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16. ABSTRACT
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HIGHWAY RESEARCH REPORT

LANDLOCK AS A SPRAY-ON EROSION CONTROL AGENT

FINAL REPORT

September, 1973

STATE OF CALIFORNIA

BUSINESS AND TRANSPORTATION AGENCY

DEPARTMENT OF TRANSPORTATION

DIVISION OF HIGHWAYS

TRANSPORTATION LABORATORY

RESEARCH REPORT

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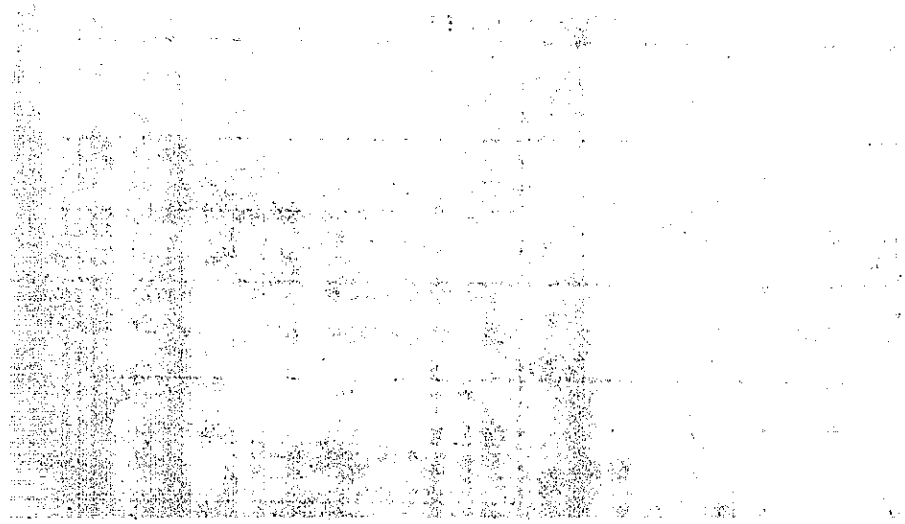

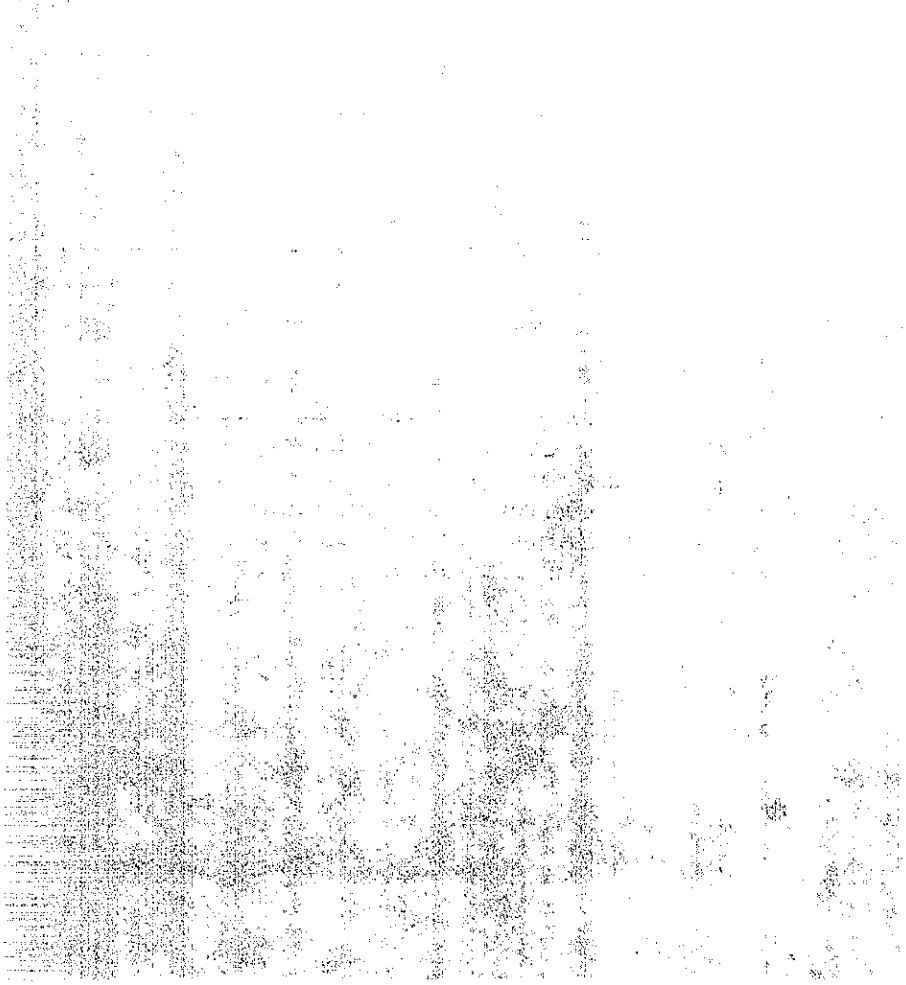

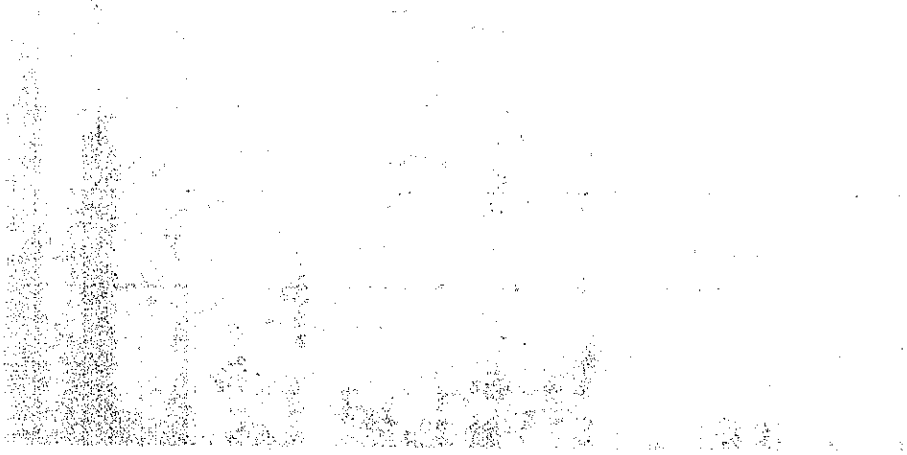

STATE OF CALIFORNIA—BUSINESS AND TRANSPORTATION AGENCY
RONALD REAGAN, Governor

DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
TRANSPORTATION LABORATORY
5900 FOLSOM BLVD., SACRAMENTO 95819

September 1973
TL No. 641139A

Mr. John L. Beaton
Laboratory Director

Dear Sir:

Submitted herewith is a research report titled:

LANDLOCK AS A SPRAY-ON EROSION

CONTROL AGENT

Ronald Mearns and Thomas Hoover
Co-Investigators

Raymond A. Forsyth, P.E.
Principal Investigator

Very truly yours,

Raymond A. Forsyth
Chief, Foundation Section

APPROVED

John L. Beaton Date 9/27/73
Laboratory Director

ACKNOWLEDGEMENTS

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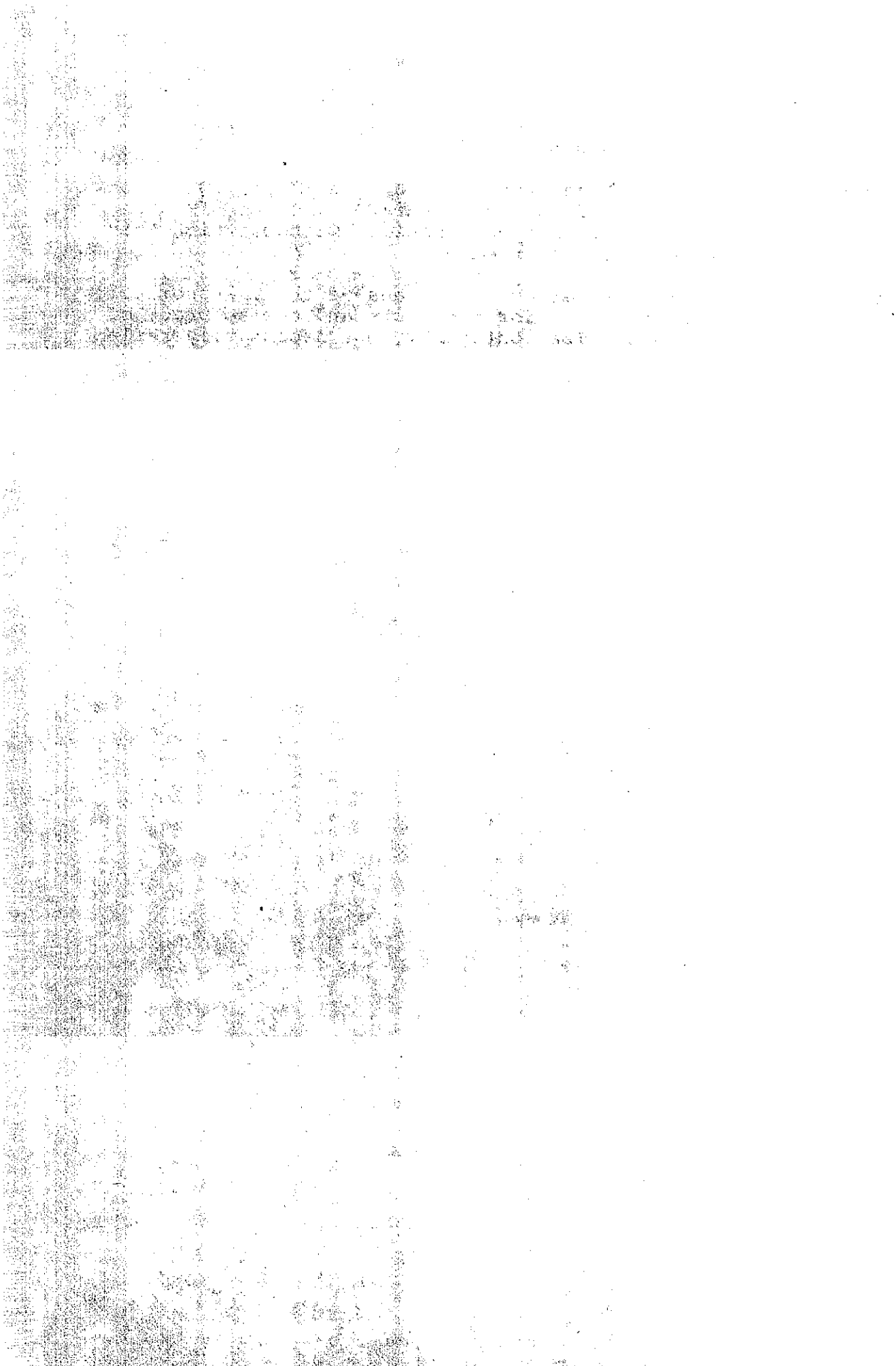
The contents of this report reflect the views of the Transportation Laboratory which is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. This report does not constitute a standard, specification, or regulation.



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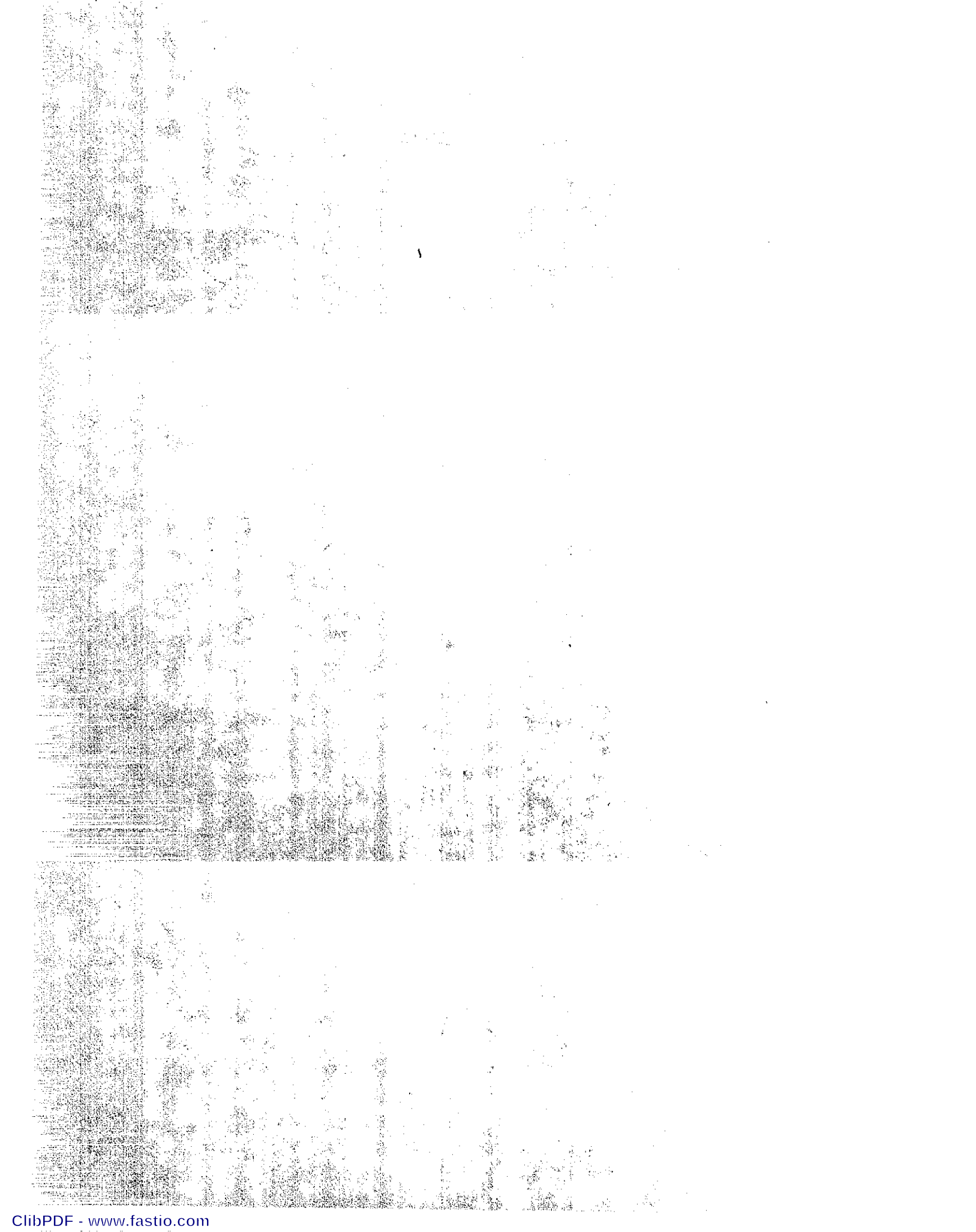

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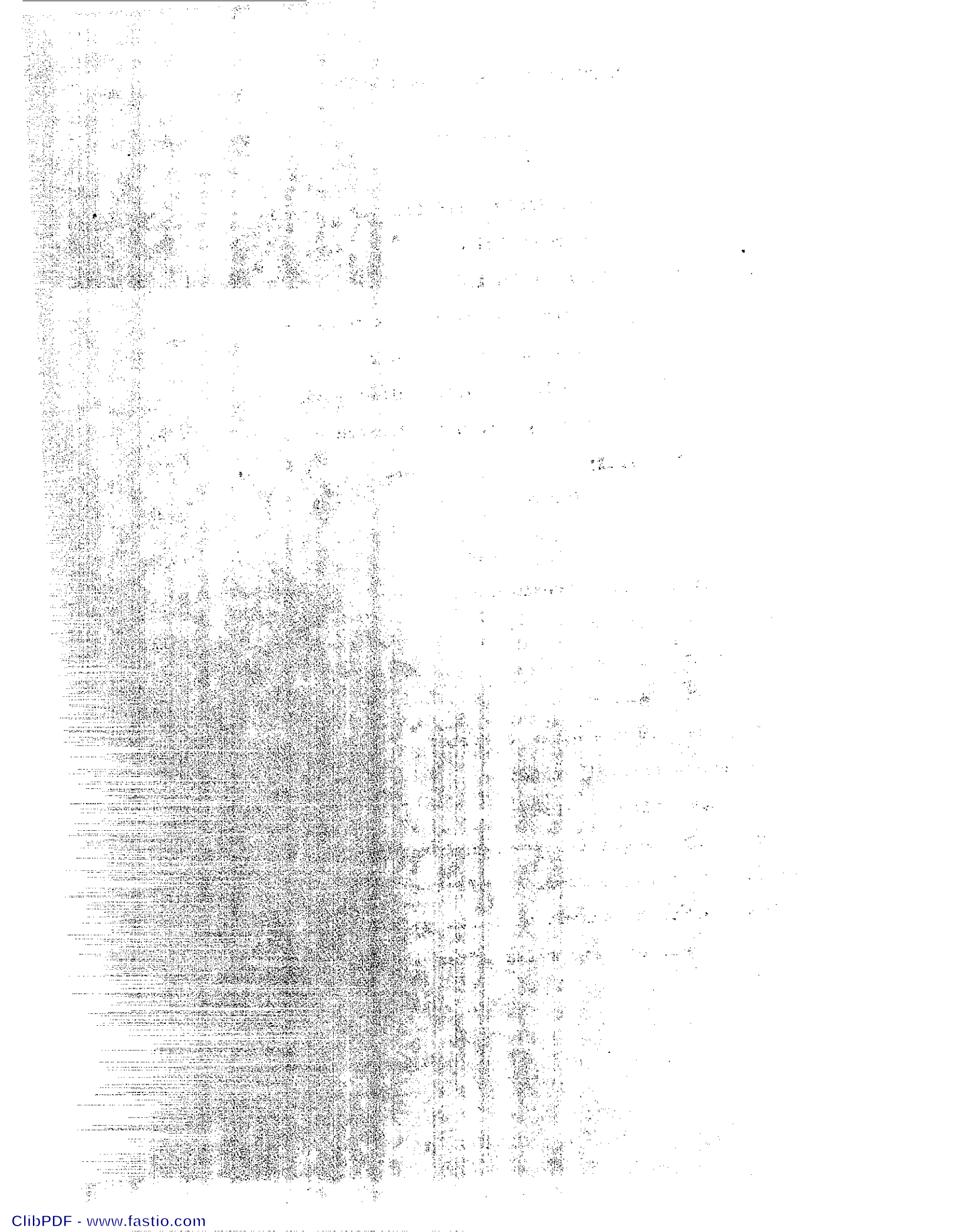
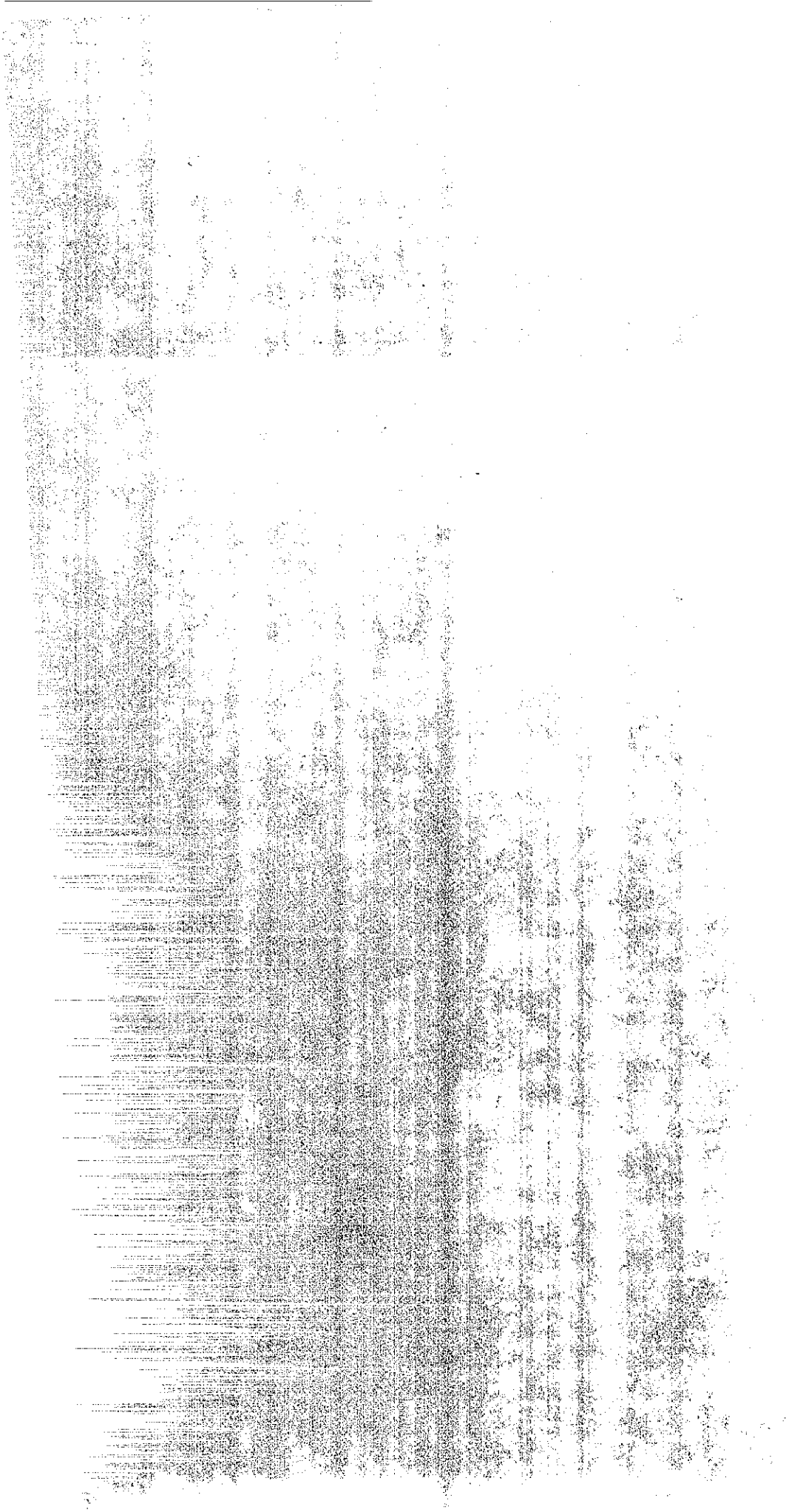


Plates (cont.)



