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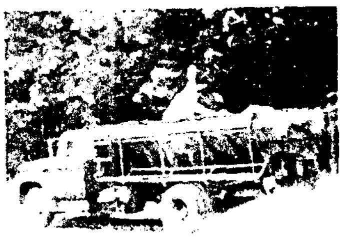

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VEGETATION AS AN AGRONOMIC METHOD OF DUST CONTROL ON HELICOPTER TRAINING AREAS AT FORT RUCKER, ALABAMA

by

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13. ABSTRACT *(Maximum 200 words)*

Intense, low-altitude training in rotary-wing aircraft (helicopters) on the predominantly infertile, sandy clay soils of Fort Rucker, Alabama, has led to erosion of the soil surface and the generation of dust clouds of such severity as to impair pilot vision and increase wear and maintenance costs on the helicopters. Pilot safety became an issue, and some of the severely eroded training areas were closed as a consequence. US Army Engineer Waterways Experiment Station (WES) personnel visited Fort Rucker to investigate the problem and provide assistance in remediation.

Some of the possible approaches to alleviate the problem included chemical soil stabilizers, membranes, limestone gravel, concrete/asphalt pavement, and vegetation. Chemical soil stabilizers alone were considered a temporary approach, and membranes were believed to be a safety hazard themselves due to possible torn pieces being pulled into the rotary blades of helicopters. Concrete or asphalt pavement and limestone gravel would provide a more permanent solution. However, the cost on large areas may be considered excessive. Vegetation is considered a more permanent

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solution at a lower cost, but this approach had previously been considered a failure. WES personnel suggested that improving and maintaining the quality of vegetative cover would decrease soil erosion and dust generation.

Declining vegetative cover was determined to be the first step in the process of soil erosion by rotorwash. The second step is the gradual movement of soil particles away from plant roots, followed by the removal of remaining vegetation by rotorwash. The final step is the massive erosion of the unprotected soil surface by rotorwash. Decline of vegetative cover was attributed to a number of factors, including low soil fertility, poor construction of training areas, improper mowing management, and drought. WES personnel determined that dust and erosion control by improving the vegetative cover was possible on most of the helicopter training areas.

In 1988, a wide array of vegetative species were evaluated at three helicopter training areas. In 1989 and 1990, the three best-performing species (Pensacola bahiagrass, common bermudagrass, and Cochise lovegrass) were evaluated under various fertilizer rates and soil amendments. Significantly higher yields were obtained on newly established vegetation when chicken litter was incorporated and hay or wood fiber was added as a mulch. Helicopter activity over amended versus nonamended plots showed that sufficiently established and maintained vegetation prevented soil loss by rotorwash. On established bahiagrass, three applications of fertilizer during the growing season more than doubled the vegetative cover over unfertilized vegetation. Restoration of eroded areas under active helicopter use was attempted with a chemical soil stabilizer and vegetation. This method was found to be effective until lack of moisture caused vegetation failure. Irrigation would have been beneficial in this case.

Recommendations, based on the findings of this study, are provided for each type of training area in this report. These recommendations provide some guidance for maintaining a vegetative cover capable of preventing soil loss from affected areas. Recommendations are also included to address areas or instances where vegetation is not the solution to dust control.

Contents

Preface

The study reported herein was conducted by the Contaminant Mobility and Regulatory Criteria Group (CMRCG), Ecosystem Research and Simulation Division (ERSD), Environmental Laboratory (EL), of the US Army Engineer Waterways Experiment Station (WES). The work was conducted for the Directorate of Engineering and Housing (DEH), US Army Aviation Training Center, Fort Rucker, Alabama, and was sponsored by the Training and Doctrine Command, Fort Monroe, VA.

CPT Todd R. Higgins served as Principal Investigator during the period October 1987 through June 1988. Mr. Richard A. Price was Principal Investigator from July 1988 through project completion and was responsible for preparation of this report.

Technical assistance in the conduct of field tests was provided by Ms. Donna Garrett, Ms. Brenda Allen, Mr. Dennis Brandon, Mr. Thomas Sturgis, Mr. Peter Pikul, Ms. Cynthia Price, Mr. Larry Bird, Mr. Mark Chapman, Ms. Judy Breithup, Mr. Keith Fessel, and Mr. Kyle Anderson. Assistance in the preparation of tables and figures was provided by Ms. Carole Stephenson.

Special appreciation is expressed to Mr. Delarie Parmer, DEH, for assistance in acquiring equipment and materials and preparing test plots.

The study was conducted under the direct supervision of Dr. Bobby L. Folsom, Jr., Team Leader, Plant Bioassay Team; Dr. Lloyd R. Saunders, Chief, CMRCG; Mr. Donald L. Robey, Chief, ERSD; and Dr. John Harrison, Chief, EL.

Commander and Director of WES was COL Larry B. Fulton, EN. Dr. Robert W. Whalin was Technical Director.

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	4,046.873	square meters
feet	0.3048	meters
gallons (US liquid)	3.785412	liters
inches	2.54	centimeters
miles (US statute)	1.609347	kilometers
pounds (mass) per acre	0.000112	kilograms per square meter
square feet	0.09290304	square meters

1 Introduction

Background

The US Army Aviation Training Center at Fort Rucker, Alabama, is the home of rotary-wing aircraft (helicopter) instruction for personnel of the US Army and Air Force, as well as personnel from foreign countries. Students receive basic through advanced training in a variety of helicopters, including the UH-1 Iroquois, UH-60 Black Hawk, OH-58 Scout, AH-1 Cobra, AH-64 Apache, and the CH-47 Chinook.

Fort Rucker covers about 64,000 acres[1] in the southeastern Alabama counties of Dale, Coffee, Geneva, and Houston. Various types of training areas are scattered throughout these counties, on both Government-owned and leased land. Thus, management methods vary among the training areas.

Statement of Problem

Dust generation from rotary-wing downwash (rotorwash) of helicopters is adversely affecting the training mission and compromising the safety of student aviators. The poorly vegetated soil in the training areas is easily eroded under constant pressure from rotorwash, and dust generation occurs. Severe dust generation by hovering helicopters (Figure 1) can inhibit visibility, increase wear and maintenance, and cause engine failure, resulting in a crashed helicopter and loss of life. Correction of this problem was necessary to continue the safe and timely training of helicopter aviators.

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[1] A table of factors for converting non-SI units of measurements to SI (metric) units is presented on page ix.

Figure 1. Dust cloud generated by AH-64 Apache over firing point

Previous Dust Control Approaches

Since 1946, the US Army Corps of Engineers has investigated dust control methods for use on military installations (Styron 1975). Four general treatment methods have been recognized for dust control--agronomic, surface penetration, surface blanket, and admix. These methods are described in Training Manual 5-830-3 (Departments of the Army and Air Force 1974).

The agronomic method consists of establishing and maintaining a vegetative cover that protects the soil surface from rotorwash impact. Although this method requires time for plant establishment, long-term dust control can be achieved.

The surface penetration method is a quick, short-term solution consisting of sprayed-on liquid resinous, bituminous, and brine materials that penetrate the soil surface.

The surface blanket method covers the soil surface with materials such as aggregates, membranes, mesh, bituminous materials, polyvinyl acetate, and acrylic copolymer emulsions. The long-term effectiveness and cost of these materials vary greatly.

Admix methods include the mixing of cement, hydrated lime, cutback asphalt, and similar materials into the soil surface followed by compaction. This method is time consuming and requires more equipment than the previous two methods.

Some of the above-mentioned methods have been used at Fort Rucker in the past and have not demonstrated long-term effectiveness. The methods used include mostly the surface penetration and surface blanket types. Peneprime, a liquid cutback asphalt, was used extensively on eroded areas with only short-term erosion control. Cracks in the material, resulting from vehicular traffic or environmental stress, allowed the uplifting of thin sheets by rotorwash, exposing the bare soil surface (Figure 2). Also, Peneprime has been shown to totally retard seed germination on sandy soil, resulting in little if any vegetative recovery (Zhordania et al. 1983). Tests were conducted in the 1960's using membranes and mesh. These surface blanket materials were discontinued for helicopter areas after torn pieces of the materials were drawn into the rotary wings.

Figure 2. Unsuccessful use of Peneprime surface penetration dust control method

Two-inch-diameter aggregate was recently applied to severely eroded areas at Fort Rucker. This surface blanket method can provide not only a long-term solution, but also a quick solution (Figure 3). The initial high cost, however, limits its use over large areas.

Study Objectives

The objectives of this study were to (a) observe helicopter training activities on training sites at Fort Rucker and identify factors leading to dust

Figure 3. Surface blanket method using 2-in. aggregate

generation, (b) develop a strategy for reducing dust generation with the main focus on agronomic methods, (c) conduct an onsite demonstration study, and (d) provide recommendations for implementation at Fort Rucker.

2 Identification of Factors Leading to Rotorwash Erosion

Assumed Factor

The underlying notion of the dust problem was that vegetation could not survive the effects of rotorwash, that is, that rotorwash was literally blowing away the vegetative cover. After extensive observation of all types of helicopter training areas at Fort Rucker, investigators from the US Army Engineer Waterways Experiment Station (WES) determined that rotorwash does blow away vegetation, but only after the soil around the plant roots has been removed. Therefore, it was necessary to identify the other factors involved in allowing rotorwash effects to impact upon the soil surface.

Inadequate Vegetative Cover

A thick, healthy vegetative cover is required to withstand the constant pounding of rotorwash and prevent the displacement of soil particles. The sparse vegetative cover at Fort Rucker did not meet these criteria, even in areas not subject to helicopter activity (Figure 4). For reasons other than rotorwash, vegetative cover had declined to the point that rotorwash began to impact the soil surface and intensify declination of the vegetative cover.

Soil Fertility

Low soil fertility is the most important contributor to poor vegetative cover. Most of the soils in the Fort Rucker area are sandy, well-drained, infertile soils typical of the southeastern coastal plains. With proper

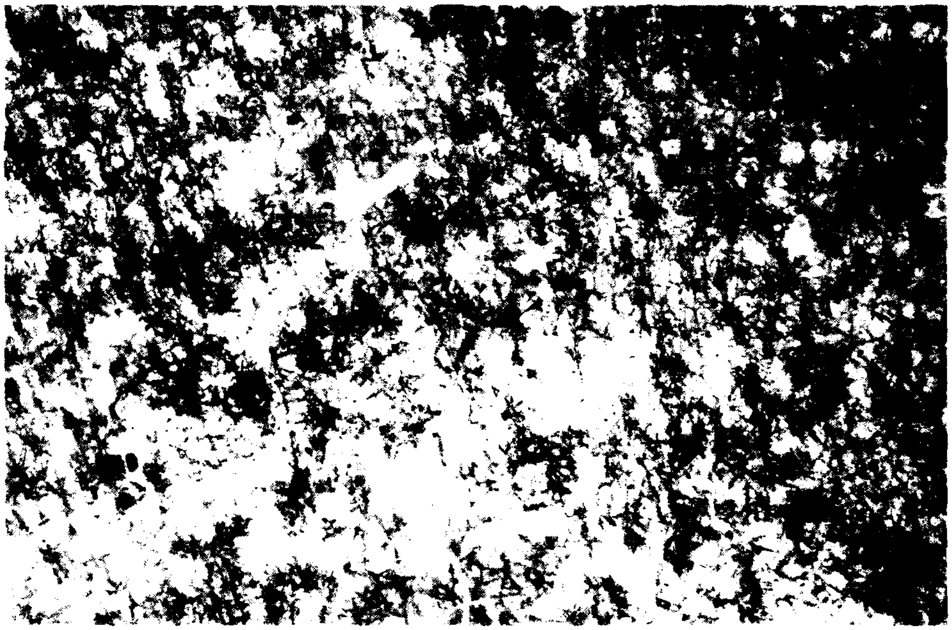


Figure 4. Typical thin vegetative cover at Fort Rucker

management, these soils are suited to pine forests, pastures, and some row crops such as cotton, peanuts, and corn. Because of the poor soil conditions, good quality turfgrass is difficult to grow and maintain with little or no management.

Chemical, mined, and organic fertilizers and soil amendments are readily available in the area and are necessary to increase and maintain soil fertility at levels required by the plants for adequate growth. According to Fort Rucker personnel, many training areas have not been fertilized in approximately 20 years.

Mowing Damage

Mowing is a necessary function to maintain helicopter training areas. Vegetation must be kept cut to reduce fire hazards, prevent security breaches, and provide an overall safe and aesthetic environment. Mowing also promotes lateral growth of sod-forming vegetation, providing for a denser cover.

However, the mowing techniques and equipment used by the contractors were found to cause an excessive amount of damage to the vegetation and soil surface. Tires on tractors are of the farm type (high-pressure rating with deep cleated or ribbed tread), which tend to dig into the soil when turning. Mowing equipment used was single- to three-gang bushhog units. The design of this type of equipment causes scraping and scalping of the soil surface when making turns and mowing over uneven surfaces (Figure 5). Dull cutting blades on this equipment tend to pull the vegetation from the soil rather than cut it. Exposed soil resulting from this type of damage is quickly eroded by rotorwash, and the damaged area begins to increase in size and severity.

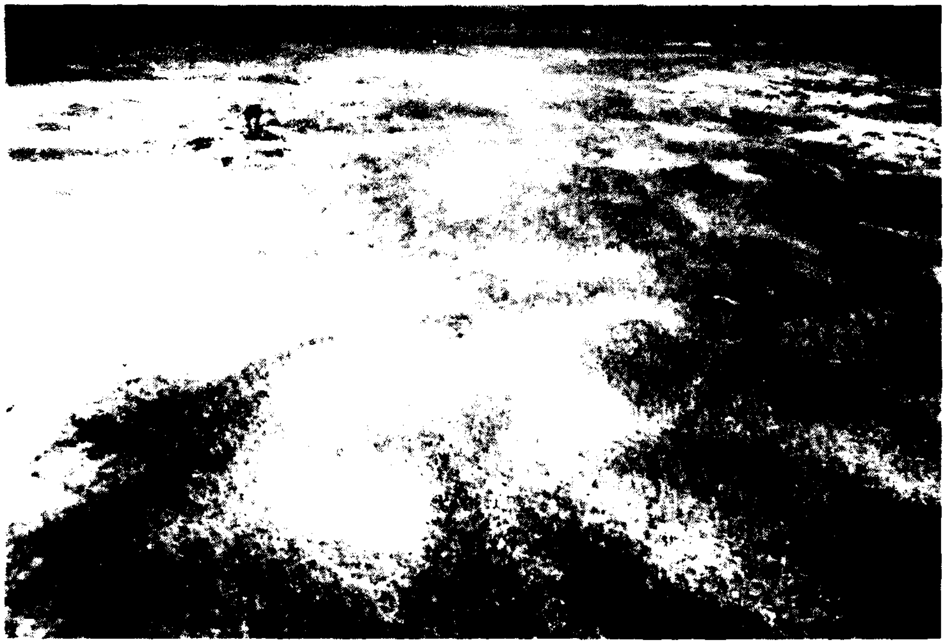


Figure 5. Scalping damage caused by mowing equipment

Mowing Height

The height of cut on stagefields, heliports, and remote training areas (RT's) was also examined and found to be too short. Specifications in the mowing contract required a 2-in. cut. Observations after mowing activities revealed that much of the vegetation was cut below 2 in. and, in places, to the soil surface.

Vegetation that has been cut this short has very little leafy tissue remaining, mostly stems and rhizomes. Lack of leafy tissue leaves the soil surface unprotected from the effects of rotorwash. Also, damage to the soil surface from the types of mowing equipment discussed above is almost certain at the 2-in. height requirement.

Stormwater Runoff

Another factor contributing to rotorwash erosion is surface water runoff. In many instances it was observed that inadequate drainage controls allowed excessive runoff to occur on poorly vegetated training grounds. Soil surfaces are easily eroded where vegetative cover is thin and surface water runoff is severe. The surface is then exposed to further erosion by rotorwash.

Suspended soil particles are carried by water runoff and are sometimes deposited in low spots on the training area. Once these deposited particles dry and are exposed to rotorwash, severe dust generation can occur. Areas severely eroded by surface water runoff can also increase difficulty and damage in mowing operations.

Ground Vehicle Damage

Mowing equipment is not the only type of ground vehicle causing damage to the soil surface. Other vehicles, such as passenger, fuel and fire trucks, and other service vehicles can create ruts on wet ground. Spinning tires on wet or dry ground strips vegetation from the soil surface.

Some of the worst damage observed had occurred on RT sites used for weekend training by National Guard/Reserve units (Figure 6). Vehicles that are driven on the grassed areas during these training exercises cause damage to the soil surface and vegetative cover, especially during periods of wet weather.

Figure 6. Tire ruts on remote helicopter training area

Helicopter Damage

Damage can result from a means other than rotorwash. This damage is caused by skid impact or drag from UH-1, AH-1, and OH-58 aircraft during takeoff and landing activity. Exhaust discharge, mostly from the UH-60 aircraft, can scorch vegetation while the aircraft sits on the ground with the engines running. These two mechanisms inflict damage severe enough to be accelerated by rotorwash, primarily on landing zone (LZ) training sites.

Landing points on these sites are generally pinpointed to a small designated area, and the site is usually remote and unimproved. Repeated landings on these sites deteriorate the vegetative cover and loosen the soil surface, which is quickly eroded by rotorwash. A pit is eventually created in the ground (Figure 7), and the site has to be closed down.

Figure 7. Pit caused by rotorwash on skid impact damage

Training Area Construction

The beginning of many of the erosion problems on helicopter training areas can be traced to the construction of these areas. Inspection of these areas reveals that very few agronomic considerations were included in their design and implementation. Raised landing/departure pads, for instance, were constructed by scraping the surrounding topsoil into a leveled mound and pouring a concrete surface on top of it.

Without extensive agronomic methods, such as deep tillage, organic amendments, and maintenance of soil nutrient levels, the disturbed area around the mound had very little chance of successful vegetative establishment. Due to the intense impact exerted by helicopters, training areas need to be constructed in such a manner as to provide a medium that is more than adequate for successful establishment of a thick, healthy vegetative cover.

3 Strategy for Dust Control

Improve Vegetative Cover

Improving the vegetative cover is the first step in reducing erosion and dust generation. Studies at the WES using a rainfall simulator/lysimeter system have shown that soil erosion by rainfall decreases exponentially as biomass increases (Lee and Skogerboe 1984). Vegetation can receive and disperse energy, reducing the energy impact on the soil surface. This is true not only for the energy produced by falling rain droplets but also for the energy produced by rotorwash.

Correcting some of the above-mentioned factors will lead to a healthier, thicker vegetative cover capable of reducing soil displacement by rotorwash as well as stormwater runoff. On some of the training areas, where vegetation is already established, improvement or modification of training and management practices may be all that is necessary to improve the vegetative cover. On other training areas, where vegetation has been totally removed, complete restoration of the site will be necessary.

Increasing and maintaining soil nutrient levels is a must for maintaining a vigorous vegetative cover. Soil pH levels are also important to plant vigor and nutrient uptake, as nutrient availability is pH dependent. Soil sampling of each training area and analysis of those samples by an approved agricultural laboratory can provide all the information needed to determine fertilizer and lime requirements for the soil.

The mowing height should be raised to keep the vegetation at a minimum of 6 in. Most of the vegetation on the training areas at Fort Rucker is bahiagrass, which performs well at this height.

Pilots had previously complained that tall vegetation was wavy and gave a distorted perception of height above the ground during night training exercises. However, conversations with the pilots indicated that a 6-in. minimum would not be a problem. Raising the mowing height will not only increase the vegetative cover but will also help to reduce possible scraping and scalping damage by mowing equipment.

Drought is not listed as a factor leading to rotorwash because short periods of dry weather only slow the vegetative rate growth temporarily. Growth rate returns to normal after rainfall occurs. The Fort Rucker area is not considered droughty for lack of rainfall. Rainfall is typically lowest in the spring and fall months, and averages 53.92 in./year (US Department of Agriculture (USDA) 1960). However, sandy soil conditions allow rapid leaching of rainfall, and droughty conditions can be created rather quickly, especially under the drying effects of frequent rotorwash.

Irrigation of helicopter traffic areas (hover and taxi altitudes) will keep vegetative cover at a normal rate of growth, reducing chances of declination. Also, by keeping soil surface particles in a moist condition, airborne movement of soil particles is greatly reduced. Irrigation will have its greatest benefit during restoration of severely eroded areas of active training areas. If irrigation is used during the restoration process, helicopter training can continue without major interruption.

