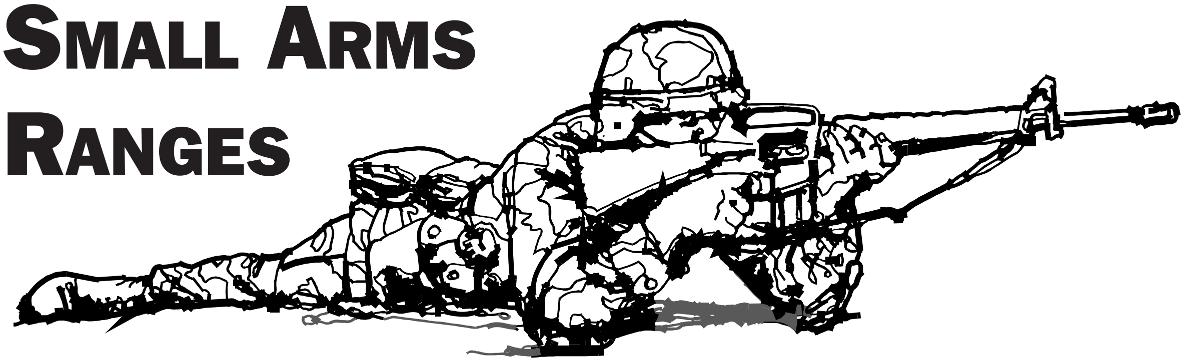
RANGE XXI

PREVENTION OF LEAD MIGRATION AND EROSION FROM SMALL ARMS RANGES



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The U.S. Army Environmental Center, in partnership with the Combat Training Support Directorate, Deputy Chief of Staff Training, Army Training and Doctrine Command (TRADOC)created this manual to help installation range managers, Integrated Training Area Management (ITAM) coordinators and environmental staff assess, develop and implement management practices that minimize adverse impact to human health and the environment from small arms range operations.

This manual will help users identify cost-effective approaches to range design and maintenance procedures that can minimize potential adverse environmental impact on small arms ranges.

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Table of Contents

Figures

1.0 Introduction

1.1 Background and Purpose

The operation and maintenance of small arms ranges is critical to maintaining individual and collective soldier skills throughout the U.S. Army. This manual is intended to help installation range managers, Integrated Training Area Management (ITAM) coordinators and environmental staff assess, develop and implement management practices that minimize adverse impact to human health and the environment from outdoor small arms range operations.

Trainers, range managers and environmental staff should be aware that although there are environmental impacts associated with the operation of outdoor small arms ranges, the degree of environmental impact is site specific and a function of many factors. Identification, evaluation and minimization of environmental impacts from active small arms ranges are highly recommended.

This manual will help users identify cost-effective approaches to range design and maintenance procedures that can minimize the potential adverse environmental impact on small arms ranges.

This manual is the result of a joint initiative between the Combat Training Support Directorate, Deputy Chief of Staff Training, Army Training and Doctrine Command (TRADOC), and the U.S. Army Environmental Center (USAEC). The information is based on research by the U.S. Department of the Army, the U.S. Department of the Navy, the U.S. Department of Agriculture and private institutions.

1.2 Scope

This manual provides a practical guide for:

a. Identifying environmental issues related to water and soil quality on small arms ranges.

b. Evaluating risk to surface and groundwater from lead migration and erosion on small arms ranges.

c. Identifying best management practices to reduce the impacts from small arms range operations.