INTRODUCTION

Various erosion control projects throughout California have utilized the Minnesota Mining and Manufacturing Company (3M) product called Landlock. It was installed to judge its erosion control characteristics under differing conditions, thus, helping us to evaluate the practicality of using it for erosion control. The materials for these tests was generally provided by the 3M Company, with the labor of installation shared by the California Division of Highways and the 3M Company.

The areas where Landlock was tested are:

1. U.S. Highway 199 PM 31.2 in Del Norte Co. near Collier tunnel
2. Interstate 5 PM 21 in Siskiyou Co. near Weed
3. Interstate 80 PM 29.3 in Nevada Co. near Farad
4. California 120 PM 47 in Tuolumne Co. near Buck Meadows
5. California 49 PM 11.5 in Mariposa Co. near Bootjack
6. California 89 PM 2.75 in El Dorado Co. near Luther Pass
7. U.S. Highway 101 at 156 in Monterey Co. near Prunedale
8. U.S. Highway 101 at 154 in Santa Barbara Co. near Buellton
9. Interstate 10 PM 11.5 in Riverside Co. near Palm Springs
10. California 1 at Non-Com Road in Monterey Co. near Fort Ord

These locations were selected because of known erosion problems.

CONCLUSION AND RECOMMENDATIONS

The 3M erosion control system called Landlock did reduce erosion and establish vegetation when applied in quantities of 138 gals/A or more. Landlock did not reduce erosion when applied over saturated soils or in areas subject to extreme freeze-thaw or frost-heave. It was found to be less effective on steep slopes (1:1 or steeper). Landlock's erosion control capabilities last only 1 season. The 3M Co. was developing its product as it was being researched. Thus, minor changes in the composition of Landlock were made as our work progressed. Based on the experience gained in these projects, and the fact that 3M has developed its final product we recommend further study of Landlock. Any further applications should be at rates of 150 gals/A or more. The polymer should be cosprayed with fiber over the seed and fertilizer. It should not be applied over saturated soils or in areas of extreme freeze-thaw or frost-heave.

PROCEDURE AND RESULTS

U.S. Highway 199 in Del Norte County near Collier tunnel

On March 23, 1972, 26 plots were sprayed at the rate of 80# of seed and 500# of fertilizer per acre. Site #3 (the northerly test site), half of Site #2 and Plot #1 of Site #1 were then sprayed with varying concentrations of fiber.

Due to operational difficulties with the hydromulching equipment, the remainder of the work had to be done the next day. There was light rain over night and the next day which may have washed some seed and probably washed some fertilizer into the gutter.

On March 24, Plots 3 through 8 of Site #1 (the southerly test site) were cosprayed with varying amounts of polymer and fiber. Plots #12 through #14 and #2 were sprayed with varying amounts of polymer while the plots in Sites #2 and #3 (Plots 9-11 and 15-23) that were previously sprayed with varying concentrations of fiber were sprayed with varying concentrations of polymer over the fiber. See Figure 1 for complete descriptions of each plot. The cuts treated in this area had 1:1 slopes in faulted and fractured sedimentary and metasedimentary rocks. Spring and fall inspections were made at this installation, including photographs, during the following year.

The attempt to establish vegetation in this area was not effective. A noteworthy observation was that the plot with the heaviest application of polymer and fiber had the largest increase in vegetation, though very slight. Also, the existing trees in the treated and fertilized plots appear greener.

Interstate 5 in Siskiyou County

On June 23 and June 24 in 1972 Landlock and fiber were cosprayed on the slope at the rate of 240 gals. of polymer and 600# of fiber per acre. Also applied to the slope were 613#/A of nutrients and 25#/A of seed mixture (see Appendix A). The seeds and nutrients were cosprayed with the polymer and fiber except at the toe of slope. The center had no seed, and the top was preseeded. This 1:1 slope was cut through volcanic debris. See Figure 2 for the slope description. Spring and fall photographic records were kept of the erosion at this location.

The stress of frost-heave and the freeze-thaw action broke the Landlock blanket into small pieces which, due to the steepness of the slope, fell to the gutter (see Plates 1 and 2). The treatment did, however, appear to increase the growth in the fertile cut flanks before it failed.

Interstate 80 in Nevada County

This slope was treated on June 22, 1972. The treatment was with 240 gals. of polymer/A and 600#/A of fiber. The seed mixture and rate was the same as at Weed (I-5 Siskiyou) with 420#/A of nutrients (see Appendix A). The polymer and fiber were cosprayed with the seeds and nutrients over the glacial deposit exposed in this 1:1 slope. See Figure 3 for the slope configuration. Spring and fall photographic records of the erosion were taken.

The Landlock blanket was broken up by frost-heave, animal traffic, and rubble which fell from the slope above the cut face. Thus, rockfall or sediment deposition in the gutter was not reduced (see Plates 3-5). There was no significant increase in vegetation.

California 120 in Tuolumne County

This test section was treated on June 20, 1972. Most of this cut was cosprayed with a seed, fertilizer, fiber and polymer. There was, however, a short section which was hand seeded and fertilized then sprayed with fiber and polymer for comparison (see Figure 4). The polymer was used at 175 gals/A with 600#/A of fiber. Nutrients were applied at 620#/A with 25#/A of seed (see Appendix A). This 1:1 cut slope is composed of disintegrated granitic rocks. Spring and fall photographic records of the erosion were taken.

The steepness of this slope and the frost action encountered destroyed the Landlock blanket. However, some vegetation was established in the loose material within the rills, and in the Landlock blanket which is falling off (see Plates 6-9).

California 49 in Mariposa County

On December 14, 1971, 6 miles southeast of Mariposa on Route 49 near Bootjack four plots (each about 750 sq. ft.) were laid out and sprayed on the northeasterly cut slope, a 1 1/2:1 cut slope in disintegrated granitic rock (see Figure 5). The sprayed plots were numbered from east to west and delineated with white paint on the asphalt berm. In the center area of the cut is a control area that was left untreated, Plots 1 and 2 being on the easterly side of this area and Plots 3 and 4 being on the westerly side. Plots 1 and 4 were fertilized and seeded with 65# perennial rye grass seed and 260# amonium sulphate per acre as were the east and west ends of the cut adjacent to Plots 1 and 4.

After the application of seed and fertilizer, Plots 1 and 2 were sprayed with 240 gals. of polymer per acre and Plots 3 and 4 with half this rate. The ratio of water to polymer was 10:1. In Plots 1 and 2 there was some runoff of material during the spraying process, no doubt partly due to ground saturation near the surface. Periodic inspections, including photographs, were made until April 4, 1973.

These plots indicate that 120 gals/A is insufficient polymer to do an adequate job of erosion protection. Also, better plant establishment occurs when polymer is applied in conjunction with seeding (see Plates 10-13). The polymer was lifted off the surface here by the freezing of the saturated soil beneath the Landlock.

California 89 in El Dorado County near Luther Pass

This slope was treated on June 21, 1972. The seed mix is the same as at Buck Meadows (California 120 - Tuolumne). Half of the slope had the seed and nutrients cosprayed with polymer while the other half had the seed and nutrients raked in first (see Figure 5).

This 1 1/2:1 cut slope in disintegrated granitic rocks was treated with polymer at 155 gals/A and 550# fiber/A in addition to 620#/A of nutrients. Photographic records of the erosion and sediment measurements of 1 treated and 1 untreated test plot were obtained periodically.

A large portion of the sediment collected originated from ant hills and rodent burrows (see Plate 14). The exact amount attributed to animals is impossible to measure. Since this effects the whole slope and its erosion characteristics, the sediments contributed by animal activity are included in our analysis. At this location the Landlock plot only yielded 83% of the sediment which was measured as yield from the control plot. Further investigation may substantiate the decrease in the sediment lost from a slope when treated with Landlock.

The animal activity and freeze-thaw action which takes place here destroyed the integrity of the 3M blanket allowing erosion to take place in many places (see Plate 15). There appears to be no increase in vegetation in the treated area as compared to the control plot.

U.S. Highway 101 at 156 in Monterey County near Prunedale

This test area, a 1 1/2:1 slope in uncemented beach sand, was treated on June 19, 1972. One area was seeded then sprayed while the other was cosprayed (see Figure 7). The seed mix

was applied at 50#/A and 620#/A of nutrients (see Appendix A). These were either raked in first and then sprayed with 138 gals/A of polymer and 600#/A fiber, or cosprayed with 112 gals/A polymer and 600#/A fiber. Periodic inspections of this area including photographic records of the erosion, were made. Inspections were often made upon notification from the Maintenance Department that changes in the slope had occurred. This notification permitted the recording of storm damage immediately after its occurrence.

At this location, in this climate, it soon became apparent that 112 gals/A was not enough polymer and that 138 gals/A was marginal. The applications here should probably have been at a minimum of 150 gals/A. It was also evident that cospraying delayed the germination of the vetch by approximately three weeks. It had no apparent effect upon the ultimate yield of vetch cover, or any other vegetative cover, however. The 3M treatment at 138 gals/A was clearly superior to that at 112 gals/A and the control plot (see Plates 16-18).

U.S. Highway 101 in Santa Barbara Co. near Buellton

On October 20, 1971, three test applications were installed near Buellton (see Figure 8), on a 1:1 cut slope of uncemented blow sand. Two of these plots were left seeded and fibered while two were raked clean for comparison purposes. One of the raked plots was treated with Landlock while the other was left as a control section. The seeding and fiber coverage was by the contractor who constructed the cut prior to our test program. The plots were treated with two rates of polymer: 1089 gals/A and 545 gals/A. These high rates of application were arrived at by applying the polymer until the ground appeared to have sufficient coverage. This method and these rates have since been revised. Periodic inspection, including photographs, was maintained until April 4, 1973.

At this location it was apparent that the polymer was superior to the control or fiber only treatment, both in erosion control and vegetation establishment (see Plates 19 and 20). The use of fiber in combination with the polymer yielded better vegetation establishment than polymer alone. These results were obtained with a polymer application rate that is unrealistic at this time.

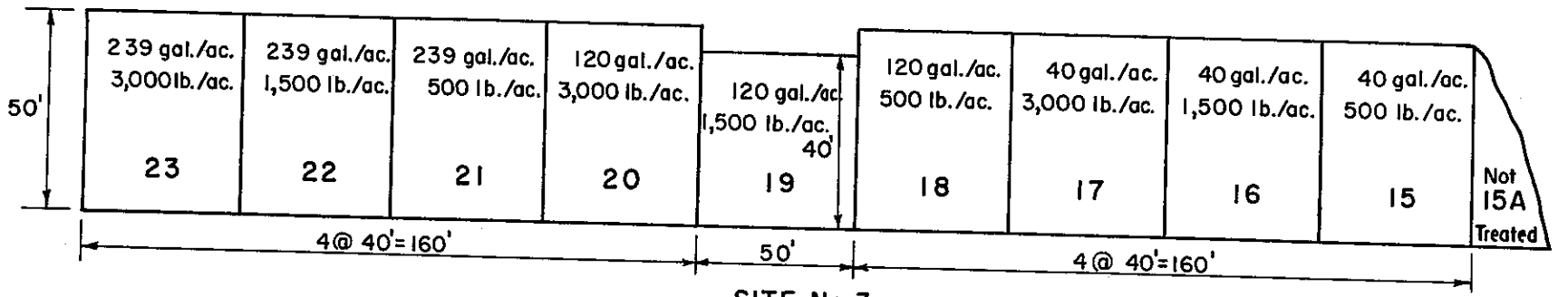
Interstate 10 in Riverside Co. near Indio

On December 13, 1971, 12 1/2 miles west of Indio on Route 10 four flat adjacent plots of blow sand were treated on the north side of the roadway just inside the right-of-way fence (see Figure 9). Each plot was 20' x 50'. The plots were numbered

progressing from the fence toward the roadway. Plots 1 and 2 used 240 gals/A and Plots 3 and 4 each had half this amount. Plot 4 was prewet to a depth of two inches before spraying. The ratio of water to polymer used was 10:1. Periodic inspection was maintained until April 4, 1973. No significant wind erosion was apparent. Much of the treatment was covered with sand deposited from up wind areas. It was still intact as of April 4, 1973 and performing well (see Plates 21 and 22).

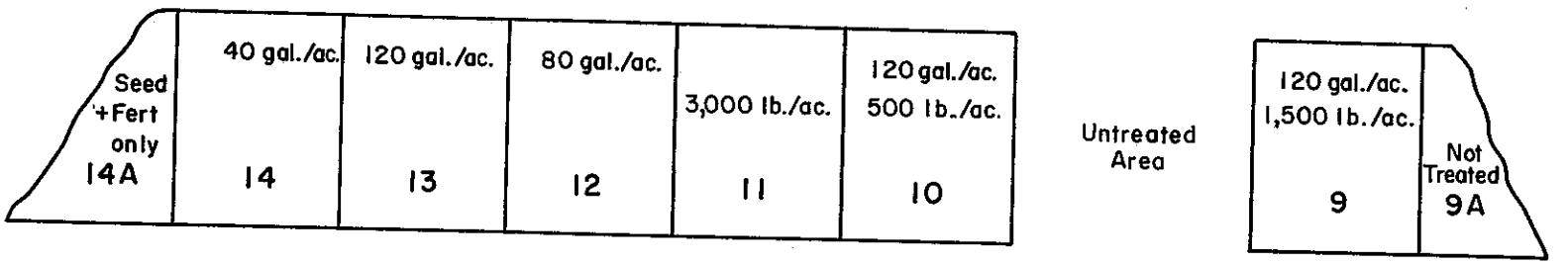
California 1 in Monterey Co. near Fort Ord

This area was treated December 15, 1971. It is thoroughly discussed in Appendix B, "Fort Ord Erosion Control Study." Various plots of blow sand were treated with: 80 gals/A, 120 gals/A, and 240 gals/A of polymer. Due possibly to mild weather, very little erosion was observed. (One significant observation from this test plot was that Landlock permits revegetation by native plants.)



SITE No. 3
(Most Northerly)

Plots 9, 10 & 15–23··· Sequence of spraying: 1. Seed+Fertilizer, 2. Fiber, 3. Polymer



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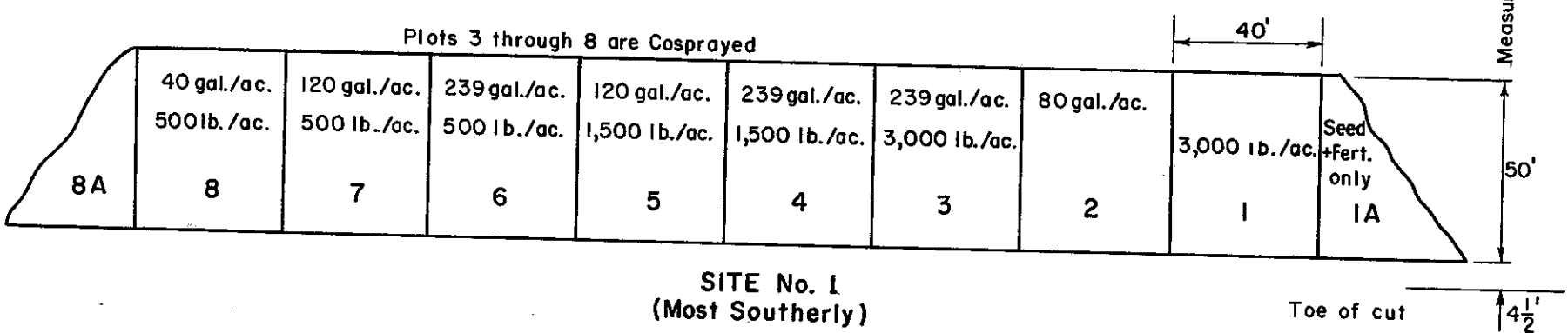


SITE No. 1
(Most Southerly)