Reduce Damage to Vegetative Cover

Of the above-listed causes of damage, mowing damage probably contributes the most to the destruction of vegetative cover and eventual erosion by rotorwash. This damage can be greatly reduced by specifying turf-type tires for tractors, prohibiting the use of large-gang bushogs on grassed taxi lanes and around departure/recover pads, and ensuring that mower blades are maintained with a sharp edge. Smaller commercial turf mowers would be more desirable around the departure pads and taxi lanes, because of the better-quality cutting with less damage from the mowing deck.

Damage from helicopter skid impact and exhaust can be reduced by frequently rotating landing points where landing points are specifically marked or designated. On small LZ's, where space for relocation of landing points is not available, a landing mat or gravel pad may have to be provided, or a larger LZ may need to be acquired.

Damage caused by trucks and other ground vehicles can be reduced by limiting access to grassed areas to "emergency access" only. National Guard/Reserve units should have limited nonhelicopter use of helicopter training areas. Where vehicles are allowed on a training area, use should be limited to paved areas only.

4 Area RT14 Site Demonstration

Background

Area RT14 was selected as a site requiring total soil restoration and re-vegetation. RT14 is located in Dale County, Township 5 North, Range 23 East, between Blacks Mill Range and Lake Tholocco. The Dale County Soil Survey (USDA 1960) lists the soil at this site as a Lakeland loamy fine sand, with 0 to 5 percent slopes. This soil is excessively drained, low in organic matter, and extends 6 to 10 ft in depth. These soil conditions result in rapid leaching of nutrients from the already infertile soil.

The Lakeland soil series is the most extensive and covers the largest portion of the county. All the area surrounding RT14 is in woodland, mostly pine and scrub oak.

Area RT14 is used exclusively by the AH-64 Apache for training purposes. The observed flight routine was usually to hover at an altitude of about 3 to 10 ft for a period of a couple minutes to 20 min or more. The Apache may also land and rest on the ground for extended periods of time with the rotor blades in high-speed operation. The site consists of a 1,400-ft airstrip with a 40,000-sq ft landing pad attached. Landing and hover activities occur on both paved and nonpaved areas.

For all practical purposes, vegetation was nonexistent at the site, and severe dust generation occurred during helicopter operations. As much as 12 in. of topsoil had been removed from the site by rotorwash and stormwater runoff.

Figures 8 and 9 show area RT14 prior to establishment of test plots. The site was to remain closed until establishment of new vegetation (estimated at 6 weeks after planting). The objective at RT14 was to evaluate methods of restoring the site with a vegetative cover capable of reducing the dust generation by rotorwash from Apache aircraft. Methods would include various species of vegetation and soil amendments.

Figure 8. Training area RT14 prior to demonstration

Figure 9. Massive topsoil loss from RT14

Methods

Year 1

In February 1988, soil samples were collected from the site for analysis to determine lime and fertilizer requirements. Area RT14 was in need of fill material to return the soil surface to the original elevation. Soil from a nearby borrow pit was hauled in, placed, and leveled by the 46th Engineer Battalion of Fort Rucker. The soil from the borrow pit was also a Lakeland loamy sand.

The soil was disked three times as deep as the disk would go (compaction from leveling and construction limited the depth to 6 in. or less). Dolomitic limestone was then applied by spreader truck to the entire test area, at the rate of 2,000 lb/acre. The soil was disked again to incorporate the limestone.

Randomly assigned replicate plots were then marked as shown in Figure 10. Fifteen plots (three replicates of five species), measuring 100 by 40 ft each, were located on the north side of the airstrip. Sixteen plots on the south side (four treatment plots replicated four times) measured 100 by 75 ft each.

Hand spreaders were used to apply nitrogen (34-0-0), phosphorus (0-46-0), and potassium (0-0-60) fertilizers to individual plots according to the rates given in Table 1. A final light disking was used to incorporate the fertilizer into the root zone. A cultipacker was used to firm the seedbed before planting.

Table 1
Fertilizer Rates for Area RT14 (1988)

Treatment	N-P_2O_5-K_2O Fertilizer lb/acre
1X rate (60-98-52) (single application)	400 (13-13-13) 100 (0-460) 25 (34-0-0)
2X rate (120-196-104) (split in two applications)[1]	800 (13-13-13) 200 (0-46-0) 50 (34-0-0)
0.5/0.5 rate (60-98-52) (split in two applications)[1]	400 (13-13-13) 100 (0-46-0) 25 (34-0-0)

[1] Second part of split application was not applied.

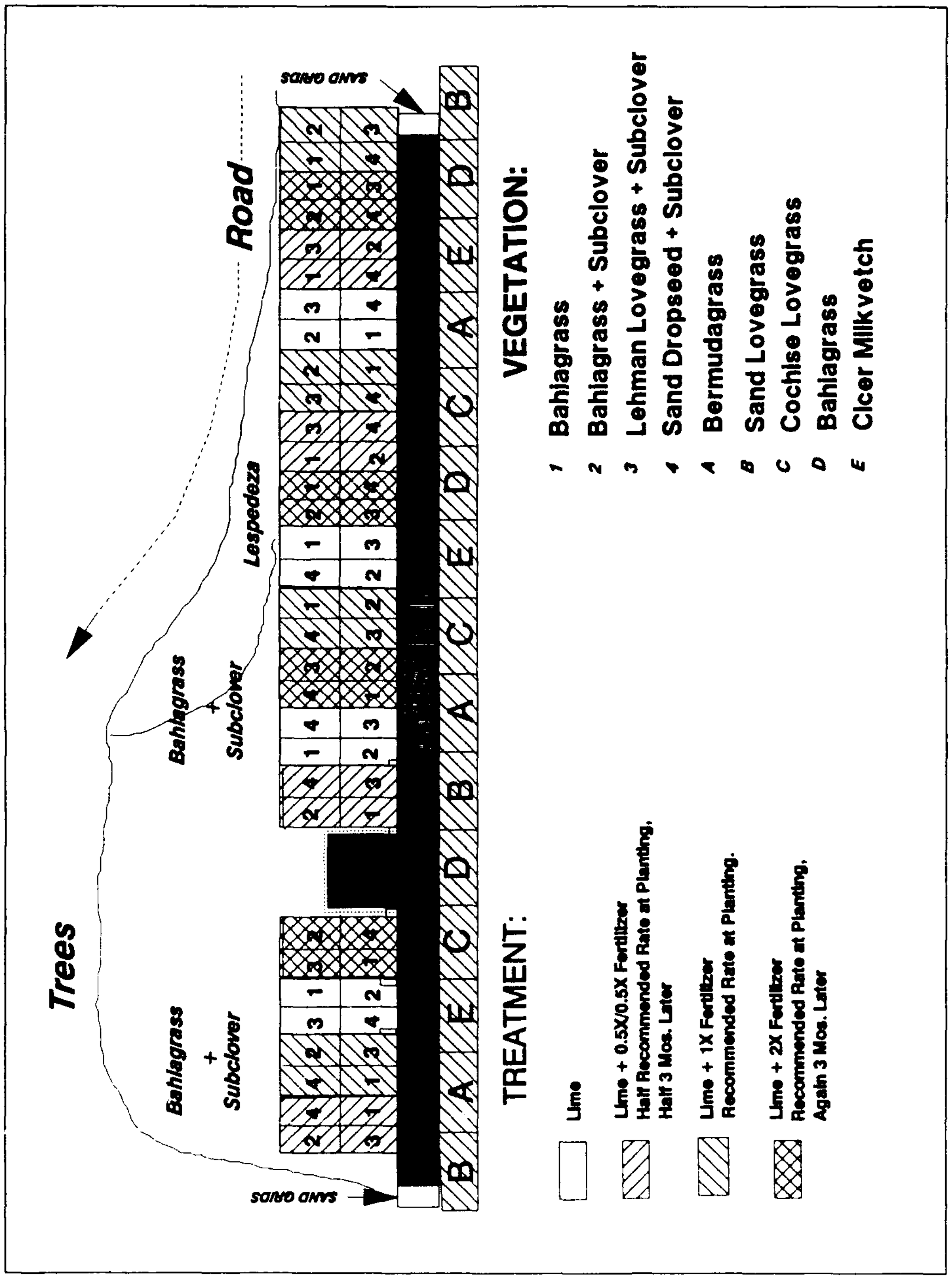


Figure 10. RT14 test plots, 1988

The plots were seeded using hand equipment according to the seeding design illustrated in Figure 10 and the seeding rates given in Table 2. After seeds were applied to the plots, the cultipacker was used to lightly cover and compress the seeds into the soil. The remaining open area south of the test plots was planted with Pensacola bahiagrass, subterranean clover, and sericea lespedeza, as shown in Figure 10.

Table 2
Seeding Rates for RT14 Test Plot Species, 1988

Common Name*	Pounds/Acre
Pensacola bahiagrass	31
Lehmann lovegrass	2
Subterranean clover	20
Sand dropseed	8
Common bermudagrass	8
Sand lovegrass	2
Cochise lovegrass	2
Cicer milkvetch	20
Sericea lespedeza	30

*Scientific names available in Appendix A.

Year 2

As a result of the severe drought in the spring and summer of 1988, success of establishment and survival of planted vegetation was very limited. The three successful species were selected for use in 1989 along with more extensive soil improvement methods, as shown in the test plot design (Figure 11). Soil samples were collected from each plot in February 1989 and submitted for analysis.

Soil preparation and seeding were conducted in June 1989. All test plots were ripped, using the chisel teeth on a roadgrader (Figure 12), to fracture the hardpan caused by excessive construction traffic and to allow for greater root penetration. After three passes with a disk, lime was applied to all plots at the rate of 2,000 lb/acre. A spreader truck was used to apply chicken litter at the rate of 20,000 lb/acre to designated plots (Figure 13). The lime and chicken litter were then incorporated with one pass of the disk. Nitrogen, phosphorus and potassium fertilizers were applied by hand equipment to designated plots, and then incorporated with a disk. A heavy section of chain-link fencing was dragged behind a tractor to level the soil surface.

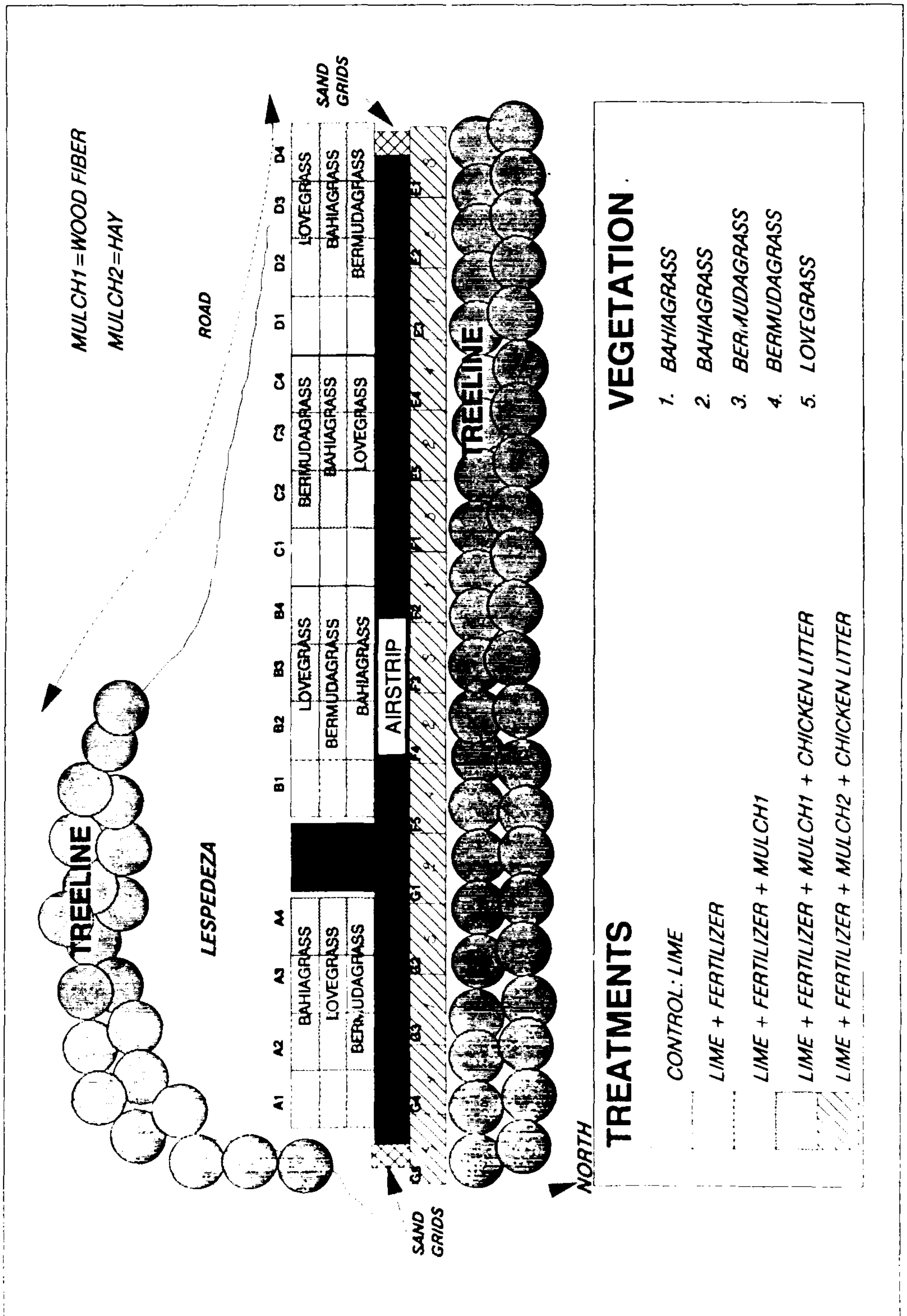


Figure 11. RT14 test plots, 1989

Figure 12. Ripping soil with teeth on a roadgrader

Figure 13. Applying chicken litter by spreader truck

Seeds of three species were applied using hand equipment to designated plots. The blades on the disk were straightened, and one pass was made to lightly incorporate the seeds. This was followed by one pass of the cultipacker. Hay mulch was spread by hand (a mechanical hay spreader was not available) over designated plots at the rate of 6,000 lb/acre. Wood fiber mulch was applied with a hydromulcher at the rate of 2,000 lb/acre to designated plots. Seed and soil amendment rates are shown in Table 3.

Table 3
Seed and Amendment Rates
Area RT14, 1989

Seeded Species	Pounds/Acre
Pensacola bahiagrass	35
Common bermudagrass	10
Cochise lovegrass	3
Sericia lespedeza	35
Browntop millet	50
Soil Amendments	**Pounds/Acre**
Chicken litter	20,000
Hay mulch	6,000
Wood fiber mulch	2,000
Lime	2,000
34-0-0 fertilizer[1]	235[2]
0-46-0 fertilizer[1]	195[3]
0-0-60 fertilizer[1]	316[4]

[1] Granular form.
[2] Yields 80 lb actual nitrogen per acre.
[3] Yields 90 lb P_2O_5 per acre.
[4] Yields 190 lb K_2O per acre.

Year 3

In March 1990, soil samples were collected from each plot for chemical analysis and determination of soil fertility levels and fertilizer needs. In May 1990, biomass samples were harvested to compare the previous year's growth between treatments and vegetation. A three-sided square of 0.75-in. polyvinyl chloride pipe was randomly thrown in each plot, and the vegetation was collected to the soil surface (Figure 14).

Figure 14. Collecting biomass samples for yield analysis

Three replicates were harvested from each plot. These samples were transported to the WES and dried in a forage dryer at 70 °C to determine pounds per acre on an oven dry weight basis.

Liquid fertilizer was applied in May to all plots that received fertilizer in 1989. Liquid 15-7.5-15 fertilizer was applied at 400 lb/acre to yield 60 lb nitrogen, 30 lb phosphoric acid (P_2O_5), and 60 lb potash (K_2O) per acre. Biomass samples were collected in September in the same manner as before, and pound per acre values were determined. Visual observations were made to determine percent of planted species in each plot.

Results and Discussion

Year 1

After planting of vegetation in March 1988, very little rainfall fell on the Fort Rucker area. On an inspection trip in May, germination of seeded vegetation was very low. The only notable vegetation was Cochise lovegrass, Pensacola bahiagrass, common bermudagrass, and occasional weeds. Additional fertilizer applications were canceled since very little benefit was derived.

The Fort Rucker area began receiving normal rainfall in July 1988. By August, significant growth of the above-mentioned species, especially Cochise lovegrass, had occurred in the fertilized plots (Figure 15). Unfertilized plots had little if any vegetation.

Figure 15. Cochise lovegrass on recommended fertilizer rate (1X) plot

The observed results of the 1988 test show the importance of species selection and soil fertility for the successful establishment of vegetation in a droughty environment. Results also indicated a need for increased soil tillage (ripping soil hardpan) to allow better root penetration and increased soil moisture retention for faster germination and establishment.

Years 2 and 3

In 1989, extensive soil sampling and analysis was conducted to provide a more accurate accounting of soil amendment needs. Also, it was necessary to identify any significant variation in nutrient levels between treatment plots due to 1988 fertilizer additions or added soil material.

As expected, the nutrient levels were mostly low to very low, with no statistically significant differences between treatment plots prior to treatment except for potassium, as shown in Table 4. Detailed results of the soil analysis are shown in Appendix B.

Table 4
Comparison of Soil Potasssium Levels in Treatment Plots Prior to 1989 Demonstration, Area RT14, February 1989

Treatment	Pounds/Acre
Lime	43.625AB[1]
Lime + fertilizer	40.250B
Lime + fertilizer + wood mulch	56.875AB
Lime + fertilizer + wood mulch + chicken litter	54.125AB
Lime + fertilizer + hay mulch + chicken litter	58.667A

[1] Means with the same letter are not significantly different at $\alpha = 0.05$.

Soil analysis in March 1990 showed significant differences between treatment plots after the addition of fertilizer, mulch, and chicken litter. Phosphorus levels were statistically higher in plots amended with lime + fertilizer + hay mulch + chicken litter than in plots without chicken litter (Table 5). Potassium levels were statistically higher in plots amended with hay mulch versus no hay mulch, chicken litter versus no chicken litter and no mulch, and fertilizer and wood mulch versus no fertilizer and mulch (Table 6).

Comparisons of vegetative cover are used to evaluate the dust control value of soil amendments, considering greater dust control with increasing vegetative cover. For example, the striking contrast between a lime plot (foreground) and a lime + fertilizer + wood mulch + chicken litter plot in May 1990, after 6 months of AH-64 Apache activity, can be seen in Figure 16. For all practical purposes, the lime-only plots were void of vegetation.

Figure 17 shows dust generation over a lime-only plot, while Figure 18 shows no dust generation over a lime + fertilizer + wood mulch + chicken litter plot. Both photos were taken in May 1990.

Comparisons of treatment versus total biomass for each vegetation plot are presented in Appendix C (Tables C1 and C2). Vegetative cover in the lime + fertilizer and the lime + fertilizer + wood mulch plots was significantly higher than lime only for both bahiagrass and lovegrass. Lime + fertilizer + wood mulch increased biomass significantly over lime plots for bermudagrass. Biomass was higher in chicken litter versus no-chicken litter plots for all vegetation, and hay mulch plots were statistically higher than wood mulch plots for bahiagrass.

The lime and lime + fertilizer + wood mulch + chicken litter plots shown in Figure 16 are shown 4 months later (September 1990) in Figure 19. Notice the severe erosion caused by surface water runoff in addition

Table 5
Comparison of Soil Potassium Levels in Treatment Plots After Treatment, Area RT14, March 1990

Treatment	Pounds/Acre
Lime	34.63D[1]
Lime and fertilizer	81.25CD
Lime and fertilizer and wood mulch	137.25CB
Lime and fertilizer and wood mulch and chicken litter	185.37B
Lime and fertilizer and hay mulch and chicken litter	276.33A

[1] Means with the same letter are not significantly different at $\alpha = 0.05$.

Table 6
Comparison of Soil Phosphorus Levels in Treatment Plots After Treatment, Area RT14, March 1990

Treatment	Pounds/Acre
Lime	15.75B[1]
Lime and fertilizer	22.25B
Lime and fertilizer and wood mulch	20.75B
Lime and fertilizer and wood mulch and chicken litter	41.38AB
Lime and fertilizer and hay mulch and chicken litter	78.00A

[1] Means with the same letter are not significantly different at $\alpha = 0.05$.