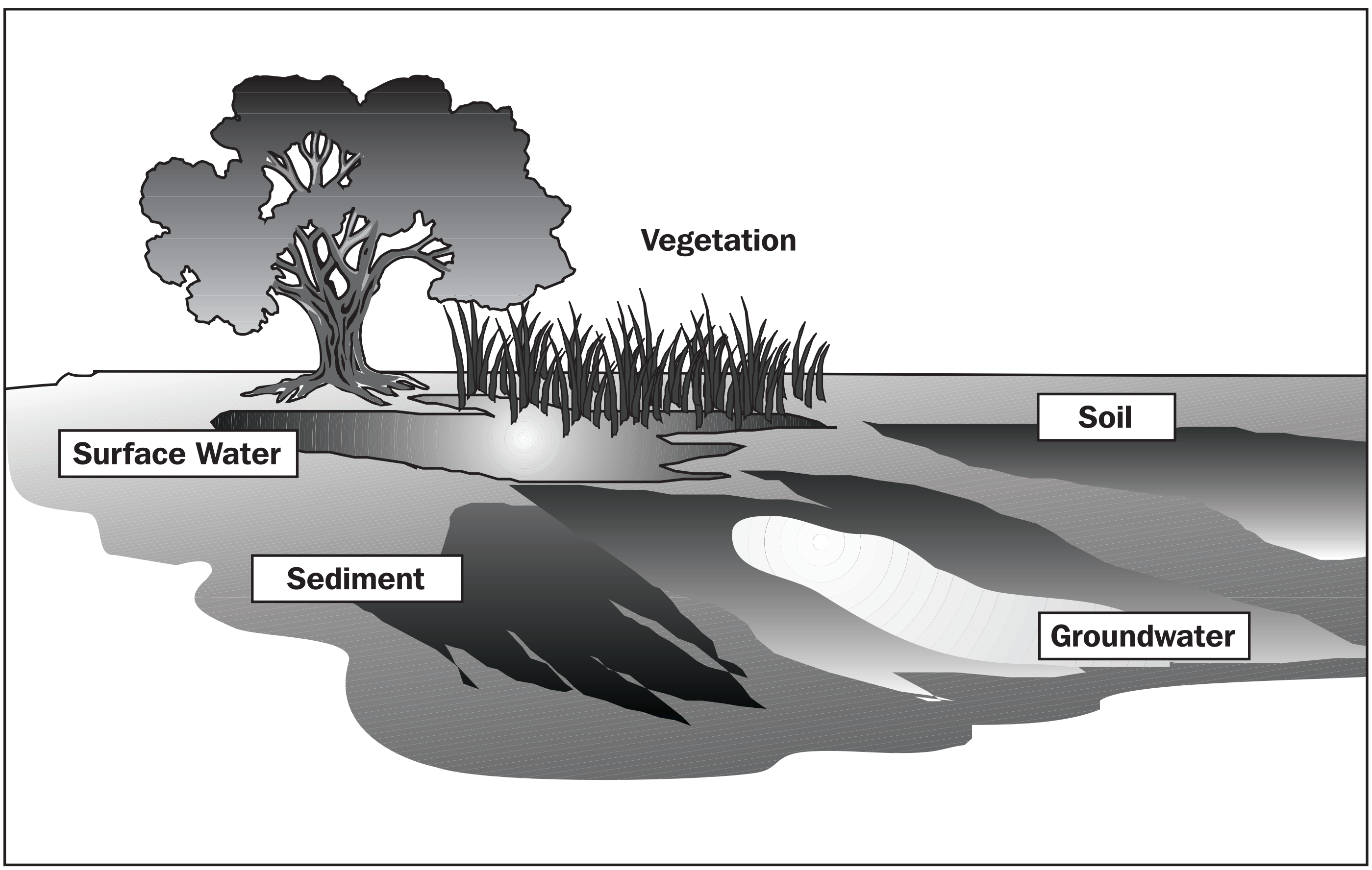
This manual provides suggested management and maintenance techniques to reduce lead migration and erosion on outdoor small arms ranges. It identifies specific environmental impacts associated with small arms range operations and suggests measures that can be adapted for use on individual ranges.

2.0 Environmental Issues and Impacts

2.1 Issues

The Army has developed, within its Range and Training Land Program, an environmental strategy that reaches across the life cycle of ranges. This strategy, which encompasses proposed, active and inactive ranges, comes as a response to the increasing environmental regulations that impact how ranges are managed and operated. This can result in the curtailment of training on ranges for investigations or cleanup of contaminants in soil, groundwater or surface water. For small arms ranges, the major issues are lead and erosion. Lead from small arms ammunition accumulates in backstops, range floors and berms. Lead can leach into groundwater, be carried off site by stormwater, or become airborne. Erosion can overload streams and rivers with sediments. The impacts can easily result in non-compliance with many environmental regulations, including the Clean Water Act, Safe Drinking Water Act and Section 7003 of the Resource Conservation and Recovery Act (RCRA).

Figure 1 Human & Ecological Risk



Lead on small arms ranges is a potential ecological risk because of its toxicity and its ability to persist in the environment (Figure 1). Human exposure to lead can occur through either inhalation of dust and vapors or through ingestion of contaminated soil. Exposure to high levels of lead can result in lack of muscular coordination, stupor, convulsions, kidney dysfunction or coma.

For animals, the major routes of exposure are through direct ingestion of lead fragments or contaminated vegetation and water. Lead attached to sediments — transported by stormwater to surface water — can pose a serious ecological risk. Birds, especially waterfowl, can ingest lead fragments when dabbling in the water or eating vegetation that has absorbed lead through its roots. The results can lead to birth defects, deformities and death.

2.2 Impacts: Lead Migration to Groundwater

Lead is generally stable in the environment, but when exposed to certain environmental conditions it will break down and become soluble in water. Once soluble, lead becomes mobile and can be transported through the soil to groundwater. For lead to become mobile and migrate to groundwater, certain physical factors and site conditions must exist. These factors are very site specific. Therefore, the risk of lead migration to groundwater must be judged individually at each small arms range.

Physical factors such as soil type, pH, water chemistry in the pores of the soil and rainfall determine how quickly the rounds will corrode in the soil. These physical factors will increase or decrease the likelihood of lead migrating to groundwater. Site conditions must also be considered when determining risk of vertical migration. The most critical factors are depth to groundwater, type and amount of ammunition used, and type and frequency of maintenance performed on the backstop and range floors.

Soils

Porous soils, such as sands or sandy loams with either a low or high pH, will increase the likelihood of vertical lead migration to groundwater. Lead becomes soluble when the pH of the soil is less than 6.5 or greater than 8.5. Once soluble, the lead can be transported vertically through the soil by water. The permeable nature of certain soils gives the "mobilized" lead a quick avenue to groundwater. However, lead is least likely to become soluble when the pH of the soil falls between 6.5 and 8.5. Lead has a strong tendency to bind to clay particles or organic matter in the soil. Soils with a neutral pH (pH = 7.0) and clay content help bind the lead to the soil so that it is less likely to move vertically.

