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Erosion Control of Sandy Soils

FINAL REPORT
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Submitted by

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In cooperation with

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and
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16. Abstract

The southern half of New Jersey is composed primarily of sandy, nutrient-poor soils that do not support traditional roadside grasses well. The decreasing amount of funds for mowing, the need to reduce pollution from mowing operations and the need to find a grass that would provide good erosion control on poor, sandy soils lead to a demonstration of the potential to use weeping love grass in place of traditional roadside grass mixes. By enriching the soil with bio-solids it was demonstrated that a good stand of weeping love grass could create a meadow in place of mostly barren soil. Since the grass thrives with only a single fall mowing, maintenance costs are significantly reduced and potential reduction in air pollutants are possible.

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BACKGROUND

The soils in most of the southern half of New Jersey are primarily composed of sandy, nutrient deficient soils that do not support the growth of traditional roadside grasses planted to control erosion. These soils have low fertility coupled with an inability to retain the moisture needed to sustain vegetation. When vegetation is not sustainable along roadsides, the soil is susceptible to dramatic erosion, especially after intense rainfalls. The foundation of the pavement is washed away and the pavement begins to crumble and fall away. On slopes, erosion causes soils to slip and begin to clog drainage structures. Reconstructing these slopes is costly, especially if non-vegetative erosion control methods such as rip-rapping are used.

PROPOSED SOLUTION

Vegetation is generally the most cost-effective and aesthetically pleasing solution to controlling erosion. To sustain vegetation on sandy soils two criteria must be met: firstly, the soils must be enriched with organic matter to improve their fertility and moisture retention; and secondly, appropriate plant species must be chosen that are adapted to these harsh conditions. For safety and maintenance considerations only grass species should be considered. Federal Highway guidelines restrict the planting of any plant species, usually woody plants, that can grow to a stem diameter of four inches or greater, to allow for recovery zones for vehicles leaving the paved roadbed. Groundcovers are usually more expensive to plant and maintain than grasses and do not has the dense surface root masses necessary to fight erosion.

TEST SITE

A section of Route 55's median was selected to test some new approaches to vegetating the roadside. This median contains some of the poorest, sandy soils in New Jersey. There was little existing vegetation in place since the traditional grasses such as tall fescues were unable to survive. Large areas of white sand were clearly evident. Median drainage inlets were filled with sand and erosion had already crumbled parts of the edge of the roadbed by undermining the ground supporting it. The area from milepost (mp) 40 south to mp 28.1 and again from mp 23.5 to mp 20.9 was selected because these areas were particularly barren and because a construction contract was in place that contained monies for reseeding in these areas.

IMPLEMENTATION

Amending the existing soils was the first task. Soil sampling confirmed the high sand content and low fertility of the soils. Due to the large acreage involved, any proposed soil amendment would have to be inexpensive and easy to apply to minimize grade disruption. At the beginning of the project the use of bio-solids as a soil amendment was discussed. Two sources of bio-solids existed within reasonable proximity to the test site. After some initial inspections and then further discussions with both parties, Landis Sewage Authority was selected to provide the bio-solids. The decision was based on their proximity to the road and their agreement to provide and apply the bio-solids at no cost as a demonstration project monitored by New Jersey Department of Environmental Protection (NJDEP). Using application rates determined through discussions with Rutgers University and NJDEP an initial application of bio-solids was applied in 1996 by a surface injection process (see appendix 2 for amounts of all applications).

The second task, finding suitable grass species to seed, was done through a literature search and field observations of similar sites for vigorous plants. It was discovered that weeping lovegrass, *Eragrostis curvula,* had been sown on parts of Route 55 sixteen years prior to the start of this project. Where the grass had not been mown it was thriving.