Figure 1 SOIL EROSION CONTROL PLOTS NEAR COLLIER TUNNEL

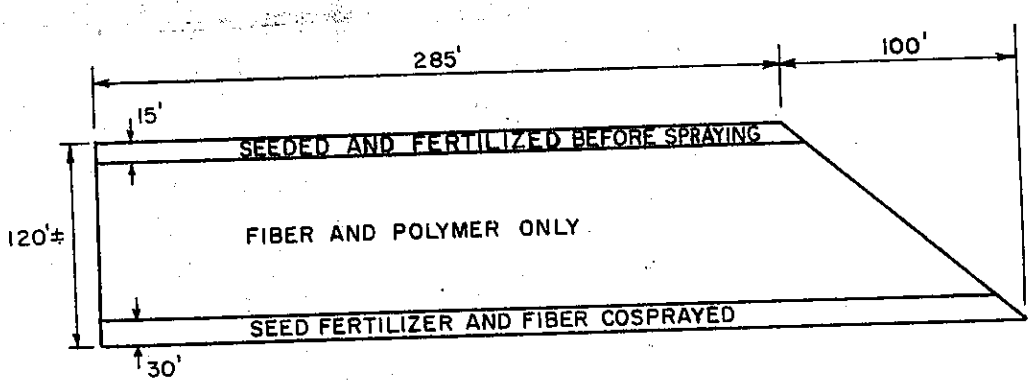


Figure 2 I-5 – SISKIYOU COUNTY NEAR WEED

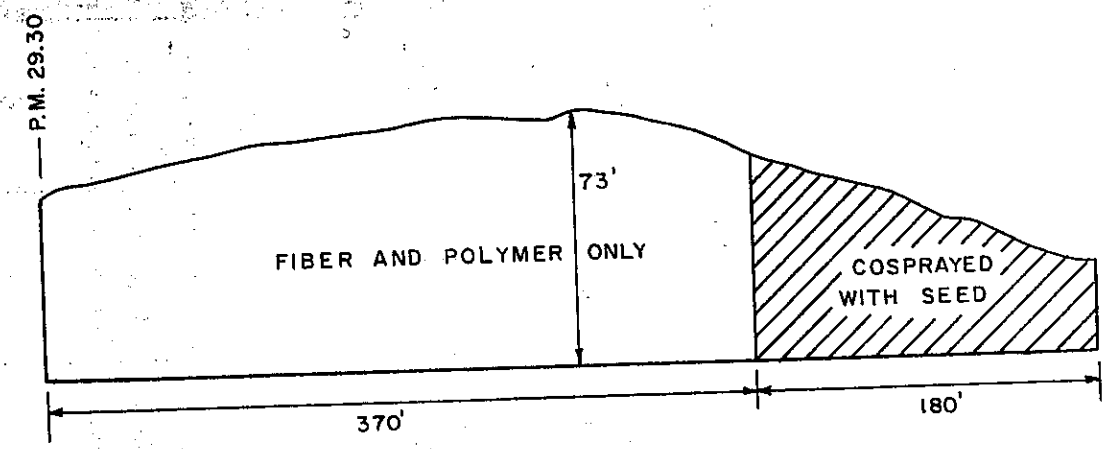


Figure 3 I-80 - NEVADA COUNTY NEAR FARAD

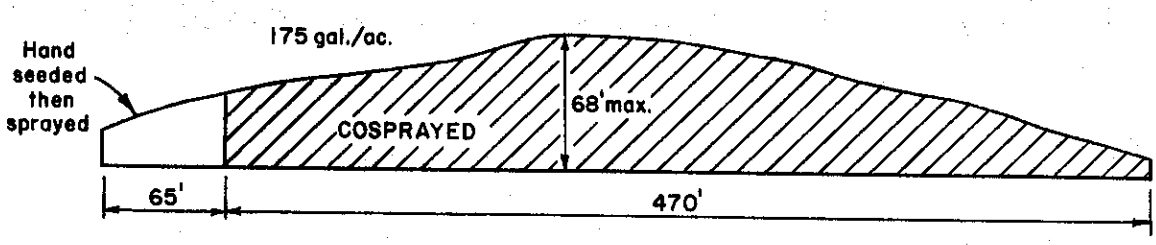


Figure 4 CALIFORNIA 120 TOULUMNE CO. NEAR BUCK MEADOWS

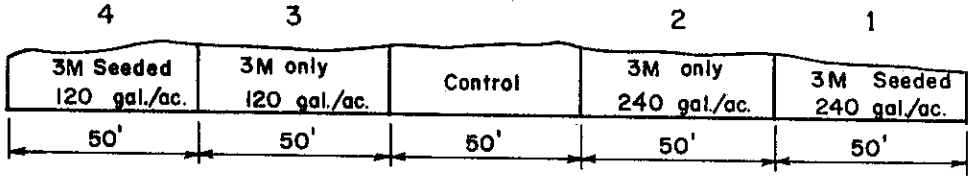


Figure 5 CALIFORNIA 49 MARIPOSA CO. NEAR BOOTJACK

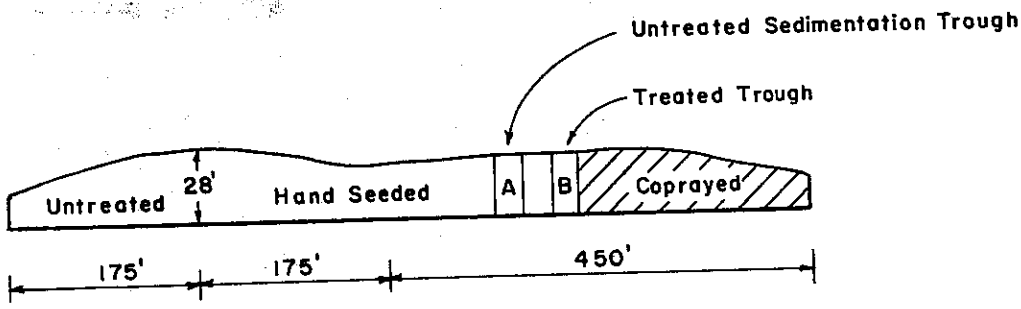


Figure 6 CALIFORNIA 89-EL DORADO CO. NEAR LUTHER PASS

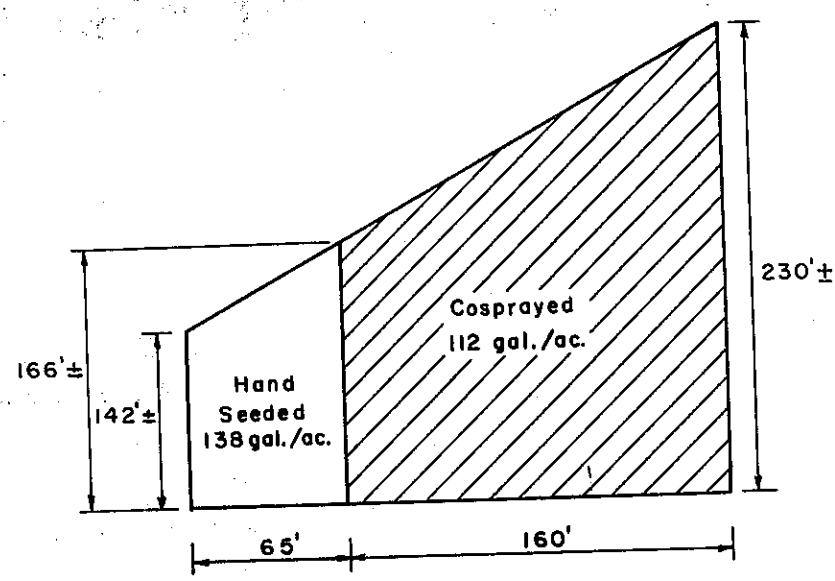


Figure 7 U.S. 101 AT 156 MONTEREY CO. NEAR PRUNEDALE

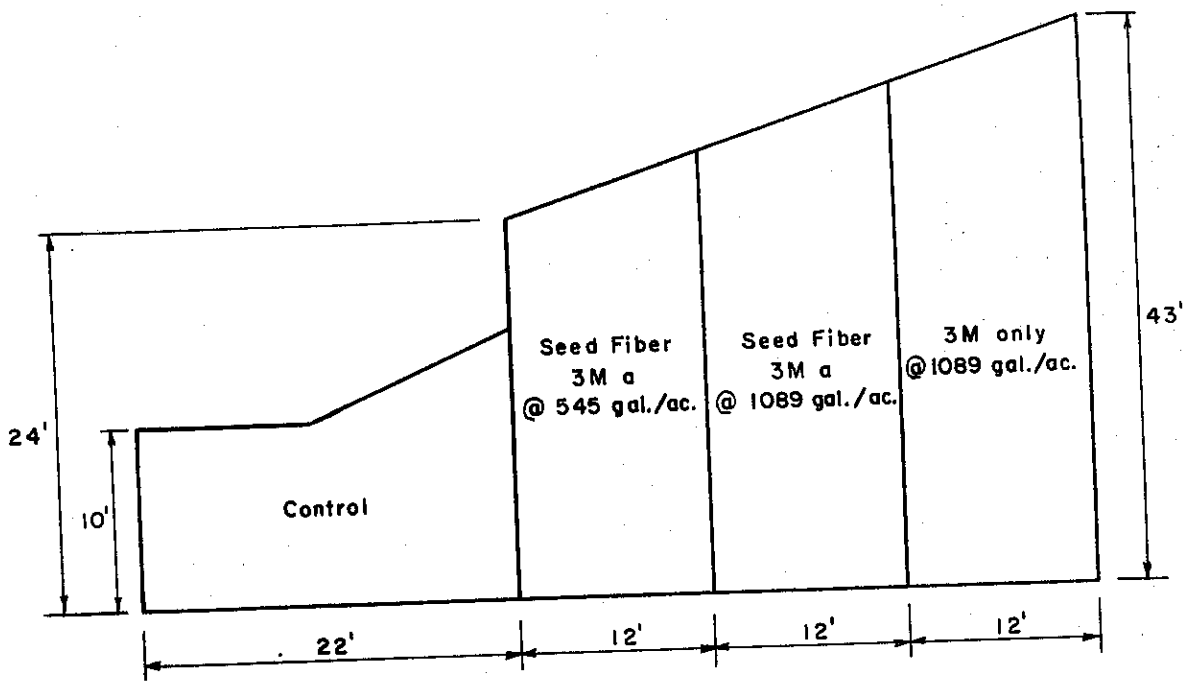


Figure 8 U.S. HIGHWAY 101 NEAR BUELLTON

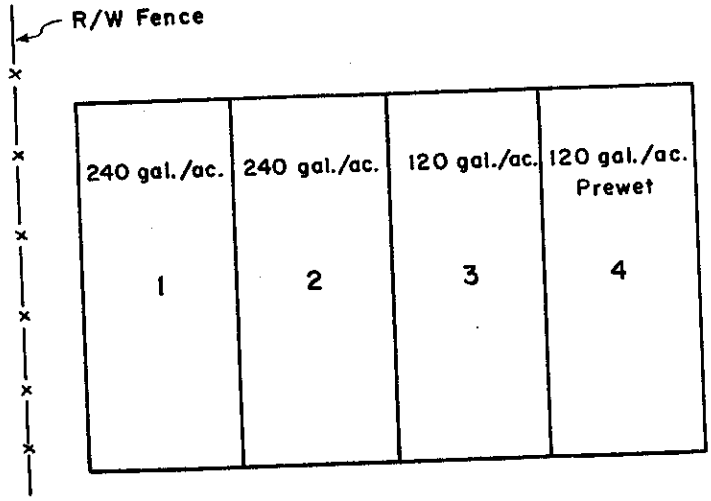
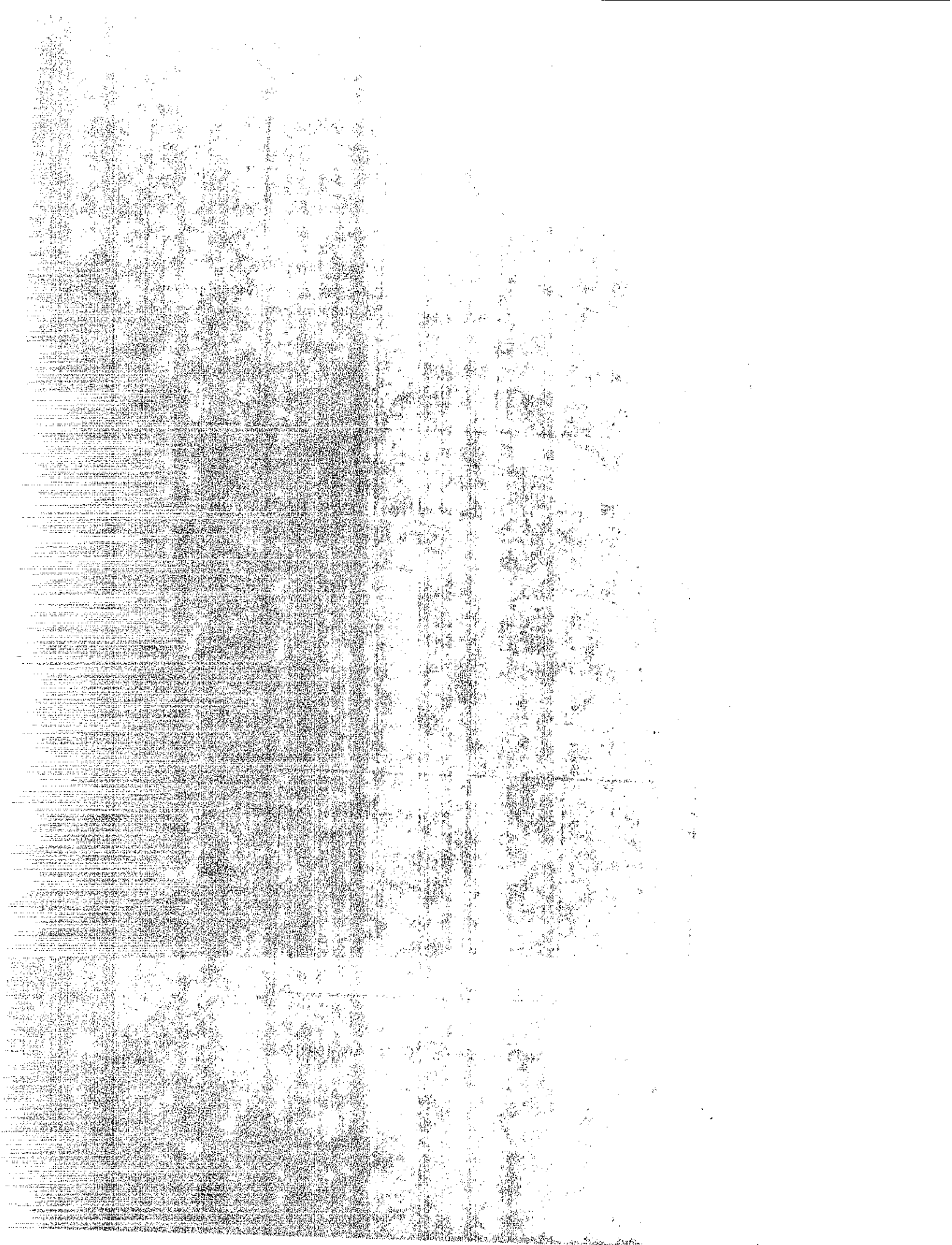


Figure 9 INTERSTATE 10 NEAR INDIO



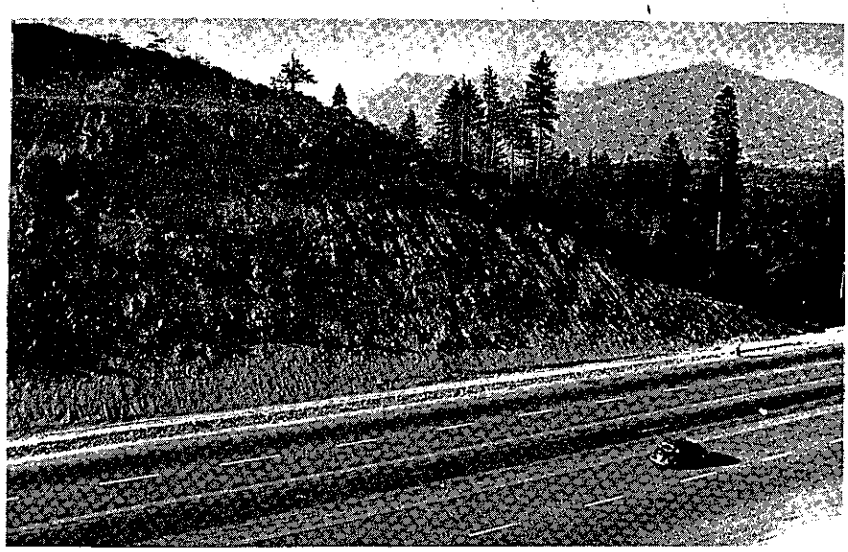


Plate 1 Weed after Landlock treatment

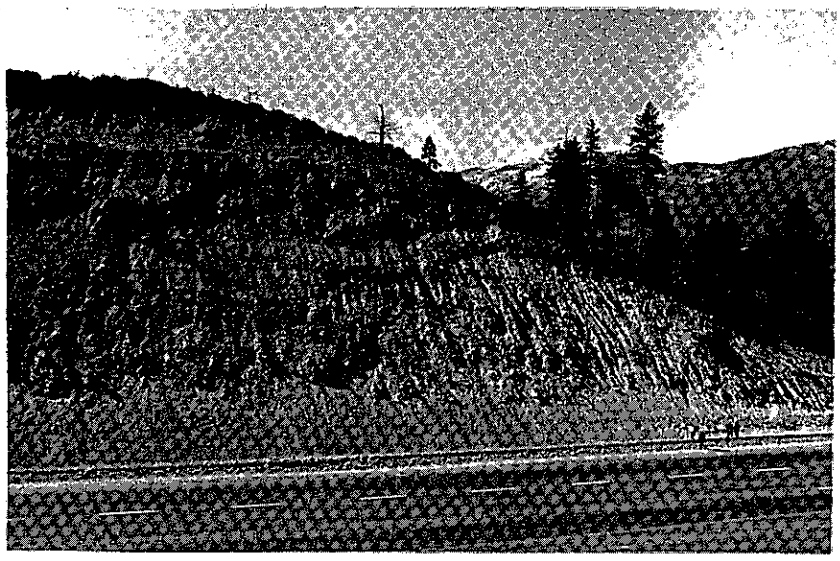
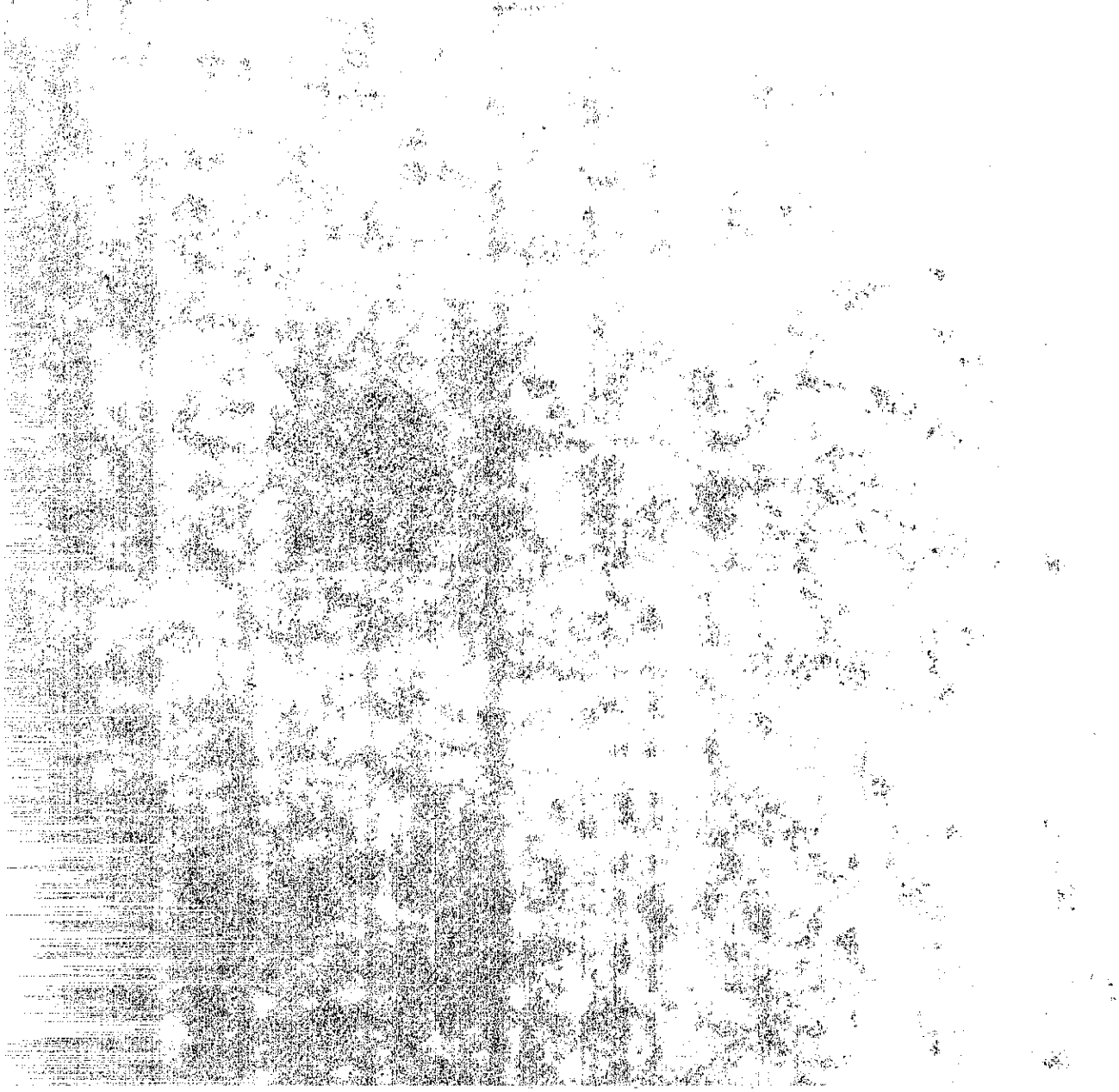


