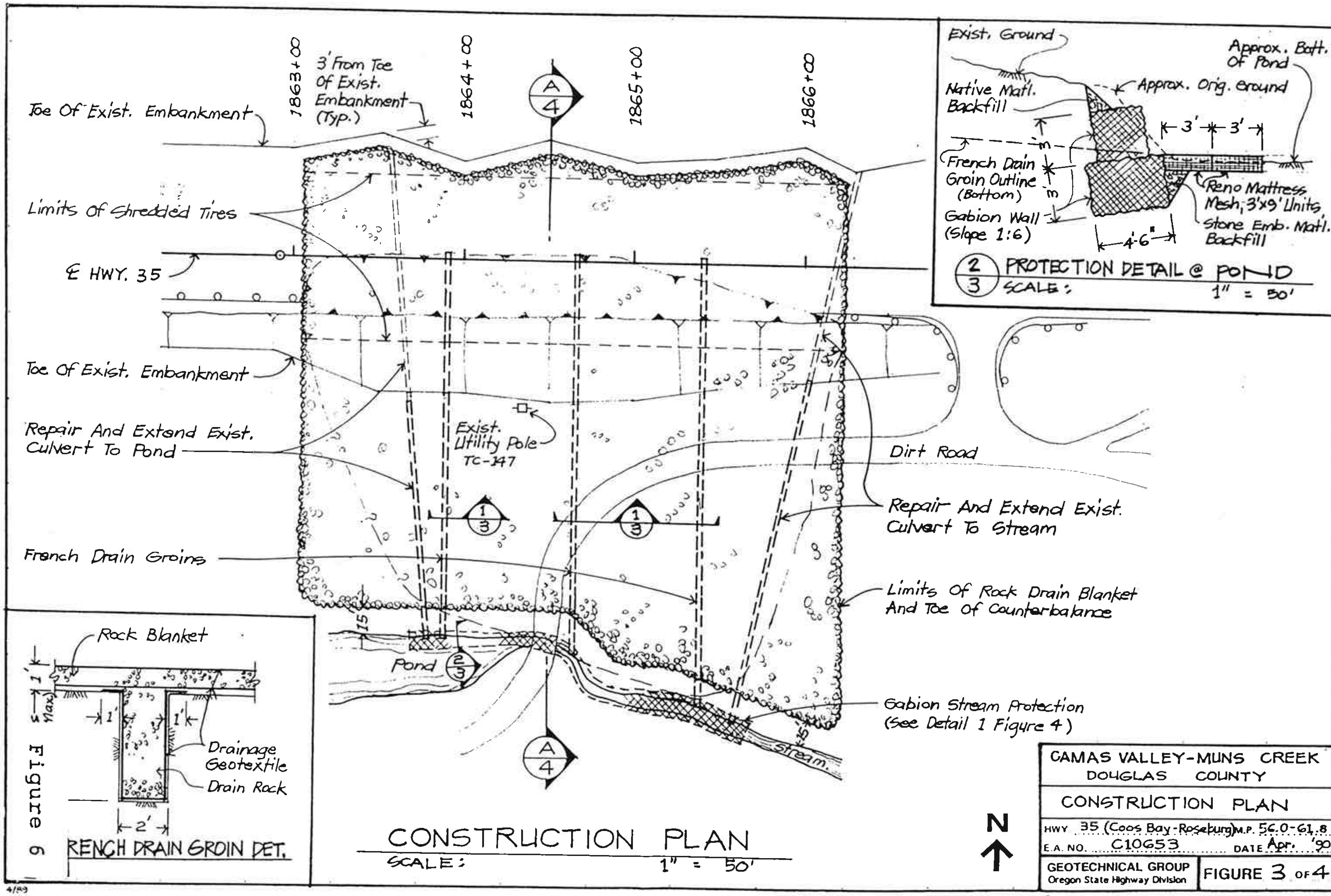
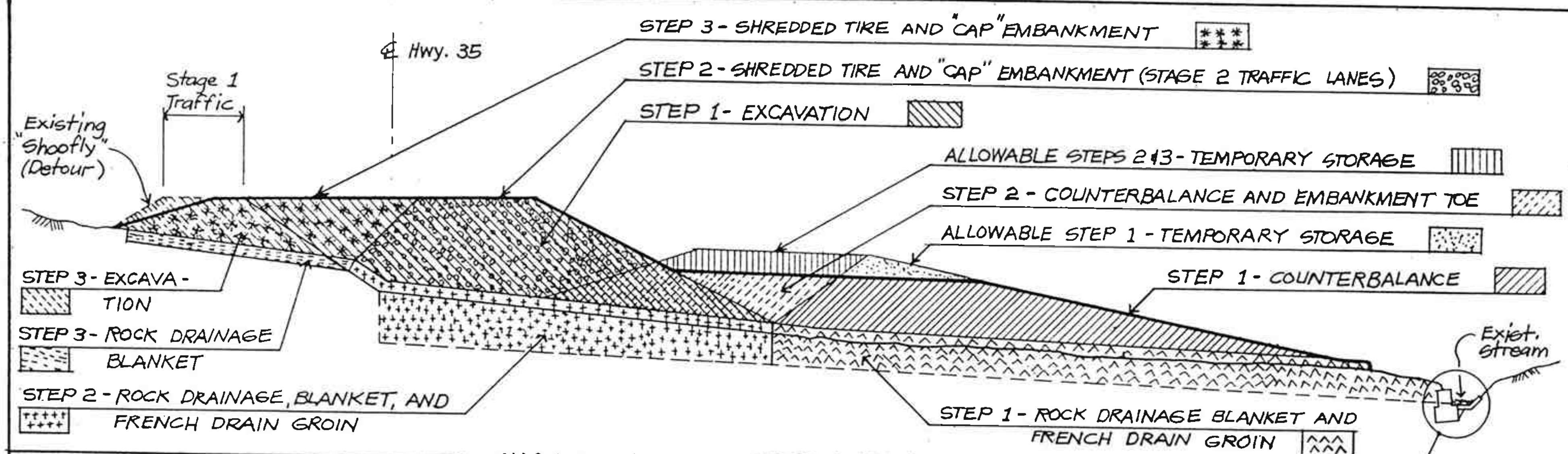