Literature stated that the species is particularly adapted to poor, sandy soils. The grass had been imported from southern Africa to southwestern United States in the early 1900's as a possible forage grass for ranching. While the nutritive values of the grass proved to be low, the ability of the grass to survive long droughts and poor soils was demonstrated. This warm-season perennial grass grows to a height of three to four feet (.9 to 1.3 meters). Due to the grass=s fibrous root system the species provides excellent protection to soil from both wind and water erosion. The grass is also unique in another way - it thrives on neglect. Being a warm-season grass it produces the bulk of its vegetation during the hot summer months when other grasses, mostly cool-seasoned varieties, go dormant and turn brown.[1]

During the fall of 1997 bio-solids were applied at the rate of 377,600 gallons to 67.3 acres of road median (5,611 gallons/acre) using soil injection machinery. Existing weeds were then treated with a 41% Roundup herbicide at a rate of 2 1/4 quarts per acre treated using forty-five gallons of water. A sprayer, using a ten foot wide application width nozzle, was used. Weeping lovegrass seed was supplied that had a certified germination rate of 87%. In May of the same year, a brilliant seed drill was used to sow weeping love grass seed at a rate of eight to ten pounds of seed per acre. Fertilizer of a 10-20-10 composition was also applied at a rate of three hundred pounds per acre. Within fourteen days, germination occurred. Areas where no germination occurred were identified as skips in the seeding process. Their location was noted for future re-seeding. During the summer, no mowing was allowed. In October, another application of bio-solids was made by surface applying the material in order to minimize disturbance to the weeping lovegrass plants.

The following spring, bare areas were reseeded following the third application of bio-solids by surface application. The grass was again allowed to grow without mowing until late fall at which time additional bio-solids were applied. Prior to this fall application of bio-solids, the grass was cut to a height of approximately six inches. This sequence of applying bio-solids

[1] G. M. Lodge, G. G. Robinson and P. C. Simpson. A**Grasses - native and naturalized: recognition, value, distribution.**@ In AGFACTS, report no. P2.5.32, New South Wales Agriculture, Australia, 1990, pp.9-10+

in the spring and fall and then mowing in the fall was followed for four additional years.

PUBLIC EDUCATION

It was recognized early in the implementation of the test site that the public would require an education about the new vegetative appearance of the highway median. Although the test section of highway existed in a mostly rural section of New Jersey, motorists and local landowners were accustomed to low mown grass despite how barren most of the site was. As the weeping lovegrass matured and developed into a substantial cover the appearance changed to resemble more a meadow. The New Jersey Department of Transportation received some complaints about the lack of mowing often with incorrect accusations of neglect by the Department. An educational program was thus started to explain the concept of meadows and their value. The program was entitled AShore Meadows≅ as Route 55 is a corridor to the beach from inland areas.

The Department=s Communications section developed signage identifying the weeping lovegrass plantings. Two bill boards were erected as well as several small signs saying, AExperimental grass - do not mow.≅ An educational flyer was made for distribution to legislators and the public. A booth explaining the project was manned at the New Jersey State Fair and several county fairs. The local Chambers of Commerce were also made aware of the project. Complaints were directed to myself for response and further education.

MAINTENANCE

The main maintenance requirement of the newly created weeping love grass meadow is the annual fall mowing which must occur as late in the fall as possible. Weeping love grass turns a golden brown color in the fall that remains very attractive until heavy snows crush and pack down the grass. A late fall mowing allows for the maximum enjoyment of the grass and prevents the establishment of any woody shrubs or trees that could potentially grow to a large size and thereby present a safety hazard.

After three growing seasons a appreciable amount of cut grass can build up on the ground. This dried grass can in certain conditions present a fire risk. The Route 55 median separated forests on most of its length. The New Jersey Fire Fighters unit of NJDEP was concerned that as dead grass accumulated on the median, Route 55 was losing its ability to act as a fire break. To remove the dead grass two approaches were demonstrated.

The first approach was to use hay baling equipment to harvest the weeping love grass in the fall in place of a fall mowing. Both conventional and round bales were produced. A potential market exists for the hay as either erosion control bales or as animal bedding.

The second approach was to conduct a controlled burn of the roadway median in late winter. The affected road section was temporarily closed to traffic from 11:00 pm to 5:00 am by diverting the light traffic onto secondary roads. New Jersey Fire Fighters with assistance from local fire departments set the median afire using drip cans of a gasoline/kerosine mix. The dead grass was quickly burned without incident. Within one month, the warming weather caused the burnt grass to resprout and grow vigorously.

Both approaches to managing the accumulated dead grass worked well with the added advantage of no mowing being needed during the year that the hay making or burning occurred.

