MODEL PESTICIDE REDUCTION PLAN

November 1996

Developed By:

THE AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
POLLUTION PREVENTION DIRECTORATE

AFCEE/EP
3207 North Road
Brooks Air Force Base, Texas 78235-5363

Prepared by:
EARTH TECH, Inc.

Prepared For:
Department of the Air Force
Air Force Materiel Command

Through the Contracting Offices of:
Department of the Air Force
Air Force Center for Environmental Excellence
Contract No F41624-94-D-8138
Delivery Order No. 12

THIS PAGE INTENTIONALLY LEFT BLANK

PREFACE

BACKGROUND

This Air Force Model Pesticide Reduction Plan can aid you in reducing the amount of pesticides used at your installation and help you meet the Department of Defense (DoD) goal for reduction in pesticide usage. This DoD goal requires all installations to reduce their pesticide usage by 50 percent by the year 2000. The intent of this program is to reduce human exposure to pesticides and to reduce environmental impacts caused by pesticides usage.

The following Air Force personnel provided significant contributions to the development of this Model Pesticide Reduction Plan:

Wayne Fordham, Air Force Pest Management Program Coordinator, HQ AFCESA/CESM
Michael Cornelius, HQ AFMC Command Entomologist, HQ AFMC/CEVC
Terri Lucas, Wright-Patterson AFB Environmental Flight, 88ABW/EME
Michael Clawson, Project Manager for Model Pesticide Reduction Plan, HQ AFCEE/EP

The Model Pesticide Reduction Plan is designed to supplement a base's existing Integrated Pest Management (IPM) Program by providing pesticide reduction alternatives in addition to those that are a part of an effective IPM program. For information on IPM, contact your MAJCOM Entomologist listed in Appendix L of this document or the Air Force Pest Management Program Coordinator: HQ AFCESA/CESM, Attn: Wayne Fordham, Phone: (904)283-6465, DSN: 523-6465, Fax (904) 536-6219, DSN Fax:523-6219, E-mail: fordhamw@afcesa.af.mil

This report is designed to be used in two different ways. It can be used as a guide for conducting a base-wide pesticide reduction opportunity assessment and preparing a management action plan for reducing pesticide usage. The report is also structured so that pest management shop personnel and other pesticide users can extract and implement pesticide reduction alternatives without going through the opportunity assessment process.

IMPLEMENTATION INFORMATION

For information and assistance on technologies to implement the pollution prevention alternatives in this report, Contact one of the many sources of information listed in Appendix L of his report: Air Force personnel are recommended to use the two following sources as a starting point for obtaining additional information on pesticide alternatives and pollution prevention.

Air Force Pest Management Program Coordinator, HQ AFCESA/CESM, Attn: Wayne Fordham, Phone: (904)283-6465, DSN: 523-6465, Fax (904) 536-6219, DSN Fax:523-6219, E-mail: fordhamw@afcesa.af.mil

PRO-ACT at DSN 240-4214, (210) 536-4214, Fax: (210) 536-4254, DSN Fax: 240-4254, Wang E-mail: PRO-ACT, or Internet E-mail: proact@osiris.cso.uiuc.edu.

THE MODEL SHOP INITATIVE

This Model Pesticide Reduction Plan is one in a series of Pollution Prevention Model Shop reports developed by the Air Force Center For Environmental Excellence. These reports were developed because the pollution prevention opportunity assessments being performed at different Air Force bases often identified the same pollution prevention opportunities. The function and processes performed in the shops vary little from base to base, resulting in common opportunities. The purpose of the model shop reports is to identify typical potential pollution prevention opportunities available in a chosen shop (in the case of this report the chosen shops are ones that use pesticides). Because this report is a summary of various opportunity assessments, many of the opportunities identified may not apply to your base.

OTHER MODEL SHOP REPORTS

Transportation Model Shop Report - This report identifies pollution opportunities available in the areas of vehicle maintenance.

Flightline Maintenance Model Shop Report - This report identifies pollution opportunities available in the areas of aircraft and support equipment maintenance.

Civil Engineer's Model Shop Report - This report identifies pollution opportunities available in the areas of facility maintenance(i.e. the Civil Engineering Operations Flight).

Retail Sales Model Shop Report - This report identifies pollution opportunities available in the areas of retail operations (i.e. Commissaries, Base Exchanges, etc.) This report is currently being developed and will be released in July 1997.

Dinning Hall Model Shop Report - This report identifies pollution opportunities available in the areas of food service operations (i.e. Dinning halls, Clubs, Grills, etc.) This report is currently being developed and will be released in July 1997.

These reports can be a valuable tool in your pollution prevention program. If you would like a copy of any of these reports, contact the program manager listed below. We intend to update these reports regularly to include emerging technology, and we invite any comments or suggestions you might have to improve these reports or other future model shop reports. If you have any comments, or suggestions, contact the Program Manager at the address below.

Michael X. Clawson, PE, REM
AFCEE/EP
3207 North Road (Bldg 532)
Brooks AFB TX 78235-5318

Phone: (210) 536-3517
FAX: (210) 536-4254
DSN 240
E-mail: mclawson@afceeb1.brooks.af.mil

DISCLAIMER

Please note that the identification of specific products within this document does not constitute endorsement or approval of these products by the Air Force. These names are provided for discussion purposes only   These products are referenced as examples only of the types of chemicals currently available and in use for control of insect and plant pests. Other manufacturers may produce similar products. Specific examples are used for purposes of providing sample calculations of cost and amount of active chemical ingredients applied as part of a basewide pesticide reduction program. The product merits and capabilities must be gauged in relationship to the specific tasks addressed and local factors. The reader is advised to contact Pro-Act, their base or command entomologists, and/or other bases for additional product names and recommendations.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
AFCESA	Air Force Civil Engineer Support Agency
AFI	Air Force Instruction
AFOSH	Air Force Occupational Safety and Health
AFPD	Air Force Policy Directive
AI	active chemical ingredient
BIRC	Bio-Integral Resource Center
BT	*Bacillus thuringiensis*
BTi	*Bacillus thuringiensis israelensis*
CE	Civil Engineering
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DESCIM	Defense Environmental Security Corporate Information Management
DoD	Department of Defense
DOT	Department of Transportation
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-To-Know Act
EO	Executive Order
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FY	fiscal year
IPM	Integrated Pest Management
LD_{50}	Lethal dose
MAP	Management Action Plan
MOM	Measure of Merit
MSDS	material safety data sheet
NPK	nitrogen: phosphorus: potassium
OA	opportunity assessment
OSHA	Occupational Safety and Health Administration
RQ	reportable quantity
®	registered trade name
SARA	Superfund Amendments and Reauthorization
WIMS	Work Information Management System

THIS PAGE INTENTIONALLY LEFT BLANK

1.0 INTRODUCTION

1.1 PURPOSE

The Department of Defense (DoD) established three Measures of Merit (MOMs) for pest management at its installations (Memorandum from the Office of the Under Secretary of Defense, dated 23 September 1994). In order to help reduce human and environmental exposure to pesticides, MOM 2 sets a goal of 50-percent reduction in the amount of pesticides used at DoD installations by fiscal year (FY) 2000, compared to baseline use in FY 93. This is equivalent to a 7.15-percent reduction in overall pesticide usage each year. In FY 94, the Air Force use overall was 96 percent of the FY 93 baseline, a reduction of only 4 percent (Figure 1-1). In FY 95, the Air Force exceeded the goal, achieving a pesticide use of 77.4 percent of the FY 93 baseline. Nevertheless, some individual bases have not achieved the annual goals for reduction, and some have even shown an increase in pesticide use since FY 93.

The Air Force is committed to environmental leadership and preventing pollution by reducing use of hazardous materials, generation of hazardous wastes, and releases of pollutants into the environment. The Air Force developed its pollution prevention policy in response to the National Pollution Prevention Act of 1990 and Executive Order 12856, Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements, and prepared an installation Pollution Prevention Program Guide (July 1994) to guide installation personnel in implementing the policy. Although pesticides are not specifically addressed in the guide, pesticide reduction should be considered as part of the Air Force Pollution Prevention Program.

1.2 SCOPE

In order to help individual Air Force installations meet the reduction goal under MOM 2, this Model Pesticide Reduction Plan has been prepared under the direction of the Air Force Center for Environmental Excellence (AFCEE) at Brooks Air Force Base (AFB), Texas. This plan is designed to be used in two different ways. It can be used as a guide for conducting a base-wide pesticide reduction opportunity assessment (OA) and preparing a management action plan (MAP) for reducing pesticide usage. At some bases, however, it may not be necessary or cost-effective to complete the entire OA and MAP process. Thus, the report is also structured so that pest management shop personnel and other pesticide users can extract and implement pesticide reduction alternatives for particular pest management practices.

The alternatives presented in this plan include applications of herbicides, fungicides, insecticides, and miticides, which constitute the majority of pesticides applied on most Air Force bases. Pesticides used to control birds and mammals (e.g., rodents) typically constitute a small percentage of total pesticide use, and are not addressed.

Chapter 2 of this model provides information on how the document is organized and how it can be used to support either the OA/MAP process or identification of alternative to reduce pesticide use for particular practices. Chapter 3 describes how to establish the baseline pesticide usage against which reduction goals will be measured. Chapter 4 presents some best management practices that are straightforward, easily implemented, low-cost practices that can help reduce pesticide use immediately. Chapter 5 provides information on generic alternative pest management practices that minimize the use of chemicals, and how to select alternatives that are appropriate for a particular base.

Chapter 6 describes how to conduct a base-specific OA for pesticide reduction if, after following the procedures outlined in Chapters 4 and 5, it is necessary to implement additional measures to achieve the 50-percent reduction goal. Chapter 7 describes how to prepare a decision briefing for the base commander to obtain command support for selecting pest management practices, and describes how to prepare an MAP for implementing the selected alternatives.

The heart of the document is contained in Appendices A through H, which describe the generic alternatives for reducing pesticide use. The alternatives are grouped by pest management practice (turf weed control, bare ground control, controlling fungi, controlling outdoor insects, etc.). The text for each alternative includes a brief description of how the alternative would be implemented, advantages and disadvantages, sources of additional information, and sample equations that provide guidance on calculating capital costs (if applicable), annual operating costs, and pounds of active chemical ingredient (AI) applied annually.

Appendices I through O provide information on regulatory requirements; alternatives that are currently in the development or testing stages, but appear promising and should be available in the next 1-2 years; alternatives that are most appropriate for use in new construction to reduce the need for application of pesticides; general and specific sources of information on pesticide reduction; an example decision document; an example MAP; and a description of how this plan was prepared.

2.0 HOW TO USE THIS PLAN

This section explains how to use the document to support reduction in the amount of pesticides used at an Air Force base.

2.1 CATEGORIES OF PEST MANAGEMENT PRACTICES

The discussions of pest management practices in this plan are arranged by categories of pest and type of practice, as follows:

Herbicides

- Turf weed control (non-golf course areas)
- Bare ground and fence line control
- Aerial spraying (ranges)
- Aquatic weed control.

Fungicides

Insecticides - Outdoor

- Japanese beetles
- Mosquitoes
- Fire ants
- Bees/wasps/hornets
- Mole crickets
- Cutworms.

Insecticides - Indoor

- Cockroaches
- Termites
- Fleas.

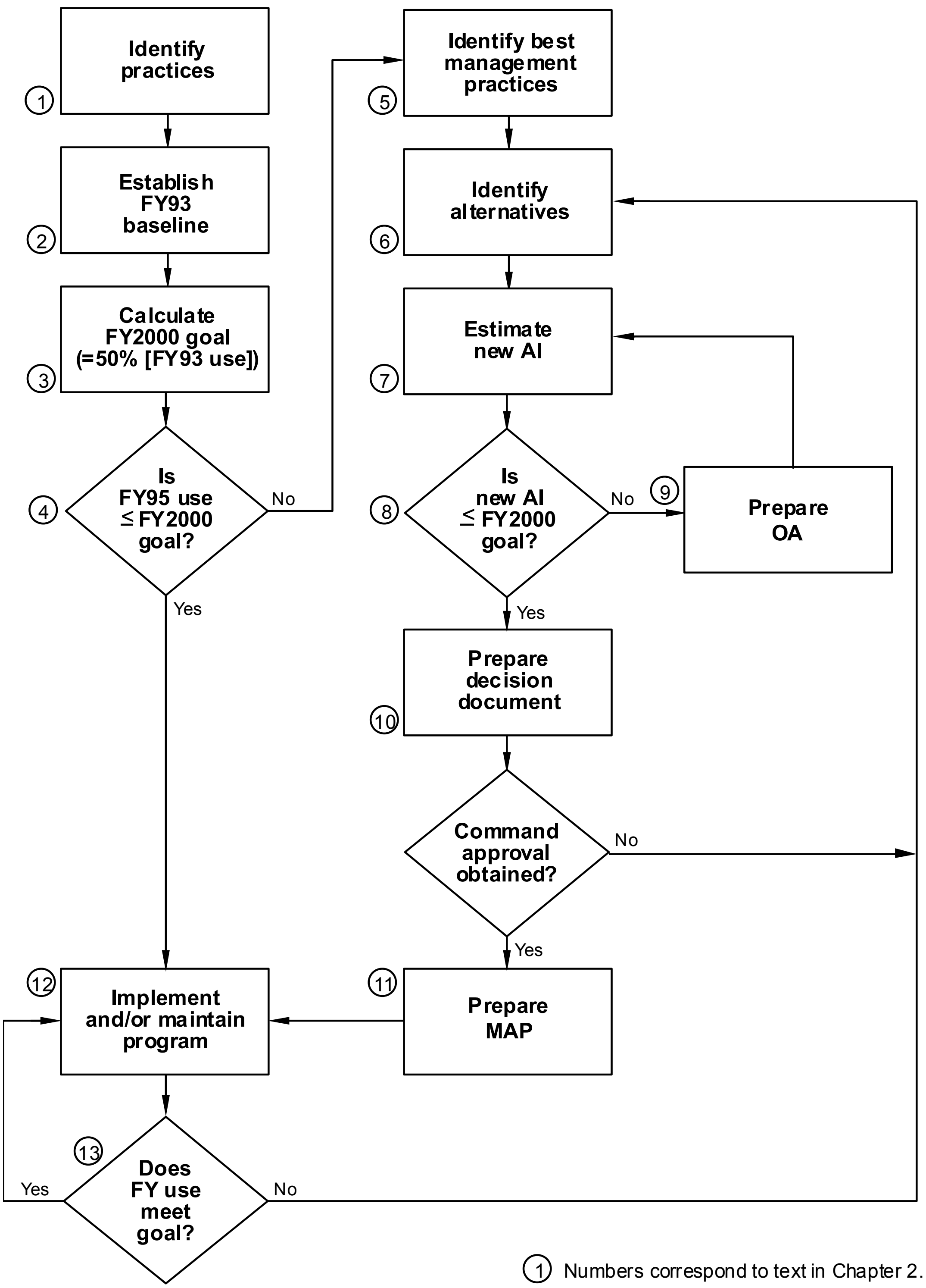
Golf Course Turf Management

These practices are considered to be common at many Air Force bases in the United States. For regional or specific pest problems that are not included in the above list, please refer to Appendix L for a list of general as well as regional and pest-specific sources of pest management information.

2.2 STEP-BY-STEP APPROACH TO PESTICIDE REDUCTION

The steps involved in developing a program for reducing pesticide use to meet the 50-percent reduction goal are summarized below and illustrated in the flow diagram in Figure 2-1. Base personnel should consult with the appropriate Major Command Pest Management Consultant (listed in Appendix L) when conducting this process.

Figure 2-1. Reducing Pesticide Use



1. Identify pest management practices currently used (see list above).

2. Establish baseline use (Chapter 3) in FY 93 from pesticide applications records (Work Information Management System [WIMS] database or Forms 1532), for each pest management practice; sum to obtain total FY 93 usage. (This should already have been accomplished for each base.)

3. Calculate goal for FY 2000 (equal to 50 percent of total FY 93 pesticide use).

4. Review use in FY 94 and FY 95 for each pest management practice, compared to FY 93 use, to identify trends. If the 50-percent goal has already been achieved through implementation of reductions, the current program should be maintained, although additional alternatives described in Appendices A through H may be implemented to further reduce pesticide use. If pesticide use has been unchanged or is increasing, then the recommendations presented in this plan should be implemented to assist in reducing pesticide use.

5. Identify Best Management Practices (Chapter 4) that are consistent with current practices.

6. Review alternatives presented for each pest management practice (Chapter 5; Appendices A through H) to identify those that could be implemented at a specific base (note that, although pesticide reduction should be practiced wherever possible, meeting the 50-percent reduction goal can best be achieved by focusing on reducing those practices that use the largest amounts of AI).

7. Calculate the amount of pesticides that would be used if all alternatives were implemented.

8. Compare estimated pesticide use to FY 2000 goal; if goal can be met or exceeded (i.e., 50 percent or less of FY 93 use), proceed to step 11. If not, additional effort may have to be expended to reduce pesticide use (Steps 9 and 10).

9. Preparation of an OA (Chapter 6) will help to identify other alternatives for reducing pesticide use and select the most cost-effective methods to meet the FY 2000 goal.

10. After alternatives have been identified to reach the 50-percent reduction goal by FY 2000, it is important to prepare a decision briefing document to obtain base command support for the recommended alternatives (Chapter 7).

11. When the base commander has approved the alternatives to be implemented for pesticide reduction, an MAP should be prepared (Chapter 7) to describe in detail how and by whom they will be implemented, and to provide a schedule for implementation and methods of monitoring progress.

12. Implement the approved pest management program.

13. If, during the implementation of the alternatives, it is determined that one or more alternatives is not effective, or not as effective as previously estimated, it may be necessary to return to Step 6 to try to identify other alternatives. In any case, it is recommended that Steps 6-12 be repeated every 1-2 years, in order to keep abreast of new products that may be more effective, or entail use of less AI.

Note that although MOM 2 specifies a 50-percent reduction in the amount of chemicals applied, the intent of the initiative is to reduce the exposure of humans and the environment to harmful chemicals. Thus, if reduction greater than 50 percent can be achieved in a cost-effective manner, it should be implemented to minimize exposure to chemicals.

2.3 ALTERNATIVE USES FOR THE MODEL PESTICIDE REDUCTION PLAN

Personnel who intend to conduct a complete OA and MAP process should read Chapters 2-7, which will guide them through the whole process. They will also find value in Appendices A through H, and may want to include some of the alternatives in their OA. In this case, the user would complete all steps shown in the flow chart for reducing pesticide use (Figure 2-1).

On the other hand, pesticide users who do not intend to prepare an OA, or who simply want information on specific pest management practices that result in reduced pesticide use, should focus on the information in Chapters 4 and 5 and Appendices A through H. Information in these sections is organized by pest management practice, and the user can turn directly to the relevant section(s). These users of the plan would omit steps 9-11 shown on the flow chart (Figure 2-1).

Whatever the intended use of the document, it is recommended that personnel at every base repeat the process of reviewing annual pesticide usage, reviewing/researching alternative uses to reduce pesticides, and reviewing the pest management program every year. This will help ensure that all portions of the program are being implemented correctly, that program effectiveness is monitored, and that new alternatives that were not previously available are identified and adopted as appropriate.

3.0 PREPARING A BASELINE INVENTORY

For purposes of calculating pesticide reduction to meet the DoD MOM 2, it is necessary to establish the FY 93 baseline use. This baseline should already have been calculated and reported to the major command, but this section presents guidelines for consistency among different bases. These procedures should be followed for quarterly and annual reporting of pesticide usage.

The process of calculating baseline quantities of pesticides used consists of three major steps:

1. Identify all organizations that use pesticides
2. Identify and collect pesticide data records
3. Calculate pounds AI.

These steps are described below.

3.1 IDENTIFY PESTICIDE USERS

Identify the different organizations on base that use pesticides. These typically include the Civil Engineering (CE) Pest Management Shop, golf course, Self-Help Store, and grounds maintenance personnel and their contractors. It is recommended that all organizations that apply pesticides and self-help stores that dispense pesticides coordinate with the CE Pest Management Shop in reporting amounts of AI used, types of pesticides applied, and locations. If private contractors or other entities (e.g., tenant organizations) apply pesticides, the contract should include provisions for quarterly and annual reporting of amounts of AI applied, clearly specifying what information is to be provided.

3.2 IDENTIFY AND COLLECT PESTICIDE DATA

The easiest method of tracking pesticide use is to have all applicators enter application data into a single database. Many Air Force bases use the WIMS database, although not all organizations that apply pesticides use the database. Current plans in DoD call for FY 97 and future year reporting to be conducted using the Defense Environmental Security Corporate Information Management (DESCIM) system. Whatever system is used, the database should be organized so that the operator enters information on product used, date, amount of product used, and location. The computer can calculate pounds AI used (based on label information, which must be entered into the computer for each product used).

Golf courses typically use DD Form 1532 to log each application of pesticide; these forms should be submitted to the CE Pest Management Shop for quarterly and annual reporting for the entire base.

When calculating baseline pesticide usage, it is most helpful to aggregate pesticide usage data by pest management practice (for example, see Section 2.1), for ease of measuring reduction by practice.

Use of the application records provides a more accurate accounting of amount of product actually used. If use is calculated based on inventory or base supply records, it is more difficult to track amounts used, especially if base personnel use pesticides obtained through channels other than base supply (e.g., through use of “impact cards” at off-base stores). In addition, some supply items that contain pesticides may not be listed in supply records as pesticides. For example, weed and feed products, although often stock coded as fertilizers, contain herbicides. Some paints contain insecticides to prevent insect nests. Pest management personnel should try to ensure that pesticides in these types of supply items are included in the pesticide tracking/accounting system.

This method of establishing a baseline will not allow tracking of materials used by base residents in their homes and yards, although if the products are obtained through the base Self-Help Store, the records of amount of product distributed may be obtained (this will still not show total amount applied).

3.3 CALCULATE AMOUNT OF PESTICIDES USED

The total amount of AI applied can be calculated for each pesticide as follows:

(pounds of product applied) x (percent AI) = total pounds AI applied

For liquid formulations, AI content is usually provided on the label as pounds AI per gallon of product. Therefore, for liquids, use:

(gallons of product applied) x (pounds AI per gallon of product) = total pounds AI applied

The weight of AI applied should be calculated for each product used and summed to obtain a total. If many products and many applications are identified, establishing a baseline can be quite time-consuming. Use of a computer database can facilitate this process by calculating and summing pounds AI quarterly and annually if the database is set up correctly.

4.0 BEST MANAGEMENT PRACTICES

4.1 DOD INTEGRATED PEST MANAGEMENT PROGRAM

Integrated Pest Management (IPM) is an approach to pest control that utilizes routine monitoring to determine if pest control measures are necessary. IPM employs mechanical, physical, cultural, biological, and educational methods to maintain pests at populations low enough to prevent undesirable damage or annoyance. Application of least-toxic chemical applications is utilized as a last resort. Table 4-1 provides a comparison between traditional pest control methods and those implemented under an IPM program.

Table 4-1. Contrasts between Traditional Pest Control and IPM

Pest Management	Traditional Pest Control	Integrated Pest Management
Program Strategy	Reactive	Preventive pest control
Customer Education	Minimal	Extensive
Potential Liability	High	Low
Emphasis	Routine pesticide application	Pesticides used when exclusion, sanitation, etc., are inadequate
Inspection and Monitoring	Minimal	Extensive
Pesticide Application	By schedule	By need
Insecticides in Occupied Spaces	Sprays and aerosols	Baits
Application of Sprayed Insecticides	Surface treatment	Mostly crack and crevice
Use of Insecticide Space Spraying and Fogging	Extensive	Minimal
Weed Control	Emphasis on herbicide	Good fertilizer, mowing, aeration practices, and use of native and weed-resistant plants

In implementing IPM programs, predetermined or regular treatments/applications are not conducted. Pest control measures are implemented only when monitoring determines that a pest will cause unacceptable economic, medical, or aesthetic damage if not treated. Treatments are chosen and scheduled to be the most effective and least disruptive to natural pest control.

Under an IPM program, execution of individual pest management practices involves steps:

- Identify pest
- Develop plan/strategy
- Establish action thresholds
- Monitor pest population
- Control pest (optional)
- Document results
- Evaluate/redesign plan.

4.2 BEST MANAGEMENT PRACTICES

In addition to the alternatives evaluated in Appendices A through H, a number of practices were identified that would help reduce pesticide use, although the actual amount of reduction cannot be quantified or the amounts of pesticides involved represent only a small percentage of total use. Typically, these practices include "best management practices" that should be incorporated into the overall IPM program at a base, and most can be implemented immediately, with no special equipment or training.

Turf Management

- Hand-pull weeds or use a mechanical trimmer (weed-whacker) instead of spraying herbicides, wherever possible.
- Consult with the local extension service to identify weed-resistant and insect-resistant turf types suitable for your area, or use ground covers other than turf that provide a presentable appearance and are less susceptible to weeds than turf.
- Improve turf health through a program of fertilization, aeration, irrigation, and increased mowing height to promote resistance to weeds, disease, and insects.
- When herbicides are applied, use spot treatment instead of broadcast spraying.
- Apply post-emergent herbicides when weeds are small and most vulnerable.
- Use herbicides that contain a low percentage AI or have a low application rate of AI per acre.
- Consult with the local extension service agent for expert advice on soil testing, herbicide formulations, application regimens, etc.
- Do not apply herbicides during times of high stress for weeds, such as drought or freezing conditions, when the weeds go into a dormant phase, because the herbicides will not be as effective.
- Try to promote an increased tolerance of weeds in some turf areas as part of an overall pollution prevention awareness, emphasizing the reduction in application of chemicals.

Bare Ground and Fence Line Control

- In ornamental beds, weed and mulch or use geotextile weed barriers for maintenance.
- Cease weed control in selected areas, such as campgrounds and other small areas where a natural appearance is acceptable and weeding is not necessary.
- Do not apply herbicides during times of high stress for weeds, such as drought and freezing conditions, when the weeds go into a dormant phase, because the herbicides will not be as effective.
- Use a scraper or other mechanical method to remove vegetation in areas such as campgrounds, weapons storage areas, athletic fields, training areas, and around stables.
- Create a mow strip or mulch strip along fence lines.
- Pave or fill in cracks in parking lots and flightline pavements to reduce occurrence of vegetation.

Aquatic Weeds

- Use grass carp in states where they are legal.
- Divert nutrient-laden runoff (e.g., from leach fields and fertilizers) away from water retention ponds.
- Use slow-release nitrogen sources and control application of fertilizers and other plant nutrients upgradient of water sources.

Fungicides

- Have a laboratory test soil samples from the golf courses to analyze the specific types of fungus present, and make recommendations regarding the suite of fungicides currently used. Not all may be necessary.
- Improve turf health and resistance to disease through fertilization, aeration, irrigation, and increased mowing height.
- Consult with the local extension service to identify turf types that are more disease-resistant and suitable for your area, or use other ground covers and native vegetation that are more disease resistant than turf.

Outdoor Insects

- For aphids, use a water or soap/water spray only.
- Use plant foods that repel insects on roses and other ornamentals.
- For bees, wasps, and hornets, apply a soap (dishwashing soap) and water mixture from a hand-held pressure sprayer on insects and hives.
- Call a local bee keeper to remove bee hives.
- For bagworms, pick the insects off of plants.
- For scale insects (sucking insects with shell coverings, related to aphids), use dormant oil only if it can be applied at the correct developmental phase.
- Encourage natural predators, such as birds and bats, by placing bird and bat houses in outdoor areas where flying insects are a problem (away from flightline areas).
- Use traps for flies and bees.
- Eliminate areas of standing water that may provide habitat for breeding mosquitos.
- Vary the chemicals used to control mole crickets so that they do not develop a resistance to a particular chemical.
- Replace ornamentals that are attractive to pests with other varieties.
- Physically remove fall webworm nests from trees.

Indoor Insects

- Seal/caulk cracks and crevices in structures to keep out ants, roaches, and other insects.
- Use baits and gels for ants and roaches.
- Use a fly swatter.
- Use heat treatment to kill roaches; follow up with sticky traps to monitor reappearances and treat when population increases above tolerable levels (instead of routine treatment).
- Vary the chemicals used to control roaches so that they do not develop a resistance to a particular chemical.
- Use insect growth regulators to control cockroaches and to control fleas on pets.
- Keep food products and food wastes in tightly sealed containers to discourage ants and roaches.
- Use boiling water to destroy ant mounds.
- Use a boric acid product to control ants and cockroaches.

Golf Course Turf

- Implement public participation programs, such as “adopt a hole,” among base organizations and local youth groups to assist in weeding, trimming, and other maintenance activities on the courses to maintain healthy turf and minimize the need for pesticides.
- Use natural vegetation and other ground covers in some areas of the roughs instead of turf.

General Pest Management

- Use surfactants and adjuvants as recommended on the label to increase the effectiveness of any chemical pesticides, and to reduce the amount of AI.
- Ask for trial demonstrations by product manufacturer representatives to be sure the recommended treatment is appropriate for the specific conditions at a base.
- Continue to research new products that are in the development and testing stages (see Appendix J).
- The Self-Help Store on base should stock products with low percentages of active ingredients, such as those recommended in the HQ AFCESA/CV memorandum dated 18 August 1993.
- The Self-Help Store should provide advice for residents regarding lawn care, such as recommending a regimen of fertilization, proper grass height, and aeration for lawns to decrease the necessity for herbicide applications.

THIS PAGE INTENTIONALLY LEFT BLANK

5.0 SELECTING ALTERNATIVE PESTICIDE REDUCTION OPTIONS

5.1 PESTICIDE REDUCTION ALTERNATIVES

In general, pesticide reduction alternatives can be grouped into the following types of practices:

- Chemical pesticide with low AI [A]
- Chemical baits (insect control) [C]
- Reduction in area treated [R]
- Spot treatment [S]
- Mechanical control [M]
- Biological control [B].

Where possible and practical, it is preferred to use a nonchemical method of pest control in order to reduce the exposure of humans and the environment to chemical toxins.

When selecting alternatives for implementation, it is important to recognize that some of the alternatives may not be completely effective at eliminating the target pest. Continued use of pesticides at lower usage rates, or a combination of two or more alternatives for a specific practice in order to provide the most effective control may be required. For controlling turf weeds, for example, the most effective approach may be to reduce the area treated, provide a strong program of fertilization and aeration to maintain healthy turf, and apply low-AI herbicide in spot treatments only, or hand-pull weeds in selected areas.

Appendices A-H provide detailed information regarding alternative pest management practices, grouped by category. Information presented for each alternative includes a brief discussion of the practice; a list of advantages and disadvantages, including precautions for using the product; formulae to be used for calculating costs and pounds AI for that practice at an example or hypothetical base (with worked examples); and manufacturer/supplier information. For additional information on these pesticide reduction alternatives, contact PRO-ACT at: (210) 536-4214; DSN: 240-4214; DSN FAX: 240-4254; Toll Free: 800-233-4356; Wang E-mail: PRO-ACT; Internet: proact@osiris.cso.vivc.edu.

APPENDIX A - ALTERNATIVES FOR CONTROLLING TURF WEEDS

Herbicides include any chemical used to kill or inhibit the growth of vegetation, whether targeted specifically at weeds or used to destroy all vegetation. Control of turf weeds includes all lawn care practices typically implemented by CE Pest Management. Typically, this category consists of control of weeds in selected areas of turf that are maintained on the base. The primary areas are along “VIP Routes,” and include those areas that are most visible to visitors touring the base. (The letters in brackets shown after each alternative indicate the type of practice, as listed above).

- Spot treat weeds [S]
- Improve fertilization, irrigation, and aeration practices [M]
- Hand-pull weeds [M]
- Decrease area treated (less visible areas) [R]
- Replace turf with other ground cover (e.g., native vegetation, mulch, rock) [R]
- Alternative herbicide with low percentage AI [A].

APPENDIX B - ALTERNATIVES FOR BARE GROUND AND FENCE LINE WEED CONTROL

Bare ground control refers to treatment of many areas on base with nonselective herbicides designed to kill all vegetation. Areas treated include flightline pavements in cracks and around runway and taxiway lighting, parking lots, railroad rights-of-way, and areas around some facilities such as electrical substations and storage tank farms. These areas are kept vegetation-free for reasons of safety (reduced fire hazard) and security (increased visibility). Fence lines are treated primarily for reasons of security. Often, the same nonselective products are used as described for bare ground practices, although total elimination of vegetation is not necessary along fence lines.

- Fill cracks in pavements [M]
- Hand-pull weeds [M]
- Weed-Seeker® sprayer [S]
- Scraping/dragging (physical removal) [M]
- Decrease area treated [R]
- Flames or Steamers [m]
- Alternative herbicide with low percentage AI [A]
- Plant growth regulator [A]
- Mechanical trimming (weed whacking) [M].

APPENDIX C - ALTERNATIVES FOR AERIAL HERBICIDE SPRAYING

Aerial application of herbicides is conducted at bases where vegetation must be controlled over large acreages. Typically, herbicides are applied on target ranges to maintain the visibility of the targets. Aerial application techniques are used because the coverage of large areas is more cost-effective, or because there may be unexploded ordnance on the ranges, making ground-based application unsuitable.

- Mechanical removal of vegetation [M]
- Aerial application of Krovar I DF® and mechanical target maintenance [A,M]
- Aerial application of herbicides with low percentage AI [A]
- Ground-based application of herbicides with low percentage AI [A].

APPENDIX D - ALTERNATIVES FOR CONTROLLING AQUATIC WEEDS

Aquatic weeds can develop in bodies of water, typically in the shallow areas. This vegetation is usually unsightly and can interfere with recreational use of the water body. The vegetation can also provide breeding habitat for insect pests, and if it begins to decay, can deplete the oxygen supply in the water, making it uninhabitable for desirable aquatic animal species, such as fish.

- Grass carp [B]
- Physical removal - tilt mower [M].

APPENDIX E - ALTERNATIVES FOR CONTROLLING FUNGI

Fungicides are defined as substances that destroy or inhibit the growth of fungi. Fungi grow from spores that may be present in the soil and grow when environmental conditions (temperature and moisture) are suitable.

- Envirocaster disease prediction model [R]
- Reveal test kits [R]
- Alternative fungicide with low percentage AI [A].

APPENDIX F - ALTERNATIVES FOR CONTROLLING OUTDOOR INSECTS

Insecticides are defined as substances that kill or interfere with the life cycle of insects. Outdoor insect pests vary by geographic area. This model plan addresses some of the insects pests that are common over large sections of the country, and that may be pests on many Air Force installations.

Japanese beetles first appeared in this country in 1916 in the New Jersey area. Since then, they have been migrating westward, and currently inhabit areas east of Michigan, southern Wisconsin, and Illinois, and south through the southern portion of Alabama. The adult beetles live in and eat leaves of trees and shrubs. They lay their eggs on the ground and the larvae, or grubs, live in the ground and come to the surface to feed on grass. Separate management practices are recommended for the two phases of the Japanese beetle life cycle.

Adult Japanese beetles

- Alternative insecticide with low percentage AI (synthetic pyrethroids) [A]
- Eliminate preferred food sources [M]
- Manual removal [M]
- Neem oil [B].

Japanese beetle larvae

- Spikes of death [M]
- Milky spore disease [B]
- Beneficial nematodes [B]
- Alternative insecticide with low percentage AI [A].

Numerous species of **mosquitoes** occur throughout the country. The female lays the eggs in water that is still or very slow-moving. In addition to being annoying, many mosquito species sting humans (and animals) to feed on blood, causing itchy, irritating welts. In some cases, mosquitoes can become a disease vector. Typical pest management practices include fogging with insecticides to kill the flying adults. IPM practices focus on eliminating aquatic habitat for development of the larvae.

- *Bacillus thuringiensis israelensis* (Bti) [B]
- Mosquito fish [B]
- Insect growth regulator (Altosid®) [A]
- Improve drainage to eliminate standing water [M]
- Synthetic pyrethroids [A].

Numerous species of **ants** occur throughout the United States. Some can bite and produce stinging welts. Most are just annoying. Ants are described in this appendix as outdoor insects, but can also be an indoor pest in areas where food is accessible. The management practices recommended here are suitable for use outdoors or indoors, unless otherwise specified.

- Alternative insecticide with low percentage AI [A]
- Baits [C]
- Boiling water (small areas) [M].

A variety of **bees, wasps, and hornets** are found across the country. Most will sting humans (and animals) if irritated, producing small inflammations; some people are extremely allergic, and can become very sick or even die of anaphylactic shock if not treated promptly.

- Soap and water with surfactants [M]
- Insecticides with a low percentage AI (e.g., synthetic pyrethroids) [A].

Mole crickets are turf pests that are quite common throughout the southeastern portion of the United States.

- Beneficial nematodes [B]
- Tachinid fly [B]
- Alternative insecticide with low percentage AI (Mocap®) [A].

Cutworm refers to the larval phase of a number of moth species. The larvae live under the ground, but come up to the surface to eat plants. Cutworms can be a major source of damage to lawns and golf courses.

- Beneficial nematodes [B]
- Alternative insecticide with low percentage AI [A].

APPENDIX G - ALTERNATIVES FOR CONTROLLING INDOOR INSECTS

The most common indoor pests are cockroaches, ants, termites, and fleas. Ant control practices are described in Appendix F for outdoor pests.

Cockroaches are present throughout the country in a number of species. Because they can develop a resistance to chemical insecticides, the most effective treatments are mechanical (thermal control), biological (insect growth regulators), or applying a variety of insecticides in rotation.

- Gel bait insecticides [C]
- Cockroach bait stations [C]
- Thermal control [M]
- Insect growth regulator [C].

Subterranean termites live in colonies underground. Worker termites forage for wood to feed the colony, and can produce serious damage to wooden structures. IPM measures include pre-treating wood used in construction or placing barriers around the structure that make it difficult for the termites to reach the wood portions of the structure.

- Colony elimination system [C]
- Alternative insecticide with low percentage AI (e.g., Premise®) [A]
- Thermal control [M].

Fleas live, feed, and lay their eggs on animals. The eggs fall off of the animal, in the home or outside. There they hatch, go through the larval and pupal stage, and become adults. As adults, they find another animal host and repeat the cycle. In homes where pests are present, flea treatment can consist of applying insecticides (liquid sprays or powders) to pets as well as to areas of the home and yard where the pets spend time. New products available for pet owners include insect growth regulators that are given to the pets in their food.

- Insect growth regulators (pets) [C]
- Alternative insecticides with low percentage AI (pet areas) [A].

APPENDIX H - ALTERNATIVES FOR GOLF COURSE TURF MANAGEMENT

Golf courses are typically managed by the Morale, Welfare, and Recreation organization on base. Because there are very specific standards for golf course greens, tees, and fairways, these management practices are treated separately from turf management practices used by CE Pest Management personnel on other parts of a base.

- Replace portions of roughs with natural vegetation [R]
- Create “environmentally friendly“ course (eco-course) [B, R].

5.2 CALCULATING COST AND POUNDS AI

Two of the most important factors in evaluating an alternative pest management practice in comparison to the current practice are the difference in cost and the reduction in pounds AI. Appendices A through H include information to help calculate cost and pounds AI for the recommended alternatives. The following paragraphs present some guidelines for comparison to the current practice.

5.2.1 Calculating Increase or Decrease in Cost

There are several types of costs that may be associated with calculating whether a new pest management practice will be more or less expensive in the long run than the current method. These are summarized below.

Capital costs are one-time costs associated with the initiation of a new practice. Typically, capital costs entail purchase of equipment or training, but may also be associated with a one-time practice that would replace recurring maintenance practices. An example would be relandscaping with weed-resistant turf, or filling in cracks in parking lots and flightlines. These one-time costs would replace annual costs for materials and labor involved in applying herbicides to these areas. Capital costs will vary greatly among alternatives; the descriptions of alternatives include information that will help base personnel estimate capital costs for that practice for a specific base.

Annual operating costs consist of recurring costs that must be expended each year. Primarily, annual operating costs include costs for materials, such as pesticides, and labor costs for implementing the practice. Labor would be associated not only with application of pesticides, but with mechanical measures that may be implemented instead of applying pesticides, such as mechanical trimming, hand-pulling weeds, or other lawn care practices. Material costs depend on the cost per unit of material used, the recommended application rate (pounds per acre), the acreage covered, the number of applications required annually, and a number of other factors. Labor costs are dependent on the number of acres that can be treated in an hour, the number of applications required per year, and the hourly wage of the personnel assigned to the task. The information supplied for each alternative includes equations that show how to calculate annual costs and include calculated examples. These same equations can be used to calculate the annual costs of the current practice based on labor rates, application rates, acreage covered, and pesticides presently used. Worked examples are provided for each alternative, using product costs and labor rates obtained from regional sources. These costs will vary for different suppliers, regions of the country, etc. Local sources can provide cost information for a specific base.

The total annual operating cost equals the material costs plus the labor cost. Calculating increase or decrease in annual costs must consider both. For example, a recommended practice may be a mechanical method for removing weeds. In that case, material costs for pesticide would be zero, although there may be very minimal materials costs associated with, for example, fuels for the mowers or trimmers required. But increase or decrease over present use cannot be calculated without considering the probable increase in labor required for such a practice. If the work can be accomplished using less expensive labor than pesticide applicators, the alternative may be cost-competitive.

Payback should be calculated in cases where the alternative would entail a large capital cost, but it is compensated for by reduced annual costs. Payback refers to the number of years over which the alternative would have to be practiced before the annual savings in operating costs made up for the initial capital cost. The equation is:

Time to payback = (Initial capital investment)/[(Annual operating cost of current practice) - (annual operating cost of new alternative)]

For example, if a capital investment of $50,000 is required for equipment to implement an alternative, and the annual operating costs of the alternative would be $5,000 compared to current annual operating costs of $10,000, then payback would be calculated as:

Time to payback = ($50,000)/($10,000-$5,000) = $50,000/$5,000 = 10 years.

Because the current operating costs at each installation will vary substantially, personnel at each base will have to calculate increase or decrease in cost, including payback, based on the particular current practice compared to the alternative under consideration.

5.2.2 Calculating Decrease in Pounds AI

Similar to cost, the reduction in pounds AI applied annually will vary for each base. This value will depend upon the particular current practice used, the alternative under consideration, and local conditions that contribute to the degree of success of the alternative. The descriptions of alternatives include information to be used in estimating the pounds AI that would be used if that alternative were implemented. Current use for that practice should have been calculated as part of the baseline (see Chapter 3). For some alternatives, reduction can only be estimated, for example, 30- or 50-percent reduction is considered reasonable based on previous experience. Actual reduction will vary with local conditions. For application of alternative pesticides or similar products, pounds AI can easily be calculated using the basic equation:

Annual AI usage = (% AI)(lb. product/acre)(acreage treated)(# annual applications)

For example, if a product contains 5 percent AI, and the recommended application rate is 20 pounds of product per acre, and 100 acres are treated twice per year, then the weight of AI is calculated as:

Annual AI usage = (0.05)(20 lbs./acre)(100 acres)(2) = 200 lbs. AI.

Note that pounds AI applied is a factor of not only percent AI, but also application rate and number of annual applications required. If a recommended product has a lower percentage AI, but is less effective and must be applied at a higher application rate (pounds per acre) or more frequently, it may not result in a lower overall use of pesticides. The calculations should be worked for each base, for the current practice and the alternative under consideration, accounting for all of these factors, to determine if this method will contribute to a reduction in pounds AI. Even if pounds AI are not reduced, it may be wise to calculate the cost difference as well; some alternatives may have a lower cost for the same amount of AI. The priority of criteria used in evaluating alternatives will vary from base to base.

6.0 CONDUCTING AN OPPORTUNITY ASSESSMENT FOR PESTICIDE REDUCTION

Preparing the OA begins with establishing the baseline for comparison (see Chapter 3). The baseline use should be calculated separately for each pest management practice. This will allow identification of the practices that account for the major uses of pesticide. Although reduction of all pesticide uses is the goal, often it is effective to concentrate on reducing the major pesticide use categories in order to meet the 50-percent reduction goal. It may not be possible to achieve 50-percent reduction in each practice; however, it may be possible to achieve greater than 50-percent reduction in some practices to compensate for those in which less reduction is achieved.

First, any alternatives referenced in Chapter 5 and Appendices A through H of this model should be selected to provide some percentage of reduction in pesticide use. Combining alternatives can be a very effective way to achieve greater reduction in pounds AI. If implementing these alternatives will not enable the base to meet the 50-percent reduction goal, additional options must be researched and evaluated.

One option to be considered immediately is simply reducing the use of pesticides, by treating less frequently, treating less area, or using spot treatment only when the pest is present rather than routine broadcast spraying (see Chapter 4). The natural result of this strategy may be an increase in pest population, and it must be considered what level of pest is tolerable or acceptable. Many bases have ceased or largely curtailed use of herbicides on turf areas, or reduced fogging for mosquitos, and are learning to tolerate a higher level of pests.

6.1 SOURCES OF INFORMATION ON ALTERNATIVE PEST MANAGEMENT PRACTICES

A detailed list of references and sources of information is provided in Appendix L. The following paragraphs discuss the types of sources that are available.

Manufacturer Literature. Product manufacturer representatives may be contacted to obtain literature on specific equipment and pesticides, especially product labels. In addition, several reference documents provide consolidated collections of particular pesticide labels and other information. These included the 1993 Crop Protection Chemicals Reference and the three-volume reference set published by Pest Control Technology.

Literature Available from State Extension Services. Specific literature and brochures may be obtained from the various state extension services. Available references include publications on lawns, weed control, turf pest management, and control of insects.

Literature from the Environmental Protection Agency. The Environmental Protection Agency (EPA) provides publications relating to pollution prevention, OA procedures, pesticides in general, and safer pesticide use.

Publications from the Bio-Integral Resource Center. Several Bio-Integral Resource Center (BIRC) publications were obtained and provided information on lawn pests, least-toxic pesticides, nonchemical weed control, lawn care, and specific biological/botanical controls. In particular, *Common Sense for Pest Control* (Olkowski, 1991), published by BIRC, contains an abundance of helpful information for reducing use of pesticides.

DoD Agencies. Within the Air Force and other DoD agencies, a number of groups are conducting research and coordinating information regarding IPM and alternative pest management practices. These include the Air Force Pest Management Board, Air Force Civil Engineer Support Activity, and entomologists at the Major Commands. In other services, the U.S. Army Center for Health Promotion and Preventive Medicine, and Naval Facilities Engineering Command also provide information on pest management activities. Addresses and telephone numbers for these organizations are provided in Appendix L.

6.2 IDENTIFYING AND EVALUATING ALTERNATIVE PEST MANAGEMENT PRACTICES

It is helpful to apply a consistent evaluation system to alternative pest management practices. The system should consider all factors that are involved in pest control, and enable a fairly objective means of rating the alternatives. One suggested method is described below.

Identifying Options. Potential pest management options can be identified through a variety of sources, including experienced base personnel, the Local Extension of the U.S. Department of Agriculture, and State Extension Service staff. At this point in the OA, no reasonable option should be excluded. Preference should be given to identifying those options that avoid the use of chemical pesticides. The following data may be used in developing alternatives:

- Technical information - Pests managed, pest management substances/methods used, application methods and frequency, effectiveness, amounts used, other management needs. Technical information may include vendor information such as advertisements, brochures, figures, diagrams, product labels, etc.

- Cost information - Current and future costs of capital, materials, labor, compliance, maintenance, training, permitting, waste management.

- Toxicity Data - Where available, toxicity information, typically provided in the form of lethal dose (LD_{50}) values, may be referenced.

- Environmental protection information - Regulatory status (restricted use, prohibited), potential environmental impacts.

- Acceptability to the general public, area occupants, users.

Screening Options. The identified options should be reviewed for technical and cost feasibility. Options that are not considered to be technically practical to implement, or not considered effective, should be eliminated from further consideration. Some options considered may be new, and not yet fully tested; although quite promising, these probably should be eliminated from further evaluation at this time, as should products that are not yet available. Cost should also be considered in the screening process. An option with a higher associated cost may be considered economically feasible if it contributes significantly to reaching the 50-percent reduction goal and results in reduced worker/population exposure to toxic chemicals. Options considered to be both technically and economically feasible should be retained for additional evaluation in the next step.

Evaluating Options. Options that passed the screening review should be subject to a detailed evaluation in comparison to both current practices and the other options considered for evaluation. The single most important factor in evaluating alternatives should be reduction in pounds AI that would be achieved using that alternative instead of current practices. In most cases, the amount of AI that would be used can be calculated based on the FY 93 usage (in acreage covered or amount of product applied) to provide a comparison. However, where data for FY 93 are not available or are considered unrepresentative of typical practices, usage data from another year may be used for reference purposes in calculating estimated pounds AI.