Corrosion Rate, Rainfall and Depth to Groundwater

These physical factors determine how quickly the rounds corrode in the soil. Corrosion (oxidation) causes the rounds to break down and the lead to become mobile. Once the lead is mobile, the risk of it being transported vertically to groundwater increases. Increased lead mobility can especially be a problem at small arms ranges located near the ocean or brackish water, where high concentrations of salt in the soil cause the rounds to oxidize more quickly.

Rainfall also influences the solubility of lead. The more rainfall, the greater the likelihood the soil will become saturated, increasing the time the round stays in contact with the rainwater. The longer the round stays in contact with moisture, the faster it will corrode. Acid rain accelerates the corrosion process.

The risk of lead migration to groundwater becomes greater when the corrosion rate is high and depth to groundwater is shallow (less than 10 feet). Basically, the closer the groundwater is to the surface, the greater the chances of contamination.

Ammunition and Maintenance

The type and amount of ammunition used on the range along with its operational history will greatly influence the risk of lead migration to groundwater. Different calibers of ammunition contain varying amounts of lead. For instance, the 5.56mm round contains 52% lead; the .50 cal contains only 1% lead (see Figure 2). Therefore, when looking at the risk of lead migration, both the total number and type of rounds fired must be taken into consideration. This risk is substantially reduced if regular maintenance has been performed on the backstop and apron areas to remove rounds and fragments from the soil.

Figure 2

Lead Content in Small Arms Ammunition

PROJECTILE	(grams)
5.56mm M193 Ball	2.49
5.56mm M196 Trace	2.16
5.56mm M855 Ball	2.07
5.56mm M856 Trace	1.85
7.62mm M80 Ball	6.28
7.62mm M62 Trace	4.67
9mm M882 Ball	6.54
.45 Caliber M1911 Ball	12.77
.50 Caliber M33 Ball	0.74
.50 Caliber M17 Trace	13.41
.50 Caliber M8 API	0.74

2.3 Impacts: Soil Erosion and Surface Water Degradation

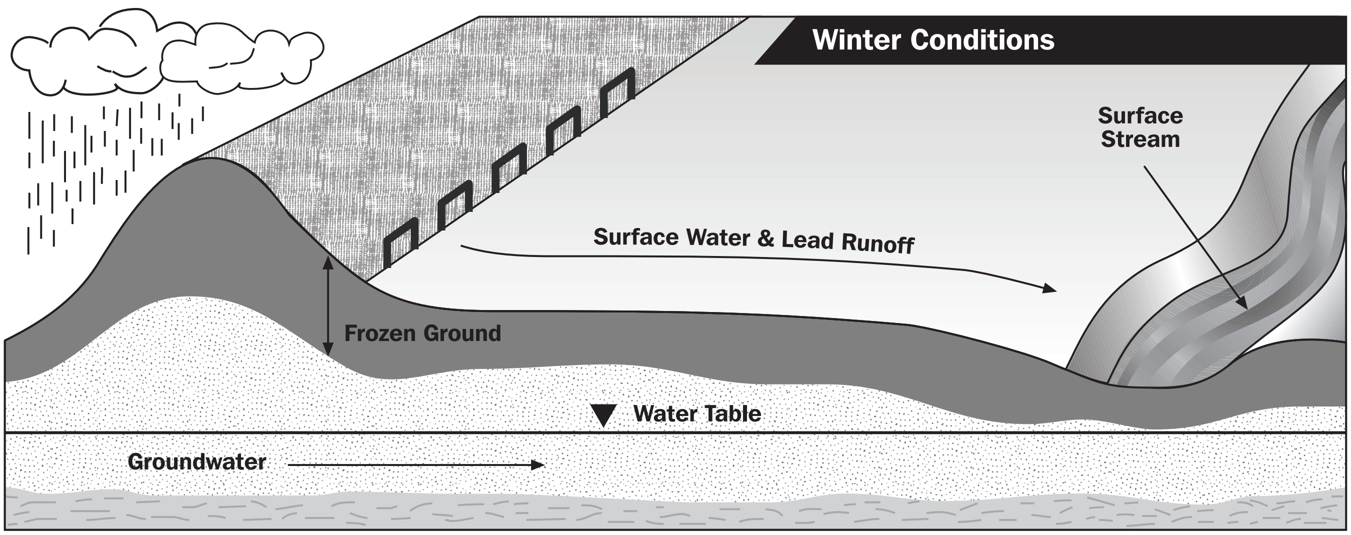
Berms and backstops, which are continuously under fire and lack vegetation, are highly susceptible to erosion during rainstorms. Eroded soil transported by stormwater to creeks, rivers, lakes or wetlands results in an increase of suspended sediment in surface water, which can affect aquatic organisms and vegetation. Left unchecked, erosion on a range can increase the cost of maintenance to repair backstops, target frames, and even firing lines because of the formation of rills and gullies (Figure 3). Soil erosion problems are compounded when lead attached to the soil is transported off the range during heavy storms (horizontal migration).