Plate 2 Weed after 1 winter



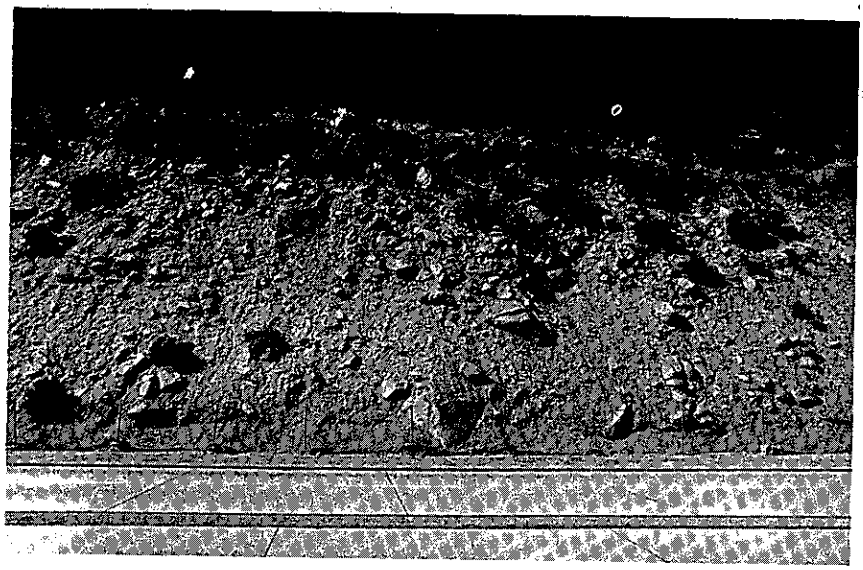
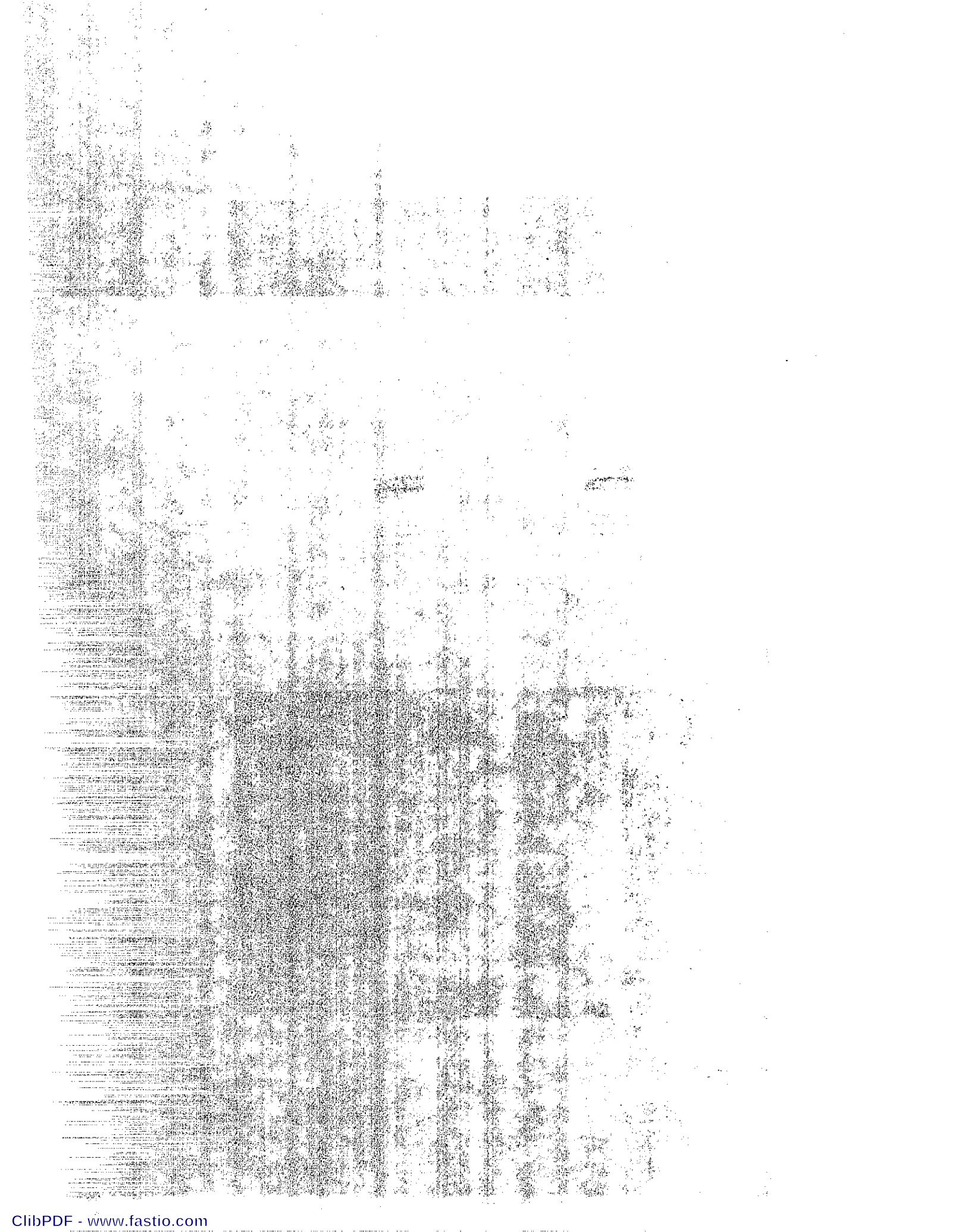


Plate 3 Farad after treatment

Plate 4 Farad after 1 winter



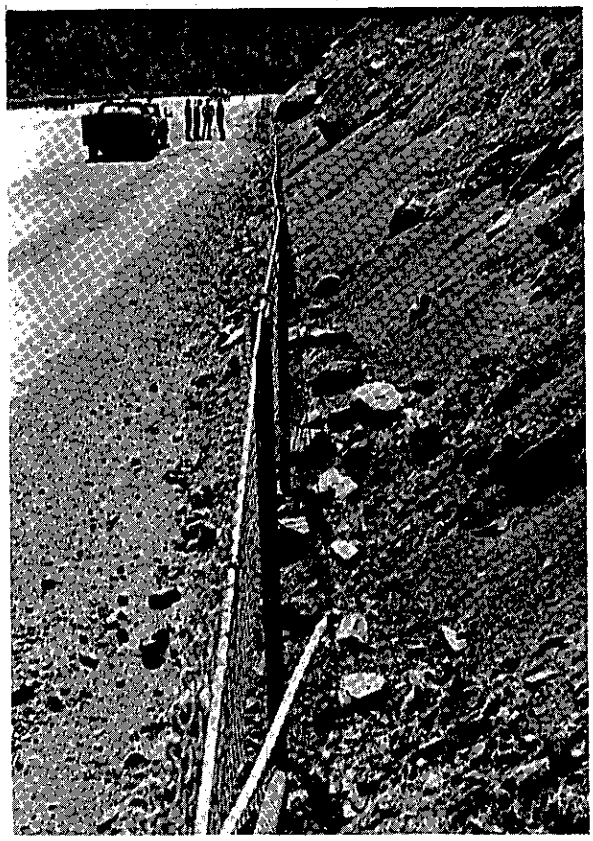
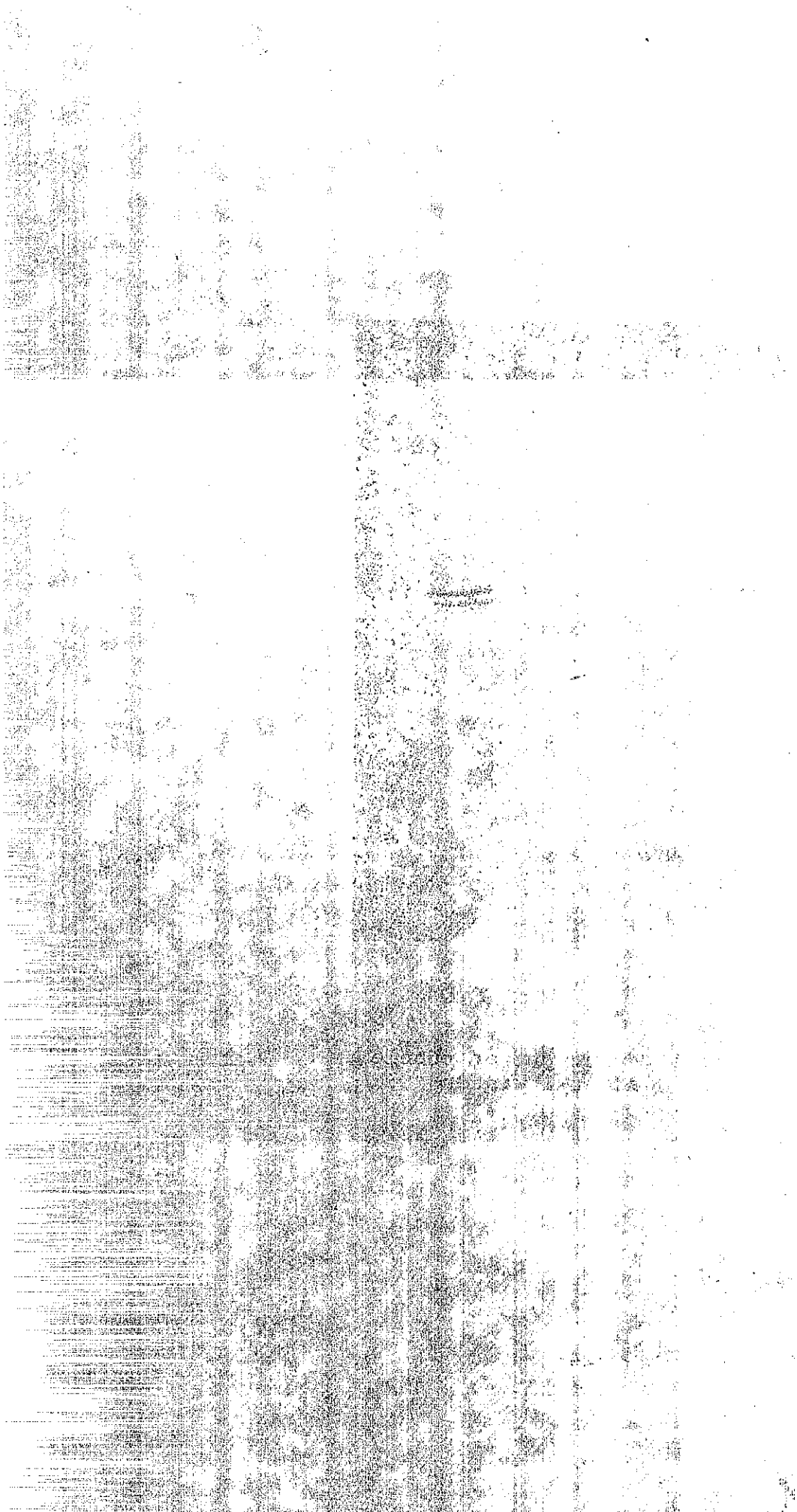


Plate 5 Farad gutter rubble after 1 winter



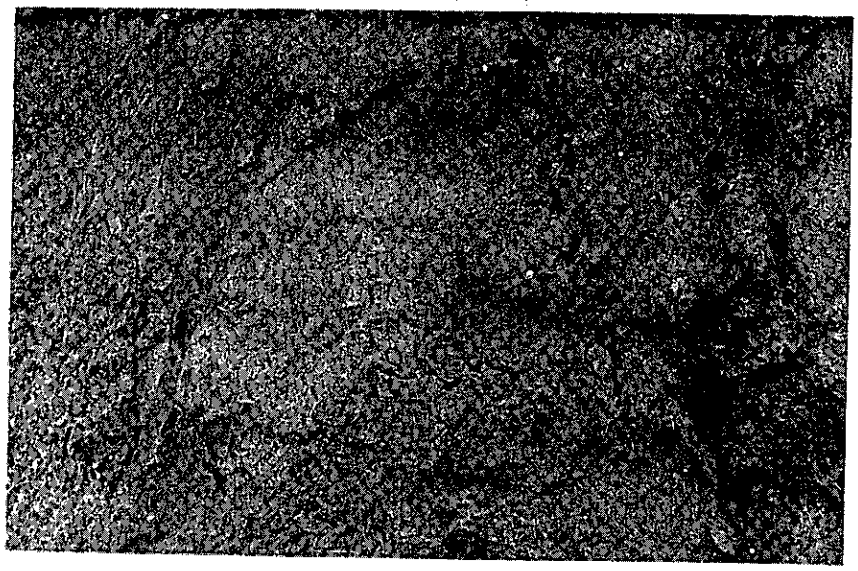


Plate 6 Buck Meadows after 1 winter

Plate 7 Buck Meadows after 1 winter

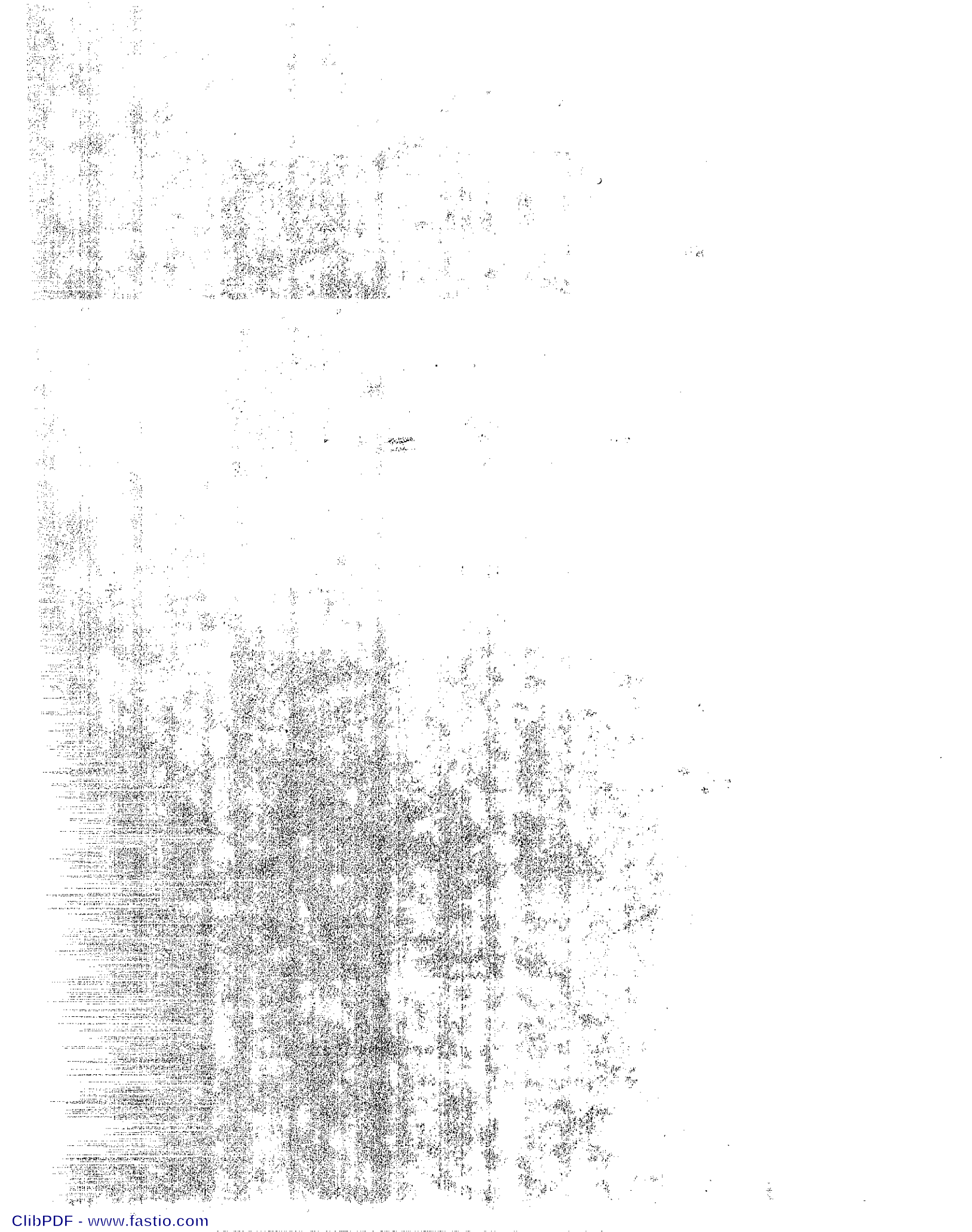


Plate 8 Vegetation in loose rills at Buck Meadows

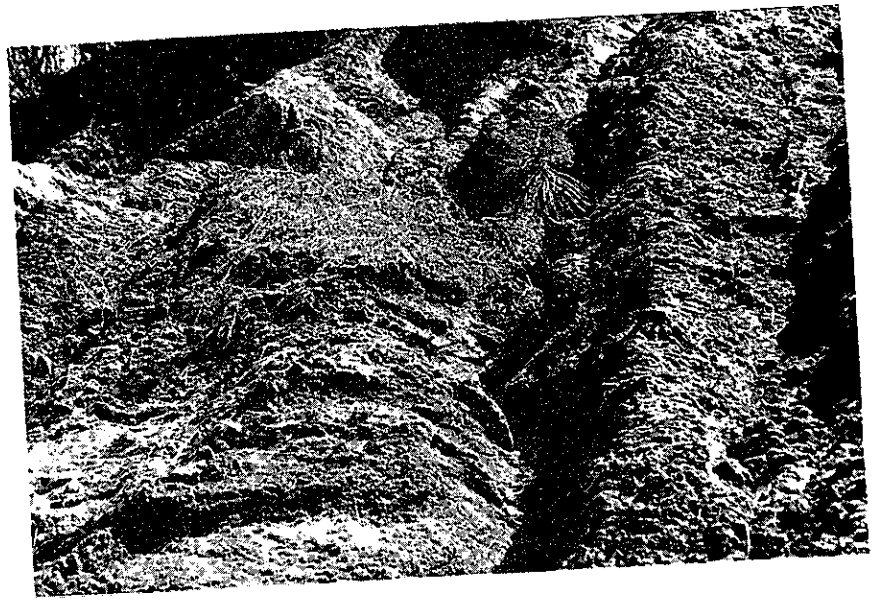
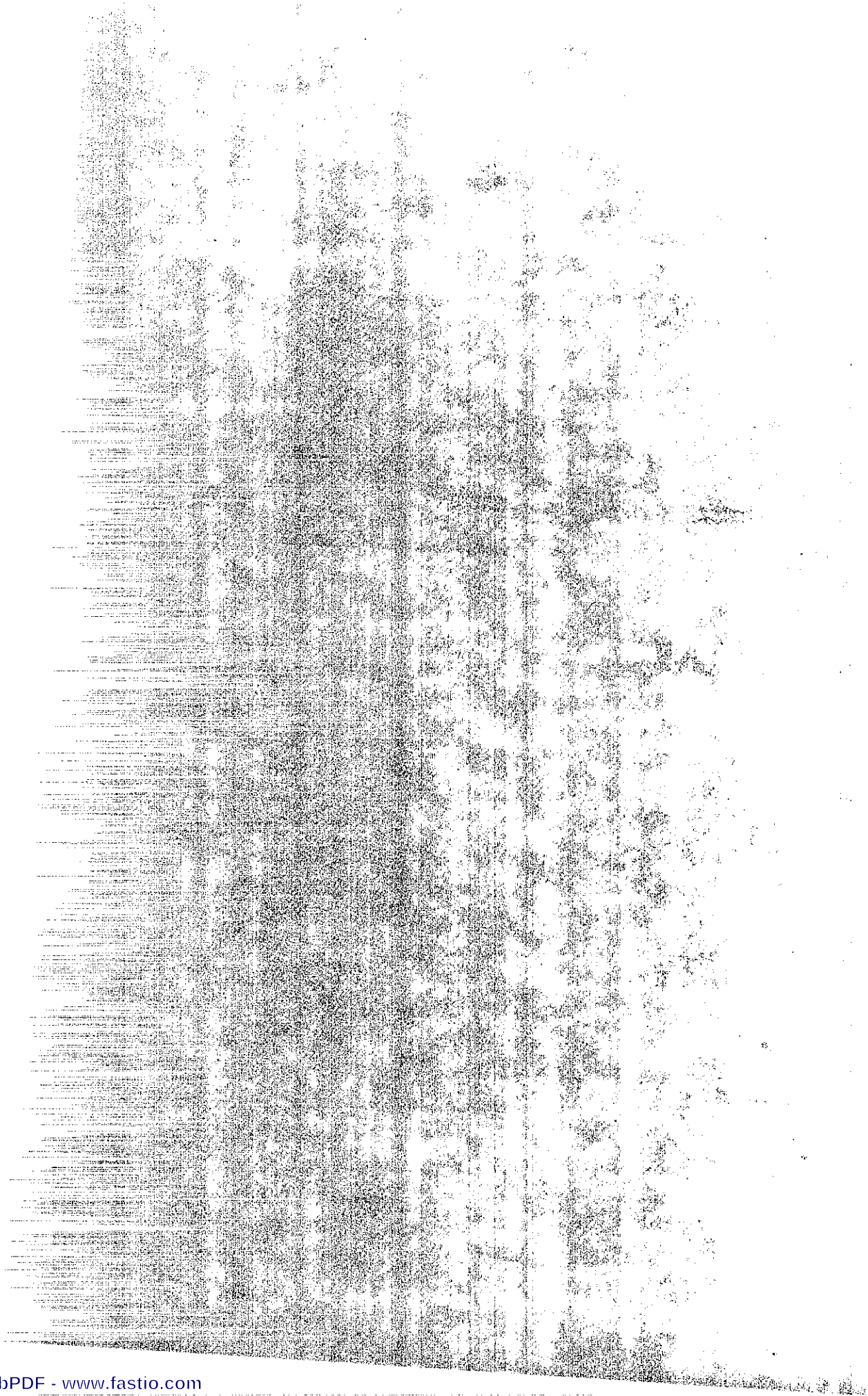