Figure 16. Lime (foreground) versus lime + fertilizer + wood mulch + chicken litter (beyond foreground), May 1990

Figure 17. AH-64 Apache generating dust over a lime-only plot

Figure 18. AH-64 Apache over lime + fertilizer + wood mulch + chicken litter plot with no dust generation

Figure 19. Lime versus lime + fertilizer + wood mulch + chicken litter, September 1990

to rotorwash. As much as 12 in. of topsoil was lost to erosion. Comparisons of September 1990 biomass showed statistically higher biomass in lime + fertilizer and lime + fertilizer + wood mulch versus the lime-only plots for all vegetation. Plots with chicken litter were statistically higher in biomass than those without, for all vegetation. A summary of September 1990 biomass is presented in Figure 20.

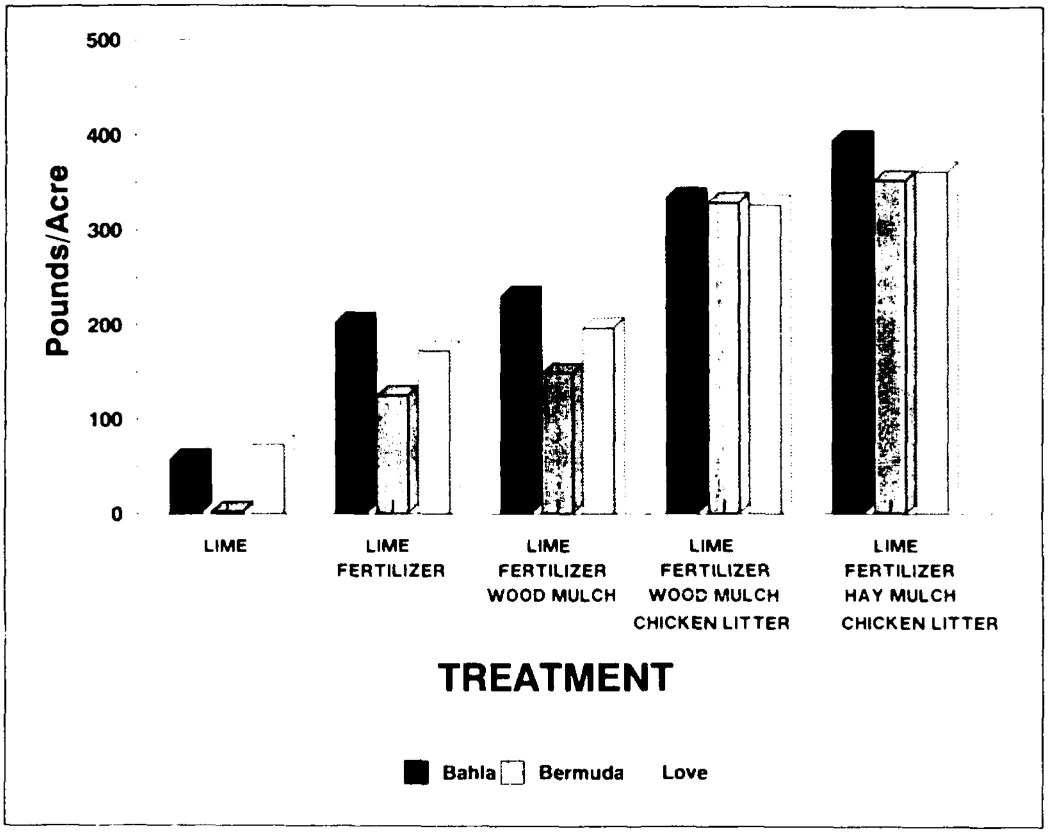


Figure 20. RT14 total biomass, September 1990

Some of the other techniques demonstrated at RT14 are worthy of mention. Sand grids, placed on both ends of the airstrip, helped hold the soil in place with marginal vegetation. Browntop millet, planted as a quick, temporary cover along the southern perimeter of the test site, gave good results considering no fertilizer was added. Sericea lespedeza, although slow to establish, gave good results in the unfertilized soil but was subject to leaf wilt in short periods of drought. Neither species was planted in an area subject to direct helicopter impact.

5 Lowe Army Heliport Demonstration

Background

Lowe Army Heliport is located in Dale County, on the bounding line of Township 5 North/Township 4 North, approximately 2 miles northwest of the main post area. According to the Dale County Soil Survey (USDA 1960), the soil on the airfield area is mostly Lakeland loamy fine sand, 0 to 5 percent slopes (LaB). The airfield also contains some 5 to 12 percent (LaC) and 12 to 24 percent (LaE) slopes. The airfield is vegetated mostly with bahiagrass of poor to moderate coverage. Management of the vegetation over the last 20 years has consisted mainly of mowing to a 2-in. height.

The airfield is used as a base for over 300 UH-1 Iroquois training helicopters. Helicopters launch and recover at this airfield during daytime and nighttime operations. All taxi maneuvers over the airfield before launch and after recovery are conducted at an altitude of approximately 6 ft. Although the airfield consists of an array of paved taxi lanes, most taxi maneuvers are conducted over grassed areas. The paved lanes are used for parking of the helicopters. The repeated low-altitude flight over a poor vegetative cover has created problem areas of soil erosion and dust generation.

The objective at Lowe Army Heliport was to improve the existing vegetation to a condition capable of reducing rotorwash impact on the soil surface and to restore severely eroded areas around launch/recover pads and in taxi lanes. Shore junipers would also be planted around taxi lanes in an attempt to deflect and disperse downwash from the soil surface. Sand grids in combination with vegetation and junipers would be used to check erosion on steep slopes.

Plans also included the use of chemical soil stabilizers in combination with vegetation. Normal operations were ongoing at this airfield during establishment of the test plots and throughout the demonstration.

Methods

Year 1

In March 1988, plots were established on the upper approach area and around the northeast launch/recover pads (Figure 21). A tractor and disk were used to till barren areas before planting. Severely eroded areas were repaired by hauling in fill soil (Eustis loamy sand and Lakeland loamy fine sand) from a nearby borrow pit, prior to planting. Lime was applied by spreader truck to all test plots at 2,000 lb/acre.

Liquid fertilizer (12-20-10) was applied by a spray truck at the rate of 500 lb/acre to 1× and 2× plots and at 250 lb/acre to 0.5× /0.5× plots. The 2× and 0.5× /0.5× plots were to receive the same rates again in May 1988. The liquid fertilizer was applied immediately after liming to minimize blowing of the lime by rotorwash.

Barren areas were also lightly disked again to incorporate both lime and fertilizer. Pensacola bahiagrass and subterranean clover were planted in all test plots using a grain drill at the rate of 31 and 20 lb/acre, respectively.

A severely eroded slope was leveled with a backhoe tractor prior to placing the sand grids (Figure 22) *and filling the grids with soil.* Granular fertilizer was applied by hand spreaders according to the rates given in Table 7. Garden rakes were used to incorporate the applied materials into the soil.

Shore junipers were planted along the grassed taxi lane and along the contour of the sand grid slope. Two rows were planted along the taxi lane, with spacing of 8 ft between rows and 2 ft between plants. Four rows were planted along the slope, with two of the rows on the sand grids.

Year 2

In February 1989, plots were revised as shown in Figure 23 (divided to show detail). Soil samples were collected from each test plot, and subsequent soil analysis was conducted. Based on soil test recommendations, lime and liquid fertilizer were applied according to the rates and times shown in Table 8. Existing vegetation was allowed to produce mature seedheads prior to mowing for reseeding purposes.

Severely eroded areas (no topsoil) were ripped with a road grader, and soil was transported by truck from the nearby borrow pit. After spreading the soil in place, lime and granular fertilizer were applied with hand equipment and incorporated with tractor and disk. Lime and fertilizer rates

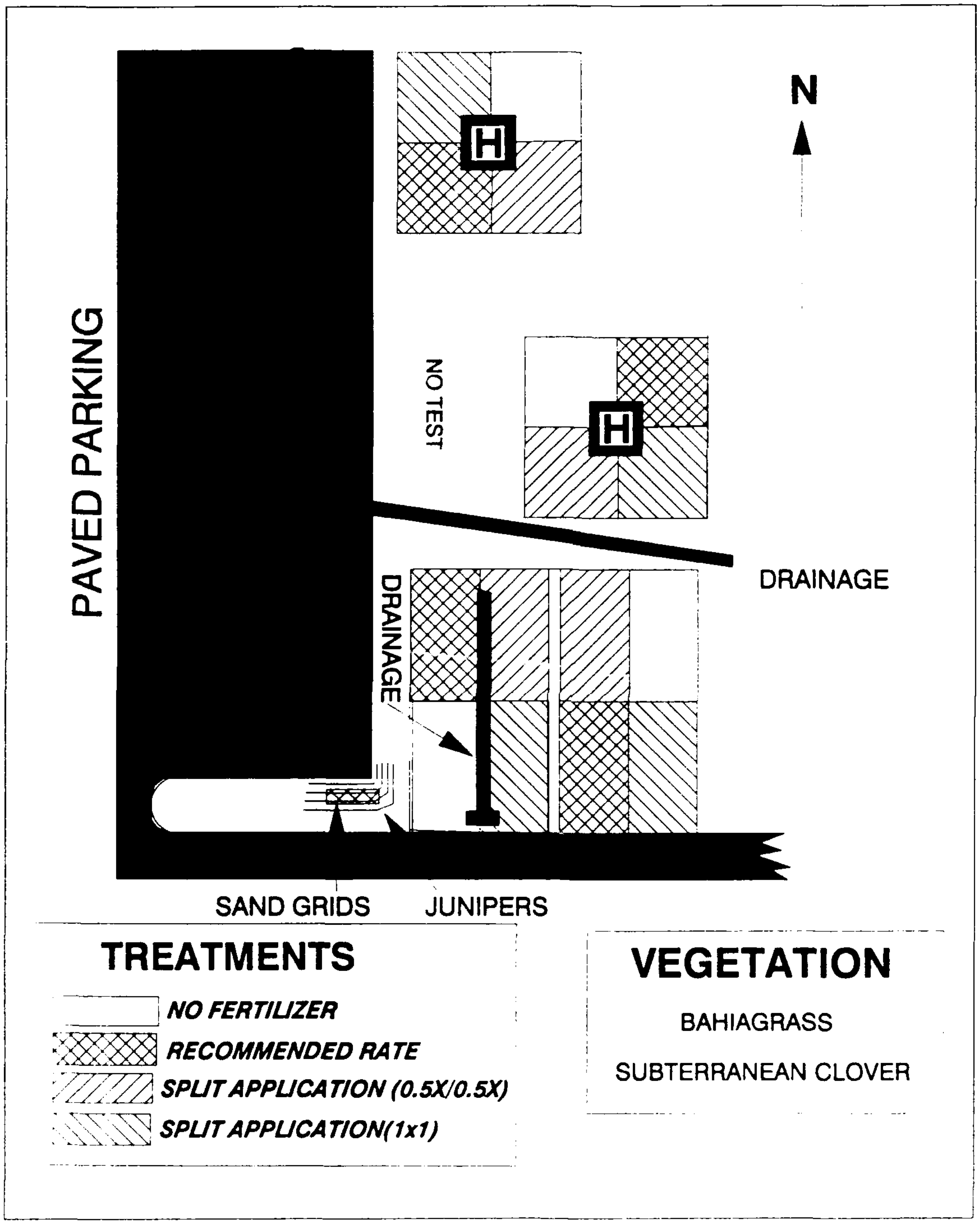
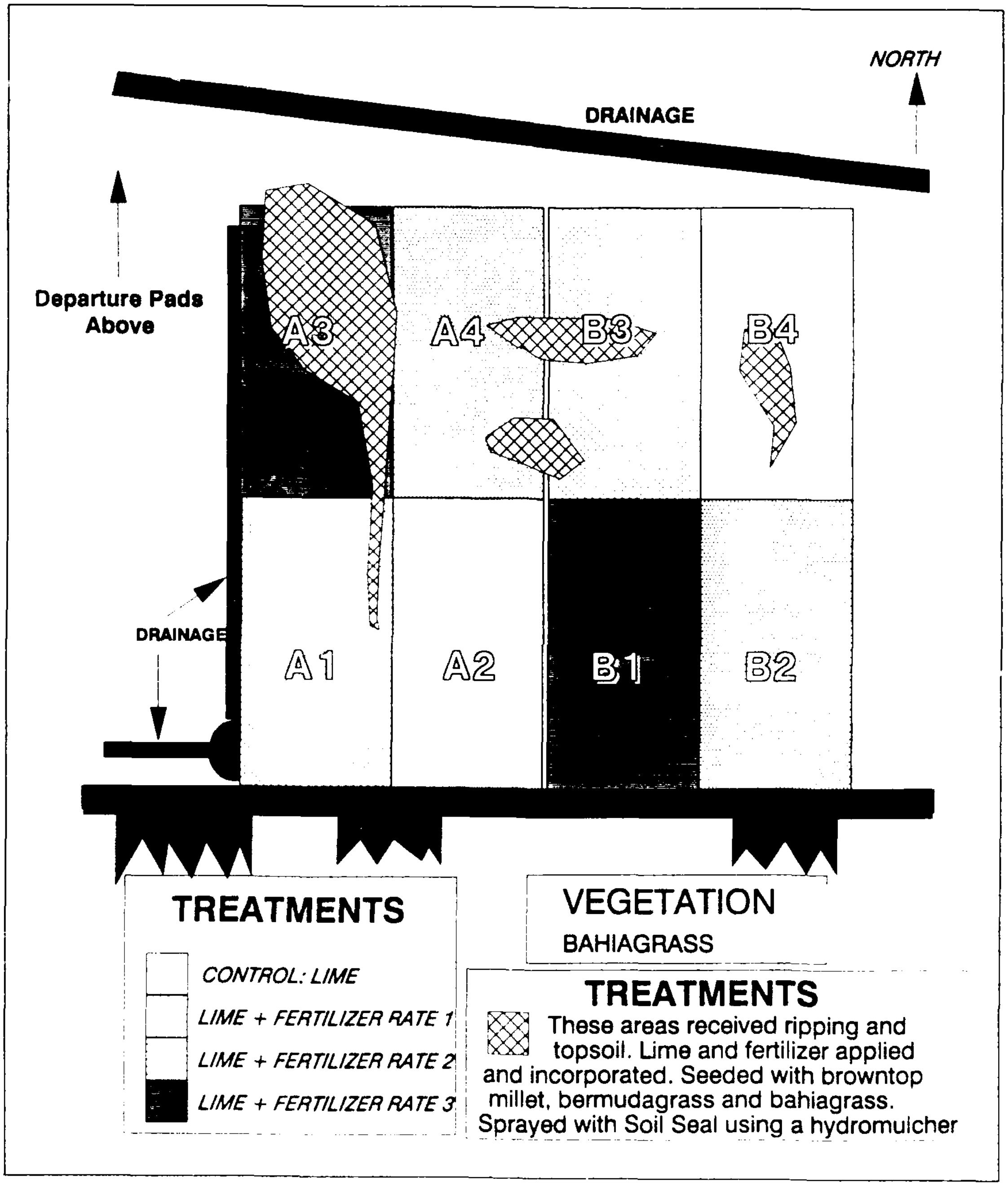


Figure 21. Lowe Army Heliport test plots, 1988

Figure 22. Sand grids placed on steep eroded slope

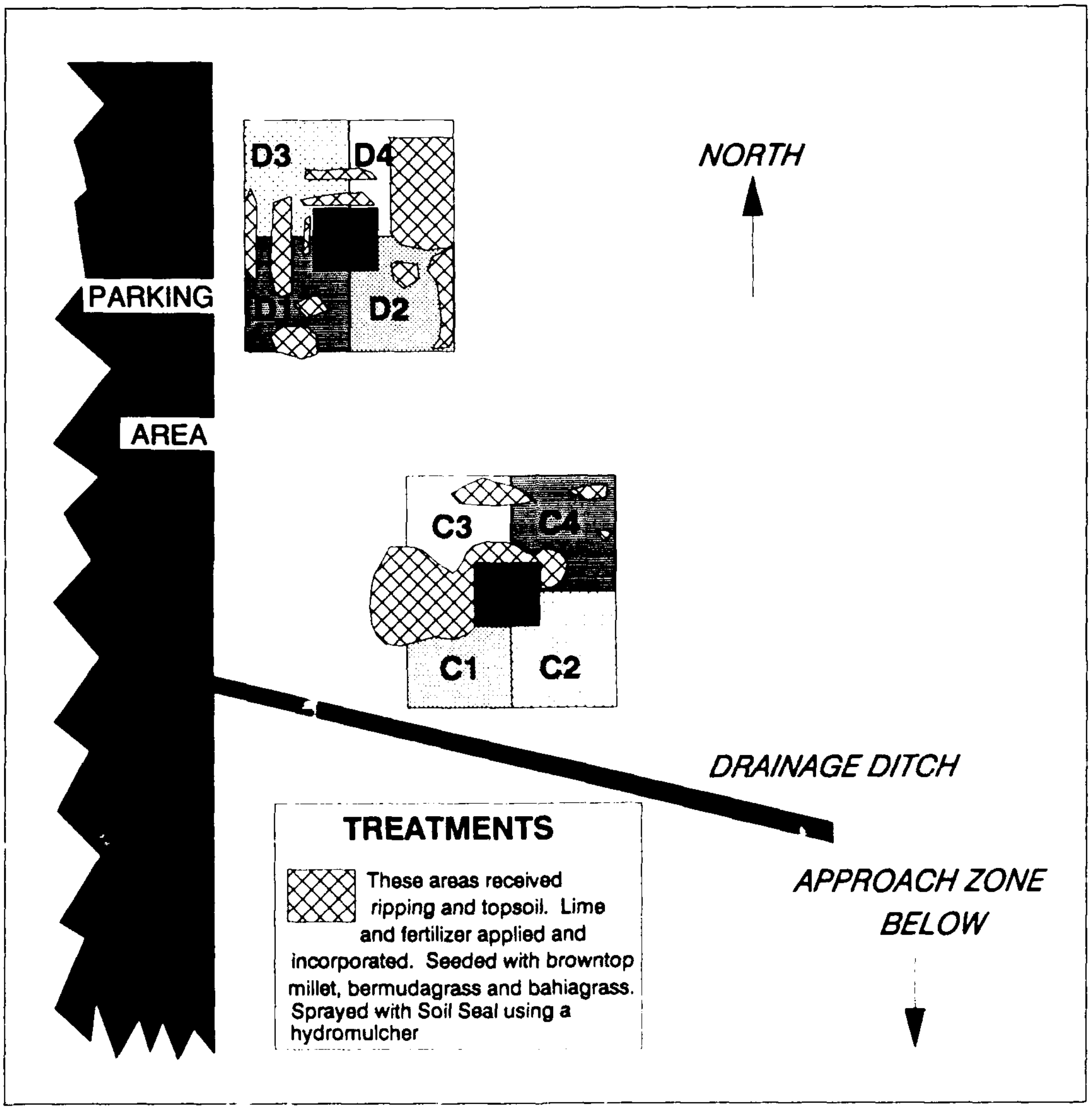
Table 7
Fertilizer Rates for Lowe Sand Grid Area

Treatment	$N-P_2O_5-K_2O$ Fertilizer, lb/acre
1X rate (60-98-52) (Single application)	400 (13-13-13) 100 (0-46-0) 25 (34-0-0)



a. Approach zone plots

Figure 23. Lowe Army Heliport test plots, 1989 (Continued)



b. Departure pad plots

Figure 23. (Concluded)

Table 8
Fertilizer Rates and Schedule for Lowe, 1989

Treatment Plot	Fertilizer Applied	Time	Total Fertilizer Applied
Rate 0	None	None	None
Rate 1	77-35-161[1]	May	77-35-161
Rate 2	77-35-161 80-0-0[2]	May Jun	157-35-161
Rate 3	77-35-161 80-0-0 80-60-60	May Jun Sep	237-95-221

[1] 77-35-161 = 77 lb/acre N, 35 lb/acre P_2O_5, and 161 lb/acre K_2O.
[2] Granular form of ammonium nitrate.

were the same as Rate 1 plots. Browntop millet, Pensacola bahiagrass, and common bermudagrass were then planted at 50, 35, and 10 lb/acre, respectively.

A chemical soil stabilizer (Soil Seal) was applied to the disturbed soil using a 1,500-gal hydromulcher (Figure 24). Ninety gallons of Soil Seal concentrate was applied per acre at a ratio of 1 gal of concentrate in 30 gal of water. This rate was the manufacturer's highest labeled rate.

Figure 24. Applying Soil Seal to barren areas after seeding

Year 3

In March 1990, soil and biomass samples were collected from each test plot. Lime and fertilizer were applied to test plots according to the rates and times shown in Table 9. In September 1990, biomass samples were again collected from each test plot.