Each option should be evaluated quantitatively for its performance on six criteria considerations: cost, effectiveness, environmental impact, toxicity, regulatory concerns, and acceptability. The factors considered in rating the alternatives for each criterion are described below.

- ***Cost*** considers all costs associated with implementing the practice. It includes cost of chemicals that would be required on an annual basis; special equipment that may have to be obtained, either as one-time capital costs or recurring costs (for monitoring or maintenance);

and labor costs (generally addressed in the form of the difference in labor hours from current practices). Representative product and equipment costs may be obtained from the manufacturer or local vendors.

- ***Effectiveness*** is evaluated based on the demonstrated ability of the alternative to control the target pest. Ratings for effectiveness should be based on discussions with experts in the particular field who have experience with the new option as well as with the current practice.

- ***Environmental impact*** refers to the extent to which the environmental resources of the surrounding area may be affected by the option (e.g., by off-site mobility of chemical products).

- ***Toxicity*** reflects the extent to which a chemical product may adversely affect humans or animals through direct contact. Where information on LD_{50} values is available (typically from manufacturers' label information), it may be used as the basis for toxicity ratings.

- ***Regulatory Concerns*** should be evaluated to identify any specific issues associated with permitting or EPA approval of any of the options evaluated.

- ***Acceptability*** considers the subjective perceptions of the affected population (e.g., base personnel, military commanders, golfers) in response to the alternative. Ratings for acceptability are difficult to predict and quantify, but a general consideration of the likelihood of resistance based on nontechnical aspects of the alternative's performance may be provided for each.

Each option should be given a rating for each criterion, in comparison to current practices, on a scale of 1 to 5. A rating of 1 indicates that the option performs less favorably than the current practice (e.g., has more environmental impacts or a higher cost). A rating of 3 indicates that the option would perform similarly to the current practice for that criterion. A rating of 5 indicates that the option compares very favorably in comparison to the current practice (e.g., has a lower toxicity or reduced labor requirements). The total rating for the current practice will be 18. Alternatives with total ratings close to or greater than 18 should be considered for implementation.

6.3 RECOMMENDING ALTERNATIVES

Selection of the most suitable alternative for a particular base must be made with due consideration of budget, labor availability, and other base-specific conditions. All else being equal, preference should be given to alternatives that minimize or eliminate application of chemicals. Note that combining several alternatives can sometimes provide the most cost-effective approach, and almost always increases the reduction in pesticide use that can be achieved by use of only one alternative. If the rating system described in Section 6.2 is used, the alternative(s) that provide(s) the best combination of low AI and high criteria rating would represent the best overall method of pest control for that practice.

One alternative or a combination should be recommended for each pest management practice. The estimated weight of AI for each practice should be summed to obtain the total estimated pesticide use at the base. This value should be compared to the goal for FY 2000 to ensure that at least 50-percent reduction from the FY 93 baseline can be achieved by the combination of alternatives. If this cannot be verified, it may be necessary to select one or more alternatives that provide lower AI at a higher cost in order to meet the reduction goal. Note that it may not be possible to achieve 50-percent reduction for each practice. It may, however, be possible to achieve a reduction of more than 50 percent for some practices in order to compensate for others for which a reduction of less than 50 percent is obtained. The goal is a 50-percent reduction in basewide pesticide use.

7.0 IMPLEMENTING A PESTICIDE REDUCTION PROGRAM

Once suitable alternatives to reduce pesticide use have been identified and recommended, the next steps are to obtain command support and a decision to implement, and then to develop and circulate an implementation plan to all involved parties so that everyone will understand not only their own responsibilities but the entire program. These steps are described in this section.

7.1 DECISION BRIEFING DOCUMENT

Preparation of a decision document and/or briefing to present the results and recommendations for pesticide reduction is critical in order to obtain command support for the recommended program. The decision document should be a summary of the OA (if an OA was prepared) (Chapter 6) or of the alternatives reviewed and selected for reduction from those presented in this model (Chapter 5). The document should briefly describe why the study was done (i.e., in order to meet the pesticide reduction goal set in MOM 2), how the study was conducted, current pesticide practices, alternatives evaluated for each practice, and recommended alternatives for each practice, with rationale for selection. It will be helpful to present a matrix or table for each practice to allow comparison of criteria ratings, estimated pounds AI, costs, advantages, and disadvantages of each alternative in relation to both the current practice and the other alternatives evaluated. Indicate whether the suite of recommended alternatives will allow the base to meet (or exceed!) the 50-percent reduction goal. An example decision briefing document is presented in Appendix M.

7.2 MANAGEMENT ACTION PLAN

When command support has been obtained and alternatives have been selected, the base should prepare an MAP that presents a detailed description of how the program will be implemented. The MAP should describe the current practices and required changes to the current practices; identify who is responsible for what activities; present a schedule for implementation; describe costs (including capital costs, operating costs [compared to current costs], labor costs, and payback), reporting procedures, and how to monitor progress and incorporate procedures for regular evaluation of progress and identification/evaluation of new alternatives.

A recommended format for an MAP is provided in the U.S. Air Force Installation Pollution Prevention Program Guide (HQ AFCEE/EP, July 1994). The guide recommends preparing the MAP in three sections: Process, Program, and Execution. The Process section should describe the steps that have been taken to develop and implement a pollution prevention (here, a pesticide reduction) program, as well as those steps necessary to modify and measure program success. The Program section should list the costs, benefits, and return on investment (ROI) for the proposed projects (here, the selected pesticide reduction alternatives). The Execution section will list the actions that must occur to implement each alternative, including identification of the Office of Primary Responsibility (OPR) for each action and a schedule for implementation. Excerpts from a sample pesticide reduction MAP are provided in Appendix N of this model plan.

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX A

ALTERNATIVES FOR CONTROLLING TURF WEEDS

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

APPENDIX A
ALTERNATIVES FOR CONTROLLING TURF WEEDS

THIS PAGE INTENTIONALLY LEFT BLANK

TURF WEED CONTROL ALTERNATIVE 1

Spot Treat Weeds

DESCRIPTION OF ALTERNATIVE

Involves replacing broadcast spraying with use of spot treatment with appropriate herbicide as needed.

TECHNICAL ANALYSIS

Herbicide application would be done with hand-held equipment (e.g., spray gun) and would be limited to target weeds only. The specific herbicide used would depend on the target weed and its susceptibility to the herbicide. Often, a 2,4-D formulation is used for post-emergent broadleaf control.

Ideally, this treatment should be implemented in conjunction with a program of regular fertilization, irrigation, and aeration (see Turf Weed Control Alternative 2) to promote healthy, weed-resistant turf.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Eliminates large quantities of herbicides

+ Minimal training required

+ No special equipment costs.

<u>Disadvantages</u>

– Can be labor intensive if large areas are involved

– Does not provide pre-emergent control or control of weeds not readily visible on the surface

– Can be ineffective for large areas with more than minimal weed infestation problem

– Requires more tolerance for weed presence

– Does not help increase turf health, which limits weed infestation.

<u>Contact for Additional Information</u>

Contact local extension service for assistance with weed identification and selection of appropriate herbicide.

COST ANALYSIS

This cost analysis assumes use of a product such as Strike 3®, at a cost of $2.32 per pound and an application rate of 3 pounds per acre. It assumes 10-percent coverage, so out of a 500-acre area, a total of about 50 acres would be treated. Spot treatment (spray gun) application takes approximately 1 hour per acre.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost)(application rate)(area covered)(application/year) + (labor hrs.)(labor rate)
	=	($2.32/lb.)(3 lbs./acre)(50 acres) + (50 hrs.)($15.00/hr.)
	=	$348 + $750
	=	**$1,098**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI usage	=	% AI (amt. applied)
	=	50% (3 lbs./acre)(50 acres)
	=	**75 lbs. AI**

TURF WEED CONTROL ALTERNATIVE 2

Improve Fertilization, Irrigation, and Aeration Practices

DESCRIPTION OF ALTERNATIVE

Involves increasing or modifying fertilization of turf, increasing irrigation where dry conditions exist, and adding aeration to improve turf health.

TECHNICAL ANALYSIS

Often weed infestation can be controlled or eliminated by improving the health of the turf and reducing the stress on the lawn. Increased fertilization and/or proper fertilization (use of correct NPK (nitrogen: phosphorus: potassium) ratio, at appropriate times, (use of a slow-release form) can add needed nutrients and should be based on a soil test analysis that is normally available through the local Cooperative Extension Service office. Aeration (or other dethatching methods) reduces thatch and soil compaction. If needed, additional irrigation can reduce stress from drought conditions. Proper irrigation practices should be followed, avoiding light, frequent irrigation. If the turf height is too low or mowing is done too infrequently, correction of mowing height and timing can also help strengthen the turf. The exact improvement program selected will depend on an analysis of the current turf maintenance program, and perhaps discussions with local extension service experts and soil testing. Some spot treatment with herbicides may be necessary (see Turf Weed Control Alternative 1). Mowing frequency will increase by an amount that will depend on many factors including type of grass, type of fertilizer used, mowing height, soil test values, and frequency of irrigation/precipitation.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Healthy turf resists weeds and requires less application of herbicides; can significantly reduce use of herbicides and limit pounds AI

+ No special training required

+ No special equipment required, unless addition of sprinklers or aeration equipment is needed

+ Healthy turf also prevents infestations of other pests, such as insects and fungus.

<u>Disadvantages</u>

– Requires monitoring of turf conditions and periodic soil testing

– Can cause groundwater contamination or aquatic weed problems if nitrogen is applied at too high a rate in permeable soils with high water table

– Will increase mowing frequency and associated labor costs

– Increased irrigation may be a concern in water conservation districts.

Contact for Additional Information

Contact local extension service for assistance with improvement program development -- recommendations on all aspects mentioned above, especially fertilization amounts, NPK ratio, timing, etc.

COST ANALYSIS

This cost analysis assumes use of a typical fertilizer containing 30 percent nitrogen (NPK ratio should be determined on a case-by-case basis) at a cost of approximately $0.16 per pound and an application rate of 3.5 pounds nitrogen/1,000 ft^2/year, which is equivalent to approximately 127 pounds fertilizer per acre. It is also assumed that 500 acres are treated four times a year, and that the labor time required is approximately 0.25 hour per acre for fertilization, and 0.5 hour per acre for aeration or mowing.

CAPITAL COSTS
No capital costs have been identified, assuming irrigation and aeration equipment is available.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(fertilizer cost)(application rate)(area covered)(# applications/year) + (labor hrs.)(labor rate)(# applications/year) + (additional mowing labor hrs.)(labor rate)(# applications/year)
	=	($0.16/lb.)(127 lbs./acre)(500 acres)(4 applications) + (0.25 hr./acre) (500 acres)($15.00/hr.)(4 applications) + (500 acres)(0.5 hr./acre) ($15.00/hr.) (4 applications)
	=	$40,640 + $7,500 + $15,000
	=	**$63,140**

COMPUTING AI

ANNUAL AI APPLICATION
Not applicable (assuming no spot treatments); if spot treatments are required, see Turf Weed Control Alternative 1.

TURF WEED CONTROL ALTERNATIVE 3

Hand-Pull Weeds

DESCRIPTION OF ALTERNATIVE

Involves hand weeding of small turf areas, ornamental beds.

TECHNICAL ANALYSIS

Hand weeding can be effective if done properly and if labor is available. This option is generally used in small areas and especially in borders and ornamental beds. To be effective, the entire weed, root and all, must be removed.

ADVANTAGES/DISADVANTAGES

Advantages

+ No chemical use

+ No special training or equipment required.

Disadvantages

– Very labor intensive

– Can be ineffective if entire weed is not removed

– Does not provide control of weed growth from seeds.

Contact for Additional Information

Not applicable.

COST ANALYSIS

The cost analysis is calculated for hand-weeding an area of 1 acre, and assumes that it takes 2 hours to pull all weeds. Weeding time can vary considerably depending on the type and density of weeds and area covered.

CAPITAL COSTS
No capital costs have been identified (other than garden tools expected to be available)

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(labor hrs.)(labor rate)
	=	(2 hrs.)($15/hr.)(1 acre)
	=	**$30**

COMPUTING AI

Does not entail use of chemical AI.

TURF WEED CONTROL ALTERNATIVE 4

Decrease Area Treated

DESCRIPTION OF ALTERNATIVE

Involves reducing the area that is maintained as “weed-free” turf (especially VIP routes).

TECHNICAL ANALYSIS

Many of the areas currently maintained to high “weed-free” standards are those areas known as VIP routes and adjoining areas. These expanses of turf generally receive high priority and account for a large amount of herbicide use. If there are portions of these areas that could be considered for less intensive maintenance, then the area receiving herbicides could be reduced. Candidate areas would be those farther away from the main VIP routes and large expanses maintained relatively far away from roads or walkways to high-use buildings.

ADVANTAGES/DISADVANTAGES

Advantages

+ Eliminates a large amount of chemical use

+ No special training or equipment required.

Disadvantages

– Requires greater tolerance of weeds in some areas less visible to visitors and employers

– May not be acceptable if base is “showcase” type facility.

Contact for Additional Information

Not applicable.

COST ANALYSIS

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
There are no specific operating costs for reducing acres treated. However, assuming current turf maintenance costs are $60,000 per year for 500 acres and one-quarter of the area is removed from the maintenance program, then annual operating costs would be reduced proportionately.		
Total Annual Costs	=	$60,000 (3/4)
	=	**$45,000**

COMPUTING AI

ANNUAL AI APPLICATION		
Similar to cost, the annual AI application will be reduced to reflect the reduced area treated. If one-quarter of a 500-acre area is eliminated from the maintenance program and 2,000 lbs. AI were used on all acres, then:		
Annual AI Usage	=	(current lb. AI)(3/4)
	=	(2,000 lb.)(3/4)
	=	**1,500 lbs. AI**

TURF WEED CONTROL ALTERNATIVE 5

Replace Turf with Other Ground Cover; includes “naturalization” of areas

DESCRIPTION OF ALTERNATIVE

Involves removal of grass turf that requires high maintenance (including application of herbicides) and replacing it with a low-maintenance ground cover.

TECHNICAL ANALYSIS

The replacement ground cover selected would vary with the extent of area involved, the use of the area, the visibility of the area, local climatic conditions (temperature, precipitation), soil type, and the desire to increase “natural” cover. Options for replacement covers include:

- Mulch - could replace turf in some ornamental beds or borders; can still provide habitat for weeds, however.

- Weed/pest-resistant turf cultivars - could replace “traditional” bluegrass or other cultivars with blends that provide more resistance to weed infestation. This option is more cost effective and attractive when planting new areas where turf is desirable.

- Natural covers - could use native plant mix, “wildflowers” to create low-maintenance cover that outcompetes weeds and is attractive visually; can also provide benefits to wildlife, depending on location.

- Xeriscape covers - in dry areas of the country, could use plants that require less water and maintenance; often includes plants native to the area that have adapted to xeric (dry) conditions. This can reduce both pesticide use and water use.

- Use of rock or other nonvegetative landscaping.

ADVANTAGES/DISADVANTAGES

Advantages

\+ No (or minimal) chemical use needed for maintenance

\+ Natural covers can benefit wildlife and biodiversity goals

\+ Especially beneficial in new construction areas

\+ Xeriscape can reduce water use as well as pesticide use.

Disadvantages

– If not a turf cover, may not be accepted in certain high visibility areas

– Natural covers may be difficult to establish in certain areas and require ongoing monitoring

– Cost of removal of existing turf and adding new cover can be high, especially if large areas are involved

– Use of mulch, rock will probably not eliminate weed problem entirely

– Mulch can attract insects.

Contact for Additional Information

Contact local extension service or state natural areas/parks program for advice on naturalization; the extension service can provide specific recommendations on weed/pest-resistant turf cultivars.

COST ANALYSIS

CAPITAL COSTS
Capital cost will vary considerably, depending on the nature and extent of the options. These may include: 1. Removal and disposal of existing turf. 2. Cost of new ground cover materials.

ANNUAL OPERATING COSTS
Operating costs will vary considerably, depending on the nature and extent of the options selected. For mulch or rock covers, some weeding will be necessary. For new weed-resistant turf and natural covers, initial maintenance will be required until the cover is well established. The amount of effort required will depend on the type of cover selected and the site conditions.

COMPUTING AI

ANNUAL AI APPLICATION
Not applicable (except spot treatments possibly needed)

TURF WEED CONTROL ALTERNATIVE 6

Alternative Herbicide with Low Percentage AI

DESCRIPTION OF ALTERNATIVE

Involves replacing the current chemical used with a chemical that has a low percentage AI and/or lower application rate and is equally or more effective.

TECHNICAL ANALYSIS

This alternative may not be viable if the herbicides currently in use are the ones most highly recommended for the specific weed control problem. Further, none of the most effective/popular formulations such as those containing 2,4-D, dicamba, and MCPP appear to be extremely low AI choices. However, there are some organic herbicides on the market such as Amaizing Lawn® and Sharpshooter® that could be effective in certain locations and for certain weed problems. Use of a product such as Amaizing Lawns® for pre-emergent treatment would contain zero pounds AI because it is an all-natural product made from corn. In comparison, use of a typical "weed and feed" type of pre-emergent product on 500 acres would result in application of approximately 805 pounds AI.

ADVANTAGES/DISADVANTAGES

Advantages

+ Lower chemical use; can be greatly reduced if organic herbicides are used

+ No special training required

+ No special equipment required.

Disadvantages

– Organic herbicides may not be effective under very wet conditions or on deep rooted species

– Some alternatives may not be as effective on certain weeds

– Organic herbicides can be more expensive to apply on a "per acre" basis and may need to be applied more frequently, especially in the first years, thus increasing costs and labor requirements. However, some of the organic products also contain fertilizer, which may reduce fertilization costs.

Contact for Additional Information

Contact local extension service for potential lower AI formulations that could be effective on the particular target weeds. For information on organic herbicides:

Amaizing Lawns®:
Gardens Alive!, Inc.
5100 Schenley Place
Lawrenceburg, Indiana 47025
(812) 537-8652

Sharpshooter®:
Safer, Inc.
465 Milner Ave.
Scarborough Ontario M1B2K4 Canada
(800) 387-5306

COST ANALYSIS

The cost analysis assumes use of Amaizing Lawns®, with a labor rate of 0.25 hour per acre for fertilization/application.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost)(area covered) + (labor hrs.)(labor rate) (Chemical cost will vary, depending on herbicide used.)
	=	($250/acre)(500 acres) + (125 hrs.)($15/hr.)
	=	$125,000 + $1,875
	=	**$126,875**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	% AI (amt. applied)
If organic herbicide such as Amaizing Lawns® is used; no AI would be applied.		

APPENDIX B

ALTERNATIVES FOR BARE GROUND AND FENCE LINE WEED CONTROL

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

APPENDIX B
ALTERNATIVES FOR BARE GROUND AND FENCE LINE WEED CONTROL

THIS PAGE INTENTIONALLY LEFT BLANK

BARE GROUND CONTROL ALTERNATIVE 1

Fill Cracks in Pavement

DESCRIPTION OF ALTERNATIVE

Involves filling cracks in parking lots and flightline joints to prevent weed growth.

TECHNICAL ANALYSIS

Parking lot cracks can be filled with an asphalt-based solvent, and flightline joints can be filled with various products developed for expansion joint repair. The recommended sealant will vary depending on the type of pavement and environmental conditions. Contact your base/MAJCOM Pavements Engineer for product recommendations. Often joint and crack filling is done as part of ongoing maintenance, which serves to make needed repairs as well as to deter weed growth. (In general, sealing of sidewalk cracks is not a viable option, due to high cost and labor requirements and limited effectiveness).

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

\+ No chemical application involved

\+ Long lasting control (unless weeds develop in dirt that enters filled cracks or regrow from deep roots)

\+ Provides for improved integrity of parking lots and flightline as well as weed control

\+ No special training involved

\+ No special equipment involved for asphalt crack repair.

<u>Disadvantages</u>

– Can be very costly

– Special equipment or contractor needed for some flightline joint filling

– May still need some herbicide treatment if weeds re-establish in older joints/cracks.

<u>Contact for Additional Information</u>

Contact your base/MAJCOM Pavements Engineer.

COST ANALYSIS

This cost analysis assumes use of an asphalt sealant costing ~0.025/linear foot and a flightline sealant costing ~ $4.50/linear foot, approximately 200,000 linear feet of parking lot cracks, ~30,000 linear feet of flightline cracks/joints, and labor requirements of ~1 hour/3,000 linear feet for asphalt repair and 12 hours/3,000 linear feet for flightline repair.

CAPITAL COSTS		
For asphalt sealant:		
Capital Cost	=	($0.025/linear ft.)(linear ft. filled) + (labor hrs.)(labor rate)
	=	($0.025)(200,000) + (67 hrs.)($15/hr.)
	=	$5,000 + $1,005 ≅ **$6,000**
For flightline sealant:		
In addition to sealant cost, requires:		
$15,000 for pump and associated equipment to apply		
Capital Cost	=	($4.50/linear ft.)(linear ft. treated) + (labor hrs.)(labor rate) + $15,000
	=	($4.50)(30,000) + (120 hrs.)($15/hr.) + $15,000
	=	$135,000 + $1,800 + $15,000 ≅ **$152,000**
Total Capital Cost	=	**$158,000**

ANNUAL OPERATING COSTS
No operating costs; assume since the sealants last 8-12 years that all application costs are considered as capital costs.

COMPUTING AI

Does not entail use of chemical AI.

BARE GROUND CONTROL ALTERNATIVE 2

Hand Pull Weeds

DESCRIPTION OF ALTERNATIVE

Involves hand weeding of small areas, ornamental beds.

TECHNICAL ANALYSIS

Hand weeding can be effective if done properly and if labor is available. This option is generally used in small areas and especially in borders and ornamental beds, where all vegetation (including grass, weeds, etc.) except the desired species (flowers, shrubs) are removed. To be effective, the entire weed, root and all, must be removed. A typical current practice for these areas is use of Roundup®, at 4 pounds AI per acre.

ADVANTAGES/DISADVANTAGES

Advantages

+ No chemical use

+ No special training or equipment required.

Disadvantages

– Very labor intensive

– Can be ineffective if entire weed is not removed

– Does not provide control of weed growth from seeds.

Contact for Additional Information

Not applicable.

COST ANALYSIS

The cost analysis is calculated for hand-weeding a total area of 1 acre, and assumes that it takes 4 hours to weed the area. Weeding time can vary considerably depending on the type of weeds and area covered.

CAPITAL COSTS
No capital costs have been identified (other than garden tools expected to be available).

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(labor hrs.)(labor rate)
	=	(4 hrs.)($15/hr.)(1 acre)
	=	**$60**

COMPUTING AI

Does not entail use of chemical AI.

BARE GROUND CONTROL ALTERNATIVE 3

Weed-Seeker® Sprayer

DESCRIPTION OF ALTERNATIVE

Involves use of a new product called the Weed-Seeker® sprayer, which helps to apply the minimal amount of herbicide in areas with scattered weed infestations (e.g., parking lot cracks).

TECHNICAL ANALYSIS

The Weed Seeker® sprayer would be used in conjunction with a herbicide application program. The sprayer works by detecting chlorophyll by spectral reflectance and involves mounting the sprayers on a boom connected to a tractor or truck. The sprayers are pulled over the site and dispense the herbicide when chlorophyll is detected. This option is not fully tested or proven in industrial use. However, test plots have been conducted at Purdue University, and the manufacturer (Patchen, Inc.) has conducted numerous tests as well. Based upon these tests, use of the equipment is expected to reduce the amount of herbicide applied by approximately 20 to 50 percent over that used during manual spot treatment. For example, the test plots conducted on railroad rights-of-way at Purdue University showed that the sprayer resulted in a usage of 6 to 9 gallons per acre, compared to 18 gallons per acre from manual spot spraying and 35 gallons per acre from broadcast spraying over the same area. The manufacturer claims that it would perform 70 percent better than broadcast spraying and 20 percent better than spot spraying. The initial startup cost would be approximately $1,150 per spray unit, and several units would be required, along with a controller that is currently selling at $925.

ADVANTAGES/DISADVANTAGES

Advantages

+ Can reduce herbicide application rates substantially over conventional application methods (according to test plot data)

+ Can reduce labor costs, compared to spot treatment if there are large areas with scattered weed problems (assume would require approximately 0.5 hour per acre, compared to approximately 1 hour per acre for spot treatment)

+ Can be attached to conventional herbicide spray tractors/trucks.

Disadvantages

- Capital costs for equipment
- Requires new training and equipment
- Still requires use of chemicals.

Contact for Additional Information

George Vashel
Patchen, Inc.
Los Gatos, California
(408) 399-9112

COST ANALYSIS

This cost analysis assumes use of Roundup® at a cost of $27 per gallon and an application rate of 1 gallon per acre. It also assumes that 100 acres are treated and that labor requirements are 0.5 hour per acre for the Weed Seeker® Sprayer application from a lawn tractor.

CAPITAL COSTS		
Capital Costs	=	cost of equipment
	=	$1,150/spray unit + $925/controller unit; may need several spray units, depending on size of areas requiring treatment. Each unit covers approximately 12 inches. Assume purchase of 3 units, for a total capital cost of **$4,375**

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost)(application rate)(area covered)(applications/year) + (labor hrs.)(labor rate)
	=	($27/gal.)(1 gal./acre)(100 acres)(once/year) + (50 hrs.)($15/hr.)
	=	$2,700 + $750
	=	**$3,450**

COMPUTING AI

Assume a 25 percent reduction from current broadcast spraying practice, which uses 1,000 pounds AI (will depend on chemical used).

ANNUAL AI APPLICATION		
Annual AI Usage	=	(% AI)(amt. applied)
	=	current AI usage (0.75)
	=	1,000 lbs. (0.75)
	=	**750 lbs. AI**

BARE GROUND CONTROL ALTERNATIVE 4

Scraping or Dragging Areas to Remove Weeds

DESCRIPTION OF ALTERNATIVE

Involves use of mechanical control of vegetation in industrial yards.

TECHNICAL ANALYSIS

Several Air Force installations have successfully used mechanical scraping, disking, or dragging to remove weeds in relatively large industrial areas such as tank farms and other POL yards. This involves dragging a steel mesh grader or disking device behind a utility vehicle to remove surface vegetation. (See also Alternative I for aerial herbicide application).

ADVANTAGES/DISADVANTAGES

Advantages

+ No chemical use involved

+ Easy to implement; usually equipment is available

+ No special training needed

+ Can cover large area with minimal labor cost.

Disadvantages

– May not remove subsurface parts of weeds and therefore weeds will regrow

– Can cause soil erosion problems, especially if unpaved areas are disturbed prior to heavy precipitation

– Does not eliminate germination from seeds

– Most effective on young weeds

– May not be possible or effective on paved or heavily graveled areas.

Contact for Additional Information

MSgt Clarence Ragland
355 CES/CEVA
Davis-Mothan AFB, Arizona 85707
(602) 750-5897
or

SSgt Richard Toumberlin
355 CES/CEOHE
Davis-Mothan AFB, Arizona 85707
(520) 750-5368

COST ANALYSIS:

The cost analysis assumes disking 100 acres, at a rate of 4 acres per hour, using a two-person crew. Minimal fuel costs for the equipment would also be incurred.

CAPITAL COSTS
If appropriate equipment is not available, could entail purchase of a 60- to 80-hp tractor, wheel disk (12 ft.), or a scraper. A dragging device could be constructed by base CE personnel. tractor= $48,000 disker = $9,700 scraper = $8,500

ANNUAL OPERATING COSTS		
Total Annual Costs	=	minimal fuel cost + (labor hrs.)(labor rate)
Total Annual Costs	=	(acreage treated)(rate in acres/hr.)(labor rate)(2-person crew)(treatments/year)
	=	(100 acres)(4 acres/hr.)($15/hr.)(2 people)(2 treatments/year)
	=	**$24,000**

COMPUTING AI

Does not entail use of chemical AI.

BARE GROUND/FENCE LINE CONTROL ALTERNATIVE 1

Flamers or Steamers

DESCRIPTION OF ALTERNATIVE

Involves using heat; hot water, in the form of steam, or fire (propane torch flames); to kill weeds.

TECHNICAL ANALYSIS

A relatively new treatment for bare ground weed control in the United States is flaming. Flaming uses a propane torch that passes slowly over weeds and sears the leaves enough to rupture the cell walls and cause the plant to wilt and die. The temperature of the torch is approximately 2,000° Fahrenheit. Although flaming is a relatively new technology in the United States, it has been used for several decades overseas to clear land of unwanted vegetation. It is inexpensive in that there are no expensive chemicals to purchase. However, flaming often does not kill grasses and even some broadleaf weeds with deep taproots, such as dandelions, although these limitations may be overcome with frequent treatments over several seasons, or use in conjunction with other treatments. None of the contacts could verify successful bare ground control over an extended period. Further, flaming could be considered a safety issue, especially on some flightline areas. Flaming should be considered in the future as a feasible nonchemical pest management method as longer term results are provided and Air Force personnel acquire more experience with the technology.

Another relatively new treatment for weed control in this country is steaming. Steaming is similar to flaming in that the leaves of a weed are exposed to a high temperature for a short time. This causes the cell walls to rupture and the plant to wilt and die. Steam application is less proven than flaming, but it may be more applicable for use on flightline areas because the safety issues are less problematic. This alternative should be considered in the future as a feasible nonchemical pest management method as more research results are provided. This method is similar to hot water application (e.g., Aqua Heat®), which has been tested at one base and is scheduled to be retested at Aberdeen Proving Ground in spring 1996. Prior testing resulted in personnel safety concerns due to burns from the steam application equipment.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ No chemicals involved

+ Relatively inexpensive

+ Minimal training required

+ Especially effective for annuals, small area application (e.g., sidewalk cracks).

<u>Disadvantages</u>

– Safety concerns - can cause burns and flamers could cause grass fires

– Not used extensively in United States; no proven track record (steamers may not yet be available)

– May not kill grasses and/or deep-rooted species (e.g., dandelions) unless used frequently over several seasons or in conjunction with other treatments

– Treatment is more labor-intensive than spraying herbicide

– Flaming especially may be a safety issue on flightline because of volatile organic presence

– Requires initial capital investment in new equipment.

Contact for Additional Information

For flamers:
Flame Engineering, Inc.
P.O. Box 577
LaCrosse, Kentucky 67548
(800) 255-2469

For hot water application:
Aqua Heat
5155 E. River Road
Suite 405
Minneapolis, Minnesota 55421
(800) 426-4328

For steamer:
Aleysha Ricards
Bio-Integral Resource Center
Berkeley, California
(510) 524-2567

or contact:
Wayne Fordham
HQ AFCESA/CESM
Tyndall AFB
(904) 283-6465

Donald Teig
HQ ACC/CEOO
Langley AFB, Virginia
(804) 764-2764

COST ANALYSIS

One manufacturer estimates that it takes about 1.25 times longer to use a flamer than to spray herbicide on the same area. Thus, the cost analysis assumes 4 hours per acre to spray herbicides on pavement cracks, and 5 hours per acre to use a flamer. A total of 100 acres is assumed.

CAPITAL COSTS
For flamer: Approximately \$100 per flamer torch kit; up to \$234 for backpack model. Several kits would be needed, depending on size of installation. For hot water application (e.g., Aqua Heat®): \$12,000/unit (does not include tank)

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(acres treated)(labor hr./acre)(labor rate)
	=	(100 acres)(5 hrs./acre)(\$15/hr.)
	=	**\$7,500 per treatment**

COMPUTING AI

Does not entail use of chemical AI.

BARE GROUND/FENCE LINE CONTROL ALTERNATIVE 2

Decrease Area Treated

DESCRIPTION OF ALTERNATIVE

Involves elimination of some areas from bare-ground treatment program.

TECHNICAL ANALYSIS

Some areas that are treated with herbicides for bare-ground control may be removed from the program. These include areas where natural vegetation (even "weeds") is acceptable (e.g., campgrounds, training areas, some small semi-improved areas), or where minimal weed growth can be tolerated or perhaps controlled with physical removal if necessary (near kennels and stables, athletic fields, some rights-of-ways). Although individually these areas may represent minor usage in overall lbs. AI applied, collectively they could contribute to minimizing bare ground herbicide use.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Eliminates some chemical use

+ Easy to implement

+ No special training, equipment required

+ Can help to minimize human exposure to chemicals in areas of high non-military use (e.g., campgrounds, ball fields, etc.).

<u>Disadvantages</u>

– May not contribute substantially to reduction in pesticide use

– May not be acceptable to have weeds in some areas, especially if poisonous varieties are involved.

<u>Contact for Additional Information</u>

Not available.

COST ANALYSIS

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS
There are no operating costs associated with discontinuing herbicide application in these areas. Overall operating costs would be reduced proportionately to the acreage not treated.

COMPUTING AI

ANNUAL AI APPLICATION
No AI would be applied to the areas where herbicide treatment is terminated. Similar to cost, the annual AI application will be reduced to reflect the reduced area treated.

BARE GROUND/FENCE LINE CONTROL ALTERNATIVE 3

Alternative Herbicide with Low Percentage AI

DESCRIPTION OF ALTERNATIVE

Involves using herbicides with low percentage AI and/or low application rates that also provide effective bare ground control.

TECHNICAL ANALYSIS

Generally, the standard bare ground control practice at many Air Force installations involves broadcast application of nonselective herbicides that are persistent and require less frequent reapplication. These chemicals often include Borocil®, Hyvar XL®, Karmex DF®, and Krovar I DF® (i.e., herbicides containing either diuron and/or bromocil, which work well and last for a relatively long time). However, these herbicides also contribute a substantial amount of AI. Therefore, this option involves substituting other nonselective herbicides that contribute relatively low amounts of AI (i.e., have either low percentage AI and/or low application rates).

Possible substitutes identified include Arsenal® (imazapyr), Escort® (metsulfuron methyl), and Oust® (sulfometuron methyl). Based on recommended application rates, use of these alternative herbicides would result in the following pounds AI per acre (e.g., compare to 16 pounds AI per acre for 1 Hyvar® and 98 pounds AI per acre for Borocil®, common currently used products):

Arsenal®:	0.75 pound AI per acre (2 pounds AI per gallon; 3 ounces per acre)
Oust®:	0.14-0.19 pound AI per acre (75 percent AI; 3-4 ounces per acre)
Escort®:	0.1 pound AI per acre (60 percent AI; 2 ounces per acre)

Information and opinions were gathered from Dr. Harvey Holt of Purdue University, utility company representatives, and chemical company representatives to determine if there were other potential alternatives, their appropriate uses, and limitations. In developing options for bare ground control, it is important to remember that it is generally a tradeoff between a herbicide that has soil activity (persistence) that works very well but perhaps can damage offsite non-target vegetation, and a less persistent herbicide that requires more frequent application, but will not harm sensitive vegetation. An example would be selecting an appropriate herbicide for a parking lot with trees located in islands or nearby that have roots under the area to be treated, or a sidewalk area near desirable turf grasses.

The sources and experts consulted provided information on advantages and disadvantages of the alternative herbicides and emphasized the need to select the best herbicide or herbicide mix for the specific site conditions and weed species present. The following factors should be considered in developing an alternative herbicide option for bare ground control:

- Some contacts indicated that there may be a concern with Escort® and Oust® moving off the treatment area and causing more non-target vegetation damage than with other products.
- Although Arsenal® was described as not moving off site as much as the other alternatives, it could affect adjacent non-target vegetation or trees with roots extending under the treatment area; therefore, it should not be used in situations such as parking lots containing ornamental beds with trees.

- Persistence is an issue; the alternatives identified probably will not last as long as the currently used bromacil-based herbicides. Escort®'s label indicates that it needs to be applied at high rates to achieve more than short-term control of listed weeds; this could exacerbate runoff/non-target problems. Oust®'s longevity may also be shorter than desirable (Oust® and Escort® are very similar chemically). Arsenal®'s persistence will vary with site conditions (soil, rainfall), but can extend from 3 months to 2 years (Weed Science Society of America, 1989). Although Arsenal® can work well by itself, information recently obtained indicates less than long-lasting control performance.

- Based on conversations with utility company personnel, Arsenal® has generally performed well in utility company applications. It is also relatively nontoxic, and does not readily leach (Weed Science Society of America, 1989). Therefore, many utility company representatives recommend its use, but preferably in combination with a diuron-based product to extend the length of control. However, adding diuron increases the lbs. AI applied. For example, American Cyanamid manufactures a product called Sahara® that is an Arsenal®/diuron mix. It is applied at a rate of 6.75 pounds AI per acre, which is a considerable increase over Arsenal® alone at 0.75 pound AI per acre, but much less than the current use (16 or 98 pounds AI per acre).

- Dr. Holt of Purdue University recommended a completely different herbicide mix consisting of Oust®, Roundup®, and 2,4-D; however, he again emphasized the need to select the correct mix for the specific weed problem.

- An Arsenal®/Oust® mix was suggested as a good choice to achieve acceptable control but with minimal use of AI (0.89 pound AI per acre). However, continued use of this tank mix alone may result in the development of resistance in the target weeds. In general, repeated use of just one chemical (or a mix containing chemicals that have the same mode of action) can result in the development of naturally occurring resistant weed biotypes that then become dominant and cannot be adequately controlled. In general, tank mixes of different herbicides are advantageous in preventing resistance and also increasing the spectrum of weeds controlled.

Given all of the above information, it was apparent that there is a range of herbicides/mixes that could be considered as lower AI alternatives. Several alternatives are summarized on the Table B-1. The alternatives range from use of an Arsenal®/Oust® mix at 0.89 pound AI per acre to an Arsenal®/Karmex DF® mix at 8.75 pounds AI per acre. Although the Arsenal®/Oust®mix, or even Arsenal® alone in certain situations, may provide the needed control, any of the mixes on the table should be considered and perhaps tested to determine the best mix for specific site conditions.

ADVANTAGES/DISADVANTAGES

Advantages

\+ Many of these products work well, especially in mixes with smaller amounts of diuron

\+ Can reduce chemical AI use substantially, especially if large areas are tested

\+ No special training required

\+ No special equipment required

\+ Some of these products (e.g., Arsenal®) have low toxicity

+ Costs probably same as current practice; even though material cost may be higher, application rates are generally much lower.

Disadvantages

– May not be as effective as currently used soil-sterilant type products (diuron, bromocil), especially in high rainfall areas

– May require additional applications; if very frequent, they may increase AI to point at which the benefit is lost

– Some products (e.g., Oust®) may move off-site more than others

– May need to do repeated test plots on trials to determine best mix for the specific weed problem present

– Cannot use these where sensitive vegetation may be affected; still need some Roundup® usage.

Contact for Additional Information

For several of the recommended substitutes:

Arsenal®, Sahara®:
American Cyanamid
(800) 545-9525
or (800) 327-4645

Oust®:
DuPont
(800) 432-7671

Also, contact the local extension service or expert at the state extension university for recommendations for site-specific conditions.

Table B-1. Suggested Alternative Tank Mixes for Bare Ground Control

Tank Mix [a]	Lbs. AI/acre	Relative Persistence
Arsenal® (3 pts.) and Oust® (3 oz.)	0.89	Low-moderate- one season to several years[b]
"Sahara®" Co-Pak: 1.13 gals. Arsenal® 2 (11.5 lbs.) Karmex DF®	6.75	High (low end)
Use ½ Sahara® or similar tank mix (on areas requiring longer control); ½ Arsenal® Oust® mix	3.8	Moderate-High; combination of 1) and 2)
Roundup® - 2 qts. + Oust® - 3-4 oz. + 2,4-D - 1 pt.	< 3	Unknown; probably low (with Roundup® and 2,4-D being least persistent of all components listed in this table)
Initial Treatment[c] Arsenal® (3 pts.) + Karmex DF® (10 lbs.)	8.75	Very high (high rate for Karmex®; initial treatment)
Maintenance Treatment Various combinations of Krovar 1 DF®, Oust®, and Karmex DF® e.g., Krovar 1 DF® (6 lbs.) + Oust® - (3 oz.)	~5	High
Topsite® (0.5% imazapyr and 2.0% diuron-granular)	5-7.5	High (low end)

Notes: (a) Common Chemical Names for ® Products listed:
Arsenal® - imazapyr
Oust® -sulfometuron methyl
Karmex DF® - diuron
Roundup® - glyphosate
Krovar DF® - diuron and bromacil

(b) Dependent upon climatic factors. Generally, about 1 year in temperate climates with low-average rainfall; less than 1 year in areas with high rainfall; longer than 1 year in desert areas.

COST ANALYSIS

This cost analysis assumes use of an Arsenal®/Oust® mix, one application per year, at a cost of $210 per gallon for Arsenal® and $10 per ounce for Oust®. Application rates are 3/8 gallon (3 pints) per acre for Arsenal®, and 3 ounce per acre for Oust®. It is also assumed that 100 acres are treated at a rate of 2 hours per acre.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost)(application rate)(area covered)(application/year) + (labor hrs.)(labor rate)
	=	($210/gal.)(3/8 gal./acre)(100 acres) + ($10/oz.)(3 oz./acre)(100 acres) +(200 hr.)($15.00/hr.)
	=	$7,875 + $3,000 + $3,000
	=	**$13,875**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(% AI)(amt. applied) - for each chemical in the mix
	=	(2 lb./gal.)(3/8 gal./acre)(100 acres) + (75%)(0.2 lb./acre)(100 acres)
	=	75 + 15
	=	**90 lbs. AI**

FENCE LINE CONTROL ALTERNATIVE 1

Plant Growth Regulator

DESCRIPTION OF ALTERNATIVE

Involves use of a chemical that reduces plant growth rather than killing the plant.

TECHNICAL ANALYSIS

This option is desirable where absolute bare ground control is not needed, but where the height of vegetation must be kept to a minimum (e.g., fence lines). A recommended mix includes Embark® (mefluidide) plant growth regulator, plus six other herbicides in a formulation that totals 1.64 pounds AI per acre (compared to 16 pounds AI per acre for Hyvar® XL and 4 pounds AI per acre for Roundup®). However, more frequent application would be needed, possibly twice per year. It is expected that labor requirements would be similar for each on a "per application" basis; therefore, labor costs would be greater with the more frequently applied growth regulator.

ADVANTAGES/DISADVANTAGES

Advantages

+ Involves lower chemical AI use

+ Can maintain vegetation at low height without adverse visual effects of total kill from herbicide

+ Relatively low material cost

+ No special training or equipment needed

+ Mefluidide has relatively low toxicity; oral LD50 exceeds 5,000 milligrams per kilogram.

Disadvantages

– Will not provide long-lasting control; therefore, more frequent applications needed, with associated increased labor needs/costs and AI use

– Not effective for areas where bare ground control is needed.

Contact for Additional Information

For information on Embark® mix:
Tom DeBold
PBI/Gordon
(216) 275-3814
1-800-821-7925

COST ANALYSIS

This cost analysis assumes use of the Embark® mix recommended by Tom DeBold of PBI/Gordon, at a cost of $32 per acre and an AI of 1.64 pounds AI per acre. It also assumes that 100 acres are treated, that 2 applications per year are needed, and that labor requirements are 5 hours per acre.

CAPITAL COSTS

No capital costs have been identified

ANNUAL OPERATING COSTS	
Total Annual Costs	= (chemical cost)(area covered)(application/year) + (labor hrs.)(labor rate)
	= (\$32/acre)(100 acres)(2 applications/year) + (500 hrs.)(\$15.00/hr.)
	= \$6,400 + \$7,500
	= **\$13,900**

COMPUTING AI

ANNUAL AI APPLICATION	
Annual AI Usage	= (lb. AI/acre for mix)(total acres covered/year)
	= (1.64 lb. AI/acre)(100 acres)(2 applications)
	= **328 lbs. AI**

FENCE LINE CONTROL ALTERNATIVE 2

Mechanical Trimming (weed whacking)

DESCRIPTION OF ALTERNATIVE

Involves use of gasoline-powered (or electric) trimmers to cut vegetation to desirable level where bare ground control is not needed.

TECHNICAL ANALYSIS

This option involves no chemical use, but rather mechanical weed trimming along the fence lines or other borders as needed. Material costs are relatively low and involve minimal fuel and equipment costs. The primary drawbacks of this application are high labor requirements and limited effectiveness, and therefore the number of repeat treatments required. If the weeds along the fence lines grow back rapidly, it could take ten treatments per year (5 months, twice per month) or more to keep weeds to an acceptable height. This would mean 30 treatments over a 3-year period, compared to 1 to 3 treatments of an herbicide mix such as Arsenal®/Oust®. Therefore, labor requirements and associated costs would be significantly higher for this option. However, this option would reduce the total amount of AI per acre to zero and has no special training requirements or other outstanding issues.

ADVANTAGES/DISADVANTAGES

Advantages

\+ No chemical application involved

\+ No special training or equipment required

\+ Easy to do, especially for smaller areas

\+ Minimal costs for gasoline, trim line.

Disadvantages

– Very labor intensive, especially if large areas involved

– If fence line treated, must do each side separately

– No growth reduction included; therefore, requires repeated treatments over the growing season.

Contact for Additional Information

Chris Tatro
EPA Ltd. Grounds Maintenance
Beale AFB, California 95903
(916) 755-9263

COST ANALYSIS:

A 1-mile strip equals approximately 0.25 acre. It is assumed that one person can cover 2 feet per second, or 1.4 miles per hour (an estimate of 1 mile per hour was assumed to allow for some down time), and a strip 1 mile long and 2 feet wide (along a fence) is 0.25 acre, then 20 acres would take 80 person hours to cover. However, this could only be done on one side of the fence at a time; therefore, total labor time for that fence length would be approximately 160 hours. This cost analysis assumes that 20 acres are treated, 10 times per year, and that labor requirements are 4 hours per acre.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	minimal material cost + (labor hrs.)(labor rate)
	=	$500 + (800 hrs.)($15/hr.)
	=	**$12,500**

COMPUTING AI

Does not entail use of chemical AI.

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX C

ALTERNATIVES FOR AERIAL HERBICIDE SPRAYING

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

APPENDIX C
ALTERNATIVES FOR AERIAL HERBICIDE SPRAYING

THIS PAGE INTENTIONALLY LEFT BLANK

AERIAL HERBICIDE APPLICATION ALTERNATIVE 1

Mechanical Removal of Vegetation

DESCRIPTION OF ALTERNATIVE

This alternative involves using mechanical methods to remove vegetation from target areas, eliminating the use of herbicide. Vegetation removal could include disking (turning) soils, scraping, or dragging. Vegetation regrowth will occur on a regular basis, depending on growing seasons, seasonal/annual precipitation, and vegetation type. Therefore, two or more vegetation removal operations annually are anticipated to control target vegetation.

TECHNICAL ANALYSIS

This labor intensive alternative would be conducted on a regular basis and require the use of heavy equipment. Disking operations would require a 70- to 80-horsepower, rubber-wheeled, four-wheel-drive, tractor pulling a wheel disk (sizes range from 8 to 12 feet) that would turn over soils to a selected depth. Scraping the top soils could be conducted using the same type of tractor pulling a scraping apparatus of similar width. Dragging could be conducted by dragging a weighted screen or fencing material, or heavy timber (e.g. railroad tie) behind a truck or tractor.

Disking introduces new/additional seeds to surface soils where they germinate. Also, breaking up the soils provides a foothold for root development, and the break down of existing vegetation acts as a mulch. Therefore, an increase in vegetation regrowth is likely. Additionally, breaking up the soils would allow any munitions utilized on a target to penetrate to the subsurface, making EOD activities difficult. Disking in two directions may be required for areas of dense vegetation.

Scraping would remove the top layer of soil (approximately 1 to 2 inches), cutting the plant off at the root, as well as filling in holes and leveling mounds. Disturbance of soils by scraping is likely to result in an increase in regrowth by exposing a new layer of seeds to the surface. Dragging a target may require two or more passes over the same area to remove all vegetation. Dragging is also likely to result in an increase in regrowth.

Disking can be conducted at an estimated rate of 4 acres per hour. Scraping can be accomplished twice as fast (8 acres per hour) and dragging can be conducted at an estimated rate of 6 acres per hour, but requires dragging the same area twice; therefore, the coverage rate is 3 acres per hour. These mechanical maintenance rates also would require a two person operation, and account for time for refueling and minor vehicle maintenance. Vegetation controls of this type would result in extensive periods of target down time. However, target maintenance activities could be coordinated with EOD removal activities, scheduled during periods of aircraft deployment, or periods of mission inactivity. If more than one target is utilized, as well as requiring vegetation removal, the proximity of one target to another must be considered to make sure maintenance personnel are not within the safety/exclusion zone of an active adjacent target.