1863+00
1864+00
1865+00
1866+00
3' From Toe Of Exist. Embankment (Typ.)
Toe Of Exist. Embankment
Limits Of Shredded Tires
℄ HWY. 35
Toe Of Exist. Embankment
Repair And Extend Exist. Culvert To Pond
Exist. Utility Pole TC-147
French Drain Groins
Dirt Road
Repair And Extend Exist. Culvert To Stream
Limits Of Rock Drain Blanket And Toe Of Counterbalance
Gabion Stream Protection (See Detail 1 Figure 4)
Pond
Stream
Exist. Ground
Approx. Bott. Of Pond
Native Matl. Backfill
Approx. Orig. Ground
French Drain Groin Outline (Bottom)
Gabion Wall (Slope 1:6)
Reno Mattress Mesh; 3'x9' Units
Stone Emb. Matl. Backfill
4'-6"
PROTECTION DETAIL @ POND
SCALE: 1" = 50'
Rock Blanket
Drainage Geotextile
Drain Rock
RENCH DRAIN GROIN DET.
CONSTRUCTION PLAN
SCALE: 1" = 50'
N
CAMAS VALLEY-MUNS CREEK
DOUGLAS COUNTY
CONSTRUCTION PLAN
HWY 35 (Coos Bay-Roseburg) M.P. 56.0-61.8
E.A. NO. C10653 DATE Apr. '90
GEOTECHNICAL GROUP
Oregon State Highway Division
FIGURE 3 OF 4

Figure 6



SUGGESTED CONSTRUCTION SEQUENCING AND STAGING

NOTE:
Bold lines represent completed construction repair after removal of temporary storage material.

CAMAS MOUNTAIN STATION 1865 SLIDE

SUGGESTED CONSTRUCTION SEQUENCING AND STAGING

A. Construct Gabion Stream Protection. (See Figures 3 & 4.) Schedule as convenient.

1. Construct Step 1 sections of French Drain Groins between the stream and the toe of existing embankment.
2. Construct the Step 1 portion of the Rock Drainage Blanket between the stream and the toe of the existing embankment.
3. Excavate Step 1 Excavation. Use the excavated material to construct Step 1 of the counterbalance with a temporary 1.5:1 or flatter slope on the north (left) side.
4. Construct Step 2 French Drain Groins and Rock Drainage Blanket in the bottom of the Step 1 excavation.
5. Construct the Step 2 Counterbalance and Embankment Toe using excavated materials.

(Items 3-5 above can broken into multiple substeps to minimize offsite haul.)

6. Construct the Step 2 Shredded Tire Embankment and "Cap" Embankment. A subgrade geotextile must be placed between the shredded tire embankment and the capping soil embankment.
7. Construct base rock on Stage 2 traffic lanes at the top of the Step 2 Embankment and move traffic to Stage 2.
8. Excavate the Step 3 remaining original embankment (and "shoofly").
9. Construct the Rock Drainage Blanket in the bottom of the Step 3 excavation.
10. Construct the Step 3 Shredded Tire Embankment and "Cap" Embankment, including ATB.
11. Wait at least 3 weeks to allow consolidation of the shredded tire embankment prior to final surfacing.
12. Pave final surface.

4/93

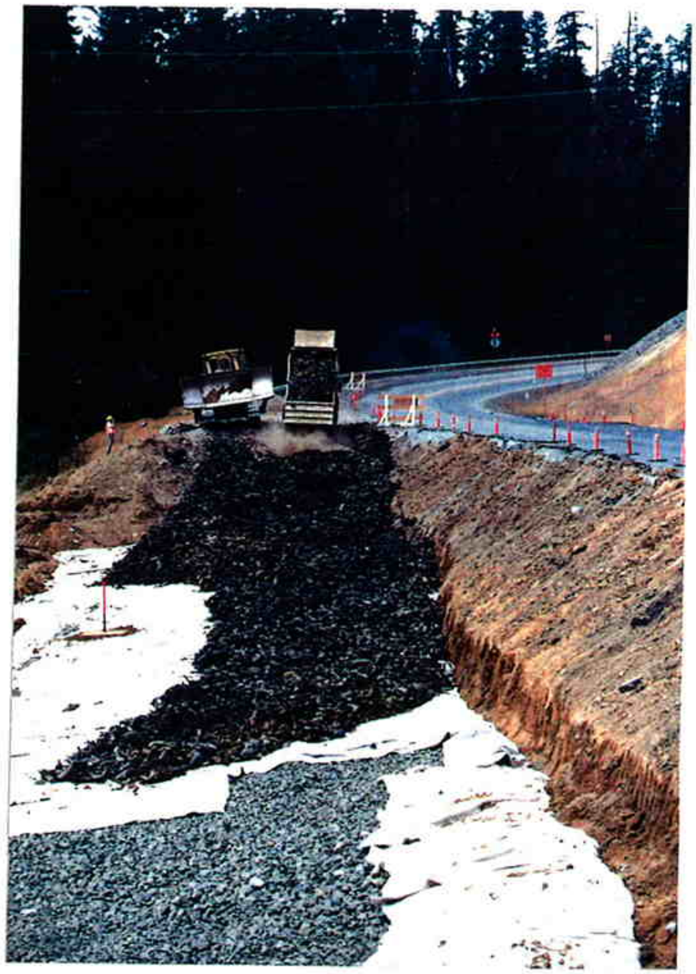
CAMAS VALLEY-MUNS CREEK DOUGLAS COUNTY	
SUGGESTED CONSTRUCTION SEQUENCING AND STAGING	
HWY 35 (Coos Bay-Roseburg) M.P. 56.0-61.8	
E.A. NO. C10653 DATE Apr. '90	
GEOTECHNICAL GROUP Oregon State Highway Division	FIGURE 2 OF 4

Figure 7

PREPARATION FOR COUNTERBALANCE CONSTRUCTION
(Bottom Geotextile for Drain Blanket)

PHASE 1 EXCAVATION

Figure 8



PLACING STAGE 1 TIRE FILL
(Drainage Blanket Visible in Foreground)

Figure 9

NEAR-VERTICAL SLOPE IN TIRE FILL

PLACING STAGE 2 TIRE FILL

Figure 10

LOADING TIRES FOR TRANSPORT

"WALKING BOTTOM" IN TRAILER

Figure 11

UNLOADING TIRE CHIPS

STOCKPILE OF TIRE CHIPS

Figure 12

CLOSEUPS OF COMPACTED TIRE FILL

Figure 13

COARSELY SHREDDED TIRE CHIPS
(From Shredding Machine with Dull Cutters)

Figure 14

COMPLETED RUBBER TIRE EMBANKMENT

Figure 15

VIDEOTAPE

Ted Burney of the ODOT Highway Division Photo Lab has produced a videotape documenting the construction of the subject project. Copies of the videotape may be purchased for $20.00 from:

Attn: Ted Burney
Oregon Department of transportation, Photo Services.
Transportation Building, Room 14A
Salem, Oregon 97310

COST

SHREDDED TIRES DELIVERED TO THE SITE

The ODOT Highway Division paid the vendors of the shredded-tire material <u>$30/ton</u> for material delivered to the stockpile near the project site. This was a negotiated price. One of the vendors was located approximately 150 miles from the project, two were at approximately 200 miles, and the other one was approximately 250 miles from the project. The Oregon Department of Environmental Quality reimbursed the Highway Division $20/ton for using the waste tires in a beneficial application. The net cost of <u>$10/ton</u> is equivalent to <u>$7.02/yd^3</u> at the final in-place unit weight of 52 pcf.

