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Final Report

EVALUATION OF SLOPE STABILIZATION METHODS

(US 40 BERTHOUD PASS)

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DEPARTMENT OF TRANSPORTATION RESEARCH

July 2002

COLORADO DEPARTMENT OF TRANSPORTATION

RESEARCH BRANCH

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16. Abstract
In 1995 US 40 on the west side of Berthoud Pass had several cut and fill slopes that were the result of 1960's erosion control practices. Snowmelt runoff and severe spring and summer rain storms frequently washed away the easily eroded sandy soil, preventing vegetation from establishing itself on the slopes.

Originally, sixteen different products, including erosion control mats, mulches and tackifiers, were to be tested for this study. The steep slopes and the severe weather at the site cause rapid erosion of exposed soils and would provide enough area to test several products. However, the severe conditions limited the plant cover established during the first growing season, so the slopes were re-seeded and fertilized several times during subsequent years. Because the re-seeding and additional fertilization were done using standard materials and methods, no data was available on the performance of the mulches, tackifiers, and germination enhancers. Therefore, this report evaluates only the soil containment products used in three test sections of zone 1 and three test sections of zone 2. The fertilizers, tackifiers, and mulches originally used for this study are not evaluated.

Based on observations of the surface conditions and quantities of plant material on the slopes:

- It appears that all of the blankets and cellular confinement products provide reinforcement to the scarp forming area of the cut slopes.
- All of the cellular confinement materials and soil retention blankets were successful in holding and reinforcing the plants' root systems.

IMPLEMENTATION: This study found that all of the blankets and geocell products evaluated were effective in reducing erosion in this high-altitude environment. Any of the products tested will help to prevent the loss of the topsoil and plant growth.

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Evaluation of Slope Stabilization Methods

(US 40 Berthoud Pass)

by

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Report No. CDOT-DTD-R-2002-10

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EXECUTIVE SUMMARY

In 1995 US 40 on the west side of Berthoud Pass had several cut and fill slopes that were the result of 1960's erosion control practices. Snowmelt runoff and severe spring and summer rain storms frequently washed away the top layer of soil, preventing vegetation from establishing itself on the easily eroded sandy soil of the slopes.

Originally, sixteen different products, including erosion mats, mulches and tackifiers, were to be tested for this study (Price 1996). The steep slopes and the severe weather at the study site cause very rapid erosion of exposed soils. These severe conditions limited the plant cover that was initially established, so the slopes were re-seeded and fertilized several times during the subsequent years. Because the re-seeding and additional fertilization were done using standard materials and methods across all of the test zones, no data on the performance of the tackifiers, fertilizers and mulches originally used was available. Therefore, this report evaluates only the soil containment products used in three test sections of zone 1 and three test sections of zone 2. The fertilizers, tackifiers, and mulches originally included in this study are not evaluated.

Based on observations of the surface conditions and quantities of plant material on the slopes:

- It appears that all of the blankets and cellular confinement products provide reinforcement to the scarp forming area of the cut slopes.
- All of the cellular confinement materials and soil retention blankets were successful in holding and reinforcing the plants' root systems.

Implementation Statement

This study found that all of the blankets and geocell products evaluated were effective in reducing erosion in this high-altitude environment. Any of the products tested will help to prevent the loss of the topsoil and plant growth.

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BACKGROUND

In 1995, at the start of this study project, US 40 on the west side of Berthoud Pass had several cut and fill slopes that were the result of 1960's erosion control practices. The easily eroded sandy soil contained a large quantity of rocks, some of which were more than six feet in diameter. Snowmelt runoff and severe spring and summer rain storms frequently washed away the top layer of soil, preventing vegetation from establishing itself on the slopes.

During 1995 enhancement funds became available to rehabilitate some of the eroded slopes. Three test zones were established to evaluate various erosion control materials and methods on the slopes that, in some places, were steeper than 1-to-1.

Phase I, the preparation work done prior to the installation of the various erosion control systems, included removal of large rocks from the slopes and construction of drain facilities and concrete barrier walls at the bases of the cut sections. This phase of construction and the installation of the erosion control materials is described in Colorado Department of Transportation Report Number CDOT-DTD-R-96-6, "Evaluation of Slope Stabilization Methods (US 40 Berthoud Pass)" (Price 1996).