ADVANTAGES/DISADVANTAGES

Advantages

+ No chemicals utilized for vegetation control

+ Lower cost than aerial application of herbicides

+ No special training needed.

Disadvantages

– Capital cost may be incurred for purchase of equipment

– Substantial target down time

– Target maintenance may be required 2 or more times per year

– Possible EOD safety concerns

– May not remove subsurface parts of weeds and therefore will regrow

– High labor requirement.

Contact for Additional Information

MSgt Clarence Ragland
355 CES/CEVA
Davis-Mothan AFB, Arizona 85707
(602) 750-5897

or

SSgt Richard Toumberlin
355 CES/CEOHE
Davis-Mothan AFB, Arizona 85707
(520) 750-5368

COST ANALYSIS

This cost analysis assumes that mechanical methods can treat 4 acres per hour (32 acres per day) at a labor rate of $15.00 per hour, using a 2-person crew, and that 1,000 acres are treated.

CAPITAL COSTS		
Capital cost would include the purchase of a 60 to 80 hp rubber wheel, four-wheel drive tractor, a wheel disk (estimate 12 ft.), and/or a scraper (estimated 12 ft.). Dragging device could be constructed by base CE personnel.		
tractor	=	$48,000
disker	=	$ 9,700
tractor	=	$48,000
scraper	=	$ 8,500

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(# treatments/year)(# acres treated/rate in acres/hr.)(labor rate)
	=	(2 treatments/year) (1,000 acres/4 acres/hr.)($15/hr.)(2 people)
	=	**$15,000**

COMPUTING AI

Does not entail use of chemical AI.

AERIAL HERBICIDE APPLICATION ALTERNATIVE 2

Aerial Application of Krovar I DF® and Mechanical Target Maintenance

DESCRIPTION OF ALTERNATIVE

This alternative involves the use of Krovar I DF® at an application rate of 5 pounds AI per acre combined with mechanical maintenance of target areas. This rate of application would result in a total of 5,000 pounds AI for treatment of 1,000 acres; this compares to a typical practice of applying Krovar® at a rate of 10 pounds AI per acre for a total of 10,000 pounds AI to treat 1,000 acres.

Use of Krovar® at this rate would most likely result in the vegetation regrowth within a year. Therefore, conducting additional, mechanical vegetation removal would be necessary. This could be conducted by using a vehicle (truck or tractor) to drag a weighted screen, sled, or other device behind it to knock-down new growth as a means of target maintenance.

TECHNICAL ANALYSIS

The initiation of this alternative would result in a more labor intensive/time consuming target maintenance program. Dragging operations are estimated to be conducted at a rate of 3 acres per hour (see Alternative No. 1); this estimate includes dragging a target in two directions to maximize plant elimination. This could result in substantial target down time. Maintenance of this type is estimated to be required two or more times per year based on target use, precipitation rates, and plant type.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Substantial decrease in chemical use

+ Decrease in chemical costs.

<u>Disadvantages</u>

– Labor intensive (estimated 40 days to drag 1,000 acres)

– Target maintenance may be required two or more times per year

– Down time of target areas.

<u>Contact for Additional Information</u>

Terry L. Biery, Lt. Col., USAFR
Pest Management Professional
757 AS/DOS
3976 King Graves Road
Youngstown-Warren Regional Airport ARS
Vienna, Ohio 44473-0910
(216) 392-1178

Mike Cornelius
HQ AFMC/CEVC

4225 Logistics Avenue, Suite 8
Wright-Patterson AFB, Ohio 45433-5747
(513) 257-5878/5879

Marcus Blood, Natural Resources Manager,
OO/ALC/EMX
Hill AFB, Utah 84056
(801) 777-4618

John Cantlon
DuPont - Vegetation Management
3483 South Ashbury
Boise, Idaho 83706
(208) 342-5939

Aerial Applicators Association
1005 "E" Street SE
Washington DC 20003
(202) 546-5722

COST ANALYSIS

This cost analysis assumes the aerial application of Krovar I DF® over 1,000 acres at 5 pounds AI per acres at a cost of $6.60 per pound AI, utilizing Air Force personnel and equipment at a cost of $200 to aerially treat each acre and to drag the same area at a rate of 3 acres per hour using 2 persons at a labor rate of $15.00 per hour.

CAPITAL COSTS
No capital costs anticipated; operations would be conducted using existing equipment.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	[(# applications)(# acres)($/unit AI/acres) + (# acres)($ aerial application/acre)] + [(# applications)(# acres) ($ labor/acre) ÷ (acres maintained/hour)]
	=	(1 application)(1,000 acres)(5 lbs. AI/acre)($6.62/lb. AI) + (1,000 acres)($200.00 labor/acre) + [(1 application)(1,000 acres)(2 people x $15.00/hr.) ÷ (3 acres/hour)]
		$33,100 + $200,000 = $10,000
	=	**$241,000**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(AI applied/acre)(# acres)(# applications)
	=	(5 lbs./acre)(1,000 acres)(1 application)
	=	**5,000 lbs. AI**

AERIAL HERBICIDE APPLICATION ALTERNATIVE 3

Aerial Application of Herbicides with Low Percentage AI

DESCRIPTION OF ALTERNATIVE

This alternative involves the use of nonselective herbicides or mixtures of these herbicides with a lower percentage of AI and/or lower application rates that will provide effective/similar bare ground control. These lower percentage AI herbicides would be applied using a commercial aerial applicator.

TECHNICAL ANALYSIS

Alternative chemicals involved with this alternative could include the following: Arsenal® at 0.75 lb. AI per acre, Escort® at 0.1 pound AI per acre, Oust® at 0.14-0.19 pound AI, Roundup® at 4 pounds per acre, or TELAR® at 0.02 pound AI per acre. Chemical mixtures include a mixture of Oust® and Arsenal® at 0.89 pound AI per acres or Sahara® (Arsenal®/diuron mix at 6.75 pounds AI per acre). Using Arsenal® at the suggested rate would result in a total of 1,500 pounds AI for treatment of 1,000 acres, compared to the current practice of applying Krovar® at a rate of 10 pounds AI per acre for a total of 10,000 pounds AI to treat 1,000 acres.

These herbicides may not be as persistent as chemicals with a higher percentage AI (i.e. Krovar I DF®), and may require additional applications, resulting in increased labor costs and "down time" of target areas. Some chemicals may have a tendency to migrate off site and affect non-target vegetation or may be less effective in certain soil conditions. Additional information regarding these chemicals and mixtures is provided as Alternative 3 for Bare Ground/Fenceline Control (Appendix B).

ADVANTAGES/DISADVANTAGES

Advantages

+ Substantial decrease in AI

+ No additional training required

+ No additional equipment required (use commercial applicator equipment)

+ Some of these herbicides have low toxicity.

Disadvantages

– May require testing of individual herbicides to determine the best treatment for individual areas

– Granular product require substantial amount of soil moisture (i.e. rainfall) to be effective

– Herbicide effectiveness will differ with soil conditions

– Some may not be suitable for use in areas with sensitive vegetation

– May not be as persistent, target areas may require more than one applications per year

– Increased target "down time" due to additional treatments.

Contact for Additional Information
American Cyanamid
(Arsenal®, Sahara®)
(800) 545-95525
or (800) 327-4645

John Cantlon
DuPont - Vegetation Management
3483 South Ashbury
Boise, Idaho 83706
(208) 342-5939

National Aerial Applicators Association
1005 "E" Street SE
Washington DC 20003
(202) 546-5722

COST ANALYSIS

This cost analysis assumes two aerial applications of Arsenal® at a cost of $210.00 per gallon at 3/8 pints per acre (or $20.00 per acre) and treating 1,000 acres using a commercial aerial applicator at $15.00 per acre.

CAPITAL COSTS
No capital costs are required, use of equipment provided by commercial applicator

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(# applications per year)(chemical cost/acre)(# acres treated) + (labor rate/acre)(# acres)(# applications/year)
	=	(2 aerial applications)($20.00/acre)(1,000 acres) +($15.00/acre)(1,000 acres)(2 applications)
	=	$40,000 + $30,000
	=	**$70,000**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(AI applied/acre)(# acres)(# applications)
	=	(0.75 lb. AI/acre)(1,000 acres)(2 applications)
	=	**1,500 lbs. AI**

AERIAL HERBICIDE APPLICATION ALTERNATIVE 4

Ground-Based Application of Herbicides with Low Percentage AI

DESCRIPTION OF ALTERNATIVE

This alternative involves the use of ground-based application equipment to treat target areas using the nonselective herbicides and herbicide mixtures identified in Alternative 3, Application of Herbicides with Low Percentage AI. Information regarding these herbicides and herbicide mixtures is provided in Alternative 3 for Bare Ground/Fence Line Control (Appendix B).

TECHNICAL ANALYSIS

This alternative involves a different method of application of those herbicides identified in Alternative 3; however, their effectiveness may improve as a result of more direct application by ground-based equipment versus an aerial application method in which small amounts of herbicide may be lost to drift or evaporation. Additionally, aerial applications may miss the intended target area. The alternative will use a 60- to 70-horsepower rubber wheeled, four-wheel drive tractor pulling a 12-foot boom sprayer with a 250-gallon capacity tank. The use of such a large tractor will make it easier to pull a sprayer of that size and decrease the overall wear and subsequent maintenance on the tractor. Spray equipment can vary in boom sizes, tank capacities, and self-propelled or trailer mounted sprayers. Spreaders can be utilized for application of granular products.

This alternative will be useful in calculating the costs involved with applying herbicides only to areas requiring treatment (i.e. spot treatment). Some target areas may require only spot treatments, whereas other areas may utilize spot treatments between regular aerial applications (see Alternative 3).

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

\+ Substantial decrease in AI

\+ More direct application of herbicide onto vegetation, less loss to drift and/or evaporation and no over-spraying or skipping areas

\+ No additional training required

\+ No capital expenditures (if use of existing equipment)

\+ Some proposed herbicides have low toxicity.

<u>Disadvantages</u>

− Labor intensive

– Some target "down time"

– Heavy equipment usage

– Presence of unexploded ordnance may present a safety concern

– May require testing of individual herbicides to determine the best treatment for individual areas:

  - Granular herbicides require substantial amount of soil moisture (i.e. rainfall) to be effective

  - Herbicides effectiveness will differ with soil conditions

  - Some herbicides may not be suitable for use in areas with sensitive vegetation

  - Some herbicides may not be as persistent, target areas may require more than one applications per year.

<u>Contact for Additional Information</u>
American Cyanamid
(Arsenal, Sahara)
(800) 545-95525
or (800) 327-4645

John Cantlon
DuPont - Vegetation Management
3483 South Ashbury
Boise, Idaho 83706
(208) 342-5939

COST ANALYSIS

This cost analysis assumes a two applications of Arsenal® at a chemical cost of $20.00 per acre, treating 1,000 acres using a tractor-pulled boom sprayer that treats 60 acres per day, or 7.5 acres per hour. A two-person crew will be used at an hourly labor rate of $15.00 per person per hour. Also assume the use of diesel fuel at 3-gallons per hour at a cost of $1.50 per gallon.

CAPITAL COSTS
No capital costs have been identified, if using existing equipment.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(# applications/year)(chemical cost/acre)(# acres treated) + [(# acres/treatment rate)(labor rate)(# applications/year) + (fuel rate)(# acres/treatment rate)]
	=	(2 applications)($20.00/acre)(1,000 acres) + (1,000/7.5 acres/hr.)(2 x $15.00/hr.)(2 applications) + (3 gals./hr.)($1.50/gal.)(1,000 acres/7.5 acres/hr.)
	=	$40,000 + $8,000 + $600
	=	**$48,600**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(AI applied/acre)(# acres)(# applications)
	=	(0.75 lb. AI/acre)(1,000 acres)(2 applications)
	=	**1,500 lbs. AI**

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX D

ALTERNATIVES FOR CONTROLLING AQUATIC WEEDS

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

APPENDIX D
ALTERNATIVES FOR CONTROLLING AQUATIC WEEDS

THIS PAGE INTENTIONALLY LEFT BLANK

AQUATIC WEED CONTROL ALTERNATIVE 1

Grass Carp

DESCRIPTION OF ALTERNATIVE

Involves introducing grass carp to ponds, lakes, and other bodies of water to control aquatic weeds.

TECHNICAL ANALYSIS

Herbivorous fish, specifically grass carp, provide one means of biologically controlling aquatic weeds. Triploid grass carp is the recommended species because these are bred so that they have an extra set of chromosomes making it impossible for the fish to reproduce. Grass carp are generally effective in controlling submergent weeds, but not at controlling surface or emergent weeds. Some states, such as Florida, require a permit before grass carp can be introduced into a body of water. In Florida, this permit can be obtained from the Florida Game and Fresh Water Commission or the U.S. Fish and Wildlife Service. Consultation with state fish and wildlife officials is recommended prior to stocking fish, because some states do not allow use of grass carp.

In order to properly maintain grass carp, fish barriers are sometimes required to prevent fish from leaving the diked area. To obtain the optimum result, fish barriers should be designed to (1) contain the carp; (2) have openings large enough to allow floating materials, suspended detritus, and weed fragments to pass through the barrier during periods of water flow; and (3) permit easy removal of vegetation and debris from the front of the barrier, for example, by manual removal with a rake. A free-standing barrier consisting of vertical bars can be placed across a ditch, canal, or from shore to shore across any body of water at a location where it is desired to restrict carp movement. A walkway across such a barrier may be necessary for easy removal of accumulated debris. These bars may be stainless steel or PVC pipe. The spacing of the vertical bars should be set as wide as possible to allow for the passage of the maximum amount of water and debris, but small enough to prevent carp from escaping. A scale of 1/2-inch Schedule 40 PVC pipe in a single row on 2-inch centers should contain most of the grass carp currently being produced.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Biological control method, so there is no chemical use

+ Florida Air Force bases have had relatively good success with carp for submergent weed control

+ Following initial purchase of carp, there are few costs.

Disadvantages

– Not effective on surface (i.e., lotus) or emergent weeds (i.e., cattails)

– Some states do not allow use of grass carp

– The pond must meet certain containment requirements before carp are allowed.

Contact for Additional Information

Mr. David Eggeman
Florida Game and Fresh Water Fish Commission
620 South Meridian Street Tallahassee, Florida
32301 (904) 488-4066 or (904) 487-1400

Tyndall AFB
Mr. Steven Shea, Natural Resources
(904) 283-2641

COST ANALYSIS

CAPITAL COSTS
Grass carp cost is $6-10/fish; a recommended stocking density is 10 fish/acre. Capital costs will therefore vary depending on the acreage stocked. Containment structure costs can vary from minimal for small culverts to several thousand dollars to cover a 20-foot-wide opening.

ANNUAL OPERATING COSTS
No annual operating costs have been identified.

COMPUTING AI

Does not entail use of chemical AI.

AQUATIC WEED CONTROL ALTERNATIVE 2

Physical Removal (tilt mower)

DESCRIPTION OF ALTERNATIVE

Physical control method that involves mowing perimeter weeds, such as cattails.

TECHNICAL ANALYSIS

This involves physically removing weeds that grow in low-lying or wetland areas, such as cattails. One control method is the use of a tilt mower to mow these weeds. Mowing would need to be conducted periodically when weeds become overgrown. If this activity involves only mowing and no excavation of plant roots, then no Clean Water Act Section 404 permit or notification is required from the U.S. Army Corps of Engineers (USACE). If any root removal/excavation or other dredging/filling activity is conducted, the USACE should be consulted.

ADVANTAGES/DISADVANTAGES

Advantages

+ No chemical use

+ Direct control over number of weeds eliminated.

Disadvantages

– Would need to be conducted frequently

– Does not eliminate roots; therefore, weeds would continue to grow

– No control over other types of vegetation that would also be eliminated in the process

– Labor intensive.

Contact for Additional Information

Tyndall AFB
Mr. Steven Shea, Natural Resources
(904) 283-2641

COST ANALYSIS

This cost analysis assumes that 10 acres are mowed and that labor requirements are 4 hours per acre, assuming small areas are involved.

CAPITAL COSTS
No capital costs have been identified, assuming a tilt mower is available

ANNUAL OPERATING COSTS		
Total Annual Costs	=	minimal fuel costs + (labor hrs.)(labor rate)
	=	$500 + (40 hrs.)($15/hr.)

=	**$1,100**

COMPUTING AI

Does not entail use of chemical AI.

APPENDIX E

ALTERNATIVES FOR CONTROLLING FUNGI

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

APPENDIX E
ALTERNATIVES FOR CONTROLLING FUNGI

THIS PAGE INTENTIONALLY LEFT BLANK

FUNGICIDE CONTROL ALTERNATIVE 1

Envirocaster Disease Prediction Model

DESCRIPTION OF ALTERNATIVE

The Envirocaster is a soil and weather monitor with built-in disease prediction model used as a tool to predict the occurrence of diseases

TECHNICAL ANALYSIS

The Envirocaster, manufactured by Neogen Corp., is a combination weather station, soil monitor, and turf disease predictor model. The monitor uses weather and soil data to indicate that conditions are optimum for a particular disease. It can also give advance warning of the presence of a disease which will assist in modifying turf maintenance practices. For example, the Envirocaster may state that high moisture conditions overnight could result in pythium growth. In this case, the turf manager may decide not to irrigate overnight. Some users report that fungicide usage has dropped by up to 90 percent with use of the Envirocaster. A conservative estimate of 30-percent reduction in fungicide usage is considered reasonable.

Currently, there are models for Brown Patch, Pythium Blight, and Anthracnose. A Dollar Spot model is undergoing final testing and should be available soon.

ADVANTAGES/DISADVANTAGES

Advantages

+ Does not require extra labor

+ Minimal training required to operate the device

+ Small capital investment.

Disadvantages

– Models not yet developed for all diseases.

Contact for Additional Information

Neogen Corporation
620 Lesher Place
Lansing, Michigan 48912
(800) 234-5333

COST ANALYSIS

CAPITAL COST
The Envirocaster costs approximately $7,000 including models calibrated for specific diseases. When new models are made available, they will have to be purchased at a cost of approximately $500 each.

ANNUAL OPERATING COSTS
There are no additional labor or operating costs associated with the use of the Envirocaster. There will be a reduction in fungicide use (estimated at 30 percent), which would result in a reduction in labor hours.

COMPUTING AI

ANNUAL AI APPLICATION		
Assuming a 30% reduction and a previous usage of 1,000 lbs. AI:		
Annual AI Usage	=	(current AI usage) (0.70)
	=	(1,000 lbs.) (0.70)
	=	**700 lbs**.

FUNGICIDE CONTROL ALTERNATIVE 2

Reveal Test Kits

DESCRIPTION OF ALTERNATIVE

The Reveal test kits are used to detect the presence of disease in the soil. The kits are self-contained, and the tests can be performed on site and require no sampling or analytical experience.

TECHNICAL ANALYSIS

In order for a disease to occur in turf, the specific environmental conditions must be correct, the host (turf) must be susceptible, and the disease must be present. If the disease is not present, it is impossible to cultivate the disease even with the correct climate conditions and weakened turf. The Reveal test kits are able to detect the presence of common turf diseases in soil. If climate conditions seem correct for disease growth, a test can be performed to determine if a disease of concern is present. If the test results are negative, that disease is not present and chemicals to control it need not be applied. If the test results are positive, the turf managers may want to spray preventatively for that disease.

There are currently Reveal test kits for the analysis of Brown Patch, Pythium, and Dollar Spot. It is estimated that fungicide usage could be reduced by at least 10 percent using the Reveal test kits. Use these test kits in combination with fungicide alternatives 1 and/or 3 would provide more cost-effective reduction.

ADVANTAGES/DISADVANTAGES

Advantages

+ Minimal training required to use test kits
+ Can reduce AI
+ Reduce labor costs.

Disadvantages

– Samples may miss areas of disease.

Contact for Additional Information

Neogen Corporation
620 Lesher Place
Lansing, Michigan 48912
(800) 234-5333

COST ANALYSIS

CAPITAL COST
No capital costs have been identified.

ANNUAL OPERATING COSTS
The cost of the Reveal test kits is $167 for ten tests. Each test kit will analyze one sample of soil for one disease. If the turf manager tests for three common diseases, the cost will be approximately $50 per analysis. Assuming 15 analyses per year, the annual cost of using the kits is approximately $750. It will take approximately 1 hour per analysis to obtain a soil sample and complete the analysis using the kit. If the annual cost for fungicides is $15,000 and 15 Reveal test kit analyses are performed per year testing for 3 diseases each time, the cost can be calculated as: Total Annual Costs = (current cost)(0.9) + (# of test analysis)($50/analysis) = ($15,000) (0.9) + (15)($50) = $13,500 + $750 = **$14,250**

COMPUTING AI

ANNUAL AI APPLICATION
Assuming an annual application of 1,000 lbs. AI before using the Reveal test kits: Annual AI Usage = (current AI usage) (0.90) = (1,000 lbs.) (0.90) = **900 lbs**.

FUNGICIDE CONTROL ALTERNATIVE 3

Alternative Fungicide with Low Percentage AI

DESCRIPTION OF ALTERNATIVE

Involves replacing the current chemical used with a chemical that has a low percentage AI and is equally or more effective

TECHNICAL ANALYSIS

A recommended chemical replacement is Sentinel® produced by the Sandoz Corporation. Sentinel® (cyproconazole) is applied to the turf at a rate of 0.44 to 0.90 pound AI per acre to control Dollar Spot. For comparison, some common fungicides used for prevention and treatment of Dollar spot and their average application rates (from label information) are as follows:

Fungicide	Application Rate (Pounds AI per acre)
Banner	0.08
Bayleton	2.08
Chipco 26019	0.48
Daconil 2787	3.44
Fore	7.62
Rubigan	0.52

Sentinel® is generally incorporated as part of a treatment rotation and thus can either replace an existing Dollar Spot fungicide or simply be inserted into the rotation. Labor requirements would be similar to current common practice of applying other fungicides. Sentinel® has been judged to be of low to moderate acute toxicity.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Reduction in AI
+ Minimal training necessary
+ No capital costs.

<u>Disadvantages</u>

– Cost per pound AI can be from two to five times higher than some other fungicides (e.g., Banner, Bayleton) used to control or treat for Dollar Spot. The increased cost is partially offset by a reduced average application rate (i.e., approximately 3.7 times lower than the other fungicides). Thus, the overall cost per acre is comparable to that of other fungicides.

Contact for Additional Information

Sandoz Agro Incorporated
1300 East Touhy Avenue
Des Plaines, Illinois 60018

COST ANALYSIS

CAPITAL COST
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost/lb.)(lbs./acre)(acreage treated) + (labor hrs.)(labor rate)
	=	($285/lb. AI)(0.67 lb./acre)(100 acres) + (15 hrs.)($15/hr.)
	=	$19,095 + $225
	=	**$19,930**

COMPUTING AI

ANNUAL AI APPLICATION		
Fungicides are generally applied on a rotational basis so the diseases will not develop resistance to any particular fungicide. Sentinel® can be inserted into the rotation. The equation used to calculate the new usage is as follows:		
Annual AI Usage	=	(current AI usage)[(number of chemicals used - 1/number of chemicals used)] + (current AI usage)(1/number of chemicals used)(0.67/application rate)
For example, if seven fungicides are currently used to treat for Dollar Spot and the average application rate of these seven fungicides is 2.50 lbs. AI/acre for a total annual usage of 1,000 lbs. AI:		
Annual AI Usage	=	(1,000 lbs.)[(6/7)] + (1,000)[1/7][0.67/2.50]
	=	857 + 38
	=	**895 lbs. AI**

APPENDIX F

ALTERNATIVES FOR CONTROLLING OUTDOOR INSECTS

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

APPENDIX F
ALTERNATIVES FOR CONTROLLING OUTDOOR INSECTS

TABLE OF CONTENTS
(Continued)

APPENDIX F
ALTERNATIVES FOR CONTROLLING OUTDOOR INSECTS

ADULT JAPANESE BEETLE CONTROL ALTERNATIVE 1

Alternative Insecticide with Low Percentage AI

DESCRIPTION OF ALTERNATIVE

Involves replacing the current chemical used with a chemical that has a low percentage AI and/or low application rate, and is equally or more effective.

TECHNICAL ANALYSIS

A recommended chemical replacement is a synthetic pyrethroid, such as Tempo®, which is produced by Bayer Specialty Products and contains the active ingredient cyfluthrin. This pesticide is mixed at a ratio of 1.9 ounces to 100 gallons of water, which can cover approximately 20 trees. The manufacturer recommends only one application per year, which would keep labor time to a minimum. In addition, Tempo® is less carcinogenic than many conventional pesticides. For example, treating 2,000 trees with Tempo® would use only 2.4 pounds AI, compared to 49 pounds of Orthene®, a common spray for trees/ornamentals.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Low AI
+ Often less expensive to use than other chemicals
+ Only one application per year is recommended, which would keep labor costs to a minimum
+ Less toxic to mammals and birds than conventional chemicals, such as Carbaryl®
+ No special equipment or training costs
+ Pyrethroids have a high (almost 100 percent) control rate.

<u>Disadvantages</u>

– Toxic to fish and marine invertebrates; therefore, should not be used near ponds, lakes, or other bodies of water.

<u>Contact for Additional Information</u>

Mr. David Shetlar
Ohio State Extension Agency
(614) 292-5274

Bayer Corporation
Specialty Products
Box 4913
Kansas City, Missouri 64120-0013
(800) 842-8020

COST ANALYSIS

This cost analysis assumes use of Tempo® at a cost of $49 per pound and that this is mixed at a rate of 0.12 pound per 100 gallons of water to produce a spray. The spray is applied at a rate of 5 gallons per tree, and 2,000 trees are sprayed once a year. It is also assumed that approximately 10 minutes per tree are required for labor (approximately 300 hours for 2,000 trees).

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	[(chemical cost)(application rate)(# trees)(# applications/year)] + [(labor hrs.)(labor rates)]
	=	[($49/lb.)(.006 lb./tree)(2,000 trees)(1 application/year)] + [(300 labor hrs.)($15.00/hr.)
	=	$588 + $4,500
	=	**$5,088**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	% AI (amount applied)
	=	20%(.006 lb./tree)(2,000 trees)
	=	**2.4 lbs. AI**

ADULT JAPANESE BEETLE ALTERNATIVE 2

Eliminate Preferred Food Source

DESCRIPTION OF ALTERNATIVE

This would involve cutting down or removing those trees and shrubs that the Japanese beetles feed on, and replacing them with trees and shrubs that they do not feed on.

TECHNICAL ANALYSIS

This method would involve removal of the Japanese beetle's preferred food sources such as lindens, crabapples, and roses, and replacing them with less preferred plants such as oaks, maples, and geraniums. If this method is used, it should be based on a gradual elimination and replacement of these food sources, such as those trees or shrubs that have been damaged, diseased, or are unsightly due to beetle infestation. This method would need to be performed in conjunction with other methods of control, since all food sources would not be eliminated at once. A list of regional preferred food sources is available from the local extension service.

ADVANTAGES/DISADVANTAGES

Advantages

+ Some entomologists believe this is the most effective control method

+ Low upkeep cost

+ Entails no chemical use.

Disadvantages

– Not all entomologists are convinced that this is an effective method.

– Aesthetically, immature trees may not be as pleasing as the mature trees that are being replaced

– Very high initial cost of tree removal and replanting

– Labor intensive to remove trees and replace with new trees

Contact for Additional Information

Mr. Dan Potter
University of Kentucky
(606) 257-7458

COST ANALYSIS

CAPITAL COSTS
Capital costs would be rather high; however, these can be spread out over a period of time by first eliminating trees, shrubs, and flowers which are diseased or badly damaged as a result of the beetle infestation. The capital costs involved with this method include costs for cutting down and removing the trees or shrubs and the costs with replacing these with new trees and shrubs. In addition, this may involve hiring an outside tree service which would have the equipment needed for tree removal and new trees for planting.
Capital Costs = (# of trees replaced)(cost/tree removed)+(# of trees replaced)(cost/tree planted) If assume 1,000 trees are replaced: = (1,000)($150) + (1,000)($100) = **$250,000**

ANNUAL OPERATING COSTS
No annual operating costs have been identified.

COMPUTING AI

Removal of food sources entails no chemical use. Overall small amounts of insecticides (e.g., synthetic pyrethroids, see Alternative 1) to central Japanese beetles may be applied for more effective control.

ADULT JAPANESE BEETLE CONTROL ALTERNATIVE 3

Manual Removal

DESCRIPTION OF ALTERNATIVE

This method involves manually removing the beetles from the trees by shaking the trees and/or shrubs in which the beetles are known to exist.

TECHNICAL ANALYSIS

This is a labor-intensive method that requires employees to shake the trees and/or shrubs where adult beetles are known to feed and rest. This must be performed before the beetles become active, which is generally sometime after 7:00 a.m. As a result of shaking the tree, beetles will fall to the ground at which time they should be removed with a vacuum. The vacuum bag containing the beetles should then be dropped in soapy water or placed in the sunshine to ensure the beetles' termination. The bag may then be discarded.

ADVANTAGES/DISADVANTAGES

Advantages

+ Would not require use of chemicals

+ Direct control over number of beetles terminated.

Disadvantages

– Must be completed before approximately 7:00 a.m.

– If population density is high, would require to be performed at least several times a month, or possibly more

– This is a labor intensive task, thus increasing cost in number of personnel and/or labor rate

– Tall trees would be difficult to treat in this manner.

Contact for Additional Information

Not available.

COST ANALYSIS

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	[(labor hrs.)(labor rate)](# of times/year)
if assume it takes 200 hrs. for manual removal:		
	=	[(200)($15.00)](10)
	=	**$30,000**

COMPUTING AI

Manual removal of beetles entails no chemical use. Small amounts of insecticides (e.g., synthetic pyrethroids, see Alternative 1) may be applied for more effective control.

ADULT JAPANESE BEETLE CONTROL ALTERNATIVE 4

Neem Oil

DESCRIPTION OF ALTERNATIVE

Involves application of Neem®, an organic oil preparation made from the oil of the neem tree found in Asia and Africa.

TECHNICAL ANALYSIS

Neem® can reduce Japanese beetle populations since it reduces the palatability of host plant leaves. In a study by a major distributor reported in "Common Sense Pest Control" (Olkowski, et al 1991), 99 percent of the adult Japanese beetles given leaves sprayed with Neem® oil refused to eat and starved to death. However, contacts made with several extension agents and entomology researchers indicated that Neem® is not widely used for Japanese beetle control because of "marginal effectiveness." Neem® may work better on some food sources than others. Neem® is available commercially as the product Margosan-O®, manufactured by W.R. Grace Co.

ADVANTAGES/DISADVANTAGES

Advantages

+ No chemical AI involved

+ No special equipment or training needed.

Disadvantages

– Effectiveness not well proven; effective on certain plants, but not all plants

– Low residual, so it requires frequent application.

Contact for Additional Information

Contact the local extension service for more information on Neem®'s effectiveness in the area. Also:

Aleysha Ricards
Bio-Integral Research Center
P.O. Box 7414
Berkeley, California 94707
(510) 524-2567

COST ANALYSIS

This cost analysis assumes Neem® costs $100 per gallon, that approximately 4 gallons of Neem® are mixed with water to make 100 gallons of spray, that 5 gallons of spray are applied per tree, and that 2,000 trees are treated. It is also assumed that the labor requirement is approximately 10 minutes per tree (approximately 300 hours for 2,000 trees).

CAPITAL COSTS

No capital costs have been identified.

ANNUAL OPERATING COSTS	
Total Annual Costs	= [(chemical cost)(gal. used/application/tree)(# trees)(# applications/year)] + [(labor hrs.)(labor rates)]
	= [($100/gal./)(4 gal./100 gal. spray)(5 gal. spray/tree)(2,000 trees) (1 application/year)] + [(300 labor hrs.)($15.00/hr.)
	= $4,000 + $4,500
	= **$8,500**

COMPUTING AI

No chemical AI.

JAPANESE BEETLE LARVAE CONTROL ALTERNATIVE 1

Spikes of Death

DESCRIPTION OF ALTERNATIVE

This is a mechanical control method involving the use of spikes that stab the larvae.

TECHNICAL ANALYSIS

This method entails use of 3-inch nails with two nail points per square inch. These nails can be attached to shoes or on a roller. Currently, the shoes are more often used than the roller, since these can be purchased at most of the large nurseries or through mail-order garden catalogs. Attach the shoes and walk the infested areas, or use a roller and cover all infested areas. This method generally achieves a control rate of 50 to 70 percent.

ADVANTAGES/DISADVANTAGES

Advantages

+ Does not involve the use of chemicals

+ Control rate is comparable to other biological control methods that are currently available.

Disadvantages

– If shoes are used, this would be a very labor-intensive and time-consuming task

– Control rate is lower than that achieved with chemical pesticide use

– Holes in the turf may be aesthetically displeasing.

Contact for Additional Information

Mr. Whitney Cranshaw
University of Colorado Cooperative Extension Service
(303) 491-6781

COST ANALYSIS

This cost analysis assumes that 100 acres are treated and that labor requirements are 2 hours per acre, with two treatments per year.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	[(labor hrs.)(labor rate)](# of times/year used)
	=	[(200 hrs.($15.00/hr.)](2 treatments)
	=	**$6,000**

COMPUTING AI

This method does not entail use of chemicals. More effective control may be achieved by combining use of biological controls (see Alternatives 2 and 3) or low-AI insecticides (see Alternative 4).

JAPANESE BEETLE LARVAE CONTROL ALTERNATIVE 2

Milky Spore Disease

DESCRIPTION OF ALTERNATIVE

This is a biological control method that uses a bacterial strain (*Bacillus popilliae*) to infest the larvae with a disease that adversely affects their digestive system.

TECHNICAL ANALYSIS

Bacillus popilliae is toxic to Japanese beetle grubs and several other scarab grubs, but harmless to other organisms, including humans. Milky spore dust is available in commercial formulations known as Doom®, Japidemie®, and Grub Attack®. It can be applied to soil containing grubs any time except when the ground is frozen or a strong wind is blowing, usually at a rate of 10 pounds per acre. After application, light irrigation is recommended to work the spores into the soil. Grubs become infected when they feed on the grass or thatch where the spores have been applied. As the infected grubs die and decompose, more spores are released back into the soil. High soil temperatures are required for rapid buildup of spores; therefore, this option is less effective in northern states.

ADVANTAGES/DISADVANTAGES

Advantages

+ Biological control method that does not involve the use of chemicals

+ Low toxicity to nontarget organisms, including humans.

Disadvantages

– This method is currently comparatively expensive at about $200 per acre.

– Due to environmental conditions, this method has not been found effective in certain areas, such as Ohio and other northern states

– Does not produce rapid results; may take several seasons to have substantial impact

– Application of fungicides on turf may kill the milky spore bacteria.

Contact for Additional Information

Mr. David Shetlar
Ohio State Extension Agency
(614) 292-5274

COST ANALYSIS

This cost analysis assumes 100 acres are treated once per year with milky spore, at a cost of $200 per acre. Labor requirements for application (spraying) are assumed at 0.5 hour/acre.

CAPITAL COSTS

No capital costs have been identified.

ANNUAL OPERATING COSTS	
Total Annual Costs	= [(chemical cost)(# acres)(# applications/year)] + [(labor hrs.)(labor rates)] = [($200/acre)(100 acres)(1 application/year)] + [(50 labor hrs.)($15.00/hr.) = $20,000 + $750 = **$20,750**

COMPUTING AI

Does not entail use of chemical AI.

JAPANESE BEETLE LARVAE CONTROL ALTERNATIVE 3

Beneficial Nematodes

DESCRIPTION OF ALTERNATIVE

Biological control that involves the release of microscopic worms, which act as a parasite to the larvae.

TECHNICAL ANALYSIS

For application, nematodes are mixed with water and sprayed on the ground, using existing equipment, such as spray guns. The most important factor in distributing the nematodes is to ensure that the ground is heavily saturated. Nematodes are quite sensitive to heat and drought stresses; therefore, sufficient water is a continual necessity. For this reason, the ground should be well saturated prior to distribution, and then resaturated following distribution of the worms, so that the worms will be able to burrow into the ground. In addition, nematodes require the soil temperature to be less than 90° Fahrenheit. Two applications of nematodes are recommended, in early spring and late summer.

ADVANTAGES/DISADVANTAGES

Advantages

+ No chemical use

+ May be used around water where certain chemicals should not be used

+ Possibly less expensive than current conventional chemical control methods

+ No adverse effect or threat to humans, mammals, or other wildlife other than insects.

Disadvantages

– May be an increase in water use in order to maintain saturated conditions

– Nematodes are extremely sensitive to environmental conditions; therefore, although they are capable of a high success rate, it is difficult to provide them with the necessary environmental conditions, such as ample water. However, a new strain may be available in a year or two that will be less environmentally sensitive and therefore more effective.

Contact for Additional Information

Mr. Joel Coats
Iowa State University
(515) 294-4776

COST ANALYSIS

This cost analysis assumes use of beneficial nematodes at a cost of $40 per acre and that 100 acres are treated, with labor requirements of 0.5 hour per acre for spray application.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	[(nematode cost)(# acres)] + [(labor hrs.)(labor rate)]
	=	($40/acre)(100 acres) + (50 hrs.)($15/hr.)
	=	$4,000 + $750
	=	**$4,750**

COMPUTING AI

Does not entail use of chemical AI.

JAPANESE BEETLE LARVAE CONTROL ALTERNATIVE 4

Alternative Insecticide with Low Percentage AI

DESCRIPTION OF ALTERNATIVE

Involves replacing the current chemical used with a chemical that has a low percentage of AI and/or low application rate, and is equally or more effective.

TECHNICAL ANALYSIS

A recommended chemical replacement is Merit®, which contains the AI imidacloprid. This product is produced Miles Corporation, Inc. This pesticide is applied at a rate of 6.4 ounces per acre at a cost of approximately $100 per acre. Treating 100 acres with Merit® would use 30 pounds AI, compared to 200 pounds AI using Oftanol®, and 100 pounds AI using Carbaryl 4L®. Merit® has a relatively low toxicity. To ensure the pesticide permeates the soil, it is recommended that the area be irrigated within 24 hours after application. Alternatively, the pesticide can be applied when it is raining.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Low chemical AI

+ Only one application per year is recommended, which would minimize labor costs

+ Less toxic to mammals and birds than other chemicals, such as Oftanol®

+ No special equipment or training costs.

<u>Disadvantages</u>

– Relatively high permeability; therefore, may impact local groundwater. Not recommended for areas with a shallow groundwater table.

<u>Contact for Additional Information</u>

For Merit®:
Miles, Inc.
(800) 842-8020

COST ANALYSIS

This cost analysis assumes use of Merit® at a cost of $100/acre, treating 100 acres, one application per year, and labor requirements of approximately 0.5 hours/acre for spray application.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS

Total Annual Costs	=	[(chemical cost/acre)(# acres)(applications/year)] + [(labor hrs.)(labor rates)]
	=	[($100/acre)(100 acres)(1 application/year)] + [(50 labor hrs.)($15.00/hr.)
	=	$10,000 + 750
	=	**$10,750**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	% AI (amount applied)
	=	75% (0.4 lb./acre)(100 acres)
	=	**30 lbs. AI**

MOSQUITO CONTROL ALTERNATIVE 1 (LARVAE)

Bacillus thuringiensis israelensis (BTi)

DESCRIPTION OF ALTERNATIVE

Involves use of the bacterium BTi to infect and kill mosquito larvae.

TECHNICAL ANALYSIS

BTi is one of several *Bacillus thuringiensis* strains used in pest control. It is a bacterium that acts as a stomach poison. When mosquito larvae ingest BTi spores and crystals, the mosquito gut wall breaks down, the spores enter the body cavity, and the larvae die. BTi can be applied in a liquid or granular form with conventional sprayers or spreaders. However, the "briquet" form is often used and provides for longer-term release and easy application. In flooded sites, one Bactimos® briquet is applied for up to 100 square feet of surface area, regardless of depth. The briquets can be anchored or staked in place to prevent washout. If the water is highly organic, the application rate should be increased. BTi is most effective on earlier stages of larval growth and may also be toxic to blackfly species, while being nontoxic to other aquatic life.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Provides effective biological control
+ No chemical AI
+ No special application equipment needed
+ No special training needed
+ Briquets are very easy to apply and provide residual control (30 days)
+ Nontoxic to desirable nontarget aquatic species and humans
+ Can be used for pre-flood treatment in dry areas that are known or suspected to become breeding areas when flooded.

<u>Disadvantages</u>

– Must be ingested at young stages to be effective; not effective on later instars or pupal stage
– Subject to interference from organics in water
– More costly than conventional chemical control.

<u>Contact for Additional Information</u>

Summit Chemical Co.
Baltimore, Maryland 21224
(410) 282-5200

Tyndall AFB Pest Management
Oscar Hickman, Supervisor
(904) 283-4358

COST ANALYSIS

This cost analysis assumes use of Bactimos® briquets at a cost of $0.89 per briquet and application rate of 1 briquet per 100 square feet (1 acre = 43,560 square feet). Labor requirements are estimated at 200 hours to cover approximately 10 acres of drainages, ponds, etc., per year (includes travel time to reach water bodies).

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost)(application rate)(area covered) + (labor hrs.)(labor rate)
	=	(\$0.89)(436 briquets/acre)(10 acres) + (200 hrs.)(\$15/hr.)
	=	\$3,880 + \$3,000
	=	**\$6,880**

COMPUTING AI

Does not entail use of chemical AI.

MOSQUITO CONTROL ALTERNATIVE 2 (LARVAE)

Mosquito Fish

DESCRIPTION OF ALTERNATIVE

Involves stocking mosquito fish (*Gambusia affinis*) in man-made, closed bodies of water to control mosquito populations.

TECHNICAL ANALYSIS

Mosquito fish (and also goldfish) eat mosquito larvae and help to control insect populations. Mosquito fish can be introduced to small, man-made bodies of water with no connection to natural waters. Natural waters should not be stocked with mosquito fish, since they can outcompete native species or adversely alter habitat. Mosquito fish seed stock can usually be obtained (often free of charge) from the local mosquito control agency/district or any suppliers advertising in mosquito control or pest management journals. A brood pond can be maintained to furnish future stock. Mosquito fish in ponds will require protection from natural predators; a piece of clay pipe at least 1 foot long should be placed in the pond to provide this protection. Some states require permits or notifications before mosquito fish are stocked; contact the state Fish and Game agency for more information before releasing mosquito fish.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Provides good biological control in ponds, ditches

+ No chemicals involved

+ Relatively easy to obtain and stock; minimal training required

+ Relatively inexpensive; seed stock can often be obtained free of charge from local mosquito control districts

+ Will provide essentially permanent control in ponds, ditches, canals

+ No special equipment required (other than small tank, nets).

<u>Disadvantages</u>

– Need to ensure introduced fish do not reach natural waters where native species can be affected; use is therefore limited to non-connected, man-made bodies of water

– Fish may not survive winter in cold climates; need to re-stock from supplier or maintain heated harborage pond or indoor tanks

– If insufficient food, may need to maintain by feeding with Tetramin® or similar fish food.

<u>Contact for Additional Information</u>

Contact your local mosquito control district or extension service for more information; also:

Dr. John Smith
Florida A&M
John A. Mulrennan, Sr., Research Laboratory
Panama City, Florida 32405-1933
(904) 872-4184

COST ANALYSIS

CAPITAL COSTS
Assuming seed stock can be obtained free of charge from local mosquito control district, no capital cost has been identified.

ANNUAL OPERATING COSTS
No regular operating costs have been identified (there may be periodic maintenance for restocking, feeding, weed removal in ponds).

COMPUTING AI

Does not entail use of chemical AI.

MOSQUITO CONTROL ALTERNATIVE 3 (LARVAE)

Insect Growth Regulator - Altosid®

DESCRIPTION OF ALTERNATIVE

Involves use of insect growth regulator that affects ability of mosquito to molt and reach adulthood.

TECHNICAL ANALYSIS

Altosid® is an insect growth regulator with the AI methoprene. It induces damaging morphological changes in the second, third, and fourth instars (stages of larval development), resulting in failure of adult mosquitoes to emerge from pupae. It can be applied as a liquid spray from the air or ground, or coated onto sand particles or granules that provide better foliage penetration. It is also available in a slow-release briquet form. The briquets are applied at a rate of one per 100-200 square feet, depending on the species of mosquito to be controlled. Label instructions state that briquets are designed to control mosquitoes in small bodies of water that are not known fish habitats, although Altosid®'s toxicity is very low (34,000 milligrams per kilogram acute oral LD_{50}), and it does not bioaccumulate.

ADVANTAGES/DISADVANTAGES

Advantages

+ Provides effective control if used at correct time

+ Involves minimal chemical AI (e.g., 1.8 percent for briquets; 0.43 pound per gallon for non-concentrate liquid with application rate of 3-4 fluid ounces per acre)

+ Very selective; little effect on nontarget organisms

+ Much lower toxicity than conventional pesticides

+ Biodegradable; does not accumulate in food chains

+ No special application equipment needed

+ No special training needed

+ Briquets are very easy to apply and provide residual control (150 days)

+ Can be applied to dry sites that will be flooded, as well as existing water bodies.

Disadvantages

– Only effective if applied before second to fourth instar stage; not effective on earlier instars or pupal stage

– More costly than conventional chemical control.

Contact for Additional Information

Sandoz Agro Inc.
Des Plains, Illinois 60018
(800) 248-7763

COST ANALYSIS

This cost analysis is based on the use of Altosid® briquets at a cost of $2.72 per briquet and application rate of 1 briquet per 100 square feet (1 acre = 43,560 square feet). Labor requirements estimated similar to those for Alternative 2, BTi, and assume 200 hours per year including travel time to cover 10 acres of drainages, etc.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost)(application rate)(area covered) + (labor hrs.)(labor rate)
	=	($2.72)(436 briquets/acre) (10 acres) + (200 hrs.)($15/hr.)
	=	$11,859 + $3,000
	=	**$14,859**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(% AI)(amount applied)
	=	(0.018)(4,360 briquets)(0.08 lb. AI/briquet)
	=	**6.3 lbs. AI**

MOSQUITO CONTROL ALTERNATIVE 4 (LARVAE)

Improve drainage to eliminate standing water.

DESCRIPTION OF ALTERNATIVE

Involves establishing or improving drainage and/or eliminating standing water to prevent mosquito breeding.

TECHNICAL ANALYSIS

Most mosquitoes require quiet standing water to lay their eggs and support their early growth stages. Therefore, removal of standing water sources and/or promotion of drainage can eliminate breeding sites. Examples of actions that can be taken include:

- Dredge/clean out drainage ditches or canals to increase water flow; this may include removal of emergent vegetation and associated sediment
- Remove shoreline weeds in ponds to increase wave action
- Drain or fill in small woodland pools (if this can be done without adverse ecological consequences)
- Remove containers that catch/trap water (e.g., buckets, old tires, cans)
- Keep roof drains, gutters clear of debris
- Grade landscaped areas so that water does not stand in temporary pools; use drain tiles, etc., as needed.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ No chemical use

+ Wide variety of solutions available

+ Many actions can be done at a very low cost

+ No special equipment needed

+ No special training needed.

Disadvantages

- Will not provide complete control
- Dredging costs could be high, depending on extent of problem
- Some solutions may have associated adverse ecological effects (e.g., draining/filling small woodland pools).

Contact for Additional Information

Contact the local extension service or mosquito control district for more information or ideas.

COST ANALYSIS

Costs for the various actions described above will vary, depending on the action taken and the extent of drainage control needed. Dredging ditches can be expensive, but most Air Force installations will have the necessary equipment. Other actions require minimal material costs and varying labor requirements.

COMPUTING AI

Does not entail use of chemical AI.

MOSQUITO CONTROL ALTERNATIVE 5 (ADULTS)

Synthetic Pyrethroids

DESCRIPTION OF ALTERNATIVE

Involves periodic application of synthetic pyrethroids in a ground application when monitoring indicates a problem.