Attachment D is the Administrative Rules of the Oregon DEQ relating to reimbursements to users of waste tires. These rules describe the subsidy program used by the State of Oregon.

EMBANKMENT CONSTRUCTION WITH SHREDDED TIRES

The construction of the shredded-tire fill was done on a force-account basis. It was part of a landslide correction that was an unanticipated item added to the original contract. The original contract included construction of the raised grade and embankment widening that resulted in the landslide occurrence. We have separated out the cost of the work associated only with construction of the shredded-tire fill. Our best estimate is that the cost for placement and compaction of the tires was <u>$8.33/ton</u> which is equivalent to <u>$5.85/yd^3</u> at the final in-place density of 52 pcf.

TOTAL COST OF SHREDDED TIRE CONSTRUCTION

Prior to reimbursement by the DEQ, the cost is $38.33/ton or $26.91/yd^3 at the final in-place density. After reimbursement the cost is <u>$18.33/ton</u> which is equivalent to <u>$12.87/yd^3</u>.

The slide occurred during construction which necessitated paying for the slide correction work on a Force Account basis. We anticipate that the cost would be significantly lower for projects that are bid.

CONCLUSIONS

1. This project Demonstrated that embankment construction using waste shredded tire chips is a viable technology.

2. The use of shredded tires for lightweight fill (or as "standard fill") provides the significant benefit of utilizing a troublesome waste product (scrap tires) in a beneficial highway engineering application.

3. The use of shredded tires in embankments offers the potential benefit of disposing of large volumes of tires in short sections of highway.

4. The in-place cost of shredded tire embankment may vary significantly depending on whether or not the State has a rebate program and depending on the availability and proximity to the site of required tire quantities and shredding equipment.

5. For the subject embankment, which utilized 5.5 feet of cover over the tire chips (3 feet of soil, 2 feet of aggregate base, and 0.5 feet of asphalt), the initial measured dynamic pavement deflections were twice as great as would be expected of the same pavement over an earth embankment. It is expected that, since the increase in dynamic deflection is apparently due to a deep layer (the tires), the deflection increase may have a large radius and cause less stress in the pavement than similar magnitudes of dynamic deflection with conventional embankment underlying the pavement.

Pavement deflection measurements will be repeated in the fall of 1991 after the final 2 inches of asphalt pavement are placed. Those measurements will be reported in our final report.

REFERENCES

1. - Geisler E., Cody, W., and Niemi, M., **"Tires for Subgrade Support"**, Paper No. 897550, a presentation to the American Society of Agricultural Engineers St. Joseph, MI, at the 1989 International Winter Meeting, New Orleans, LA.

2. - Minnesota Pollution Control Agency, **"Waste Tires in Sub-grade Road Beds"**, a Report on the Environmental Study of the Use of Shredded Waste Tires for Roadway Sub-grade Support, Waste Tire Management Unit, Minnesota Pollution Control Agency, 520 Lafayette Road, St. Paul, MN 55155, Feb 19, 1990

3. - Oregon Department of Environmental Quality, **"Administrative Rules, Division 62 - Waste Tires"**, Department of Environmental Quality, 811 SW Sixth Avenue, Portland, OR 97204-1390, Nov 8, 1990

ATTACHMENT A

CAMAS MOUNTAIN 1865 SLIDE

SUGGESTED CONSTRUCTION SEQUENCING AND STAGING

(Refer to Figures 4 through 7)

A. Construct Gabion Stream Protection. Schedule as convenient.

1. Construct Step 1 sections of French Drain Groins between the creek and the toe of existing embankment. Temporarily lap geotextile over the top of the drain rock until ready to install the bottom geotextile of the Rock Drainage Blanket.

2. Construct the Step 1 portion of the Rock Drainage Blanket between the creek and the toe of the existing embankment. Just prior to placing the bottom drainage geotextile, "lay back" the French Drain geotextile to expose the rock in the drain so that only the one layer of geotextile will separate the drainage blanket rock and the french drain rock.

3. Excavate Step 1 Excavation. This excavation step will have a 1.5:1 backslope coming down from the shoulder of the Stage 1 traffic surface on the north side of the existing embankment. Use the excavated material to construct Step 1 of the counterbalance with a 1.5:1 or flatter slope on the north (left) side. (Use standard embankment compaction specifications for the counterbalance.) Some of the excavated material may have to be hauled to a temporary storage area. Storage of materials on top of the counterbalance is allowable to a maximum height of 5 feet. However, the south (right) slope of the storage pile must not be steeper than 5:1.

4. Construct Step 2 French Drain Groins and Rock Drainage Blanket in the bottom of the Step 1 excavation. Connection must be made to the groins and rock blanket constructed under the Step 1 Counterbalance. At the north (left) boundary, the rock blanket extends up the 1.5:1 slope in a 4-foot-wide section to an elevation that will intersect the 10:1 slope from the toe of the ditch on the north (left) side of the existing embankment.

5. Construct the Step 2 Counterbalance and Embankment Toe using materials previously excavated and stored. The north boundary of the embankment constructed in Step 2 should have a 3:1 slope. The point of intersection of the counterbalance and the embankment slope must be located for this construction step. The intersection is located at an elevation 13.5 feet below the elevation of the right edge of pavement. Temporary storage of materials will be allowed on

top of the counterbalance during this step, to a maximum height of 5 feet (8.5 feet below pavement).

(Items 3-5 above can be broken into multiple sub-steps to minimize offsite haul.)

6. Construct the Step 2 Shredded Tire Embankment and "Cap" Embankment. The north (left) slope of the embankment should be constructed at 1.5:1 or flatter during this step. The "Cap" embankment can include base rock or ATB construction. Some settlement will occur due to consolidation of the tire embankment following placement of the "Cap." The surface of the embankment constructed in Step 2 will carry Stage 2 traffic.

   A subgrade geotextile must be placed between the shredded tire embankment and the capping soil embankment.

   The shredded tires shall be compacted in 2- to 3-foot lifts by 3 or more "full-coverage" passes by a D-8 or larger dozer (a "full-coverage" pass being a pass during which at least one track of the dozer passes over every portion of the lift surface being compacted). The tire volume can be expected to shrink approximately 35% during the compaction process. The density will increase from approximately 22 pcf "truck weight" to approximately 34 pcf "compacted weight." An additional 10 to 11% shrinkage can be expected under the load of the 3-foot-thick soil cap and the aggregate base, yielding a final in-place density of approximately 38 pcf. Prior to placement of the soil cap, the top of the shredded tire fill should be constructed with a top elevation approximately 12 inches above the design top elevation in order to make partial allowance for shrinkage that is expected to occur during and following placement of the soil cap and aggregate base. At least 3 weeks must be allowed for consolidation of the tires under the cap load prior to paving. (For purposes of estimating the quantity of tires required for construction, we recommend a 40 pcf in-place density be assumed.)