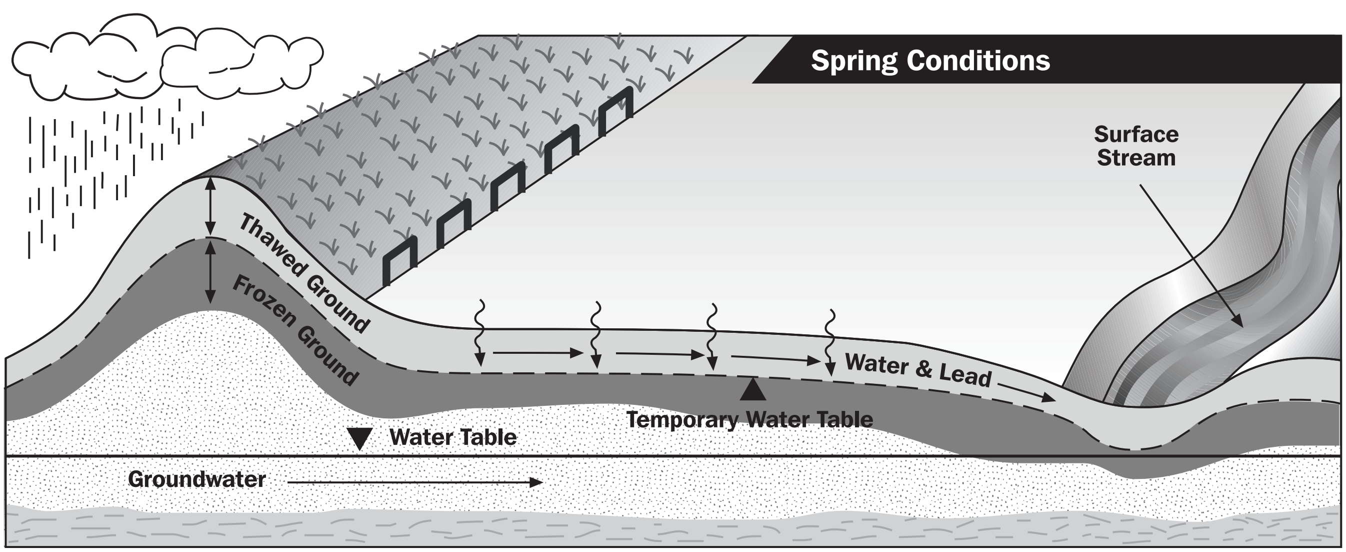
Figure 3

Depending on the geography and history of the range, certain conditions may increase the rate of horizontal migration. For example, in cold regions where the ground freezes to depths of several feet during the winter, spring often brings surface conditions that can partially thaw the upper portion of the frozen ground. The thawed portion of the ground allows dissolved lead to be vertically transported until it reaches the boundary of the frozen soil. Once it reaches this frozen boundary, the dissolved lead will move rapidly and horizontally with the water along the frozen boundary until it reaches ground level or surface water - a temporary condition that might significantly decrease the depth to the groundwater (Figure 4, *on following page*). Natural events such as this should be considered when determining the risk of lead migration to surface water. Frequent preventive maintenance, such as lead removal from the backstop, can reduce or prevent the risk of this migration.

Horizontal migration is also a problem on ranges built on drained wetlands. Clay or plastic tiles used to drain water from the soil to the groundwater table can act as a transport vehicle for soluble lead to surface water.

Figure 4 Seasonal Impact of Freeze/Thaw Conditions on Transport of Lead to Surface Water





3.0 Existing Conditions

Identifying and determining the risk associated with lead migration or erosion from a small arms range can be difficult. The Army has a planning tool available for use by installation staff to *qualitatively and quantitatively* determine the risk of lead from small arms ranges. Developed by the U.S. Army Environmental Center for use by installation staff, the Range Evaluation Software Tool (REST) is a Windows-based application that estimates the potential for lead migration and erosion. REST displays a series of input screens that request information on range use, physical and geological characteristics, geographic location and climate. REST also scores for the user the potential risk of lead migration to surface or groundwater. Field tested at three Army National Guard sites, REST can help determine management measures for preventing migration on new or existing small arms ranges.

REST includes an optional **Army Sampling and Analysis Plan (ASAP)** for installations that want to *quantitatively* confirm lead migration. ASAP provides instructions on how, when and where to collect and analyze soil samples.

REST can be obtained free of charge by contacting:

U.S. Army Environmental Center

Pollution Prevention & Environmental Technology Division

1-800-872-3845
e-mail:
t2hotline@aec.apgea.army.mil

4.0 Management Measures

The best practices for reducing the impact of lead on the environment are those that reduce risks to ecological and human health. This can be accomplished by a single technique or combination of measures to include stormwater control, erosion control, vegetation management, soil amendments, bullet traps and soil pH modifiers.

Standard Army small arms range designs can be modified to control erosion and prevent vertical migration of lead. Such design considerations may include re-contouring backstops to provide greater slope stability, grading the range floor to direct runoff, vegetating backstops and range floors to control erosion, and modifying the soil to inhibit vertical movement of lead to groundwater. In addition, bullet traps can be incorporated into the design of the range where appropriate. The following section describes specific management measures that can be implemented on small arms ranges to prevent erosion and lead migration. Refer to Figure 5 *(see following page)* for a flowchart illustrating these measures.