TECHNICAL ANALYSIS

Often application of a ground-based malathion fog is the standard method to control adult mosquitoes, after monitoring results indicate that established action levels have been reached. An alternative is to use a synthetic pyrethroid-based pesticide, such as resmethrin or permethrin. A typical synthetic pyrethroid is Scourge® 4+12, which contains 0.3 pound per gallon of resmethrin and 0.9 pound per gallon of piperonyl butoxide, for a total AI of approximately 1.2 pounds per gallon. A recommended application rate (truck-mounted fogging at 10 miles per hour) of 3 fluid ounces per acre is equivalent to a total of 0.028 pound AI per acre, which is much less than the AI used with a malathion application (malathion is 9.7 pounds AI per gallon and is applied at 3.2 fluid ounces per acre ≅ 0.24 pound AI per acre). The application method is the same used for malathion, using ground-based truck-mounted sprayers and releasing the chemical as a fog according to label instructions. Where dense vegetation is present, higher application rates or slower speeds are recommended. It is best to fog when air currents are low (2-8 miles per hour), usually in the early evening. The application should be done so that the fog moves with the breeze over the target areas.

ADVANTAGES/DISADVANTAGES

Advantages

+ Provides good control and fast "knock down

+ Relative low AI

+ Low toxicity to nontarget organisms, including pets and humans

+ No special equipment needed

+ No special training needed

+ Not as corrosive as other chemicals (fogs).

Disadvantages

– More costly than conventional malathion application

– Similar problems as occur with malathion:

- Can get interference from vegetation, buildings
- Need to apply when weather conditions are right - low wind
- Can be toxic to fish and birds

- Need good access to affected areas for thorough coverage.

Contact for Additional Information

Roussel Uclaf Corporation
Montvale, New Jersey 07645
(for Scourge®)
(201) 307-1113

Tyndall AFB Pest Management
Oscar Hickman, Supervisor
(904) 283-4358
Also: Beale & Tinker AFB
Pest Management Shops

COST ANALYSIS

This cost analysis assumes use of Scourge® at a cost of $75 per gallon and application rate of 0.02 gallon per acre (3 fluid ounces per acre). It also assumes 1,000 acres are treated and 50 person-hours are needed for the fogging, which may occur on several occasions during the summer season.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost)(application rate)(area covered) + (labor hrs.)(labor rate)
	=	($75/gal.)(0.02 gal./acre)(1,000 acres) + (50 hrs.)($15/hr.)
	=	$1,500 + $750
	=	**$2,250**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(% AI)(amount applied)
	=	(1.2 lbs. AI/gal.)(0.02 gal./acre)(1,000 acres)
	=	24 **lbs. AI**

ANT CONTROL ALTERNATIVE 1

Alternative Insecticide with Low Percentage AI

DESCRIPTION OF ALTERNATIVE

Involves replacing the current chemical used with a chemical that has a low percentage of AI and/or low application rate, and is equally or more effective.

TECHNICAL ANALYSIS

A recommended chemical replacement is a synthetic pyrethroid, such as Tempo® (cyfluthrin), which is produced by Bayer Specialty Products. This pesticide acts as both a contact poison and a stomach poison. It is mixed at a ratio of 0.1 pound of AI per acre (7.7 ounces ≅ 0.5 pound total product per acre, with 20 percent AI). In comparison, products commonly applied for ant control, such as Dursban® (chlorprifos), Ficam® (bendiocarb), and diazinon, are recommended to be applied at rates of 2 to 8 pounds AI per acre. For fire ant control, Tempo® should be reapplied as necessary. It is important to ensure that product is not applied near ponds, streams, lakes, or other bodies of water. Tempo® controls a broad spectrum of insect pests, both indoor and outdoors.

ADVANTAGES/DISADVANTAGES

Advantages

+ Low chemical AI

+ Often less expensive to use than other chemicals

+ Less toxic to mammals and birds than other chemicals

+ No special equipment or training costs

+ Controls many different insect pests: cockroaches, ants, spiders, earwigs, millipedes, centipedes, ticks, flies, wasps, bees, mosquitoes, beetles, etc. (see manufacturer's data/label for all pests controlled).

Disadvantages

− Toxic to fish and marine invertebrates; therefore, should not be used near ponds, lakes, or other bodies of water.

Contact for Additional Information

Bayer Miles, Inc., Specialty Products
Kansas City, Missouri 64120
(800) 842-8020

COST ANALYSIS

This cost analysis assumes use of Tempo® 2OWP (wettable powder) at a cost of $49 per pound and an application rate of 0.5 pound per acre, and that 100 acres are treated. Labor requirements are assumed at 2 hours per acre, since individual mound treatment is needed.

CAPITAL COSTS

No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost)(application rate)(area covered)(application/year) + (labor hrs.)(labor rate)
	=	(\$49/lb.)(0.5 lb./acre)(100 acres) + (200 hrs.)(\$15.00/hr.)
	=	\$2,450 + \$3,000
	=	**\$5,450**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(% AI)(amount applied)
	=	(20%)(0.5 lb./acre)(100 acres)
	=	**10 lbs. AI**

ANT CONTROL ALTERNATIVE 2

Baits

DESCRIPTION OF ALTERNATIVE

Baits are a synthetic and poisonous food source that the ants consume and carry back to the mound for the queen and other ants to feed upon.

TECHNICAL ANALYSIS

Baits are designed on the premise that the worker ants will transfer the bait to the colony for a food source on which the other ants, including the queen, will feed upon. Baits are in a granular form and are available as a toxicant, a sterilant/toxicant, or a growth regulator. One bait commonly used is Amdro®, which contains 0.73 percent AI (hydramethylnon). Application of Amdro® involves distributing five level tablespoons (approximately 0.1 pound) of the product around the base of the mound. It typically takes 1 to 4 weeks to eliminate the queen and subsequently exterminate the colony. In very large mounds, some worker ants may persist after the queen is dead. In such cases, a follow-up treatment may be necessary within 4 to 6 weeks following initial treatment. Logic®, an IGR, is also effective for fire ant control

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Low chemical AI involved

+ Effective; eliminates queen

+ Simple to use; no special training required

+ No special equipment is necessary.

<u>Disadvantages</u>

– Possibly time consuming to individually eliminate each colony.

<u>Contact for Additional Information</u>

For Amdro®: American Cyanamid Company (800) 545-9525	or:	Tyndall AFB Pest Management Shop Oscar Hickman, Supervisor (904) 283-4358

For Logic®:

Ciba-Geigy Corporation
Greensboro, North Carolina
(910) 547-1000

COST ANALYSIS

This cost analysis assumes use of Amdro® at a cost of approximately $10 per pound, and that 5 tablespoons weigh approximately 0.1 pound and are applied to one mound. It is also assumed that 200 mounds are treated, taking approximately 0.5 hour per mound in labor.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost)(application rate)(area covered) + (labor hrs.)(labor rate)
	=	($10/lb.)(0.1 lb./mound)(200 mounds) + (100 hrs.)($15.00/hr.)
	=	$ 200 + $1,500
	=	**$1,700**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(% AI)(amount applied)
	=	(0.0073)(0.1 lb./mound)(200 mounds)
	≅	**0.2 lb. AI**

ANT CONTROL ALTERNATIVE 3

Boiling Water

DESCRIPTION OF ALTERNATIVE

Involves pouring boiling water (190-212° Fahrenheit) on each mound.

TECHNICAL ANALYSIS

Boiling water is applied slowly at a rate of approximately 3 gallons per mound. The water should drain into the vertical tunnels and eventually collapse the mound structure. Treatments may be more effective if applied on cool, sunny mornings. It has been reported that 20 to 60 percent of those mounds treated will be eliminated. Surviving mounds will require further retreatment.

ADVANTAGES/DISADVANTAGES

Advantages

\+ No chemicals are used

\+ Low cost

\+ Can be effective (up to 60 percent).

Disadvantages

– Time consuming

– Cumbersome to carry boiling water to each mound

– Not as high of a control rate as the other methods

– Safety concerns with use of hot water; burns to applicator could occur

– May affect nontarget vegetation adjacent to treated mounds.

Contact for Additional Information

David Oi or Philip Koehler
University of Florida Cooperative Extension Service
Gainesville, Florida

ANT CONTROL ALTERNATIVE 4

Boric Acid Product

DESCRIPTION OF ALTERNATIVE

Involves replacing the current chemical used with a chemical that has a low percentage of AI and is equally or more effective.

TECHNICAL ANALYSIS

A recommended chemical replacement is Niban® produced by the Nisus Corporation. The AI is boric acid, a stomach poison. Niban® is applied around the base of an ant mound or may be applied using a hand-held spinning spreader at a rate of 4 pounds per 1,000 square feet. Areas that are treated should be well irrigated prior to application; however, do not irrigate immediately after application. The solution may also be applied in inaccessible areas such as crawl spaces or attics and in cracks and crevices. Niban® can be placed in food service facilities, hospitals, near electrical equipment, or anywhere ant problems exist. Niban® should be applied only in areas inaccessible to children and pets. Bait visible after application must be brushed into cracks and crevices or removed. Corrective treatments may be necessary when there is evidence of reinfestation Labor involved in applying Niban® would be similar to common practices of applying pesticides.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Can be used to control many ant species

+ Low AI percentage (5 percent)

+ May be used in any location ant problems exist

+ No special equipment costs.

<u>Disadvantages</u>

– Food area application is limited to crack and crevice treatment

– Not recommended for areas accessible to children and pets

– Cost is significantly higher than common practice for ant control.

<u>Contact for Additional Information</u>

Nisus Corporation
215 Dunavant Drive
Rockford, Tennessee 37853
(800) 264-0870

COST ANALYSIS

CAPITAL COSTS

No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical costs)(acres treated) + (labor hrs.)(labor rate)
	=	(174 lbs./acre)($6.25/lb.)(10 acres) + (5)(15.00)
	=	**$10,925**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(lbs. product/acre)(% AI)(acres treated)
	=	(74 lbs./acre)(0.05 AI)(10 acres)
	=	**87 lbs. AI**

BEE CONTROL ALTERNATIVE 1

Soap and Water

DESCRIPTION OF ALTERNATIVE

Involves spraying bee hive with soap and water solution. The soap coats the bees, thereby suffocating them.

TECHNICAL ANALYSIS

This method involves the use of common dish washing soap and a reusable fire extinguisher. The soap and water should be mixed, placed in the fire extinguisher, and all affected areas should be sprayed. No chemical pesticides are necessary. A surfactant, such as Guardsman®, may be added to improve the adherence of the soap to the bees. Some pesticide use, such as resmethrin, pyrethrins, or Dragnet®, may be necessary to eliminate an entire hive.

ADVANTAGES/DISADVANTAGES

Advantages

+ Inexpensive in that there are no chemicals to purchase

+ No chemical application required

+ Minimal training would be required

+ No special equipment costs involved.

Disadvantages

– A surfactant may be necessary to improve the adherence of the soap to the bees

– Some pesticide usage may be necessary to achieve complete elimination of a bee swarm.

Contact for Additional Information

SSgt Richard Toumberlin
355 CES/CEOHE
Pest Management Shop
Davis-Mothan AFB, Arizona 85707
(520) 750-5368

COST ANALYSIS

This cost analysis assumes minimal costs for soap and water, plus 100 labor hours per year for bee treatment.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(cost of soap and water) + (labor hrs.)(labor rate)
	=	$100 + (100 hrs.)($15.00/hr.)
	=	$100 + $1,500
	=	**$1,600**

COMPUTING AI

Does not entail use of chemical AI.

BEE CONTROL ALTERNATIVE 2

Alternative Insecticide with Low Percentage AI

DESCRIPTION OF ALTERNATIVE

Involves replacing the current chemical used with synthetic pyrethroids that have low percentages of AI and/or low application rates, and are very effective.

TECHNICAL ANALYSIS

Several products containing synthetic pyrethroids (e.g. resmethrin, permethrin, allethrin, cyfluthrin) are effective against bees and other flying insect pests. Examples of products include Tempo® (cyfluthrin) and Raze® (permethrin and allethrin). Generally, these products involve low AI amounts because they contain a small percent AI and also have low application rates. Often these are applied directly to the hive/nest, using ready-to-use aerosol sprays. Applications should be made in the late evening when the insects are at rest. When nests are in building walls, entrance holes should be plugged with treated steel wool to prevent escape of dying insects.

ADVANTAGES/DISADVANTAGES

Advantages

+ Low AI products

+ Very effective

+ Easy to use; no special training required

+ No special equipment needed

+ Relatively nontoxic to nontarget organisms.

Disadvantages

− Can result in stings

− Still requires some chemical use.

Contact for Additional Information

SSgt Richard Toumberlin
355 CES/CEOHE
Pest Management Shop
Davis-Mothan AFB, Arizona 85707
(520) 750-5368

COST ANALYSIS

This cost analysis assumes use of a product similar to Raze®, which is available in a ready-to-use spray container. A cost of $10 per can is assumed, with a 50 can use per year at a labor cost of 100 hours.

CAPITAL COSTS

No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost)(amount used) + (labor hrs.)(labor rate)
	=	($10.00/can)(50 cans) + (100 hrs.)($15.00/hr.)
	=	$500 + $1,500
	=	**$2,000**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(% AI)(amount used)
	=	(0.0035)(1 lb./can)(50 cans)
	=	**0.2 lb. AI**

MOLE CRICKET CONTROL ALTERNATIVE 1

Beneficial Nematodes

DESCRIPTION OF ALTERNATIVE

Biological control that involves the release of microscopic worms, *Steinernema scapterisci* (Ss), which act as a parasite to the larvae.

TECHNICAL ANALYSIS

Nematodes work as a parasite to mole crickets by getting in through the mouth of the insect or through its spiracles (breathing holes). From here, the nematodes break into the body cavity where they excrete bacteria from their own digestive system. It is the bacteria that eventually kill the host mole cricket. Death of infected mole crickets is certain; however, not all mole crickets will come into contact with these nematodes. Nematodes cannot move far through the soil, so infestation depends almost entirely on a host coming into contact with a nematode. Generally, a higher population of mole crickets, relative to a comparable number of nematodes, will yield a better control rate. Nematodes are currently being sold in Florida, where experimental populations have proven effective; however, the price is still relatively high.

The *Steinernema scapterisci* strain is the only strain known to reproduce in the mole crickets and thus is the most effective. This strain is available as Proactant® Ss from Biocontrol, Inc. The quality of the nematodes can be tested by exposing mole crickets to a sample of nematodes in a bucket of soil. If the mole crickets die, then these nematodes are probably of good quality.

Nematodes should be applied when the mole cricket population is high, typically in spring, late summer, or fall. It is important to apply the nematodes when exposure to ultraviolet radiation from the sun is at its lowest. This is generally at dusk or shortly after dark, but may also be possible on cloudy days. Furthermore, the ground soil must be quite wet for nematodes to be able to burrow into the area of the mole crickets. For sandy soils, 1/4-inch of water is recommended before application, and 1/2-inch of water is recommended after application. A possible alternative to extensive irrigation is to apply the nematodes during rainfall.

Although the initial cost of applying nematodes to turfgrass is high, and sometimes higher then the cost of chemical pesticides, if the treatment is successful, then the long-term cost will be lower. As mentioned, the nematode has a residual effect and will aid in the termination of the mole cricket population for a much longer period of time than chemical insecticides.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Biological control method so that there is no use of chemicals

+ Effective control; kills a large percentage of mole crickets if applied properly

+ The strain *S. scapterisci* reproduces in the mole cricket so that the population is residual and does not often require reapplication

+ Method is safe to the environment and will not harm vertebrates, animals, beneficial insects, or grasses.

<u>Disadvantages</u>

– Nematodes are environmentally sensitive

– High initial cost ($115 per acre for 5-15 acres and $110 per acre for 20 acres or more)

– Crickets may not come in contact with the nematodes.

Contact for Additional information:

For Proactant® Ss:
Biocontrol, Inc.
4411 N. Thatcher Avenue
Tampa, Florida 33614
(800) 737-8019

COST ANALYSIS

This cost analysis assumes use of nematodes at a cost of $110 per acre to cover 100 acres, with application once per year. Labor requirements are assumed at 0.5 hour per acre.

CAPITAL COSTS		
Capital Costs	=	[(nematode cost)(# of acres)(# applications/year)] + [(labor hrs.)(labor rate)]
	=	[($110/acre)(100 acres)(1)] + [(50 hr.)($15.00/hr.)
	=	$11,000 + 750
	=	**$11,750**

ANNUAL OPERATING COSTS
This will depend on how successfully the nematodes are reproducing. If the reproduction rate is high, then an annual cost may not be applicable.

COMPUTING AI

Does not entail use of chemical AI.

MOLE CRICKET CONTROL ALTERNATIVE 2

Tachinid Fly

DESCRIPTION OF ALTERNATIVE

The *Ormia depleta* species of the tachinid fly acts as a parasite to the mole cricket by attaching its larvae on the mole cricket. In turn, the larvae burrows into the mole cricket and hatches within a week, during which time it kills the mole cricket.

TECHNICAL ANALYSIS

This fly has been raised in the laboratory and subsequently released in some areas of Florida, where it has begun to breed and establish permanent populations. In these areas, there is no reason to release any more. However, there may be a northern limit to the areas in which the fly can successfully breed. It may be possible that flies can survive in the spring and summer when the nectar they require for feeding is available.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Does not involve the use of hazardous materials

+ Assuming that breeding is successful, then only the initial cost is involved

+ Flies are generally only active at night so they are rarely seen or disturb humans.

<u>Disadvantages</u>

− May not breed successfully.

<u>Contact for Additional Information</u>

D. Short
University of Florida, Cooperative Extension Service
Gainesville, Florida

COST ANALYSIS

CAPITAL COSTS
This would involve the initial cost of introducing the fly to the area. The aid of local or regional experts may be required. (Specific cost not available; may be provided free of charge from state agencies involved in the mole cricket control.)

ANNUAL OPERATING COSTS
If breeding is successful, then there will be no additional costs for labor or materials.

COMPUTING AI

Does not entail use of chemical AI.

MOLE CRICKET CONTROL ALTERNATIVE 3

Alternative Insecticide with Low Percentage AI

DESCRIPTION OF ALTERNATIVE

Involves replacing the current chemical used with a chemical that has a low percentage AI and is equally or more effective

TECHNICAL ANALYSIS

A recommended chemical replacement is Merit® (imidacloprid), manufactured by Bayer Corporation. Merit is applied to the turf at 0.39 pound of AI per acre to control mole crickets (compared to 8.75 pounds AI per acre for Mocap®). It is applied for mole cricket control when the insects are in their peak egg-hatching period. When the mole crickets have reached adults or large nymph state, it is best to accompany the application of Merit® with a curative insecticide such as Mocap®. Merit® is also effective against larvae of several beetles, weevils, and pillbugs.

ADVANTAGES/DISADVANTAGES

Advantages

+ Will not require extra training or expertise

+ Will not require the purchase of new equipment

+ Low AI dosage

+ Also controls larvae of several beetles, weevils, and pillbugs.

Disadvantages

– Timing is critical, since Merit® is not effective against mole crickets during peak egg-hatching period.

– Application should not exceed 0.4 pound AI per acre.

Contact for Additional Information

Bayer Corporation
Specialty Products
Box 4913
Kansas City, Missouri 64120-0013
(800) 842-8020

COST ANALYSIS

The cost calculated assumes use of Merit® at a cost of $100 per acre, treatment of 100 acres, one application per year, and a labor requirement of 0.5 hour per acre for spray application.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost/acre)(acres treated) + (labor hrs.)(labor rate)
	=	($100/acre)(100 acres) + (50 hrs.)($15/hr.)
	=	$10,000 + $750
	=	**$10,750**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(% AI)(application rate)(acreage treated)
	=	(0.75)(0.39 lb./acre)(100 acres)
	=	**29.25 lbs. AI**

CUTWORM CONTROL ALTERNATIVE 1

Beneficial Nematodes

DESCRIPTION OF ALTERNATIVE

Biological control that involves the release of microscopic worms, which act as parasites to the cutworms.

TECHNICAL ANALYSIS

For application, nematodes are mixed with water and sprayed on the ground using existing equipment, such as spray guns. The most important factor in distributing the nematodes is to ensure that the ground is heavily saturated. Nematodes are quite sensitive to heat and drought stresses; therefore, sufficient water is a continual necessity to nematodes. For this reason, the ground should be well saturated prior to distribution, and then resaturated following distribution of the worms, so that the worms will be able to burrow into the ground. In addition, nematodes require the soil temperature to be less than 90° Fahrenheit. Two applications of nematodes are recommended, in early spring and late summer.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ No chemical use

+ May be used around water where certain chemicals should not be used

+ Possibly less expensive than current conventional chemical control methods

+ No adverse effect or threat to humans, mammals, or other wildlife other than insects.

<u>Disadvantages</u>

– Nematodes are extremely sensitive to environmental conditions; therefore, although they are capable of a high success rate, it is difficult to provide them with the necessary environmental conditions, such as ample water. However, a new strain may be available in a year or two that will be less environmentally sensitive and therefore more effective.

<u>Contact for Additional Information</u>

Mr. Joel Coats
Iowa State University
(515) 294-4776

COST ANALYSIS

The cost analysis assumes use of beneficial nematodes at a cost of $40 per acre and that 100 acres are treated, with labor requirements of 0.5 hour per acre for spray application.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	[(nematode cost)(# acres)] + [(labor hrs.)(labor rate)]
	=	($40/acre)(100 acres) + (50 hrs.)($15/hr.) $4,000 + $750
	=	**$4,750**

COMPUTING AI

Does not entail use of chemical AI.

CUTWORM CONTROL ALTERNATIVE 2

Alternative Insecticide with Low Percentage AI

DESCRIPTION OF ALTERNATIVE

Involves replacing the current chemical used with a chemical that has a low percentages AI and is equally or more effective

TECHNICAL ANALYSIS

Cutworms and other caterpillars that live in the soil come to the surface at night to feed on turf. These pests can cause extensive damage to lawns and golf courses. A recommended chemical replacement is Tempo® 20 WP produced by Bayer. Tempo® 20 WP (cyfluthrin) is applied to the turf at a rate of 0.096 pound AI per acre, compared to other insecticides used to control cutworms, which have application rates ranging from 1.0 pound AI per acre for Dursban® to 8.75 pounds AI per acre for Mocap®.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Will not require extra training or expertise

+ Will not require the purchase of new equipment

+ Low AI dosage.

<u>Contact for Additional Information</u>

Miles Incorporated
Specialty Products
Box 4913
Kansas City, Missouri 64120-0013
(800) 842-8020

COST ANALYSIS

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Cost	=	(cost/lb. AI)(lbs. AI/acre)(acreage treated) + (labor hrs.)(labor rate)
	=	($49/lb. AI)(0.096 lb./acre)(100 acres) + (15 hrs.)($15/hr.)
	=	$470.40 + 225
	=	**$694.40**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(application rate)(acreage treated)
	=	(0.096 lb. AI/acre)(100 acres)
	=	**9.6 lbs. AI**

APPENDIX G

ALTERNATIVES FOR CONTROLLING INDOOR INSECTS

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

APPENDIX G
ALTERNATIVES FOR CONTROLLING INDOOR INSECTS

THIS PAGE INTENTIONALLY LEFT BLANK

COCKROACH CONTROL ALTERNATIVE 1

Gel Bait Insecticides

DESCRIPTION OF ALTERNATIVE

This type of insecticide is available through various manufacturers and under various brand names. These baits are effective against both small species (e.g., German, Brown-Banded) and large species (e.g., American, Smoky Brown, Oriental) of cockroaches. Siege® and MAXFORCE® are applied with a prefilled disposable syringe containing 30 to 60 grams of insecticide. These gel type baits are non-repellent; therefore, they won't drive cockroaches to adjacent untreated areas. Once the cockroaches feed on the bait, they return to their harborage and die.

TECHNICAL ANALYSIS

The Siege® and MAXFORCE® gel baits contain 2 percent hydramethylnon (a stomach poison) and work immediately, usually providing control within 24 to 72 hours. These baits have a 3- to 6- month residual effect. The application rate depends on the level of infestation; lower rate for low to moderate infestations, and higher rate for severe problems. A typical 1,200-square-foot home would require approximately three syringes of the gel bait. The only area the Siege® bait gel is not approved for treatment is in commercial food- handling areas. These baits contain no volatile compounds and have an acute oral LD_{50} of >5,000 milligrams per kilogram in rats. MAXFORCE® gel bait insecticide is the commonly used cockroach control method; approximately 0.3 pound AI would be used annually to treat 20 housing units. The cost is $25.25 per case of three MAXFORCE® syringes.

ADVANTAGES/DISADVANTAGES

Advantages

+ Is effective against cockroaches

+ Low chemical AI used

+ Low cost

+ Is environmentally safe; acute oral LD_{50} of >5,000 milligrams per kilogram in rats

+ No site preparation required

+ Odorless

+ Can be used in sensitive areas (e.g., homes, hospitals, offices, computer areas, pet areas).

Disadvantages

– Gel bait is not approved for treatment of commercial food handling areas.

Contact for Additional Information

American Cyanamid Company (Siege)
Vegetation and Pest Control Department
One Cyanamid Plaza
Wayne, New Jersey 07470
(800) 452-1289 Ext. 300

MAXFORCE® Insect Control Systems
B & W Sales and Marketing
P.O. Box 2072
Stone Mountain, Georgia 30086
(800) 843-6334

MAXFORCE® Dallas office (214) 484-6326

COST ANALYSIS

The cost analysis is based on use of three MAXFORCE® syringes for a typical 1,200-square-foot home, at a cost of $25.25. Each syringe contains 2.1 ounces of bait, at 2 percent AI.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS	
Total Annual Costs	= (# homes treated)(treatment cost/application)(# applications/year)
=	(20 homes)($25.25/treatment)(2)
	= $1,010

COMPUTING AI

ANNUAL AI APPLICATION	
Annual AI Usage	= (lbs. AI/home))(# homes treated)(# applications/year)
	= (2.1 oz./syringe)(3 syringes/home)(0.02 AI)(20 homes)(2 applications)
	= 4.8 oz.
	= **0.3 lb. AI**

COCKROACH CONTROL ALTERNATIVE 2

Cockroach Bait Stations

DESCRIPTION OF ALTERNATIVE

This type of insecticide is available through MAXFORCE® Insect Control Systems under the brand name MAXFORCE® Roach Killer Bait Stations. Small bait stations may be used for control of small cockroach species (e.g., German, Brown-Banded). The large bait stations are recommended for control of larger cockroach species (e.g., American, Oriental) as well as waterbugs and palmetto bugs. The child-resistant stations are simply placed in areas where cockroaches have been seen. The bait stations can be adhered to vertical surfaces. The stations contain a bait that cockroaches eat even with the presence of other food items.

TECHNICAL ANALYSIS

The MAXFORCE® bait stations contain 2 percent hydramethylnon. The bait works immediately with population reductions usually apparent within 2 weeks. Two to three stations per 100 square feet is recommended and should be replaced every 3 months. MAXFORCE® bait stations may be placed in any area where cockroaches are present, including food handling and preparation areas and hospital. MAXFORCE® bait stations would involve the application of approximately 0.5 pound AI to treat 20 housing units. This is a small increase from the 0.3 pound AI applied using MAXFORCE® gel bait. The cost for a 72-count case of small stations is $30.15 and $15.88 per case of 24 large bait stations.

ADVANTAGES/DISADVANTAGES

Advantages

+ Is effective against cockroaches

+ Low chemical AI used

+ Low cost

+ No site preparation required

+ Can be used in all sensitive areas (e.g., homes, hospitals, offices, computer areas, pet areas, food handling areas)

+ Easy application/placement (residents may install).

Disadvantages

– Use only in areas not easily accessible to children and pets

– Avoid freshly sprayed surfaces as this will repel cockroaches from the bait stations.

Contact for Additional Information

MAXFORCE® Insect Control Systems
B&W Sales and Marketing
P.O. Box 2072
Stone Mountain, Georgia 30086
(800) 843-6334

MAXFORCE® Dallas office (214) 484-6326

COST ANALYSIS

The cost has been calculated assuming placement of two large bait stations per 100 square feet to provide coverage for a 1,200-square-foot home, and three applications per year. A case of 24 bait stations contains 6.98 ounces of bait at 2 percent AI; assume 0.0058 ounce AI per station.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS	
Total Annual Costs	= (# homes treated)(2 stations/100 sq. ft.)(sq. ft.)(cost/station)(# of applications)
	= (20 homes)(2 stations/100 sq. ft.)(1,200 sq. ft.)($0.66/station) (3 treatments)
	= $950.40

COMPUTING AI

ANNUAL AI APPLICATION	
Annual AI Usage	= (lbs. AI/bait station)(# stations)(# homes treated)(# applications/year)
	= (0.0058 oz. AI/station)(24 stations/home)(20 homes)(3 treatments)
	= 8.35 oz.
	= **0.52 lb. AI**

COCKROACH CONTROL ALTERNATIVE 3

Thermal Control

DESCRIPTION OF ALTERNATIVE

This control measure involves the use of propane heaters that pump heated air into a designated area or facility. Exposure to high heat degrades the integrity of the cell membrane and affects the nervous system.

An insect growth regulator (e.g., Gentrol®; see Cockroach Control Alternative 4) may be used in combination with the thermal treatment to sterilize cockroaches as they attempt to establish themselves following the thermal treatment.

TECHNICAL ANALYSIS

Thermal treatment utilizes no chemical AI to control cockroaches. Past treatments have shown that cockroaches will die after approximately 30 minutes at 120° Fahrenheit. Vacuum cleaners are used at regular intervals and at the completion of the treatment to collect cockroaches seeking shelter at the wall/floor interface. This treatment method has shown success in eight of ten facilities treated. Thermal treatment is a good alternative in areas where cockroaches have been treated with an insecticide and have developed a resistance. Thermal treatment kills the cockroaches and, over time, new roaches will no longer be resistant to typical insecticides.

Following the final vacuuming, an application of residual insect growth regulator may be used to kill or sterilize any remaining cockroaches that may have survived the heat treatment. Monitoring with sticky traps following the thermal treatment may catch a large number of cockroaches the night after treatment; however, after this initial monitoring, cockroach populations in the area treated should decrease dramatically. Food preparation facilities are the primary areas to be treated thermally. The approximate cost for thermal treatment of a typical 7,000-square-foot facility is $1,100, including labor. Costs do not include the application of sealers and caulking in cracks and crevices, which should be conducted as IPM practice prior to thermal treatment. A capital cost of approximately $30,000 would be necessary to procure the propane heaters and other miscellaneous equipment needed to conducts these activities. Installations that do not want to develop their own thermal control system may contract the treatment to commercial applicators. Additionally, capital costs can be shared by purchasing thermal equipment for an individual MAJCOM or by a number of installations sharing the expense.

Major site preparation involving removal of perishable foods, shutting off of electrical equipment, removal of compressed gas cylinders, removal of electrical equipment (e.g., televisions, computers), and sealing cracks and drains is required. Range hood fire suppression systems must be insulated during treatment; internal heat is monitored from the outside.

ADVANTAGES/DISADVANTAGES

Advantages

+ Is effective against cockroaches

+ No chemical AI used

+ Cost per treatment is reasonable

+ Very little damage to interior of facility from heat

+ Significant long-term reduction of cockroach populations

+ High degree of interest from food service agencies

+ Commercial contractors are available to provide heat treatment.

Disadvantages

– Substantial site preparation required

– Facility must be shut down for a minimum of 2 days

– Supplies (e.g., food, electrical equipment) must be relocated temporarily

– Ineffective against cockroaches at the wall/floor interface, especially in recessed mortar joints

– Treatment has not been conducted in facilities with sprinkler systems. Means of insulating sprinkler heads must be developed

– Inside of block walls and crawl spaces are not heated to sufficient temperatures to be effective.

Contact for Additional Information

United States Army Center for Promotion and Preventative Medicine (USACHPPM)
Entomological Sciences Program
Mr. Brian Zeichner
Aberdeen Proving Ground, Maryland 21010-5422
(410) 671-3613
DSN 584-3613

COST ANALYSIS

CAPITAL COSTS		
Capital Costs	=	cost of heating equipment
	=	**$30,000**

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(# applications)(treatment cost/application)
	=	(1)($1,100)
	=	**$1,100**
Typical structure size is approximately 7,000 sq. ft.		

COMPUTING AI

Does not entail use of chemical AI.

COCKROACH CONTROL ALTERNATIVE 4

Insect Growth Regulator

DESCRIPTION OF ALTERNATIVE

Replace current chemical with an insect growth regulator (IGR). An IGR for control of cockroach infestations is available through Sandoz Agro, Inc., under the brand name Gentrol® Point Source.

TECHNICAL ANALYSIS

Gentrol® Point Source contains no AI, rather it is an IGR that sterilizes adult cockroaches so no new eggs can be produced. Gentrol® Point Source is effective against all species of cockroaches and has a 90-day residual effect. The IGR is released from an enclosed capsule onto filter paper; then the IGR molecules are released into the air, which eventually access cracks and other cockroach harborages. The cockroach does not have to come in contact with the device. Gentrol® Point Source devices are placed in areas of heavy infestations and treat an area of approximately 75 square feet. The Gentrol® Point Source IGR has a very low toxicity and is safe for treatment in all areas of infestation (e.g., commercial food handling areas, homes, hospitals). Gentrol® Point Source, in combination with a gel bait insecticide, will increase the effectiveness of cockroach control. The Gentrol® Point Source IGR does not involve using chemical AI; this is a small reduction from the use of MAXFORCE® gel bait. The cost is $23.58 per case of 20 devices.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Is effective against cockroaches
+ No chemical AI used
+ Low cost
+ Is environmentally safe
+ No site preparation required
+ Odorless
+ Can be used in sensitive areas (e.g., food preparation areas, homes, hospitals, offices, computer areas, pet areas).

Disadvantages

- Does not kill the cockroach, only sterilizes it
- Should be used with other cockroach control measures
- Is not available for use in all parts of the country.

Contact for Additional Information

Sandoz Agro, Inc.
1300 E. Touhy Avenue
Des Plaines, Illinois 60018
(800) 248-7763

COST ANALYSIS

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(sq. ft. treated)(1 device/75 ft.)(cost/device)(treatments/year)
	=	(1,200 sq. ft./75 ft.)($1.18/device)(4)
	=	**$75.52**

COMPUTING AI

Does not entail use of chemical AI.

TERMITE CONTROL ALTERNATIVE 1

Colony Elimination System

DESCRIPTION OF ALTERNATIVE

This type of system is currently available through DowElanco under the name of Sentricon®. The Sentricon System® is effective against all subterranean termite species (except drywood) in the continental United States. A small block of wood is placed into bait tubes that are spaced approximately 10 to 20 feet apart around individual affected structures. Monthly monitoring of the wood within the bait tubes determines the presence of a termite colony. Once a colony has been detected, a growth regulating bait is placed into the bait tube. The growth regulator prevents the molting process in termites, and they eventually die.

TECHNICAL ANALYSIS

This treatment is relatively new (sales started in 1995) to termite control practices. The Sentricon® System is not just a product, it is a service. Each Sentricon® bait tube contains 4 ounces of bait, with 0.1 percent hexaflumuron and 99.9 percent inert material (sawdust). Installing the Sentricon® System for treatment of 50 housing units would require approximately 1,500 bait tubes containing a total of less than 1 pound AI. This compares to a typical treatment using Dursban TC® of 260 pounds AI. Once the system is installed, it may take from a few weeks to a few months for termites to enter the stations, depending on several factors (i.e., time of year, geography, and termite species). The process of colony elimination begins once the termites are transferred to bait tube devices and begin feeding on the termite bait. Colony elimination may occur as quickly as 3 to 5 months after termites are transferred to bait tube devices. After a colony has been eliminated, the bait is replaced by monitoring devices (wood blocks) and inspected monthly.

ADVANTAGES/DISADVANTAGES

Advantages

+ Is effective against all subterranean termites in the continental U.S. (except drywood)

+ Very low chemical AI used (0.1 percent)

+ Cost is comparable to current termite control practices

+ Is environmentally safe because the AI does not come in contact with the environment.

Disadvantages

– The Sentricon® System is in the test and refining stage of development

– The Sentricon® System is only available to applicators who have met the training requirements and other standards established by DowElanco

– Applicators of the Sentricon® System will have to be specially trained and certified

– Regular monitoring of the bait tube devices is required.

Contact for Additional Information

DowElanco
9330 Zionsville Road
Indianapolis, Indiana 46268-1054
(800) 352-6776

COST ANALYSIS

Costs and lbs. AI are calculated below for treating 1,500 linear feet. Estimated time to inspect and apply AI to bait tube is 10 minutes and a linear rate of $15 per hour is assumed.

CAPITAL COSTS		
Capital Costs	=	(# bait tubes)(cost/bait tube)
	=	(1,500)($10.00/bait tube)
	=	**$15,000**

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(annual monitoring cost/bait tube)(# of bait tubes) ($2.50/bait tube)(1,500 bait tubes)
	=	**$3,750**
Note: For immediate short-term control of termites, some applicators of the Sentricon® System also apply standard pesticides (e.g., Dursban®) using trenching around a facility. Cost to apply the Sentricon® System and apply the trench pesticides is approximately $6 to $9/linear ft.		

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(lbs. AI/bait tube)(# bait tubes installed)
	=	(0.004 oz.)(1,500 bait tubes)
	=	6 ounces
	=	**0.38 lb. AI**
Note: AI application presented is for Sentricon® System only and does not include any trench application of pesticides.		

TERMITE CONTROL ALTERNATIVE 2

Alternative Insecticide with Low Percentage AI

DESCRIPTION OF ALTERNATIVE

Involves replacing the current chemical used with a chemical that has a low percentage AI and is equally or more effective.

TECHNICAL ANALYSIS

A recommended chemical replacement is Premise®75 produced by the Bayer Corporation. Premise®75 (imidacloprid) is mixed at a ratio of 6.75 ounces AI to 100 gallons of water. The Premise®75 solution is applied in a trench dug to a depth of 6 inches around the affected area at a rate of 4 gallons per 10 linear feet. This rate of application would result in a total of 26 pounds AI for treatment of 50 housing units, which is much less than the 260 pounds AI of Dursban TC®, a product commonly used for control of termites. The solution may also be applied in inaccessible areas such as crawl spaces at a rate of 1 gallon per 10 square feet, or beneath slabs by drilling through the foundation or treating existing cracks and expansion joints with the application as for trenches. Premise®75 can be used for long-term termite control because it is environmentally persistent, remaining in the soil for an extended period of time. Corrective treatments may be necessary when there is evidence of reinfestation or when there has been a disruption in the chemical barrier (e.g., landscaping). Labor involved in applying Premise®75 would be similar to common practices of applying pesticides such as Dursban®.

ADVANTAGES/DISADVANTAGES

Advantages

+ Can be used to control all termite species
+ Persistent control barrier
+ Low AI percentage (6.75 ounces per 100 gallons of solution)
+ May be used as a preconstruction termite control measure
+ May be applied as a liquid or a foam
+ Minimal training to familiarize personnel with new chemical
+ No special equipment costs.

Disadvantages

– Is now registered for use in all states except New York and Mississippi
– Not recommended for structures with cisterns or wells

– Not recommended for application near heat pipes, ducts, water and sewer lines, or electrical conduits

– Area should not be planted with plants for the purpose of consumption

– Cost is slightly higher than the common practice of applying Dursban® as a termite control measure.

Contact for Additional Information

Bayer Corporation
Specialty Products
Box 4913
Kansas City, Missouri 64120-0013
(800) 842-8020

COST ANALYSIS

The analysis is based on an application rate of 400 gallons per 1,000 linear feet, at a cost of $450, or $0.45 per linear foot. A mixture of 6.75 ounces of Premise® in 100 gallons of water is applied at 4 gallons per 10 linear feet, or 0.027 ounce per linear foot.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS	
Total Annual Costs	= (chemical cost/ft.)(linear ft. treated) + (labor hrs.)(labor rate)
	= ($0.45/ft.)(10,000 ft.) + (1,000 hrs.)($15.00/hr.)
	= $4,500 + $15,000
	= **$19,500**

COMPUTING AI

ANNUAL AI APPLICATION	
Annual AI Usage	= (lbs. AI/linear ft.)(linear ft. treated)
	= (0.027 oz./ft.)(10,000 ft.)
	= 270 oz.
	= **16.9 lbs. AI**

TERMITE CONTROL ALTERNATIVE 3

Thermal Control

DESCRIPTION OF ALTERNATIVE

This control measure involves the use of propane heaters to pump heated air into a facility. Exposure to high heat degrades the integrity of the cell membrane and affects the nervous system, eventually killing the termite.

TECHNICAL ANALYSIS

Thermal treatment utilizes no chemical active ingredient to control termites. Past treatments have shown that termites will die after approximately 35 minutes at 120° Fahrenheit. Thermal control can be extremely cost competitive with fumigation techniques (e.g., if only one or two units of a condominium need treatment; it is less expensive to use heat than to evacuate the entire building). The approximate cost is $1,080 per thermal treatment, including labor for a 5,000-square-foot area (e.g., typical dining facility). A capital cost of approximately $30,000 would be necessary to procure the propane heaters and other miscellaneous equipment. Installations that do not want to develop their own thermal control system may contract the treatment to commercial applicators. There are approximately 18 companies licensed to conduct thermal treatment, some reporting daily thermal control jobs.

Major site preparation involving removal of perishable foods, shutting off of electrical equipment, removal of compressed gas cylinders, and removal of electrical equipment (e.g., televisions, computers). Range hood fire suppression systems must be insulated during treatment; internal heat is monitored from the outside.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

\+ Is effective against drywood termites

\+ No chemical active ingredient used

\+ Cost per treatment is reasonable

\+ Very little damage to interior of facility from heat

\+ Commercial contractors are available to provide heat treatment.

<u>Disadvantages</u>

– Some site preparation is required.

– Supplies (food, electrical equipment) must be relocated temporarily.

<u>Contact for Additional Information</u>

United States Army Center for Promotion and Preventative Medicine (USACHPPM)
Entomological Sciences Program
Brian Zeichner
Aberdeen Proving Ground, Maryland 21010-5422
(410) 671-3613
DSN 584-3613

COST ANALYSIS

CAPITAL COSTS
Capital Costs = **$30,000** (propane heaters and other equipment)

ANNUAL OPERATING COSTS	
Total Annual Costs	**=** (# applications)(treatment cost/application)
	= (50 units)($1,080/unit)
	= $54,000

COMPUTING AI

Does not entail use of chemical AI.

FLEA CONTROL ALTERNATIVE 1

Alternative Insecticide with Low Percentage AI (pet areas)

DESCRIPTION OF ALTERNATIVE

Involves replacing the current chemical used with a chemical that has a low percentage AI and is equally or more effective.

TECHNICAL ANALYSIS

A recommended chemical replacement is Crack-shot® produced by the Drummond American Corporation. Crack-shot® (chlorpyrifos and piperonyl butoxide) is applied as a spot treatment to infested areas such as pet beds, adjacent cracks and crevices, and floor areas where pets are normally present. Current practices for flea control vary from region to region; however, as shown in the annual AI application analysis, 100 housing units would require less than 1 pound AI. Crack-shot® also contains Dursban®. Crack-shot® should not be sprayed directly on pets. Children and pets should not come in contact with the spray until it has dried. Crack-shot® is a residual insecticide that should last for several weeks. Labor involved in applying Crack-shot® would be similar to common practices of applying pesticides.

ADVANTAGES/DISADVANTAGES

Advantages

+ Has a residual effect for several weeks

+ Low AI percentage (0.8 percent)

+ No special equipment costs.

Disadvantages

– Food area application is limited to crack and crevice treatment

– Children and pets should avoid treated areas until the solution has dried

– Electrical equipment should be deactivated prior to spraying.

Contact for Additional Information

Drummond American Corporation
1700 Sherwin Avenue
Des Plaines, Illinois 60018
(312) 297-1777

COST ANALYSIS

The analysis assumes use of 0.5 can per 1,000-square-foot structure, at a cost of $2.50 per can.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost/structure)(# structures treated)
	=	($1.25/structure)(100)
	=	**$125**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(lbs. AI/structure)(# structures treated)
	=	(8.5 oz./structure)(0.8% AI)(100 structures)
	=	7 oz.
	=	**0.44 lb. AI**

FLEA CONTROL ALTERNATIVE 2

Alternative Insecticide with Low Percentage AI (pet areas)

DESCRIPTION OF ALTERNATIVE

Involves replacing the current chemical used with a chemical that has a low percentage of AI and is equally or more effective.

TECHNICAL ANALYSIS

A recommended chemical replacement is Precor® produced by Zoecon Corporation. Two Precor® products are used to control all stages of the flea life cycle. Precor® IGR concentrate (methoprene) is used to control the immature life stages (eggs and larvae). Precor 2000 (methoprene and permethrin) is used to control both adult and pre-adult fleas. Methoprene is an insect growth regulator that kills flea eggs, and prevents larvae from emerging as adults. Methoprene, with permethrin, kills adult and pre-adult fleas. Both products have a residual effect of 7 months. Precor® IGR concentrate is mixed at a rate of 1 ounce per 1 gallon of water and applied at a rate of 1 gallon per 1,500 square feet. Precor® 2000 is available in ready-to-use 16-ounce spray cans that will treat approximately 2,000 square feet. Current practices for flea control vary from region to region; however, as shown in the annual AI application analysis, 100 housing units would require less than 1 pound AI. Precor® should be applied to infested areas such as pet beds, carpets, and furniture. These products are not recommended for food preparation areas and should not be sprayed directly on pets. Labor involved in applying Precor® would be similar to common practices of applying pesticides.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Has a residual effect for several months

+ No smell and no staining

+ No need to remove pet bedding after treatment

+ Precor® 2000 solution is also available in fogger form

+ No special equipment costs.

<u>Disadvantages</u>

– Not recommended for food preparation areas

– Recommended for indoor control only

– Two products must be used to control all stages of flea life cycle.

<u>Contact for Additional Information</u>

Zoecon Corporation
1200 Denton Drive
Dallas, Texas 75234
(800) 248-7763

COST ANALYSIS

The analysis assumes two pesticides to treat all stages of the flea life cycle: one to control immature life stages and one to control adults. One chemical costs $3.20 per ounce, and is used at a rate of 1ounce per structure, at 1 percent AI. The other costs $11.30 per can, and is used at a rate of one 16-ounce can per structure at 0.575 percent AI. The analysis is based on treating 100 structures.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost/structure)(structures treated) + (chemical cost/structure)(structures treated)
	=	($3.20/structure)(100) + ($11.30/structure)(100)
	=	$320 + $1,130
	=	**$1,450**

COMPUTING AI

ANNUAL AI APPLICATION		
Annual AI Usage	=	(lbs. AI/structure)(structures treated)
	=	(0.01 oz./structure)(100 structures) + (0.09 oz./structure)(100 structures)
	=	1 oz. + 9.2 oz.
	=	10.2 oz**.**
	=	**0.64 lb. AI**

FLEA CONTROL ALTERNATIVE 3

Insect Growth Regulator (pets)

DESCRIPTION OF ALTERNATIVE

Involves supplementing the current chemical used to control fleas within a home with an insect growth regulator that controls fleas living on pets.

TECHNICAL ANALYSIS

A recommended product is Program®, produced by the Ciba-Geigy Corporation. Program® (lufenuron) is provided for dogs in pill form and for cats as a liquid in their food once a month during flea season. The AI mimics a hormone in fleas, and prevents them from reproducing. Program® breaks the flea life cycle. When a female flea bites a treated pet, she swallows the AI, which is passed into her eggs. The AI prevents the eggs from hatching. Program® has a very low toxicity for mammals and is recommended for dogs and cats of any size, weight, or breed and is also safe for pregnant pets and pets as young as 6 weeks old. It is a prescription product, and can only be obtained from a veterinarian. The dosage is based on the weight of the animal.

Flea control may take 60 to 90 days, depending on the environmental conditions and degree of the current flea infestation within a home. For faster control of flea infestations, use of a pesticide for controlling other stages of the flea life cycle is recommended. If the animal has access to both outdoor and indoor areas, it may be necessary to use other insecticides on an as-needed basis to treat the home, yard, and pet.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Monthly treatment for pets

+ AI does not come in contact with the environment

+ Very low toxicity. Safe for all pets over 6 weeks old.

<u>Disadvantages</u>

– Not available over-the-counter

– Additional pesticide application may be required in the home and yard and on the pet for short-term control of new flea infestations.

<u>Contact for Additional Information</u>

Ciba-Geigy Corporation
Greensboro, North Carolina
(910) 547-1000

Additional information can be collected from your local veterinarian.

COST ANALYSIS

Program may be obtained from a veterinarian at an approximate cost of $40 for a 6-month supply.

CAPITAL COSTS
No capital costs have been identified.

ANNUAL OPERATING COSTS		
Total Annual Costs	=	(chemical cost)(months treated)
	=	($40/6 months)(6 months)
	=	**$40/pet**

COMPUTING AI

ANNUAL AI APPLICATION
Not applicable; AI does not come in contact with the environment.