   Normal compaction procedures can be used for compaction of the soil embankment "cap" above the shredded tires. Some deflection or "bouncing" can be expected during compaction of the first 8-inch lift above the subgrade geotextile and 90% compaction should be allowed for this first lift. However, subsequent lifts should be easily compacted to 95% of maximum density by normal procedures.

7. Construct base rock on Stage 2 traffic lanes at the top of the Step 2 embankment and move traffic to Stage 2.

8. Excavate the Step 3 remaining original embankment (and "shoofly"). Some of this material may have to be hauled off-site for storage. The same 5-foot maximum height still applies to any materials temporarily stored on the

counterbalance. The bottom of the excavation should be on a 10:1 slope down to the south (right) from a point one foot below original ground at the existing embankment toe.

9. Construct the Rock Drainage Blanket in the bottom of the Step 3 excavation. Connection must be made to the Step 2 Rock Drainage Blanket. The blanket shall terminate 3 feet inside the toe of the new embankment in order to provide for a common embankment seal against surface water infiltration.

10. Construct the Step 3 Shredded Tire Embankment and "Cap" Embankment.

11. Wait at least 3 weeks to allow consolidation of the shredded tire embankment prior to final surfacing (paving).

12. Construct the final pavement surface. Pavement design may require adjustment to compensate for settlements that occurred during the Item 11 delay.

ATTACHMENT B

LIGHTWEIGHT RUBBER FILL SPECIFICATIONS

The lightweight fill shall consist of chipped rubber tire pieces meeting the following specifications:

A. 80 percent of the material (by weight) must pass an 8" screen.

B. At least 50 percent of the material (by weight) must be retained on a 4" screen.

C. All pieces shall have at least one sidewall severed from the face of the tire.

D. The largest allowable piece is ¼ circle in shape or 24" in length whichever is the lesser dimension.

E. All metal fragments shall be firmly attached and 98% embedded in the tire sections from which they were cut. NO METAL PARTICLES SHALL BE PLACED IN THE FILL WITHOUT BEING CONTAINED WITHIN A RUBBER SEGMENT. Ends of metal belts and beads are expected to be exposed only in the cut faces of some tire chips.

F. The lightweight fill material supplied shall weigh less than 600 pounds per cubic yard, truck measure.

G. Unsuitable material delivered to the project shall be rejected in truckload quantities and removed from the site at no cost to ODOT.

H. ODOT, by use of this material, does not absolve the supplier of the responsibility of proper disposal of the lightweight rubber fill material if the section should fail to perform as expected.

NOTE: These specifications do not adequately describe the material that has been experimented with to date. Many of the shred segments are incompletely severed from each other which results in long supple rubber pieces. Those pieces could be pulled through an 8" screen but would not necessarily fall through one. The processing for the chips has been a single pass through a rotary slow speed shear shredder equipped with 2" cutters. As long as the cutter tolerance is kept close and new cutters are installed as they wear, this produces an acceptable product for road construction. A hammermill process is not acceptable.

The Minnesota Department of Natural Resources assumes no liability or responsibility for the use of these specifications.

COMMENTARY

As indicated by the final paragraph, this specification was borrowed from the Minnesota Department of Natural Resources.

As mentioned in the body of the foregoing report, some of the material used on the subject project was judged suitable although it did not meet some aspects of these specifications:

1. Some chips were larger than the maximum specified, but they were well "perforated" by cuts made during the shearing process. A few had both sidewalls attached.
2. Numerous chips had more wire exposed than the specifications intend. The Vendor #1 shredder especially did not meet the 98% embedment spec.
3. Specification "F" is not appropriate. The typical "truck" density of chips was measured to be over 700 pounds per cubic yard.

ATTACHMENT C

WORK PLAN

FOR

FHWA EXPERIMENTAL PROJECT NO. 1

GEOTECHNICAL INNOVATIONS ON TRANSPORTATION PROJECTS

"USE OF SHREDDED TIRES FOR LIGHWEIGHT FILL"

Workplan
for
Use of Shredded Tires for Lightweight Fill

BACKGROUND

The United States has an estimated 2 billion scrap tires stockpiled around the country. Another 240 million tires are discarded each year. Disposal of waste tires is one of the country's most pressing environmental problems.

Within the past few years, the Minnesota Department of Forestry has demonstrated the feasibility of using shredded tires as lightweight fill in embankment construction over soft ground. Use of shredded tires as lightweight fill also has application on landslide repair projects.

BENEFITS

The use of shredded tires for lightweight fill provides the significant benefits of cost-effectively utilizing a troublesome waste product (scrap tires) in a beneficial highway engineering application. Further, the present commercial uses for scrap tires utilize only a small portion of the amount stockpiled and generated annually in the U.S. The use of shredded tires in embankments offers the benefit of disposing of large volumes of tires in a hurry in short sections of highway. For example, the use of an asphalt-rubber pavement overlay utilizes only about 3600 tires per mile of 2-lane road while a mile of 2-lane embankment 20-feet high would utilize about 5 million tires (one tire equals approximately one cubic foot).

OBJECTIVE OF EXPERIMENTAL EVALUATION

The use of shredded tires for lightweight fill represents a very new technology. There are many questions to be answered regarding the construction and performance of this type of structure. The objective of this experimental evaluation is to provide information to help answer the following questions:

1. Is lightweight fill constructed of shredded tires effective in stabilizing a landslide or soft ground problem?

2. What special construction problems are associated with shredded tire embankments? Can construction methods (details) be improved?

3. What is the density of the shredded tire material:

    a. during haul (loose "bulk" density)?
    b. following compaction in an embankment?
    c. following loading with 4-foot "capping embankment" and pavement?

4. Will shredded tire fill in embankments undergo continuing long-term compression?

5. Will pavement over shredded tire embankments be subject to abnormal distress?

6. Are shredded tire fills cost-effective?

PROPOSED OREGON SLIDE REPAIR PROJECT

The slide to be repaired is located at mile point 59.3 on Highway U.S. 42 (Oregon Hwy 35), approximately 13 miles west of Roseburg, Oregon. The slide as shown on Figure 1 occurred in a 15-foot-high highway embankment and the slide block extends approximately 150-feet beyond the toe of the embankment to a small creek below the highway.