Plate 9 Vegetation in loose Landlock blanket



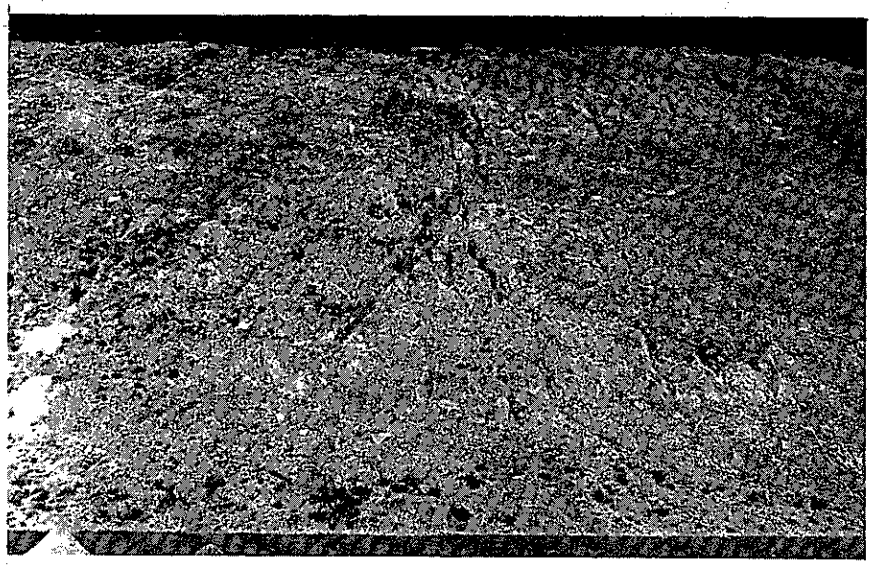


Plate 10 Mariposa after treatment with 120 gals/A

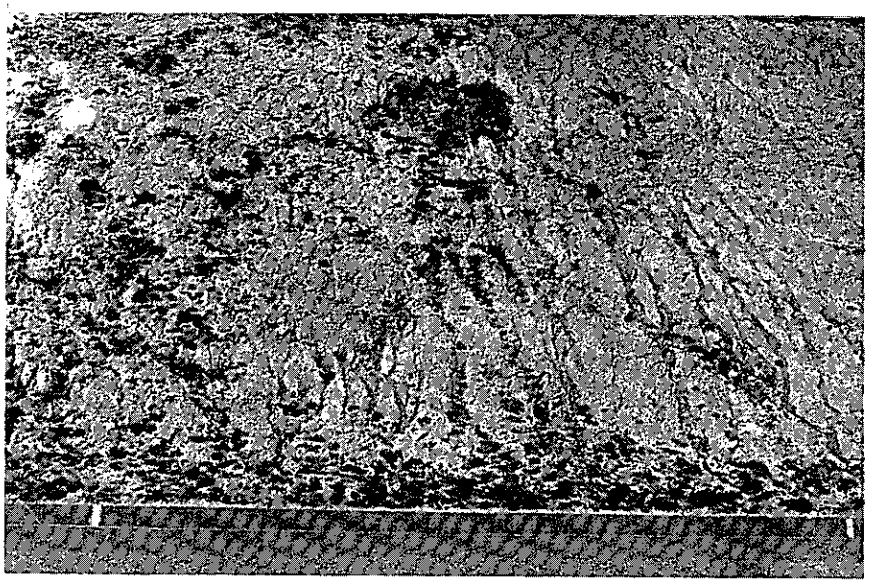


Plate 11 Vegetation increase after 1 year with with increased erosion rills from insufficient Landlock

Plate 12 Seeding prior to treatment

Plate 13 Increased Vegetation after 1 1/2 years

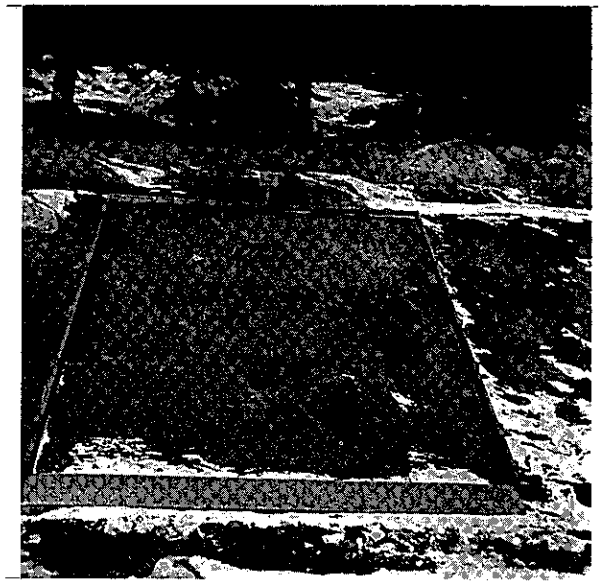


Plate 14 Landlock at Luther Pass with loose mound (dark spot) from rodents

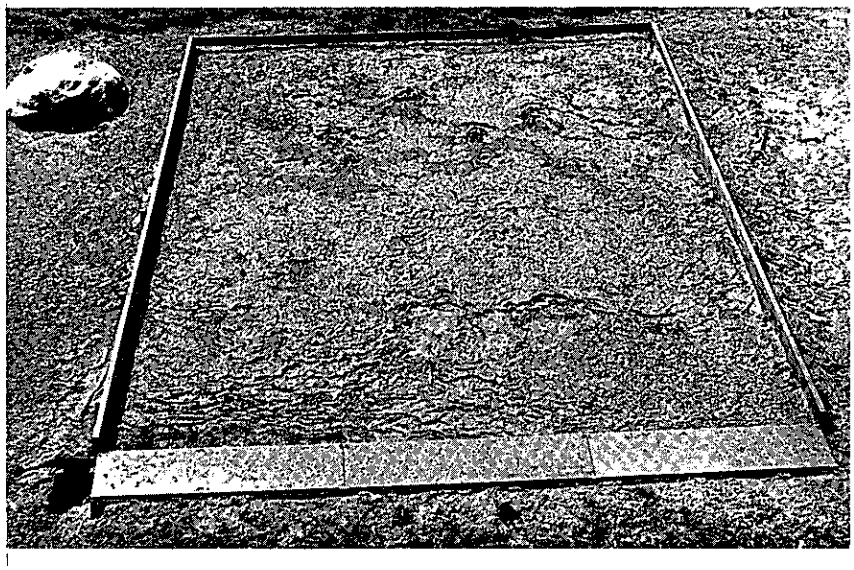
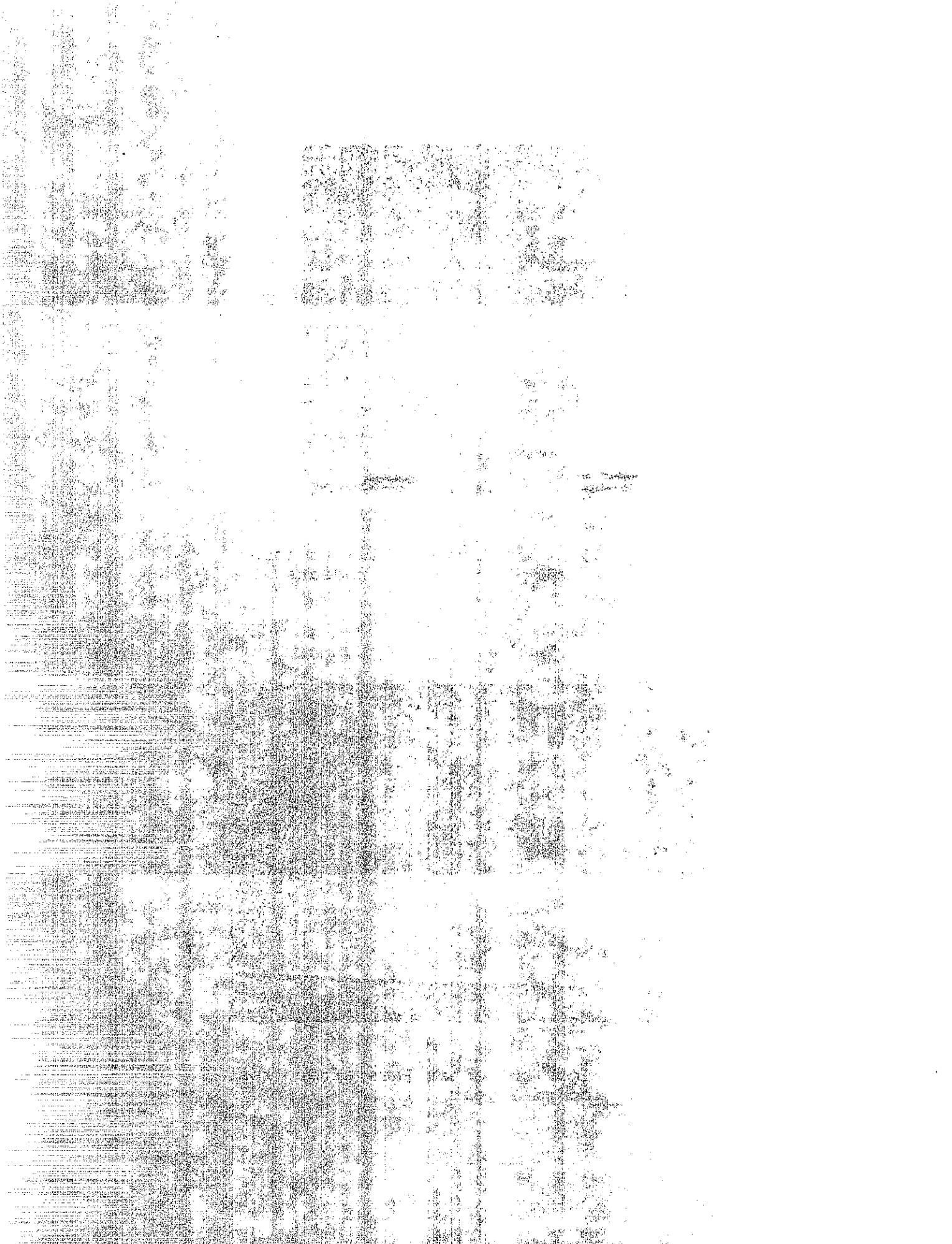


Plate 15 Landlock at Luther Pass after frost action of 1 year



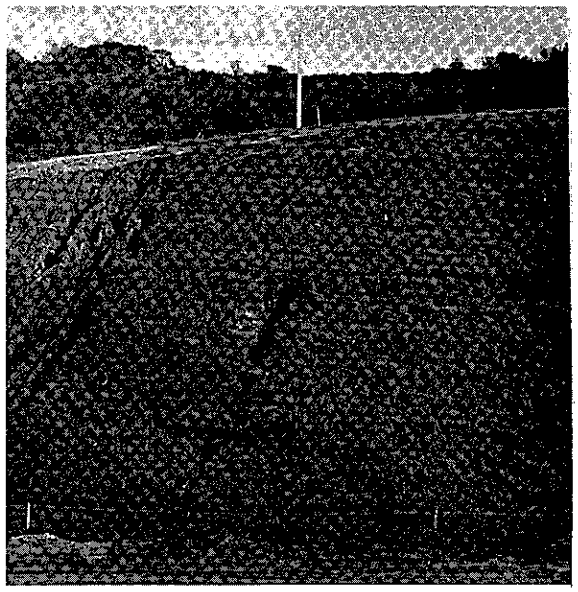
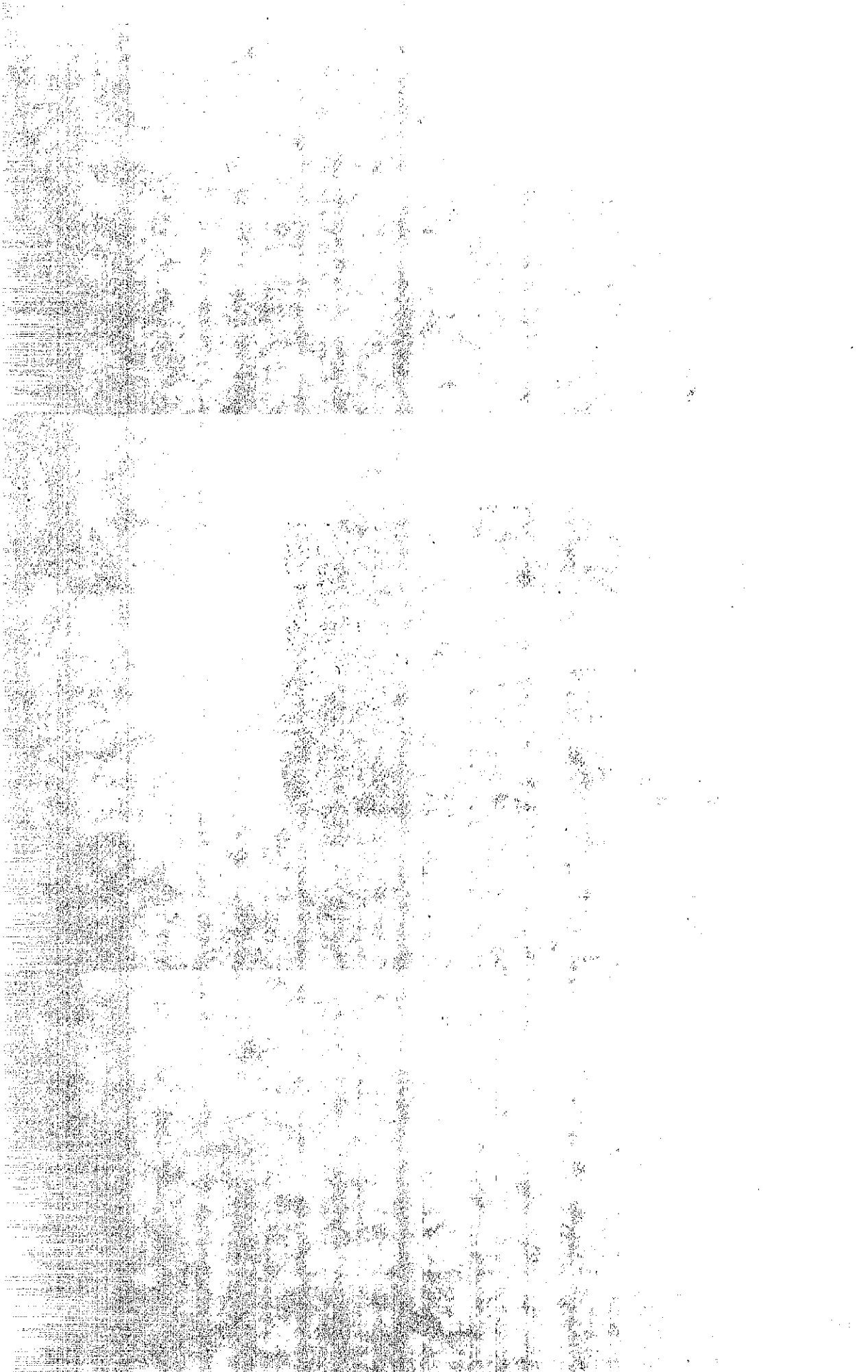


Plate 16 Landlock at 138 gals/A at Prunedale

Plate 17 Landlock at 112 gals/A at Prunedale

Plate 18 Untreated area at Prunedale



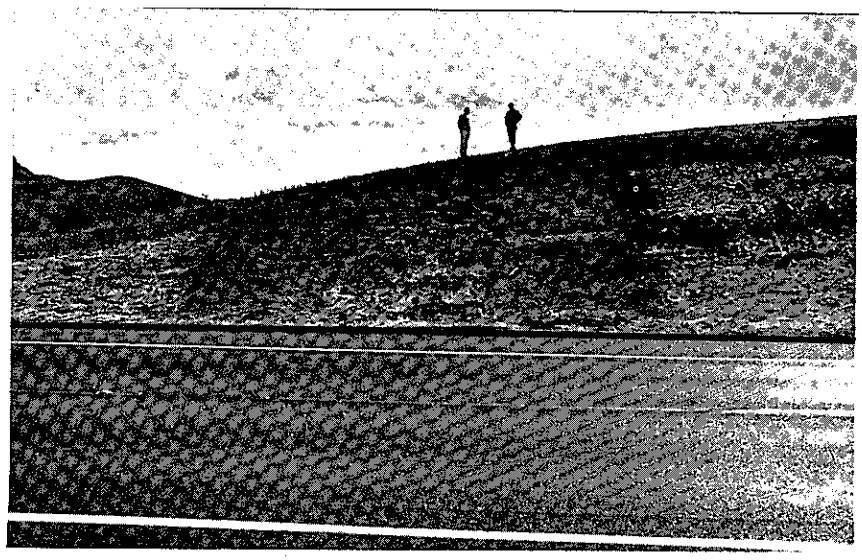


Plate 19 Buellton after 1 month (Landlock and fiber on the left 2/3 of the dark area)

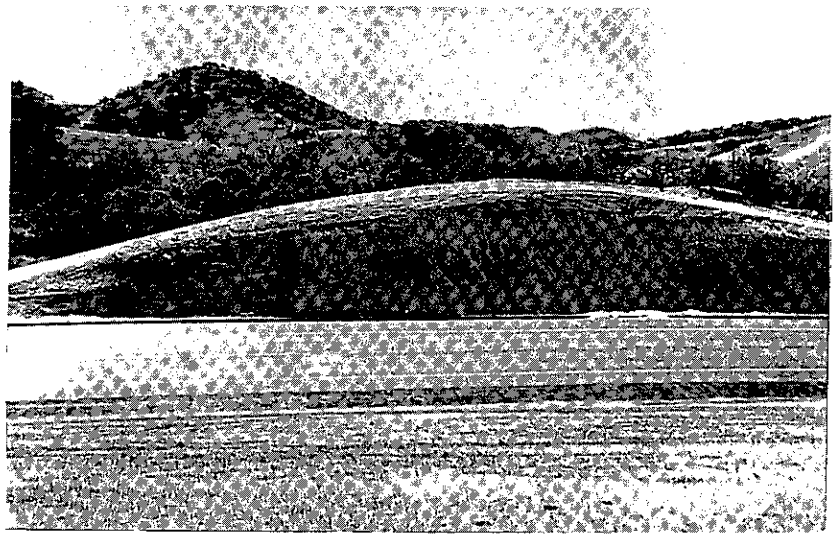


Plate 20 Buellton after 4 months

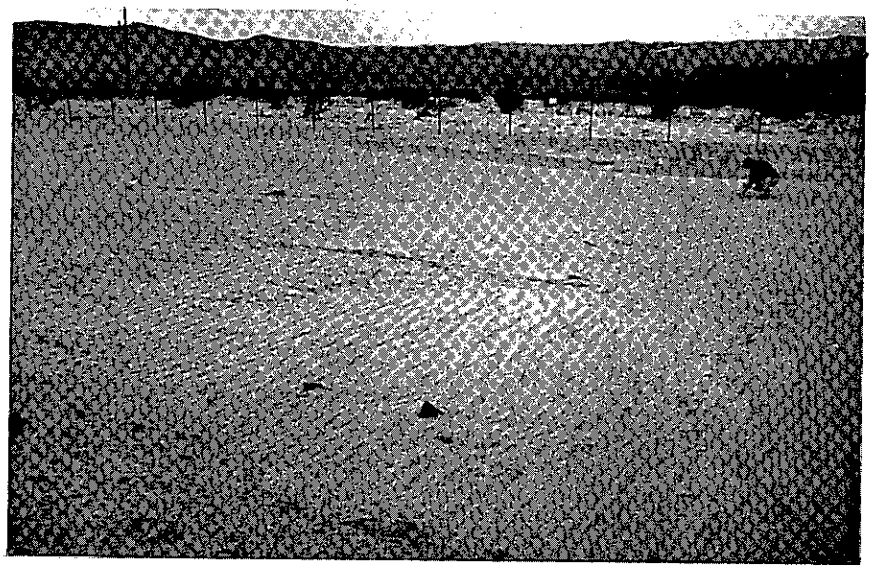


Plate 21 Landlock with deposited sand

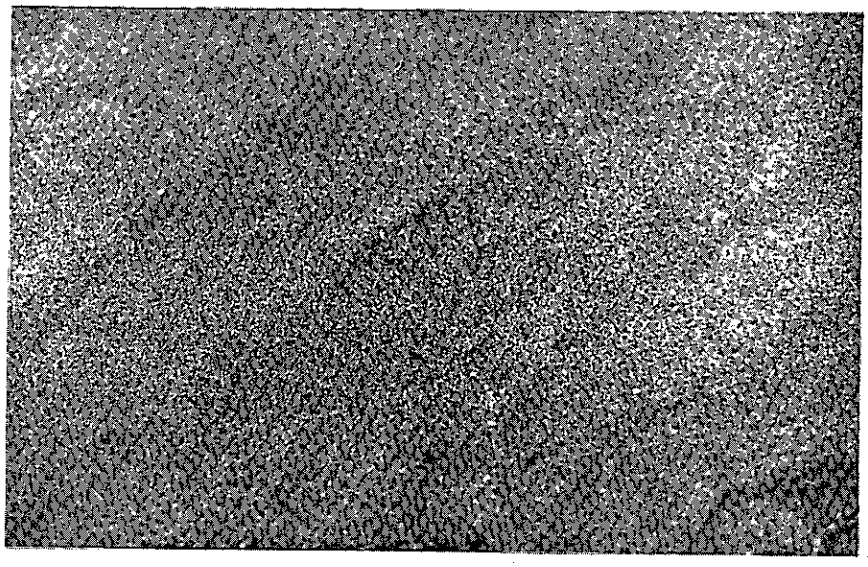
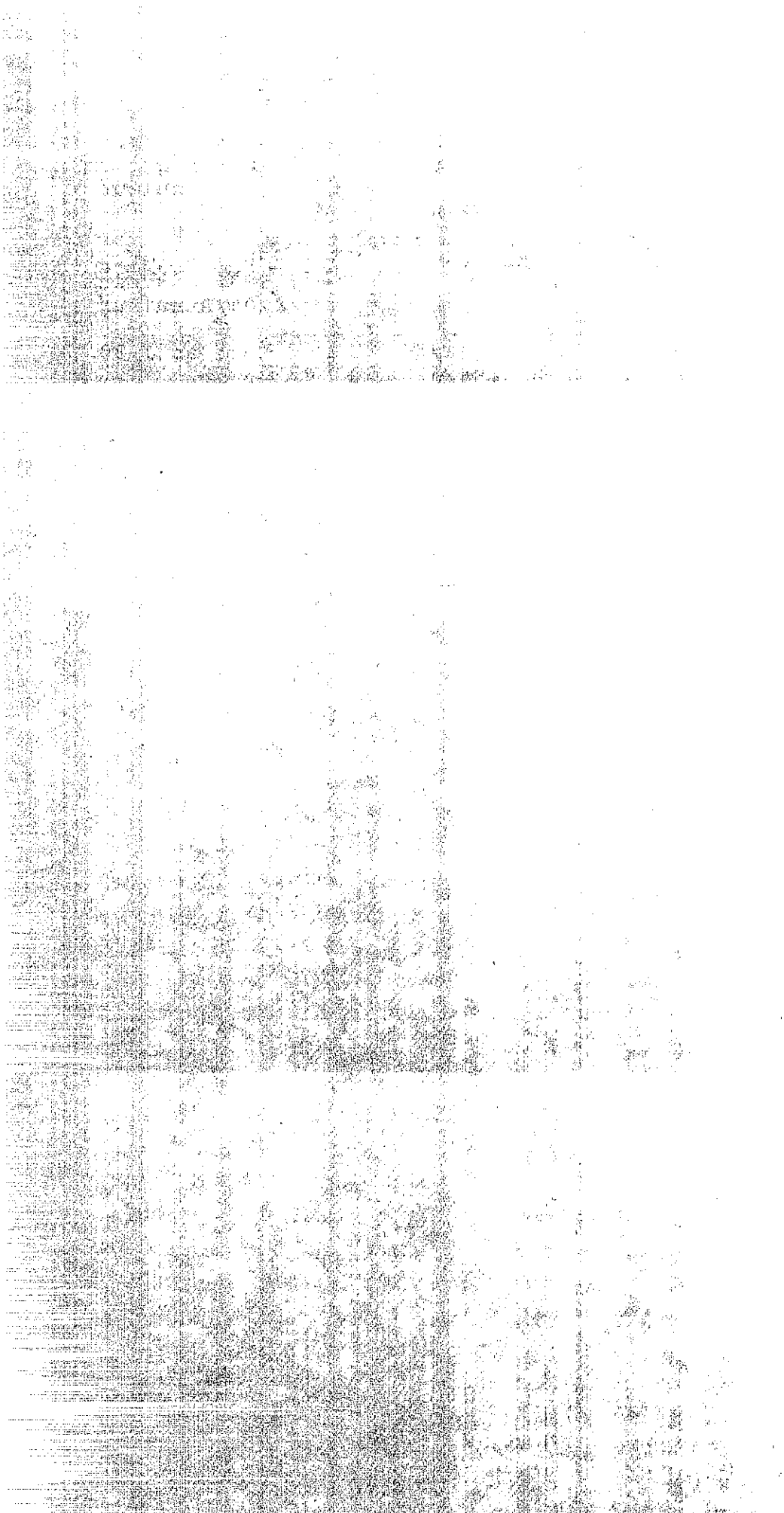