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX H

ALTERNATIVES FOR GOLF COURSE TURF MANAGEMENT

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

APPENDIX H
ALTERNATIVES FOR GOLF COURSE TURF MANAGEMENT

Page

THIS PAGE INTENTIONALLY LEFT BLANK

GOLF COURSE TURF CONTROL ALTERNATIVE 1

Replace Portions of Roughs with Natural Vegetation

DESCRIPTION OF ALTERNATIVE

Involves replacing turf treated currently with chemical pesticides with natural vegetation or vegetation that does not require treatment such as shrubbery, trees, and natural grasses.

TECHNICAL ANALYSIS

Portions of a golf course may be developed into natural areas that may be playable or nonplayable. Naturalized playable areas can be developed using natural grasses or other similar ground cover including wildflowers. This may result in a loss of turf quality but the area will still be playable. Naturalized nonplayable areas can be developed using larger, more permanent vegetation such as shrubs or trees. This will not sacrifice turf quality or likely aesthetics but will result in a smaller, more challenging course. Replacement vegetation will vary from site to site depending on climatic and soil conditions. Other areas which may undergo a reduction in pesticide treatment include the area between the front edge of the fairway and the tees and the outlying rough areas. There may be other areas as well depending on the layout of the individual course. In addition to reducing pesticide usage directly, maintenance practices on specific areas can be altered to reduce pesticides indirectly. For example, areas once mowed at standard fairway height may be mowed slightly higher to reduce insect infestation and disease susceptibility.

(A low-cost variation of this alternative is to simply stop applying pesticides on these areas of the roughs and let the grass grow higher).

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Can be used to reduce all pesticides applied on selected turf

+ Other than loss of playing area, does not adversely affect aesthetics or playability of turf/course

+ No training necessary

+ Reduced labor costs.

<u>Disadvantages</u>

– Could have high capital cost associated with landscaping

– Courses with small areas will not be able to reduced treated area further.

Contact for Additional Information

Audobon Cooperative Sanctuary Program
131 Rarick Road
Selkirk, New York 12158
(518) 767-9051

COST ANALYSIS

CAPITAL COSTS

Capital costs will be dependent on the type and amount of vegetation required to naturalize a particular area. Some costs that may be useful in calculating the capital costs are:

Trees (~1▯ in. diam.)	=	\$150.00/tree
Shrubs	=	\$40.00/shrub
Wildflower seed	=	\$0.05/ft^2
Native grasses	=	\$600/acre

If the turf is naturalized to a playable status (i.e., resident grasses and wildflowers) the cost will consist of placing flower seed and allowing natural turf to reside. If 1 acre of turf is naturalized using 0.80 acre of native seed and 0.20 acre of wildflower seed, the total cost would be calculated as follows:

Capital Cost = (0.2 acre x 43,560 ft^2/acre x \$0.05/ft^2) + (0.8 acre x \$600/acre)
= \$435.60 + \$480
= **\$915.60**

If the mow height is increased in this area but still at a playable height, disease resistance will increase dramatically and turf insects will be less likely to lay their eggs, resulting in less grub damage.

If the turf is naturalized to a nonplayable status (i.e., trees and shrubs), the costs will be for planting vegetation to fill the area. If 1 acre of turf is replaced with 5 trees, 10 shrubs, and 8,000 ft^2 of wildflowers, the total cost of landscaping would be:

Total Landscaping Cost = (5 x \$150) + (10 x \$40) + (8,000 x \$0.05)
= **\$1,550**

ANNUAL OPERATING COSTS

Labor hours can be estimated on a per acre basis. If the area was naturalized using turf that required lower maintenance, the labor requirement will be different from areas that were naturalized using trees or shrubs. If the area was naturalized using native grasses or wildflowers, the turf could still require some pesticide treatment depending on the demands of the players. It will also require some grounds maintenance such as mowing and fertilizing. If it is assumed that no pesticide treatment will be required, the labor hours to maintain a naturalized area will be based on mowing, fertilizing, and irrigating. If the area was naturalized using permanent vegetation such as trees or shrubs, labor hours will consist of picking up limbs, trimming shrubs, and other similar tasks.

The new herbicide costs can be calculated using the percentage of area naturalized.

Total Annual Costs = (Total Cost for Pesticides on Rough)(New Rough Acreage after Naturalization)/(Old Rough Acreage Before Naturalization)

For example, if 20 of 100 acres are naturalized and the cost of pesticides on the rough (or whatever area is naturalized) is \$5,000, the new cost can be calculated as:

=	($5,000) x (80 acres)/(100 acres)
=	**$4,000**

COMPUTING AI

ANNUAL AI APPLICATION
The annual application can be calculated by multiplying the ratio of the areas (by specific area - roughs, fairways) naturalized by the lbs. AI applied. For example, if roughs are being naturalized, the following equation could be used: Annual AI Usage = (Total Pesticides Used on Rough)(New Rough Acreage after Naturalization) / (Old Rough Acreage Before Naturalization) If 1,000 lbs. AI were used in the rough formerly and 20 of the 100 acres are being naturalized, the new usage could be calculated as: = (1,000 lbs.)(80 acres) / (100 acres) = **800 lbs.**

GOLF COURSE TURF CONTROL ALTERNATIVE 2

Create "Environmentally Friendly" Course (eco-course)

DESCRIPTION OF ALTERNATIVE

A course or portion of a course is dedicated to nonchemical or reduced chemical approaches to pest management

TECHNICAL ANALYSIS

An eco-course would rely on nonchemical methods for insecticide and herbicide application. Turf diseases would be treated with chemicals, as necessary, because they can damage turf beyond recovery. The use of fungicides would be minimized, using the techniques described in Appendix E. The use of fungicides may, however, be detrimental to some of the biological pest management techniques such as beneficial nematodes or bacteria. This should be studied on a case by case basis. There are many nonchemical approaches to insect and weed management. Some of these approaches are proven and some are experimental. Appendices A and F provide more information on some nonchemical methods for control of weeds and insects. Some of the more proven nonchemical approaches are:

- Use of *Bacillus thuringiensis* (BT) - This bacteria species causes diseases in certain insects. Over 35 different species of BT have been identified and each attacks a different host insect. BT is applied to the leaves where it is ingested by an insect and acts as a toxin.

- Beneficial Nematodes - Some nematodes can be beneficial in that they kill certain insects. Nematodes are applied in a similar fashion as herbicides (as a solution). Irrigation is extremely important for successful use of nematodes.

- Organic Herbicides - Organic herbicides such as corn gluten meal sold as the commercial Amaizing Lawns use no chemical active ingredient. Amaizing Lawns acts as a preemergent to stop crabgrass growth.

- Mechanical Controls - Weeds can also be reduced in certain areas using hand-pulling or "weed-whacking" techniques. Although the labor is increased, there is no active ingredient applied.

- Adopt-a-Hole - This program enables different groups around the base to choose a hole and provide the labor to maintain it using nonchemical methods. They may also choose to provide decorative plants for aesthetics. This program usually turns into a competition among the different groups which increases the output they provide.

Proven technologies can be tested on the eco-course and, if successful, can be implemented over the entire course. This information can be shared with neighboring courses (both military and private) as well for good public relations. The superintendent can also work with companies to experiment with nonproven nonchemical technologies. These results can also be beneficial to the golf course superintendent community. Reduced green fees can also be implemented to gain acceptance of the course especially in cases where turf quality is sacrificed.

ADVANTAGES/DISADVANTAGES

<u>Advantages</u>

+ Good public relations

+ Opportunity to experiment with proven and nonproven forms of nonchemical pest management

+ Elimination of herbicides and insecticides on the eco-course area.

Disadvantages

– Possible sacrifice in turf aesthetics and playability

– Difficulty in gaining acceptance from some golfers, and may result in some loss of revenue from reduced greens fees and fewer players unless properly "marked."

Contact for Additional Information

Audobon Cooperative Sanctuary Program
131 Rarick Road
Selkirk, New York 12158
(518) 767-9051

The local extension service will also be able to provide information on weed- and insect-resistant turf cultivars, as well as in biological control methods for insects that are suitable for your area.

COST ANALYSIS

CAPITAL COSTS
There will be no quantifiable capital costs associated with the eco-course. If some areas are naturalized as part of the eco-course concept, the costs would be as described in Alternative 1 for golf courses.

ANNUAL OPERATING COSTS
Operating costs will be dependent on the nonchemical pest management methods chosen. A commercially available organic herbicide is Amaizing Lawns with a cost of approximately $700 per acre. Fungicide treatments will probably need to be continued so the operating costs for disease treatment will be similar (see Appendix E). Costs for chemical herbicides and insecticides will be discontinued. Labor costs will be roughly unchanged because the nonchemical treatments used should have roughly the same labor requirements. An example of determining cost for a nonchemical herbicide that costs $700 per acre and requires 2 treatments a year is as follows: Total Annual Costs = (chemical cost/acre)(acreage treated)(treatments/year) + (labor hrs.)(labor rate)(# treatments/year) = ($700/acre)(25 acres)(2 treatments/year) + (12.5 hrs./treatment)($15/hr.)(2 treatments/year) = $35,000 + $375 = **$35,375** Costs for other nonchemical weed control methods are provided in Appendix A. The cost of nematodes is also based on the area treated. The materials cost to treat approximately 1 acre is $40. The same equipment used to spray pesticides can be used to apply nematodes. The application cost for 25 acres can be approximated using the following formula: Total Annual Costs = (nematode cost/acre)(acreage treated)(# treatments/year) + (labor hrs.)(labor rate)(# treatments/year) = ($40/acre)(25 acres)(2 treatments/year) + (12.5 hrs.)($15/hr.)(2) = $2,000 + $375 = **$2,375** Costs for other biological control methods for insects are provided in Appendix F.

COMPUTING AI

ANNUAL AI APPLICATION
Assuming that the only pesticides used on the eco-course are fungicides, the amount of AI used in the eco-course should be calculated as shown in Appendix E for the appropriate fungicide use. Pesticide use on the non-eco-course portions of the golf course can be calculated as follows: Annual AI Usage = (current pesticide usage)(total acreage treated - eco-course acreage/ total acreage treated) For example, if 25 acres of a 100-acre course were converted to an eco-course, and the previous pesticide usage was 1,000 lbs. AI, the new usage in the non-eco-course portion would be: = 1,000(100-25/100) = **750 lbs. AI**

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX I

REGULATORY OVERVIEW

THIS PAGE INTENTIONALLY LEFT BLANK

REGULATORY OVERVIEW

This appendix provides a summary of the major federal, Department of Defense (DoD), and Air Force regulations, guidelines, and policies governing the use of pesticides, and the requirements to reduce the use of pesticides.

I.1 FEDERAL REQUIREMENTS

I.1.1 Federal Insecticide, Fungicide, and Rodenticide Act

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacture, use, storage, and disposal of chemicals used as pesticides as described in 40 Code of Federal Regulations (CFR) Parts 150-180. The focus of FIFRA is on pesticide producers; however, the following emphasizes the parts of the regulation applicable to the use, storage, and disposal of pesticides. The key points of FIFRA are as follows:

- Regulates storage, use, and disposal of all pesticides including herbicides, insecticides, fungicides, and plant growth regulators
- Regulates all pesticide labels and packaging
- Classifies pesticides as unclassified, general use, or restricted use (40 CFR Part 152, Subpart I). Restricted use may prescribe restrictions relating to the products, composition, labeling, packaging, uses, or the status or qualifications of the user
- Describes the written records that certified applicators need to keep
- May give fines of up to $25,000 and jail sentences of up to 1 year for misapplication of pesticides and violation of FIFRA standards
- Provides for the registration of pesticides or the cancellation of a registration
- Provides worker protection standards.

I.1.2 Comprehensive Environmental Response, Compensation, and Liability Act

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is the primary federal regulation dealing with past releases of hazardous substances, which may include pesticides. The key points of CERCLA include:

- Regulates methods of cleaning up recent and past spills of hazardous substances
- Defines the time period within which the Environmental Protection Agency (EPA) and other agencies must be notified of current spills of hazardous substances

- Uses reportable quantities (RQs) of hazardous substances to decide when federal and state agencies should be notified of spills

- Specifies federal Natural Resource Trustees.

I.1.3 Superfund Amendments and Reauthorization Act of 1986, also known as the Emergency Planning and Community Right-To-Know Act:

Superfund Amendments and Reauthorization Act (SARA) is also referred to as the Emergency Planning and Community Right-To-Know Act (EPCRA). The primary focus of SARA is on emergency planning and Community Right-to-Know provisions, as discussed below.

- Sets up state Emergency Response Commissions and local emergency planning committees

- Requires industrial facilities to provide written plans to describe what they would do in the event of a "chemical emergency"

- Requires an annual inventory of all chemicals on site when certain amounts are exceeded (generally 10,000 pounds unless classified as an extremely hazardous substance and then reporting quantity is lower and is chemical-specific)

- Must provide the state Emergency Response Commissions, local emergency planning, and the local fire department with names and quantities of hazardous substances stored.

I.1.4 Occupational Safety and Health Administration Hazard Communication Standard

Occupational Safety and Health Administration (OSHA) was developed to protect the safety of workers. The main points of OSHA are as follows:

- Requires workers be provided with a Material Safety Data Sheet (MSDS) for all hazardous materials, including pesticides

- Requires training for workers on the hazards of the materials handled

- Provides information to workers on how to protect themselves and what to do during emergencies such as hazardous substance spills and fires, including notification requirements.

I.1.5 Hazardous Materials Transportation Act

The Hazardous Materials Regulations of the Department of Transportation (DOT) govern all persons involved with hazardous materials in commerce including container and packaging manufacturers; shippers; forwarders; and carriers by rail, air, water vessel, and highway. The main requirements for shipping include:

- Placards and shipping papers for shipping certain quantities of hazardous materials
- Reporting of transportation accidents involving hazardous chemicals
- Training of commercial driver and workers who unload hazardous chemicals.

I.1.6 Federal Noxious Weed Act of 1974:

This Act was passed to protect livestock and other plant resources from weeds that possess one or more of the following qualities: aggressive competition with cultivated crops, toxicity, livestock, or habitat degradation. Following are the key requirements mandated in this Act.

- Defines a noxious weed as any living state of a plant that can directly or indirectly injure crops; other useful plants, livestock, or poultry; or other interests of agriculture including irrigation, navigation, or the fish and wildlife resources of the United States or the public health
- Regulates the sale, purchase, and transportation of noxious weeds into or through the United States
- Regulates the inspection and quarantine of areas suspected of infestation and provides for the disposal or destruction of infested products, articles, means of conveyance, or noxious weeds
- May give fines of up to $5,000 and/or imprisonment for up to 1 year for violation of this regulation
- Requires federal agencies to work with the state and local agencies to develop and implement noxious weed management programs on federal lands.

I.1.7 The Endangered Species Act

This Act was developed to protect species that are endangered to prevent extinction. The key points of the Act follow.

- Protects listed plants and animals that are threatened by habitat destruction, pollution, overharvesting, disease, predation, or other natural or man-made factors
- Stipulates that listed species cannot be possessed, taken, or transported without special permission. All federal agencies must ensure that their activities do not jeopardize a listed species or its critical habitat
- Provides for review of pesticide formulations, and their application methods and rates to determine if pesticide use may have potential adverse effects on listed species or their critical habitats.

I.1.8 Pollution Prevention Act of 1990

The objective of this legislature was to shift the focus from management of wastes generated by an industrial process (i.e., end-of-pipe) to elimination or reducing the waste prior to initiating the industrial process (i.e., source control). The Act established a pollution prevention hierarchy as a national policy, declaring that:

- Pollution should be prevented or reduced at the source whenever possible.
- Pollution that cannot be prevented should be recycled whenever feasible and in an environmentally safe manner.
- Pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible.
- Disposal or other release into the environment should be employed only as a last resort and should be conducted in a manner that is safe to the environment.

Further, the Pollution Prevention Act of 1990 directs the U.S. EPA to:

- Promote source reduction practices in other federal agencies (including DoD)
- Identify opportunities to use federal procurement to encourage source reduction.

In addition, the U.S. EPA Fiscal Year (FY) 1991 Appropriation Act requires the U.S. EPA to develop and implement a pollution prevention strategy for the federal government, thus establishing the federal government as the national leader in implementation of pollution prevention policies.

I.2 DEPARTMENT OF DEFENSE POLICY

I.2.1 Executive Order 12856 - Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements

This Executive Order (EO) signed by President Clinton in August 1993, requires each federal agency to develop a written pollution prevention strategy to achieve the following requirements:

- **Toxic Chemical Reduction Goals** - Each federal agency must reduce the total amount of toxic chemicals released to the environment or transferred off site (i.e., recycled, treated, or disposed of) by 50 percent by 31 December 1999.
- **Acquisition and Procurement** - Each federal agency shall develop a plan and establish goals for the reduction/elimination of extremely hazardous substances.
- **Toxics Release Inventory/Pollution Prevention Act Reporting** - Each federal agency shall comply with the provisions of Section 313 - Toxic Chemical Release Reporting of EPCRA. The reports for calendar year 1994 are due on or before 1 July 1995.
- **Emergency Planning and Community Right-to-Know Report** - Each federal agency shall comply with EPCRA requirements for Emergency Planning, Emergency Release Reporting, Hazardous Chemical Inventory Reporting, and Annual Hazardous Chemical Release Reporting.

I.2.2 Department of Defense Instruction 4150.7 - Pest Management Program

DoD Instruction (DODI) 4150.7 states that it is DoD policy to establish and maintain safe, effective, and environmentally sound integrated pest management (PM) programs to prevent or control pests and disease vectors that may adversely impact readiness or military operations by affecting the health of personnel or damaging structures, materiel, or property. It sets the Measures of Merit (MOM) for installation pest management, which are as follows:

- **Installation Pest Management Plans** - all DoD installations will have a Pest Management Plan prepared, reviewed, and updated annually by the end of FY 1997.

- **Annual Amount of Pesticide Applied** - by the end of FY 2000, DoD installations will reduce the amount of pesticides applied annually by 50 percent from the FY 1993 baseline in lb. of active ingredients.

- **Installation Pesticide Applicator Certification** - by the end of FY 1998, all DoD installation pesticide applicators will be properly certified within 2 years of employment.

I.2.3 Air Force Policy Directive 32-70 - Environmental Quality

Air Force Policy Directive **(**AFPD) 32-70 established Air Force policy for maintaining environmental standards applicable to all Air Force operations, cleaning up sites of contamination resulting from past Air Force activities, planning and initiating future activities to minimize impacts to the environment, and eliminating pollution from Air Force activities whenever possible. Air Force commanders are responsible for compliance with national and Air Force environmental policy. To achieve environmental quality, the Air Force will develop and implement a program based on:

- Cleanup

- Compliance

- Conservation

- Pollution prevention.

I.2.4 Air Force Instruction 32-1053 - Pest Management Program

Air Force Instruction (AFI) 32-1053 provides guidance on pest management with an emphasis on impacts to the environment. This AFI discusses procedures and identifies responsibilities for pest management programs at Air Force installations and other operation locations under Air Force control. The content of this AFI are consistent with the applicable/pertinent environmental requirements of the U.S. EPA, OSHA, and the Air Force Occupational Safety and Health (AFOSH) standards. Procedures provided under this AFI include:

- Cooperation with Civilian Pest Management Projects
- Identifying Pests
- Good Housekeeping Practices
- Personnel Protective Clothing
- Managing Pesticides and Equipment
- Managing Pest Control Vehicles
- Contracting for Pest Management Services.

I.2.5 Air Force Instruction 32-7080 - Pollution Prevention Program

The guidance and procedures identified in this AFI are intended to provide the framework for complying with AFPD 32-70. AFI 32-7080 identifies the Air Forces' "hierarchy of actions" to achieve pollution prevention:

- **Source Reduction** - to reduce/eliminate use of hazardous materials and reduce waste streams
- **Recycling** - reuse or recycle generated wastes
- **End-of-Pipe Treatment** - treatment of generated wastes.

AFI 32-7080 also provides a framework and guidelines for development and implementation of a Pollution Prevention Management Plan, including management strategies for the following programs:

- Ozone Depleting Chemicals
- EPA 17 Industrial Toxics
- Hazardous Wastes
- Municipal Solid Wastes
- Affirmative Procurement of Environmentally Friendly Products
- Energy Conservation
- Air and Water Pollutant Reduction.

APPENDIX J

ALTERNATIVES IN DEVELOPMENT/TESTING STAGES

THIS PAGE INTENTIONALLY LEFT BLANK

ALTERNATIVES IN DEVELOPMENT/TESTING STAGES

Several alternatives were identified during the course of preparing this plan that are currently under testing or development. Although not currently available on the market, they appear promising, and should be available within the next 1 to 3 years. It is recommended that base pest management personnel keep abreast of those products that may be applicable to their specific pest management practices and suitable for use in their areas. Information is provided below for some of these promising new products.

Japanese Beetles

Use of biological controls for Japanese beetles (natural predators). At Purdue University, research is being conducted in the use of the tachinid fly as a parasite on adult Japanese beetles. Recent studies have shown that this fly, a naturally occurring parasite found in the northeastern states, acts as a parasite to the Japanese beetle by feeding on its internal organs. The researcher has received permission to bring the fly to Illinois for research purposes, but the study has not gone further. This may be considered a viable method in future years. In addition, two species of wasps have been identified as Japanese beetle parasites, but they may not be effective in all areas where Japanese beetles are found.

Dr. Corey Gerber
Purdue University
Entomology Department
(317) 494-0868

Use of *Bacillus thuringiensis* for Japanese beetles. *Bacillus thuringiensis* (BT) is used as a microbial insecticide for control of caterpillars and mosquito larvae. Mycogen Corporation has developed a new strain of BT that is effective against Japanese beetles. This new strain is currently under research and is expected to be released for public use by early 1997. Although not yet on the market for Japanese beetle grub control, its potential as a reliable control source for grubs appears promising. Mycogen Corporation has been testing its product for 2 years. The test results indicate a 95-percent control rate for grubs. The timing of the application of BT is critical in its success; BT will be successful only if applied when the larvae are quite small, generally in the first two life stages. If applied too late, BT will not be effective and a chemical control will be necessary. As with the milky spore, BT may not be suitable for use on golf courses because the fungicides applied may kill the bacillus.

Dr. Jerry Feitelson
Dr. Paul Zorner
Mycogen Corporation
(619) 453-8030

Dr. Dave Shetlar
Ohio State University
(614) 292-5274

Termites

Nematodes. The use of infective nematodes as a termite control measure for active termite infestations has been evaluated. Nematodes are applied to the soil or directly into termite mud tubes that multiply and disperse to kill the majority of the termite colony. Nematodes are not recommended as a preventative termite control measure because they will eventually disperse from the area in search of other host insects. Laboratory tests have shown high levels of termite mortality following application of nematodes; however, field tests have failed to demonstrate the same success rate. Variables such as nematode strain, nematode integrity after shipment, and micro-habitats such as temperature, soil type, soil moisture, and season may affect the success of termite control. Further research may eventually improve the success of applying nematodes as a termite control measure. For additional information:

George Poinar
Department of Entomology Sciences
University of California, Berkeley

Electrocution. A hand-held unit that delivers high-voltage and high-frequency electrical energy to targeted wood has been developed as a spot treatment for control of drywood termites. During application, an electrical charge is applied by slowly sweeping the instrument over infested wood. Moist termite bodies and galleries serve as conductors, attracting the passing current. Most termites are killed instantly by electric shock but, in some cases, live termites have been found after treatment; however, those survivors also die within a short period of time. The device's design guards against electrocution of the operator and structural damage. The low current does not raise the temperature of the wood to the point of burning or ignition. As with all localized treatments, infestations must be accurately identified within a structure to completely eradicate the infestation. This procedure is currently available in several states; however, field effectiveness has not yet been evaluated. For additional information:

Phil Holt
Etex, Ltd.
Las Vegas, Nevada

Dog inspection teams. Several companies train beagles to survey in and around structures to identify sites of live wood-destroying organisms. Human handlers relay information from the dogs' responses to pest controllers. The dogs are conditioned from an early age, and react to a combination of odor and acoustical stimuli. Proponents contend that the dogs can precisely locate areas of active infestations, even in inaccessible areas such as crawl spaces. The service can be applied as an initial inspection or as a call back or verification to ensure the infestation is controlled. Only one study of the effectiveness of the dogs has been conducted. Results indicate considerable variance in accuracy of individual dogs, especially at low termite densities. However, on average, the dogs identified the infestation correctly 83 percent of the time. Field studies to determine the effectiveness of the dogs have not yet been conducted. For additional information:

Robert Outman
TADD Services Corporation
1617 Old County Road
Belmont, California 94002
1 (800) 345-TADD

Fungus

Low-AI fungicide. A new chemical fungicide is undergoing tests on various forms of turf fungus. The new chemical is manufactured by the Zenica Corporation under the name Heritage®. Heritage® has a very low percent active ingredient with an application rate of 4 to 6 ounces per acre and a 21- to 28-day control period. Therefore, it would require monthly applications during periods of fungus activity. No printed literature is available to date because it has not yet been approved for use by the EPA; however, registration with the EPA is expected by the end of 1996. For additional information:

Zenica Corporation

Agricultural Products Division
Wilmington, Delaware
(302) 886-3000

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX K

CONSTRUCTION PRACTICES

THIS PAGE INTENTIONALLY LEFT BLANK

CONSTRUCTION PRACTICES

The primary focus of this Model Pesticide Reduction Plan is to recognize and evaluate opportunities to adjust current practices to reduce the amount of AI used in pest management activities. Several measures were identified that would be very expensive to implement for existing facilities, but would be reasonable to implement as part of new facility construction to minimize pesticide use in the future. These measures are presented below for informational purposes.

Installation of a geotextile weed barrier or Biobarrier® beneath substations and storage yards. The use of geotextile weed barriers or Biobarrier®, which is a geotextile impregnated with herbicides nodules, is being tested by some utility companies. This option was discussed with several utility representatives (Roybal, personal communication; Steigerwalt, personal communication) and it may be a viable option for new construction, but not for existing facilities. It is not considered economically feasible or technically practicable to scrape off existing gravel and base, and then lay a Biobarrier® base. There is some question as to whether Biobarrier® would prevent weed growth in the gravel above the barrier at new facilities (from soil and seeds carried by the wind), and the test plots have not yet proven effective use of this barrier to date. For more information, contact:

ReeMay, Inc.
70 Old Hickory Boulevard
P.O. Box 511
Old Hickory, Tennessee 37138
(800) 257-6687

Create a mow strip or mulch strip along fence lines and mow pads around fixtures (e.g., traffic and directional signs, poles, airfield lighting). Creating a mow strip, either with concrete or with mulch, would be very costly for existing fence lines. For new construction, however, a concrete strip could be easily poured (or a mulch strip created) before placement of the fence. This would allow a nonvegetated area in which mowing equipment could turn without leaving a "fringe" near the fence. Similarly, concrete or asphalt mow pads can be created when installing signs, poles, and lighting fixtures, such as airfield lighting, to help eliminate fringe areas that mowers cannot reach. The mulch strip could require yearly mulch applications to keep weeds from growing in any decomposed mulch. A concrete mow strip may be considered unsightly in some areas.

Particle-size barriers. The use of untreated sand as a physical barrier to prevent termite entry into a structure is currently under evaluation. The barrier consists of specific particle sizes that are impenetrable to subterranean termites. The particle size is such that the large particles are too big for termites to be mobile, and the smaller particles between the larger particles prevent termites from crawling through the gaps. Particle-size barriers are primarily a preventative treatment for use prior to construction, but they have been installed as a remedial treatment. In crawl spaces, a 4-inch thick, 23-inch wide layer of sand is placed next to the interior of the structure foundation and around supports. In addition, a soil-drench termiticide is applied around the exterior of the structure. Structures on slabs or structures having a basement are not candidates for this treatment. Initial results indicate that the use of particle-size barriers is as effective as chemical treatments; however, long-term effects of disturbance from ant and wind and water erosion are uncertain. Initial cost estimates to install a particle-size barrier is $6.00 per linear foot with an initial capital investment of approximately $15,000 for equipment and training. For additional information:

Doug Carver
Live Oak Structural
Berkeley, California
(510) 524-7101

Termite mesh. A physical barrier known as termite mesh may be installed as both a pre- or post-construction termite control measure for subterranean termites. The mesh consists of a stainless steel wire mesh placed around support columns. Termite mesh has not been found to be entirely effective and is somewhat costly to install. Termites have been able to avoid the mesh barrier. In addition, there are chemical and bait technologies on the market that are more effective and less costly. For additional information:

Michael Rust
Department of Entomology
University of California, Riverside
Riverside, California 92521
(909) 787-5831

Boric acid. Boric acid and borate solutions have been found to be effective against both cockroaches and termites. For cockroaches, boric acid can be applied as a fine dust that is available to homeowners in retail over-the-counter markets. The dust may be applied between wall board as a preconstruction control measure or applied into voids, cracks, and other cockroach harborages. If during a renovation, a wall is being refinished, boric acid powder can be injected into the wall through holes that will be covered when the wall is refinished. Boric acid has long residual effectiveness and has a very low repellency to cockroaches. Repellency is an important factor in that if a cockroach is not repelled from the bait (boric acid) it will continue to travel through those areas acquiring the solution. Atmospheric moisture does not adversely affect the insecticidal effectiveness of boric acid; in fact, a water-saturated atmosphere actually improves performance. Up to 95-percent control with boric acid has been documented; however, this was with a 33-percent boric acid solution. A lower percent solution may decrease the effectiveness. This method of cockroach control has an extremely low human exposure to pesticides.

For termites, the use of borates in preventative and remedial control is a relatively new technology. There are three registered products currently available that use disodium octaborate tetrahydrate as an active ingredient: TimBor®, Bora-Care®, and Impel Rods®. The objective of borate applications is to have the material penetrate into wood for local control of termites. Borate solution can be applied to the wood either through surface coating or pressure injection prior to construction or installing drywall to prevent infestations. Borates will come out of the wood only when water flows over treated areas for extended periods; therefore, sealers are recommended for exterior use. Borate treatments are difficult in slab structures with sealed walls or hidden sill plates. Preferred locations for borate treatments are areas allowing access to large expanses of wood such as crawl spaces, attics, and unfinished basements or garages. The greater the number of wood surfaces treated, the more rapid the expected control of active infestations and the greater probability of preventing new activity. Multiple applications are recommended to enhance penetration toward the center of the wood and effectiveness of termite control. For additional information:

Michael Rust
Department of Entomology
University of California, Riverside
Riverside, California 92521
(909) 787-5831

Weed- and insect-resistant vegetation. In selecting the ground cover for new construction areas, consideration should be given to planting cultivars that are more weed resistant or more resistant to insect infestation. For example, often Kentucky bluegrass itself is not very resistant. Adding in fescue or planting a ryegrass/fescue mix can help. The local extension service staff can be of assistance in selecting the appropriate mix for the specific site conditions and the appearance desired. For additional information:

Local USDA Extension Service or
State Extension Personnel (see listing in Appendix L)

Soil sterilant under gravel or pavement. Many herbicide labels include instructions for use of the product under paved surfaces or in an asphalt mix. The presence of the herbicide delays or prevents weed growth from the start. For example, the labels for Arsenal® and OUST® describe uses under paved surfaces. The area should be properly prepared and all vegetative plant parts should first be removed. Paving should follow herbicide application as soon as possible. Care must be taken to avoid areas with nearby desirable plants or trees, especially if tree roots extend under the area to be paved. Generally, the labels do not recommend this practice in residential and recreational areas. For additional information, contact manufacturer or regional representative for specific herbicides, e.g.,

Arsenal®:	American Cyanamid (800) 545-9525
OUST®:	(800) 432-7671

Divert runoff to control growth of aquatic weeds in retention ponds. Aquatic weeds require nutrients to grow; therefore, placement of retention ponds relative to nutrient sources has an impact on aquatic weed populations. Because of this relationship, it would be beneficial to determine sources of upgradient runoff that may contain high percentages of nutrients before constructing a water-holding body. For instance, water bodies should not be located downgradient of areas in which large amounts of fertilizers are applied. Also, water bodies should not be located downgradient of sanitary waste sources, such as leach fields. An additional control method is to instruct employees on the relationship between pesticide application upgradient of water sources and the subsequent growth of aquatic weeds resulting from such applications. Such growth can be reduced if nutrients are applied in the exact amounts required, and over-fertilization is eliminated. For more information, contact the USDA. Cooperative Extension Service in your area. Also:

D. D. Thayer et al., Weed Control in Aquaculture and Farm Ponds,
Florida Cooperative Extension, Circular 707

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX L

SOURCES OF INFORMATION

THIS PAGE INTENTIONALLY LEFT BLANK

SOURCES OF INFORMATION

U.S. ENVIRONMENTAL PROTECTION AGENCY

EPA Office of Pesticide Programs
Kennon Garvey
(703)305-7106
FAX (703) 305-6244

EPA Biopesticides and Pollution Prevention Division
(703) 308-8712

DEPARTMENT OF DEFENSE

DoD Pesticide Hotline
U.S. Army Center for Health Promotion and Preventive Medicine
Entomological Sciences Programs
Aberdeen Proving Ground, Maryland 21010-5422
(410) 671-3613

Armed Forces Pest Management Board
Col. Robert McKenna
Forest Glen Section, WRAMC
Washington, DC 20307-5001
(301) 295-7476 DSN 295-7476
FAX (301) 295-7473 DSN 295-7473

AIR FORCE

Air Force Civil Engineer Support Agency
Wayne Fordham
139 Barnes Drive, Suite 1
Tyndall AFB, Florida 32403-5319
(904) 283-6465 DSN 523-6465
FAX (904) 283-6219 DSN 523-6219

PRO-ACT (A Free Air Force Environmental Information Service)
AFCEE/EP
Pollution Prevention Directorate
3207 North Road (Bldg 523)
Brooks AFB TX 78235-5363
Phone: (210)536-4214
DSN 240-4214
Fax: (210) 536-4254
DSN Fax: 240-4254
Internet E-mail: proact@osiris.cso.uiuc.edu
Wang E-mail: PRO-ACT

MAJCOM ENTOMOLOGISTS

HQ ACC/CEOO
ATTN: Mr. Teig
129 Andrews Street, Suite 102
Langley AFB, Virginia 23665-2769
(804) 764-2766

HQ AFMC/CEVC
ATTN: Mr. Cornelius
4225 Logistics Ave, Suite 8
Wright-Patterson AFB, Ohio 45433-5739
(513) 257-5878/5879

HQ PACAF/CEVP
ATTN: Mr. Buckman
25 E Street, Suite D-306
Hickam AFB, Hawaii 96853-5412
DSN 449-9695

HQ AFSPC/CEVC
ATTN: Mr. Rowland
150 Vandenberg Street, Suite 1105
Peterson AFB, Colorado 80914-4150
DSN 696-9915

HQ AMC/CEVC
ATTN: Maj. Holck
507 A Street
Scott AFB, Illinois 62225-5022
(618) 256-5763

HQ ANG/CEVP
ATTN: Ms. Richerson
3500 Fetchet Avenue
Andrews AFB, Maryland 20762-5157
DSN 278-8798

HQ AETC/CEVC
ATTN: Mr. Lahser
226 F Street West
Randolph AFB, Texas 78150-4321
(210) 652-3959

HQ USAFE/CEVC
ATTN: Capt. Meigiian
Unit 3050 Box 10
APO AE 09094-5010
DSN 480-6480

GOLF COURSE ASSOCIATIONS

W.A. Gebhart
Code 1333
Naval Facilities Engineering Command
200 Stovall Street
Alexandria, Virginia 22330-2300
(703) 325-2480

The United States Golf Association Golf House
P.O. Box 708
Far Hills, New Jersey 07931-0708
(908) 234-2300

Golf Course Superintendents
Association of America
(800) 472-7878

USGA GREEN SECTION OFFICES

Northeastern Region
(CT, MA, ME, NH, NY, RI, VT)
P. O. Box 4717
Easton, Pennsylvania 18043
(610) 515-1660
(or)
500 North Main Street
Palmer, Massachusetts 01069
(413) 283-2237

Mid-Atlantic Region
(DE, MD, NJ, PA, VA)
P.O. Box 2105
West Chester, Pennsylvania 19380
(610) 696-4747

Southeastern Region
(AL, GA, MS, NC, SC, TN)
P.O. Box 95
Griffin, Georgia 30224
(404 229-8125
(or)
4770 Sandpiper Lane
Birmingham, Alabama 35244
(205) 444-5079

State of Florida Region
(FL)
P.O. Box 1087
Hobe Sound, Florida 33475-1087
(407) 546-2620

North-Central Region
(IN, KY, MI, MN, MT, ND, OH, SD, WI, WV)
P.O. Box 15249
Covington, Kentucky 41015-0249
(606) 356-3272
(or)
11431 North Port Washington Road, Suite 203
Mequon, Wisconsin 53092
(414) 241-8742

Mid-Continent Region
(AR, IL, IA, KS, LA, MO, NE, NM, OK, TX)
720 Wooded Crest
Waco, Texas 76712
(817) 776-0765
(or)
P.O. Box 1130
Mahomet, Illinois 61853
(217) 586-2490

Western Region
(AK, AZ, CA, CO, HI, ID, NV, OR, UT, WA, WY)
5610 West Old Stump Drive NW
Gig Harbor, Washington 98332
(206) 858-2266
(or)
22792 Centre Drive, Suite 290
Lake Forest, California 92630
(714) 457-9464

STATE EXTENSION SERVICES

Auburn University
203 Extension Hall
Auburn, Alabama 36849
Talmadge Balch
Pesticide Education Specialist
(205) 844-6390

Cooperative Extension Service
2221 E. Northern Lights Boulevard #240
Anchorage, Alaska 99508
Wayne Vandre, Horticulture Specialist, Pesticide Coordinator
(907) 279-6575

University of Arizona
1109 E. Helen Street
Tucson, Arizona 85719
Paul Baker, Pesticide Coordinator
Gary Cramer, Assistant in Extension Pesticide Training
(602) 621-4012

Cooperative Extension Service
P.O. Box 391
Little Rock, Arkansas 72203
Ples Spradley
(501) 373-2640

University of California

Davis, California 95616
Michael W. Stimmann, Statewide Pesticide Coordinator
Cooperative Extension
OPIC
(916) 752-7011

Patrick Marer, Pesticide Training Coordinator
IPM Education and Publications
(916) 752-9336

Colorado State University
116 Weed Science Building
Fort Collins, Colorado 80523
Bert L. Bohomont, Coordinator, Pesticide Programs
(303) 491-5237

Cooperative Extension Service
1800 Asylum Avenue
West Hartford, Connecticut 06117
Candace L. Bartholomew, Pesticide Coordinator
(203) 241-4940

University of Delaware
Townsend Hall/Room 254
Newark, Delaware 19711-1303
Susan Whitney, Pesticide Coordinator
(302) 451-2526

Cooperative Extension Service
University of D.C.
901 Newton Street, NE
Washington, DC 20017
M. Shaheed Khan, Coordinator
(202) 576-7419

University of Florida
Building 847
Gainesville, Florida 32611
O. Norman Nesheim, Pesticide Coordinator
(904) 392-4721

Cooperative Extension Service
Barrow Hall
University of Georgia
Athens, Georgia 30602
Burton R. Evans, Coordinator, PAT
(404) 542-3685
College of Agriculture
University of Guam

Mangilao, Guam 96923
Lee S. Yudin, Pesticide Coordinator
(011 671) 734-2518

Department of Agriculture Biochemistry
University of Hawaii
1800 East-West Road
Honolulu, Hawaii 96822
Barry M. Brennan, Extension Specialist-Pesticide Chemicals
Charles Nagamine, Assistant Coordinator
Alan Higashi, Assistant Coordinator
(808) 948-8352

Department of Plant, Soil & Entomology Sciences
University of Idaho
Moscow, Idaho 83843
Gene Carpenter, Pesticide Coordinator
(208) 885-7541
Hugh W. Homan, Pesticide Applicator, Training Coordinator
(208) 885-7542

University of Illinois
360-L Agriculture Engineering Science Building
1304 W. Pennsylvania Avenue
Urbana, Illinois 61801
Loren Bode
(217) 333-3000

University of Illinois
172 Natural Resources Building
607 E. Peabody Drive
Champaign, Illinois 61820
Phillip Nixon, Assistant Pesticide Coordinator
(217) 333-6650

Purdue Pesticide Programs
Room G316
Lilly Hall of Life Sciences
West Lafayette, Indiana 47907
Thomas N. Jordan, Pesticide Coordinator
(317) 494-4566

Iowa State University
109 Insectary Building
Ames, Iowa 50011
Wendy Wintersteen, Extension Entomologist
Pest Applicator Training Coordinator
(515) 294-1101

Department of Entomology
Waters Hall
Kansas State University
Manhattan, Kansas 66506
Donald C. Cress, Extension Pesticide Coordinator
(913) 532-5891

University of Kentucky
Department of Entomology
S225 Ag. Science Center N
Lexington, Kentucky 40546-0091
Lee Townsend, Coordinator, PAT
(606) 257-7455

Cooperative Extension Service
Knapp Hall
Louisiana State University
Baton Rogue, Louisiana 70803
Mary L. Grodner, Pesticide Chemical Coordinator
(504) 388-3180

UMCES - Pest Management Office
491 College Avenue
Orono, Maine 04473
Dr. James F. Dill, Pest Management Specialist
(207) 581-3879

Department of Entomology
University of Maryland
College Park, Maryland 20742
Amy E. Brown, Pesticide Coordinator
(301) 405-3928

Department of Entomology
Fernald Hall
University of Massachusetts
Amherst, Massachusetts 01003
Natalia P. Clifton, Extension Specialist
(413) 545-2283

Michigan State University
Room 11 Agriculture Hall
East Lansing, Michigan 48824-1039
Larry G. Olson, Pesticide Education Coordinator
Joy Landis, Assistant Coordinator
(517) 355-0117

Plant Pathology Department
495 Borlaug Hall
1991 Buford Circle
University of Minnesota
St. Paul, Minnesota 55108
Richard A. Meronuck, Coordinator
(612) 625-6290
Dean Herzfeld, Assistant Extension Agriculturist
(612) 625-6290

Cooperative Extension Service
Mississippi State University
P.O. Box 5446
Mississippi State, Mississippi 39762
Ruth Morgan, Pesticide Coordinator
(601) 325-2085

University of Missouri
I-87 Agriculture Building
Columbia, Missouri 65211
Darryl Sanders, PAT
(314) 882-7181

Entomology Research Laboratory
Montana State University
Bozeman, Montana 59717
Gregory D. Johnson, Pesticide Education Specialist
(406) 994-3518

University of Nebraska
101 Natural Resources Hall
Lincoln, Nebraska 68583-0818
Larry D. Schulze, Extension Pesticide Coordinator
(402) 472-1632
Edward F. Vitzhum, Associate Coordinator
Environmental Programs
(402) 472-1446

Plant Science Department
University of Nevada-Reno
Reno, Nevada 89557-0107
Clyde Sorenson, Extension IPM/Pesticide Specialist
(702) 784-6911

University of New Hampshire
Nesmith Hall
Durham, New Hampshire 03824
Stanley R. Swier, Pesticide Coordinator
(603) 862-1159

Rutgers University
J.B. Smith Hall, Room 108
P.O. Box 231
New Brunswick, New Jersey 08903
George C. Hamilton, Extension Pesticide Coordinator
(201) 932-9801

Pesticide Chemicals & Entomology
Box 3AE
New Mexico State University
Las Cruces, New Mexico 88003
L. Michael English, Coordinator
(505) 646-2546

Cornell University
5123 Comstock Hall
Ithaca, New York 14853
Donald A. Rutz, Director, Chemicals-Pesticides Program
Ronald D. Gardner, Assistant Coordinator
W.G. Smith, Associate Coordinator
(607) 255-3283

Department of Horticultural Science
North Carolina State University
Box 7609
Raleigh, North Carolina 27695
John H. Wilson, Jr., Pesticide Coordinator
(919) 737-3113

Department of Horticulture
North Dakota State University
P.O. Box 5658
Fargo, North Dakota 58105
Gregory K. Dahl, Pesticide Program Coordinator
NDSU Pesticide Programs
(701) 237-7180

Ohio State University

1991 Kenny Road
Columbus, Ohio 43210
Acie C. Waldron, Pesticide Coordinator
Extension Entomology
Joanne Kick-Raack, Training Specialist
(614) 292-7541

Department of Entomology
Oklahoma State University
501 Life Science West
Stillwater, Oklahoma 74078
Jim T. Criswell, Pesticide Coordinator
Pesticide Program Specialist
(405) 744-5531

Department of Agricultural Chemistry
Oregon State University
Corvallis, Oregon 97331
Terry L. Miller, Coordinator
Pesticide Applicator Training
(503) 737-1811

Pennsylvania State University
University Park, Pennsylvania 16802
Winand K. Hock, Pesticide Coordinator
113 Buckhout Lab
Kerry Hoffman
116 Buckhout Lab

Scott A. Harrison
Pesticide Education Specialist
115 Buckhout Lab
(814) 863-0263

College of Agricultural Sciences
Mayaguez Campus
University of Puerto Rico
Mayaguez, Puerto Rico 00708
Hipolito O'Farrill-Nieves, State Pesticide Training Coordinator
(809) 832-4040

University of Rhode Island
Plant Science Department
Woodward Hall
Kingston, Rhode Island 02881
Steven Alm, Pesticide Coordinator
(401) 792-5998
Clemson University
Department of Entomology

103 Long Hall
Clemson, South Carolina 29634
Paul MacHorton, Pesticide & Chemical Coordinator
(803) 656-3111
Bob Bellinger, Pesticide Information Specialist
(803) 656-5042

South Dakota State University
Agriculture Hall, 152B
P.O. Box 2207A
Brookings, South Dakota 57007
Jim Wilson, Coordinator, PAT
(605) 688-4752

University of Tennessee
Entomology & Plant Pathology Section
P.O. Box 1071
Knoxville, Tennessee 37902
Gene Burgess, Pesticide Coordinator
(615) 974-7137

Texas A & M University
115 Agronomy Field Laboratory
College Station, Texas 77843
Rodney Hollaway, Agriculture Chemist
(409) 845-3849

Utah State University
Logan, Utah 84322
Howard M. Deer, Extension Pesticide Coordinator
(801) 750-1600

University of Vermont
217 Hills Building
Burlington, Vermont 05405
Gordon R. Nielson, Coordinator
Pesticide Chemicals
(802) 656-0487

Virginia Polytechnic Institute & State University
Blacksburg, Virginia 24061
Michael J. Weaver, Coordinator

Patricia A. Hipkins, Assistant Coordinator
Chemical, Drug & Pesticide Unit
(703) 231-6543
UNI, CES
Route 02, Box 10,000 Kingshill
St. Croix, Virgin Islands 00850

K. Olesee Davis, Extension Specialist
(809) 788-0246

Washington State University
7612 Pioneer Way East
Pullman, Washington 98371
Gary L. Thomasson, Extension Pesticide Education Specialist
Carol Ramsay, Assistant Coordinator
(206) 840-4577

West Virginia University
404 Brooks Hall
Morgantown, West Virginia 26506
Jack Baniecki
Pesticide Coordinator
(304) 293-3911

University of Wisconsin
1575 Linden Drive
Madison, Wisconsin 53706
Ronald E. Doersch, Coordinator
(608) 262-1392
Roger Flashinski, Specialist
(608) 263-6358

Department of Plant, Soil & Insect Science
University of Wyoming
Box 3354
Laramie, Wyoming 82070
Mark A. Ferrell, Extension Pesticide Coordinator
(307) 766-5381

USDA Extension Service
Room: 3347 - South Building
Washington, DC 20250
Bonnie L. Poli, Program Leader
Pesticide Education
(202) 447-6506

Regional Advisors

North Central
Iowa Cooperative Extension Service
108 Curtiss Hall
Iowa State University
Ames, Iowa 50011
Jerry DeWitt, Associate Dean
(515) 294-7801

Southern
Clemson University
108 Long Hall
Clemson, South Carolina 29634
Dr. Elwin Deal, Assistant Director ANR
(803) 656-3384

Northeast
University of Delaware
127 Townsend Hall
Newark, Delaware 19717
Dave Woodward, Agriculture Program Leader

MISCELLANEOUS

Bio-Integal Resource Center (BIRC)
Berkeley, California
(510) 524-2567
FAX (510) 524-1758

Center for Integrated Pest Management
Cooperative State Research, Education, and Extension Service (CSREES)
(202) 720-6583

Florida A&M University
Mosquito Research Laboratory
Panama City, Florida 32405-1933
(904) 872-4184
(also check other mosquito control centers/districts in your area)

INTERNET SOURCES OF PESTICIDE INFORMATION

Generally, the Internet site for the state's extension service, located at its Land Grant University, is an excellent source for state-specific information on weed and other pest control, pesticides, and nonchemical control options. To find these sites, first locate the university's main or home page (i.e., search for the name of the university). Then look for entries that include "extension" or "extension service," and follow any menus provided to access the pertinent information. Some universities (e.g., Purdue) support more regional and general information on Integrated Pest Management (IPM) and other pest-related topics.