The first slide symptoms appeared shortly after construction of new embankment that raised the previous highway embankment 4-feet and widened it about 20-feet. The original highway embankment was approximately 11-feet high. The original ground is gently sloping at about 7:1 below the embankment and about 15:1 from the embankment to the creek. The slide is a block slide riding on an old slip plane of an ancient slide. The highway embankment is at the head of the slide and constitutes the slide "driving force." Geotechnical analyses indicate that a cost-effective repair scheme as shown on the attached drawings is removal of some of the embankment weight by replacement with shredded tires and use of the excavated embankment soil to construct a "counterbalance" berm between the embankment toe and the creek. Subsurface drainage trenches will also be installed in the foundation subsoil below the new fill and counterbalance. Design drawings and specification and a description of the proposed construction sequence are attached.

PROPOSED EXPERIMENTAL EVALUATION

We propose the following instrumentation, monitoring and evaluation of the slide repair:

1. Construction and Post-Construction Observations

Visual observations and photographs by State Construction personnel prior to construction, during construction, and post-construction. Observers will document methods and difficulty of shredded-tire hauling, unloading, placement and compaction during construction. Following construction inspection will be made to observe and document any visible signs of earth movement or pavement distress.

2. Fill Density Measurements

The shredded tires will be hauled to the project site in 80 cubic yard chip trucks.

a. An average loose bulk density in the haul vehicle will be determined by weighing a minimum of 3 trucks empty and loaded and physically measuring the load volume.

b. Compacted density in the embankment will be determined by cross-sectioning before and after the shredded tires are placed combined with the truck weight measurements.

c. Density following loading with 4-foot capping fill and pavement will be determined from the 1-year post-construction monitoring using surface survey points and foundation settlement plates.

3. Instrumentation and Monitoring

1. Two settlement plates will be installed at the bottom of the shredded tire fill. The plates will be located under the outside edge of pavement approximately 100-feet in from each end of the slide and be used to measure any foundation settlement below the tires. Internal settlement within the tire fill can then be determined by the difference between the roadway surface settlement and the base settlement.

2. Three lines of survey monuments will be installed running parallel to the centerline of the highway: one on the centerline, one on the shoulder, and one at the toe of the embankment. Monuments will be installed on 50-foot spacing and will extend to at least 50-feet beyond each end of the slide repair. Monuments will be used for measurement of both horizontal and vertical movements.

3. Two plastic slope inclinometer tubes will be installed to measure the lateral stability of the embankment and to serve as groundwater sampling wells: one at the embankment toe, and one at 75-feet from the toe, toward the creek. The inclinometer tubes will be located along the center cross-section of the slide and installed to a depth of 35-feet (well below the slide failure plane). The inclinometer tubes will be slotted for groundwater sampling and appropriately sealed against surface-water infiltration. The tubes will be installed after fill construction has progressed to the point where the tubes will not be damaged by fill placement equipment.

4. Frequency of Readings

Instrumentation (slope inclinometers, settlement plates, and survey monuments) will be read on the following schedule by State personnel:

a. Initial readings immediately after installation.
b. Every 2-months for the first 6-months, i.e. @ 2, 4, and 6-months.
c. Every 3-months for the next 6-months, i.e. @ 9 and 12-months.

REPORTING

The following reports will be prepared by State personnel:

1. Within 60-days of completion of construction, a "post-construction" report will be provided describing the construction process and any special

problems encountered. Photographs of the pre-construction condition, the construction and completed embankment will be provided. Based on estimated project scheduling this report should be delivered in October, 1990.

2. An interim post-construction report will be provided within 60 days after the 6-month monitoring data has been obtained. This report will include instrumentation data and visual observations of the post-construction performance of the embankment and the pavement. Photographs will be included showing any visible abnormal conditions. Based on estimated project scheduling, this report should be delivered in April, 1991.

3. A final report similar to the interim post-construction report will be provided within 60-days following the completion of the 12-month post-construction monitoring period. The final report will include conclusions and recommendations. Based on estimated project scheduling, this should be delivered in October, 1991.

STAFFING

The principal investigators for the experimental evaluation will be Mr. John Read, Oregon Department of Transportation (ODOT) Construction Project Manger and Mr. Tim Dodson, Geotechnical Team Leader with ODOT Roadway Section Headquarters Geotechnical Unit. Visual observations and installation and monitoring of all instrumentation will be by Mr. Read's construction project staff, under his close supervision, except that the slope inclinometer tubes will be installed by the ODOT Region 3 Soils and Geology personnel. The Geotechnical Unit staff will also perform periodic visual observation and assist in data reduction. The two principal investigators will jointly write the three reports.

The principle investigators can be contacted as follows:

Mr. Tim Dodson
Geotechnical Group
Oregon Department of Transportation
Highway Division
800 Airport Road S.E.
Salem, Oregon 97310
PH#: (503) 373-7994

Mr. John Read
Oregon Department of Transportation
Highway Division
1547 S.E. Jackson Street
P.O. Box 1128
Roseburg, Oregon 97470
PH#: (503) 440-3429

DELIVERABLES

The reports as listed above.

EVALUATION BUDGET

	Evaluation Item	Time Incurred	Cost
1.	Tire density measurements in haul vehicle	During construction	$ 500
2.	Install inclinometers	End of construction	$ 4,000
3.	Install survey monuments	End of construction	$ 500
4.	Monitor survey monuments	At 2, 4, and 6 months	$ 1,800
5.	Monitor survey monuments	At 9 and 12 months	$ 1,200
6.	Monitor inclinometers	At 2, 4, and 6 months	$ 600
7.	Monitor inclinometers	At 9 and 12 months	$ 400
8.	Visual observations	During and after construction	$ 1,500
9.	Prepare Post-construction Report	End of construction	$ 1,500
10.	Prepare Interim Report	End of 6 months	$ 1,500
11.	Prepare Final Report	End of 12 months	$ 1,000
TOTAL ESTIMATED COST			$14,500

REIMBURSEMENT SCHEDULE

Oregon State Highway Division to be reimbursed 70 percent of the total cost upon FHWA acceptance of the post-construction report. The remaining 30 percent will be paid upon FHWA acceptance of the final report.

FHWA FIELD TECHNICAL MONITOR

The FHWA Field Technical Monitor will be Mr. Ronald G. Chassie, Region 10 Geotechnical Engineer.

S20304]
RON CHASSIE: lr
(revised May 21, 199(

ATTACHMENT D

OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
ADMINISTRATIVE RULES
DIVISION 62 - WASTE TIRES

RELATING TO REIMBURSEMENTS TO USERS OF WASTE TIRES
AND CLEANUP FUNDS FOR TIRE STORAGE SITES

Effective November 8, 1988

Definitions

340-62-010 As used in these rules unless otherwise specified:

(1) "Buffings" -- a product of mechanically scarifying a tire surface, removing all trace of the surface tread, to prepare the casing to be retreaded.

(2) "Commission" -- the Environmental Quality Commission.

(3) "Department" -- the Department of Environmental Quality.

(4) "Director" -- the Director of the Department of Environmental Quality.