CLEAN AIR CREDITS

Prior to the establishing of a weeping love grass meadow, the existing weeds were mowed six times per year to keep the vegetation cropped to six inches or less. When the weeping love grass was established mowing needs were reduced to once a year. This resulted not only in a significant amount of maintenance work but also in a reductional of the amounts of pollutants released into the air by the mowing equipment. A survey of the mowing equipment was given to an NJDOT consultant working on emissions credits. They analyzed the savings in various pollutants. A report of the findings is attached (see appendix 3). The possibility exists for using these pollution reductions to obtain federal clean air credits.

FURTHER APPLICATIONS

A visual survey was conducted of all the roadways under the jurisdiction of NJDOT=s and the various highway authorities to determine what roads may have the climatic, environmental and soil conditions to support establishing weeping lovegrass meadows. The determination criteria were: 1) the plant hardiness zone must be 6B or higher to insure winter survivability; 2) the soils must be predominately sandy and infertile (nutrient-rich soils that hold moisture favor the growth of other grass species and weeds over weeping lovegrass preventing the establishment of a fairly uniform stand of weeping lovegrass); and 3) the roadside must exist in a rural to somewhat suburban area to be appropriate for a meadow creation (highly suburban to urban environments usually require mown turf for aesthetic reasons as well as practical reasons such as the higher amounts of litter generated on these types of roads). Appendix 1 lists the sites deemed appropriate. The total appropriate road lengths and acreage were:

- NJDOT jurisdiction - 140 miles, 927 acres
- Atlantic City Expressway - 44 miles, 430 acres
- Garden State Parkway - 98 miles, 1,300 acres
- New Jersey Turnpike - 13 miles, 60 acres

CONCLUSIONS AND RECOMMENDATIONS

By increasing the organic content of sandy, infertile soils through the application of biosolids a successful stand of weeping lovegrass could be sustained indefinetly provided that correct maintenance procedures are followed. The most critical maintenance procedure to follow is to only mow the grass once in the fall after the grass has gone dormant. Mowing the grass during the summer growing season weakens weeping lovegrass and decreases its potential to control erosion. By not mowing the grass during the summer, the grass is able to produce viable seeds that continue the ongoing process of producing a denser turf.

“The weeping love grass emissions benefits are very small (0.0003 tons per day of VOC) compared to most programs in the SIP (10 to 100 tons per day of VOC). However, compared to other transportation control measures (TCMs), weeping love grass benefits are in the same range.”

“Weeping love grass reductions of VOC are on the low end (similar to the benefits of a small intersection improvement optimizing signalization or geometry or a bicycle path).”

“Weeping love grass reductions of NOx are on the order of 10 times more than VOC reductions. Since NOX is more difficult to reduce by TCMs, the weeping love grass reduction of 0.0017 tons per day of NOx is similar to the benefits of a much larger project such as one-way toll collection on the Delaware River Bridges.”

“I would suspect that if weeping love grass was planted statewide, the acreage could increase 10 to 100 fold which would provide significant NOx benefits near the top of the TCM range and moderate VOC benefits in the middle of the TCM range.”

“(regarding) SIP, .these benefits are small, but are significant strategy to include in the conformity analysis. “[2]

There are many roadways in New Jersey that would be conducive to planting weeping lovegrass meadows. NJDOT management should review the results of this project for possible changes to policies regarding vegetation establishment and maintenance on roads under their jurisdiction. The separate highway agencies operating in New Jersey should also be made aware of the findings of this study.

2 Memorandum from Cherl Brennan, NJDOT to William Hoffman, NJDOT explaining possible emissions credits from planting weeping lovegrass.

APPENDIX 1

The following roads were deemed appropriate for weeping lovegrass meadows:

Route 18 (from route 9 south to route 138) NJDOT Region Central

Approximate length: 25 miles

Approximate acreage: 220 acres

County of Monmouth

Route 34 (from route 18 south to route 33) NJDOT Region Central

Approximate length: 4 miles

Approximate acreage: 25 acres

County of Monmouth

Route 195 (from route 537 east to route 34) NJDOT Region Central

Approximate length: 18 miles

Approximate acreage: 180 acres

Counties of Monmouth and Ocean

Route 70 (from route 206 east to route 37) NJDOT Regions South & Central

Approximate length: 26 miles

Approximate acreage: 90 acres

Counties of Burlington and Ocean

Route 72 (from rte. 70 east to Garden State Parkway) NJDOT Regions South & Central