Figure 1. Lifting materials to the top of the slope.

Originally, sixteen different products (Appendix A), including erosion mats, mulches and tackifiers, were to be tested for this study (Price 1996). However, the steep slopes and the severe weather at the study site cause very rapid erosion of exposed soils. Because the severe conditions limited the plant cover that was established during the first year, the slopes were re-seeded and fertilized several times during subsequent years using the CDOT three-stage soil preparation method described below. Because the re-seeding and additional fertilization were applied across all of the test zones and controls (Appendix B), performance data for the fertilizer, tackifier, mulch and germination enhancement products was not available. Therefore, this report evaluates only the soil containment products used in three test sections of zone 1 and three test sections of zone 2. The fertilizers, tackifiers, and mulches used on the slopes are not evaluated.

For seeding in areas similar to Berthoud Pass, CDOT currently uses a three-stage soil preparation consisting of:

1. Humagrow (2250 Kg/Ha), Biosol (2250 Kg/Ha), K_2O (85 Kg/Ha), and seed 64.9 (Kg/Ha)
2. followed by an application of mulch in the form of hay (4.5 ton/Ha)
3. and a final application of tack (340 Kg/Ha) and wood fibers (250 Kg/Ha).

As mentioned above, this procedure was used several times over all of the test and control zones on the slopes on Berthoud Pass as part of subsequent stages of the construction project during the years following the initial construction.

The materials tested on Berthoud Pass for this study were subjected to one of the most hostile environments in Colorado:

- High altitude – about 10,000 feet.
- Short growing season.
- Severe rain in the summer and heavy snow in the winter.
- Steep, rocky slopes.

Figure 2. The number of plants in a sample area of each zone were carefully counted.

In late 2000, five years after the completion of construction, the slopes were evaluated for the amount of plant material growing within the erosion control blanket and cellular confinement test areas. Plants in each test area were counted based on culms (stems and shoots – one individual grass plant may contain 10-15 culms) within a 1-meter square transect.

Figure 3. A frame marks the area to be counted.

Two zones were evaluated:

- Zone one – cellular confinement methods (Table 1, p. 5), with a control section adjacent to the test sections.

Figure 4. The steep slope in zone 1 necessitated safety ropes.

- Zone two – soil retention blankets (Table 1, p. 5), with a control section below the blanket sections.

Figure 5. Pyramat near the top of zone 2 in August of 2000.

Table 1. Product name, installation zone, and plant counts.

Product Name (see Appendix A)	Zone	No. of plants (as % of Control)	Average Stems/Shoots per m^2
*ENVIRO GRID	1	+276%	116
*GEOCELL-ARMATER	1	+164%	69
*GEOWEB	1	+196%	82.5
Zone One CONTROL	1	--	42
**ENKAMAT 20S	2	+121%	52
**TENAX MULTIMAT	2	+119%	51.2
**PYRAMAT	2	-20%	34.5
Zone 2 CONTROL	2	--	43
*Cellular Confinement ** Soil Retention Blanket			

The following observations and suggestions were made during construction:

- In the future no machinery should be allowed above the eyebrow on similar projects.
- Soil Guard did not perform well on the steep slopes on Berthoud Pass – hay worked better.
- Silva Tack did not mix and shoot as well as other tackifiers.
- Multimat held the soil very well.
- The long pins used to hold the Geoweb made the installation difficult in the rocky soil.
- The Enkamat 20 blanket did not hold topsoil well and restricted the ability of the new growth to come through.
- Armater Geocell was preferred by the contractor. Even though it was expensive, its performance outweighed the cost in his opinion.
- The contractor felt that the installation costs were lower for the Armater Geocell material than for the Enkamat blanket.

- Airtol, a gypsum plaster applied after seeding and mulching, did not work as well as some of the other products.

Observations during post-construction evaluations of the site:

- All of the cellular confinement materials and soil retention blankets were successful in holding and reinforcing the root systems on the top 23 feet of the slopes where they were installed.
- With the exception of Pyramat, all of the treatments showed an increase in average plant density over the associated control area.
- Plant counts in the two control sections were very similar – 42 and 43 culms per square meter. This would appear to indicate that comparisons between the blankets and the cellular containment materials would be valid.