Ohio State University Extension Information
http://www.ag.ohio-state.edu/”ohioline
For weed information:
http://www.ag.ohio-state.edu/’ohioline/lines/hygs.html//WEEDS

Oregon State Extension (Contains EXTOXNET with good chemical profiles used by EPA National Pesticide Telecommunication Network (1-800-858-7378)
http://www.ors.ofst.edu

Florida Agricultural Information Retrieval Systems (FAIRS)
http://hammock.ifas.ufl.edu/

IPM Network
http://ipm_www.ncsu.edu

Biological Control Virtual Information Center
http://impwww.ncsu.deu/biocontrol/biocontrol.html

National IPM Materials Database
http://info.aes.purdu.edu/ipmdb.html

National Agricultural Pest Information System (NAPIS)
http://ceris.purdue.edu/napis

Cooperative Agricultural Pest Survey (CAPS)
http://www.ceris.purdue.edu/napis/caps/index.html

Federal Agency Databases

USDA Research Database
http://os.gdb.org/best/fedfund/usda/usda-intro.html

National Agricultural Library, Alternative Farming Systems Information Center
gopher://gopher.nalusda.gov/11/infocntr

Food and Drug Administration, Food additives, Pesticides, and chemical Contaminants
http://vm.cfsan.fda.gov/-lrd/foodadd.html

State and Cooperative Extension Services
http://cos.esusda.gov (may be down, unable to connect 6/96)

Army entomology home page
http://chppm-www.apgea.army.mil/ento/index.htm

Armed Forces Pest Management Board
http://www-afpmb.acq.osd.mil

Other Databases

FAQ - The Water (info in testing your water for pesticides)
http://wwwsiouxlan.com/water/faq.html

United Nations Commission on Sustainable Development
gopher://gopher.undp.org/1/ecosocdocs/csd

International Fund for Agriculture Development
http://www.unicc.org/ifad/home.html

Label and MSDS Distribution System
http://www.aginfo.com/label/label.html

EcoNet, Pesticides and Sustainable Agriculture
gopher://gopher.igc.apc.org/11/environment/susag

World Health Organization
gopher://gopher.who.ch/

Food and Agriculture Organization
(has statistics on pesticide use by geographic region)
gopher://gopher.fao.org/

APPENDIX M

EXAMPLE DECISION BRIEFING DOCUMENT

THIS PAGE INTENTIONALLY LEFT BLANK

EXAMPLE DECISION BRIEFING DOCUMENT

The following document was prepared in order to obtain command support for the recommendations made in the *Opportunity Assessment for Pesticide Reduction at Wright-Patterson AFB, Ohio* (OA). The information presented in the Decision Briefing Document is a summary of the OA that explains why the study was done, the methods and approach used in conducting the analysis, the alternatives considered but eliminated, and the alternatives evaluated. Criteria ratings for each alternative reflect a quantitative assessment of factors important in selecting pest management practices including cost, effectiveness, environmental impacts, toxicity, regulatory concerns, and acceptance. Reduction in pounds of active ingredient (AI) and advantage and disadvantages of each alternative are presented in summary form as well. The final chapter provides the recommendations for implementation, including the rationale for selection, and indicates overall percent reduction in AI that would be achieved by fiscal year 2000. This example is presented to assist other Air Force bases in preparing a summary decision document that contains sufficient information for command briefing.

THIS PAGE INTENTIONALLY LEFT BLANK

Decision Briefing Document for Pesticide Reduction at Wright-Patterson AFB, Ohio

March 1996

TABLE OF CONTENTS

Page

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

1.0 INTRODUCTION

1.1 PURPOSE

The Department of Defense (DoD) has established three Measures of Merit (MOM) for pest management at its installations (Memorandum from the Office of the Under Secretary of Defense, dated 23 September 1994). MOM 2 sets a goal of 50-percent reduction in the amount of pesticides used at DoD installations by fiscal year (FY) 2000, compared to baseline use in FY 93. In order to meet this goal, Headquarters, Air Force Materiel Command (HQ AFMC) requested that an opportunity assessment (OA) be prepared for reducing the use of pesticides at Wright-Patterson Air Force Base (WPAFB), Ohio.

1.2 SCOPE

1.2.1 Data were collected at WPAFB to establish the current baseline for pest management practices. Appropriate sources of information on pesticide use were contacted to obtain information on possible alternative products and procedures that might be implemented at WPAFB to reduce the amount of chemical pesticides used. Initial options that passed the screening evaluation were studied further to provide more detailed comparisons to current practices. The primary criterion used in assessing options was estimated pounds of active chemical ingredient (AI) required for control of the pest(s) in question. A final OA was submitted in March 1996.

1.2.2 This decision briefing document summarizes the findings and recommendations presented in the OA for review by the WPAFB Base Commander, who will select the options to be implemented. The methods used in developing and evaluating alternatives are presented in Chapter 2. Chapter 3 describes the baseline pesticide use at WPAFB for FY 93. Pesticide uses in FY 94 and FY 95 are also presented to illustrate trends in application practices. Chapter 4 summarizes the alternatives considered in the OA, and Chapter 5 presents the recommended options.

1.2.3 The procedures for implementing the alternatives selected by the Base Commander will then be developed and described in detail in a Management Action Plan (MAP).

THIS PAGE INTENTIONALLY LEFT BLANK

2.0 METHODS

2.1 DATA COLLECTION

In October 1995, a six-person team visited WPAFB to collect relevant data on current pest management practices. The team collected records of pesticide usage for FY 93-95, and interviewed base personnel regarding management practices for indoor and outdoor pests, lawns and turf, and base golf courses. During and after the site visit, personnel at regulatory and local extension service agencies, universities, and manufacturing companies were contacted to obtain information regarding pest management practices and product information. In addition, the team consulted relevant source data in reference libraries, government and commercial publications, and database files regarding alternative pest management practices.

2.2 ALTERNATIVE DEVELOPMENT

2.2.1 Identifying Options

Potential alternative pest management practices were identified through interviews with base personnel and several available data sources, including the Local Extension of the U.S. Department of Agriculture. All reasonable options were considered, with preference given to identifying options that avoid the use of chemical pesticides.

2.2.2 Screening Options

The identified options were reviewed in terms of technical and cost feasibility. Options that were not considered to be technically practical to implement, or that were not considered to be cost-effective, were eliminated from further consideration. Some options considered are quite new, and have not yet been fully tested; although some are quite promising, these were eliminated from further evaluation for this effort, as were products that are not yet available. Cost was also considered in the screening process. An option with a higher associated cost may be considered economically feasible if it contributes significantly to reaching the 50-percent reduction goal and results in reduced environmental and human exposure to toxic chemicals.

2.2.3 Evaluating Options

2.2.3.1 Options that passed the screening review were subject to a detailed evaluation in comparison to both current practices and the other options considered for evaluation. The single most important factor in evaluating alternatives was reduction in pounds of AI that would be achieved using that alternative instead of current practices. Each option was then evaluated with regard to its performance on the following six criteria considerations:

- ***Cost*** considers all costs associated with implementing the practice. It includes cost of chemicals that would be required on an annual basis; special equipment that may have to be obtained, either as one-time capital costs or recurring costs (for monitoring or maintenance); and labor costs (generally addressed in the form of the difference in labor hours from current practices). Representative product and equipment costs were obtained from the manufacturer or local vendors.
- ***Effectiveness*** was evaluated based on the demonstrated ability of the alternative to control the target pest(s). Ratings for effectiveness were generally based on discussions with experts in the particular field who have experience with the new option as well as with the current practice.
- ***Environmental impact*** refers to the extent to which the environmental resources of the surrounding area may be affected by the option (e.g., migration of chemical products to non-target locations).

- ***Toxicity*** reflects the extent to which a chemical product may adversely affect humans or animals through exposure. Where information on lethal dose (LD_{50}) values was available (typically from manufacturers' label information), it was used as the basis for toxicity ratings.

- ***Regulatory Concerns*** were evaluated to identify any specific issues associated with permitting or Environmental Protection Agency (EPA) approval of any of the options evaluated.

- ***Acceptability*** considers the subjective perceptions of the affected population (e.g., base personnel, military commanders, golfers) in response to the alternative. Ratings for acceptability were difficult to predict and quantify, but a general consideration of the likelihood of resistance based on nontechnical aspects of the alternative's performance is provided for each.

2.2.3.2 Each option was given a rating for each criterion, in comparison to current practices, on a scale of 1 to 5. A rating of 1 indicates that the option performs less favorably than the current practice (e.g., has more environmental impacts or a higher cost). A rating of 3 indicates that the option would perform similarly to the current practice for that criterion. A rating of 5 indicates that the option compares very favorably in comparison to the current practice (e.g., has a lower toxicity or reduced labor requirements). A total score was obtained for each option by summing the ratings for each criterion.

3.0 ESTABLISH CURRENT USE

3.1 BACKGROUND

3.1.1 DoD MOM 2 calls for a 7.15-percent reduction in overall pesticide usage each year (Figure 3-1). In FY 94, the overall Air Force use was 96 percent of the FY 93 baseline, a reduction of only 4 percent. In FY 95, the Air Force exceeded the goal, achieving a pesticide use of 77.4 percent of the FY 93 baseline. AT WPAFB, however, the amount of pesticides used increased from FY 93 to FY 94, by 133 percent. Although pesticide use at WPAFB decreased from FY 94 to FY 95, the FY 95 total was approximately twice the FY 93 baseline. HQ AFMC requested an OA for pesticide reduction at WPAFB in order to reverse this trend and ensure that the base meets the 50-percent reduction goal by FY 2000.

3.1.2 This section summarizes pest management practices at WPAFB for FY 93-95. The FY 93 baseline pesticide usage at WPAFB (Table 3-1) was used as the basis for calculating the goal, in pounds AI, for pesticide use in FY 2000. However, because in some cases, FY 93 was not a representative year, and because base pest management personnel have changed some practices since FY 93, use and management information are also presented for FY 94 and FY 95.

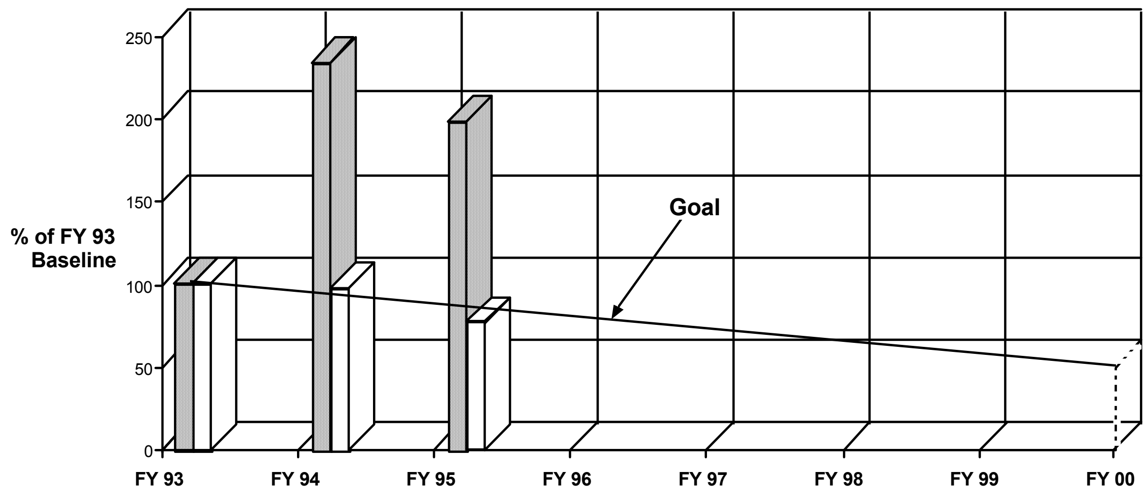
3.2 HERBICIDES

Herbicides include any chemical used to kill or inhibit the growth of vegetation, whether targeted specifically at weeds or used to destroy all vegetation in certain areas for safety or security purposes. Herbicides comprise the single largest category of pesticides used at WPAFB, and represent 51 percent of total base pesticide use in FY 93 (Table 3-1). Herbicide practices have been categorized by type of practice and by office of primary responsibility, as summarized below.

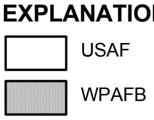
3.2.1 **Turf Weeds.** This category of herbicide practice includes all lawn care practices implemented by Civil Engineering (CE) Pest Management. Typically, this category consists of control of weeds in selected areas of turf that are maintained on the base. The primary areas are along “VIP Routes,” and include those areas that are most visible to visitors touring the base. CE Pest Management personnel do not provide lawn care services for the Military Family Housing (MFH) areas.

3.2.2 **Lawn Care.** For the past several years, lawn care in the MFH areas on base has been accomplished by a contractor. This care consisted primarily of quarterly treatment with pre- and post-emergent herbicides for weed control, combined with fertilization. The lawn care contract was terminated in September 1995. At present, there are no plans to replace this treatment and residents will be responsible for caring for their own lawns. Alternatives for this practice were not evaluated in the OA.

3.2.3 **Bare Ground.** CE Pest Management treats many areas on base with nonselective herbicides designed to kill all vegetation. Areas treated include flightline pavements in cracks, and around runway and taxiway lighting), parking lots, railroad rights-of-way, and areas around some facilities



EXPLANATION



WPAFB Pesticide Usage

Figure 3-1

Table 3-1. Inventory of Pesticide Usage at Wright-Patterson AFB FY 93-95

	Pesticide Usage pounds of active ingredient (percent)		
Pesticide Category	**FY 93**	**FY 94**	**FY 95**
HERBICIDES			
Turf weeds (CE)	329	516	2,115
Bare ground	582	6,005	2,020
Fence lines	295	29	18
Turf (golf courses)[(a)]	592	833	672
MFH lawn care (contractor	544	494	494
Subtotal - Herbicides	2,342 (51%)	7,877 (74%)	5,319 (58%)
FUNGICIDES			
CE	2	4	0
Golf courses	1,307	1,666	2,821
Subtotal - Fungicides	1,309 (29%)	1,670 (16%)	2,821 (31%)
INSECTICIDES			
Outdoor Pests			
Adult Japanese beetles (CE)	28	49	27
Adult Japanese beetles (golf courses)	27	133	18
Japanese beetle larvae (CE)	0	112	138
Japanese beetle larvae (golf courses)	101	249	231
Cutworms (golf courses)	137	426	184
Other (CE)	237	14	5
Other (golf courses)	18	19	22
Indoor Pests			
Termites (contractor)	261	96	235
Other (includes CE-applied termiticides)	126	54	108
Subtotal - Insecticides	935 (20%)	1,152 (10%)	968 (11%)
TOTAL	**4,586**	**10,699**	**9,108**

Note: (a) Includes plant growth regulators.

such as electrical substations and storage tank farms. These areas are kept vegetation-free for reasons of safety (reduced fire hazard) and security (increased visibility).

3.2.4 Fence Lines. Fence lines are treated by CE Pest Management personnel primarily for reasons of security. Typically, the same nonselective products are used as described for bare ground practices, although total elimination of vegetation is not necessary along fence lines.

3.2.5 Golf Courses. The two golf courses at WPAFB are managed by the Membership Support Flight. Because there are very specific standards for golf course greens, tees, and fairways, these management practices are distinct from turf management practices used on other parts of the base, and are treated separately in the OA.

3.3 FUNGICIDES

Fungicides are defined as substances that destroy or inhibit the growth of fungi. The major use for fungicides on WPAFB is on the maintained areas of the golf courses, which are highly susceptible to fungi. CE Pest Management applies small amounts of fungicides elsewhere on the base as needed, but those applications constitute a negligible portion of overall pesticide use on base. Fungicide treatment on the golf courses constituted 29 percent of total pesticide use on WPAFB, and is the only fungicide use evaluated for reduction in the OA.

3.4 INSECTICIDES

Insecticides are defined as substances that kill or interfere with the life cycle of insects. Insecticides are used at WPAFB by CE Pest Management to treat indoor and outdoor areas, by golf course personnel to treat outdoor pests on the courses, and by a contractor to treat termite problems in the MFH areas. In FY 93, insecticides accounted for 20 percent of total pesticide use on base. The primary insect problems at WPAFB are Japanese beetles, both as adult beetles and as grubs (larvae), cutworms (on the golf courses), and termites (in the MFH areas).

3.4.1 Japanese Beetles. Japanese beetles are present in a number of areas throughout the base. FY 93 was the first year the beetles were identified on WPAFB, and the first year insecticides were applied to control them. Application of insecticides for control of these pests has increased since then as the infestation has progressed. CE Pest Management treats trees for the adult beetles and grassy areas for the larvae. Japanese beetles (adults and larvae) are also a problem pest at the golf courses, and both phases are treated by golf course personnel.

3.4.2 Cutworms. This term is used to refer to the larval phase of a number of moth species. The larvae live under the ground, but come up to the surface to eat plants. Cutworms are a major source of damage to the golf courses.

3.4.3 Other Outdoor Pests. Other outdoor pests treated at the base include mosquitoes, aphids, wasps/bees/hornets, and miscellaneous others. Since the base stopped using malathion for mosquito control after FY 93, insecticide use for outdoor pests other than Japanese beetles/larvae and cutworms has decreased to less than 1 percent of total pesticide use at the base. Therefore, insecticide use for other outdoor pests was not evaluated in the OA.

3.4.4 Termites. WPAFB employs a contractor for termite control in MFH areas. Residents contact MFH if they suspect termites are present. If CE Pest Management personnel confirm the presence of termites, MFH calls the contractor to treat the affected residence(s).

3.4.5 Other Indoor Pests. Other indoor pests treated by CE Pest Management include primarily ants, earwigs, cockroaches, and termites in areas other than MFH. These pests do not present a health concern at WPAFB, and account for less than 3 percent of total pesticide use at the base. Control measures for these pests were not evaluated quantitatively in the OA, although the text does address measures that could help reduce human exposure to insecticides used for these common pests.

THIS PAGE INTENTIONALLY LEFT BLANK

4.0 ALTERNATIVE PEST MANAGEMENT PRACTICES

This chapter presents the pest management practices and amounts of pesticides used in FY 93-95, alternative practices that were considered but eliminated during the screening process, and the alternatives that were evaluated further. For each alternative that was evaluated further, we summarize the advantages and disadvantages of using that practice instead of the current practice, present the ratings for the six criteria described in Chapter 2, and estimate the pesticide usage, in pounds of AI annually, that would be applied. Unless indicated otherwise, estimated usage in pounds AI is compared to FY 93 usage for each practice.

4.1 HERBICIDES

4.1.1 Turf Weed Management

Turf weed management refers to weed control and grounds maintenance activities conducted throughout the base, except in MFH areas and the golf courses.

4.1.1.1 Current Practices. The CE Pest Management Shop at WPAFB is responsible for weed control along the "VIP Routes" (Figure 4-1), which comprise approximately 470 acres. The current practice generally consists of application of a "weed and feed" pre-emergent herbicide with a fertilizer mixture in the spring, followed by application of a post-emergent herbicide applied as needed, generally at least twice during the year. In 1995, in an attempt to inhibit weed growth and reduce the use of herbicides, the Grounds Maintenance Shop began a fertilization and aeration program on the VIP Route area.

Relatively small amounts of herbicides were applied along the VIP routes in FY 93 and FY 94 (329 and 516 pounds, respectively), reportedly due to a limited budget and conflicting priorities, along with the fact that the turf seemed to be in relatively good condition. In FY 95, essentially all of the VIP routes and adjoining areas were treated, resulting in a total of 2,115 pounds AI. Thus, use in FY 95, which is a more representative year, was the basis for comparison in estimating weight of AI for the options evaluated (Table 4-1).

4.1.1.2 Alternatives Identified and Eliminated during Screening

- **Use Spot Treatment Only.** Spot treating only would not be effective and would be extremely labor intensive and costly.

- **Hand-pulling Weeds.** Hand-pulling weeds would be extremely labor intensive, costly, and not very effective, especially considering the size of the area to be treated. Also, hand-pulling often does not remove deep tap roots, so the plant will resprout.

- **Decrease Area Treated/Replace with Other Cover.** This alternative was eliminated primarily because of the cost involved, and because other ground covers are not likely to be as acceptable as well-maintained turf along VIP routes. Because other suitable alternatives were identified that could contribute to significant reductions in herbicide use, this alternative was eliminated from further evaluation.

EXPLANATION

Base Boundary

State Highway

VIP Areas

0 615 1230 2460 Feet

VIP Areas

Figure 4-1

Mowing Only. This alternative was eliminated because it would not be very effective.

- **Alternative Herbicides.** No other herbicides were identified that would be as effective as the currently used mixture and that would also significantly decrease the pounds of AI.

4.1.1.3 Alternatives Identified for Further Evaluation

Option 1 - Increase fertilization and aeration. This option involves a new program of increased fertilization and aeration, possibly increased irrigation during drought in selected areas, and a continued program of maintaining a 3.5-inch mowing height. Estimated herbicide use would total 70 pounds AI for spot treatments.

Advantages:
- Increased turf health and decrease weed populations
- Substantial reduction in herbicide use
- Similar labor requirements.

Disadvantages:
- Higher materials cost (fertilizer).

Option 2 - Decrease the area treated. Eliminating 25 percent of the currently treated 470 acres in areas that are not highly visible, and 50 acres of the larger open areas would result in a reduction in treated acreage of approximately 35 percent. This would result in a total application of 1,375 pounds AI.

Advantages:
- Reduction in herbicide use
- Reduction in cost
- Reduction in labor.

Disadvantages:
- Increased weed population in non-treated areas.

Option 3 - Increase fertilization and aeration and decrease area treated. The combination of improving fertilization and aeration along with decreasing some of the acreage treated would maximize the reduction of chemical herbicide use, resulting in application of approximately 45 pounds AI per year for spot treatment.

Advantages:
- Substantial reduction in herbicide use
- Healthier turf
- Reduction in labor.

Disadvantages:
- Increased weed population in non-treated areas.

Table 4-1. Summary Comparison - Turf Weed Management

Evaluation Factor	Current Practice (1995)	Option 1 Fertilization/ Aeration	Option 2 Reduce Acreage	Option 3 Combination
Evaluation Criteria				
1. Cost (includes material, labor, equipment, other)	3	2	4	3
1 = high				
5 = low				
2. Effectiveness	3	3	1.5	3
1 = poor				
5 = very good				
3. Environmental Impacts	3	4.5	3	5
1 = bad/many				
5 = none/few				
4. Toxicity	3	4.5	3.5	4.5
1 = bad/many				
5 = none/few				
5. Regulatory Concerns	3	5	3	5
1 = problems				
5 = none/few				
6. Acceptance	3	2.5	1.5	2
1 = poor				
5 = very good				
Total Score	18	21.5	16.5	22.5
Total lbs AI/year	2,115	70	1,375	45
Annual Materials Cost	$23,000	$38,000	$15,000	$25,000

Note: Shading indicates the recommended option.

4.1.2 “Bare Ground” Control (Elimination of All Vegetation)

4.1.2.1 Current Practices. The focus for bare ground control is elimination of all unwanted vegetation, especially where weeds could create a health and safety/fire hazard problem. Areas treated include flightline pavements, parking lots and sidewalks, campgrounds, training areas, athletic fields, and the areas around substations and storage yards. On the flightline, a sealant is used as a filler for the cracks and areas surrounding runway lights and markers and expansion joints along the runways and taxiways to discourage weed growth. Most of the weed problems in the cracks occur in areas where the sealant is cracking or missing.

4.1.2.1.1 Generally, the CE Pest Management Shop has used a nonselective, soil sterilant formulation, particularly in areas where there is no sensitive nontarget vegetation nearby and where long-lasting control is desired. Typical application rates for the two products used are 16 pounds per acre and 98 pounds per acre. In areas where sensitive nontarget vegetation is present or nearby, or there are roots underneath the treatment area, Roundup® or a Roundup® mixture has been used, at an application rate of about 4 pounds per acre. These products do not have a long persistence or soil activity and are therefore safer to use in areas where sensitive vegetation is an issue.

4.1.2.1.2 In FY 93, the Pest Management Shop treated approximately 70 acres of parking lots and facility yards with 421 pounds of AI. In addition, 161 pounds of AI were applied to cracks in flightline pavements. In FY 94, approximately 400 acres of non-flightline areas were treated with a total of 5,925 pounds of AI; an additional 80 pounds were used to treat flightline pavements. In FY 95, the treated area consisted of approximately 95 acres of non-flightline areas, and a total of 1,952 pounds AI were applied. Herbicide applications on the flightline totaled 68 pounds of AI. Calculations of weight of AI for the alternatives evaluated were based on treating 100 acres, and compared to FY 95 use (Table 4-2).

4.1.2.2 Alternatives Identified and Eliminated during Screening

- **Filling in Cracks in Sidewalks.** This alternative was eliminated due to the extraordinarily high cost, labor intensive process, and ability of weeds to grow back through the caulking.

- **Use of Flamers or Steamers to Kill Weeds, Especially in Cracks.** Flaming uses a propane torch that passes slowly over weeds and sears the leaves enough to rupture the cell walls and cause the plant to wilt and die. The temperature of the torch is approximately 2,000 degrees Fahrenheit. It is inexpensive, but often does not kill grasses and even some broadleaf weeds with deep taproots, such as dandelions. The effectiveness of this method for bare ground control is not proven, and could pose a safety issue in some flightline areas.

  Steaming is similar to flaming in that the leaves of a weed are exposed to a high temperature for a short time. Steam application is less proven than flaming, but it may be more applicable for use on the flightline because the safety issues are less problematic. Prior testing resulted in personnel safety concerns due to burns from the steam application equipment.

- **Paving or Surfacing Parking Lots and Storage Yards.** Costs for paving or resurfacing areas were found to be considerably higher than current practices and other options.
- **Hand Picking Weeds.** This option would be labor intensive and costly, and would probably result in the regrowth of weeds from roots not pulled.

- **Installation of a Geotextile Weed Barrier or Biobarrier® Beneath Substations and Storage Yards.** The use of geotextiles impregnated with herbicides may be a viable option for new construction, but not for existing facilities. It is not considered economically feasible or technically practicable to scrape off existing gravel and base, and then lay a Biobarrier® base.

- **Use of a Weed Seeker® Sprayer.** The sprayer works by detecting chlorophyll by spectral reflectance and dispensing the herbicide when chlorophyll is detected. This option is not fully tested or proven in industrial use and was therefore not further evaluated in this OA.

4.1.2.3 Alternatives Identified for Further Evaluation

Option 1 - Use of herbicides with a lower percent AI. This option involves substituting new herbicides/herbicide mixes for the currently used herbicides. A combination of Arsenal®/Oust® and Sahara® (an Arsenal®/diuron product) is recommended as a reasonable alternative for WPAFB for the areas that would require longer-lasting control and have no sensitive non-target vegetation issues. Based on a representative treatment area of 100 acres, use of the recommended herbicide mixes would result in a total usage of 386 pounds AI annually.

Advantages:
- Reduced AI
- Similar labor requirements.

Disadvantages:
- May be necessary to experiment with other herbicide mixes to determine their effectiveness against particular target weeds and particular conditions at WPAFB.
- Slightly higher costs than current practice.

Option 2 - Fill cracks in parking lots and flightline pavements and apply alternative herbicide with lower AI in other areas. Under this option, the cracks in parking lots would be filled or patched with an asphalt-based sealer. Cracks in the flightline pavements and around lights and signage would be sealed with a compound specifically for use in the expansion joints of airfield runways. The remaining bare ground treatment area would receive the herbicide application discussed in Option 1.

This would result in the application of a total of 306 pounds AI for this option.

Advantages:
- Reduced AI
- Sealant would be long-lasting
- Annual cost of herbicides comparable to current practice.

Disadvantages:
- High cost for sealing cracks and joints

Table 4-2. Summary Comparison - Bare Ground Control

Evaluation Factor	Current Practice (1995)	Option 1 Use Herbicides w/ Less AI	Option 2 Fill Cracks/Herbicide with Less AI
Evaluation Criteria			
1. Cost (includes material, labor, equipment, other)	3	2	1
1 = high			
5 = low			
2. Effectiveness	3	2	2.5
1 = poor			
5 = very good			
3. Environmental Impacts	3	4	4
1 = bad/many			
5 = none/few			
4. Toxicity	3	4.5	4.5
1 = bad/many			
5 = none/few			
5. Regulatory Concerns	3	3	3
1 = problems			
5 = none/few			
6. Acceptance	3	3	3
1 = poor			
5 = very good			
Total Score	18	18.5	18
Total lbs AI/year	2,020	386	306
Annual Materials Cost	$7,200	$8,200	$7,600[(a)]

Note: (a) Does not include labor and material costs for sealing cracks in parking lot and flightline pavements.

4.1.3 Control of Vegetation Along Fence Lines

4.1.3.1 Current Practices. The CE Pest Management Shop's current practice is to use essentially the same herbicides that are used for bare ground control along the fence lines. FY 93 usage totaled 295 pounds AI over approximately 14.4 acres (Table 4-3). In FY 94, usage totaled only 29 pounds AI and in FY 95 only 18 pounds AI were applied.

4.1.3.2 Alternatives Identified and Eliminated during Screening

- **Create a Mow Strip or Mulch Strip along the Fence Lines.** Creating a mow strip, either with concrete or mulch, was considered to be too costly and/or probably not very effective.

- **Use of Flamer/Steamer.** This technology generally does not work well on perennial grasses, and would require extensive labor and additional training. There would also be potential safety concerns associated with the risk of igniting grasses surrounding the fence lines.

- **No Treatment.** Not applying any herbicide or using any physical control and letting the weeds grow along fence lines was not considered a viable option in most locations, particularly along the flightline, primarily for security reasons.

4.1.3.3 Alternatives Identified for Further Evaluation

Option 1 - Use a growth regulator mix. This option involves substituting a plant growth regulator mix for the herbicides presently used along fence lines. This option could result in the application of approximately 47 pounds AI per year.

Advantages:
- Reduced AI
- Annual materials cost less than current practice.

Disadvantages:
- May require more frequent application than current products.

Option 2 - Use of herbicides with a lower percent AI. This option would entail substitution of a herbicide mixture that would be applied at a rate of 0.9 pound AI per acre. The total amount of AI would be 13 pounds annually.

Advantages:
- Reduced AI
- Reduced materials cost
- Labor requirements similar to current practice.

Disadvantages:
- Herbicide may require more frequent application than current practice.

Option 3 - Mechanical trimming. This option involves no chemical use, but rather mechanical weed trimming along the fence lines as needed.

Advantages:

- Herbicide use virtually eliminated.

Disadvantages:

- More labor-intensive
- Less effective than current practice; would require more frequent treatment.

Table 4-3. Summary Comparison - Fence Line Vegetation Control

Evaluation Factor	Current Practice (1993)	Option 1 Growth Regulator Mix	Option 2 Herbicides w/ Less AI	Option 3 Mechanical Trimming
Evaluation Criteria				
1. Cost (includes material, labor, equipment, other)	3	2	2.5	1
1 = high				
5 = low				
2. Effectiveness	3	2.5	2.5	2
1 = poor				
5 = very good				
3. Environmental Impacts	3	4	4	5
1 = bad/many				
5 = none/few				
4. Toxicity	3	4	4.5	5
1 = bad/many				
5 = none/few				
5. Regulatory Concerns	3	3	3	5
1 = problems				
5 = none/few				
6. Acceptance	3	3	3	1
1 = poor				
5 = very good				
Total Score	18	18.5	19.5	19
Total lbs AI/year	295	47	13	0
Annual Materials Cost	$5,400	$1,000	$1,600	0

4.1.4 Golf Courses

The 27-hole Wright-Patterson Golf Course (WPGC) consists of a 9-hole course and an 18-hole course, which together cover approximately 268 acres. The 18-hole Twin Base Golf Course (TBGC) covers approximately 160 acres.

4.1.4.1 Current Practices. The superintendents of the golf courses are responsible for deciding when to apply herbicides and which herbicides to apply. Herbicides are applied using a boom sprayer. In FY 93, a total of 592 pounds AI were applied on the two courses (Table 4-4), including herbicides (524 pounds) and plant growth regulators (68 pounds). In FY 94, 833 pounds AI were applied, and in FY 95, the total use was 672 pounds AI.

4.1.4.2 Alternatives Identified and Eliminated during Screening

- **Substitute Herbicides with a Lower Percent AI.** Because no other products were identified that contain a lower percentage of AI and would be as effective as those currently in use, this alternative was not further evaluated.

- **Reduce the Turf Quality Standards at TBGC.** Reducing the standards for turf quality at one of the golf courses would allow reduction of pesticide use, but acceptability would be an issue, and it is expected that many players would stop using the course.

- **Close the 9-Hole Course at WPGC.** Closing the 9-hole course (or just discontinuing pesticide treatment) would reduce overall pesticide usage. However, there might be reduced revenue from greens fees, and this alternative would not be acceptable to golfers or golf course personnel.

4.1.4.3 Alternatives Identified for Further Evaluation

Option 1 - Allow for more natural acreage on both courses. There are areas on both golf courses (primarily the roughs) where turf could be replaced with more natural vegetation that would require little or no pesticide application. If the roughs were reduced by 25 percent at WPGC and by 15 percent at TBGC, this would result in a total FY 2000 usage of approximately 444 pounds AI.

Advantages:
- Reduction in AI
- Lower annual materials cost.

Disadvantages:
- Capital costs for landscaping/revegetating.

Option 2 - Convert the 9-hole WPGC course into an "eco-course." This alternative would involve implementing a combination of nonchemical or low-chemical measures on the 9-hole course at WPGC. In place of chemical herbicides, organic herbicides would be used. Providing natural vegetation in the rough areas, as described in Option 1, would help create a natural appearance and reduce the turf acreage that must be maintained. This alternative would result in a total FY 2000 herbicide usage of 405 pounds AI on the 18-hole golf courses. Because this would be a first in the Air Force (and possibly in DoD), the course could become a showcase for techniques of natural turf management and minimal pesticide application. The course could be used as an experimental course for testing nonchemical pest management techniques, such as new biological control measures. With appropriate planning and community relations activities, such an endeavor would reflect very well on the environmental responsibility of WPAFB and the Air Force, while helping the base meet the goal for pesticide reduction.

Advantages:
- Low toxicity; low environmental impact

- Can be used as good community relations
- Reduction in AI.

Disadvantages:
- May result in reduced play
- Some increase in weeds likely
- Organic herbicides are more costly and require more frequent application.

Implementing both options would result in the lowest weight of AI, estimated at 352 pounds annually.

Table 4-4. Summary Comparison - Golf Course Herbicides

Evaluation Factor	Current Practice (1993)	Option 1 Natural Acreage	Option 2 9-hole Eco-course	Combination
Evaluation Criteria				
1. Cost (includes material, labor, equipment, other)	3	1.5	2	2
1 = high				
5 = low				
2. Effectiveness	3	4	4	4
1 = poor				
5 = very good				
3. Environmental Impacts	3	4.5	4.5	4.5
1 = bad/many				
5 = none/few				
4. Toxicity	3	4.5	5	4.5
1 = bad/many				
5 = none/few				
5. Regulatory Concerns	3	3.5	4	4
1 = problems				
5 = none/few				
6. Acceptance	3	1.5	1.5	1.5
1 = poor				
5 = very good				
Total Score	18	19.5	21	20.5
Total lbs AI/year[(a)]	524	444	405	352
Annual Materials Cost	$27,700	$23,400	$21,400	$18,600

Note: (a) Excludes plant growth regulators.

4.2 FUNGICIDES

4.2.1 Current Practices

In FY 93, a total of 1,307 pounds AI were applied as fungicides on the golf courses (Table 4-5). This usage increased to 1,666 pounds AI in FY 94, and again to 2,821 pounds in FY 95, which was a very wet year. The treatment regimen for some types of fungi involves rotating the applied fungicides so that the target fungus does not develop a resistance to a particular fungicide. The products currently used are those recommended by Ohio State University Extension Service.

4.2.2 Alternatives Identified and Eliminated during Screening

- **Change to a More Fungus-Resistant Grass Type.** No other type of grass was identified that would provide better overall resistance to fungus.

- **Install a Multiple Row Irrigation System.** Installing a multiple-row irrigation system, instead of the current single-row system, would provide more even distribution of water over the entire fairway area. However, installation of a new irrigation system would be quite costly and would not significantly decrease the occurrence of fungus on the fairways.

4.2.3 Alternatives Identified for Further Evaluation

Option 1 - Include Sentinel® in the treatment regimen. Sentinel® has a lower percentage of AI than the products currently used and would be added as part of the rotating application program. The total weight of AI applied for fungus control on the golf courses would be 1,185 pounds.

Advantages:
- Lower toxicity
- Reduced AI.

Disadvantages:
- Higher cost than current practice.

Option 2 - Use EnviroCaster disease prediction tool. The EnviroCaster is a device that monitors climatic and soil conditions, and uses the data as input to a disease predicting model. A conservative estimate is that the EnviroCaster would reduce fungicide application by 30 percent. This would result in a total FY 2000 usage of 915 pounds AI on both golf courses.

Advantages:
- Helps reduce application of fungicides (use only when needed)
- Annual cost savings in amount of fungicides applied
- Reduced labor requirements.

Disadvantages:
- Capital cost of $7,000 for device.

Option 3 - Use of Reveal disease identification test kits. The Reveal disease detection kit is used to test soil and evaluate what diseases are present in the soil. If the amount of fungicides is reduced by 10 percent, the FY 2000 usage on both golf courses would be 1,177 pounds AI.

Advantages:

- Low cost (about $17 per test)
- Helps reduce fungicide application
- Reduced labor requirements.

Disadvantages:

- Sampling may miss some areas.

Implementing all three of these options would result in an estimated total use of 731 pounds AI annually. If fungicide use was not required on the proposed natural areas in the roughs (see Section 4.1.4.3), the estimated total weight of fungicides used annually on the golf courses would be further reduced.

Table 4-5. Summary Comparison - Fungicide Management (Golf Course)

Evaluation Factor	Current Practice (1993)	Option 1 Sentinel	Option 2 EnviroCaster	Option 3 Reveal Tests	Combination (All 3)
Evaluation Criteria					
1. Cost (includes material, labor, equipment, other)	3	2	4	4.5	3.5
1 = high					
5 = low					
2. Effectiveness	3	3	3.5	2.5	3
1 = poor					
5 = very good					
3. Environmental Impacts	3	3	4	4	4
1 = bad/many					
5 = none/few					
4. Toxicity	3	4	3.5	3	4
1 = bad/many					
5 = none/few					
5. Regulatory Concerns	3	3	3	3	3
1 = problems					
5 = none/few					
6. Acceptance	3	3	4.5	4.5	4
1 = poor					
5 = very good					
Total Score	18	18	22.5	21.5	21.5
Total lbs AI/year	1,307	1,185	915	1,177	731
Annual Materials Cost	$44,600	$49,900	$31,200	$40,100	$29,900

4.3 INSECTICIDES

Japanese beetles first appeared in this country in 1916 in the New Jersey area, after they had accidentally been transported to the United States from Japan. Since then, Japanese beetles have gradually been migrating west and currently inhabit areas east of Michigan, southern Wisconsin, and Illinois; and south through the southern portion of Alabama (Shetlar, n.d). Japanese beetles have two life-cycle phases, the adult beetle and the larvae. Different methods of control are applied for each; thus, they are treated separately in this OA.

4.3.1 Outdoor Pests - Adult Japanese Beetles

4.3.1.1 Current Practices. In FY 93, the first year these pests appeared on the base, a total of 55 pounds AI were applied for control of adult Japanese beetles; 28 pounds were applied by CE Pest Management and 27 pounds on the golf courses. In FY 94, treatment increased to 49 pounds AI applied by CE Pest Management and 133 pounds applied on the golf courses. In FY 95, CE Pest Management applied 27 pounds AI and golf course personnel applied 18 pounds for control of adult Japanese beetles. Insecticides are applied to trees and shrubs that are preferred foods of the beetles, including arbor vitae and linden. Because the beetles first appeared in FY 93, use in FY 94 was considered a more representative basis for comparison in calculating estimated weight of AI for the options evaluated (Table 4-6).

4.3.1.2 Alternatives Identified and Eliminated during Screening

- **Traps.** Traps capture beetles through food attractants or sex pheromones that lure the beetles to the traps. The effectiveness of this method is not proven, however, and studies have indicated that these traps may actually attract more beetles than they are able to kill.

- **Handpicking/Vacuuming.** This method simply involves shaking the tree and allowing the beetles to fall and be collected for disposal, or vacuuming the beetles into a bag that can be left in the sun or dropped in soapy water to kill the beetles. However, this procedure is quite labor intensive, and is effective only if conducted in the early morning before the beetles become active.

- **Use of a Biological Control (Neem®).** Neem® is an organic oil preparation made from the oil of the neem tree, found in Asia and Africa. Its effectiveness for control of Japanese beetle populations has not been proven.

- **Use of Biological Controls (Natural Predators).** Testing is under way to study the effectiveness of several parasitic insects on the Japanese beetles. To date, results are inconclusive.

4.3.1.3 Alternatives Identified for Further Evaluation

<u>Option 1 - Synthetic Pyrethroids</u>. Use of a synthetic pyrethroid would result in a total of 11 pounds AI for control of Japanese beetles.

Advantages:
- Reduction in AI
- More potent than current product
- Low toxicity
- Lower cost.

Option 2 - Remove Food Source. Japanese beetles have preferred food sources, some of which are quite common at WPAFB. These food sources could be gradually eliminated as trees that have been damaged die off or are removed because they are unsightly or diseased. If it is assumed, for calculation purposes, that approximately 50 percent of the major food sources are removed over the next 4 years, then approximately 91 pounds AI would be applied to the remaining plants for control of adult Japanese beetles.

Advantages:
- Provides long-term control
- Reduces need for chemical control.

Disadvantages:
- Not proven effective
- High cost to replace trees and shrubs.

Option 3 - Combination of Options 1 and 2. This option entails spraying the food sources with a synthetic pyrethroid, and beginning a gradual removal of the food source, particularly the linden trees. Possible replacements include oak, red maple, and sugar maple. If, as was assumed above, 50 percent of the food sources could be eliminated and the remainder were treated, the total weight of AI applied for control of adult Japanese beetles would be 5.5 pounds.

Advantages:
- Reduction in AI
- Synthetic pyrethroids more potent than current product
- Low toxicity
- Lower annual materials cost
- Provides long-term control.

Disadvantages:
- Removing food source not proven effective
- High cost to replace trees and shrubs.

Table 4-6. Summary Comparison - Adult Japanese Beetle Control

Evaluation Factor	Current Practice (1994)	Option 1 Synthetic Pyrethroids	Option 2 Remove Food Source	Option 3 Combination
Evaluation Criteria				
1. Cost (includes material, labor, equipment, other)	3	4	1	2
1 = high				
5 = low				
2. Effectiveness	3	4	2	4.5
1 = poor				
5 = very good				
3. Environmental Impacts	3	3	2	2.5
1 = bad/many				
5 = none/few				
4. Toxicity	3	4	4	4
1 = bad/many				
5 = none/few				
5. Regulatory Concerns	3	3	5	4
1 = problems				
5 = none/few				
6. Acceptance	3	3	1	2.5
1 = poor				
5 = very good				
Total Score	18	21	15	19.5
Total lbs AI/year(a)	182	11	91	5.5
Annual Materials Cost	$2,800	$2,700	$1,400(b)	$1,400

Notes: (a) Includes insecticides applied on both golf courses and rest of base.
(b) Does not include cost of removing/replacing trees and shrubs.

4.3.2 Outdoor Pests - Japanese Beetle Larvae

Japanese beetles lay their eggs in the ground, and the larvae reside below ground, feeding on a variety of plant roots including ornamental trees, shrubs, turf, and garden grasses.

4.3.2.1 Current Practices. In FY 93, a total of 101 pounds AI were applied to turf areas for control of Japanese beetle larvae on WPAFB. This treatment increased to 361 pounds in FY 94 and 369 pounds in FY 95. FY 95 use was the basis of comparison for calculating estimated AI for the options evaluated (Table 4-7).

4.3.2.2 Alternatives Identified and Eliminated during Screening

- **"Spikes of Death."** The term Spikes of Death refers to a method that involves using 3-inch nails with two nail points per square inch to "stab" the grubs. The area affected at WPAFB is too large for this method to be effective.

- **Milky Spore Disease.** This involves infesting the grub population with a bacterial disease, through larvae feeding, which eventually causes death. However, research has shown that due to the temperature and climate of the Ohio area, this method does not provide control. Further, it is likely that the fungicides applied on the golf courses would kill the bacteria.

- **Use of BT.** BT (*Bacillus thuringensis*) is currently used as a microbial insecticide for control of caterpillars and mosquito larvae at WPAFB. Mycogen Corporation has developed a new strain of BT that is effective against Japanese beetles. This new strain is currently under research and is expected to be released for public use by early 1997. However, because it is not presently available, it was not evaluated in the OA.

- **Turf Maintenance/Irrigation Control.** Increasing the height of the grass and decreasing irrigation can discourage adult beetles from laying eggs. However, WPAFB Grounds Maintenance is already keeping mowing heights to a recommended 3.5 inches, and most of the base is not irrigated.

4.3.2.3 Alternatives Identified for Further Evaluation

Option 1 - Use of Merit® instead of Oftanol® by CE Pest Management. The chemical product replacement for control of Japanese beetle larvae is Merit® (imidacloprid). Using Merit® at the manufacturer's recommended application rate would result in a total of 28 pounds AI used by CE Pest Management on non-golf course areas. If the golf course managers, who currently use Merit® and several other products, used only Merit® for control of Japanese beetle larvae, application would total 101 pounds AI annually.

Advantages:
- Labor similar to current practice
- Lower toxicity.

Disadvantages:
- More permeable than current product
- Higher cost.

Option 2 - Cease grub control in some areas. In combination with the above-mentioned treatment program for adults, it may be appropriate to control the grubs in localized areas where grubs are prevalent and/or turf appearance is of concern. If it is assumed that grub control is terminated on approximately 35 percent of the acreage treated (comparable to the reduction in VIP Route turf maintenance proposed under the Turf Weed Management discussion), approximately 18 pounds AI would be applied in non-golf course areas.

This option would probably not be suitable for the golf courses, which clearly maintain a higher quality turf than in other areas on base. However, if the options of allowing more natural acreage on the roughs and/or the conversion of the 9-hole WPGC course to an "eco-course" were implemented, chemical insecticides would not be applied in those areas for control of beetle larvae, and overall pesticide application would be reduced. It is estimated that 172 pounds AI would be applied annually for control of Japanese beetle larvae on the golf courses.

Advantages:
- Reduced chemical application
- Reduced cost.

Disadvantages:
- Increased turf damage.

Option 3 - Parasitic nematodes. Although nematodes are not as effective as other options for areas that are not regularly irrigated, they may be a reasonable alternative for use on the golf courses, which are well irrigated. A 50-percent reduction in larvae control pesticides would result in a total annual application of 115 pounds AI for larvae control at the golf courses. Because this is a completely biological control method, it would be a very appropriate measure to implement as part of the "eco-course" at WPGC.

If nematodes only were used on the 9-hole course, and no treatment used in the proposed natural areas in the roughs on both courses, it is estimated that a total of 86 pounds AI would be used on the golf courses for control of Japanese beetle larvae.

Advantages:
- Non-chemical approach
- Reduced AI
- Same treatment will help control beetle larvae and cutworms.

Disadvantages:
- Not 100-percent effective
- Increased labor.

Table 4-7. Summary Comparison - Japanese Beetle Larvae Control

Evaluation Factor	Current Practice (1995)	Option 1 Alternative Chemical (Merit)	Option 2 Reduce Grub Control	Option 3 Parasitic Nematodes
Evaluation Criteria				
1. Cost (includes material, labor, equipment, other)	3	4	5	3
1 = high				
5 = low				
2. Effectiveness	3	4	2.5	2
1 = poor				
5 = very good				
3. Environmental Impacts	3	3	2	4.5
1 = bad/many				
5 = none/few				
4. Toxicity	3	3	5	5
1 = bad/many				
5 = none/few				
5. Regulatory Concerns	3	3	5	3.5
1 = problems				
5 = none/few				
6. Acceptance	3	3	2	3
1 = poor				
5 = very good				
Total Score	18	20	21.5	21
Total lbs AI/year (CE/Golf Course)	138/231	28/101	18/172	NA/115
Annual Materials Cost	$2,700/ $32,100	$10,600/ $38,200	$6,900/ $28,500	NA/ $21,600

Note: Each of the options is recommended for either golf course or non-golf course use; therefore, none of the columns are shaded to indicate the recommended option.