Approximate length: 22 miles

Approximate acreage: 55 acres

County of Burlington and Ocean

Route 206 (from route 30 north to co. rte. 541) NJDOT Region South

Approximate length: 11 miles

Approximate acreage: 45 acres

Counties of Atlantic and Burlington

Route 322 (from route 50 east to route 40) NJDOT Region South

Approximate length: 4 miles

Approximate acreage: 12 acres

County of Atlantic

Route 55 (from route 322 south to rte.55) NJDOT Region South

Approximate length: 30 miles

Approximate acreage: 300 acres

Counties of Gloucester, Salem & Cumberland

Atlantic City Expressway (from start east to rte.9)

Approximate length: 44 miles

Approximate acreage: 430 acres

Counties of Camden and Atlantic

Garden State Parkway (from start north to routes 195/138)

Approximate length: 98 miles

Approximate acreage: 1,300 acres

Counties of Cape May, Atlantic, Ocean and Monmouth

New Jersey Turnpike (from beginning north to exit 2)

Approximate length: 13 miles

Approximate acreage: 60 acres

Counties of Salem and Gloucester

Totals:

New Jersey State Highways and Interstates

X 140 miles

X 927 acres

Atlantic City Expressway

X 44 miles

X 430 acres

Garden State Parkway

X 98 miles

X 1,300 acres

New Jersey Turnpike

X 13 miles

X 60 acres

Route 18 (from route 9 south to route 138) NJDOT Region Central

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County of Monmouth

Route 18 (from route 9 south to route 138) NJDOT Region Central

Approximate length: 25 miles

Approximate acreage: 220 acres

County of Monmouth

APPENDIX 2

The following applications of biosolids were made to the route 55 weeping lovegrass test site:

- 1996: fall application - 377,600 gallons applied to 67.3 acres for a total nitrogen application of 42.7 pounds.
- 1997: spring and fall application - 779,984 gallons applied to 67.3 acres for a total nitrogen application of 84 pounds.
- 1998: spring and fall application - 1,269,500 gallons applied to 100 acres for a total nitrogen application of 104 pounds.
- 1999: spring and fall applications – 806,501 gallons applied to 100.26 acres for a total nitrogen application of 73.9 pounds.
- 2000: spring application – 406,000 gallons applied to 100.26 acres for a total nitrogen application of 32.1 pounds.

APPENDIX 3

Memorandum

TO: Abbas Hirya and Chuck Grill

FROM:Laureen Hartnett and Chris Porter

DATE: October 19, 1999

RE: Estimating Emission Reductions for Use of Weeping Love Grass

SUMMARY

This memorandum identifies the potential emission reductions resulting from the use of Weeping Love Grass on highway medians and shoulders in New Jersey. Use of this type of grass reduces required mowings from six to one per year, thereby reducing emissions from equipment used for mowing operations. The calculation of emission reductions is performed for a pilot application of Weeping Love Grass along a 14.1-mile stretch of Route 55. The methodology may be applied for use of this grass along other state highways.

The estimates are based on two primary factors: (1)the emission characteristics of mowing equipment, and (2) usage patterns of this equipment. Data on lawnmower emissions for a tractor similar to the type used by New Jersey Department of Transportation (NJDOT) were obtained from U.S. Environmental Protection Agency (EPA) documents. Data on equipment usage patterns were provided by NJDOT.

Emission reductions for this pilot project are shown in Table I for both unregulated equipment. as currently used, and for equipment meeting new standards implemented by the EPA in 1998. Once equipment meeting these new standards is phased in, the estimated NOx emission benefits will be slightly reduced, since the new equipment will be cleaner. The time at which this phase-in occurs will depend on the age and lifetime of current NJDOT mowing equipment. Only NOx will be regulated under the new emission standards, so other pollutants are assumed not to be affected

Table 1 Emission Benefits of Weeping Love Grass, Route 55, New Jersey

	Savings (tons)	
POLLUTANT	**UNREGULATED**	**1998 STANDARDS**
HC	*-0.057*	*-0.057*
co	-0.512	-0.512
NOx	-0.413	-0.349
PM	-0.037	-0.037