Plate 22 Intact footprint made in polymer 12/13/71

APPENDIX

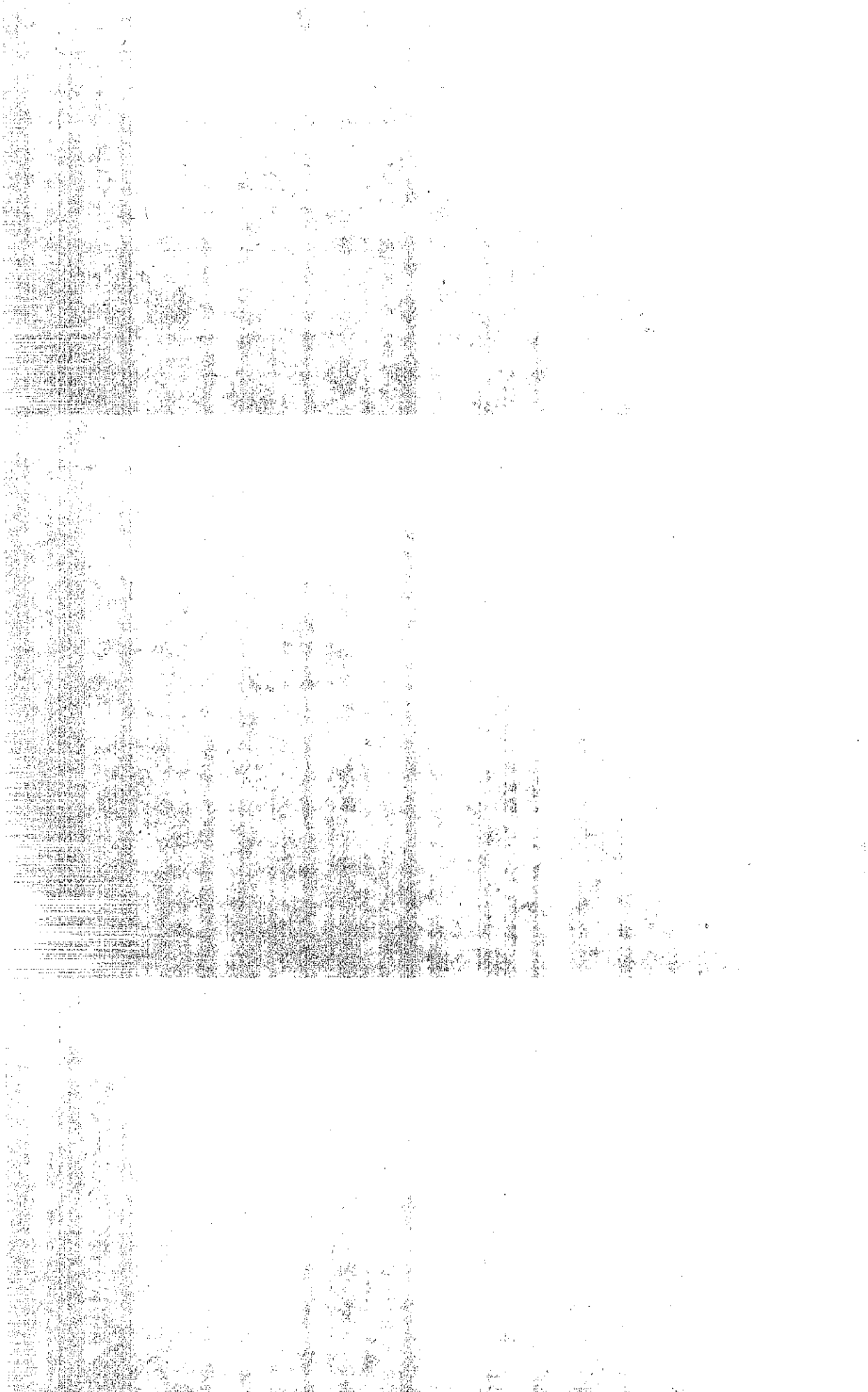
A

Job	Seed Mix	Nutrients
I-5 Siskiyou Co.	Topar wheat grass 10#/A Potomac wheat grass 5#/A Big bluegrass 5#/A Durar hard fescue 5#/A	500#/A fertilizer 100#/A gypsum 13#/A sulfur
I-80 Nevada Co.	Same as I-5 Siskiyou	300#/A fertilizer 100#/A gypsum 20#/A sulfur
Calif. 120 Tuolumne Co.	Topar wheat grass 10#/A Sodar wheat grass 5#/A Potomac orchard grass 5#/A Durar hard fescue 5#/A	Same as I-80
Calif. 89 El Dorado Co.	Same as Calif. 120 Tuolumne Co.	Same as I-80
U.S. 101 Monterey Co.	Blando brome grass 20#/A Lana vetch 15#/A Wilton rose clover 10#/A Crimson clover 5#/A	Same as I-80



APPENDIX

B



December 15, 1972

MEMO TO FILES:

FROM: R. Mearns

SUBJECT: Fort Ord Erosion Control Study

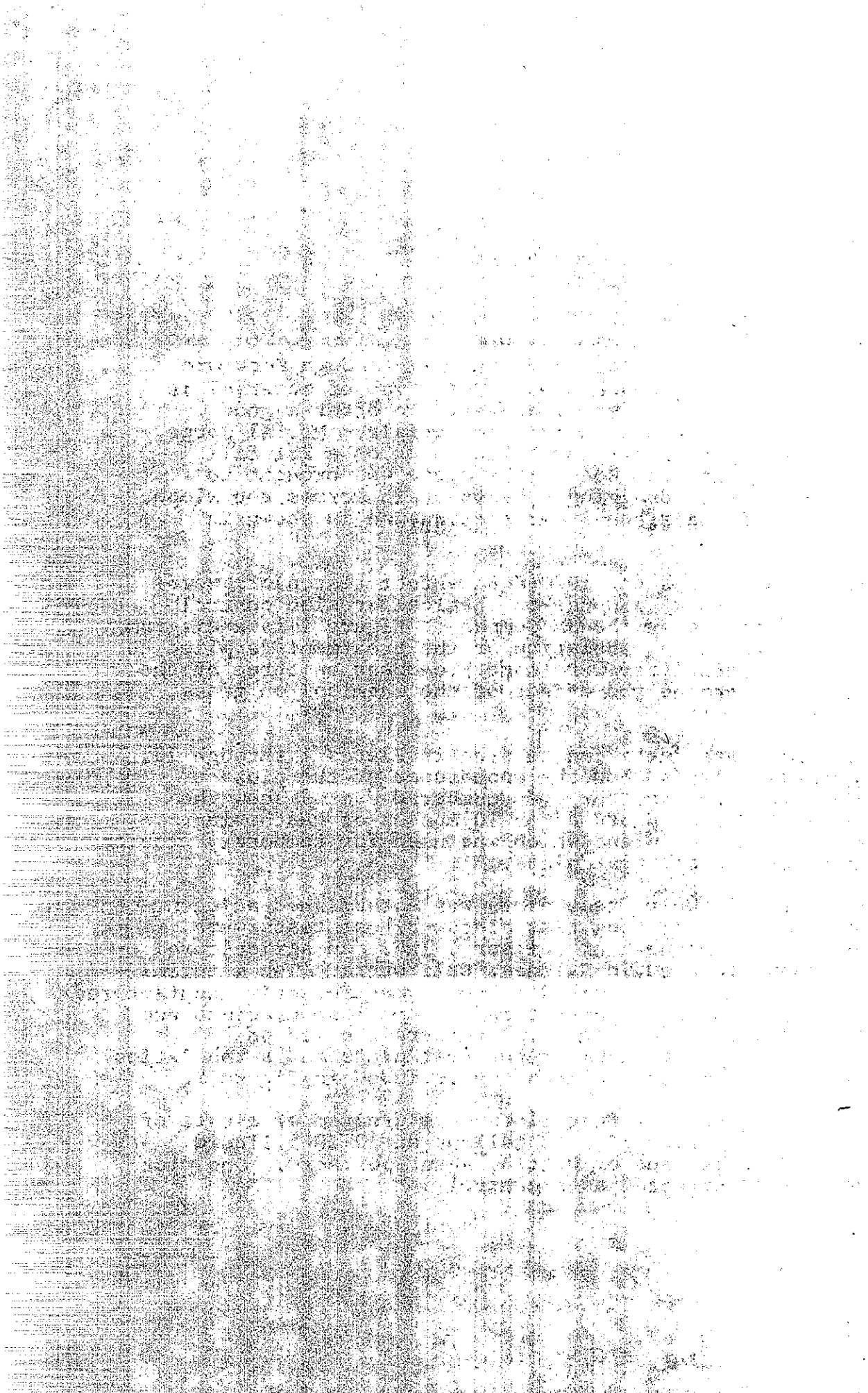
The construction of fills on Road 05-Mon-1 through Fort Ord was accomplished using beach sand. This type of material is frequently highly erosive so it appeared to offer a good opportunity to test erosion control materials. Mr. Al Jorge, Resident Engineer, arranged for a test area on a 2:1 fill slope adjacent to Non-Com Road. The slope was brought to grade and smoothed by dragging a heavy chain across the slope. The appearance of the slope after preparation is shown in Plate 1.

On December 15, 1971, seven 1000-square-foot test plots were treated with Land Lock, a spray-on chemical erosion control material manufactured by the 3M Company. Figure 1 is a diagram of the test plots and a tabulation of the treatments applied to each. Seed and fertilizer were hand broadcast on three of the test plots to determine the effect of the chemical on grass establishment.

The results of these tests can be seen in Plates 1 through 18. The odd numbered plates show the appearance of the plots at the time of treatment and the even numbered plates show the appearance of the same plots after 10 months of weathering. Plate 19 shows the ice plant which was used for temporary erosion control adjacent to the test plots.

A second series of twelve test plots was established adjacent to and east of the Land Lock test plots. These tests were established at the request of Soilserv, Inc., an agricultural chemical company located in Salinas, California. The material tested on these plots was DCA-70, a copolymer formerly manufactured by Union Carbide and now manufactured by American Cyanimid and marketed as Aerospray 70. These plots were treated on December 30, 1971. A diagram of the test plots and a tabulation of the treatments applied to each are included in Figure 2.

Soilserv reports that all test plots were treated at a rate of 1000 gallons of solution plus 50 gallons of 10-10-5 liquid fertilizer and 10 gallons of wetting agent per acre. One plot, No. 11, was left untreated as a control.



The appearance of these test plots after one season is shown in Plates 20 through 32. No photos were taken at the time of treatment because we were not aware of the application.

The results of these studies were not conclusive because of only limited rainfall during the test period. The only serious erosion occurred in Plot 11 of the DCA-70 study. This erosion was caused by the channelization of runoff water from the street.

All of the test plots were damaged to some extent by truck, motorcycle, bicycle and foot traffic. However, in spite of the damage, traces of the protective film were still detectable on all of the treated test plots of both materials.

The grass seed germinated only in local spots and very sparsely. Plot 1A, 3 and 5 in Land Lock appeared to be about the same suggesting that the Land Lock neither helped or hindered the germination. The seeded DCA-70 test plots were seeded more heavily than the Land Lock test plots and did exhibit better germination, but they still lacked good coverage. The grass in all test plots grew about 2 to 3 inches then died.

As can be seen in the Plates, native plants and volunteer ice plants have established themselves in the Land Lock test plots and in the untreated DCA-70 test plot. This didn't happen in any of the DCA-70 treated test plots. DCA-70 apparently inhibited establishment of native vegetation.

This project is being terminated at this time because of extensive damage due to channelized runoff from the street and the disturbance cause by correction of the damage. The current Resident Engineer, Mr. Frank Avila, would like to plant ice plant throughout the area when he next has the ice planting crew on the job.

FIGURE 1

Land Lock Installation

Non-Com Road

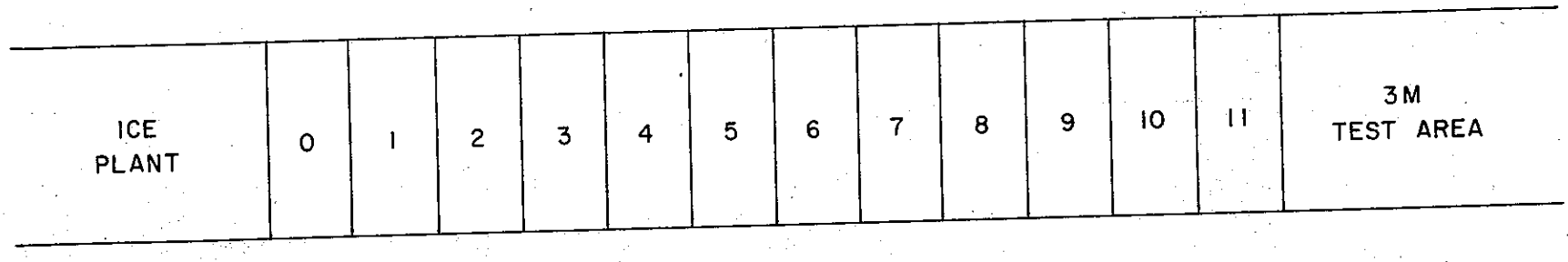
DCA-70 TEST AREA	7	6	5	4	3	2	1	1A	ICE PLANT

Plot	# of Solids per 1000 ft^2	Dilution
1A*	0	
1	10	10:1
2	15	10:1
3*	30	10:1
4	15	10:1**
5*	30	10:1**
6	15	15:1
7	30	15:1

*Seeded with 1½ lbs. of perennial rye and fertilized with 12 lbs. of ammonium nitrate.
**Surfactant added to the chemical to act as a wetting agent.

FIGURE 2

DCA-70 Installation



Plot	# Solids/1000 ft^2	Dilution
0*	15.91	7:1
1*	15.91	7:1
2*	15.91	7:1
3*	15.91	7:1
4**	15.91	7:1
5	15.91	7:1
6**	7.51	16:1
7	7.51	16:1
8**	7.51	16:1
9	7.51	16:1
10**	7.51	16:1
11	no treatment	

*Seeded with 3# of perennial rye.
**Seeds were raked into the soil.