NA = not applicable

4.3.3 Outdoor Pests - Cutworms

4.3.3.1 Current Practices. The golf courses applied 137 pounds AI in FY 93 (Table 4-8), 426 pounds AI in FY 94, and 184 pounds AI in FY 95. Pesticides are routinely applied when bird damage is apparent on the greens (evidence of birds eating the cutworms) or by visual inspection.

4.3.3.2 Alternatives Identified and Eliminated during Screening

- **BT.** As discussed for Japanese beetles, this involves the use of a microbial insecticide that infests the cutworm population and eventually causes death. This method of control was eliminated due to the use of fungicides on the golf courses that could possibly kill the bacillus, rendering this control method useless.

- **Milky Spore Disease.** As discussed for Japanese beetles, this involves infesting the cutworm population with a bacterial disease that eventually causes death. This has not been proven effective in Ohio due to the temperature and climate of the area. In addition, there is concern that use of fungicides on the golf courses would kill the bacteria.

4.3.3.3 Alternatives Identified for Further Evaluation

Option 1 - Alternative chemical. Use of the insecticide Tempo® would result in a total usage of 26 pounds AI annually for cutworm control.

Advantages:
- Reduction in AI
- Reduced cost.

Option 2 - Parasitic nematodes. As discussed above for Japanese beetle larvae, use of parasitic nematodes would be appropriate on the golf courses, and especially on the 9-hole "eco-course" at WPGC, resulting in a total of 69 pounds AI applied for cutworm control (using the current insecticides).

Advantages:
- Non-chemical approach
- Same treatment will help control beetle larvae and cutworms
- Reduced cost.

Disadvantages:
- Not 100-percent effective.

Option 3 - Combination of Options 1 and 2. Tempo® has been found to be compatible with all commonly used fungicides, miticides, liquid fertilizers, and other insecticides; therefore, no effect to the nematodes is expected from the Tempo® application. Assuming a 50-percent reduction in cutworm control pesticides due to the application of nematodes and the replacement of current chemical pesticide applications with Tempo®, the resulting usage would be 13 pounds AI for cutworm control annually.

Advantages:
- Reduced AI
- Reduced cost
- Nematodes can be used for control of beetle larvae and cutworms.

Table 4-8. Summary Comparison - Cutworm Control

Evaluation Factor	Current Practice (1993)	Option 1 Alternative Chemical	Option 2 Parasitic Nematodes	Option 3 Combination
Evaluation Criteria				
1. Cost (includes material, labor, equipment, other) 1 = high 5 = low	3	4.5	3	4
2. Effectiveness 1 = poor 5 = very good	3	3	2	3
3. Environmental Impacts 1 = bad/many 5 = none/few	3	3	4.5	3
4. Toxicity 1 = bad/many 5 = none/few	3	3	5	4
5. Regulatory Concerns 1 = problems 5 = none/few	3	3	3.5	3
6. Acceptance 1 = poor 5 = very good	3	3	3	4
Total Score	18	19.5	21	21
Total lbs AI/year	137	26	69	13
Annual Materials Cost	$7,200	$6,400	$3,600	$3,200[(a)]

Note: (a) Does not include approximately $5,600 for nematodes, which was included in Table 4-7 for Japanese beetle larvae control.

4.3.4 Indoor Pests

Insecticides applied by CE Pest Management personnel for control of indoor pests accounted for approximately 2 percent of total pesticide usage in FY 93. The largest amount of AI used for control of indoor (structural) pests is applied by a contractor for control of termites in the MFH areas.

4.3.4.1 Current Practices. In FY 93, 261 pounds of Dursban TC® were applied (Table 4-9) to 50 MFH units on WPAFB under the termite control contract. In FY 94, 96 pounds were applied to 23 housing units, and in FY 95, 235 pounds were applied to 48 housing units.

4.3.4.2 Alternatives Identified and Eliminated during Screening

- **Termite Mesh.** The installation of termite mesh would be costly and would be required on a regular basis. Termite mesh has been found to be not entirely effective.

- **Particle-size Barriers.** Although this control method is a very effective nonchemical alternative for subterranean termites, the installation of particle-size barriers is a preconstruction termite control measure.

- **Voltage Injection.** This alternative would not be appropriate for use at WPAFB since it is only used to kill drywood termites. Subterranean termites are prevalent at WPAFB.

4.3.4.3 Alternatives Identified for Further Evaluation

Option 1 - Colony elimination system. The Sentricon® System is effective against all subterranean termite species (except drywood) in the continental United States. Control is achieved through placing a growth-regulating bait where termites will contact it, bringing it back to the colony. The growth regulator prevents the molting process of termites, and they eventually die. A very small amount of the bait is used, and estimated use for treating 50 MFH units would be less than 1 pound AI. Standard termiticide chemicals may be used in conjunction with the bait system for short-term control until the colony is eliminated.

Advantages:
- Very low AI
- Environmentally safe; bait remains in trap
- Long-term control.

Disadvantages:
- High contractor cost for installing and monitoring bait tubes plus application of Dursban® for short-term control.

Option 2 - Alternative chemical. An alternative chemical to the currently used Dursban TC® is Premise® 75, which would result in a total of 26 pounds AI.

Advantages:
- Lower AI than current practice.
-

Disadvantages:
- Slightly higher cost than current practice.

CE Pest Management personnel apply a 1-percent solution of Dursban® for termite control around structures in non-MFH areas. In FY 93, approximately 65 pounds AI were applied for this termite control practice. Use of Premise® instead of Dursban® for non-MFH areas would require only 6.5 pounds AI, and would help reduce human exposure to insecticides.

Table 4-9. Summary Comparison - Termite Control

Evaluation Factor	Current Practice (1993)	Option 1 Bait Tubes	Option 2 Alternative Chemical
Evaluation Criteria			
1. Cost (includes material, labor, equipment, other)	3	2	3
1 = high			
5 = low			
2. Effectiveness	3	4	3
1 = poor			
5 = very good			
3. Environmental Impacts	3	5	4
1 = bad/many			
5 = none/few			
4. Toxicity	3	5	3
1 = bad/many			
5 = none/few			
5. Regulatory Concerns	3	3	3
1 = problems			
5 = none/few			
6. Acceptance	3	5	4
1 = poor			
5 = very good			
Total Score	18	24	20
Total lbs AI/year	261	1	26
Annual Materials Cost	$27,400	$19,000 ($100,000)[a]	$29,500

Note: (a) Costs for bait traps only would be $15,000 for installation and approximately $3,750 annually for monitoring. Contractor quote for installation of bait tubes, monthly monitoring, and trenching with application of Dursban® for short-term control is $6-$9 per linear foot, or $93,000-$138,000 to treat the same area treated in FY 93.

5.0 SUMMARY AND CONCLUSIONS

Table 5-1 summarizes the pounds of AI that would be used for each option considered for each pest management category presented in Chapter 4. In developing a recommended strategy for pesticide reduction at WPAFB, the total criteria ratings based on cost, effectiveness, acceptability, etc. (Table 5-2), were considered in conjunction with the estimated weight of AI for the various options. This section presents recommendations, with supporting rationale, for a set of options that would result in an estimated total weight of AI in FY 2000 of 1,817 pounds (Table 5-3), or 40 percent of the FY 93 baseline.

Table 5-1. Projected Pesticide Usage for Evaluated Alternatives

Category	Current Practice	Option 1	Option 2	Option 3	Option 4
HERBICIDES					
Turf weeds (CE)	2,115[c]	70	1,375	45	
Bare ground	2,020[c]	386	306		
Fence lines	295[a]	47	13	0	
Turf (golf courses)	524[a]	444	405	352	
Plant growth regulators (golf courses)	68[a]				
FUNGICIDES					
Golf courses	1,307[a]	1,185	915	1,177	731
CE	2[a]				
INSECTICIDES					
Outdoor Pests					
Adult Japanese beetles (CE)	49[b]	3	25	1	
Adult Japanese beetles (golf courses)	133[b]	8	66	4.5	
Japanese beetle larvae (CE)	138[c]	28	18	NA	
Japanese beetle larvae (golf courses)	231[c]	101	172	115	
Cutworms (golf courses)	137[a]	26	69	13	
Other (CE)	5[c]				
Other (golf courses)	18[a]				
Indoor					
Termites	261[a]	1	26		
Other	126[a]				

Notes: (a) FY 93 is the reference for the current practice.
(b) FY 94 is the reference for the current practice.
(c) FY 95 is the reference for the current practice.

Table 5-2. Summary of Criteria Ratings for Suggested Alternatives

Category	Option 1	Option 2	Option 3	Option 4
HERBICIDES				
Turf weeds (CE)	21.5	16.5	22.5	
Bare ground	18.5	18		
Fence lines	18.5	19.5	19	
Golf courses	19.5	21	20.5	
FUNGICIDES				
Golf courses	18	22.5	21.5	21.5
INSECTICIDES				
Outdoor Pests				
Adult Japanese beetles	21	15	19.5	
Japanese beetle larvae	20	21.5[b]	21[b]	
Cutworms	19.5[a]	21[a]	21[a]	
Indoor Pests				
Termites	24	20		

Notes: (a) Applies to golf courses only.
(b) Does not apply to golf courses.

5.1 TURF WEED MANAGEMENT (CE)

Implementation of a program of fertilization and aeration in the VIP Route areas (Option 1) would provide a dramatic reduction in herbicide use. Reducing the area treated (Option 2) would not provide as much reduction in AI. Option 3, a combination of increased fertilization and aeration on a reduced acreage, offers the best of both. Although the additional turf maintenance activities would result in increased labor costs, reduction of acreage treated would minimize this increase. Option 3 also received the highest total criteria rating (see Table 5-2). Option 3 is recommended as providing the most cost-effective reduction in herbicide use while still maintaining turf appearance along VIP routes (see Table 5-3).

5.2 BARE GROUND CONTROL

Substituting a chemical with a lower percentage AI for bare ground vegetation control (Option 1) would achieve a significant reduction in this herbicide usage. Sealing cracks in flightline and parking lot pavements where possible and using an alternative herbicide elsewhere(Option 2) would provide only a small decrease from Option 1 use, at a substantial additional cost in terms of materials and labor to apply sealant. Criteria ratings for the two options are very similar (see Table 5-2). Option 1 is recommended as providing the most cost-effective reduction in herbicide use for bare ground vegetation control (see Table 5-3).

5.3 FENCE LINES

Use of either a plant growth regulator (Option 1) or an alternative herbicide with a lower percentage of AI (Option 2) would provide a significant reduction in the amount of herbicides used along fence lines. The two have similar criteria ratings. Mechanical trimming (Option 3)

Table 5-3. Recommended Alternatives for Pest Management Practices at WPAFB

Category	Recommended Option	Annual Pesticide Usage	Total Criteria Rating
HERBICIDES			
Turf weeds (CE)	3: Increased fertilization and aeration, reduced area	45	22.5
Bare ground	1: Use alternative herbicide with lower percent AI	386	18.5
Fence lines	2: Use herbicide with lower percent AI	13	19.5
Turf (golf courses)	1 & 2: Allow more natural areas and create eco-course	352	20.5
Plant growth regulators (golf courses)	NA	68	NA
FUNGICIDES			
Golf Courses	1, 2, & 3: Add Sentinel®, use Envirocaster and Reveal	731	21.5
CE	NA	2	NA
INSECTICIDES			
Outdoor Pests			
Adult Japanese beetles	1: Use synthetic pyrethroids	11	21
Japanese beetle larvae (CE)	1 and 2: Use insecticide with lower percent AI and cease treatment in some areas	18	21.5
Japanese beetle larvae (golf courses)	2 and 3: Reduce treatment (natural areas) and use parasitic nematodes	86	22
Cutworms (golf courses)	3: Use parasitic nematodes and alternative chemical with lower percent AI	13	21
Other (CE)	NA	5	NA
Other (golf courses)	NA	18	NA
Indoor			
Termites	1: Use colony elimination system	1	24
Other	Use Premise to treat termites in non-MFH areas	68	NA
Total		1,817	

would theoretically reduce this herbicide use to zero, and has the highest criteria rating, but is a very labor-intensive approach. It is recommended that Option 2 be implemented, using an alternative herbicide, with good effectiveness and a reduction in herbicide use of more than 95 percent (see Table 5-3).

5.4 GOLF COURSE TURF MANAGEMENT

Reducing application of herbicides by allowing more natural areas in the roughs (Option 1) would provide a reduction of about 15 percent in this herbicide use. Converting the 9-hole course at WPGC to an eco-course (Option 2) would result in a 23 percent reduction. It is recommended that both Options 1 and 2 be implemented to achieve an overall reduction that is better than that estimated for either alone (see Table 5-3), with acceptable criteria ratings and good acceptance.

5.5 FUNGICIDE APPLICATION ON GOLF COURSES

No nonchemical alternatives for control of fungus were identified. Including a fungicide with a lower percentage of AI (Sentinel®) in the application regimen for pythium control (Option 1) would provide a 10-percent reduction in fungicide application. Use of the EnviroCaster (Option 2) and Reveal test kits (Option 3) to provide information on the appropriate conditions for application of fungicide would also help reduce the amount of fungicides applied. It is recommended that all of these measures be implemented in order to provide the greatest reduction possible in this use. If all of these measures were implemented, it is estimated that fungicide use on the golf courses would total approximately 731 pounds AI annually. In addition, allowing more natural areas in the roughs of the golf courses, rather than maintaining turf, should further reduce the occurrence and treatment of fungi.

5.6 ADULT JAPANESE BEETLE CONTROL

Synthetic pyrethroids (Option 1) have proven effective for controlling Japanese beetles and contain a lower percentage of AI than the currently used products. The effectiveness of eliminating the food source of the pests (Option 2) is not certain; it is likely that they would find alternative food sources. It would also be very expensive. Therefore, the combination of this practice with use of an alternative chemical would not likely be very cost-effective either. Thus, it is recommended that WPAFB personnel begin use of synthetic pyrethroids, such as Tempo® (Option 1), for control of adult Japanese beetles, basewide. This alternative would achieve a significant reduction in this insecticide use, and has the highest criteria rating for this category (see Table 5-2).

5.7 JAPANESE BEETLE LARVAE CONTROL (NON-GOLF COURSE)

Because turf conditions on the golf course are quite different from those on the rest of the base, different options are recommended for control of Japanese beetle larvae in the two areas. Use of Merit® (Option 1) is recommended for areas where larvae control is necessary. Total cessation of treatment is probably not practical, because there will still be some damage to turf. However, chemical treatment for larvae could be terminated in some non-golf course areas that are less visible, or where turf appearance is not as important (Option 2). It is recommended that both options be implemented together, to achieve the greatest reduction in pounds AI.

5.8 JAPANESE BEETLE LARVAE CONTROL (GOLF COURSES)

On the golf courses, Merit® (Option 1) is already being applied. With an increase in natural areas in the golf course roughs and creation of the eco-course at WPGC, use of chemical insecticides will be eliminated or reduced (Option 2). It is suggested that application of beneficial nematodes (Option 3) be implemented on the eco-course as the only treatment for beetle larvae, and on the greens and tees of the other courses in addition to application of Merit®, to provide additional control of these pests. Application of nematodes on the golf courses will also help control cutworms (see below). Implementing both Options 2 and 3 would result in application of approximately 86 pounds AI on the golf courses for control of beetle larvae.

5.9 CUTWORM CONTROL

Although use of an alternative insecticide (Option 1) would achieve a respectable reduction, it is preferable to use nonchemical means of controlling pests where possible. Use of parasitic nematodes (Option 2) is recommended for control of Japanese beetle larvae on the golf courses (see above), and should also be used for control of cutworms. In combination, these measures would achieve the greatest reduction in insecticide use, with a total estimated usage of 13 pounds AI. In addition, replacing turf with natural vegetation in the roughs would allow further reduction of turf acreage to be treated.

5.10 TERMITE CONTROL

Use of the Sentricon® System (Option 1) for elimination of termite colonies provides a greater reduction in AI, and has a higher criteria rating than use of Premise® (Option 2). The Sentricon® System is highly recommended, available for use in the WPAFB area, and is suited to conditions where there is a major infestation, as is the case at the base. Therefore, this option is recommended for use in the MFH areas. It is further recommended that the CE Pest Management Shop use Premise® instead of Dursban® for spot treatment of other facilities in the cantonment area, which would reduce insecticide use in the “Other Indoor Pests” category to approximately 68 pounds AI.

5.11 OVERALL PESTICIDE USE

If all of the above recommendations are selected for implementation at WPAFB, it is estimated that by FY 2000 pesticide use at the base would total approximately 1,817 pounds AI. This represents a 60-percent reduction from the FY 93 baseline of 4,586 pounds AI and would allow the base to meet the DoD goal of 50-percent reduction mandated in MOM 2.

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX A

DESIGN GUIDELINES
FOR FUTURE CONSTRUCTION

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX A
DESIGN GUIDELINES FOR FUTURE CONSTRUCTION

The primary focus of the Opportunity Assessment is to recognize and evaluate opportunities to adjust current practices to reduce the amount of AI used in pest management activities. Several measures were identified that would be very expensive to implement for existing facilities, but would be reasonable to implement as part of new facility construction to minimize pesticide use in the future. These measures are presented below for informational purposes.

- In new turf areas, consider planting different cultivars/blends that are more weed-resistant than the currently used bluegrass. For example, rye grass or fine fescue could be added to the blend, or perhaps some areas could be planted with native grasses or "wildflowers." The local extension service can provide assistance with cultivar selection and soil testing.

- Consider applying a soil sterilant under new gravel or paving, and/or using asphalt with a herbicide in the mix, to discourage weed growth from the start. Several herbicides have instructions on their labels for use under asphalt.

- For new facility construction, consider the use of other natural ground covers instead of turf. These covers should be weed-resistant, and suited to the regional climate.

- If growth from tree roots under pavement is an issue, consider use of a biobarrier-type product. This would be placed under new yards, substations, or similar areas. It would function like weed barriers (geotextiles, plastics, roofing paper) that could also be placed under new ornamental beds to discourage weed growth.

- Consider creating a mow strip along new fence lines. This would involve pouring a concrete strip or perhaps creating a mulch strip with underlying weed barrier. This is easier and cheaper to do before the fence is installed and would allow for adequate weed control by mowing only.

- Consider planting pest-resistant species when new trees or shrubs are planted. Especially, avoid planting any preferred food sources for the Japanese beetle such as linden trees, crabapples, or roses. Instead, substitute oaks, red maples, or sugar maples. The local extension service can provide help with identifying the best choices.

- Preconstruction treatment such as termite mesh or particle-size barriers, or pretreating the wood used in structures, can protect against infestation by termites. Use of wood in structures should also be minimized to prevent termites.

- Place boric acid inside the wall spaces of new structures to discourage cockroaches.

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX N
EXAMPLE MANAGEMENT ACTION PLAN

THIS PAGE INTENTIONALLY LEFT BLANK

MANAGEMENT ACTION PLAN
FOR PESTICIDE REDUCTION
AT WRIGHT-PATTERSON AIR FORCE BASE, OHIO

September 1996

Prepared by:
EARTH TECH

Prepared for:
Department of the Air Force
Air Force Materiel Command

Through the Contracting Offices of:
Department of the Air Force
Air Force Center for Environmental Excellence
Contract No. F41624-94-D-8138
Delivery Order No. 0012

LIMITATIONS

EARTH TECH prepared an opportunity assessment for pesticide reduction at Wright-Patterson Air Force Base (WPAFB), Ohio, presenting recommendations to help the base meet the Department of Defense (DoD) goal of 50-percent reduction in pesticide use from fiscal year (FY) 93 to FY 2000. Comments from the base on the draft opportunity assessment were incorporated in the final document, and the recommendations briefed to the Commander, 88 Advanced Bomb Wing. Subsequently, HQ AFMC/CEVC identified the alternatives to be presented in this Management Action Plan (MAP) for implementation by base personnel. After reviewing the Draft MAP, the base elected to defer implementation of portions of three of the selected alternatives. Implementation of the following recommended measures will be deferred and reevaluated for FY 98:

- Use of Envirocaster® disease prediction model and Reveal® soil test kits to help reduce application of fungicides on the golf courses
- Use of beneficial nematodes to reduce use of insecticides to control Japanese beetle larvae on the golf courses
- Use of beneficial nematodes to reduce use of insecticides to control cutworms on the golf courses.

Failure to implement all of the alternatives recommended in this final MAP may prevent WPAFB from meeting the DoD goal for reduction of pesticide use.

____________________________________ ____________________

Sandra L. Cuttino, P.E., Program Manager Date
EARTH TECH

____________________________________ ____________________

Barbara Zeman, Delivery Order Manager Date
EARTH TECH

TABLE OF CONTENTS

LIST OF FIGURES

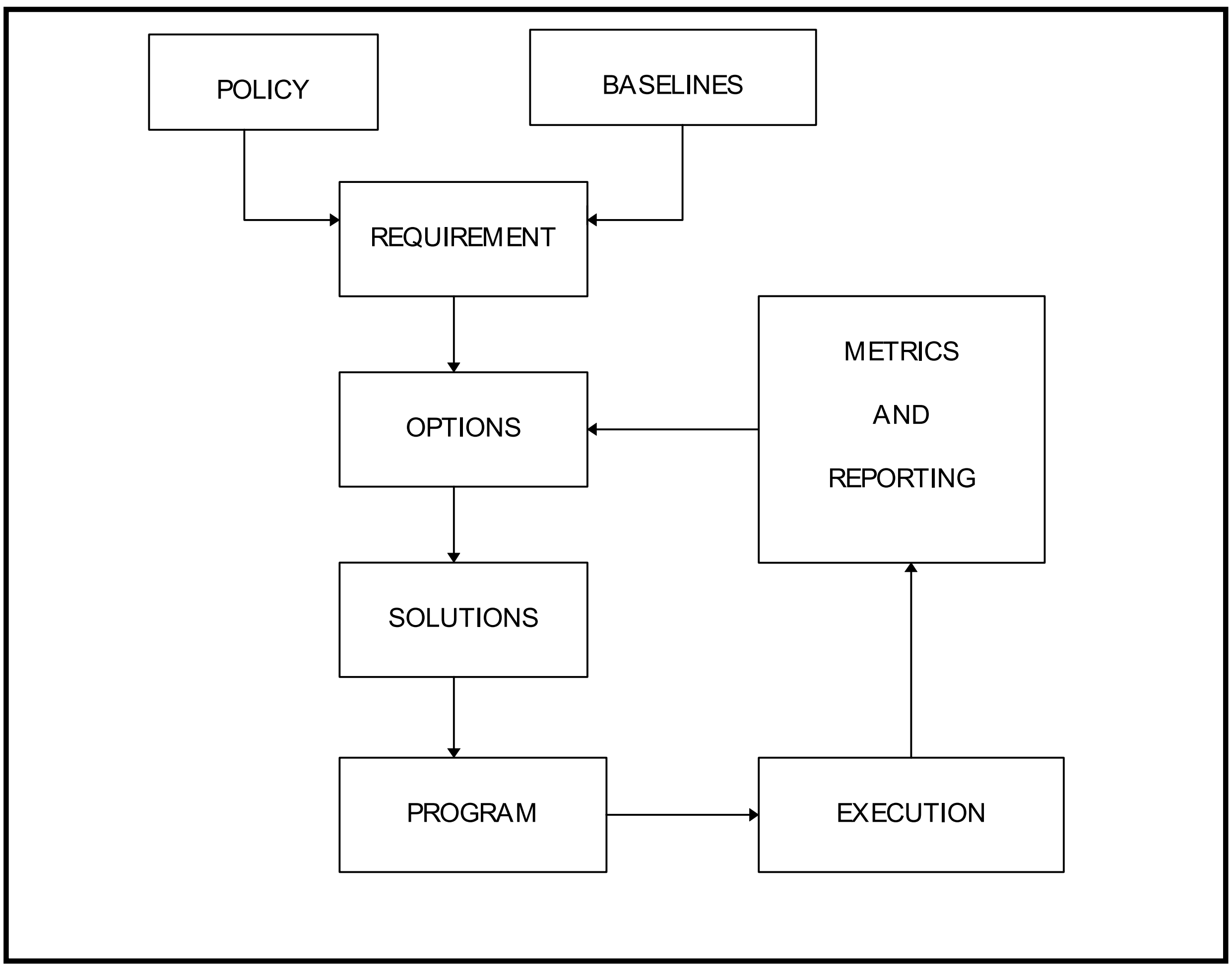
LIST OF TABLES

1.0 PROCESS

The Department of Defense (DOD) has established three Measures of Merit (MOM) for pest management at its installations (Memorandum from the Office of the Under Secretary of Defense, dated 23 September 1994). MOM 2 sets a goal of 50-percent reduction in the amount of pesticides used at DOD installations by fiscal year (FY) 2000, compared to baseline use in FY 93. Headquarters, Air Force Materiel Command (HQ AFMC) requested that an opportunity assessment (OA) be prepared for reducing the use of pesticides at Wright-Patterson Air Force Base (WPAFB), Ohio, in order to help the base meet the reduction goal. Results of the OA and recommended alternatives were presented to the WPAFB Wing Commander. This Management Action Plan (MAP) describes the actions required to implement the alternatives selected by the base. Details of the alternatives are based on information presented in the OA, and information provided by Civil Engineering (88 CEG/CEOG), Environmental Management (88 ABW/EM), and golf course management (88 SPTG/SVBG) personnel.

Pesticide reduction is being implemented as part of the overall pollution prevention program at WPAFB. The pollution prevention process is outlined in Figure 1-1. This section describes the initial and recurring management actions needed to implement the pesticide reduction program at WPAFB. It identifies offices of primary responsibility (OPRs) for each action, and identifies dates of estimated and actual (when known) completion for each step.

Figure 1-1. The Pollution Prevention Process



1.1 POLICY

Although not specifically identified as part of the Air Force Pollution Prevention Program, pesticide reduction should be incorporated as part of the pollution prevention program at WPAFB. Responsibility for day-to-day implementation of pest management practices is the responsibility of 88 CEG/CEOG and 88 SPTG/SVBG. 88 ABW/EM provides support as needed, and writes or reviews any contracts involving pesticides. Overall responsibility for reviewing and establishing the pesticide reduction program should be the responsibility of the Environmental Protection Committee (EPC). The Base Commander will be responsible for ensuring that the program is implemented appropriately throughout the base.

		Completion Date	
Action	OPR	Estimated	Actual
Recommend a structure and process for management of the pesticide reduction program.	EPC	Sept-Oct 96	
Identify OPRs for implementation and monitoring of the pesticide reduction program.	EPC	Sept-Oct 96	
Identify a process for monitoring and reporting progress of pesticide reduction program.	EPC	Sept-Oct 96	

OPR = office of primary responsibility

1.2 BASELINES

DOD MOM 2 specifies that the baseline year for pesticide reduction is FY 93 usage. Therefore, the FY 93 baseline pesticide usage at WPAFB was used as the basis for calculating the goal, in pounds of active ingredient (AI), for pesticide use in FY 2000. However, because in some cases, FY 93 was not a representative year, and because base pest management personnel have changed some practices since FY 93, use and management information for FY 94 and FY 95 were also considered in developing alternative practices. In FY 93, WPAFB applied 4,586 pounds AI in pesticide usage.

		Completion Date	
Action	OPR	Estimated	Actual
Establish FY 93 baseline pesticide usage.	88 CEG/CEOGE	Mar 96	Mar 96

1.3 REQUIREMENT

DOD MOM 2 calls for a 50-percent reduction in pesticide usage from FY 93 to FY 2000. This is equivalent to a 7.15-percent reduction in overall pesticide usage each year. At WPAFB, the amount of pesticides used increased from FY 93 to FY 94, by more than 100 percent. Although pesticide use at WPAFB decreased from FY 94 to FY 95, the FY 95 total exceeded the FY 93 baseline by 80 percent. The FY 2000 goal for pesticide use at WPAFB is 50 percent of the FY 93 baseline (4,586 pounds), or 2,293 pounds AI.

Action	OPR	Completion Date Estimated	Actual
Establish goal for reduction in pesticide usage for FY 2000.	88 CEG/CEOGE	Mar 96	Mar 96

1.4 OPTIONS

The OA for pesticide reduction at WPAFB identified and evaluated a number of options for reducing pesticide use for each pest management practice at the base. Several options were eliminated during the initial screening because they were not cost effective, not feasible, or not yet thoroughly tested and available for use. The remaining options were evaluated with regard to reduction in AI, cost, effectiveness, environmental impact, toxicity, regulatory concerns, and acceptability. A suite of options was recommended for the overall pest management program, and presented to the WPAFB Wing Commander in a decision document and briefing in April 1996.

The OA also identified a number of options that are currently in the development or testing stages, but that appear promising and that should be available within the next 2 years. Base pest management personnel should re-evaluate possible options regularly, as well as evaluate the cost-effectiveness of current practices and new alternatives. The personnel who use these strategies every day will be the best judges of how effective they are, and how to implement them for maximum benefit.

Action	OPR	Completion Date Estimated	Actual
Prepare OA to identify and evaluate options for reducing pesticide use.	88 ABW/EM	Mar 96	Mar 96
Periodically update OA and re-evaluate additional options for reducing pesticide use.	88 ABW/EM 88 CEG/CEOGE 88 SPTG/SVBG	As needed	

1.5 SOLUTIONS

The base selected all but one of the recommended options for implementation. These selected options are described in this MAP and were selected based on cost-effectiveness, contribution to the required reduction in pesticide usage, and continued mission effectiveness.

Action	OPR	Completion Date Estimated	Actual
Develop recommendations for reducing pesticide use.	88 ABW/EM	Mar 96	Mar 96
Brief Wing Commander.	88 ABW/EM	Apr 96	Apr 96
Select most cost-effective options that will achieve reduction goal.	88 ABW/CC	May 96	May 96
Continue to re-evaluate and prioritize options to maintain most cost-effective pest management program.	88 ABW/EM 88 CEG/CEOGE 88 SPTG/SVBG	As needed	

1.6 PROGRAM

A draft MAP has been circulated and reviewed by affected organizations on base. The final MAP, incorporating comments from base reviewers, will be put in place as part of the pest management program at WPAFB. The Pest Management Plan will be amended, adding the solutions identified through the OA and decision document process and described in this MAP.

Action	OPR	Completion Date	
		Estimated	Actual
Circulate Draft MAP for review by affected organizations.	88 ABW/EM	July 96	August 96
Prepare final MAP.	88 ABW/EM	Sept 96	
Adopt MAP as part of Pest Management Plan.	88 ABW/EM	Oct 96	
Re-evaluate MAP options and implementation strategy as part of periodic updating of Pest Management Plan.	88 ABW/EM	Annually	

1.7 EXECUTION

88 ABW/EM will have responsibility for ensuring that the Pest Management Plan is updated to reflect the practices described in the MAP, and that all practices are implemented in accordance with the plan.

Action	OPR	Completion Date	
		Estimated	Actual
Update Pest Management Plan to reflect MAP.	88 ABW/EM	Oct 96	
Establish schedule for revising/updating Pest Management Plan.	88 ABW/EM	Oct 96	
Implement pesticide reduction projects incorporated in Pest Management Plan.	88 CEG/CEOG 88 CEG/CEOGE 88 SPTG/SVBG	As scheduled in MAP	

1.8 METRICS AND REPORTING

Once the steps to implement the pesticide reduction practices have been taken, it is important to monitor progress and track pesticide usage accurately and consistently to ensure that established goals will be met. WPAFB has an in-place system for quarterly and annual reporting of pesticide usage. Pesticide use by the Pest Management Shop (88 CEG/CEOGE) is reported using the Work Information Management System (WIMS) database. Pesticides used at the golf courses are reported on DD Form 1532. Pesticides applied by contractors are reported under the terms of the contract. 88 CEG/CEOGE has been the focal point for compiling pesticide use data for the entire base. Quarterly and annual pesticide use data are reported to HQ AFMC/CEVC.

Actual reported pesticide use should be compared to use estimated in the MAP and to FY 2000 goals for reduction. Options should be re-evaluated if reported use significantly exceeds estimated use.

Action	OPR	Completion Date	
		Estimated	Actual
Establish review process for evaluating monitoring data.	88 CEG/CEOGE	Oct 96	
Prepare quarterly pesticide usage reports.	88 CEG/CEOGE	Quarterly	

Prepare annual pesticide usage reports.	88 CEG/CEOGE	Annually
Compare actual pesticide use to use estimated in MAP and to FY 2000 goal.	88 CEG/CEOGE	Annually
Adjust practices as necessary to meet goal.	Various	As needed

2.0 PROGRAM

This section summarizes the pesticide reduction program and the actions required to implement the projects for the various pest management practices. The alternative for each pest management practice is described briefly, and the costs, benefits (reduction in pounds AI), actions, office of primary responsibility (OPR), and estimated schedule for completion of the steps required to implement the new practices are presented in table form.

The calculated baseline pesticide usage in FY 93 at WPAFB was 4,586 pounds AI. Reduction by 50 percent to meet the goal set by MOM 2 would result in application of 2,293 pounds AI in FY 2000. Table 2-1 summarizes the FY 93 baseline usage, the estimated use assuming implementation of the recommended alternatives, and the estimated reduction in usage from FY 93 (benefit) for each practice. As the table shows, if WPAFB implements all of the recommended practices, it would exceed the required 50 percent reduction, achieving an estimated reduction of 56 percent. Recognizing that some practices may exceed the estimated use, this program should still allow the base sufficient flexibility to meet the reduction goal by FY 2000.

Table 2-1. Pesticide Reduction Benefits (Pounds AI)

Pest Management Practice	Baseline Usage FY 93	Estimated Use FY 2000[a]	Benefit (Reduction)	Percent of Total Reduction
VIP turf areas (herbicides)	329	45	284	11
Bare ground/fence lines (herbicides)	877	509	368	14
Golf course turf (herbicides)	524	484	40	2
Fungicides (golf courses)	1,307	731	576	22
Adult Japanese beetles	55	8	47	2
Japanese beetle larvae (non-golf course)	[c]	18	[c]	NA
Japanese beetle larvae (golf courses)	101	51	50	2
Cutworms (golf courses)	137	13	124	5
Termites (MFH)	261	1	260	10
Miscellaneous[b]	995	159	836	32
Total	4,586	2,019	2,585	

(a) Assumes that all alternatives recommended in this document are implemented.
(b) Other pesticide uses not addressed in this MAP, including use of *Bacillus thuringiensis* (Bt) instead of malathion to control mosquitoes and termination of lawn care contract.
(c) No usage in FY 93 because that was the first year the beetles were identified on base. Use in FY 94 was 112 pounds AI, and in FY 95 was 138 pounds AI.
MFH = military family housing

Table 2-2 shows the estimated costs of the recommended alternatives, compared to estimated current costs for implementing each pest management practice. Annual costs include material and labor costs. It is anticipated that the cost of materials and labor will increase over the next 5 years. The increase cannot be predicted accurately, but inflation factors are expected to affect all costs equally. All costs in this document are presented in FY 96 dollars. Where implementing a recommended alternative would require a capital cost, it is shown, as is the return on investment (ROI) each year. Overall annual costs for materials and labor for the WPAFB pesticide program are estimated to decrease by about $7,000, or 3.5 percent; annual costs would increase for some individual practices and would decrease for other practices. Capital costs ($8,000) would be required only for fungicide use on the golf courses, and ROI should be 100 percent within the first year.

Table 2-2. Estimated Pesticide Reduction Costs

Pest Management Practice	Current Annual Cost (1,000)	Cost of Alternative (1000) in FY 2000[a] Capital	ROI	Annual	Change (1,000)
VIP Turf Area	$35[b]	NA	NA	$59	+$24
Bare Ground/Fence Lines	$17[b]	NA	NA	$14	-$3
Adult Japanese beetles	$9[c]	NA	NA	$17	+$8
Japanese beetle larvae (non-golf course)	$4[b]	NA	NA	$7	+$3
Golf Course Turf	$12	NA	NA	$15	+$3
Fungicides (golf courses)	$49	$8	100%	$28	-$21
Japanese beetle larvae (golf courses)	$35[b]	NA	NA	$24	-$11
Cutworms (golf courses)	$9	NA	NA	$7	-$2
Termites (MFH)	$27	NA	NA	$19	-$8
Total	$197	$8	100%	$190	-$7K

(a) Costs of materials and labor in FY 96 dollars. Assumes that all alternatives recommended in this document are implemented.
(b) FY 93 cost data not available; FY 95 data used for comparison.
(c) FY 93 cost data not available; FY 94 data used for comparison.
MFH = military family housing
NA = not applicable
ROI = return on investment

88 SPTG/SVBG has elected to defer implementation of portions of three recommended alternatives for the golf course, as follows:

- A low-AI fungicide will be added to the fungicide regimen in FY 97; use of Envirocaster® disease prediction model and Reveal® soil test kits to help reduce application of fungicides will be deferred.

- A low-AI insecticide will be used to control Japanese beetle larvae in FY 97; application of beneficial nematodes will be deferred.

- A low-AI insecticide will be used to control cutworms in FY 97; application of beneficial nematodes will be deferred.

Pesticide usage in FY 97 will be reviewed and, if usage has not decreased significantly, implementation of the deferred portions of these alternatives will be considered for FY 98. Table 2-3 presents usage estimates for these three alternatives, showing estimated use in pounds AI for both partial and full implementation of these alternatives. If the deferred processes are not implemented, the estimated total pesticide use at WPAFB in FY 2000 would be 2,569 pounds AI. This would represent only a 44 percent reduction from the FY 93 baseline, and would not allow the base to meet the 50-percent reduction goal.

Table 2-3. Golf Course Pesticide Use Comparison for Deterred Alternatives

Alternative	Partial Implementation Process	Pounds AI	Full Implementation Process	Pounds AI
Fungicides	Sentinel® only	1,218	Sentinel®, Envirocaster®, and Reveal® test kits	731
Japanese Beetle Larvae	Tempo® only	101	Tempo® and nematodes	51
Cutworms	Merit® only	26	Merit® and nematodes	13

Table 2-4 presents a comparison of estimated costs for partial and full implementation of the three alternatives. Full implementation of these alternatives would result in an annual cost savings of $34,693 compared to partial implementation, primarily through reduction in the amount of pesticides that would be applied.

Table 2-4. Golf Course Cost Comparison for Deterred Alternatives

	Partial Implementation		Full Implementation	
Alternative	Process	Cost	Process	Cost
Fungicides	Sentinel® only	$44,018	Sentinel®, Envirocaster®, and Reveal® test kits	$28,377
Japanese Beetle Larvae	Tempo® only	$41,287	Tempo® and nematodes	$23,632
Cutworms	Merit® only	$8,402	Merit® and nematodes	$7,005

2.1 INCREASE IN FERTILIZATION AND AERATION OF VIP TURF AREAS AND DECREASE IN AREA TREATED, WITH SPOT TREATMENTS

Current Process: The current management practice consists of applying a "weed and feed" pre-emergent herbicide with a fertilizer mixture (granular) in the spring, and applying a post-emergent herbicide (Strike-3®), a phenoxy mixture containing 2,4-D with other chemicals, as needed in certain areas for the remainder of the season, usually at least twice during the year. In FY 93, use was lower than normal (329 pounds AI), due to budget constraints. In FY 95, essentially all of the VIP areas were treated, and a total of 2,115 pounds AI were applied; approximately $35,000 was expended ($23,000 for materials and $12,000 for labor).

In fall 1995 88 CEG/CEOG initiated a program of aeration and application of an organic fertilizer (Milorganite®, a 6:2:0 formulation) on the VIP areas. 88 CEG/CEOG is continuing to experiment with different fertilizer formulations (test plots). Mowing heights are maintained at an appropriate height of approximately 3.5 inches.

New Process: The new process entails continuing the fertilization and aeration program started in late 1995, reducing the area treated, and gradually eliminating the spring broadcast application of the herbicide/fertilizer mixture. Increased fertilization and aeration will increase turf health and decrease weed infestation within the areas formerly treated with herbicides. Spot herbicide treatment would control sporadic weed occurrences.

The VIP acreage that has been treated with herbicides and more intensely maintained will be reduced in size by about 35 percent. The specific areas to be treated will be identified each year by 88 CEG/CEOG, based on factors such as use of VIP Routes and nearby facilities, turf condition, and seasonal climate conditions (rainfall, temperature).

The proposed fertilization program should continue the program initiated by 88 CEG/CEOG and expand the application to cover all the selected VIP Route areas (approximately 300 acres). In general, the proposed program should consist of application of approximately 3.5 pounds of nitrogen per 1,000 square feet of turf annually, using slow-release formulations in three applications, including a critical late fall application. The type of fertilizer used will depend on the seasonal timing of application, turf condition and location, and results of soil tests. Use of an organic product, such as the Milorganite® that is currently used by 88 CEG/CEOG, can be continued in selected areas; for the purposes of developing this program, it is assumed that approximately 50 acres would be treated with Milorganite® or a similar product in the spring and fall, at an application rate of 2.7 lbs./1,000 sq.ft./yr. The remainder of the VIP Route turf (250 acres) would be treated with higher nitrogen (30 percent N) fertilizer blends that can supply the required amount of nitrogen using far less product and at a lower cost, and yet should not cause burning or desiccation problems in non-irrigated turf. The spring “weed and feed” application (supplying approximately 1 lb. N/1,000 sq. ft.) should be applied for the first 2 years over all 300 acres, then phased out and replaced with a spring fertilization only, as the turf health and density improves.

The proposed fertilization program is outlined in Table 2-5 by calendar year. The specific fertilizer recommendations were developed in consultation with several local experts to meet the 3.5 pounds nitrogen/1,000 square feet/year goal, using formulations that would be the least expensive, but that should not cause burn or salt buildup problems in non-irrigated turf. The fertilizer blends listed in Table 2-5 are available from Coop Suppliers - e.g., Agri Urban, Lebanon, Ohio; Buckeye Country Mart, Zenia, Ohio. The program may need to be fine-tuned or otherwise modified, depending on results, and some possible substitute products are listed in footnotes; however, the substitute products would be more expensive than the products presented in the table. The program should

Table 2-5. Proposed Fertilization Program

Calendar Year	Application Time		
	March/May	August/September	October/December
1997	"Weed and Feed" (300 ac.) Terra 25-3-5[(a)] (Milorganite® -50 ac.- late May to June)[(d)]	50% slow release[(b)] 30-3-10 blend (250 ac.)	20% slow release[(c)] 30-3-10 blend (250 ac.) (Milorganite - 50 ac.)
1998	"Weed and Feed" (300 ac.) Terra 25-3-5 (Milorganite® -50 ac.- late May to June)	50% slow release 30-3-10 blend (250 ac.)	20% slow release[(c)] 30-3-10 blend (250 ac.) (Milorganite - 50 ac.)
1999	50% slow release 30-3-10 blend (250 ac.) (Milorganite® - 50 ac.)	50% slow release 30-3-10 blend (250 ac.)	20% slow release[(c)] 30-3-10 blend (250 ac.) (Milorganite - 50 ac.)
2000	50% slow release 30-3-10 blend (250 ac.) (Milorganite® - 50 ac.)	50% slow release 30-3-10 blend (250 ac.)	20% slow release[(c)] 30-3-10 blend (250 ac.) (Milorganite - 50 ac.)

(a) Or appropriate substitute "Weed and Feed"-type product.
(b) Possible substitutions:
 1) Scott's 25-3-10 100% Polycoat with 2% Iron - $0.37/lb (military rate)
 2) Scott's 30-3-9 50% Polycoat
 50% Sulfur-coated urea
 with 2% Iron- $0.26/lb. (military rate)
(c) The "slow release" nitrogen is sulfur-coated urea, which also has a polymer coat called "PolyPlus." Recommendation of 20% slow release for late fall is based on desire for plants to take up all the nitrogen supplied, so little is lost through leaching after plants are dormant. If application occurs in the earlier part of the late fall period, a higher slow release percentage could be used. Other N:P:K ratios could also be considered, depending on soil analysis and budget (e.g., 46-0-0).
(d) For FY 97, it is assumed that 88 CEG/CEOG will apply Milorganite® on 50 acres in fall 1996, but that the full program would not be implemented until calendar year 1997.

be reviewed annually, along with results of test plots, so that appropriate modifications can be made as needed.

Local Extension and fertilizer company experts who were consulted to develop the recommended program are listed below, and may be contacted for assistance and advice as the program is implemented over the next few years.

Gerry Mahan
Greene Co. Extension
(513) 372-9971

Terry Burns
Plant Pathologist
Agri Urban
Lebanon, Ohio
1-800-354-0435

Cindy Flack
Scott's Pro Turf
Marysville, Ohio
1-800-543-0006 (x 7514)

John Street
Ohio State University Extension
(614) 292-9091

Bill Pound
Ohio State University Extension

(614) 292-9090

The turf should be aerated at least once a year, generally in the spring. A fall aeration can also be considered if budget allows. It is assumed that periodic spot treatments of herbicide will be needed on approximately 10 percent of the total area treated, or approximately 30 acres, each year. The herbicide used should be selected based on the weed species present. Assuming many of the weeds will be dandelions and other broadleaf species, a product such as Strike 3® can continue to be used for spot treatments. The Strike 3® would be applied in a similar manner to that used in current program herbicide applications. The fertilization and aeration program will use equipment already available in Grounds Maintenance.

Pesticide Reduction Goal: Increased fertilization and aeration and reduction of maintained VIP areas, with spot treatments as needed, will reduce annual herbicide application for control of turf weeds from 329 pounds AI (FY 93) (2,115 pounds AI in FY 95) to an estimated 45 pounds AI (spot treatments) by FY 2000.

Costs: Strike 3® cost is $2.32/lb.; application rate is 3 lbs./ac.; 30 acres spot-treated; labor requirement for spot treatment is 1 hr./ac.; fertilizer cost is $7/50-lb. bag ($0.14/lb.) for Milorganite®; an average of $0.17/lb. for bulk purchase of slow-release, 30-percent nitrogen (N) fertilizer blends available from local Co-ops; fertilizer application is 3.5 lb. N/1,000 ft^2/yr; labor requirement for fertilization is 0.25 hr./ac.; fertilization done three times/year; aeration labor requirement is 0.5 hr./ac.; aeration done once per year; labor rate is $15/hr.