CONCLUSIONS

1. All of the cellular confinement materials and soil retention blankets were successful in holding and reinforcing the plants' root systems. The average density of plant shoots in the test areas (blankets and geocell materials with seeding, fertilizer and mulch) ranged from -20% to 276% of the density in the control sections (seeding, fertilizer and mulch only).
2. Based on observations of the surface conditions and quantities of plant material on the slopes, it appears that all of the blankets and cellular confinement products provide reinforcement to the scarp forming area of the cut slopes.
3. Based on the plant counts in the six test areas, the effectiveness of the products ranks as follows from most effective to least: Enviro Grid, Geoweb, Armater Geocell, Enkamat 20-S, Multimat, Pyramat.
4. The Pyramat blanket in zone 2 did not conform to irregularities in the slope as well as the other products. This is the only zone where the plant count was lower than the count in the control section.
5. Failures occurred in the Armater test section when the anchor system failed, and where the product was placed over a large boulder.
6. Cost comparisons could not be done because the products used in the study were donated.

RECOMMENDATIONS

1. The cellular erosion control products and soil retention blankets tested for this study all performed well under harsh conditions. All of them should be installed over relatively smooth surfaces to allow them to conform closely to the surface; large rocks should be removed and hollows filled before they are installed.
2. It would be worthwhile to continue to monitor the plant densities and soil fertility at the site to see if they are able to sustain themselves without repeated re-seeding and re-fertilization.

REFERENCES

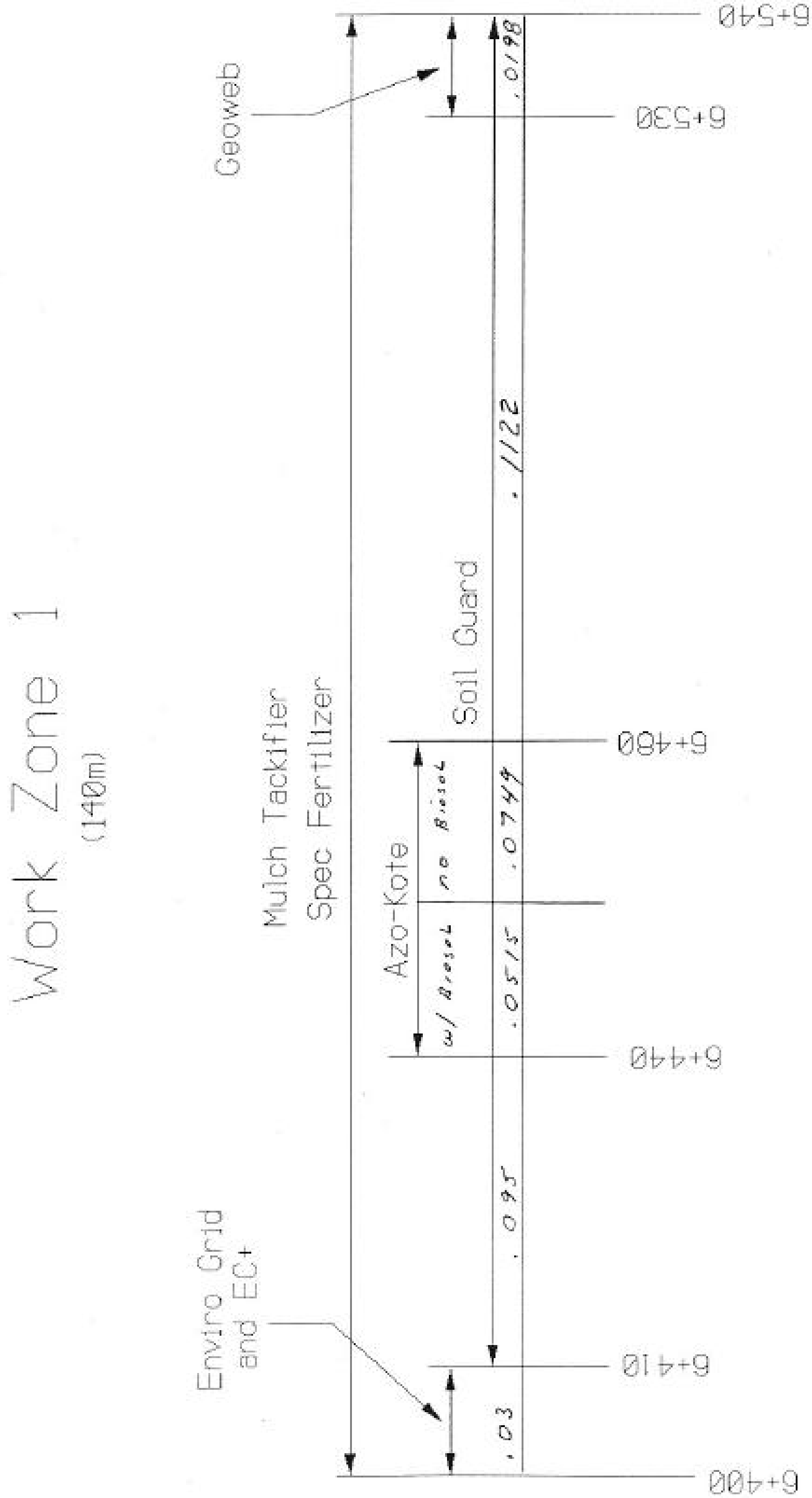
Price, D., (1996). "Evaluation of Slope Stabilization Methods (US 40 Berthoud Pass)." Construction Report. CDOT-DTD-R-96-6.