Plate 1 3M Test Area 12-15-71

Plate 2 3M Test Area 9-10-72

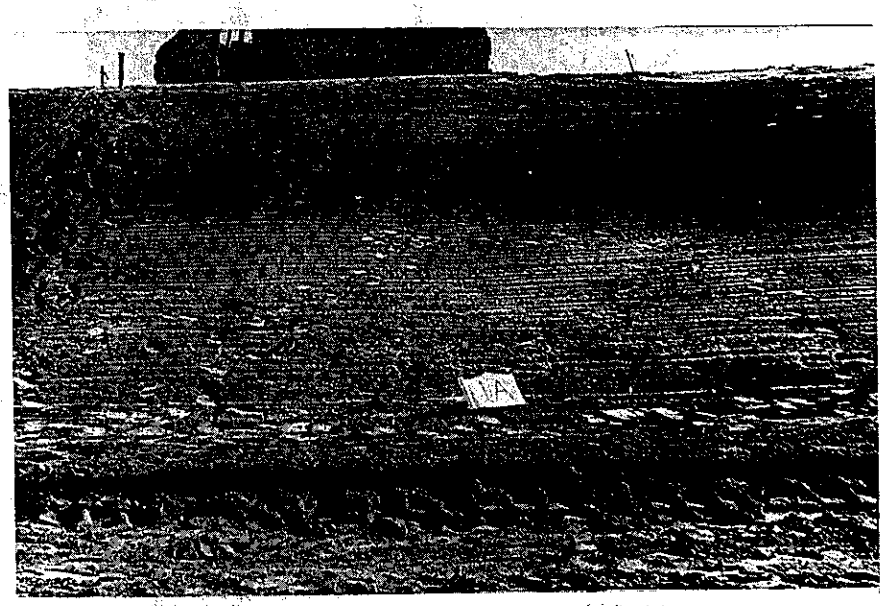


Plate 3 3M Test 12-15-71

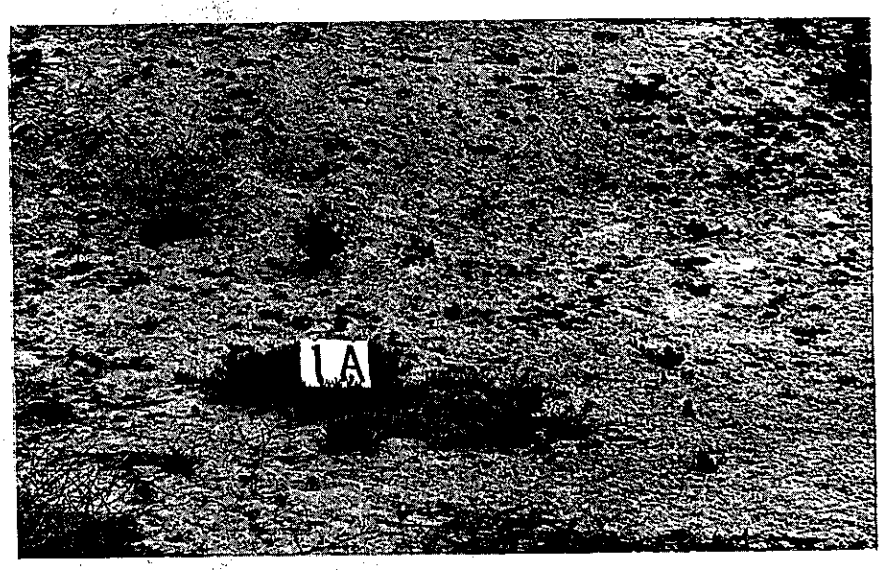


Plate 4 3M Test 9-10-72

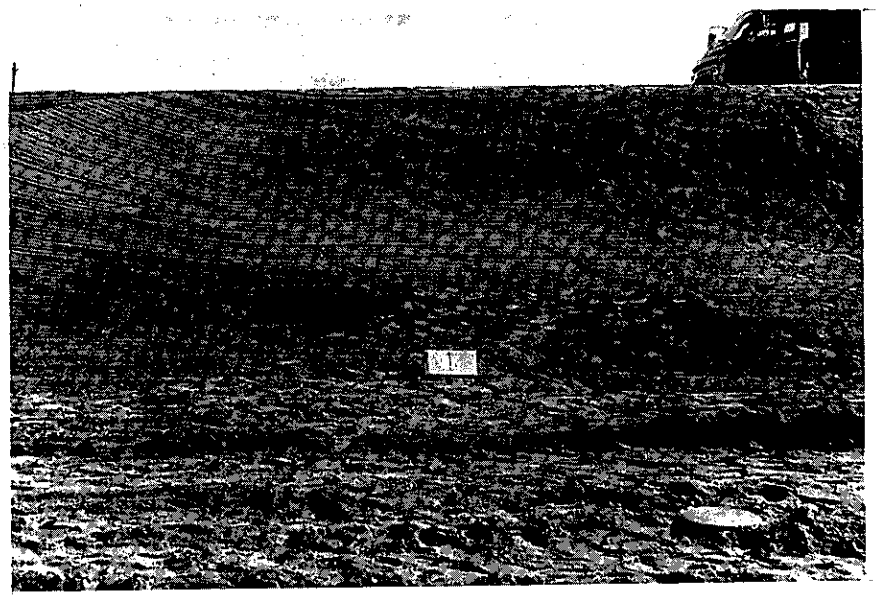


Plate 5 3M Test 12-15-71

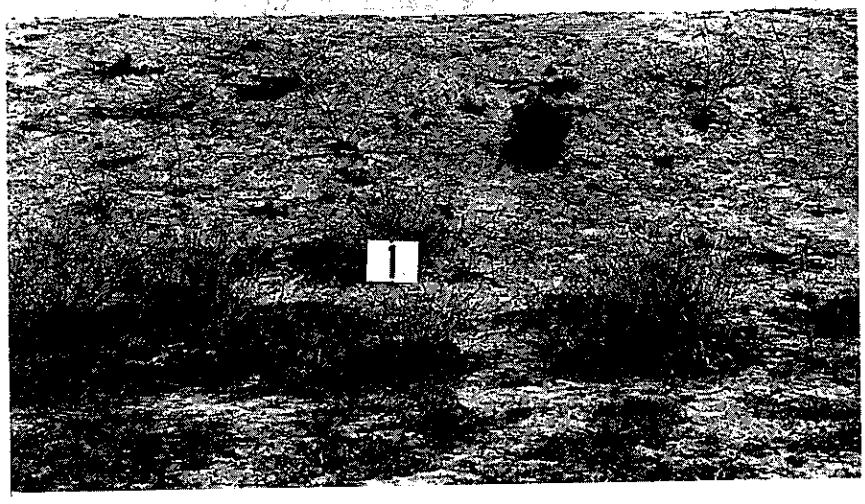


Plate 6 3M Test 9-10-72

Plate 7 3M Test 12-15-71

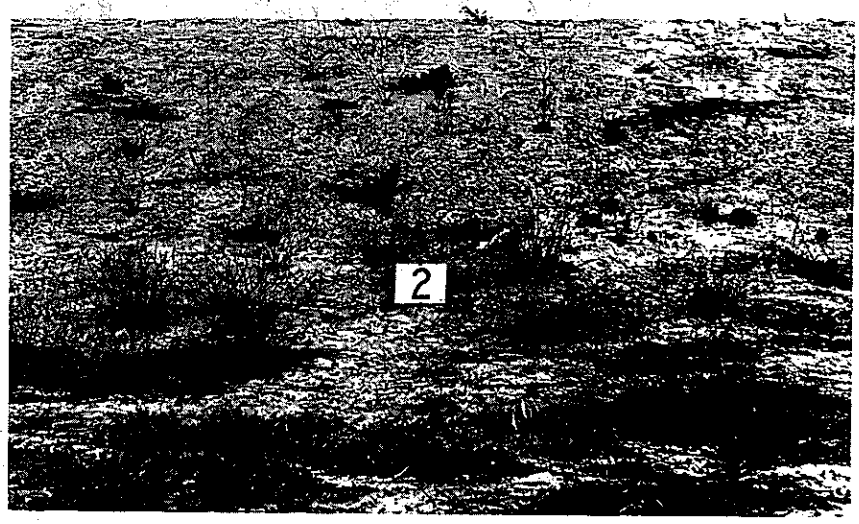


Plate 8 3M Test 9-10-72

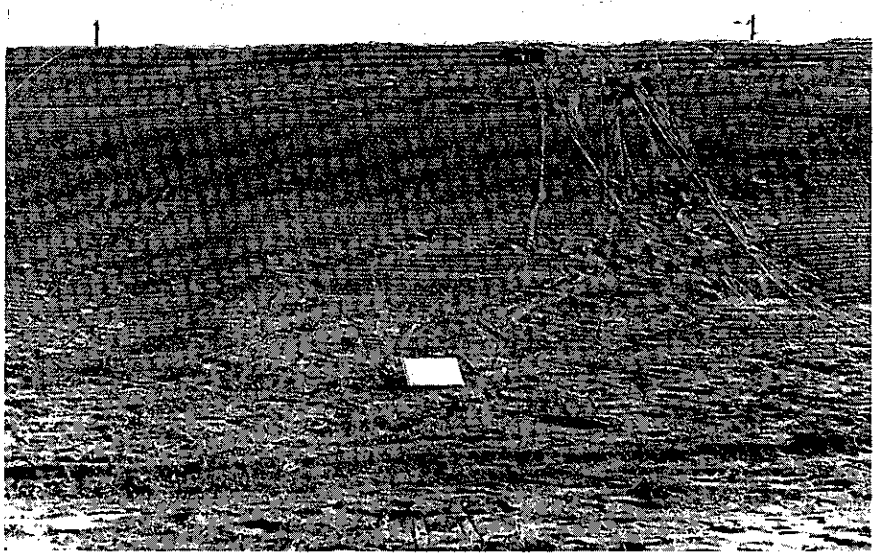


Plate 9 3M Test 12-15-71

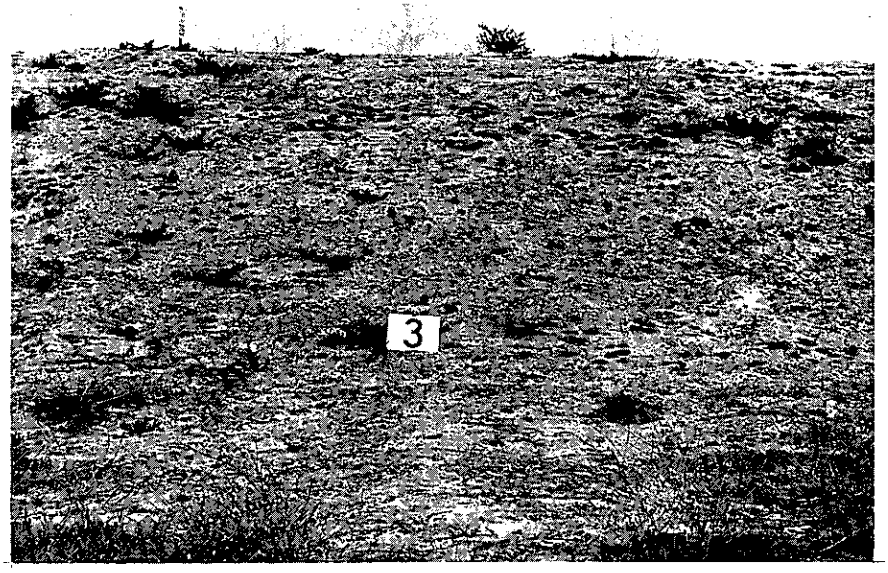


Plate 10 3M Test 9-10-72

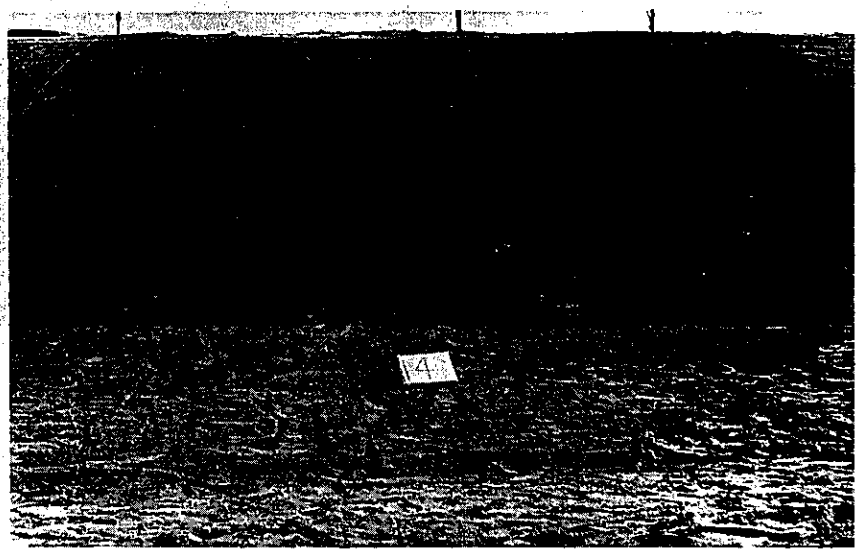
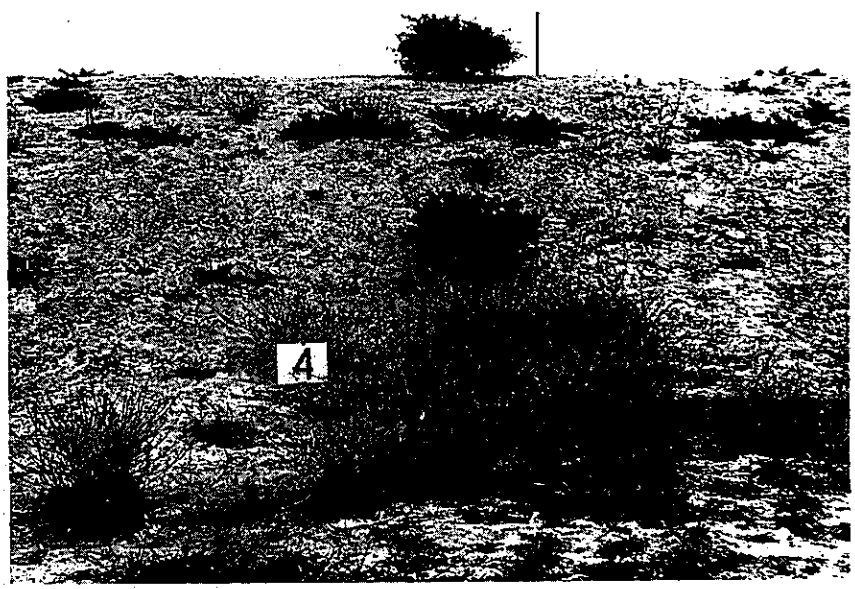


Plate 11 3M Test 12-15-71



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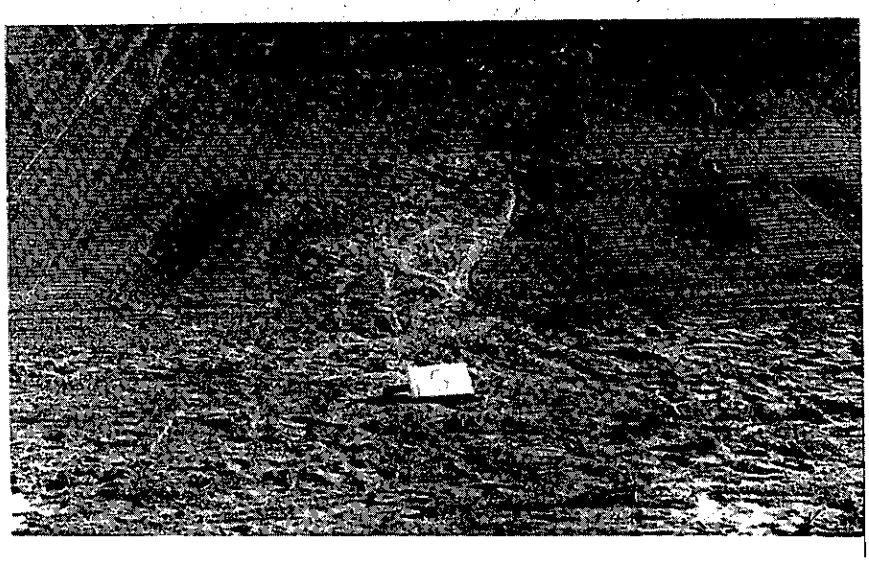


Plate 13 3M Test 12-15-71

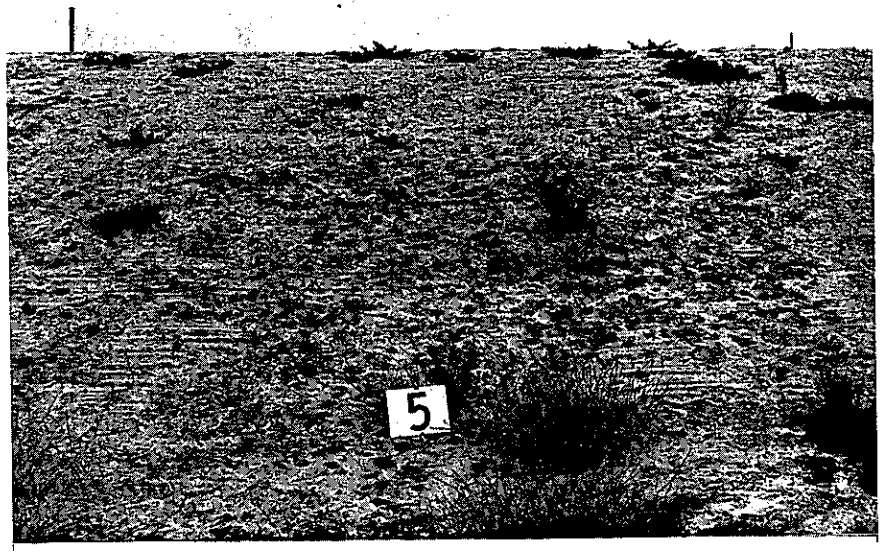


Plate 14 3M Test 9-10-72

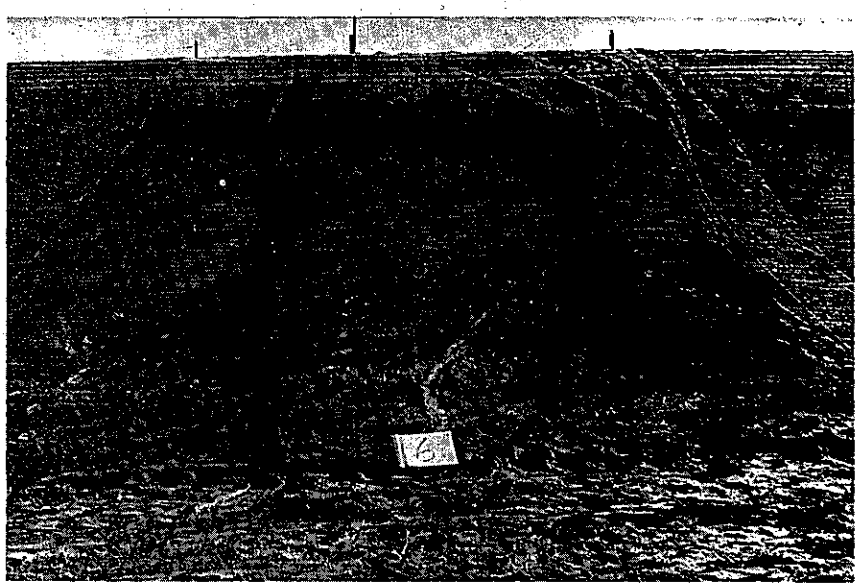


Plate 15 3M Test 12-15-71

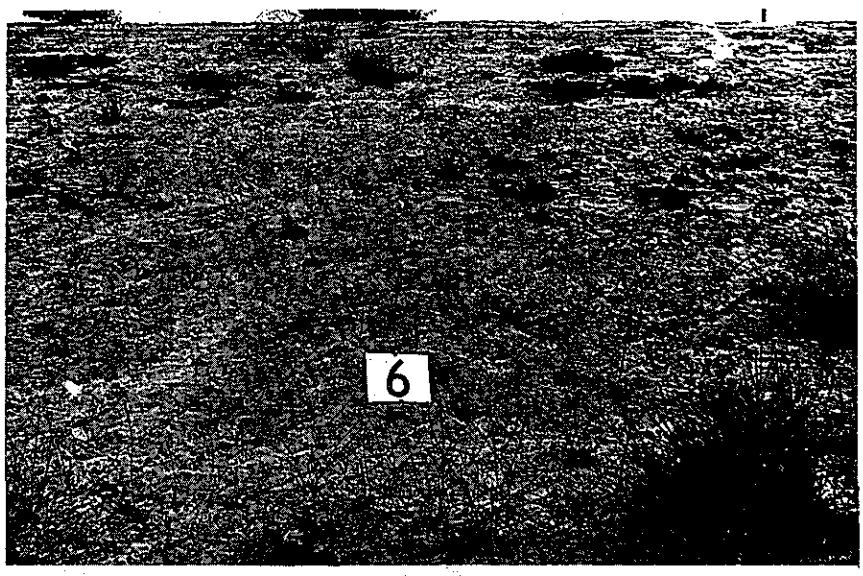


Plate 16\ 3M Test 9-10-72

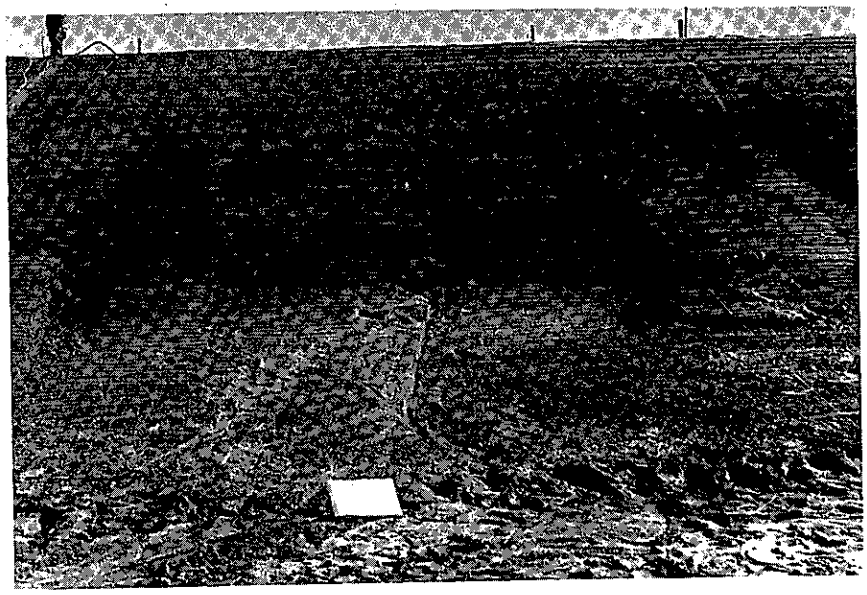


Plate 17 3M Test 12-15-71

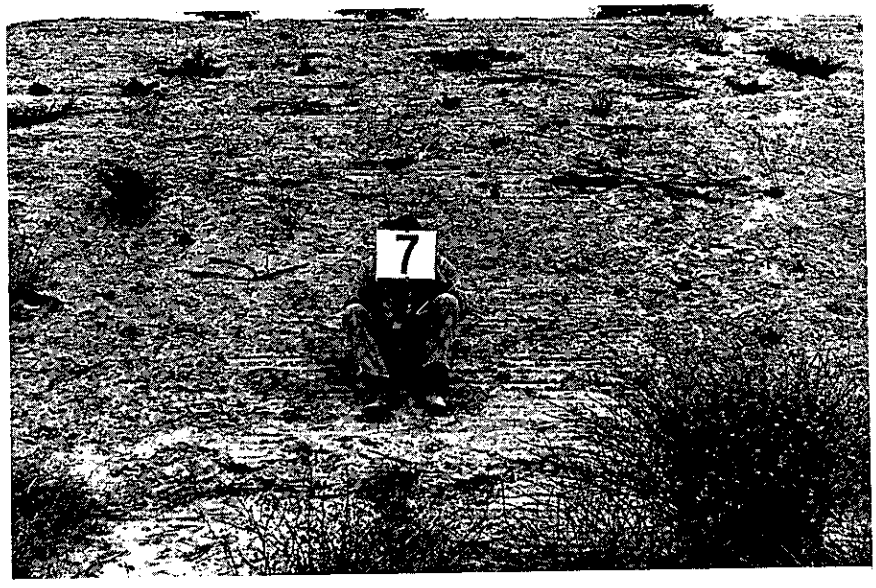
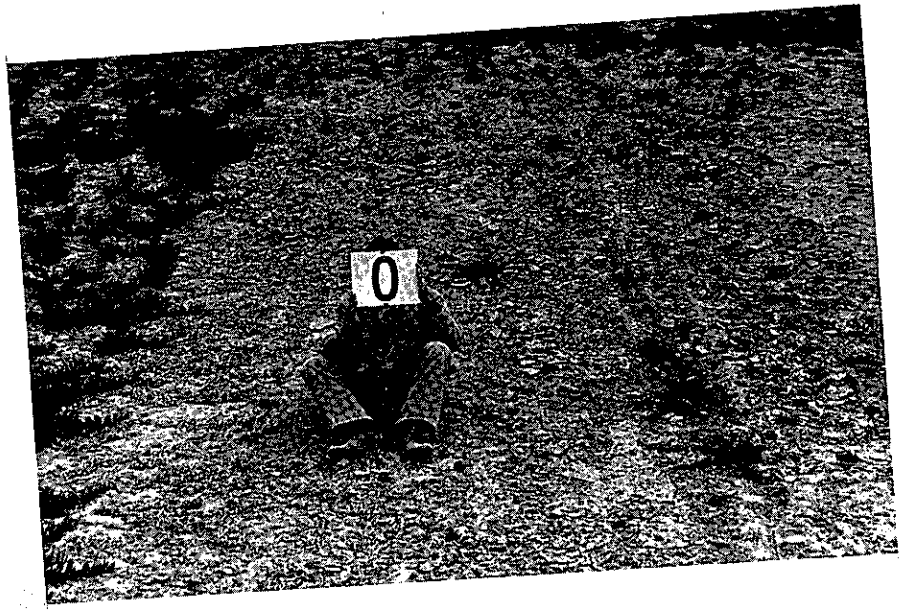