4.1 Preventing Lead Migration to Groundwater

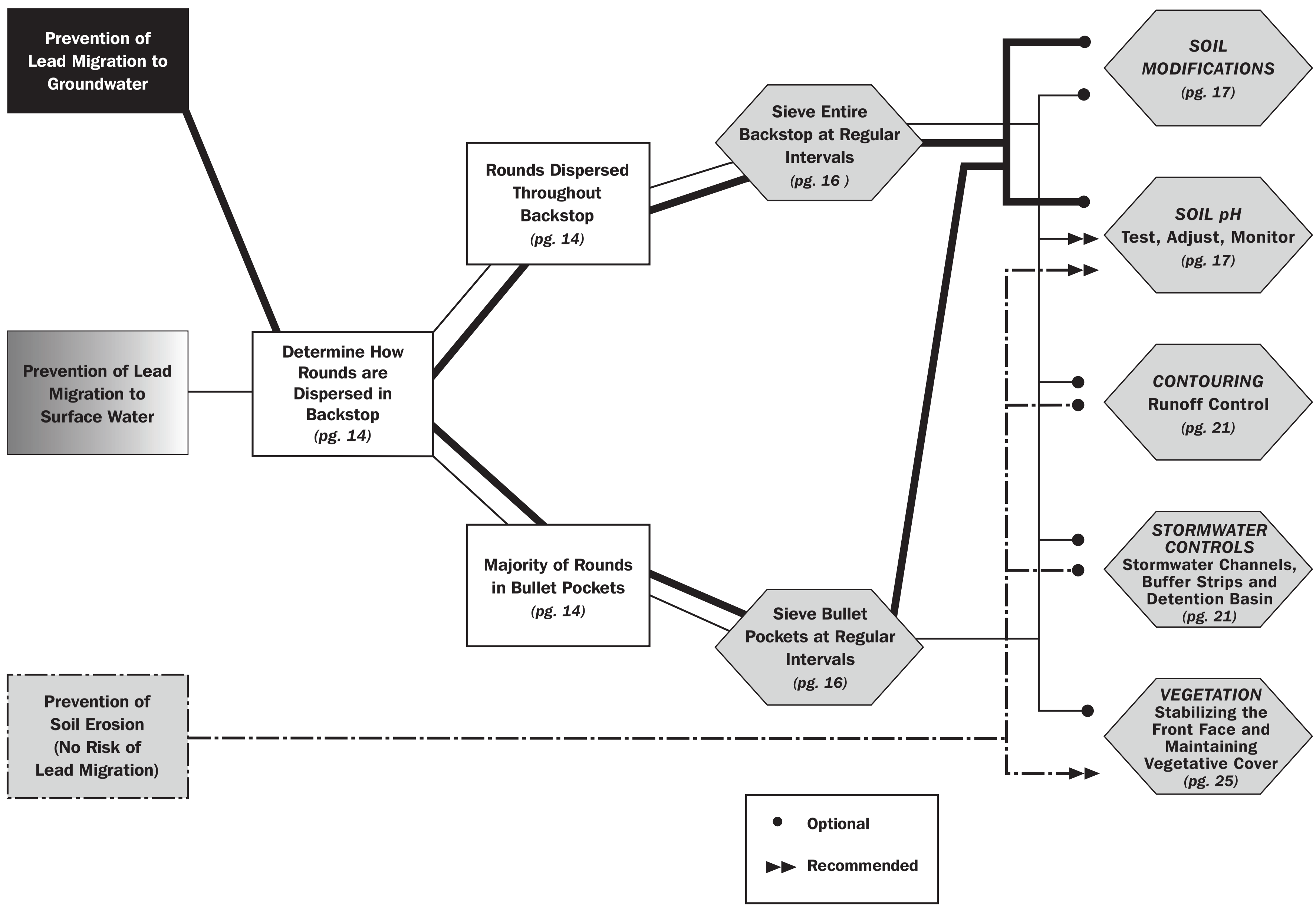
Before deciding on the best measures to reduce the risk of lead migration to groundwater, determine whether the rounds are dispersed uniformly across the backstop or concentrated in bullet pocket and toe areas. Once the distribution of the rounds is determined, techniques to reduce the risk can be selected from the following whole backstop or bullet pocket management measures (see Sections 4.1.1 and 4.1.2, respectively) based on the distribution of rounds in the berm. Many techniques used for whole backstop management can be used for managing bullet pockets. Note that a combination of whole backstop and bullet pocket management measures can be adopted where needed. These measures are designed to: 1) reduce the total amount of lead in the berm; 2) reduce the corrosion rate of the round; and 3) bind lead to clay and organic matter in the soil. These measures should be applied where there is a medium to high risk of lead migration to groundwater based on REST, individual evaluation or testing.

4.1.1 Whole Backstop Management Measures

Lead Removal and Recycling

Physical removal of lead from backstops on a regularly scheduled basis is one of the best methods to reduce lead migration problems. Combined with erosion control and pH modification, it can substantially reduce the risk of vertical migration to groundwater and surface water. Frequency of removal depends on the number and type of rounds fired into the backstop annually and the risk of lead migration.

FIGURE 5 BEST MANAGEMENT PRACTICES FOR SMALL ARMS RANGES FLOW CHART



Rounds scattered across the length of the backstop can be removed by scraping the face with a front-end loader or similar device to a predetermined depth. The rounds can then be removed by sifting (sieving) the soil, which is usually done by a local contractor. Up to 81% of the lead can be removed by sieving the soil when the backstop is made up largely of sand. The sifting process involves an initial screening to remove large debris. A second, smaller screen is then used to remove lead fragments. The cost of sifting the lead varies with the methods, the type of soil and desired efficiency. Soils with large amounts of clay, silt or organic matter can reduce lead removal to 60%. Sieving will not remove the lead attached to fine soil particles or reduce the lead levels below Toxicity Characteristic Leaching Procedure (TCLP) values. Sieving will only reduce the total amount of lead that can become mobile and migrate.