Table 9
Fertilizer Rates and Schedule for Lowe, 1990

Treatment Plot	Fetilizer Applied	Time	Total Fertilizer Applied
Rate 0	None	None	None
Rate 1	60-51-66[1]	May	60-51-66
Rate 2	60-51-66 60-0-0[2]	May Jun	120-51-66
Rate 3	60-51-66 60-0-0 60-34-44	May Jun Aug	180-85-110

[1] 60-51-66 = 60 lb/acre N, 51 lb/acre P_2O_5, and 66 lb/acre K_2O.
[2] Granular form of ammonium nitrate.

Results and Discussion

As a result of the drought in the spring of 1988, very little planted vegetation was surviving on Lowe Army Heliport by early May (Figures 25 and 26). Seedlings that had emerged (mostly subterranean clover) were dead from lack of soil moisture. Existing bahiagrass was water stressed and exhibited no visible differences between treatments. Further fertilizer applications were discontinued due to the obvious loss of benefit.

Rain began falling in the Fort Rucker area in July 1988, and an onsite inspection of the test plots was conducted in August. Existing bahiagrass was green and growing well, and new seedings were growing in the disk cuts made by the grain drill. Juniper survival in established bahiagrass was near 0 percent, while in the fill material over the sand grids it was over 60 percent. Competition for water and an allopathic response are possible reasons for rapid death of junipers in bahiagrass.

Biomass samples collected from plots in May 1990 show statistically higher yields in Rate 2 versus control plots and in Rate 3 versus Rate 2 plots (Table C3). This indicates that increasing fertilizer application into the mid- to late-summer months increases biomass remaining after winter dormancy. September biomass yields, however, show statistically higher

Figure 25. Lowe test plots in the approach zone, May 1988

Figure 26. Lowe test plots around landing/departure pads, May 1988

yields in Rate 1 versus control plots and in the Rate 2 and Rate 3 versus Rate 1 plots (Table C3). This indicates that vegetative response to the third application of Rate 3 is not seen until the last part of the growing season. Also, the significantly higher yields in the fertilized plots versus unfertilized (control) plots means that helicopter activity is not reducing vegetative cover in vegetated areas. Significant improvement in all but the most severely damaged areas where Soil Seal was applied was noted in September 1990 (Figure 27).

Soil Seal allowed rapid germination and growth of the browntop millet and bermudagrass without soil erosion, even under helicopter pressure (Figure 28). Because of the longer time required for germination, very little bahiagrass was seen initially. Lack of rain and the inability of Fort Rucker fire trucks to periodically water these areas resulted in very little vegetation remaining by March 1990. However, Soil Seal, in combination with remaining dormant vegetation and stubble, was still holding the soil in place (Figure 29). By August 1990, erosion had occurred, both by rotorwash and surface water runoff, as shown in Figure 30.

The sand grids that were installed on the slope, in combination with the seeded vegetation, provided sufficient erosion control during the 3-year period. Very little erosion occurred over the sand grids; however, below the sand grids, erosion was more evident. More extensive soil amendments to increase vegetative growth may have prevented erosion altogether.

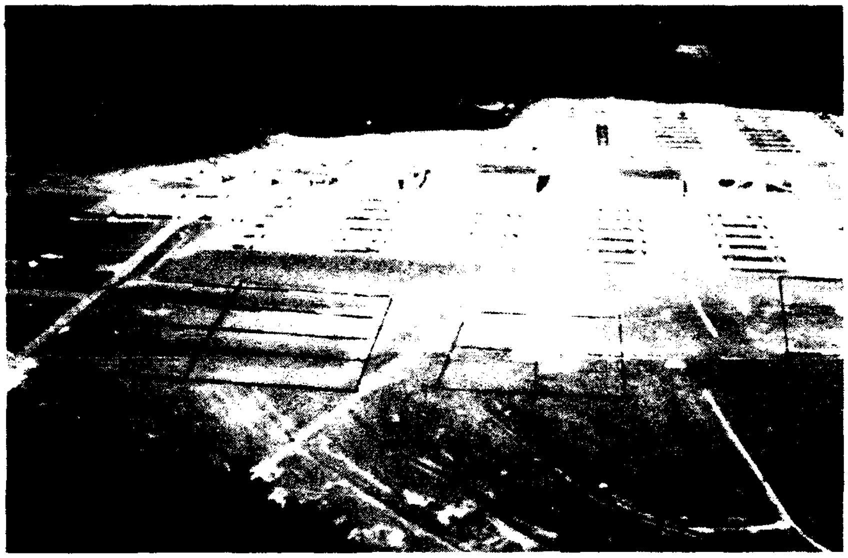


Figure 27. Approach zone and landing/departure pads, September 1990

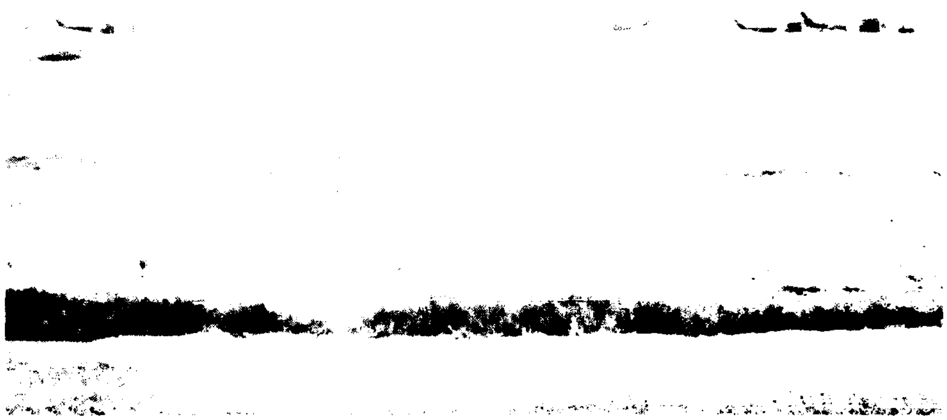


Figure 28. Barren area, September 1989, 4 weeks after planting

Figure 29. Barren area, March 1990, soil still in place

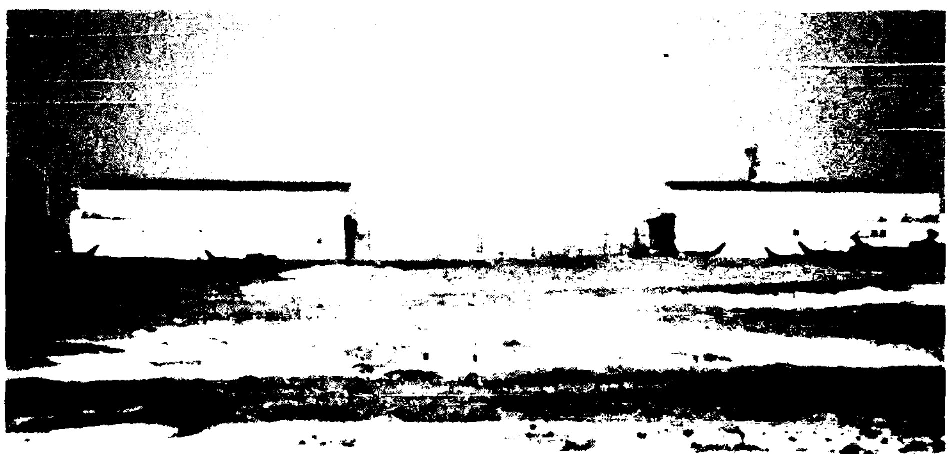


Figure 30. Barren area, August 1990, eroded by rotorwash and surface water runoff

6 Area RT333 Demonstration

Background

Remote training area RT333 is located in the southeast corner of Dale County, Alabama, near the Little Choctawhatchee River and Highway 49. The Dale County Soil Survey lists the soil on the training site as Ruston fine sandy loam, eroded, very gently sloping phase (ReB2). This soil is fine to sandy loam to a depth of approximately 16 in., and sandy to light sandy clay loam below 16 in. The soil is suited to various row crops and pasture if adequately fertilized and amended with organic matter. Contour terracing is generally practiced in farming operations on this soil.

Area RT333 is a Government-owned tract of land located in the middle of a privately owned pasture. This training area is a good example of construction techniques having major impact on erosion. Soil was scraped from the ground surface and pushed into a pile to form a pinnacle, on which a concrete landing pad was constructed. Training helicopters land on the elevated landing pad as part of their training mission. The site was also used to practice lifting of army vehicles. This results in soil surface damage from the vehicle dragged or dropped during training exercises.

The primary helicopter on this site was the CH-47. Prior to site selection, RT333 had been closed because of soil erosion under the concrete pad. This erosion was a result of water runoff entering a concrete drainage chute, not rotorwash. However, severe rotorwash erosion had occurred around and on the pinnacle slope (Figure 31). This photograph shows the occurrence of erosion around the pinnacle, where soil was scraped to construct the pinnacle, and on the side of constructed terraces.

The objectives at RT333 were to check erosion and dust generation on and around the pinnacle slope using sand grids and vegetation. Sand grids would be used on the severely eroded portion of the slope. Junipers would be planted on the slope to help disperse and slow rotorwash.

Figure 31. Area RT333 prior to test plot establishment

Methods

Year 1

In March 1988, work on RT333 began by replacing and leveling areas of soil that had been removed by erosion. Since only one treatment was used, definitive plots were not established. Sand grids were placed on severely eroded areas of the pinnacle slope and filled with soil. All disturbed or barren soil areas were disked three times. Lime was applied by spreader truck at 2,000 lb/acre, and fertilizer was applied using hand equipment at the rates shown in Table 10. Soil samples were not collected from this site prior to initiation of work in March 1988, as the availability of this site was not known prior to soil sampling.

Table 10
Fertilizer Rates for Area RT333, 1988

Treatment	$N-P_2O_5-K_2O$ Fertilizer, lb/acre
1X rate (60-98-52) (single application)	400 (13-13-13) 100 (0-46-0) 25 (34-0-0)

Fertilizer and lime rates were based on soil samples from the other two sites. The lime and fertilizer were incorporated, and then Pensacola bahiagrass and subterranean clover were seeded at 31 and 20 lb/acre, respectively. A light disking (with the blades straightened) was used to slightly cover the seeds. Shore junipers were planted in rows along the top, middle, and bottom of the slope.

Year 2

In February 1989, soil samples were collected and analyzed, and the site was divided into four plots. In June, amendments of lime, fertilizer, and chicken litter were applied to the plots as shown in Figure 32. Lime and fertilizer rates were determined by the soil analysis and are given in Table 11, along with the rates of chicken litter amendment. Pensacola bahiagrass was seeded using the grain drill, and common bermudagrass was seeded with hand spreaders to each plot.

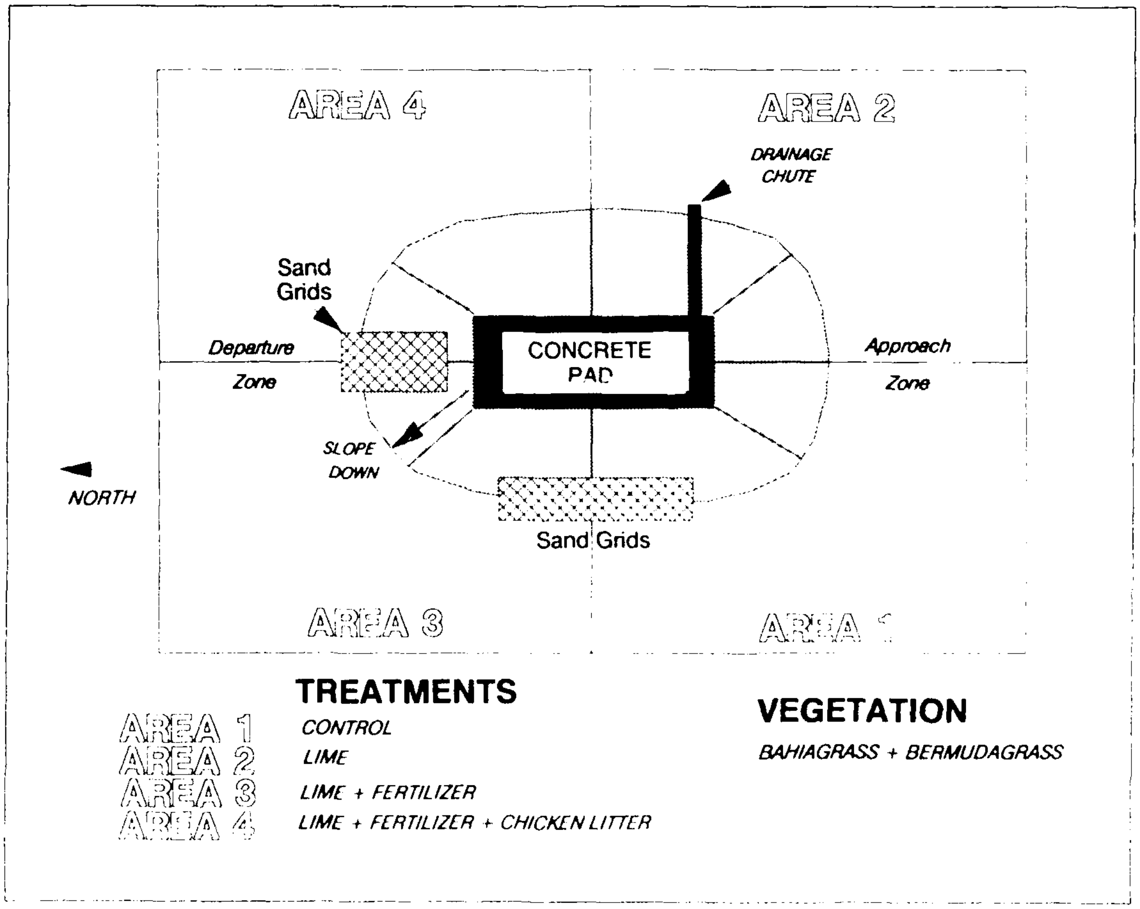


Figure 32. Area RT333 test plots, 1989

Table 11
Soil Amendment Rates for RT333, 1989

Soil Amendment	Rate, lb/acre
Lime	2,000
34-0-0	235 (80 lb N/acre
0-46-0	195 (90 lb P_2O_5/acre
0-0-60	316 (190 lb K_2O/acre)
Chicken litter	20,000

Tillage and incorporation of lime, fertilizer, and chicken litter were accomplished as before. Hay mulch was scheduled to be applied to each plot; however, this was not accomplished because of the unavailability of equipment.

Year 3

In March 1990, soil samples were collected from each of the four plots for chemical analysis and determination of fertilizer needs. Five replicate biomass samples were collected from each plot in May for yield comparisons. Granular fertilizer was applied using hand spreaders to plots 3 and 4 at the rates shown in Table 12. In September 1990, biomass samples were again collected in the same manner as before.

Table 12
Fertilizer Rates for RT333, 1990

Fertilizer	Rate, lb/acre
34-0-0	176 (60 lb N/acre
0-0-60	100 (60 lb K_2O/acre

Results and Discussion

Results of the 1988 demonstration at RT333 were similar to the results of the other two demonstration plots. Low rainfall resulted in poor germination of planted vegetation by May 1988. By August 1988, some bahiagrass had germinated and was growing well; however, coverage was not adequate (Figure 33). Analysis of soil samples taken in February 1989 indicated a need for increased fertilizer application rates.

Figure 33. Area RT333, August 1988

The application of fertilizer and chicken litter increased not only the yield of bermudagrass and bahiagrass but also the palatability to cattle in the area. In fact, the cattle preferred the fertilized versus unfertilized vegetation so much that they literally pulled the vegetation from the soil, roots and all. The surrounding pasture was unfertilized, and the small fertilized test plots had a strong appeal to the cattle. A fence was erected to keep the cattle out of the test area; however, they still managed to get in periodically.

Even with the destructive grazing in the fertilized plots, total biomass yields were still statistically higher in fertilizer versus no-fertilizer treatments (Table C4). Figure 34 shows the lime + fertilizer plot on the left half of the slope and the lime plot on the right half. Notice also the tire marks from a mowing operation. The lime + fertilizer + chicken litter plot (the most heavily damaged plot prior to demonstration) in May 1990 is shown in Figure 35.

Sand grids used on the slope to stabilize the soil until vegetation could establish were very successful in accomplishing that objective. However, juniper survival was less than 30 percent, and most of the loss occurred during the drought of 1988.

Figure 34. Lime + fertilizer versus control plot, September 1990

Figure 35. Lime + fertilizer + chicken litter plot, May 1990

7 Conclusions and Observations

Results of the Lowe Army Heliport demonstration indicate that existing vegetation can be improved by maintaining the soil fertility, and dust generation can be reduced by doing so. Late-summer fertilization is necessary to have substantial biomass prior to the summer growing season. Successful restoration of highly damaged areas, such as those around the departure pads at Lowe Army Heliport, is difficult under constant helicopter pressure. Although Soil Seal was shown to temporarily hold the soil in place under helicopter pressure, allowing seedling emergence, the lack of soil moisture prevented successful growth. This is where irrigation would be very beneficial.

Total site restoration on remote training areas, such as RT14, is possible, and dust control can be achieved quite effectively if the site remains closed during the restoration process. Closure will generally require 5 months. Chicken litter is the key to successful establishment of vegetation on these remote sites, due to its moisture-holding capacity as well as its nutrient value. Mulch, wood fiber, or hay is also important to retain soil surface moisture, thus increasing seed germination. Mulch also helps to reduce surface water runoff erosion. However, mulch can be used only if the the immediate site is closed to helicopter activity, because of the possible suction into engine parts.

Sand grids, in combination with vegetative restoration, can be very effective in stabilizing eroded slopes, such as those on RT333. Most of these areas are affected more by surface water runoff erosion than rotorwash. Fertilization of small remote training areas that are subject to cattle usage must be conducted to prevent concentrating the cattle around the landing areas. Cattle can be benficial to a training area by reducing mowing requirements and returning nutrients to the soil. Cattle can also be detrimental because of overgrazing and the creation of worn trails (which can lead to erosion by rotorwash).

The effectiveness of a low-growing shrub (shore juniper) for rotorwash dispersion was not determined because of the high rate of death during the severe drought in 1988. The survival rate may be substantially increased if better soil preparation techniques and irrigation are used to establish shore juniper. However, the intense labor required for this type of establishment would not justify the possible benefit.

Although mowing techniques were not tested, WES investigators are convinced, from observation of the present techniques, that modifying the techniques will significantly reduce damage to the soil surface, thus reducing potential dust-generation problems. Also, modification of helicopter training techniques and construction of training areas would help to reduce some of the problems that lead to rotorwash erosion.

Irrigation was recommended by WES investigators; however, it was not tested because of the funding limits and inability to provide access to water sources within the time allotted for testing. Since successful germination and growth of seeded vegetation and survival of transplanted shrubs are highly dependent on available soil moisture, irrigation is important to a dust-control strategy using solely agronomic methods.

In general, this study concluded that agronomic methods, specifically the use of managed vegetative cover, can greatly reduce erosion and dust generation by rotorwash on helicopter training areas at Fort Rucker, Alabama. However, since the study was conducted over a period of only 3 years, additional study is necessary to fully evaluate the long-term effectiveness of vegetative cover as a dust-control measure.

A controlled laboratory study, using a rotorwash simulator, can evaluate rotorwash effects on various vegetative species, mowing heights, and soil conditions, including soil types, fertility, and moisture regimes. This type of study could be easily applied to helicopter training areas anywhere in the world.

A program could also be established to monitor onsite effects of rotorwash on training areas restored and/or managed according to the recommendations in this report. A 5-year monitoring program would be adequate once the recommended management program is in place.

8 Recommendations for Dust Control at Fort Rucker

General

The recommendations contained in this report provide some guidance as a starting point for management of helicopter training areas to control dust generation by rotorwash. Recommendations are based on information in literature and on the findings of the 3-year study, which may be limiting, because of weather and site-specific factors. Recommended methods should be incorporated into the management strategy of all affected training areas and responses monitored. Modifications for specific training sites may be required.

Recommendations are presented for specific types of training areas and for new construction sites. Recommendations include repair, restoration, and vegetative management techniques as well as mowing and training modifications that will help reduce damage to vegetative cover and soil surfaces. For each training area, representative soil analysis should be conducted prior to any restoration or fertilizer application. Soil analysis should also be conducted on construction sites for new training areas. Soil analysis should include soil pH, calcium, magnesium, phosphorus, potassium, sulfur, and organic matter levels.

Fertilizer recommendations for both pasture and hay production should be requested from the soil testing laboratory. Sufficient numbers of soil samples should be collected at 0 to 6 in. and 6 to 12 in. from each soil type and/or degree of damage for each training area. Soil analysis should be conducted every 3 years for each training area, or more often if needed to identify problems with vegetative growth.