(5) "Dispose" -- to deposit, dump, spill or place any waste tire on any land or into any water as defined by ORS 468.700.

(6) "End user":

(a) For energy recovery: the person who utilizes the heat content or other forms of energy from the incineration or pyrolysis of waste tires, chips or similar materials.

(b) For other eligible uses of waste tires: the last person who uses the tires, chips, or similar materials to make a product with economic value. If the waste tire is processed by more than one person in becoming a product, the "end user" is the last person to use the tire as a tire, as tire chips, or as similar materials. A person who produces tire chips or similar materials and gives or sells them to another person to use is not an end user.

(7) "Energy recovery" -- recovery in which all or a part of the waste tire is processed to utilize the heat content, or other forms of energy, of or from the waste tire.

(8) "Financial assurance" -- a performance bond, letter of credit, cash deposit, insurance policy or other instrument acceptable to the Department.

(9) "Land disposal site" -- a disposal site in which the method of disposing of solid waste is by landfill, dump, pit, pond or lagoon.

(10) "Oversize waste tire" -- a waste tire exceeding an 18-inch rim diameter, or a 35-inch outside diameter.

(11) "Person" -- the United States, the state or a public or private corporation, local government unit, public agency, individual, partnership, association, firm, trust, estate or any other legal entity.

(12) "Private carrier" -- any person who operates a motor vehicle over the public highways of this state for the purpose of transporting persons or property when the transportation is incidental to a primary business enterprise, other than transportation, in which such person is engaged.

(13) "PUC" -- the Public Utility Commission of Oregon.

(14) "Retreader" -- a person engaged in the business of recapping tire casings to produce recapped tires for sale to the public.

(15) "Rick" -- to horizontally stack tires securely by overlapping so that the center of a tire fits over the edge of the tire below it.

(16) "Store" or "storage" -- the placing of waste tires in a manner that does not constitute disposal of the waste tires.

(17) "Tire" -- a continuous solid or pneumatic rubber covering encircling the wheel of a vehicle in which a person or property is transported or by which they may be drawn on a highway. This does not include tires on the following:

(a) A device moved only by human power.

(b) A device used only upon fixed rails or tracks.

(c) A motorcycle.
(d) An all-terrain vehicle.

(e) A device used only for farming, except a farm truck.

(18) "Tire carrier" -- a person who picks up or transports waste tires for the purpose of storage or disposal. This does not include the following:

(a) Solid waste collectors operating under a license or franchise from a local government unit and who transport fewer than 10 tires at a time.

(b) Persons who transport fewer than five tires with their own solid waste for disposal.

(19) "Tire processor" -- a person engaged in the processing of waste tires.

(20) "Tire retailer" -- a person in the business of selling new replacement tires.

(21) "Tire derived products" -- tire chips or other usable materials produced from the physical processing of a waste tire.

(22) "Waste tire" -- a tire that is no longer suitable for its original intended purpose because of wear, damage or defect, and is fit only for:

(a) Remanufacture into something else, including a recapped tire; or

(b) Some other use which differs substantially from its original use.

(23) "Waste Tires Generated in Oregon" -- Oregon is the place at which the tire first becomes a waste tire. A tire casing imported into Oregon for potential recapping, but which proves unusable for that purpose, is not a waste tire generated in Oregon. Examples of waste tires generated in Oregon include but are not limited to:

(a) Tires accepted by an Oregon tire retailer in exchange for new replacement tires.

(b) Tires removed from a junked auto at an auto wrecking yard in Oregon.

Policy on Use of Waste Tire Recycling Account Funds

340-62-090 Waste tires have a resource value to society that is lost if they are landfilled. One goal of the Waste Tire Program is to control the transportation and storage of waste tires so that illegal dumping is eliminated, and the tires do not cause environmental hazards. The major tools for this are the permitting requirements for tire sites and tire carriers, and civil penalties for illegal tire storage/disposal.

Another program goal is to enhance the market for reuse of waste tires so that their value is recovered, and the market helps divert the stream of waste tires from being landfilled. For this to happen, an economically attractive alternative to landfilling must be in place. The major tool for this is a reimbursement to users of waste tires from the Waste Tire Recycling Account. However, some existing sites will need financial help, or they will never be cleaned up. The Waste Tire Recycling Account also addresses this need, but under limited circumstances. The Department shall recommend or determine use of available funds in the Waste Tire Recycling Account, based on the following priority order:

(1) Reimbursement to people who use waste tires.

(2) Cleanup of permitted or non-permitted waste tire storage sites, following criteria established in OAR 340-62-155. Priority shall be given to abating a danger or nuisance created by waste tires, pursuant to OAR 340-62-155.

Reimbursement for Use of Waste Tires

340-62-100 (1) Funds in the Waste Tire Recycling Account may be used to reimburse persons for the costs of using waste tires or chips or similar materials.

(2) A person may apply to the Department for partial reimbursement from the Account for using waste tires. To be eligible for the reimbursement, the tires must:

(a) Be waste tires generated in Oregon;

(b) Be tire chips or similar materials from waste tires generated in Oregon; and

(c) Be used for energy recovery or other appropriate uses as specified in OAR 340-62-110.

Uses of Waste Tires Eligible for Reimbursement

340-62-110 (1) Uses of waste tires which may be eligible for the reimbursement include:

(a) Energy recovery. Energy recovery shall include:

(A) Burning of whole or chipped tires as tire-derived fuel. The tire-derived fuel shall be burned only in boilers which have submitted test burn data to the Department and whose air quality permits are not violated by burning tire-derived fuel in the quantities for which reimbursement is requested.

(B) Incineration or pyrolysis of whole tires or tire chips to produce electricity or process heat or steam, either for use on-site, or for sale.

(b) Other eligible uses. Other eligible uses shall include:

(A) Pyrolysis of tires to produce combustible hydrocarbons and other salable products.

(B) Use of tire chips as road bed base, driveway cover, and the like.

(C) Recycling of waste tire strips, chips, shreds, or crumbs to manufacture a new product. The new product may be produced by physical or chemical processes such as:

(i) Weaving from strips of waste tires.

(ii) Stamping out products from the tire casing.

(iii) Physically blending tire chips with another material such as asphalt.

(iv) Physically or chemically bonding tire chips or crumbs with another material to form a new product such as tire chocks.

(D) Use of whole tires:

(i) In artificial fishing reefs, pursuant to OAR 340-46.

(ii) For the manufacture of new products which have a market value such as buoys.

(2) If a proposed use of waste tires would in the Department's opinion cause environmental, safety or health hazards, the Department may disallow the partial reimbursement. An example of a health hazard would be use of tire chips for playground cover without removing the steel shreds.

(3) The following uses are not considered appropriate for use of the reimbursement, and shall not be eligible for the reimbursement:

(a) Reuse as a vehicle tire.