Sampling the backstop will provide a good indication of how far most of the rounds have penetrated into the face. This makes it easier to determine how much of the face actually needs to be scraped. At least two samples should be taken horizontally from the face of the backstop, between 1-3 feet from the bullet pockets, using a six-inch wide, hand-held auger. Installation staff can perform this task. Visual inspection of the samples can determine necessary depth of penetration. If sampling is not performed, excavating the front face and toe of the backstop to a maximum depth of two feet is a practical solution. Vertical core samples can be taken from the apron area, specifically around the toe of the backstop, if large numbers of rounds and fragments are suspected.

Once the lead fragments are removed, they can be sent to a smelter for recycling. The sifted soil can be put back into the face of the backstop. If sieving cannot be accomplished economically due to large amounts of clay in the soil, the soil may be sent to a smelter along with the lead fragments. The smelter will determine whether the soil and fragments can be recycled or wether it must be shipped and handled as hazardous waste.

(See Appendixes A, B and C for more information on recycling. These appendixes include questions and answers from smelters on lead recycling, a list of lead recyclers, and the U.S. Army Environmental Center Office of Command Counsel's opinion on the application of the Resource Conservation and Recovery Act on lead fragments recovered on an active range.)

Because of changes in Department of Defense (DoD) and Army regulations regarding the handling of "range residue," it is vital to coordinate this effort with the installation's environmental directorate to determine compliance with the DoD Munitions Rule Implementation Policy and federal environmental regulations.

Soil pH Modifiers

Once the initial concentration of lead in the backstop has been reduced, the pH of the soil should be kept at a neutral level to reduce lead mobility. Lead is least mobile between a pH of 6.5 and 8.5. Within this range, lead binds more easily to clay and organic matter in the soil. *Therefore, it is important to keep the pH of the soil as close to neutral (pH=7) as possible to stabilize the lead in the soil. A neutral pH will inhibit corrosion and allow the lead in the soil to bind to clay and organic particles. Maintaining a neutral pH is by far the most effective means of reducing lead mobility in the soil.* It is also important to test and maintain a neutral pH in the apron area of the backstop and on the target berms because they normally capture an appreciable amount of lead.

Limestone (lime) is universally used to raise the pH of soils. When applying lime, the larger the granule, the longer it takes to raise the pH of the soil to the desired level. Sometimes this process can take as long as six months. To speed the effectiveness of the lime, apply a pulverized variety to the soil as the face of the backstop is reconstructed. Once the optimum pH is reached, it should be checked once a year and lime applied as needed to promote vegetative growth and prevent vertical migration.

Soil Modifications

The type of soil in the backstop also determines the potential for vertical migration. Sandy soils increase the risk of soluble lead migrating to groundwater. Clays are often added to sandy soils to decrease the risk of lead transport to groundwater. The amount and type of clay needed to bind the soluble lead in the soil will vary from backstop to backstop. To determine if clay is needed in an existing backstop, a soil sample should be taken and sent to the local extension agent for analysis. The local extension agent *(see page 22)* can provide directions on taking soil samples in the backstop. Make sure the extension agent knows the sample will be used to determine the amount of clay needed to bind soluble lead in the soil. This will ensure that the soil is analyzed for the percentage of sand, clays, and loams as well as trace elements. The soil should also be analyzed for pH. Once the analysis is received, the local Natural Resources Conservation Service (NRCS) will be able to help determine the amount and type of clay needed in the backstop.

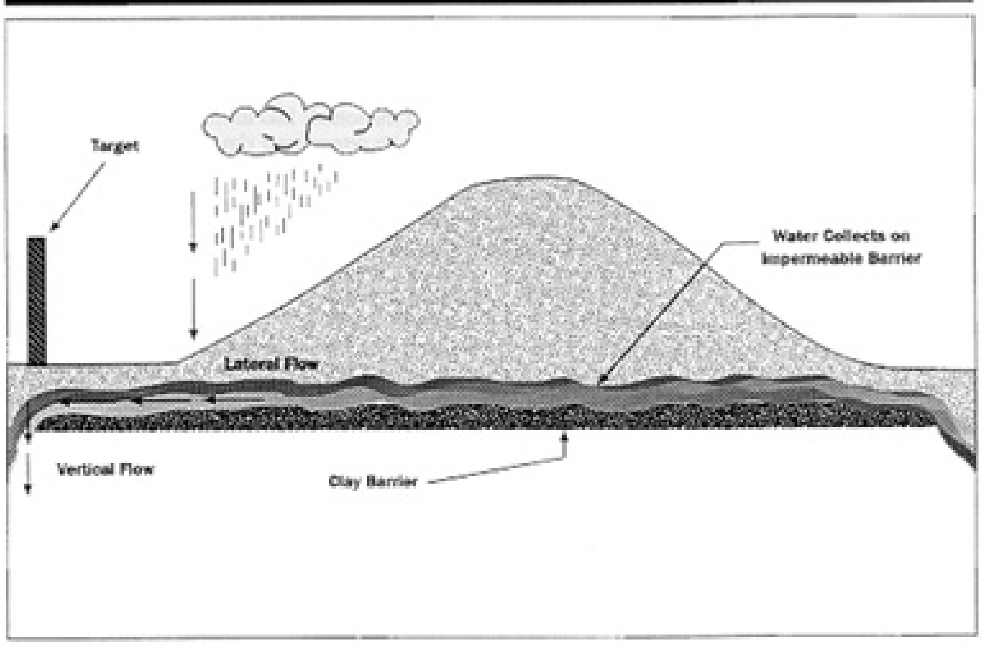
The NRCS, formerly the Soil Conservation Service, is an agency of the U.S. Department of Agriculture (USDA). NRCS specializes in solving problems associated with soil erosion as well as surface and groundwater contamination.