Increased fertilization will probably result in the need for more frequent mowing (assuming sufficient rainfall). The increase in mowing frequency will depend on many factors including type of grass, type of fertilizer used, mowing height, and especially rainfall and temperature. If a "typical" year involves approximately 24 mowings from mid-April through mid-October, and fertilization increases that by 1/3, then 8 more mowings can be expected. An additional 8 mowings would increase costs as follows: (0.5 hr./ac.) (300 ac.)(8)($15/hr.) = $18,000

Annual Operating Cost = (1) Fertilization Cost + (2) Aeration Cost + (3) Spot Treatment Cost + (4) Additional Mowing Cost:

<u>FY 97 - Annual Operating Cost</u>

1A) Fall and Spring Fertilization w/Milorganite® (assume 2.7 lbs. N/1000 sq.ft.):
(98,000 lbs. Milorganite®)($0.14/lb.) + (50 ac.)(0.25hr./ac.)(2 times)($15/hr.) =
$13,720 + $375 = $14,095

1B) Spring Weed and Feed (assume 1 lb. N/1000 sq.ft.):
(52,200 lbs. 25% N product)($0.24/lb.) + (300 ac.)(0.25hr./ac.)($15/hr.) =
$12,528 + $1125 = $13,653

1C) Late Summer Fertilization (assume 1 lb. N/1000 sq.ft.):
(36,250 lbs. 30% N product)($0.17/lb.) + (250 ac.)(0.25 hr./ac.)($15/hr.) =
$6163 + $938 = $7101

Fertilization Total = $14,095 + $13,653 + $7101 = $34,849

2) Aeration Cost = (0.5 hr./ac.)(300ac.)(1 time)($15/hr.) = $2,250

3) Spot Treatment Cost = ($2.32/lb.)(3lbs./ac.)(30 ac.) + (1hr./ac.)(30 ac.)($15/hr.) =
$209 + $450 = $659

4) Additional Mowing Cost = $18,000 (see above)

FY 97 TOTAL = $34,849 + $2,250 + $659 + $18,000 = $55,758

FY 98 - Annual Operating Cost

1A) Fall and Spring Fertilization w/Milorganite® = $14,095 (see FY 97)

1B) Spring Weed and Feed = $13,653 (see FY 97)

1C) Late Summer Fertilization = $7,101 (see FY 97)

1D) Late Fall fertilization (assume 1.5 lb N/1000 sq.ft.):
(54,500 lbs. 30% N product)($0.17/lb.) + (250 ac.)(0.25 hr./ac.)($15/hr.) =
$9,265 + $938 = $10,203

Fertilization Total = $14,095 + $13, 653 + $7,101 + $10,203 = $45,052

2) Aeration Cost = $2,250 (see FY 97)

3) Spot Treatment Cost = $659 (see FY 97)

4) Additional Mowing Cost = $18,000 (see FY 97)

FY 98 TOTAL = $45,052 + $2250 + $659 + $18,000 = $65,961

FY 99/00 - Annual Operating Cost

1A) Fall and Spring Fertilization w/Milorganite® = $14,095 (see FY 97)

1B) Spring Fertilization (not Weed and Feed) = same as Late Summer Fertilization = $7,101

1C) Late Summer Fertilization = $7,101 (see FY 97)

1D) Late Fall fertilization = $10,203 (see FY 98)

Fertilization Total = $14,095 + 2($7,101) + $10,203 = $38,500

2) Aeration Cost = $2,250 (see FY 97)

3) Spot Treatment Cost = $659 (see FY 97)

4) Additional Mowing Cost = $18,000 (see FY 97)

FY 99/2000 TOTAL = $38,500 + $2,250 + $659 + $18,000 = $59,409

Table 2-6. VIP Routes Program - Costs and Benefits

(FY) Project Title	ROI	Cost[a]	Benefit (lbs. AI/yr.)
(FY 97) Increased fertilization/ aeration with Weed and Feed; reduced area; spot herbicide application	NA	$55,758	(b)
(FY 98) Increased fertilization/ aeration with Weed and Feed; redid area; spot herbicide application	NA	$65,961	(b)
(FY 99) Increased fertilization/ aeration without Weed and Feed; reduced area; spot herbicide application	NA	$59,409	284
(FY 00) Increased fertilization/ aeration without Weed and Feed; reduced area; spot herbicide application	NA	$59,409	284

(a) FY 96 dollars.

(b) Estimated use is 645 pounds AI. This represents a decrease from FY 95 use (2,115 pounds AI), in which all VIP areas were treated; however, this usage is greater than that in FY 93 (329 pounds AI), when usage was unusually low.

NA = not applicable

ROI = return on investment

Table 2-7. VIP Routes Program Execution

Action	OPR	Completion Date Estimated	Completion Date Actual
Initial: Conduct any soil tests needed and evaluate test plot data to select best fertilizer	88 CEG/CEOG	Oct 1996	
Initial: Train staff on correct application of selected fertilizer	88 CEG/CEOG	Feb 1997	
Recurring: Order fertilizer and herbicide (Strike 3®)	88 CEG/CEOG Base Supply	as needed	
Recurring: Identify acreage to be treated	88 CEG/CEOG	Nov	
Recurring: Aerate turf	88 CEG/CEOG	Mar-Apr	
Recurring: Apply Weed and Feed (first 2 years) on 300 acres	88 CEG/CEOG	Apr - May	
Recurring: Apply Milorganite® on select areas (50 acres)	88 CEG/CEOG	May - June	
Recurring: Apply herbicide in spot treatment	88 CEG/CEOGE	as needed (June-Sept)	
Recurring: Apply 30%N fertilizer to 250 acres	88 CEG/CEOG	Aug - Sept	
Recurring: Apply fertilizer to 250 acres, Milorganite® to select areas (50 acres)	88 CEG/CEOG	Oct - Dec	
Recurring: Evaluate program and modify as necessary; eliminate Weed and Feed treatment in FY 99 or FY 00	88 CEG/CEOG 88 CEG/CEOGE	Oct - Dec	

OPR = office of primary responsibility

2.2 USE OF HERBICIDES WITH LOWER PERCENT ACTIVE INGREDIENT (AI) FOR BARE GROUND AND FENCE LINE CONTROL

Current Process: Currently, 88 CEG/CEOGE uses a number of herbicides for bare ground control. The herbicides used vary depending on the location and type of vegetation present in and around the treatment area. Generally, nonselective, bromacil-based soil sterilant formulations, either in liquid or granular form, are used in areas where there is no sensitive nontarget vegetation nearby and where long-lasting control is desired. The two products used most often for this treatment are Hyvar XL® and Borocil®. These products are very effective; however, they are applied in relatively large quantities (pounds AI per acre). Typical application rates are 16 pounds per acre of Hyvar® and 98 pounds per acre of Borocil® (which contains a large percentage of a borate compound).

In areas where sensitive, nontarget vegetation is present or nearby, or there are roots underneath the treatment area, either Roundup® or a Roundup®/Surflan® mix (liquid spray) has been used. These products contain glyphosphate and oryzalin, respectively. They do not have a long persistence or soil activity and are therefore safer to use in areas where sensitive vegetation is an issue. These chemicals are applied in a broadcast spray or granular application, except for smaller areas and treatment of cracks, which would receive a narrower spray from spot treatment such as spray guns.

For fence lines, current practice is to use essentially the same bromocil-based herbicides that are used for bare ground control, primarily Hyvar XL® and Roundup®. In FY 93, a total of 877 pounds AI were applied for bare ground and fence line vegetation control, at an approximate cost of $17,000 ($13,000 for materials and $4,000 for labor).

New Process: There are several herbicides available that provide nonselective control of weeds and grasses commonly present at the target bare ground control areas and along fence lines. The best combination of herbicides for this use depends greatly on the type of vegetation to be controlled, the need for bare ground conditions or low vegetation height, and the presence of sensitive nontarget vegetation. At WPAFB, the most common weeds to be controlled in target bare ground areas include common turf grasses (bluegrass, ryegrass), Johnson grass, chickweed, knotweed, dandelion, and other broadleaf weeds and annual grasses, such as crabgrass. In pavement cracks, grasses and knotweed are the most common weeds. Along fence lines, grasses are the primary target for vegetation control.

The new process consists of using the Roundup®/Surflan® application on approximately 20 percent of the total acreage to be treated for bare ground control, but replacing the currently used bromocil-based herbicides with two lower-AI herbicide mixes for bare ground and fence line control. These mixes will control the primary target species and provide as long-lasting control as is possible without including a large quantity of bromocil or diuron. The new tank mixes will be applied using the same method and equipment as the currently used herbicides.

The first proposed mix would be used on approximately 80 percent of the total acreage to be treated for bare ground control. This mix consists of an Arsenal®/diuron mixture that is purchased as a Co-Pack (tradename Sahara®), plus 3 ounces of Oust® per acre. Adjuvants/surfactants should be added, per label directions. The Co-Pack consists of 1.125 gallons Arsenal® (imazypyr), plus two 11.25-pound packages of diuron. The application rate suggested by the manufacturer (American Cyanamid) is one Co-Pack for every 3 acres. However, the proposed mix includes 3 ounces of Oust® per acre (sulfometuron methyl; manufactured by DuPont). Therefore, the application rate can be decreased to 4 acres per Co-Pack (plus 12 ounces of Oust®), in an attempt to reduce pounds AI, while still maintaining good control. This mix was one combination proposed by a representative of Weeds, Inc., and a representative of American Cyanamid agreed that it was a good starting point for the new program, given the required reduction in pounds AI. The overall application rate would be 5.2 pounds AI per acre.

The second new mix consists of 3 pints of Arsenal® (imazypyr) and 3 ounces of Oust® (sulfometuron methyl) per acre. This mix results in an application rate of 0.89 pound AI per acre. It is recommended that this mix be used along fence lines where it should provide more than adequate control, retarding the growth of grasses but not eliminating all vegetation. The mix should be applied carefully and not near sensitive vegetation or on steeply sloped areas, because the Oust® can move off site. It is also recommended that this mix be applied in some test plots where bare ground conditions are desired. If it is found to provide adequate control in other areas, then it can be used more widely in the future, because it has a very low application rate.

The two lower-AI mixes described above are a starting point for the new process, but 88 CEG/CEOGE may need to consider other mixtures following observation of results or test plots, especially where absolute bare ground conditions are needed or where areas have not been treated recently and have become overgrown. Selecting the best mixture to provide control at low application rates will probably involve trial-and-error to some extent; the program should include a protocol for monitoring and use of test plots. In locations with overgrown conditions, an initial treatment with a longer-lasting, higher-AI mix may be needed for control, subsequently using the lower-AI mixes for maintenance to meet the FY 2000 reduction goal.

If results from the first year of the new process are not acceptable, then 88 CEG/CEOGE should consider consulting with herbicide company representatives and/or independent herbicide consultants, such as Weeds, Inc. (Mr. Brian O'Neill, [215] 727-5539), or CDC Chemical (Mr. Dave Schoonover or Mr. Larry Sharp, [540] 992-5766). The consultants may charge a fee for their services, but they are not associated with any particular herbicide manufacturer and can perhaps offer a broader, less biased recommendation. In addition, Table 4-2 in the *Opportunity Assessment for Pesticide Reduction at Wright-Patterson AFB, Ohio,* presents alternative herbicide mixtures to reduce the amount of AI used for bare ground control. These mixes can be considered for use as appropriate at different locations on the base.

Pesticide Reduction Goal: Assuming 100 acres are treated annually for bare ground control (20 with Roundup®/Surflan® and 80 with the new Sahara®-Oust® mix), and 15 acres are treated annually along fence lines, the new process will involve the following amounts of AI:

Roundup®/Surflan® - 80 lbs.
New Sahara®/Oust® Mix - 416 lbs.
Arsenal®/Oust® Mix - 13 lbs.

The total of 509 pounds AI would be a reduction of 368 pounds AI from FY 93 usage of 877 pounds AI for bare ground and fence line vegetation control.

Costs: Cost of herbicides is Sahara® = $246/Co-Pack; Oust® = $10/ounce; Roundup® = $27/gal.; Surflan® = $83/gal.; Arsenal® = $210/gal.; Roundup®/Surflan® mix is applied at 1 gal./ac. total; Sahara®/Oust® mix is applied at 1 Co-Pack/12 oz. Oust® over 4 ac. area; Arsenal®/Oust® mix is applied at 3 pts. Arsenal® plus 3 oz. Oust®/ac.; labor requirement is 2 hrs./ac. except for fence lines (5 hrs./ac.), labor rate is $15/hr.; one application/year; 100 acres treated for bare ground and 15 acres for fence line control.

Annual cost = (1) cost of Roundup®/Surflan® mix on 20 ac. + (2) cost of new Sahara®/Oust® mix on 80 ac. + (3) cost of new Arsenal®/Oust® mix on 15 ac.

(1) ($27/gal.)(1/2 gal./ac.)(20 ac.) + ($83/gal.)(1/2 gal./ac.)(20 ac.) + (2 hrs./ac.)(20 ac.)($15/hr.) = $1,100 + $600 = $1,700

(2) ($246/Co-Pack)(1 Co-Pack/4 ac.)(80 ac.) + ($10/oz.)(12 oz. Oust®/4 ac.)(80 ac.) + (2 hrs./ac.)(80 ac.)($15/hr.) = $4,920 + $2,400 + $2,400 = $9,720

(3) ($210/gal.)(0.375 gal. (3 pts.)/ac.)(15 ac.) + ($10/oz.)(3 oz./ac.)(15 ac.) + (5 hrs./ac.)(15 ac.)($15/hr.) = $1,181 +$450 + $1,125 = $2,756

Total annual cost = $1,700 + $9,720 + $2,756 = $14,176

Table 2-8. Bare Ground and Fence Line Program - Costs and Benefits

	Annual	Benefit

Project Title	ROI	Cost[a]	(lbs. AI/yr.)
(FY 97) Use of lower AI herbicides	NA	$14,176	368
(FY 98) Use of lower AI herbicides	NA	$14,176	368
(FY 99) Use of lower AI herbicides	NA	$14,176	368
(FY 00) Use of lower AI herbicides	NA	$14,176	368

(a) FY 96 dollars.
NA = not applicable
ROI = return on investment

Table 2-9. Bare Ground and Fence Line Program Execution

Action	OPR	Completion Date: Estimated	Completion Date: Actual
Initial: Train applicators on new herbicide mixes - label, precautions, mix, application techniques, and rates	88 CEG/CEOGE	Feb 1997	
Recurring: Purchase new herbicides (Sahara®, Oust®, and Arsenal®, plus any needed Roundup® and Surflan®, including MSDSs	88 CEG/CEOGE Base Supply - HAZMAT cell	as needed	
Recurring: Identify areas to be treated (including selected test plots)	88 CEG/CEOGE	April	
Recurring: Apply herbicides to identified areas	88 CEG/CEOGE	May - July	
Recurring: Evaluate treated areas, effectiveness of new mixes (reapply as needed)	88 CEG/CEOGE	June - Oct	
Recurring: Consult with chemical company or herbicide consultant representatives regarding results; make adjustments in mix and/or arrange for test plots of alternative herbicides for next fiscal year, if necessary	88 CEG/CEOGE	Oct	

MSDS = material safety data sheets
OPR = office of primary responsibility

2.3 USE OF SYNTHETIC PYRETHROIDS (TEMPO®) FOR ADULT JAPANESE BEETLE CONTROL

Current Process: Personnel at WPAFB noted the arrival of the Japanese beetle population beginning in or just before FY 93. The primary products used for control of adult beetles are Orthene® (acephate) around the base grounds and Sevin® (carbaryl) on the golf courses. Both products are applied in a spray directed at the affected vegetation, most commonly using a hand-held spray gun. In FY 93, very little spraying for adult Japanese beetles was done, since this was the first year the beetles were observed and their occurrence was low. In FY 94, insecticide applications totaled 49 pounds AI by 88 CEG/CEOGE (covering approximately 2,000 trees) and 118 pounds AI by 88 SPTG/SVBG; the total cost was approximately $9,000 ($3,000 for materials and $6,000 for labor).

New Process: The recommended new process is use of a synthetic pyrethroid pesticide called Tempo®, which involves much less AI than the currently used products and provides the control desired. This product is available from Bayer Specialty Products (Miles, Inc.) and contains the active ingredient cyfluthrin. It is mixed at a ratio of 1.9 ounces to 100 gallons of water; an adjuvant (adhesive) should also be added per label directions. Tempo® is applied in the same manner as the currently used pesticides. At the recommended application rate, 100 gallons of this mixture, applied with a spray applicator, can cover approximately 20 trees. Synthetic pyrethroids are more potent than either chemical currently used by WPAFB, and they are equally safe to mammals and birds.

Pesticide Reduction Goal: The use of Tempo® will reduce pesticide application for adult Japanese beetle control from 167 pounds AI in FY 94 to approximately 8 pounds for a typical application (approximately 5 pounds on the golf courses and less than 3 pounds on the rest of the base grounds), since Tempo® has a very low percentage AI and a low application rate (0.0002 pound AI per gallon of spray).

Costs: Cost of Tempo® is $49/lb.; spray mix is 0.12 lb. (1.9 oz.) Tempo® per 100 gal. of water; spray is applied at rate of 5 gal. per tree; 2,000 trees sprayed/year on the grounds by 88 CEG/CEOGE and approximately 4,000 trees sprayed on the golf courses (based on reference year total usage); labor requirement is 10 min. per tree; labor rate is $15/hr.; one application/year.

Annual Cost = ($49/lb.)(0.12 lb./100 gal.)(5 gal./tree)(6,000 trees)(1 application/year) + 1,000 labor hrs. ($15/hr.) = $1,764 + $ 15,000 = $16,764

Table 2-10. Adult Japanese Beetles Program - Costs and Benefits

Project Title	ROI	Annual Cost[(a)]	Benefit (lbs. AI/yr.)
(FY 97) Use synthetic pyrethroids (Tempo®)	NA	$16,764	47
(FY 98) Use synthetic pyrethroids (Tempo®)	NA	$16,764	47
(FY 99) Use synthetic pyrethroids (Tempo®)	NA	$16,764	47
(FY 00) Use of synthetic pyrethoids (Tempo®)	NA	$16,764	47

(a) FY 96 dollars.
NA = not applicable
ROI = return on investment

Table 2-11. Adult Japanese Beetles Program Execution

Action	OPR	Completion Date Estimated	Completion Date Actual
Recurring: Obtain supply of Tempo®, including MSDS	88 CEG/CEOGE, 88 SPTG/SVBG, Base Supply, HAZMAT cell	as needed	
Initial: Train applicators on Tempo® precautions, mix, application techniques	88 CEG/CEOGE, 88 SPTG/SVBG	Feb 1997	
Recurring: Identify areas to be treated	88 CEG/CEOGE, 88 SPTG/SVBG	Mar	
Recurring: Treat affected vegetation	88 CEG/CEOGE, 88 SPTG/SVBG	July	
Recurring: Evaluate effectiveness of Tempo® application; reapply if necessary	88 CEG/CEOGE, 88 SPTG/SVBG	July - Aug	

MSDS = material safety data sheets
OPR = office of primary responsibility

2.4 USE OF MERIT® AND REDUCED TREATMENT AREA FOR CONTROL OF JAPANESE BEETLE LARVAE® (NON-GOLF COURSE)

Current Process: Currently, 88 CEG/CEOGE is using primarily Oftanol® (isofenphos) for larvae control. The chemical is applied over affected turf using either a boom or spray gun, depending on the size of area to be treated. Areas commonly sprayed for the control of grubs are grassy areas, and beneath and in the near vicinity of trees and shrubs infested with the adult beetles. In FY 95, both Oftanol® (88 pounds AI) and carbaryl (50 pounds AI) were applied, covering a total area of 94 acres, at an approximate cost of $4,100 ($2,700 for materials and $1,400 for labor).

New Process: The recommended new process is use of Merit®, combined with a reduction in the area treated. Merit® (imidacloprid) is a synthetic pyrethroid pesticide that is currently being used successfully on the WPAFB golf courses. Merit® is available from Miles Corporation, Inc., and is applied at a rate of 6.4 ounces per acre (Merit® 75 WSP) at a cost of approximately $100 per acre. Use of Merit® is recommended for areas where control of larvae is necessary (i.e., where infestation is extensive and/or turf appearance is important). Where affected areas are less visible or turf appearance is not as important, it is recommended that chemical control be stopped, thereby reducing the treatment area. Combining the use of Merit® with a reduction in treatment area would provide the greatest reduction in pounds AI. Merit® would be applied in the same manner as the currently used chemicals.

Pesticide Reduction Goal: Using Merit® at the recommended application rate and covering the same area treated in FY 95 (94 acres) would result in a total of 28 pounds AI. Limiting the application of Merit® to localized areas where grubs are quite prevalent and/or turf appearance is of concern will further reduce the pounds AI used. Assuming a reduction of approximately 35 percent of the 94 acres treated in FY 95, approximately 18 pounds AI would be applied over 61 acres.

Costs: Cost of Merit® application is $100/ac.; 61 ac. treated; labor requirement is approximately 1 hour/ac.; labor rate is $15/hr.; one application/year.

> Total annual cost = ($100/ac.)(61 ac.)(1 application/year) + (30.5 hrs.)($15/hr.) = $6,100 + $915 = $7,015

Table 2-12. Japanese Beetle Larvae Program - Costs and Benefits

Project Title	ROI	Annual Cost[(a)]	Benefit (lbs. AI/yr.)
(FY 97) Use Merit® on more limited treatment area	NA	$7,015	(b)
(FY 98) Use Merit® on more limited treatment area	NA	$7,015	(b)
(FY 99) Use Merit® on more limited treatment area	NA	$7,015	(b)
(FY 00) Use Merit® on more limited treatment area	NA	$7,015	(b)

(a) FY 96 dollars.
(b) No use in FY 93 baseline year; in FY 94 use was 112 lbs. AI; in FY 95 use was 138 lbs. AI.
NA = not applicable
ROI = return on investment

Table 2-13. Japanese Beetle Larvae Program Execution

Action	OPR	Completion Date Estimated	Completion Date Actual
Recurring: Obtain supply of Merit® including MSDS	88 CEG/CEOGE Base Supply - HAZMAT cell	as needed	
Initial: Train applicators on Merit® precautions, mix, application techniques	88 CEG/CEOGE	Feb 1997	
Recurring: Identify potential areas to be treated	88 CEG/CEOGE	May - June	
Recurring: Review areas identified and treat visible/damaged sites	88 CEG/CEOGE	July	
Recurring: Evaluate effectiveness of Merit® on treated sites	88 CEG/CEOGE	Aug	

MSDS = material safety data sheets
OPR = office of primary responsibility

2.5 REDUCE TREATED ACREAGE ON GOLF COURSE ROUGHS

Current Process: The 27-hole Wright-Patterson Golf Course (WPGC) covers approximately 268 acres, of which 204 acres are playable roughs. The 18-hole Twin Base Golf Course (TBGC) covers approximately 160 acres, of which 100 acres are playable roughs. Herbicides are sprayed primarily to control crabgrass and broadleaf weeds in the rough areas. In FY 93, the primary herbicides applied to the rough were DMA-4® and Trimec®. The sum of the FY 93 herbicide usage on the golf courses totaled 524 pounds AI; of this, 369 pounds AI were applied on the roughs. The cost of this treatment in FY 93 was approximately $12,000 ($7,000 for materials and $5,000 for labor).

New Process: Based on information provided by 88 PSTG/SVBG, it is estimated that the WPGC could reduce the treated acreage by 30 acres (15 percent) and the TBGC could reduce the treated acreage by 17 acres (17 percent) by ceasing pesticide application on portions of the roughs. The areas of rough that will no longer be treated with any pesticides may be identified with markers until the pesticide applicators become familiar with them.

The simplest and most cost-effective method of creating these naturalized areas on the roughs is to cease mowing or reduce mowing frequency and cease application of pesticides. The turf will grow longer, there would be some weeds, and the turf would become mixed with native grasses invading from nearby areas, altering the playability of these portions of the roughs. Alternatively, the areas may be seeded with wildflowers or native grasses, such as Medalist America's Scottish Links Mixture, a blend of four types of fescue that can adapt to a range of soil and climatic conditions. Appearance and playability will be factors in determining the type of vegetation that is encouraged in the naturalized areas.

As an alternative to ceasing treatment in specific areas, these areas may also be designated as 100-percent nonchemical pesticide areas. In this case, only pesticides with nonchemical AI would be used in these areas to achieve the same overall objective. Use of nonchemical pesticides would help maintain the playability of the turf while reducing the amount of chemicals applied. Nonchemical treatments that provide good results on these portions of the roughs could then be applied to other turf areas to further reduce pesticide usage.

Pesticide Reduction Goal: Total herbicide usage in the rough at WPGC (254 pounds AI) would be reduced by approximately 11 percent, or 28 pounds AI. Total herbicide usage in the rough at TBGC (115 pounds AI) would be reduced by 10 percent, or 12 pounds AI. The total new usage for both courses would be 484 pounds AI.

Costs: The annual materials cost is estimated as proportional to the decreased amount of herbicides applied.

[(484 lbs. AI)/(524 lbs. AI)] x ($12,000) = $11,084.

Labor cost is estimated based on the number of hours spent applying herbicides. If 47 acres were to be removed from the treatment acreage (considering both courses), and assuming an application rate of 2 acres per hour, labor would be reduced by 23.5 hours per treatment. Because three pesticides have been applied to these areas of the roughs, the actual reduction in labor would be three times that, or 70.5 hours. At a labor rate of $15/hour, approximately $1,058 would be saved. Based on an FY 93 labor cost of $5,000, the estimated labor cost for the new treatment area is:

$5,000 - $1,058 = $3,942.

Total annual operating costs include materials costs and labor costs:
Total annual cost = $11,084 + $3,942 = $15,026.

No capital costs would be incurred, unless portions of the naturalized roughs were to be seeded with wildflowers or native grasses to increase the resistance to insects and disease and reduce maintenance. Approximate costs would be $2,000 per acre for wildflower seeds and $600 per acre for native grasses. The cost analysis assumes no revegetation, and no capital cost.

Table 2-14. Reduce Treated Acreage on Golf Courses Program - Costs and

Benefits

Project Title	ROI	Annual Cost[a]	Benefit (lbs./yr)
(FY 97) Identify areas to be naturalized	NA	$0	
(FY 97) Herbicide application	NA	$15,026	40
(FY 98) Herbicide application	NA	$15,026	40
(FY 99) Herbicide application	NA	$15,026	40
(FY 00) Herbicide application	NA	$15,026	40

(a) FY 96 dollars.
NA = not applicable
ROI = return on investment

Table 2-15. Reduce Treated Acreage on Golf Courses Program Execution

Action	OPR	Completion Date	
		Estimated	Actual
Initial: Delineate areas to be "naturalized" and treatment (landscaping, mowing, etc.)	88 SPTG/SVBG	Sept 96	
Initial: Submit naturalization plan to base commander for approval	88 SPTG/SVBG	Nov 96	
Initial: Implement any landscaping or other treatment in identified areas	88 SPTG/SVBG	Dec 96 - March 97	
Recurring: Evaluate progress/ effectiveness of new pest control measure; modify if necessary	88 SPTG/SVBG	Sept	

OPR = office of primary responsibility

2.6 REDUCE FUNGICIDE USE ON GOLF COURSES

Current Process: In FY 93, the total fungicide usage on the golf courses was 1,307 pounds AI, at a cost of approximately $49,000 ($45,000 for fungicides and $4,000 for labor). Of the total, approximately 860 pounds AI were applied for dollar spot, at an average application rate of 2.97 pounds AI per acre. The balance of the fungicides were used primarily for control of brown patch and pythium.

Dollar spot is treated with several fungicides in rotation to prevent the disease from developing a resistance to one fungicide. These fungicides and their active ingredients are shown below.

Banner® (propiconazole)	Eagle® (myclobutanil)
Bayleton® (triadimefon)	Fore® (mancozeb)
Chipco® 26019 (iprodione)	Rubigan® (fenarimol).
Daconil® l2787 (chlorothalonil)	

The WPGC currently uses a weather station to monitor various weather parameters. This information is used by the WPGC superintendent to evaluate the most effective times to apply fungicides for preventive control of turf diseases (fungi). The TBGC does not have a similar instrument. The information is not shared between the two courses on a regular basis.

Neither course currently uses any rapid turnaround soil or turf analysis kits for the presence of disease.

New Process: Sentinel® (cyproconazole), a fungicide made by Sandoz Agro, Inc., is effective in treating dollar spot, brown patch, summer patch, gray snow mold, and pink snow mold. The recommended application rate is approximately 0.67 pound AI per acre (i.e., a reduction of 77 percent from the average application rate of the currently used fungicides). Sentinel® would be applied in the same manner as other fungicides, so no changes or additional capital expenditures would be required.

The Envirocaster® by Neogen®, Inc., is a combination weather station/disease predictor model that can predict the occurrence of pythium, brown patch, anthracnose, and seed head formation. Various modules and attachments measure the moisture of the soil at different depths to evaluate the irrigation effectiveness. The Envirocaster® also presents information necessary for predicting the growth stages of several insects, to assist in the proper timing of insecticide application.

In order for a disease to occur in turf, the climatic conditions must be correct, the turf (host) must be susceptible, and the disease must be present. Reveal® test kits, sold by Neogen®, Inc., are used to detect the presence of disease in the soil or turf. These tests can be performed on site, are completed in a short time, and no previous sampling or analytical experience is necessary. If climate conditions are correct for the cultivation of a disease (as indicated by weather station information, such as that provided by the Envirocaster®), a test can be performed to detect the presence of the disease. If the disease is present, appropriate treatment can be applied to prevent turf damage.

Pesticide Reduction Goal: Sentinel® would be included in the fungicide regimen in FY 97. Since there are currently six fungicides being used for dollar spot control, the addition of Sentinel® to the treatment rotation would result in a new seven-fungicide rotation regimen. The contribution by the original six fungicides would be 6/7 of 860 pounds AI, the current dollar spot usage. The contribution by Sentinel® would be 1/7 of the original usage (860 pounds AI) times the ratio of the application rates (i.e., 0.67/2.97). The estimated usage for controlling of dollar spot would be 770 pounds AI, a reduction of 90 pounds AI. The new total fungicide usage after including Sentinel® in the treatment rotation would be 1,218 pounds AI.

88 SPTG/SVBG has elected to defer implementation of the Envirocaster® and the Reveal® soil test kits. FY 97 fungicide use will be reviewed and use of the Envirocaster® and Reveal® test kits will be reevaluated (for implementation in FY 98) if the FY 97 fungicide use is not reduced sufficiently to assure meeting the overall 50-percent reduction by FY 2000. Based on input from superintendents who have incorporated the Envirocaster® into

their pest management routine, it is reasonable to expect that overall fungicide usage would be reduced by a minimum of 30 percent. Based on input from superintendents who have incorporated the Reveal® test kits into their pest management routine, it is reasonable to expect that overall fungicide usage would be reduced by 10 percent. Thus, total fungicide use at WPAFB would be further reduced by approximately 40 percent, to 731 pounds AI, if these two recommended alternatives were implemented in addition to using Sentinel®.

Costs: The average cost per pound of fungicide would not change significantly with the inclusion of Sentinel®. Therefore, the cost of the 1,218 pounds in fungicides that would be applied can be calculated by multiplying the ratio of the new usage (1,218 lbs. AI) to the former usage (1,307 lbs. AI) by the former cost of fungicides ($44,563):

(1,218/1,307) x $44,563 = $41,528

Treating a total area of 332 ac., at a rate of 2 ac./hr. and a labor rate of $15/hr., annual labor costs would total

[(332 ac.)/(2 ac./hr.)]($15/hr.) = $2,490.

Total annual cost = $41,528 + $2,490 = $44,018.

If the Envirocaster® and Reveal® test kits are purchased in FY 98, there would be capital costs for purchase of the Envirocaster®, but annual costs would be reduced as a result of decreased fungicide usage. The cost of the Envirocaster® is approximately $7,015, with models to predict the occurrence of brown patch, dollar spot, and seed head formation. It also includes soil moisture sensors for evaluating the effectiveness of irrigation or rain. An optional attachment for wind speed and direction costs an additional $510. There are no operations costs associated with the Envirocaster®. A new model for dollar spot should be available in the near future. Each new model will cost approximately $500.

The cost of the Reveal® test kits is approximately $17 per test. If tests are run for brown patch, dollar spot, and pythium every 2 weeks from three locations over a 24-week period, the total cost of the kits would be $1,836. There are no additional analytical or sampling costs associated with the test kits and labor is minimal.

With the use of the Envirocaster® and Reveal® test kits, the cost of fungicides is estimated by multiplying the ratio of the new usage (731 lbs. AI) to the FY 93 usage (1,307 lbs. AI) by the FY 93 cost of fungicides ($44,563):

(731/1,307) x $44,563 = $24,906

A total of 218 ac. would be treated at an application rate of 2 ac./hr. and a labor rate of $15/hr.; annual labor costs would total

[(218 ac.)/(2 ac./hr.)]($15/hr.) = $1,635.

Total annual cost = $1,836 + $1,635 + $24,906 = $28,377.

Table 2-16. Reduce Fungicide Usage Program - Costs and Benefits

Project Title	ROI	Capital Cost	Annual Cost[a]	Benefit (lbs./yr.)
(FY 97) Cost of fungicide application	NA	NA	$44,018	89
(FY 98) Purchase Envirocaster®[b]	100%	$7,015		
(FY 98) Purchase Dollar Spot Module to Envirocaster®[b]	NA	$500		
(FY 98) Cost of fungicide application and Reveal® test kits[b]	NA	NA	$28,377[c]	576
(FY 99) Cost of fungicide application and Reveal® test kits[b]	NA	NA	$28,377[c]	576
(FY 00) Cost of fungicide application and Reveal® test kits[b]	NA	NA	$28,377[c]	576

(a) FY 96 dollars.
(b) If fungicide use does not decrease significantly in FY 97, purchase of Envirocaster® and Reveal® test kits will be considered to provide further reduction.
(c) Cost represents reduction of fungicide use assuming use of Envirocaster® and Reveal® test kits. Cost without these technologies would be that shown for FY 97.
ROI = return on investment

Table 2-17. Reduce Fungicide Usage Program Execution

Action	OPR	Completion Date Estimated	Completion Date Actual
Initial: Purchase Sentinel®; identify place of Sentinel® in dollar spot treatment rotation and train personnel	88 SPTG/SVBG	Oct 1996	
Recurring: Apply fungicides	88 SPTG/SVBG	as needed	
Recurring: Evaluate progress/effectiveness of new pest control measure; review protocols, revise if necessary	88 SPTG/SVBG	Sept	
Option: Establish protocols for use of Envirocaster® and Reveal® test kits (frequency of testing, locations of soil samples, etc.)	88 SPTG/SVBG	Oct 1997	
Option: Train personnel in use of Envirocaster® and Reveal® test kits to guide fungicide application	88 SPTG/SVBG	Oct 1997	

OPR = office of primary responsibility

2.7 REDUCE INSECTICIDE USE FOR JAPANESE BEETLE LARVAE CONTROL ON GOLF COURSES

Current Process: Currently, 88 SPTG/SVBG is using several insecticides to control Japanese beetle larvae. Some of these insecticides are used for more than one target pest (i.e., cutworms). In FY 93, when the beetles first appeared on the base, 101 pounds AI were applied for beetle larvae control on the golf courses; in FY 95, this use increased to 231 pounds AI. In FY 95, 428 acres were treated, at a cost of approximately $35,000 ($32,000 for materials and $3,000 for labor). The following insecticides are used for Japanese beetle larvae control:

Dursban® (chlorpyrifos)	Sevin® (carbaryl)
Dylox® (dimethyl)	Triumph® (isazofos)
Merit® (imidacloprid)	Turcam® (bendiocarb)

New Process: The new process consists of using Merit®, the insecticide with the lowest application rate in pounds AI per acre, as the sole insecticide for Japanese beetle larvae control. Merit® will be used for Japanese beetle larvae control in FY 97.

Beneficial parasitic nematodes can be used as a nonchemical treatment to control Japanese beetle larvae. Nematodes are applied using typical pesticide application equipment with the screens removed at pressures below 300 pounds per square inch (psi). The best time to apply nematodes for Japanese beetle larvae control is in the fall. 88 SPT6/SVBG has elected to defer application of nematodes on the golf courses. Insecticide usage in FY 97 will be reviewed; if significant reduction is not demonstrated through use of chemicals alone, application of nematodes will be reevaluated for FY 98.

Pesticide Reduction Goal: If Merit® were used as the sole insecticide for Japanese beetle larvae control on the golf courses, total use would be 101 pounds AI, based on FY 95 applications. Information supplied by superintendents who have used nematodes indicates that it is reasonable to expect a reduction in insecticide use of 50 percent. This would result in a new usage of 51 pounds AI, which represents a reduction of 50 pounds AI from the FY 93 use.

Costs: The cost of Merit is $283/lb. of product, or $377/lb. AI. The cost of applying 101 lbs. AI would be $38,077.

The annual labor cost is estimated based on treating 428 ac. at an application rate of 2 ac./hr., and a labor rate of $15/hr., for an annual cost of $3,210.

Total annual costs = $38,077 + $3,210 = $41,287.

The cost of the nematodes is approximately $40/ac. If it is assumed that 70 ac. will be treated (approximate acreage of greens, tees, and fairways on both courses) once a year, the total cost of nematodes equals $2,800.

If nematodes are applied, the amount of insecticide used would be reduced to 51 lbs. AI. At a cost of $377/lb. AI, the cost of insecticide would be $19,227. A total of 214 ac. would be treated with Merit®, at an application rate of 2 ac./hr and a labor rate of $15/hr.; the annual labor cost would be $1,605.

Total annual cost = $19,227 + $2,800 + $1,605 = $23,632.

Table 2-18. Japanese Beetle Larvae Program - Costs and Benefits

Project Title	ROI	Annual Cost[(a)]	Benefit (lbs./yr.)[(b)]
(FY 97) Purchase pesticides	NA	$41,287	0

(FY 98) Purchase nematodes and pesticides	NA	$23,632[c]	50
(FY 99) Purchase nematodes and pesticides	NA	$23,632[c]	50
(FY 00) Purchase nematodes and pesticides	NA	$23,632[c]	50

(a) FY 96 dollars.
(b) FY 93 usage was 101 lbs. AI; reference year for calculations was FY 95, when usage was 231 lbs. AI.
(c) Cost represents reduction in insecticide use assuming use of beneficial nematodes. Cost without nematodes would be that shown for FY 97.
NA = not applicable
ROI = return on investment

Table 2-19. Japanese Beetle Larvae Program Execution

Action	OPR	Completion Date Estimated	Completion Date Actual
Initial: Obtain and apply Merit®	88 SPTG/SVBG	Sept - Oct 96	
Recurring: Evaluate progress/effectiveness of pest control measures; consider use of beneficial nematodes	88 SPTG/SVBG	Sept	
Option: Apply beneficial nematodes	88 SPTG/SVBG	Sept - Oct	

OPR = office of primary responsibility

2.8 REDUCE INSECTICIDE USE TO CONTROL CUTWORMS ON GOLF COURSES

Current Process: 88 SPTG/SVBG uses several insecticides to control cutworms. Some of these insecticides are used for more than one target pest (i.e., Japanese beetle larvae). In FY 93, 137 pounds AI were applied for cutworm control, at an approximate cost of $9,000 ($7,000 for materials and $2,000 for labor). The following insecticides were used for cutworm control:

Dursban® (chlorpyrifos)	Sevin® (carbaryl)
Dylox® (dimethyl)	Triumph® (isazofos)
Mocap® (ethoprop)	Turcam® (bendiocarb)

New Process: The new process for controlling cutworms on the golf courses consists of a combination of biological and chemical control measures. Chemical control would be provided as needed by applying Tempo®, an insecticide manufactured by Bayer®, Inc., that is effective against cutworms, armyworms, adult Japanese beetles, and mealybugs. The label suggests an application rate of 5 grams of product per 1,000 square feet; at 20 percent AI, this is equivalent to 0.096 pound AI per acre. Tempo® would be applied in the same manner as other insecticides, and use would begin in FY 97.

The biological control method entails applying nematodes, small parasitic worms that can be used to control several insects, including cutworms and Japanese beetle larvae. Nematodes are applied using typical pesticide application equipment with the screens removed at pressures below 300 psi. The best time to apply nematodes for cutworm control is in the early spring, after the last frost.

Pesticide Reduction Goal: The total acreage treated for cutworms in FY 93 was 271 acres. Assuming use of Tempo® over the same treated acreage, at an application rate of 0.096 pound AI per acre, the new usage would be 26 pounds AI in FY 97. 88 SPTG/SVBG has elected to defer application of nematodes on the golf courses. Information provided by golf course superintendents who have used nematodes indicates that it is reasonable to expect a 50-percent reduction in insecticide use. Insecticide use would thus be reduced further, to 13 pounds AI, an overall reduction of 124 pounds AI.

Costs: The cost of using this alternative for FY 97 is based on applying Tempo®, at a cost of $245/lb. AI ($49/lb. of product) and a total annual usage of 26 lbs. AI, which results in an annual cost of $6,370.

The annual labor cost is estimated based on treating 271 ac. at an application rate of 2 ac./hr., and a labor rate of $15/hr., for an annual cost of $2,032.

Total annual cost = $6,370 + $2,032 = $8,402

If insecticide use in FY 97 is not reduced sufficiently, the use of nematodes will be considered. The cost of the nematodes is approximately $40/ac. If it is assumed that 70 ac. will be treated (approximate acreage of greens, tees, and fairways on both golf courses), the total cost of nematodes equals $2,800. (Note that nematodes should be applied once in the fall for maximum effect on Japanese beetle larvae [see Section 2.7], and once in the early spring for cutworms; applying twice a year will provide best control for both pests.)

With application of nematodes, Tempo® application would be reduced to 13 lbs. AI. At a cost of $245/lb. AI, the total annual cost for Tempo® would be $3,185. A total of 136 ac. would be treated with Tempo® at an application rate of 2 ac./hr. and a labor rate of $15/hr. Total labor costs would be $1,020.

Total annual cost = $2,800 + $3,185 + $1,020 = $7,005.

Table 2-20. Cutworms Program - Costs and Benefits

Project Title	ROI	Annual Cost[(a)]	Benefit (lbs./yr.)
(FY 97) Purchase pesticides	NA	$8,402	111
(FY 98) Purchase nematodes and pesticides	NA	$7,005[(b)]	124
(FY 99) Purchase nematodes and pesticides	NA	$7,005[(b)]	124
(FY 00) Purchase nematodes and pesticides	NA	$7,005[(b)]	124

(a) FY 96 dollars.
(b) Cost represents reduction in insecticide use assuming use of beneficial nematodes. Cost without nematodes would be that shown for FY 97.
NA = not applicable
ROI = return on investment

Table 2-21. Cutworms Program Execution

Action	OPR	Completion Date: Estimated	Completion Date: Actual
Recurring: Apply Tempo®	88 SPTG/SVBG	March	
Recurring: Evaluate progress/effectiveness of new pest control measure	88 SPTG/SVBG	Sept	
***Option**:* Apply beneficial nematodes	88 SPTG/SVBG	March	

OPR = office of primary responsibility

2.9 TERMITE COLONY ELIMINATION SYSTEM IN FAMILY HOUSING AREAS

Current Process: Termite control in the housing areas is conducted by a commercial pest control contractor. Dursban TC® (chloropyrifos), mixed at a ratio of 1 gallon of product to 100 gallons of water, is applied every 2 to 3 feet in a trench dug to a depth of 6 to 10 inches around the affected structure. Dursban TC® is proven effective and it is persistent in the soil, eliminating the need for repeat treatments. In FY 93, the contractor applied 261 pounds AI of Dursban TC® to 50 housing units at a cost of $27,440.

New Process: The new process entails using the Sentricon® Termite Colony Elimination System, available through DowElanco. The current termite control contractor for WPAFB is certified to install and monitor the Sentricon® system. The system involves placing wood into bait-tubes placed approximately 10 to 20 feet around individual structures. The presence of a termite colony is identified through monthly monitoring of the bait-tubes. Once a colony is detected, a growth-regulating bait (hexaflumuron) is placed into the bait-tube that prevents the molting process of termites and they eventually die. It may take from a few weeks to a few months for termites to enter the stations; colony elimination can occur as quickly as 3 to 5 months after termites are transferred to bait-tube devices. After a colony has been eliminated, the bait is replaced with monitoring devices and inspected monthly to verify control.

The Sentricon® system can be used on an as-needed basis for individual structures with termite infestations, or it can be used to treat groups of structures as a preventive measure in areas of known recurrent infestations (e.g., Page Manor). Groups of units in Page Manor will be identified by 88 CEG/CEH for treatment each year, based on available budget. Areas to be treated will begin with the block east of Spinning Road, treating as many units as the budget will allow each year. When the entire area east of Spinning Road has been treated (or continued monitoring indicates that this area is free of termites), treatment will commence on units west of Spinning Road.

(Because annual budgets cannot be anticipated, costs and pounds AI are calculated below based on treating approximately 50 units, as in FY 93.)

Pesticide Reduction Goal: The Sentricon® bait-tubes each contain 4 ounces of bait with 0.1 percent AI, or 0.004 ounce AI each. In FY 93, the contractor treated approximately 15,000 linear feet for termites. Using this same length, and assuming installation of bait-tubes every 10 feet, approximately 1,500 bait-tubes would be required for a total of 6 ounces, or less than 1 pound AI. This represents a reduction of 260 pounds AI from the FY 93 use.

Costs:

Sentricon® System installation: 1500 bait-tubes x $10.00/bait-tube = $15,000

Annual monitoring cost: $2.50/bait-tube x 1500 bait-tubes = $3,750

Total annual cost = $15,000 + $3,750 = $18,750

Table 2-22. Termite Colony Elimination Program - Costs and Benefits

Project Title	ROI	Annual Cost[a]	Benefit (lbs./yr)
(FY 97) Install and monitor Sentricon® system	NA	$18,750	260
(FY 98) Install and monitor Sentricon® system	NA	$18,750	260
(FY 99) Install and monitor Sentricon® system	NA	$18,750	260
(FY 00) Install and monitor Sentricon® system	NA	$18,750	260

(a) FY 96 dollars.
NA = not applicable
ROI = return on investment

Table 2-23. Termite Colony Elimination Program Execution

Action	OPR	Completion Date	
		Estimated	Actual
Initial: Modify existing contract for termite control to include use of the Sentricon® system	88 CEG/CEH, 88 ABW/EM	Sept 1996	
Recurring: Identify MFH units/areas to be treated	88 CEG/CEOGE, 88 CEG/CEH	Oct	
Recurring: Install and monitor Sentricon® system (termite control contractor)	88 CEG/EOGE, Termite Contractor	Mar-Oct	
Recurring: Evaluate progress/effectiveness of new pest control measure	88 ABW/EM	Sept	

OPR = office of primary responsibility

APPENDIX O

PROCESS OF DEVELOPING THE MODEL PESTICIDE REDUCTION PLAN

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX O
PROCESS OF DEVELOPING THE MODEL PESTICIDE REDUCTION PLAN

The need for the Model Pesticide Reduction Plan was brought about by a Memorandum from the Under Secretary of Defense, dated 23 September 1994, that, among other things, mandated a 50-percent reduction in the amount of pesticides applied at Department of Defense (DoD) installations by fiscal year (FY) 2000. Pesticide use is measured in pounds of active ingredient applied.

The Model Pesticide Reduction Plan began in 1995 as an Air Force Material Command (AFMC) funded project at Wright-Patterson AFB (WPAFB), Ohio. AFMC wanted to develop a pesticide reduction plan for WPAFB that, when implemented, would help the base achieve the 50-percent reduction goal. As a part of this project, the following reports were developed for WPAFB: Pesticide Reduction Opportunity Assessment, Decision Briefing Document, and Management Action Plan.

While working this WPAFB project, personnel in the Pollution Prevention Directorate of the Air Force Center for Environmental Excellence (AFCEE) recognized that there was a need for a pesticide reduction plan for all Air Force installations in order to help meet the 50-percent reduction goal. It was decided to develop a pesticide reduction guide in conjunction with the pesticide reduction task for WPAFB.

To ensure that the guide would be applicable to all Air Force bases, AFCEE funded validations site visits to Tyndall AFB, Florida; Beale AFB, California; and Davis-Monthan AFB, Arizona. These validation visits ensured that the Model Pesticide Reduction Plan included pesticides used in a variety of geographic areas and climates, not just the ones used at WPAFB. A separate validation visit was conducted at Hill AFB to evaluate alternatives to the aerial application of herbicides on weapons ranges. The cooperation provided by the personnel at WPAFB and at these validation bases was invaluable for the development of this report.

The site visit to WPAFB lasted 1 week and consisted of a detailed records search of pesticide usage and interviews with base personnel (including personnel in the following shops: entomology shop; Morale, Welfare, and Recreation; golf course; grounds maintenance; environmental flight; and contracting) to determine the target pest for each pesticide usage, and approximate quantities of pesticides applied to control each type of target pest. The site visits to the validation bases lasted about 3 days at each location and primarily involved interviewing base personnel about their pesticide practices and target pests. In developing alternative pest management practices, personnel at state extension services, pesticide manufacturers and suppliers, universities, and other DoD and federal agencies were contacted for information.

The following Air Force personnel provided significant contributions to the development of this Model Pesticide Reduction Plan. Contact these individuals for more information on how the Model Pesticide Reduction Plan was developed:

Air Force Project Manager
Michael X. Clawson
AFCEE/EP
8106 Chennault Road
Brooks AFB, Texas 78235-5318

AF Pest Management Program Coordinator
Wayne Fordham
HQ AFCESA/CESM
139 Barnes Drive, Suite 1
Tyndall AFB, Florida 32403-5319

HQ AFMC Command Entomologist
Michael Cornelius
HQ AFMC/CEVC
4225 Logistics Avenue, Suite 8
Wright-Patterson, AFB, Ohio 45433-5747

Wright-Patterson AFB (Base Level)
Terri Lucas
88ABW/EME
5490 Pierson Road
Wright-Patterson, AFB, Ohio 45433-5332

The contractor selected to develop the Model Pesticide Reduction Plan was the Colton, California, office of EARTH TECH. The work was conducted under Contract No. F41624-94-D-8138, Delivery Order No. 12. The EARTH TECH Delivery Order Manager for this project was Barbara Zeman.