County soil maps can be very beneficial in determining soil types and potential uses, limitations, and general soil fertility. County agents can assist in providing interpretation of soil analysis and required fertilizer application. Also, an inventory of major vegetation should be made on each training area. This will be necessary to determine specific fertility and other management needs. The major vegetation present or desired for each training area should be reported to the soil testing laboratory upon submission of soil samples.

Although no testing was done to substantiate the recommendation that raising the mowing height would reduce dust generation, evidence of damage and exposure of soil surfaces at 2-in. mowing heights was enough justification to warrant an immediate change to a 6-in. height. This was initiated in fiscal year 1990 for all helicopter training areas at Fort Rucker.

Basefields

Basefields consist of parking areas for large numbers of helicopters, paved traffic lanes and departure pads, and grassed areas. Basefields include Cairns Army Airfield, Guthrie Army Airfield, Hanchey Army Heliport, Lowe Army Heliport, and Shell Army Heliport.

Most of the dust problems occur around the paved areas and in the grassed areas used for taxi lanes. These areas contain mostly bahiagrass and sometimes centipedegrass and bermudagrass. Bahiagrass (variety Pensacola) is the vegetation of choice for these areas.

For very thin vegetative cover, reseeding will be necessary, prior to fertilization, to increase cover. This may be accomplished by planting new seeds with a grain or grassland drill, or by allowing seedhead formation and mowing to disperse seeds. (Pensacola bahiagrass may not be the existing bahiagrass onsite.)

New seeds should be planted at 30 to 35 lb/acre from March through June; however, rainfall will control germination success. Seedheads should be grown and dispersed from June through September.

Lime and fertilizers should be applied at rates according to soil test recommendations. Lime can be applied in the spring, at or prior to the fertilizer application, or in the fall. For first-time fertilization, rates for hay production for rapid growth and establishment are recommended. Nitrogen should be split into three equal applications about 6 weeks apart (May, June, and August) at no more than 80 lb actual nitrogen per acre per application. Phosphorus and potassium rates may vary depending on the soil tests, and should be split into two applications with 60 percent of phosphorus and 70 percent of potassium applied in May. The remaining 40 and 30 percent should be applied at the end of August.

For barren areas outside of flight paths, ripping with a subsoiler (or roadgrader) and/or tillage with a disk will be necessary to establish vegetation. If a substantial amount of Peneprime (or other asphalt derivative) is present, it should be removed prior to tillage. If fill soil is necessary, soil analysis should be performed on the fill soil, and lime and fertilizer applied accordingly. Incorporation of chicken litter will greatly enhance vegetative coverage; however, weeds (from seed in the litter) may also be enhanced. Proximity to residential and office areas must also be considered because of the offensive odor.

Seeding should include a mix of browntop millet, Pensacola bahiagrass, and common bermudagrass at 50, 35, and 4 lb/acre. The final step is to apply wood fiber mulch with a chemical tack (Soil Seal may be used) using the hydromulcher. Barren areas inside flight paths can be restored by this method if the affected area is closed to traffic until vegetation is established, or 6 to 8 weeks.

Barren areas in active flight paths (grassed and paved taxi lanes and around departure pads) can be treated in the same manner as above, less the wood fiber, if Soil Seal is applied at 90 gal of concentrate per acre and the affected area is watered as necessary to maintain a moist soil. Watering, judging from experience during field tests, will not be possible unless emphasis on helicopter training areas equals that on golf recreation and housing areas. A commitment from the command level down will be necessary to supply water to needed helicopter training areas.

The alternative is to place 2-in.-diam gravel in barren areas of the flight path at a depth of 4 in. Gravel should be placed around ground lights where hand mowing or herbicides are used. Vegetation in the gravel can be controlled with a nonselective herbicide such as Roundup.

Stagefields and Special-Use Facilities

Most stagefields have sufficient paved landing, hover, and taxi areas, and most of the dust problems occur adjacent to these areas. Since these areas are numerous and the barren areas are typically smaller and adjacent to pavement, gravel may be the best solution where topsoil is removed along pavement.

The application of seed, lime, and fertilizer to improve existing vegetation and restoration of barren areas away from paved traffic lanes can be accomplished in the same manner as on basefields. On refueling facilities, where helicopters must frequently hover or park on grassed areas, either pavement or gravel should be provided.

Remote Training Areas

Many of the RT's, such as RT14, RT333, and RT4 (also used as a refuel site), are in areas somewhat inaccessible during wet conditions and are only semi-improved. Most have some type of paved landing/hover area (not al vays utilized) and are poorly constructed with regard to drainage and vegetative cover. As a result, most will require complete restoration to become fully usable by helicopters. Closing the site to air traffic is necessary until vegetative cover is fully restored (16 weeks or less).

The site must first be filled and leveled, and adequate drainage structure added. For severely eroded steep slopes, sand grids should be installed and covered with at least 4 in. of soil to stabilize the site until vegetation takes over. The site should then be ripped (except over sand grids) and disked. Lime, fertilizer, and chicken litter should be applied separately and incorporated with one pass of a disk. The lime and fertilizer rates should be determined from soil analysis of both the RT site and the fill soil borrow area. The higher fertilizer rates recommended for hay production should be used. Granular fertilizer should be used when incorporated, and the liquid form should be applied after establishment. Chicken litter should be applied at 20,000 lb/acre.

Pensacola bahiagrass is preferred for these sites, and bermudagrass may be mixed to provide faster coverage. Since Cochise lovegrass is not a sod-forming grass, it is not recommended for areas subject to rotorwash. However, it may be seeded in background areas not subject to significant erosion, where some vegetative cover is needed and access for tillage is limited.

Mulch should be applied for successful germination of seeded grasses. Hay mulch or wood fiber mulch will provide adequate results. Availability and proximity of materials and equipment must be considered before choosing the method.

Pasture rates of fertilizer should be applied beginning in the second year, as described in the basefields section above.

Landing Zones

Landing zone (LZ) training areas will perhaps be the most difficult to manage, because of their small size and remote access. Many are also on leased land. The worst damage on these sites appears to occur as a result of repeated skid impact by UH-1 helicopters, which leads to creation of deep pits by rotorwash. In some cases, LZ's damaged beyond safe use are simply abandoned. However, the pits can be filled, vegetation restored, and the entire site then managed using the techniques described above.

The problem with these sites is the specified landing points. Vegetation can be managed; however, the damage incurred by repeated skid impact and exhaust scorching needs to be reduced. This can be done by rotating the use of LZ's or merely the landing points, if the LZ is large enough. When the landing point or LZ begins to show evidence of damage, it should be closed or rotated and given time for self-repair. If the soil fertility is managed, the sites should be able to repair themselves through regrowth.

The availability of leased land for use as LZ's may be limited. Thus, the rotation of entire LZ's or landing points may not be an option. In this case, metal landing mats can be placed and anchored for use as landing pads. Gravel could also be used. However, if access to the site is limited, a landing mat could be removed more easily.

Firing Points

The AH-64 Apache and UH-1 Cobra gunships, when loaded with ammunition, create high downwash velocities while hovering over firing points. This, coupled with very poor soil conditions and safety hazards from unexploded duds at the firing point, makes soil tillage and soil fertility management difficult. Present methods of providing large gravel pads or, in the case of the Phase III firing range, asphalt pads are more efficient.

Around the older firing points that use gravel pads, Cochise lovegrass might be a good vegetation. It could be sown directly on the soil surface with fair to good success, and will provide additional dust control.

Additional Information

Lime and fertilizer (liquid or granular) can be applied to active airfields without corrosion to aircraft and blowing by rotorwash if the following guidelines are observed:

a. Apply lime and fertilizer on damp ground. This can be accomplished in the mornings just after aircraft are launched or after rainfall.

b. Conduct applications to traffic areas between launch and recovery periods first, and then to border and outlying areas.

c. Conduct applications on weekends to eliminate some of the problems; however, application around parked aircraft is more difficult.

d. Apply liquid fertilizer (although more expensive) when no incorporation is included.

Ideally, since no vegetation is removed from the site (such as by hay baling or cattle grazing), fertilizer requirements should decrease over time. A monitoring program to evaluate long-term effectiveness and response may be necessary to achieve the most efficient management strategy for maintaining vegetation as a dust-control method.

Specific recommendations are given for the three test sites in Table 13, and for all training area types in Table 14.

Table 13

Recommendations for Training Area Test Sites

Test Site and Condition	Soil[1] Prep.	Soil Amendments[2] (lb/acre)						Soil Maintenance[3] (lb/acre)				Veg[4]	Other[5]	Closure[6]
	Tillage	Lime	N	P_2O_5	K_2O	Chicken Litter	Mulch	Lime	N	P_2O_5	K_2O	Rate (lb/acre) Method	Additional Treatment or Alternate Method	Flight Restrictions
RT14	RDHC	STJ	80 JG	ST JG	ST JG	20,000	6000 Hay	ST3M	60 ML	60 ML	60 ML	PB 35 Br CB 10 Bc+	--	16 weeks All use
RT333 (Barren Areas)	RDHC	STJ	80 JG	ST JG	ST JG	20,000	6000 Hay	ST3M	60 ML	60 ML	60 ML	PB 35 Br CB 10 Bc	SG	16 weeks All use
RT333 (Vegetated Areas)	--	STJ	80 JG	ST JG	ST JG	--	--	ST3M	60 ML	60 ML	60 ML	PB 30 Dr	--	NA
Lowe AAF (Barren Areas Inside Flight Path	RDHC	STJ	80 JG	60% ST JG 40% ST AL	70% ST JG 30% ST AL	20,000	--	ST3M	60 ML 60 JL 60 AL	60 ML 40 AL	70 ML 30 AL	PB 35 Br CB 10 Bc BM 50 Dr	SS(HM) IR AG(ALT)	6 weeks Hover < 20 ft
Lowe AAF (Barren Areas Outside Flight Path)	RDHC	STJ	80 JG	60% St JG 40% St AL	70% ST JG 30% ST AL	20,000	2000 WF (HM)	ST3M	60 ML 60 JL 60 AL	60 ML 40 AL	75 ML 30 AL	PB 35 Br CB 10 Bc BM 50 Dr	SSWF (HM)	NA
Lowe AAF (Vegetated Areas Inside Flight Path)	--	STM	80 ML 80 JL 80 AL	60% ST ML 40% St AL	70% ST ML 30% ST AL	--	--	ST3M	60 ML 60 JL 60 AL	60 ML 40 AL	70 ML 30 AL	PB 30 Dr	--	None
Lowe AAF (Vegetated Areas Outside Flight Path)	--	STM	80 ML 80 JL 80 AL	60% ST ML 40% ST AL	70% ST ML 30% ST AL	--	--	ST3M	60 ML	60 ML	60 ML	PB 30 Dr	--	None
Lowe AAF (Small Barren Areas Near Paved Parking)	--	--	--	--	--	--	--	--	--	--	--	--	AG	None

Note: (HM) = Applied by hydromulcher, + = optional addition; ++ = optional hydromulching application.
[1] Soil Prep - Tillage: R = one pass with soil ripper, D = three passes with disk, H = one pass with harrow, and C = two passes with cultipacker (one before and one after seeding).
[2] Soil Amendments: First-year amendments, ST = soil test recommended rate, M = May application, J = June application, A = August application. L = liquid fertilizer, G = granular fertilizer, WF = wood fiber.
[3] Soil Maintenance: Yearly application of indicated fertilizer. Lime should be applied every 3 years according to soil test recommendation (ST3). Fertilizer rates are those necessary for good bahia grass production and should be adjusted by soil tests every 3 years.
[4] Veg - Vegetation seeding rates and methods: PB = Pensacola bahia grass, CB = common bermuda grass, BM = browntop millet; Br = brillion seeder, Bc = broadcast, and Dr = drill.
[5] Other - additional treatment or alternate method: SS = Soil Seal at 90 gal concentrate/acre, SSWF = Soil Seal at 60 gal concentrate/acre with wood fiber, AG = 2-in. aggregate, SG = sand grids, IR = irrigation; (ALT) = alternate method: AG alternate for vegetation, SSWF alternate for hay mulch.
[6] Closure - flight restrictions: All use = no aircraft use for indicated time; Hover < __ ft = no hovering less than indicated height.

Table 14

Recommendations for Different Training Area Types

Test Site and Condition	Soil[1] Prep.	Soil Amendments[2] (lb/acre)						Soil Maintenance[3] (lb/acre)				Veg[4]	Other[5]	Closure[6]
	Tillage	Lime	N	P_2O_5	K_2O	Chicken Litter	Mulch	Lime	N	P_2O_5	K_2O	Rate (lb/acre) Method	Additional Treatment or Alternate Method	Flight Restrictions
Basefields														
Barren Areas Outside Flight Path	RDHC	STJ	80 JG 80 AL	60% ST JG 40% ST AL	70% ST JG 30% ST AL	20,000	2000 WF (HM)	ST3M	60 ML	60 ML	60 ML	PB 35 Br CB 10 Bc BM 50 Dr	SSWF (HM)	NA
Barren Areas Inside Flight Path	RDHC	STJ	80 JG 80 AL	60% ST JG 40% ST AL	70% ST JG 30% ST AL	20,000	--	ST3M	60 ML 60 JL 60 AL	60 ML 40 AL	70 ML 30 AL	PB 35 Br CB 10 Bc BM 50 Dr	SS(HM) IR AG(ALT)	6 weeks Hover < 20 ft
Vegetated Areas Outside Flight Path	--	STM	80 ML 80 JL 80 AL	60% ST ML 40% St AL	70% ST ML 30% ST AL	--	--	ST3M	60 ML	60 ML	60 ML	PB 30 Dr		NA
Vegetated Areas Inside Flight Path	--	STM	80 M: 80 JL 80 AL	60% ST ML 40% ST AL	70% ST ML 30% ST AL	--	--	ST3M	60 ML 60 JL 60 AL	60 ML 40 AL	70 ML 30 AL	PB 30 Dr		None
Small Barren Areas Near Pavement (Parking Areas)	--	-	--	--	--	--	--	--	--	--	--	--	AG	None

(Continued)

Note: (HM) = Applied by hydromulcher, + = optional addition; ++ = optional hydromulching application.
[1]Soil Prep - Tillage: R = one pass with soil ripper, D = three passes with disk, H = one pass with harrow, and C = two passes with cultipacker (one before and one after seeding).
[2]Soil Amendments: First-year amendments, ST = soil test recommended rate, M = May application, J = June application, A = August application. L = liquid fertilizer, G = granular fertilizer, WF = wood fiber.
[3]Soil Maintenance: Yearly application of indicated fertilizer. Lime should be applied every 3 years according to soil test recommendation (ST3). Fertilizer rates are those necessary for good bahia grass production and should be adjusted by soil tests every 3 years.
[4]Veg - Vegetation seeding rates and methods: PB = Pensacola bahia grass, CB = common bermuda grass, BM = browntop millet, CL = cochise lovegrass; Br = brillion seeder, Bc = broadcast, and Dr = drill.
[5]Other - additional treatment or alternate method: SS = Soil Seal at 90 gal concentrate/acre, SSWF = Soil Seal at 60 gal concentrate/acre with wood fiber, AG = 2-in. aggretgate, SG = sand grids, PMT = concrete or asphalt pavement, IR = irrigation, and LM = landing mat; (ALT) = alternate method: AG alternate for vegetation, SSWF alternate for hay mulch, PMT alternate for Ag, and AG alternate for LM.
[6]Closure - flight restrictions: All use = no aircraft use for indicated time; Hover < 20 ft = no hovering less than indicated height.

Table 14 (Continued)

Test Site and Condition	Soil Prep.	Soil Amendments (lb/acre)						Soil Maintenance (lb/acre)				Veg	Other	Closure
	Tillage	Lime	N	P_2O_5	K_2O	Chicken Litter	Mulch	Lime	N	P_2O_5	K_2O	Rate (lb/acre) Method	Additional Treatment or Alternate Method	Flight Restrictions
Stagefields and Special Use Facilities														
Barren Areas Away From Pavement or Flight Path	RDHC	STJ	80 JG	ST JG	ST JG	20,000	2000 WF (HM)	ST3M	60 ML	60 ML	60 ML	PB 35 Br CB 10 Bc BM 50 Dr	SSWF (HM)	None
Small Barren Areas Near Pavement	--	--	--	--	--	--	--	--	--	--	--	--	AG	None
Large Barren Areas Near Pavement	RDHC	STJ	80 JG	60% ST JG 40% ST AL	70% ST JG 30% ST AL	20,000	--	ST3M	60 ML	60 ML	60 ML	PB 35 Br CB 10 Bc BM 50 Dr	SS(HM) IR AG(ALT)	6 weeks Hover < 20 ft
Unpaved Areas Subject to Frequent Hover or Parking	--	--	--	--	--	--	--	--	--	--	--	--	AG PMT(ALT)	None
Vegetated Areas	--	STM	80 ML 80 JL 80 AL	60% ST ML 40% ST AL	70% ST ML 30% ST AL	--	--	ST3M	60 ML	60 ML	60 ML	PB 30 Dr	--	None
Remote Training Areas (RT)														
Barren Areas	RDHC	STJ	80 JG	ST JG	ST JG	20,000	6000 Hay	ST3M	60 ML	60 ML	60 ML	PB 35 Br BC 10 Bc+	SSWF(HM) (ALT) SG	16 weeks All use
Vegetated Areas	--	STM	80 ML	ST ML	ST ML	--	--	ST3M	60 ML	60 ML	60 ML	PB 30 Dr		None
Eroded or Poorly Vegetated Perimeter (mainly slopes and limited access areas)	--	ST (HM)	80 JG (HM)	ST JG (HM)	ST JG (HM)	--	2000 WF (HM)	--	--	--	--	CL 3 HM	SSWF (HM)	NA

(Continued)

Table 14 (Concluded)

Test Site and Condition	Soil Prep.	Soil Amendments (lb/acre)						Soil Maintenance (lb/acre)				Veg	Other	Closure
	Tillage	Lime	N	P_2O_5	K_2O	Chicken Litter	Mulch	Lime	N	P_2O_5	K_2O	Rate (lb/acre) Method	Additional Treatment or Alternate Method	Flight Restrictions
Landing Zones (LZ)														
Eroded Landing Points With Rotation	RDHC	STJ	80 JG	ST JG	ST JG	20,000	6000 Hay	ST3M	60 ML	60 ML	60 ML	PB 35 Br CB 10 Bc	--	16 weeks All use
Eroded Landing Points Without Rotation	--	--	--	--	--	--	--	--	--	--	--	--	LM AG(ALT)	None
Vegetated Areas	--	STM	80 ML	ST ML	ST ML	--	--	ST3M	60 ML	60 ML	60 ML	PB 30 Dr	--	None
Firing Points														
Hover Area on Old Firing Points	--	--	--	--	--	--	--	--	--	--	--	--	AG	None
Eroded Border Around Hover Area (Old Firing Points)	RDHC	STJ or (HM)++	80 JG or (HM)++	ST JG or (HM)++	ST JG or (HM)++	20,000 or (HM)++	2000 WF (HM) (HM)	ST3	60 ML	60 ML	60 ML	PB 35 Br CB 10 Bc CL 6 HM++	SSWF (HM)	6 weeks Hover < 40 ft
Vegetated Border Around Hover Area (New Firing Points)		STM	80 ML	ST ML	ST ML	--	--	ST3M	60 ML	60 ML	60 ML	--	--	None

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Appendix A
Scientific Names of Species Planted

Common Name	Scientific Name
Browntop millet	*Panicum ramosum*
Cicer milkvetch	*Astragalus cicer*
Cochise lovegrass	*Eragrostis lehmanniana* × *trichophora*
Common bermudagrass	*Cynodon dactylon*
Lehmann lovegrass	*Eragrostis lehmanniana*
Pensacola bahiagrass	*Paspalum notatum var. 'Pensacola'*
Sand dropseed	*Sporobolus crytandrus*
Sand lovegrass	*Eragrostis trichodes*
Sericea lespedeza	*Lespedeza cuneata* var. 'Interstate'
Shore juniper	*Juniperus conferta* var. 'Blue Pacific'
Subterranean clover	*Trifolium subterraneum*

Appendix B
Detailed Results of Soil Analysis

Soil samples were analyzed by the Mississippi Cooperative Extension Service, Mississipi State University, in 1988. Soil samples collected in 1989 and 1990 were analyzed by Pettiet Agricultural Services of Leland, MS, under a purchase order issued by WES. Pettiet Agricultural Services was selected in 1989 and 1990 for their past ability to provide a faster turnaround needed for this study. This does not imply that state extension services provide any less quality. Extension laboratories normally should be used for soil analysis, as the cost of analysis is generally less than private laboratories.