A variety of clays can be utilized to modify the soil of a backstop and help prevent lead from migrating to groundwater. However, be aware that different clays have varying capacities for retaining moisture and supporting vegetation (see Section 4,1 for management measures used to mitigate erosion on backstops and range floors). Therefore, it is important to select clays that dramatically shrink when dry and swell when wet, such as montmorillonite and bentonite. These clays will have a greater tendency to slip during wet conditions and crack and crumble during dry periods if they have not been properly mixed with the soil on the backstop. Contact the local NRCS for information before selecting clays to use as amendments.

Clay Layers and Barriers

Clay layers have been successfully used as liners under solid waste landfills to prevent heavy metals from migrating to groundwater. It has been suggested that clay layers or barriers could be constructed just below the backstop to prevent lead from migrating, but there may be some drawbacks to this approach. Because clay layers are highly impermeable, they can cause water to collect at the surface of the clay boundary. Eventually, the water will flow laterally beyond the barrier, allowing the water and soluble lead to migrate

Figure 6 Problems Associated With Clay Layers and Barriers



vertically (Figure 6). In addition, clays do not have limitless capacities for absorbing soluble lead. Once the absorptive limit has been reached, the clay barrier will allow soluble lead to leach through to groundwater.

Clay layers and barriers have not been evaluated by the Department of the Army for their effectiveness on ranges. More information and technical assistance is available by contacting the U.S. Army Environmental Center's Pollution Prevention and Environmental Technology Division at 1-800-872-3845 or e-mail at t2hotline@aec.apgea.army.mil

CHEMICAL AND PHYSICAL LEAD FIXATION TECHNOLOGIES

Loose-mix Portland cement (referred to as physical fixation) as well as phosphates (chemical fixation) have been used successfully to bind lead in contaminated soils disposed of in landfills. Some private firms have introduced the concept of using physical fixation and chemical fixation to bind the lead on active small arms ranges. USAEC tested both technologies in a demonstration project at Fort Rucker, Alabama, on an active 25m pistol range, to evaluate short-term and long-term ability to bind lead in the soil during weapons training. The six-month demonstration project concluded that chemical fixation technologies tested will initially bind soluble lead in the soil on application, ***but will cease to bind the lead in the soil once additional rounds are fired into the backstop***. The use of the loose-mix Portland cement to bind lead could not be evaluated during the demonstration project because of problems with the cement hardening upon application and the potential for ricochet. In summary, the application of physical and chemical fixation technologies on active backstops is not recommended and has yet to be successfully confirmed by the Army in any demonstration project. For specific information on the technologies tested at Fort Rucker, contact the USAEC Pollution Prevention and Environmental Technology Division at 1-800-872-3845 or e-mail at t2hotline@aec.apgea.army.mil.