METHODOLOGY

The EPA gives the following formula to estimate total NOx emissions from non-road equipment

$$MASS_{I,Nox} = N_i \text{ x } Hp_{i.avg} \text{ x } LOAD_{i.avg} \text{ x } HOURS_{i.avg} \text{ x } EF_{i.NOx}$$

In this equation,

N	-	nationwide population of ith equipment type
$HP_{i.avg}$	-	average rated horsepower of ith equipment type
$LOAD_{i.avg}$	-	ratio (%) between average operational power output and rated power
$HOURS_{i.avg}$	-	average annual hours of engine operation
$EF_{i.Nox}$	-	brake specific emission rate (grams/bhp-hr)
$MASS_{i.NOx}$	-	annual nationwide NO_x emissions (grams)

This equation can be adopted for estimating mowing emission reductions in New Jersey for each pollutant, knowing the rated horsepower of the mowing equipment, the average load ratio (taken from EPA estimates), emission factors by pollutant type, and the change in hours of usage.

Current Emission Characteristics

The key parameters in the above equation are:

- Equipment is a New Holland 4630 tractor, gross engine horsepower = 63.
- Load factor is estimated at 70 percent. This is an EPA estimate for agricultural tractors in the 50 —100 hp range.
- Emission factors are estimated from the most similar equipment tested by the EPA in the above-referenced rulemaking, as shown in Table 2:

TABLE 2 EMISSION FACTORS FOR UNREGULATED FORD NEW HOLLAND 67-HP

TRACTOR

Engine Mfg. and Combustion Chamber Type	Power		g/bhp-hr (g/kW-hr~)			
			HG	CO	NO~	PM
Ford New Holland — DI	hp	67	0.98	8.80	7.10	0.64
	kW	50	1.31	11.8	9.5	0.86

Impact of Recently Adopted Emission Standards

The potential impact of new emission standards for non-road equipment on emission reductions from reduced mowing should also be considered. EPA recently promulgated new 9.2 g/kW-hr (6.9 glbhp-hr) NOx standards for the 50-100 hp compression ignition engine class; these standards took effect in January 1998. Once equipment built to the new standards is phased in by NJDOT, emission *savings* will be somewhat lower, since the percentage reduction in emissions is occurring from a lower baseline. The two key parameters in addressing this issue are:

- When will current equipment be replaced by equipment that meets the new standards; and

- How much will emissions be reduced compared to current levels.

Equipment replacement — The first question will depend upon the age of current equipment and the likely replacement date. EPA defines the “full useful life” of this type of equipment as 8,000 hours or 10 years, although distributions of equipment by age (provided in EPA documentation) indicate that most equipment survives well beyond 10 years. In this example, emission benefits are estimated for both unregulated and regulated mowers; an expected year of phase-in of new equipment can be determined through consultation with NIDOT staff.

Regulated emissions — Current NOx emissions from the New Holland 67-hp engine are estimated at 7.1 g/bhp-hr (see Table I), which is not significantly higher than the new 6.9 g/bhp-hr standard. It is likely that emissions will be reduced somewhat since manufacturers will need some “headroom” to meet the standard during certification. Based on observed practice, EPA estimates that manufacturers will build in a 13 percent safety margin. Therefore, NOx emissions from controlled equipment can be estimated at 6.9 *0.87 = 6.0 g/bhp-hr, a reduction of 14 percent from current levels. EPA has not established HC. CO, or PM standards for this engine class, so reductions in levels of these pollutants are not assumed.

Usage Patterns

New Jersey DOT has provided a methodology for estimating total person-hours of mower use, based on the length and width of the areas to be mowed. In the case of the Route 55 pilot area, this was estimated as 240 hours for a mowing. For elimination of five mowings per season, this would save a total of 1,200 hours of equipment operation.

The estimates of hours of mowing and acreage mowed provided by the New Jersey DOT can be generalized so that reduction on hours of mowing can be estimated for any project where Lovegrass is applied, based on the acreage of the application. The Route 55 calculations by New Jersey DOT suggest a factor of (240 hours) /(152 acres) = 1.58 hours per acre. Before applying this factor to other projects, the estimates should be reviewed with New Jersey DOT staff to ensure their applicability to other projects.