(b) Retreading.

(c) Use of tires as riprap.

(d) Use of whole or split tires for erosion control.

(e) Use of whole or split tires for tire fences, barriers, dock and racetrack bumpers, ornamental planters, agricultural uses such as raised beds, or other uses in which the user incurs little or no cost, the use is of limited economic value, and the use does not take place within a market.

(f) Use of tire buffings.

Who May Apply for a Reimbursement

340-62-115 (1) A person who uses waste tires generated in Oregon may apply to the Department for a partial reimbursement.

(2) To be eligible for the reimbursement, the user of a waste tire shall be the end user of the waste tire, chips or similar material for energy recovery or other appropriate uses pursuant to OAR 340-62-110. The end user need not be located in Oregon.

(3) For purposes of the reimbursement, the end user shall document the number of pounds of waste tires, chips or similar materials used by proof of purchase or sale, as appropriate, of the waste tires, chips or similar materials to or from another person. In order to qualify as a purchase or sale, the transaction cannot take place between two persons (including a firm or corporation) if:

(a) One of the persons has a financial interest in the other;

(b) One of the persons is a subsidiary of the other;

(c) The family of one of the persons has an interest in the other firm or corporation;

(d) The two firms or corporations have common officers or common directors.

Application for Reimbursement

340-62-120 (1) Application for reimbursement for use of waste tires shall be made on a form provided by the Department.

(2) An applicant may apply in advance for certification ("advance certification") from the Department that his or her proposed use of waste tires shall be eligible for reimbursement.

(a) Such advance certification may be issued by the Department if the applicant proves to the Department's satisfaction that:

(A) The use being proposed is an eligible use under OAR 340-62-110;

(B) The applicant is an eligible end user under OAR 340-62-010 (6) and OAR 340-62-115;

(C) The applicant will be able to document that the waste tires used were generated in Oregon; and

(D) The applicant will be able to document the number of net pounds of waste tires used.

(b) The applicant must still apply to the Department for reimbursement for waste tires actually used, and document the amount of that use, pursuant to sections (3) and (4) of this rule.

(c) Advance certification issued by the Department to an applicant shall not guarantee that the applicant shall receive any reimbursement funds. The burden of proof shall be on the applicant to document that the use for which reimbursement is requested actually took place, and corresponds to the use described in the advance certification.

(3) An applicant may apply to the Department directly for the reimbursement each quarter without applying for advance certification. The application shall be on a form provided by the Department.

(4) To apply for reimbursement for the use of waste tires an applicant shall:

(a) Apply to the Department no later than thirty (30) days after the end of the quarter in which the waste tires were used.

(b) Unless the applicant holds an advance certification for the use of waste tires for which they are applying, prove to the Department's satisfaction that:

(A) The use being proposed is an eligible use under OAR 340-62-110; and

(B) The applicant is an eligible end user under OAR 340-62-010(6) and OAR 340-62-115.

(c) Provide documentation acceptable to the Department, such as bills of lading, that the tires, chips or similar materials used were from waste tires generated in Oregon.

(d) Provide documentation acceptable to the Department of the net amount of pounds of waste tires used (including embedded energy from waste tires) in the quantity of product sold, purchased or used. Examples of acceptable documentation are:

(A) For tire-derived fuel: receipts showing tons of tire-derived fuel purchased.

(B) For incineration of whole tires producing process heat, steam or electricity: records showing net tons of rubber burned.

(C) For pyrolysis plants producing electricity or process heat or steam: billings showing sales of kilowatt hours or tons of steam produced by the tire pyrolysis, calculations certified by a professional engineer showing how many net pounds of tires were required to generate that amount of energy, and receipts or bills of lading for the number of waste tires actually used to produce the energy.

(D) For pyrolysis technologies producing combustible hydrocarbons and other salable products: billings to customers showing amounts of pyrolysis-derived products sold (gallons, pounds, etc.) with calculations certified by a professional engineer showing the number of net pounds of waste tires, including embedded energy, used to produce those products.

(E) For end users of tire strips, chunks, rubber chips, crumbs and the like in the manufacture of another product: billings to purchasers for the amount of product sold, showing net pounds of rubber used to manufacture the product sold.

(F) For end users of tire chips in rubberized asphalt, or as road bed material, driveway cover and the like: billings or receipts showing the net pounds of rubber used.

(G) For end users of whole tires: documentation of the weight of the tires used, exclusive of any added materials such as ballast or ties.

(5) The Department may require any other information necessary to determine whether the proposed use is in accordance with Department statutes and rules.

(6) An applicant for a reimbursement for use of waste tires, and the person supplying the waste tires, tire chips or similar materials to the applicant, for which the reimbursement is requested, are subject to audit by the Department (or Secretary of State) and shall allow the Department access to all records during normal business hours for the purpose of determining compliance with this rule.

(7) In order to apply for a reimbursement, an applicant must have used an equivalent of at least 10,000 pounds of waste tires or 500 passenger tires after the effective date of this rule. Waste tires may be used in more than one quarter to reach this threshold amount.

Basis of Reimbursement

340-62-130 (1) In order to be eligible for reimbursement, the use of waste tires must occur after the effective date of this rule.

(2) Any one waste tire shall be subject to only one request for reimbursement.

(3) The amount of the reimbursement shall be based on $.01 per pound for rubber derived from waste tires which is used by an applicant.

(4) The amount of rubber used shall be based on sales of product containing the rubber; or if the applicant is an end user who consumes and does not further sell the tires, chips or similar materials, the reimbursement shall be based on net pounds of materials purchased or used.

Processing and Approval of Applications

340-62-135 (1) An applicant shall submit a complete application for a reimbursement to the Department within 30 days of the end of the quarter in which the waste tires were used. The Department shall act on an application only if it is complete.

(2) If an application is late or incomplete, the Department shall not act on the application.

(3) The applicant may submit additional information required by the Department to complete the application. However, the Department shall not act on such an application until the end of the following quarter.

(4) The Department shall review a complete reimbursement application form for overall eligibility. The Department shall then determine the eligible number of pounds of rubber used.

(5) When the Department has received and reviewed pursuant to section (4) of this rule all completed applications for reimbursement for a quarter, the Department shall calculate the total dollar amount of eligible reimbursements requested at $.01 per pound of rubber used.

(6) The Department shall determine the amount of available funds in the Waste Tire Recycling Account. In determining the amount of funds available for the reimbursement in any quarter, the Department shall first deduct the amount of prorated reimbursement from the previous quarter "made whole" under section (8) of this rule.

(7) If the amount of eligible reimbursements requested exceeds the amount of funds available for reimbursement, the Commission shall prorate the amount of all reimbursements for eligible uses received for that quarter. The time period for reimbursement as specified by the Commission shall be a calendar quarter. The proration shall be done as follows:

(a) First, uses which reuse or recycle the waste tires, chips or similar materials shall receive one hundred percent of the eligible amount requested up to the amount of funds available. Available funds in the Waste Tire Recycling Account shall be reduced by that amount.