Soil analysis in 1988 was of samples taken from potential test sites, RT4, RT14, LZ Pam, and Lowe Army Heliport. Standard agricultural analysis was performed on these samples. Analysis in 1989 and 1990 was of extensive soil sample collections from the three actual test sites (RT14, RT333, and Lowe Army Heliport). Standard agricultural analysis, including organic matter, of two samples per plot (0 to 6 in. and 6 to 12 in.) was performed.

The following data are from the analysis of 1988, 1989, and 1990 soil samples. Rates of fertilizer used on treatment plots were determined from the average of recommended rates for each treatment.

1988 SOIL DATA

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1				Pounds			Per		Acre	% Base Saturation				ton/ac	lbs/acre
2	SAMPLE ID	PH	%OM	P	K	CA	MG	ZN	S	H	K	CA	MG	Lime	N-P205-K20 Req
3	RT14 0-3	5.7	0.89	5	99	703	156	2.7	128	37.16	3.15	43.56	16.11	1	60-100-25
4	RT14 3-8	5.8	0.35	5	43	771	221	1.6	50	30.93	1.31	45.86	21.91	1	60-100-50
5	RT14 8-12	5.5	0.47	5	42	871	192	1.5	67	34.55	1.16	47.02	17.27	1	60-100-50
6	RT4 0-6	5.5	0.33	5	45	466	84	1.4	47	38.87	2.24	45.28	13.6	1	60-100-50
7	LOWE 0-6	5.1	1.05	5	41	411	66	1.8	151	64.85	1.36	26.65	7.13	1	60-100-50
8	LZPAM 0-6	5.8	3.36	35	215	1280	441	2.5	483	49.94	2.6	30.15	17.31	1	60-50-0

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S – P O BOX 838
LELAND MISSISSIPPI 38756

SEND TO: U.S. Army Engineers – 21333 Samples c/o Richard Price

LAB NO: 89087

RECOMMENDED BY: (DR) JOE V PETTIET AGRONOMIST

DATE: February 28, 1989

SOIL TEST ANALYSIS (Lbs /acre and level)

Site Number	pH	Total Acidity	Phosphorus	Exchangeable Bases: Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Fertilizer Recommendations: Crop	Lime (T/A)	$N-P_2O_5-K_2O$ (#/A)	Other
E1 6 38-T	5.20	1.6	16 vl	56 vl	6 vl	40 vl	0.18				1.8	6- 1- 4-89	Pasture	0.5	40- 45- 60	
E1 12 S	5.11	1.6	19 l	44 vl	7 vl	10 vl	.14				1.7	1- 2- 3-94	Hay	1.0	240- 90-180	LFM *

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	CEC	Base Saturation	Crop	Lime (T/A)	$N-P_2O_5-K_2O$	Other
E2 6 39-T	5.03	1.8	17 vl	28 vl	5 vl	20 vl	0.20				1.9	3- 1- 2-94	Pasture	0.5	40- 45- 60	L
E2 12 S	5.05	1.8	15 vl	33 vl	3 vl	40 vl	.16				2.0	5- 1- 2-92	Hay	1.0	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	CEC	Base Saturation	Crop	Lime (T/A)	$N-P_2O_5-K_2O$	Other
E3 6 40-T	5.20	1.6	50 m	79 vl	23 l	110 vl	0.56				2.1	13- 5- 5-77	Pasture	0.5	40- 15- 60	L
E3 12 S	5.15	1.6	37 l	56 vl	20 l	100 vl	.38				2.0	12- 4- 4-80	Hay	1.0	240- 45-180	

REMARKS: Apply limestone in the fall; For 0-15-60, use 100 lb/A 5-15-30 and 50 lb/A 0-0-60; For 0-60-180, use 400 lb/A 5-15-30 and 100 lb/A 0-0-60;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	CEC	Base Saturation	Crop	Lime (T/A)	$N-P_2O_5-K_2O$	Other
N1 6 41-T	5.22	1.8	27 l	31 vl	8 vl	30 vl	0.38				1.9	4- 2- 2-92	Pasture	0.5	40- 30- 60	LFM
N1 12 S	5.18	1.9	14 vl	36 vl	8 vl	40 vl	.28				2.1	5- 2- 2-91	Hay	1.0	240- 60-180	

REMARKS: Apply limestone in the fall; For 0-30-60, use 200 lb/A 5-15-30 or 230 lb/A 0-13-26; For 0-60-180, use 400 lb/A 5-15-30 and 100 lb/A 0-0-60;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	CEC	Base Saturation	Crop	Lime (T/A)	$N-P_2O_5-K_2O$	Other
N2 6 42-T	5.12	2.2	18 l	92 l	14 l	80 vl	0.28				2.6	8- 2- 5-85	Pasture	0.5	40- 30- 45	LF
N2 12 S	5.13	1.8	24 l	54 vl	10 vl	60 vl	.31				2.1	7- 2- 3-87	Hay	1.0	240- 60-120	

REMARKS: Apply limestone in the fall; For 0-45-45, use 190 lb/A 0-24-24 or 225 lb/A 0-20-20; For 0-60-120, use 400 lb/A 5-15-30 or 460 lb/A 0-13-26;

L = Lime LF = Lime + Fertilizer LFM = Lime + Fertilizer + Chicken Litter Control = No Amendments

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S — P O BOX 838
LELAND, MISSISSIPPI 38756

SEND TO: U.S. Army Engineers
RT333 Samples c/o Richard Price

LAB NO: 89087

RECOMMENDED BY: (DR) JOE PETTIET AGRONOMIST

DATE: February 28, 1989

SOIL TEST ANALYSIS (Lbs./acre and level)

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Crop	Lime (T/A)	N-P2O5-K2O (#/A)	Other
43-T	5.70	1.8	57 m	89 l	38 m	460 l	0.77				3.2	36- 5- 4-56	Pasture	0	40- 15- 45	L
S	5.66	1.3	45 l	73 vl	21 l	290 l	.50				2.2	33- 4- 4-59	Hay	0	240- 45-120	

REMARKS: For 0-15-45, use 65 lb/A 0-24-24 and 50 lb/A 0-0-60; For 0-60-120, use 400 lb/A 5-15-30 or 460 lb/A 0-13-26;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Crop	Lime (T/A)	N-P2O5-K2O (#/A)	Other
44-T	5.65	2.0	20 l	70 vl	40 m	260 vl	0.54				2.9	22- 6- 3-69	Pasture	X	40- 30- 60	Control
S	5.54	2.1	11 vl	56 vl	42 m	320 vl	.33				3.1	25- 6- 2-67	Hay	X	240- 60-180	

REMARKS: An `X` lime rate suggests future limestone needs; For 0-30-60, use 200 lb/A 5-15-30 or 230 lb/A 0-13-26; For 0-60-180, use 400 lb/A 5-15-30 and 100 lb/A 0-0-60;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Crop	Lime (T/A)	N-P2O5-K2O (#/A)	Other
45-T	5.27	2.8	11 vl	230 m	37 m	130 vl	0.27				3.6	9- 4- 8-78	Pasture	0.5	40- 45- 30	Control
S	5.17	3.0	10 vl	145 l	36 m	180 vl	.28				3.8	12- 4- 5-79	Hay	1.5	240- 90- 90	

REMARKS: Apply limestone in the fall; For 0-45-30, use 165 lb/A 0-24-24 or 200 lb/A 0-20-20; For 0-90-90, use 200 lb/A 0-46-0 and 150 lb/A 0-0-60 or 375 lb/A 0-24-24;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Crop	Lime (T/A)	N-P2O5-K2O (#/A)	Other
46-T	5.40	2.1	35 l	119 l	47 m	260 vl	0.60				3.1	21- 6- 5-68	Pasture	0	40- 30- 45	LF
S	5.70	1.9	12 vl	118 l	60 h	380 vl	.24				3.3	29- 8- 5-58	Hay	1.0	240- 60-120	

REMARKS: For 0-45-45, use 190 lb/A 0-24-24 or 225 lb/A 0-20-20; For 0-60-120, use 400 lb/A 5-15-30 or 460 lb/A 0-13-26;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Crop	Lime (T/A)	N-P2O5-K2O (#/A)	Other
47-T	5.55	2.4	28 l	86 l	58 h	260 vl	0.70				3.4	19- 7- 3-71	Pasture	0	40- 30- 45	Control
S	5.57	2.4	14 vl	90 l	65 h	290 vl	.37				3.5	21- 8- 3-68	Hay	1.0	240- 60-120	

REMARKS: For 0-45-45, use 190 lb/A 0-24-24 or 225 lb/A 0-20-20; For 0-60-120, use 400 lb/A 5-15-30 or 460 lb/A 0-13-26;

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S — P O BOX 838
LELAND, MISSISSIPPI 38756

SEND TO: U.S. Army Engineers
RTI4 Samples c/o Richard Price

LAB NO: 89087

RECOMMENDED BY: (Dr.) JOE V PETTIET AGRONOMIST

DATE: February 28, 1989

SOIL TEST ANALYSIS (Lbs /acre and level)

Site Number	pH	Total Acidity	Phosphorus	Exchangeable Bases: Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Fertilizer Recommendations: Crop	Lime (T/A)	$N-P_2O_5-K_2O$ (#/A)	Other
1-T	5.66	2.4	10 vl	40 vl	35 m	470 vl	1.20				3.8	31- 4- 1-64	Pasture	0	40- 45- 60	LF
S	5.87	1.9	8 vl	38 vl	29 m	460 l	.69				3.2	36- 4- 2-59	Hay	0	240- 90-180	

REMARKS: For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity	Base Saturation	Crop	Lime	$N-P_2O_5-K_2O$	Other
2-T	6.97	1.1	10 vl	73 vl	158 h	3680 vh	1.07				11.1	83- 6- 1-10	Pasture	0	40- 45- 60	LFMI *
S	6.92	1.3	9 vl	33 vl	53 h	830 h	.86				3.6	57- 6- 1-36	Hay	0	240- 90-180	

REMARKS: For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity	Base Saturation	Crop	Lime	$N-P_2O_5-K_2O$	Other
3-T	6.05	1.6	13 vl	41 vl	73 h	410 l	0.72				3.0	34-10- 2-54	Pasture	0	40- 45- 60	L
S	6.35	1.4	14 vl	70 vl	80 h	560 m	.53				3.2	43-10- 3-43	Hay	0	240- 90-180	

REMARKS: For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity	Base Saturation	Crop	Lime	$N-P_2O_5-K_2O$	Other
4-T	6.85	0.5	10 vl	68 vl	169 vh	820 h	0.40				3.3	61-21- 3-15	Pasture	0	40- 45- 60	LFMIM *
S	7.05	0.6	14 vl	40 vl	193 vh	660 m	.43				3.1	53-26- 2-19	Hay	0	240- 90-180	

REMARKS: For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity	Base Saturation	Crop	Lime	$N-P_2O_5-K_2O$	Other
5-T	5.41	2.0	26 l	43 vl	42 m	180 vl	0.64				2.7	17- 7- 2-75	Pasture	0	40- 30- 60	LF
S	5.85	1.1	25 l	48 vl	53 h	280 l	.33				2.1	34-11- 3-53	Hay	1.0	240- 60-180	

REMARKS: For 0-30-60, use 200 lb/A 5-15-30 or 230 lb/A 0-13-26; For 0-60-180, use 400 lb/A 5-15-30 and 100 lb/A 0-0-60;

LFMI = Lime + Fertilizer + Wood Mulch   LFMIM: Lime + Fertilizer + Wood Mulch + Chicken Litter

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S - P O BOX 838
LELAND MISSISSIPPI 38756

SEND TO U.S. Army Engineers
RT14 Samples c/o Richard Price

LAB NO 89087

RECOMMENDED BY: (DR) JOE W PETTIET AGRONOMIST

DATE: February 28, 1989

SOIL TEST ANALYSIS (Lbs /acre and level)

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	EXCHANGEABLE BASES: POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS: CROP	LIME (T/A)	$N-P_2O_5-K_2O$ (#/A)	OTHER
6-T	6.10	0.9	9 vl	44 vl	70 h	350 l	0.50				2.1	41-14- 3-42	Pasture	0	40- 45- 60	L
S	6.11	1.7	12 vl	47 vl	113 vh	1420 h	1.00				5.8	61- 8- 1-29	Hay	0	240- 90-180	

REMARKS: For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY	BASE SATURATION	CROP	LIME (T/A)	$N-P_2O_5-K_2O$	OTHER
7-T	5.05	3.4	14 vl	51 vl	37 m	130 vl	0.30				3.9	8- 4- 2-86	Pasture	0.5	40- 45- 60	LFMIM
S	5.15	2.5	8 vl	47 vl	49 h	160 vl	.29				3.2	13- 6- 2-79	Hay	1.5	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY	BASE SATURATION	CROP	LIME (T/A)	$N-P_2O_5-K_2O$	OTHER
8-T	5.02	3.3	6 vl	63 vl	33 m	120 vl	0.21				3.8	8- 4- 2-86	Pasture	0.5	40- 45- 60	LFMI
S	5.05	2.8	5 [illegible]	38 vl	37 m	130 vl	.21				3.3	10- 5- 1-84	Hay	1.5	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY	BASE SATURATION	CROP	LIME (T/A)	$N-P_2O_5-K_2O$	OTHER
9-T	5.16	3.0	4 vl	41 vl	81 h	200 vl	0.21				3.9	13- 9- 1-77	Pasture	0.5	40- 45- 60	L
S	5.09	3.0	5 vl	40 vl	41 m	80 vl	.21				3.4	6- 5- 1-88	Hay	1.5	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY	BASE SATURATION	CROP	LIME (T/A)	$N-P_2O_5-K_2O$	OTHER
10-T	5.15	2.5	7 vl	59 vl	46 m	150 vl	0.28				3.1	12- 6- 2-80	Pasture	0.5	40- 45- 60	LFMIM
S	5.14	2.4	8 vl	32 vl	34 m	140 vl	.32				2.9	12- 5- 1-82	Hay	1.0	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S   P O BOX 838
LELAND MISSISSIPPI 38756

SEND TO: U.S. Army Engineers
RT-4 Samples c/o Richard Price

LAB NO: 89087

RECOMMENDED BY: (DR) JOE V PETTIET AGRONOMIST

DATE: February 28, 1989

SOIL TEST ANALYSIS (Lbs /acre and level)

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	EXCHANGEABLE BASES: POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca Mg K Acid	FERTILIZER RECOMMENDATIONS: CROP	LIME (T/A)	N P2O5 K2O (#/A)	OTHER
C3L 11-T	5.03	3.0	8 vl	41 vl	21 l	80 vl	0.25				3.3	6- 3- 2-90	Pasture	0.5	40- 45- 60	LF
C3n S	5.14	2.2	6 vl	29 vl	40 m	120 vl	.27				2.7	11- 6- 1-81	Hay	1.5	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N P2O5 K2O	OTHER
C4L 12-T	4.99	3.0	6 vl	72 vl	18 l	90 vl	0.16				3.4	7- 2- 3-88	Pasture	0.5	40- 45- 60	LFMI
C4n S	5.23	2.4	8 vl	46 vl	70 h	370 vl	.24				3.7	25- 8- 2-65	Hay	1.0	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N P2O5 K2O	OTHER
C5L 13-T	5.17	2.9	5 vl	32 vl	69 h	340 vl	0.23				4.1	21- 7- 1-71	Pasture	0.5	40- 45- 60	L
C5n S	5.27	2.3	6 vl	34 vl	50 h	300 vl	.33				3.3	23- 6- 1-70	Hay	1.0	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N P2O5 K2O	OTHER
D2L 14-T	5.43	2.9	9 vl	52 vl	63 h	380 vl	0.85				4.2	23- 6- 2-69	Pasture	X	40- 45- 60	LF
D2n S	5.33	2.3	10 vl	31 vl	20 l	130 vl	.61				2.7	12- 3- 1-84	Hay	1.0	240- 90-180	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N P2O5 K2O	OTHER
D3L 15-T	5.92	0.8	9 vl	82 vl	101 vh	690 h	0.38				3.1	57-14- 3-26	Pasture	0	40- 45- 60	LFMIM
D3n S	6.25	0.4	12 vl	54 vl	71 h	660 h	.36				2.4	68-12- 3-17	Hay	0	240- 90-180	

REMARKS: For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
[illegible]
HIGHWAY 61 S P. O. BOX 838
LELAND MISSISSIPPI 38756
SOIL TEST ANALYSIS (Lbs acre and level)

SEND TO: U.S. Army Engineers, RT14 Samples c/o Richard Price

LAB NO: 89087

RECOMMENDED BY: (DR.) JOE PETTIET AGRONOMIST

DATE: February 28, 1989

Site Number	pH	Total Acidity	Phosphorus	Exchangeable Bases: Potassium	Exchangeable Bases: Magnesium	Exchangeable Bases: Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Fertilizer Recommendations: Crop	Lime (T/A)	$N-P_2O_5-K_2O$ (#/A)	Other
16-T	5.83	1.9	21 l	72 vl	98 vh	480 l	0.57				3.6	33-11- 3-53	Pasture	X	40- 30- 60	LFM1
S	5.31	3.9	14 vl	58 vl	51 h	270 vl	.38				4.9	14- 4- 2-80	Hay	X	240- 60-180	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-30-60, use 200 lb/A 5-15-30 or 230 lb/A 0-13-26; For 0-60-180, use 400 lb/A 5-15-30 and [illegible] lb/A [illegible];

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	CEC	Base Saturation	Crop	Lime (T/A)	$N-P_2O_5-K_2O$ (#/A)	Other
17-T	5.85	1.8	34 l	83 vl	135 vh	650 l	0.30				4.1	40-14- 3-44	Pasture	X	40- 30- 60	LFM2M
S	5.16	4.2	5 vl	86 vl	63 h	110 vl	.24				4.8	6- 5- 2-87	Hay	X	240- 60-180	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-30-60, use 200 lb/A 5-15-30 or 230 lb/A 0-13-26; For 0-60-180, use 400 lb/A 5-15-30 and [illegible] lb/A 0-0-60;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	CEC	Base Saturation	Crop	Lime (T/A)	$N-P_2O_5-K_2O$ (#/A)	Other
18-T	5.22	2.8	13 vl	38 vl	54 h	220 vl	0.23				3.6	15- 6- 1-77	Pasture	0.5	40- 45- 60	LFM2M
S	5.14	3.0	5 vl	48 vl	58 h	130 vl	.15				3.6	9- 7- 2-83	Hay	1.5	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A [illegible] or 600 lb/A 5-15-30;

Site Number	pH	Total Acidity	Phosphorus	Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	CEC	Base Saturation	Crop	Lime (T/A)	$N-P_2O_5-K_2O$ (#/A)	Other
19-T	5.24	2.8	10 vl	50 vl	70 h	390 vl	0.40				4.1	24- 7- 2-68	Pasture	0.5	40- 45- 60	LFM2M
S	5.14	3.4	5 vl	47 vl	68 h	210 vl	.25				4.3	12- 7- 1-80	Hay	1.5	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A [illegible] or [illegible] lb/A 5-15-30;

LFM2M = Lime + Fertilizer + Hay Mulch + Chicken Litter

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S -- P O BOX 838
LELAND MISSISSIPPI 38756
SOIL TEST ANALYSIS (Lbs /acre and level)

SEND TO: U.S. Army Engineers
Lowe Samples c/o Richard Price

LAB NO: 89-187

RECOMMENDED BY: (signature) DR. JOE V. PETTIET AGRONOMIST

DATE: February 28, 1989

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	EXCHANGEABLE BASES: POTASSIUM	EXCHANGEABLE BASES: MAGNESIUM	EXCHANGEABLE BASES: CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS: CROP	LIME (T/A)	N-P2O5-K2O (#/A)	OTHER
A1 6 20-T	5.45	2.0	22 l	67 vl	53 h	280 vl	0.84				3.0	23- 7- 3-67	Pasture	X	40- 30- 60	Rate 1
A1 12 S	5.55	1.2	14 vl	59 vl	21 l	250 vl	.52				2.0	31- 4- 4-60	Hay	1.0	240- 60-180	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-30-60, use 200 lb/A 5-15-30 or 230 lb/A 0-13-26; For 0-60-180, use 400 lb/A 5-15-30 and [illegible] lb/A [illegible];

A2 6 21-T	5.50	2.1	10 vl	45 vl	17 l	330 vl	1.40				3.1	27- 2- 2-69	Pasture	X	40- 45- 60	Control
A2 12 S	5.54	1.3	9 vl	28 vl	11 vl	270 l	.42				2.1	33- 2- 2-63	Hay	1.0	240- 90-180	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use [illegible] lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