IMPACTS OF OTHER FACTORS

Operating cycles -- The estimates provided here involve a number of approximations. For example, emission rates will vary with the particular usage patterns and load factors of the equipment, equipment may be turned off during lunch breaks and may operate at heavier or lighter loads depending on thickness of grass, hills, etc. Emissions may also vary during transitions between load levels, e.g., ,throttling up or down may produce temporarily higher emissions. It is assumed that these variations are incorporated into the average factors used above; in the absence of developing specific operation cycles and looking in more detail at emissions as a function of cycle characteristics, the approximations are deemed reasonable.

Transport of equipment — Some emissions will be generated in the transport of mowing equipment to and from the mowing site and could be saved through reduced use of these transport vehicles. These emissions, however, are assumed to be small in proportion to the total emissions from the mowing equipment, since this equipment is used for a much longer time period; it is also not clear whether this transport equipment would be used for other activities if it were not used to carry mowing equipment.

Mowing Emission Calculation Spreadsheet

The Excel workbook, which is called “GRASS.xls” contains two spreadsheets, one for HC, CO, NO and PM emission calculations based on unregulated emission levels (for equipment sold prior to 1998), and the other using current emission standards implemented by EPA in 1998. Each spreadsheet has four major sections:

- Lawn Mower Tractor Model with equipment name and horse power data to be filled in.

- Specific Emission Factors. given by EPA (in this case. based on Ford’s New Holland 67 hp model).

- Data on Usage Patterns: Values for either “Time of Mowing” or both “Size of Area” and “Mowing Time per Area”, as well as “Mowings per Year” and “Average Load” has to be provided. The default values for “Mowing Time per Area” and “Average Load” are 1.58 hours/acre and 70 percent, respectively.

  - Total Annual Emissions, where the values from the above data are taken automatically to calculate annual emissions for all four categories. HG, GO, NO~ and PM. The output unit is English tons. The following formula was used for calculating annual emissions:

$$MASS_{emission} = 63\ HP\ xO.7(Load)\ x\ HOURS_{annual}\ x\ EF_{Emission}\ x909{,}000\ (conversion\ to\ tons)$$

In this equation,

$MASS_{Emission}$	-	annual emissions by category (English tons)
$HOURS_{annual}$	-	annual hours of engine operation (before: 1440 hrs~ after. 240 hrs)
$EFE_{Emission}$	-	brake specific emission rate,as documented in Table2 (grams(bhp-hr)

Each spreadsheet also has three columns:

- Base Case for current conditions.
- New Scenario, where the altered conditions are entered (cells which do not change can “be left blank).
- Change (New vs. Base): The changes between the New Scenario and the Base Case are computed.

The worksheets showing calculations for both unregulated and 1998 emission levels are attached.

Emission Calculator	Base Case	New Scenario	Change (New vs. Base)
Lawn Mower Tractor Model			
Name:	New Holland 4630		*NO*
HP:	63	63	*0*
Specific Emission Factors			
HC (g/bhp-hr):	0.98	0.98	*0.00*
CO (g/bhp-hr):	8.80	8.80	*0.00*
NOX (g/bhp-hr):	6.00	6.00	*0.00*
PM (g/bhp-hr):	0.64	0.64	*0.00*
Data on Usage Pattern			
Time for a Mowing (hrs)*:	240	240	*0*
Size of Area (acres)*:	152	152	*0*
Mowing Time per Area (hrs/acre)*:	1.6 1.58 Default: 1.58	2	*0*
Mowings per Year:	6	1 1	*-5*
Average Engine Load (%):	70 Default: 70	70	*0*
Total Mowing Time (hrs):	1,440	240 240	*-1,200*
* Please fill in either "Time for a Mowing" or both "Size of Area" and "Mowing Time per Area".			
Total Annual Emissions			
HC (tons):	*0.068*	*0.011*	***-0.057***
CO (tons):	*0.615*	*0.102*	***-0.512***
NOx (tons):	*0.419*	*0.070*	***-0.349***
PM (tons):	*0.045*	*0.007*	***-0.037***

Table 2: Emission Reductions from Use of Weeping Love Grass on Rt. 55, New Jersey (1998 Standards)