(b) Remaining available funds in the Waste Tire Recycling Account shall then be prorated among all eligible applicants who have used waste tires, chips or similar materials to recover their energy value. This proration shall be based on an equal reduction per pound of rubber used by all remaining eligible applicants.

(8) When the final amount of reimbursement for all applicants under section (7)(a) and (7)(b) of this rule has been determined, the Department shall make payment in that amount to each applicant.

(9) The Department shall keep track of the amount by which a proration under section (7)(b) of this rule has reduced an otherwise eligible amount of reimbursement for an applicant. Before making reimbursements for the following quarter, the Department shall first reserve funds from the Waste Tire Recycling Account for applicants to "make whole" any reductions in costs eligible for the reimbursement caused by prorating in the preceding quarter under section (7)(b) of this rule.

(10) Within 30 days of the filing of an application for advance certification, the Department shall request any additional information needed to complete the application. The application is not complete until such additional information requested by the Department has been received.

(11) If the Department determines that an application for advance certification is eligible, it shall within 60 days of receipt of a completed application issue an advance certification.

(12) The Department shall process applications for reimbursement which have "advance certification" before acting on other applications.

(13) To ensure that a use continues to be eligible for the reimbursement, the Department may review the eligibility of an approved advance certification form:

(a) Annually;

(b) After any revision of this rule; or

(c) After a finding of the Commission that a reimbursement is not necessary to promote the use of waste tires.

Use of Waste Tire Site Cleanup Funds

340-62-150 (1) The Department may use cleanup funds in the Waste Tire Recycling Account to:

(a) Partially pay to remove or process waste tires from a permitted waste tire storage site, if the Commission finds that such use is appropriate pursuant to OAR 340-62-160.

(b) Pay for abating a danger or nuisance created by a waste tire pile, subject to cost recovery by the attorney general pursuant to OAR 340-62-165.

(c) Partially reimburse a local government unit for the cost it incurred in abating a waste tire danger or nuisance.

(2) Priority in use of cleanup funds shall go to sites ranking high in criteria making them an environmental risk, pursuant to OAR 340-62-155.

(3) For the Department to reimburse a local government for waste tire danger or nuisance abatement, the following must happen:

(a) The Department must determine that the site ranks high in priority criteria for use of cleanup funds, OAR 340-62-155.

(b) The local government and the Department must have an agreement on how the waste tires shall be properly disposed of.

Criteria for Use of Funds to Clean Up Permitted Waste Tire Sites

340-62-155 (1) The Department shall base its recommendations on use of cleanup funds on potential degree of environmental risk created by the tire pile. The following special circumstances shall serve as criteria in determining the degree of environmental risk. The criteria, listed in priority order, include but are not limited to:

(a) Susceptibility of the tire pile to fire. In this, the Department shall consider:

(A) The characteristics of the pile that might make it susceptible to fire, such as how the tires are stored (height and bulk of piles), the absence of fire lanes, lack of emergency equipment, presence of easily combustible materials, and lack of site access control;

(B) How a fire would impact the local air quality; and

(C) How close the pile is to natural resources or property owned by third persons that would be affected by a fire at the tire pile.

(b) Other characteristics of the site contributing to environmental risk, including susceptibility to mosquito infestation.

(2) In determining the degree of environmental risk involved in the two criteria above, the Department shall consider:

(a) Size of the tire pile (number of waste tires).

(b) How close the tire pile is to population centers. The Department shall especially consider the population density within five miles of the pile, and location of any particularly susceptible populations such as hospitals.

(3) Financial hardship on the part of the permittee shall be an additional criterion in the Department's determination. Financial hardship means that strict compliance with OAR 340-62-005 through 340-62-045 would result in substantial curtailment or closing of the permittee's business or operation, or the bankruptcy of the permittee. The burden of proof of such financial hardship is on the permittee.

Procedure for Use of Cleanup Funds for a Permitted Waste Tire Storage Site

340-62-160. (1) The Department may recommend to the Commission that cleanup funds be made available to partially pay for cleanup of a permitted waste tire storage site, if all of the following are met:

(a) The site ranks high in the criteria making it an environmental risk, pursuant to OAR 340-62-155.

(b) The permittee submits to the Department a compliance plan to remove or process the waste tires. The plan shall include:

(A) A detailed description of the permittee's proposed actions;

(B) A time schedule for the removal and or processing, including interim dates by when part of the tires will be removed or processed.

(C) An estimate of the net cost of removing or processing the waste tires using the most cost-effective alternative. This estimate must be documented.

(c) The plan receives approval from the Department.

(2) A permittee claiming financial hardship under OAR 340-62-155 (3) must document such claim through submittal of the permittee's state and federal tax returns for the past three years, business statement of net worth, and similar materials. If the permittee is a business, the income and net worth of other business enterprises in which the principals of the permittee's business have a legal interest must also be submitted.

(3) If the Commission finds that use of cleanup funds is appropriate, the Department shall agree to pay part of the Department-approved costs incurred by the permittee to remove or process the waste tires. Final payment shall be withheld until the Department's final inspection and confirmation that the tires have been removed or processed pursuant to the compliance plan.

Use of Cleanup Funds for Abatement by the Department

340-62-165. (1) The Department may use funds in the Account to contract for the abatement of:

(a) A tire pile for which a person has failed to apply for or obtain a waste tire storage site permit.

(b) A permitted waste tire storage site if the permittee fails to meet the conditions of such permit.

(2) The Department may abate any danger or nuisance created by waste tires by removing or processing the tires. The Department shall follow criteria in OAR 340-62-155 in determining which sites shall be subject to abatement.

(3) Before taking any action to abate the danger or nuisance, the Department shall give any persons having the care, custody or control of the waste tires, or owning the property upon which the tires are located, notice of the Department's intentions and order the person to abate the danger or nuisance in a manner approved by the Department.

(4) Any order issued by the Department under this subsection shall be subject to appeal to the Commission and judicial review of a final order under the applicable provisions of ORS 183.310 to 183.550.

(5) If a person fails to take action as required under subsection (3) of this section within the time specified, the Director may contract to abate the danger or nuisance.

(6) The order issued under subsection (3) of this section may include entering the property where the danger or nuisance is located, taking the tires into public custody and providing for their processing or removal.

(7) The Department may request the attorney general to bring an action to recover any reasonable and necessary expenses incurred by the Department for abatement costs, including administrative and legal expenses. The Department's certification of expenses shall be prima facie evidence that the expenses are reasonable and necessary. The Department may consider the financial situation of the person in determining the amount of abatement costs to be recovered.