A3 6 22-T	5.52	2.8	15 vl	80 vl	68 h	460 vl	1.42				4.3	27- 7- 2-65	Pasture	X	40- 45- 60	Rate 3
A3 12 S	5.45	2.6	5 vl	22 vl	28 m	340 vl	.40				3.6	24- 3- 1-72	Hay	1.0	240- 90-180	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use [illegible] lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

A4 6 23-T	5.55	2.0	21 l	71 vl	53 h	360 vl	0.89				3.2	28- 7- 3-62	Pasture	X	40- 30- 60	Rate 2
A4 12 S	5.47	1.4	14 vl	33 vl	14 l	210 vl	.36				2.0	26- 3- 2-69	Hay	1.0	240- 60-180	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-30-60, use 200 lb/A 5-15-30 or 230 lb/A 0-13-26; For 0-60-180, use 400 lb/A 5-15-30 and 100 lb/A 0-0-60;

B1 6 24-T	5.32	3.0	14 vl	78 vl	43 m	230 vl	1.36				3.9	15- 5- 3-78	Pasture	X	40- 45- 60	Rate 3
B1 12 S	5.47	2.4	10 vl	24 vl	24 l	450 vl	.53				3.7	31- 3- 1-66	Hay	1.0	240- 90-180	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LAB
HIGHWAY 61 S. – P. O. BOX 838
LELAND, MISSISSIPPI 38756

SEND TO: U.S. Army Engineers
Lowe Samples c/o Richard Price

LAB NO: 89087

RECOMMENDED BY: (DR.) JOE D. PETTIET, AGRONOMIST

DATE: February 28, 1989

SOIL TEST ANALYSIS (Lbs/acre and level)

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	EXCHANGEABLE BASES: POTASSIUM	EXCHANGEABLE BASES: MAGNESIUM	EXCHANGEABLE BASES: CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS: CROP	LIME (T/A)	N-P2O5-K2O (#/A)	OTHER
B2 6 25-T	5.46	2.6	15 vl	65 vl	35 m	220 vl	1.13				3.4	16- 4- 2-77	Pasture	0	40- 45- 60	Rate 2
B2 12 S	5.57	1.9	8 vl	31 vl	31 m	370 vl	.56				3.0	31- 4- 1-63	Hay	1.0	240- 90-180	
B3 6 26-T	5.69	2.5	13 vl	56 vl	41 m	330 vl	1.28				3.6	23- 5- 2-70	Pasture	0	40- 45- 60	Rate 1
B3 12 S	5.60	2.4	4 vl	28 vl	26 m	480 l	.54				3.7	32- 3- 1-64	Hay	0	240- 90-180	
B4 6 27-T	5.66	2.6	13 vl	69 vl	45 m	590 l	1.64				4.4	34- 4- 2-60	Pasture	0	40- 45- 60	Control
B4 12 S	5.95	1.4	25 l	30 vl	7 vl	600 m	.81				3.0	51- 1- 1-47	Hay	0	240- 90-180	
C1 6 28-T	5.25	3.4	18 l	95 l	18 l	340 vl	1.61				4.4	19- 2- 3-76	Pasture	0.5	40- 30- 45	Rate 2
C1 12 S	5.25	2.4	8 vl	29 vl	13 l	320 vl	.37				3.3	24- 2- 1-73	Hay	1.0	240- 60-120	
6 29-T	5.05	3.8	22 l	182 m	94 vh	280 vl	1.89				5.1	14- 8- 5-74	Pasture	0.5	40- 30- 30	Rate 1
12 S	5.03	3.1	11 vl	89 l	69 h	160 vl	.43				3.9	10- 7- 3-79	Hay	1.5	240- 60- 90	

REMARKS (25-T / S): For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

REMARKS (26-T / S): For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

REMARKS (27-T / S): For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90 180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

REMARKS (28-T / S): Apply limestone in the fall; For 0-45-45, use 190 lb/A 0-24-24 or 225 lb/A 0-20-20; For 0-60-120, use 400 lb/A 5-15-30 or 460 lb/A 0-13-26;

REMARKS (29-T / S): Apply limestone in the fall; For 0-30-30, use 125 lb/A 0-24-24 or 150 lb/A 0-20-20; For 0-60-90, use 130 lb/A 0-46-0 and 150 lb/A 0-0-60 or 300 lb/A 0-24-24;

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S. · P. O. BOX 838
LELAND MISSISSIPPI 38756

SEND TO: U.S. Army Engineers
Lowe Samples c/o Richard Price

LAB NO: 89387

RECOMMENDED BY: (DR.) JOE V. PETTIET AGRONOMIST

DATE: February 28, 1989

SOIL TEST ANALYSIS (Lbs/acre and level)

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	EXCHANGEABLE BASES: POTASSIUM	EXCHANGEABLE BASES: MAGNESIUM	EXCHANGEABLE BASES: CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS: CROP	LIME (T/A)	N-P_2O_5-K_2O (#/A)	OTHER
C3 6 30-T	5.41	2.1	14 vl	83 vl	72 h	350 vl	0.98				3.4	26- 9- 3-62	Pasture	X	40- 45- 60	Control
C3 12 S	5.03	3.2	6 vl	48 vl	27 m	200 vl	.81				3.9	13- 3- 2-83	Hay	1.0	240- 90-180	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P_2O_5-K_2O	OTHER
C4 6 31-T	5.10	2.0	16 vl	65 vl	19 l	90 vl	0.88				2.4	9- 3- 3-84	Pasture	0.5	40- 45- 60	Rate 3
C4 12 S	5.06	3.1	5 vl	31 vl	29 m	70 vl	.34				3.4	5- 4- 1-90	Hay	1.0	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P_2O_5-K_2O	OTHER
D1 6 32-T	5.13	2.5	10 vl	30 vl	48 m	200 vl	0.28				3.2	15- 6- 1-77	Pasture	0.5	40- 45- 60	Rate 3
D1 12 S	5.10	2.4	4 vl	23 vl	27 m	90 vl	.18				2.8	8- 4- 1-87	Hay	1.0	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P_2O_5-K_2O	OTHER
D2 6 33-T	5.19	3.6	24 l	127 l	107 vh	490 vl	1.35				5.4	23- 8- 3-66	Pasture	0.5	40- 30- 45	Ra
D2 12 S	5.17	2.5	13 vl	46 vl	46 m	140 vl	.52				3.1	11- 6- 2-81	Hay	1.5	240- 60-120	

REMARKS: Apply limestone in the fall; For 0-45-45, use 190 lb/A 0-24-24 or 225 lb/A 0-20-20; For 0-60-120, use 400 lb/A 5-15-30 or 460 lb/A 0-13-26;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P_2O_5-K_2O	OTHER
D2 6 34-T	5.75	1.2	15 vl	60 vl	44 m	450 m	0.98				2.6	44- 7- 3-46	Pasture	0	40- 45- 60	
D2 12 S	5.65	2.0	6 vl	23 vl	15 l	490 l	.61				3.3	37- 2- 1-60	Hay	0	240- 90-180	

REMARKS: For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S — P O BOX 838
LELAND MISSISSIPPI 38756
SOIL TEST ANALYSIS (Lbs /acre and level)

SEND TO U.S. Army Engineers
Lowe Samples c/o Richard Price

LAB NO 89087

RECOMMENDED BY: (DR) JOE PETTIET, AGRONOMIST

DATE: February 28, 1989

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	EXCHANGEABLE BASES: POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS: CROP	LIME (T/A)	$N-P_2O_5-K_2O$ (#/A)	OTHER
D4 6 35-T	5.21	2.8	5 vl	41 vl	24 l	150 vl	0.27				3.3	11- 3- 2-84	Pasture	0.5	40- 45- 60	
D4 12 $	5.12	2.9	5 vl	22 vl	6 vl	90 vl	.21				3.2	7- 1- 1-91	Hay	1.5	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
E1 6 36-T	5.10	2.8	6 vl	26 vl	52 h	180 vl	0.30				3.5	13- 6- 1-80	Pasture	0.5	40- 45- 60	
$	5.10	2.8	6 vl	26 vl	52 h	180 vl					3.5	13- 6- 1-80	Hay	1.5	240- 90-180	

REMARKS: Apply limestone in the fall; For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
F1 6 37-T	5.63	1.2	11 vl	30 vl	9 vl	330 l	0.30				2.1	39- 2- 2-57	Pasture	0	40- 45- 60	
F1 12 $	5.58	1.2	12 vl	24 vl	5 vl	260 l	.21				1.9	34- 1- 2-63	Hay	0	240- 90-180	

REMARKS: For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S -- P. O. BOX 338
LELAND, MISSISSIPPI 38756

SEND TO: U.S. Army Engineers
BOR Samples c/o Richard Price

LAB NO: 89087

Borrow pit near Lowe

SOIL TEST ANALYSIS (Lbs/acre and level)

RECOMMENDED BY: (DR.) JOE V. PETTIET AGRONOMIST

DATE: February 28, 1989

	SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	EXCHANGEABLE BASES: POTASSIUM	EXCHANGEABLE BASES: MAGNESIUM	EXCHANGEABLE BASES: CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS: CROP	LIME (T/A)	N-P2O5-K2O (#/A)	OTHER
1	48-T	5.32	2.2	8 vl	15 vl	20 l	30 vl	0.14				2.4	3- 4- 1-93	Pasture	0	40- 45- 60	Borrow
	S													Hay	1.0	240- 90-180	Pit

REMARKS: For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

	SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY	BASE SATURATION	CROP	LIME (T/A)	N-P2O5-K2O (#/A)	OTHER
2	49-T	5.37	2.2	9 vl	16 vl	24 l	30 vl	0.19				2.4	3- 4- 1-92	Pasture	0	40- 45- 60	Borrow
	S													Hay	1.0	240- 90-180	Pit

REMARKS: For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

	SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY	BASE SATURATION	CROP	LIME (T/A)	N-P2O5-K2O (#/A)	OTHER
3	50-T	5.41	1.5	12 vl	18 vl	34 m	90 vl	0.15				1.9	12- 7- 1-79	Pasture	0	40- 45- 60	Borrow
	S													Hay	0.5	240- 90-180	Pit

REMARKS: For 0-45-60, use 100 lb/A 0-46-0 and 100 lb/A 0-0-60 or 225 lb/A 0-24-24; For 0-90-180, use 200 lb/A 0-46-0 and 300 lb/A 0-0-60 or 600 lb/A 5-15-30;

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S P. O. BOX 838
LELAND MISSISSIPPI 38756

SEND TO: Waterways Experiment Station, c/o Richard Price — Vicksburg, MS

LAB NO: 90145 LOWE

DATE: March 29, 1990

RECOMMENDED BY: Joe V Pettiet (DR. JOE V. PETTIET, AGRONOMIST)

SOIL TEST ANALYSIS (Lbs./acre and level)

SITE NUMBER	pH	TOTAL ACIDITY (Me/100g)	PHOSPHORUS (MEHLICH 3)	EXCHANGEABLE BASES: POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS: CROP	LIME (T/A)	N-P₂O₅-K₂O (#/A)	OTHER
4-T	5.72	2.9	36 m	132 1	48 m	530 vl	1.73				4.6	29- 4- 4-63	Bahiagrass	0	40- 20- 40	Rate 1
Sub	5.92	1.3	13 1	35 vl	13 1	290 1					2.1	34- 3- 2-61	Pasture	0	40- 15- 45	

REMARKS: For 0-20-40, use 133 lb/A 3-15-30 or 200 lb/A 0-10-20; For 0-15-45, use 110 lb/A 6-15-40 or 150 lb/A 0-10-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P₂O₅-K₂O	OTHER
5-T	5.66	3.7	35 m	112 1	52 1	710 vl	2.61				5.8	30- 4- 2-63	Bahiagrass	0	40- 20- 40	Rate 3
Sub	6.14	1.7	13 1	36 vl	12 vl	540 m					3.1	43- 2- 1-54	Pasture	0	40- 15- 45	

REMARKS: Use fertilizers containing magnesium; For 0-20-40, use 133 lb/A 3-15-30 or 200 lb/A 0-10-20; For 0-15-45, use 110 lb/A 6-15-40 or 150 lb/A 0-10-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P₂O₅-K₂O	OTHER
6-T	5.73	2.3	25 1	68 vl	53 h	400 vl	1.59				3.6	28- 6- 2-64	Bahiagrass	0	40- 40- 60	Rate 2
Sub	5.66	2.6	44 m	45 vl	48 m	660 1					4.5	37- 4- 1-58	Pasture	0	40- 30- 60	

REMARKS: For 0-40-60, use 222 lb/A 0-18-24 or 87 lb/A 0-46-0 and 100 lb/A 0-0-60; For 0-30-60, use 200 lb/A 3-15-30 or 300 lb/A 0-10-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P₂O₅-K₂O	OTHER
7-T	5.42	2.7	18 1	102 1	45 m	410 vl	2.77				4.0	25- 5- 3-67	Bahiagrass	X	40- 40- 40	control
Sub	5.13	3.9	12 1	23 vl	30 m	350 vl					4.9	18- 3- 1-79	Pasture	X	40- 30- 45	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-40-40, use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or 200 lb/A 0-20-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P₂O₅-K₂O	OTHER
8-T	5.50	3.6	45 m	107 1	39 1	430 vl	2.16				5.0	22- 3- 3-72	Bahiagrass	0	40- 20- 40	Rate 3
Sub	5.72	2.2	13 1	31 vl	9 vl	430 1					3.4	32- 1- 1-66	Pasture	0	40- 15- 45	

REMARKS: Use fertilizers containing magnesium; For 0-20-40, use 133 lb/A 3-15-30 or 200 lb/A 0-10-20; For 0-15-45, use 110 lb/A 6-15-40 or 150 lb/A 0-10-30;

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S. P.O. BOX [illegible]
LELAND, MISSISSIPPI 38756

SEND TO: [illegible] Experiment Station, Richard Price — Vicksburg, MS

LAB NO: [illegible]   LOWE

DATE: March 29, 1990

RECOMMENDED BY: JLP

SOIL TEST ANALYSIS (Lbs. acre and level)

SITE NUMBER	pH	TOTAL ACIDITY (Me/100g)	PHOSPHORUS (MEHLICH 3)	EXCHANGEABLE BASES: POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS: CROP	LIME (T/A)	N-P₂O₅-K₂O (#/A)	OTHER
9-T	5.98	2.7	41 m	157 1	82 m	710 1	2.34				5.0	35- 7- 4-54	Bahiagrass	0	40- 20- 40	Rate 1
Sub	5.63	2.4	29 1	53 vl	27 m	310 vl					3.4	23- 3- 2-72	Pasture	0	40- 15- 45	

REMARKS: For [illegible], use 133 lb/A 3-15-30 or 200 lb/A 0-10-20; For 0-15-45, use 110 lb/A 6-15-40 or 150 lb/A 0-10-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P₂O₅-K₂O	OTHER
[illegible]-T	5.28	3.5	14 1	64 vl	19 1	260 vl	1.56				4.3	15- 2- 2-81	Bahiagrass	0.5	40- 40- 60	Control
[illegible]	5.24	2.7	11 1	18 vl	14 1	300 vl					3.5	21- 2- 1-76	Pasture	0.5	40- 30- 60	

REMARKS: [illegible] a dolomitic limestone that contains magnesium; For 0-40-60, use 222 lb/A 0-18-24 or 87 lb/A 0-46-0 and 100 lb/A 0-0-60; For 0-30-60, use 200 [illegible]

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P₂O₅-K₂O	OTHER
[illegible]-T	[illegible]	2.9	23 1	193 m	51 h	490 vl	2.10				4.6	27- 5- 5-63	Bahiagrass	0	40- 40- 40	Rate 2
Sub	6.94	[illegible]	13 1	27 vl	90 h	880 h					3.6	61-10- 1-28	Pasture	0	40- 30- 45	

REMARKS: For [illegible], use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or 200 lb/A 0-20-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P₂O₅-K₂O	OTHER
[illegible]-T	[illegible]	4.2	18 1	123 1	31 1	300 vl	1.71				5.2	14- 2- 3-80	Bahiagrass	0.5	40- 40- 40	Rate 2
Sub	5.18	[illegible]	13 1	30 vl	15 1	340 vl					4.0	22- 2- 1-76	Pasture	0.5	40- 30- 45	

REMARKS: [illegible] a dolomitic limestone that contains magnesium; For 0-40-40, use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or [illegible]

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P₂O₅-K₂O	OTHER
13-T	[illegible]	1.3	16 1	58 vl	48 m	420 1	0.97				2.6	40- 8- 3-50	Bahiagrass	X	40- 40- 60	Control
Sub	5.12	2.9	11 1	35 vl	43 m	230 vl					3.7	16- 5- 1-78	Pasture	X	40- 30- 60	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-40-60, use 222 lb/A 0-18-24 or 87 lb/A 0-46-0 and 100 lb/A 0-0-60; For 0-30-60, u[illegible] 200 [illegible]

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S P. O. BOX 838
LELAND, MISSISSIPPI 38756

SEND TO: Waterways Experiment Station c/o Richard Price Vicksburg, Ms.

LAB NO: 90145 Lowe

RECOMMENDED BY: [signature] DR. JOE PETTIET, AGRONOMIST

DATE: March 29, 1990

SOIL TEST ANALYSIS (Lbs./acre and level)

Site Number	pH	Total Acidity (Me/100g)	Phosphorus (Mehlich 3)	Exchangeable Bases: Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Fertilizer Recommendations: Crop	Lime (T/A)	$N-P_2O_5-K_2O$ (#/A)	Other
14-T	5.18	4.0	23 l	95 vl	22 l	620 vl	1.99				5.8	27- 2- 2-69	Bahiagrass	0.5	40- 40- 60	Rate 3
Sub	5.07	3.3	10 vl	22 vl	15 l	240 vl					4.0	15- 2- 1-83	Pasture	0.5	40- 30- 60	

REMARKS: Use a dolomite limestone that contains magnesium; For 0-40-60, use 222 lb/A 0-18-24 or 87 lb/A 0-46-0 and 100 lb/A 0-0-60; For 0-30-60, use 200 lb/A [illegible] or [illegible] lb/A 0-20-20;

Site Number	pH	Total Acidity (Me/100g)	Phosphorus (Mehlich 3)	Exchangeable Bases: Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Fertilizer Recommendations: Crop	Lime (T/A)	$N-P_2O_5-K_2O$ (#/A)	Other
15-T	5.11	4.2	26 l	110 l	67 m	540 vl	1.80				6.0	23- 5- 2-70	Bahiagrass	1.0	40- 40- 40	Rate 1
Sub	5.00	3.8	14 l	35 vl	48 m	160 vl					4.4	9- 4- 1-85	Pasture	1.0	40- 30- 45	

REMARKS: Apply a calcium limestone; For 0-40-40, use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or 200 lb/A 0-20-20;

Site Number	pH	Total Acidity (Me/100g)	Phosphorus (Mehlich 3)	Exchangeable Bases: Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Fertilizer Recommendations: Crop	Lime (T/A)	$N-P_2O_5-K_2O$ (#/A)	Other
16-T	5.30	3.7	59 m+	287 m+	40 l	680 vl	1.77				5.9	29- 3- 6-62	Bahiagrass	0.5	40- 20- 20	Rate 3
Sub	4.95	3.4	18 l	131 l	14 l	150 vl					4.0	9- 1- 4-85	Pasture	0.5	40- 15- 30	

REMARKS: Use a dolomite limestone that contains magnesium; For 0-20-20, use 83 lb/A 8-24-24 or 100 lb/A 0-20-20; For 0-15-30, use 100 lb/A 3-15-30 or 150 lb/A [illegible];

Site Number	pH	Total Acidity (Me/100g)	Phosphorus (Mehlich 3)	Exchangeable Bases: Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Fertilizer Recommendations: Crop	Lime (T/A)	$N-P_2O_5-K_2O$ (#/A)	Other
17-T	5.85	2.0	22 l	130 l	38 m	670 l	1.69				4.0	42- 4- 4-50	Bahiagrass	X	40- 40- 40	Rate 1
Sub	5.33	2.0	12 l	103 l	21 l	210 vl					2.7	19- 3- 5-73	Pasture	X	40- 30- 45	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-40-40, use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or [illegible] 0-20-20;