APPENDIX A – PRODUCTS

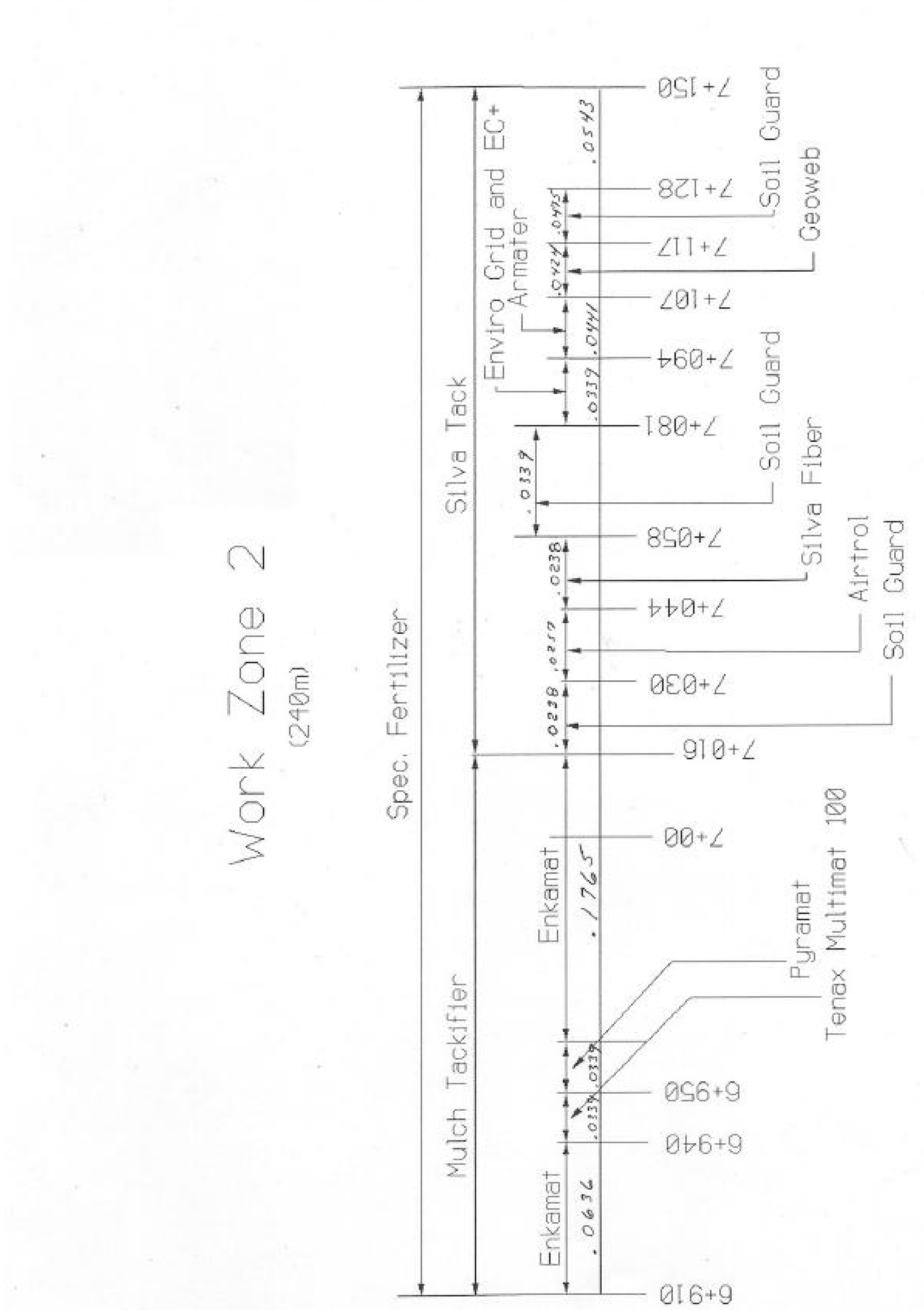
The following products were used on Berthoud Pass during the 1995 construction project:

- ENKAMAT S-20 – blanket – "…a composite nylon geo-matrix together with a polyester geo-grid…" – from Buckley Powder Co., contact Lee Johnson 303.790.7008
- TENAX MULTIMAT 100 – blanket – sewn polypropylene grids – from Buckley Powder Co., contact Lee Johnson 303.790.7008
- PYRAMAT – blanket – polypropylene matrix – contact Jim Rose 303.696.8960
- ENVIRO GRID AND EC+ - Cellular confinement system – Contact Bill Donaldson 1.800.434.4749
- ARMATER GEOCELL – cellular containment – reinforced geo-matrix honeycomb design from non woven polyester fabric – from Buckley Powder Co., contact Lee Johnson 303.790.7008
- GEOWEB – cellular containment – from Presto Products Company 1.800.548.3424
- TERA TACK SC – tackifier – "…a soluble granular polymeric electrolyte designed for tacking and binding hay, straw, paper and wood fiber mulches." – from Reinco Mulch Binder Co – contact Eric Reinecker 1.800.526.7687
- RMB PLUS – tackifier – "…tack medium with germination promoter and growth stimulant…" – from Reinco Mulch Binder Co – contact Eric Reinecker 1.800.526.7687
- ALPHA PLANTAGO CL – tackifier – 100+ lbs. per acre – more as the slope gets steeper. from Buckley Powder Co., contact Lee Johnson 303.790.7008
- AIRTOL – tackifier replacement – gypsum plaster applied after seeding and mulching at the rate of 4800 to 5400 lbs/acre – contact Jim Collette 1.800.365.5874
- SILVA TACK – tackifier – manufactured by Weyerhaeuser, it is applied at a rate of approximately 55 to 75 lb per acre on steep slopes like Berthoud Pass. – from Revegetation Exchange Inc., contact Chris Turner 1.800.666.4050
- SILVA FIBER – mulch – manufactured by Weyerhaeuser, is a wood fiber mulch mixed with water, seed and fertilizer and sprayed through a nozzle at a rate of 1500 to 2400 lb. per acre. – from Revegetation Exchange Inc., contact Chris Turner 1.800.666.4050
- AZO-KOTE – a nitrogen fixing inoculent, promotes germination. It is applied to the seed by the distributor before shipment. **At the time of this writing (July 2002) Azo-Kote is no longer available.**
- GRO POWER – fertilizer – from Revegetation Exchange Inc., contact Chris Turner 1.800.666.4050

APPENDIX B – PLANS



Work Zone 1
(140m)
Mulch Tackifier
Spec Fertilizer
Geoweb
Soil Guard
Azo-Kote
w/ Biosol
no Biosol
Enviro Grid
and EC+
.0198
.1122
.0744
.0515
.095
.03
6+540
6+530
6+480
6+440
6+410
6+400