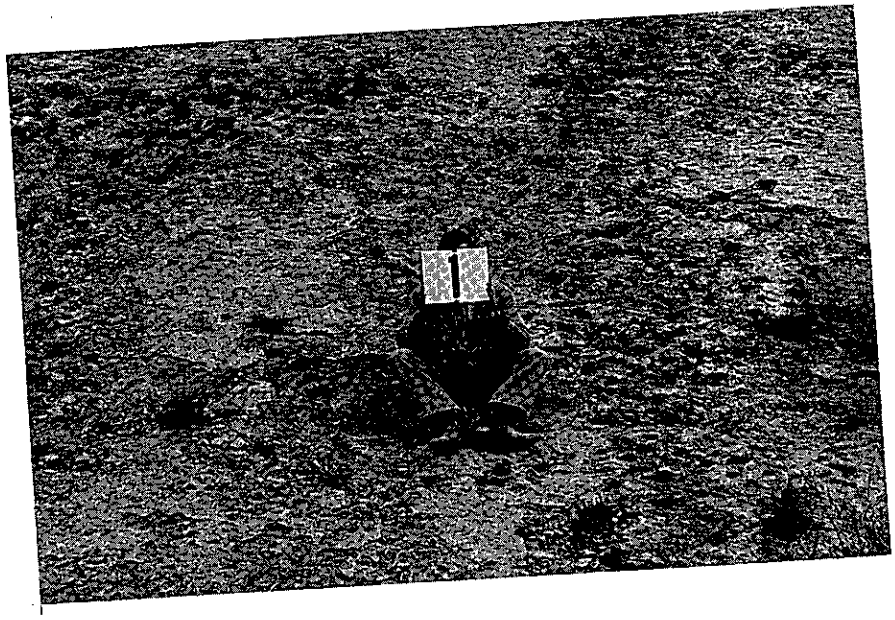
Plate 18 3M Test 9-10-72

Plate 19 - Ice Plant Erosion Control

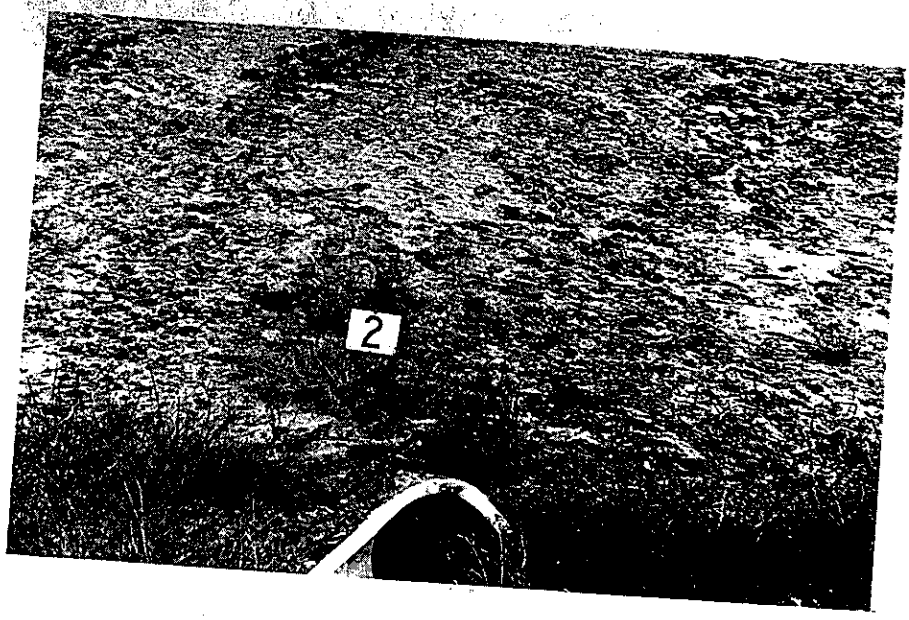
Plate 20 - DCE-70 Test Area after treatment



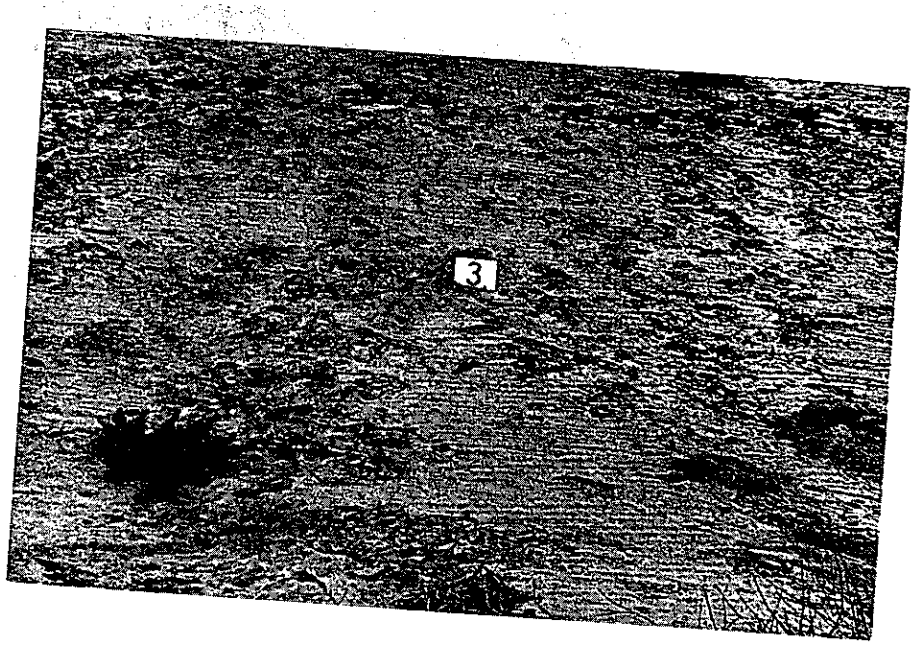
#21
9-10-72 DCA-70 with some dead grass at top



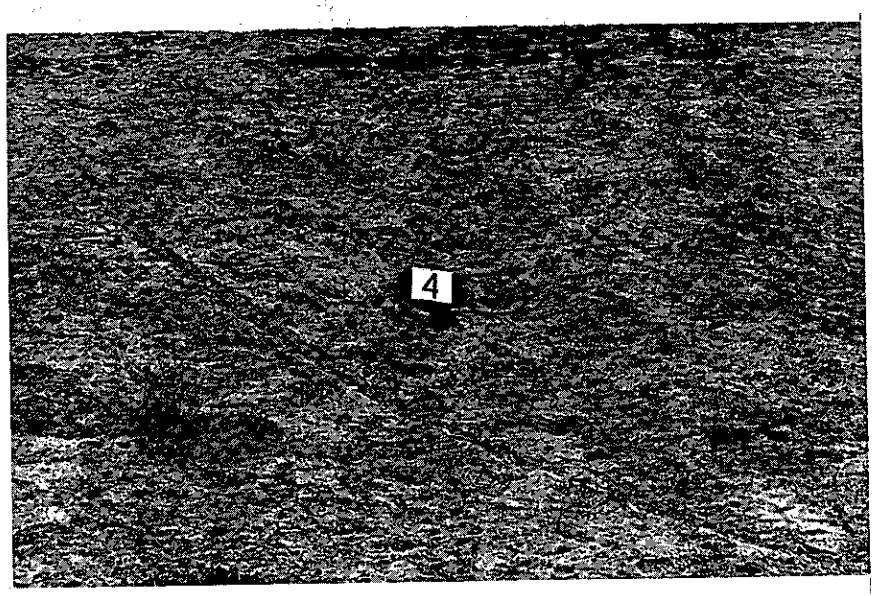
#22
9-10-72 DCA-70 Some grass
Note footprints from lower right to top center



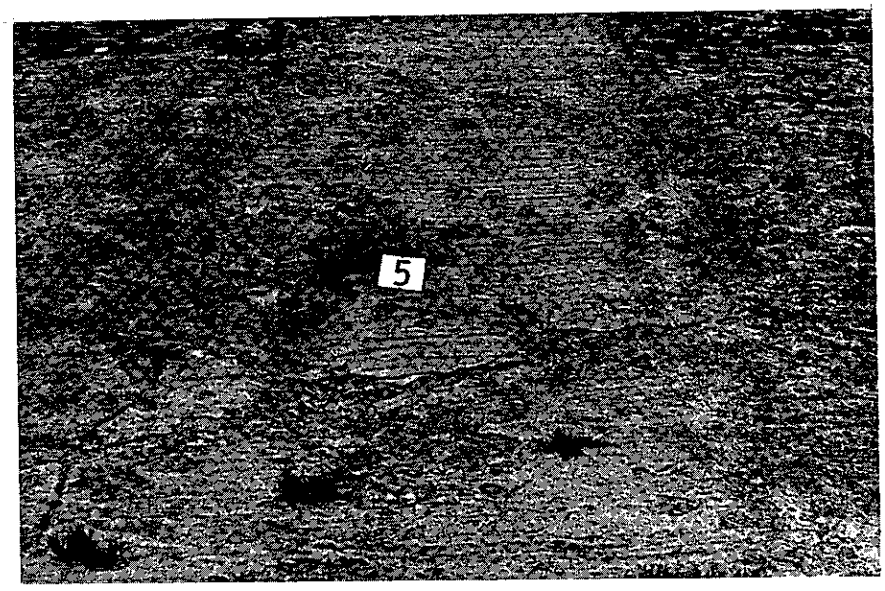
#23
9-10-72 Note native vegetation below treated area



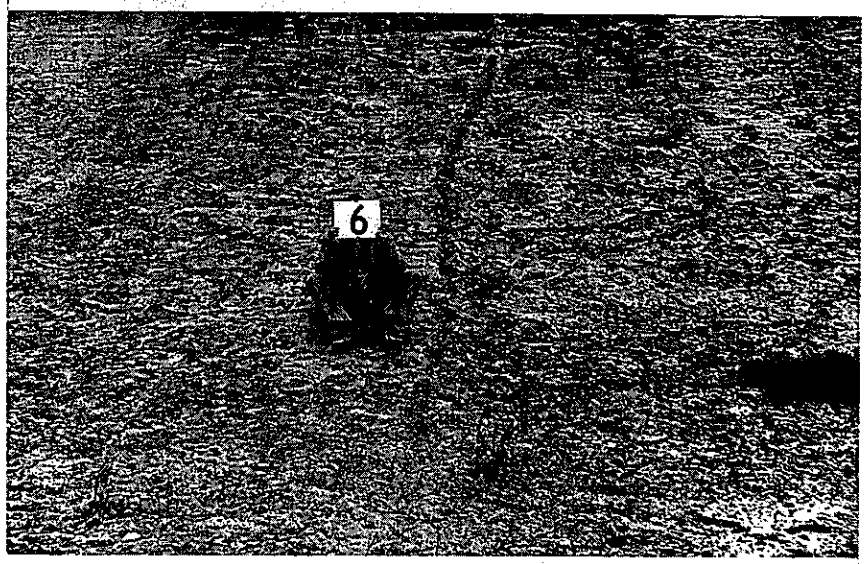
#24
9-10-72 One native plant lower left is within treated area, also gopher holes near numeral



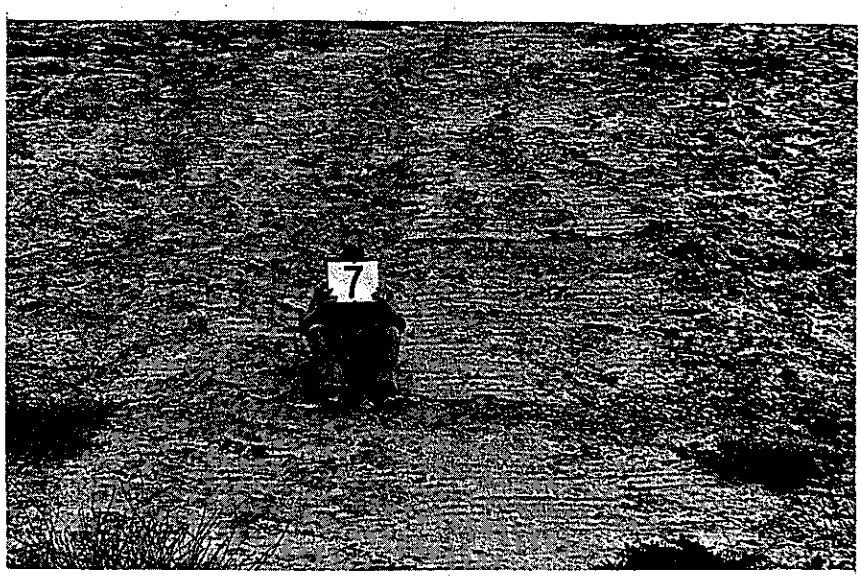
#25
9-10-72 Some grass near the top, one bike track from lower right to upper left and one gopher mound



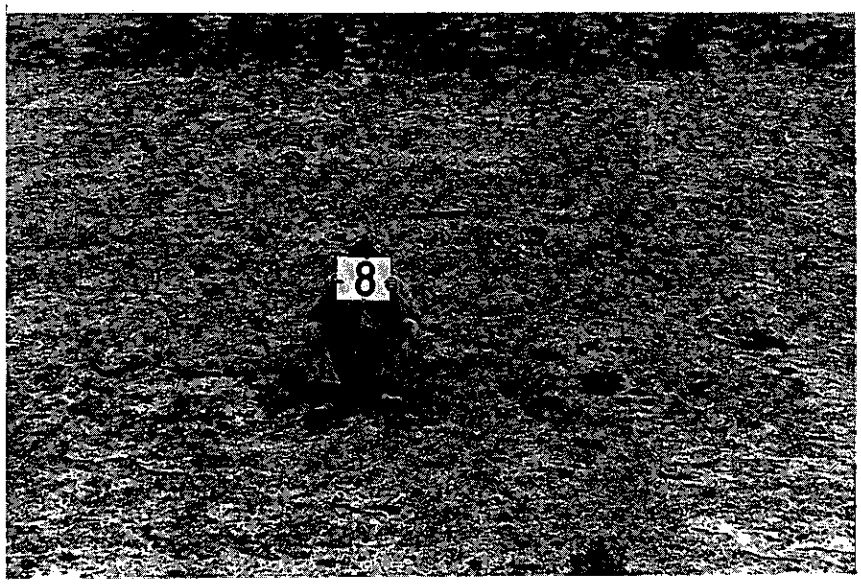
#26
9-10-72 One bike track from lower left to upper left center. Some native intrusion in broken areas



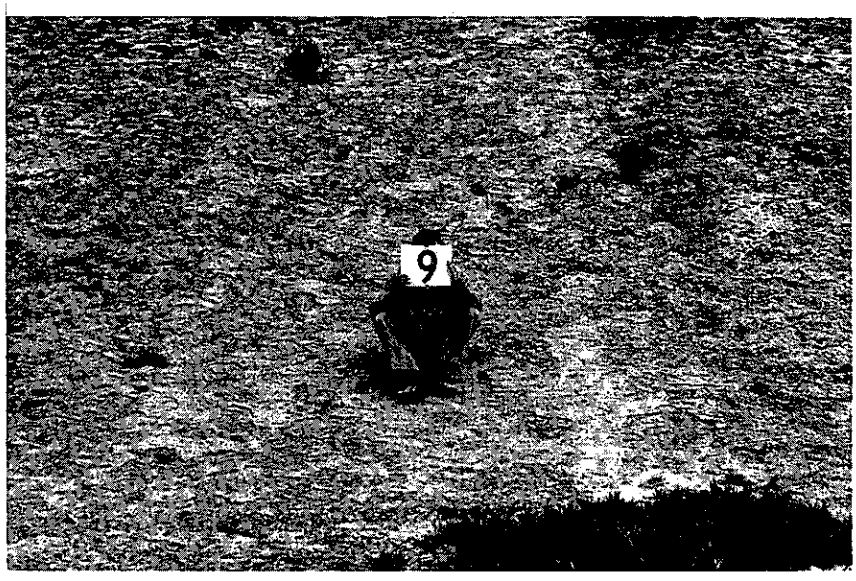
#27 Bike track in center, some grass
9-10-72 near the top



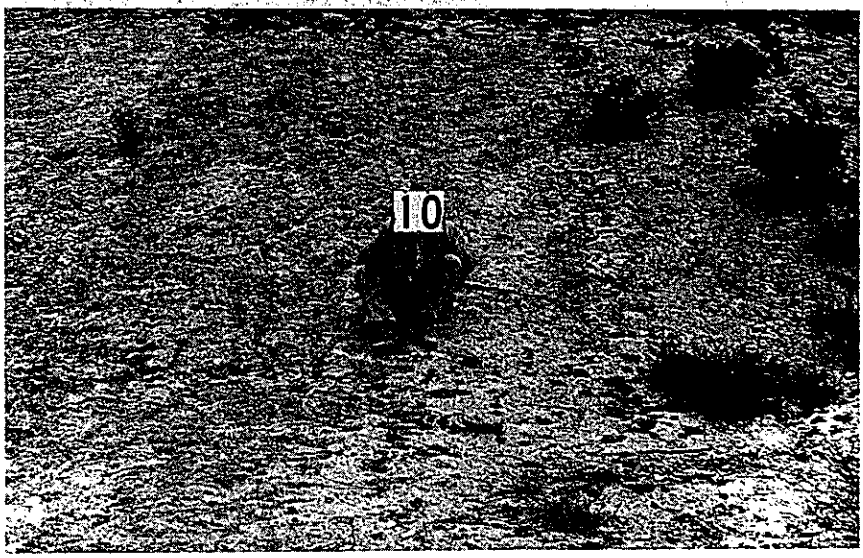
#28 Graded surface is still visible
9-10-72



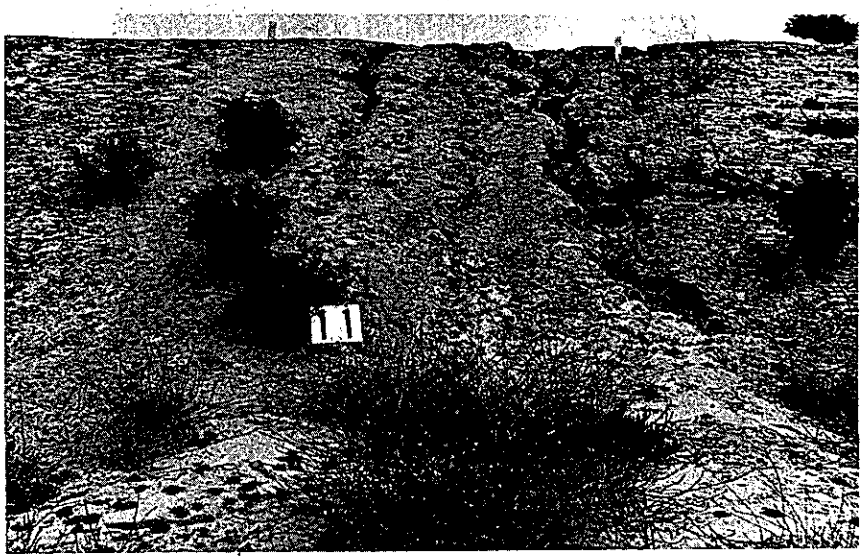
#29 Some vegetation throughout
9-10-72



#30 The ice plant is below the
9-10-72 treated area



#31 Plant at upper left is in the
9-10-72 joint where coverage is poor



#32 Control for DCA-70 Note the
9-10-72 native vegetation. The erosion
was caused by channelized
street runoff