Site Number	pH	Total Acidity (Me/100g)	Phosphorus (Mehlich 3)	Exchangeable Bases: Potassium	Magnesium	Calcium	Organic Matter (%)	Available Sulfur		Nitrate N	Cation Exchange Capacity (Me/100g)	Base Saturation (%) Ca-Mg-K-Acid	Fertilizer Recommendations: Crop	Lime (T/A)	$N-P_2O_5-K_2O$ (#/A)	Other
18-T	5.27	3.4	13 l	115 l	100 m	430 vl	1.20				5.0	21- 8- 3-67	Bahiagrass	0.5	40- 40- 40	Control
Sub	5.14	3.7	12 l	108 l	62 h	170 vl					4.5	9- 6- 3-82	Pasture	0.5	40- 30- 45	

REMARKS: Apply a calcium limestone; For 0-40-40, use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or 200 lb/A 0-20-20;

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S P O BOX 838
LELAND MISSISSIPPI 38756

SEND TO: Waterways Experiment Station c/o Richard Price Vicksburg, MS

LAB NO: 90145 LOWE

RECOMMENDED BY: (DR.) JOE PETTIET AGRONOMIST

DATE: March 29, 1990

SOIL TEST ANALYSIS (Lbs./acre and level)

SITE NUMBER	pH	TOTAL ACIDITY (Me/100g)	PHOSPHORUS (MEHLICH 3)	EXCHANGEABLE BASES: POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS: CROP	LIME (T/A)	$N-P_2O_5-K_2O$ (#/A)	OTHER
19-T	5.16	3.8	23 l	242 m	78 m	420 vl	1.24				5.5	19- 6- 6-69	Bahiagrass	0.5	40- 40- 40	Rate 2
Sub	5.19	3.2	12 l	88 vl	67 h	230 vl					4.2	14- 7- 3-77	Pasture	0.5	40- 30- 45	

REMARKS: Apply a calcium limestone; For 0-40-40, use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or 200 lb/A 0-20-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
20-T	5.68	1.9	16 l	129 l	57 h	170 vl	0.12				2.7	16- 9- 6-70	Bahiagrass	X	40- 40- 40	
Sub	5.49	1.9	15 l	65 vl	24 l	180 vl					2.5	18- 4- 3-75	Pasture	X	40- 30- 45	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-40-40, use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or 200 lb/A 0-20-20;

RT14

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
21-T	6.24	1.9	56 m+	91 vl	73 h	500 l	1.21				3.6	35- 9- 3-53	Bahiagrass	0	40- 20- 60	LF
Sub	6.10	2.1	17 l	55 vl	28 m	260 vl					2.9	22- 4- 2-71	Pasture	0	40- 15- 60	

REMARKS: For 0-20-60, use 140 lb/A 6-15-40 or 200 lb/A 0-10-30; For 0-15-60, use 150 lb/A 0-10-40 blend or 100 lb/A 3-15-30 and 50 lb/A 0-0-60;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
22-T	6.49	2.0	27 l	115 l	102 vh	840 m	2.00				4.7	45- 9- 3-43	Bahiagrass	0	40- 40- 40	LFMI
Sub	6.14	2.7	19 l	72 vl	56 h	480 vl					4.2	28- 6- 2-64	Pasture	0	40- 30- 45	

REMARKS: For 0-40-40, use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or 200 lb/A 0-20-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
23-T	7.05	1.3	18 l	76 vl	155 m	2270 h	1.52				7.7	74- 8- 1-17	Bahiagrass	0	40- 40- 60	L
Sub	6.57	2.2	18 l	26 vl	35 m	500 l					3.6	34- 4- 1-61	Pasture	0	40- 30- 60	

REMARKS: For 0-40-60, use 222 lb/A 0-18-24 or 87 lb/A 0-46-0 and 100 lb/A 0-0-60; For 0-30-60, use 200 lb/A 3-15-30 or 300 lb/A 0-10-20;

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S — P. O. BOX 838
LELAND, MISSISSIPPI 38756

SEND TO: Waterways Experiment Station, c/o Richard Price, Vicksburg, MS

LAB NO: 90145 RT14

RECOMMENDED BY: [signature] PETTIET AGRONOMIST

DATE: March 29, 1990

SOIL TEST ANALYSIS (Lbs./acre and level)

SITE NUMBER	pH	TOTAL ACIDITY (Me/100g)	PHOSPHORUS (MEHLICH 3)	EXCHANGEABLE BASES: POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS: CROP	LIME (T/A)	$N-P_2O_5-K_2O$ (#/A)	OTHER
24-T	6.99	0.9	104 h	175 l	188 vh	900 m	1.02				4.2	54-19- 5-22	Bahiagrass	0	40- 0- 30	LFMIM
Sub	6.91	1.3	23 l	271 m+	108 vh	430 l					3.2	34-14-11-41	Pasture	0	40- 0- 30	

REMARKS: For 0-0-30, use 100 lb/A Muriate of Potash (0-0-60) alternate years;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
25-T	5.92	2.0	25 l	93 l	32 m	290 vl	0.58				3.0	24- 4- 4-67	Bahiagrass	0	40- 40- 40	LF
Sub	5.76	1.8	20 l	84 vl	21 l	160 vl					2.4	17- 4- 4-75	Pasture	0	40- 30- 45	

REMARKS: For 0-40-40, use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or 200 lb/A 0-20-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
26-T	6.60	1.5	17 l	26 vl	76 h	680 m	0.65				3.6	48- 9- 1-42	Bahiagrass	0	40- 40- 60	L
Sub	5.99	2.8	16 l	27 vl	49 h	450 vl					4.2	27- 5- 1-67	Pasture	0	40- 30- 60	

REMARKS: For 0-40-60, use 222 lb/A 0-18-24 or 87 lb/A 0-46-0 and 100 lb/A 0-0-60; For 0-30-60, use 200 lb/A 3-15-30 or 300 lb/A 0-10-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
27-T	6.95	1.0	81 h	272 m+	111 vh	850 m	0.47				3.9	54-12- 9-25	Bahiagrass	0	40- 0- 20	LFMIM
Sub	6.94	1.5	22 l	196 m	90 h	510 l					3.4	37-11- 7-44	Pasture	0	40- 0- 30	

REMARKS: For 0-0-20, use 100 lb/A Muriate of Potash (0-0-60) every third year; For 0-0-30, use 100 lb/A Muriate of Potash (0-0-60) alternate years;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
28-T	7.28	0.8	28 l	160 l	134 h	1580 h	0.29				5.5	72-10- 4-15	Bahiagrass	0	40- 40- 40	LFMI
Sub	6.78	1.3	21 l	75 vl	39 m	250 vl					2.2	29- 7- 4-60	Pasture	0	40- 30- 45	

REMARKS: For 0-40-40, use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or 200 lb/A 0-20-20;

Soil Test Analysis - Fertilizer Recommendation Sheet

PETTIET AGRICULTURAL SERVICES
SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S P. O. BOX 838
LELAND MISSISSIPPI 38756

SEND TO: Waterways Experimen. Station c/o Richard Price Vicksburg, MS

LAB NO: 90145 RT14

RECOMMENDED BY: (DR.) JOE PETTIET AGRONOMIST

DATE: March 29, 1990

SOIL TEST ANALYSIS (Lbs./acre and level)

SITE NUMBER	pH	TOTAL ACIDITY (Me/100g)	PHOSPHORUS (MEHLICH 3)	EXCHANGEABLE BASES POTASSIUM	EXCHANGEABLE BASES MAGNESIUM	EXCHANGEABLE BASES CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS CROP	LIME (T/A)	$N-P_2O_5-K_2O$ (#/A)	OTHER
1 29-T	5.98	2.1	15 l	39 vl	52 h	600 l	0.16				3.9	39- 6- 1-54	Bahiagrass	X	40- 40- 60	L
Sub	5.20	2.6	16 l	31 vl	36 m	150 vl					3.2	12- 5- 1-82	Pasture	X	40- 30- 60	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-40-60, use 222 lb/A 0-18-24 or 87 lb/A 0-46-0 and 100 lb/A 0-0-60; For 0-30-60, use 200 lb/A 3-15-30 or 300 lb/A 0-10-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
2 30-T	6.91	1.3	31 m	179 l	74 h	1010 h	0.32				4.4	58- 7- 5-30	Bahiagrass	X	40- 20- 40	LFMIM
Sub	5.20	2.7	14 l	133 l	27 m	210 vl					3.5	15- 3- 5-77	Pasture	X	40- 15- 45	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-20-40, use 133 lb/A 3-15-30 or 200 lb/A 0-10-20; For 0-15-45, use 110 lb/A 6-15-40 or 15[illegible] lb/A 0-10-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
3 31-T	6.78	1.1	14 l	167 l	86 m	1410 h	0.33				5.2	68- 7- 4-21	Bahiagrass	X	40- 40- 40	LF
Sub	5.23	2.9	11 l	54 vl	50 h	[illegible]40 vl					4.0	21- 5- 2-72	Pasture	X	40- 30- 45	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-40-40, use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or 2[illegible] lb/A 0-20-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
4 32-T	7.13	1.0	26 l	140 l	93 h	1220 h	0.35				4.6	66- 8- 4-22	Bahiagrass	0	40- 40- 40	LFMIM
Sub	5.84	2.2	12 l	90 vl	51 h	570 l					4.0	36- 5- 3-56	Pasture	0	40- 30- 45	

REMARKS: For 0-40-40, use 167 lb/A 8-24-24 or 200 lb/A 0-20-20; For 0-30-45, use 188 lb/A 0-16-24 or 200 lb/A 0-20-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
5 33-T	6.91	1.5	13 l	34 vl	82 m	1300 h	0.49				5.1	63- 7- 1-29	Bahiagrass	X	40- 40- 60	L
Sub	5.36	2.4	13 l	18 vl	44 m	290 vl					3.3	22- 6- 1-72	Pasture	X	40- 30- 60	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-40-60, use 222 lb/A 0-18-24 or 87 lb/A 0-46-0 and 100 lb/A 0-0-60; For 0-30-60, use 200 lb/A 3-15-30 or 300 lb/A 0-10-20;

Soil Test Analysis - Fertilizer Recommendation Sheet

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SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S -- P O BOX 838
LELAND, MISSISSIPPI 38756

SEND TO: Waterways Experiment Station
c/o Richard Price Vicksburg, MS

LAB NO: 90145 RT14

RECOMMENDED BY: (DR.) JOE P. PETTIET, AGRONOMIST

DATE: March 29, 1990

SOIL TEST ANALYSIS (Lbs./acre and level)

SITE NUMBER	pH	TOTAL ACIDITY (Me/100g)	PHOSPHORUS (MEHLICH 3)	EXCHANGEABLE BASES: POTASSIUM	EXCHANGEABLE BASES: MAGNESIUM	EXCHANGEABLE BASES: CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me/100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS: CROP	LIME (T/A)	$N-P_2O_5-K_2O$ (#/A)	OTHER
34-T	7.14	1.6	16 l	70 vl	63 l	2430 vh	0.94				8.0	76- 3- 1-20	Bahiagrass	0	40- 40- 60	LF
Sub	7.05	1.2	19 l	36 vl	22 l	590 m					2.8	52- 3- 2-43	Pasture	0	40- 30- 60	

REMARKS: Use fertilizers containing magnesium; For 0-40-60, use 222 lb/A 0-18-24 or 87 lb/A 0-46-0 and 100 lb/A 0-0-60; For 0-30-60, use 200 lb/A 3-15-30 or 300 lb/A 0-10-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
35-T	6.23	2.1	36 m	181 l	51 h	470 l	1.01				3.7	32- 6- 6-56	Bahiagrass	X	40- 20- 40	LFM1M
Sub	5.42	2.5	20 l	76 vl	9 vl	80 vl					2.8	7- 1- 3-88	Pasture	X	40- 15- 45	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-20-40, use 133 lb/A 3-15-30 or 200 lb/A 0-10-20; For 0-15-45, use 110 lb/A 6-15-40 or 150 lb/A 0-10-30;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
36-T	7.33	1.0	18 l	244 m	92 m	1870 h	0.51				6.4	73- 6- 5-16	Bahiagrass	0	40- 40- 20	LFM1
Sub	6.66	3.0	15 l	202 l	127 m	2720 h					10.6	64- 5- 2-28	Pasture	0	40- 30- 30	

REMARKS: For 0-40-20, use 200 lb/A 10-20-10; For 0-30-30, use 125 lb/A 8-24-24 or 150 lb/A 0-20-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
37-T	7.20	1.1	27 l	554 h	139 h	1300 h	0.43				5.6	58-10-13-20	Bahiagrass	X	40- 40- 20	LFM2M
Sub	5.16	3.7	13 l	112 l	68 h	170 vl					4.6	9- 6- 3-81	Pasture	X	40- 30- 30	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-40-20, use 200 lb/A 10-20-10; For 0-30-30, use 125 lb/A 8-24-24 or 150 lb/A 0-20-20;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	$N-P_2O_5-K_2O$	OTHER
38-T	7.01	1.2	230 vh	372 h	147 h	1130 m	1.07				5.1	55-12- 9-23	Bahiagrass	X	40- 0- 0	LFM2M
Sub	5.40	2.7	26 l	324 h	45 m	240 vl					3.9	15- 5-11-69	Pasture	X	40- 0- 0	

REMARKS: An "X" lime rate suggests future limestone needs;

Soil Test Analysis - Fertilizer Recommendation Sheet

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SOIL TEST & PLANT ANALYSIS LABORATORY
HIGHWAY 61 S - P O BOX 838
LELAND, MISSISSIPPI 38756

SEND TO: Waterways Experiment Station, c/o Richard Price -- Vicksburg, MS

LAB NO: 90145 RT14

RECOMMENDED BY: (DR.) JOE V. PETTIET AGRONOMIST

DATE: March 29, 1990

SOIL TEST ANALYSIS (Lbs./acre and level)

SITE NUMBER	pH	TOTAL ACIDITY (Me/100g)	PHOSPHORUS (MEHLICH 3)	EXCHANGEABLE BASES POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER (%)	AVAILABLE SULFUR		NITRATE N	CATION EXCHANGE CAPACITY (Me 100g)	BASE SATURATION (%) Ca-Mg-K-Acid	FERTILIZER RECOMMENDATIONS CROP	LIME (T/A)	N-P2O5-K2O (#/A)	OTHER
39-T	7.12	1.1	142 vh	157 l	145 h	1920 h	0.64				6.7	72- 9- 3-16	Bahiagrass	0	40- 0- 40	LFM2M
Sub	5.90	1.8	30 l	139 l	20 l	160 vl					2.5	16- 3- 7-73	Pasture	0	40- 0- 45	

REMARKS: For 0-0-40, use 135 lb/A Muriate of Potash (0-0-60) alternate years; For 0-0-45, use 150 lb/A Muriate of Potash (0-0-60) alternate years;

RT333

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P2O5-K2O	OTHER
40-T	5.71	2.4	31 m	68 vl	37 m	210 vl	0.99				3.2	17- 5- 3-76	Bahiagrass	X	40- 20- 60	Control
Sub	5.43	4.6	25 l	126 l	35 l	300 vl					5.7	13- 3- 3-81	Pasture	X	40- 15- 60	

REMARKS: An "X" lime rate suggests future limestone needs; For 0-20-60, use 140 lb/A 6-15-40 or 200 lb/A 0-10-30; For 0-15-60, use 150 lb/A 0-10-40 blend or [illegible] lb/A 3-15-30 and 50 lb/A 0-0-60;

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P2O5-K2O	OTHER
41-T	6.22	1.8	64 m+	51 vl	22 l	480 l	1.00				3.2	38- 3- 2-57	Bahiagrass	0	40- 0- 60	L
Sub	5.76	1.9	42 m	46 vl	15 l	250 vl					2.6	24- 2- 2-72	Pasture	0	40- 0- 60	

REMARKS: Use fertilizers containing magnesium; For 0-0-60, use 100 lb/A Muriate of Potash (0-0-60);

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P2O5-K2O	OTHER
42-T	6.82	0.9	56 m+	72 vl	24 l	1060 h	0.53				3.7	71- 3- 2-24	Bahiagrass	0	40- 0- 60	LF
Sub	6.37	1.4	50 m	86 vl	19 l	400 l					2.6	39- 3- 4-54	Pasture	0	40- 0- 60	

REMARKS: Use fertilizers containing magnesium; For 0-0-60, use 100 lb/A Muriate of Potash (0-0-60);

SITE NUMBER	pH	TOTAL ACIDITY	PHOSPHORUS	POTASSIUM	MAGNESIUM	CALCIUM	ORGANIC MATTER	AVAILABLE SULFUR		NITRATE N	CEC	BASE SATURATION	CROP	LIME	N-P2O5-K2O	OTHER
43-T	7.06	0.8	214 vh	79 vl	106 m	1660 vh	1.00				5.5	76- 8- 2-15	Bahiagrass	0	40- 0- 60	LFM
Sub	6.73	1.5	148 vh	129 l	63 h	620 m					3.5	45- 8- 5-43	Pasture	0	40- 0- 60	

REMARKS: For 0-0-60, use [illegible] lb/A Muriate of Potash (0-0-60);

Appendix C
Yields and Comparisons of Biomass

General

Biomass yields were determined by collecting three (five at RT333) 1-sq ft samples from each treatment plot. Samples were scheduled for collection in October 1989. However, due to a loss of funding, samples had to be taken in May 1990 (when new funding became available). May biomass was mostly dormant vegetation from the previous (1989) summer growing season. No determinations on percent of planted species were made because of the difficulty in sorting dormant (dead) plant tissue.

Biomass samples were also collected in September 1990, and percent of planted species in each plot was determined for RT14 and RT333. Although weed infestations were high (mostly in chicken litter treatments) in August 1989, very few weeds (less than 10 percent) were present in September 1990. These determinations were not necessary for Lowe test plots, as bahiagrass was the only vegetation sampled.

Biomass samples were dried at 70 °C to constant weight and weighed in grams per square foot. The resulting value was converted to pounds per acre. Comparisons of means for each treatment are presented in the following tables.

Area RT14

Biomass samples were collected at RT14 from each treatment/species plot. Effects of treatment on total biomass are presented in Tables C1 and C2.

Table C1
Effect of Treatment on Total Biomass Yields, RT14, May 1990

Treatment	Species Plot Yield, lb/acre		
	Bahiagrass	Bermudagrass	Lovegrass
Lime	16.9D[1]	3.0C	29.6C
Lime + fertilizer	73.3C	43.7CBC	71.8B
Lime, fertilizer + wood mulch	74.5CC	67.4BB	107.1BB
Lime + fertilizer + wood mulch + chicken litter	198.9B	186.0A	199.3A
Lime + fertilizer + hay mulch + chicken litter	252.5A	198.1AA	226.9AA

[1] Means in a column with the same letter are not significantly different at $\alpha = 0.05$.

Table C2
Effect of Treatment on Total Biomass Yields, RT14, September 1990

Treatment	Species Plot Yield, lb/acre		
	Bahiagrass	Bermudagrass	Lovegrass
Lime	57.8C[1] (60)[2]	2.4C (80)	73.0C (80)
Lime + fertilizer	202.4BC (90)	124.5B (50)	171.9B (90)
Lime + fertilizer + wood mulch	230.9BB (60)	149.0BB (80)	196.2BB (50)
Lime + fertilizer + wood mulch + chicken litter	333.9A (85)	328.0A (60)	325.2A (90)
Lime + fertilizer + hay mulch + chicken litter	393.4AA (87)	351.7AA (52)	360.3AA (33)

[1] Means in a column with the same letter are not significantly different at $\alpha = 0.05$.
[2] Observed percent of planted species in treatment plot.

Lowe Army Heliport

Only previously established bahiagrass was sampled on the Lowe treatment plots. Table C3 compares the mea.is for each treatment in May and September 1990.

Table C3
Effect of Treatment on Total Biomass Yields, Lowe, May and September 1990

Treatment	Yield, lb/acre	
	May	September
Control	113.0C[1]	151.5C
Rate 1	148.0CB	234.2B
Rate 2	166.5B	316.0A
Rate 3	274.4A	358.4A

[1] Means in a column with the same letter are not significantly different at $\alpha = 0.05$.

Area RT333

Five biomass samples were collected from each plot on RT333, and the means were compared for May and September (Table C4).

Table C4
Effect of Treatment on Total Biomass Yields, RT333, May and September 1990

Treatment	Yield, lb/acre	
	May	September
Control	49.3C[1]	102.2D (60/30/10)[2]
Lime	38.5D	127.7C (60/30/10)
Lime + fertilizer	92.9B	314.9A (70/25/5)
Lime + fertilizer + chicken litter	156.1A	204.1B (60/30/10)

[1] Means in a column with the same letter are not significantly different at $\alpha = 0.05$.
[2] Percentage of species in treatment as (bahiagrass/bermudagrass/weeds).