Work Zone 2
(240m)
Spec. Fertilizer
Silva Tack
Mulch Tackifier
Enviro Grid and EC+
Armater
Soil Guard
Geoweb
Soil Guard
Soil Fiber
Silva Fiber
Airtrol
Soil Guard
Enkamat
Pyramat
Tenax Multimat 100
Enkamat
.0543
.0339
.1765
.0636
7+150
7+128
7+117
7+107
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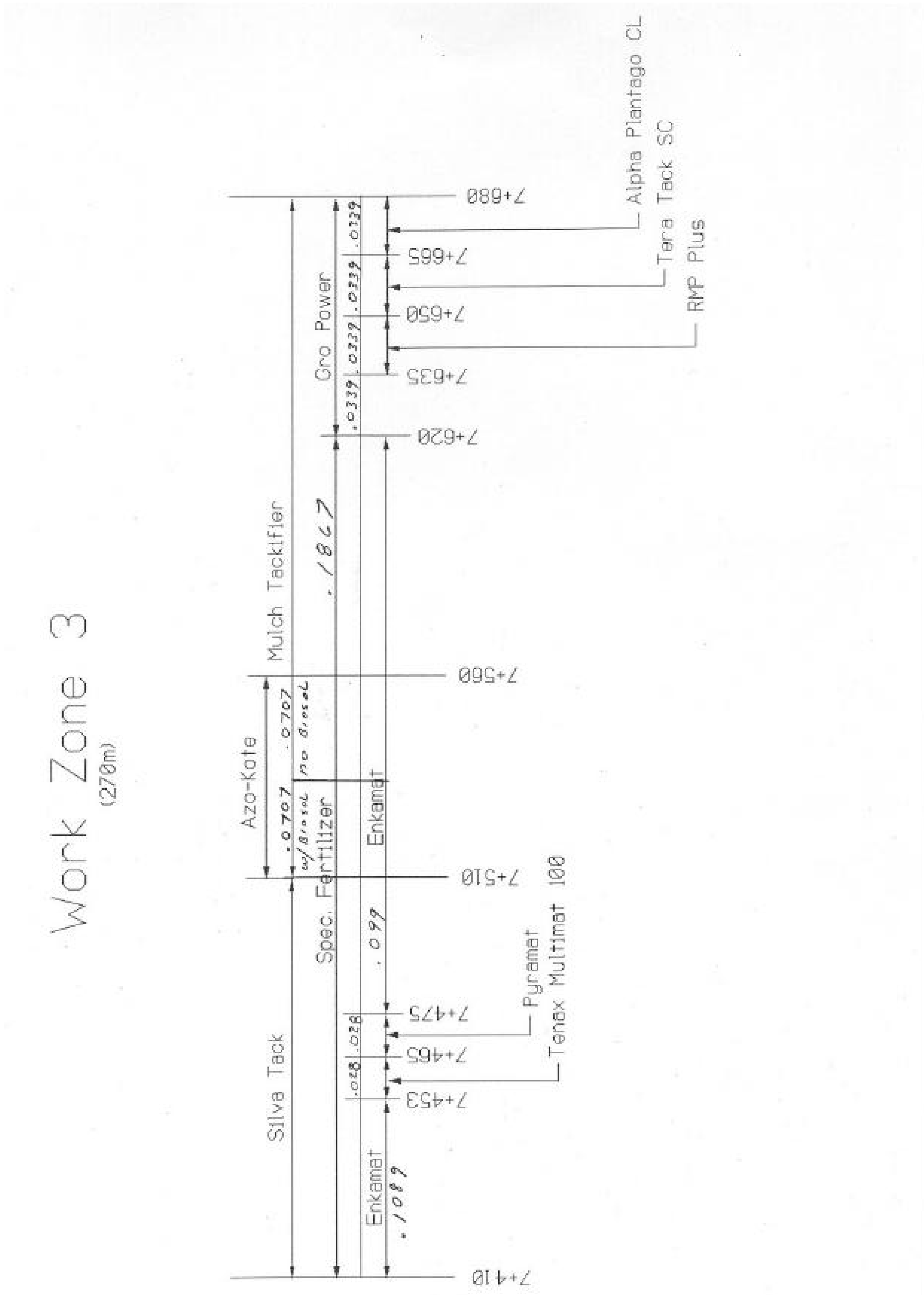
6+950
6+940
6+910



Work Zone 3
(270m)
Silva Tack
Azo-Kote
Mulch Tackifier
Spec. Fertilizer
Gro Power
Enkamat
Enkamat
.0707 w/ Biosol
.0707 no Biosol
.1867
.099
.1089
.028
.028
.0339
.0339
.0339
.0339
.0339
7+410
7+453
7+465
7+475
7+510
7+560
7+620
7+635
7+650
7+665
7+680
Pyramat
Tenax Multimat 100
Alpha Plantago CL
Tera Tack SC
RMP Plus