4.1.2 POCKET AND TOE MANAGEMENT MEASURES

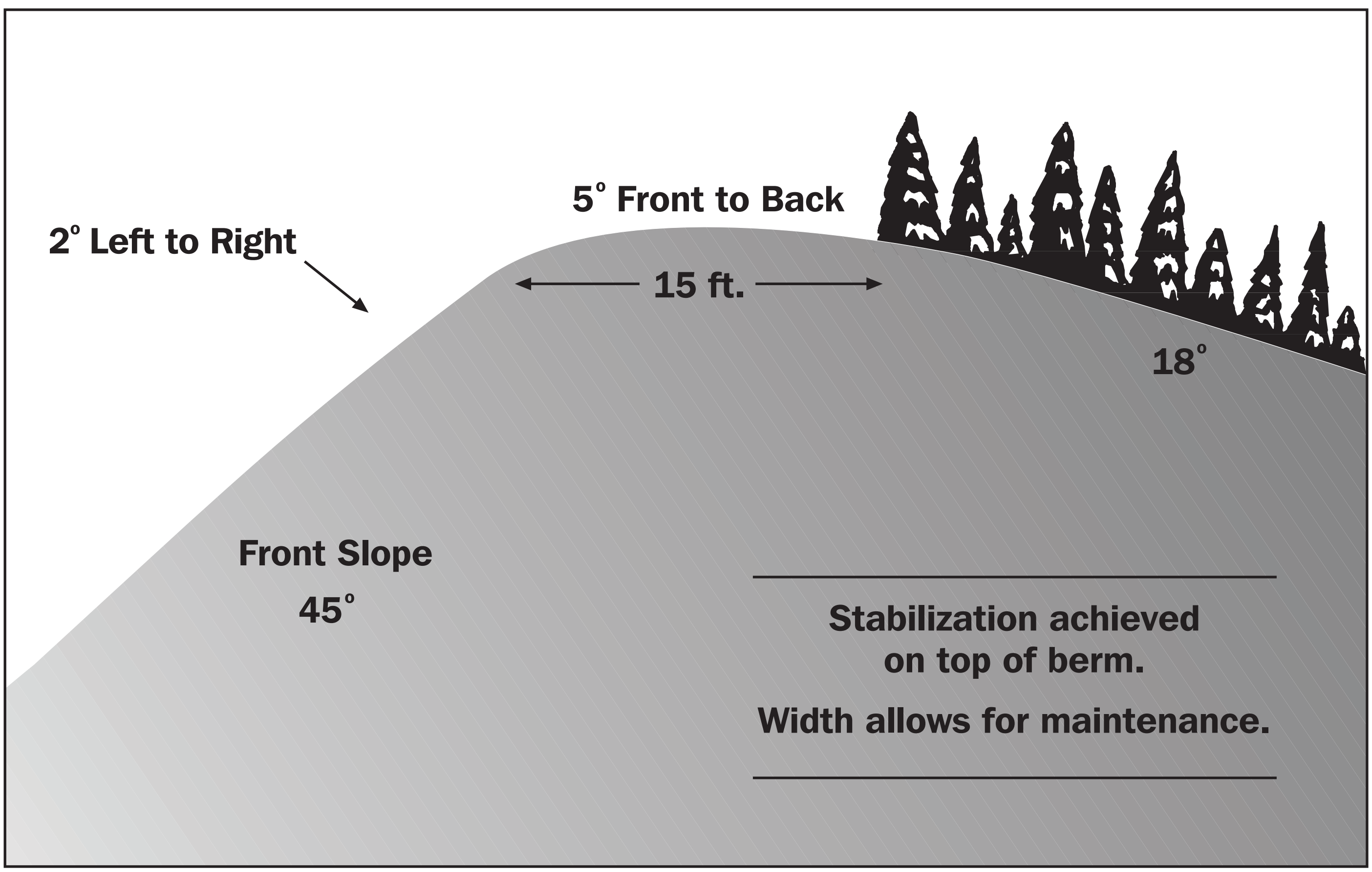
On some ranges, rounds are evenly dispersed throughout the backstop as well as concentrated in bullet pockets. In such cases, mitigation measures should be applied to the entire backstop as well as the bullet pocket and toe areas. Ranges that concentrate rounds in bullet pockets can mitigate this problem by focusing on the pockets themselves rather than the entire backstop. The most effective way to prevent lead migration is to keep a low total lead mass in the bullet pockets. Rounds should be removed from the bullet pockets when they become visible. This also applies to the "toes" at the foot of the backstop below the bullet pockets. This can be accomplished by sieving the rounds and fragments out of the pockets or removing the soil with a backhoe and shipping it directly to a smelter through the Defense Reutilization and Marketing Office (DRMO). The other, less desirable alternative is to dispose of the lead and soil as a hazardous waste. Either option requires coordination with the installation's environmental division.

When bullet pockets erode in spite of routine maintenance, more aggressive engineering actions may be necessary. This may include the use of commercially available bullet traps or site-specific engineered bullet traps. Unfortunately, the use of commercial bullet traps on standard small arms ranges is somewhat limited and can be costly. High maintenance costs, durability and operational feasibility are the major limitations associated with commercial traps. USAEC has completed the **Bullet Trap Feasibility Assessment** and a **Bullet Trap Users Guide** that provide a consumer's approach to choosing, installing and maintaining commercial traps on outdoor small arms ranges. Both documents are available by contacting the USAEC hotline at t2hotline@aec.apgea.army.mil.

4.2 Preventing Erosion and Lead Migration to Surface Water

This section discusses the management techniques for controlling erosion on backstops and range floors and curbing stormwater runoff. When a risk of off-site transport of lead to surface water exists, the management techniques in this section can be combined with lead removal from the backstop and/or bullet pockets to reduce the risk.

Figure 7 Contouring Backstops to Control Erosion



Modifications to an existing range design can be used to reduce soil erosion. A number of different features can be used to build or modify ranges without interfering with the operational integrity of Army standard range designs. These features incorporate contouring, stormwater control and vegetative cover to slow stormwater runoff without causing small, irregular erosion channels known as rills.

Contouring

Contouring includes the reshaping of an existing backstop or construction of a new backstop to direct and reduce the velocity of runoff. Soil erosion on backstops is the principal mechanism for transport of lead to surface water. In addition, soil erosion increases the cost and frequency of range maintenance and can reduce operational capability. Optimally, the backstop should be constructed so that the front face has a maximum slope of 45 degrees. The top of the backstop should be wide enough to support maintenance equipment such as lawn mowers, with a 5-degree slope toward the back of the backstop. The rear of the backstop should have a slope no greater than 18 degrees, or 3:1 (see Figure 7). A combination of design features such as these can substantially reduce erosion as well as migration of lead.

Stormwater Controls

Stormwater controls are design features that may be implemented to preclude erosion either from the face of the backstop or the range floor. These features include: channels to slow and direct runoff; buffer strips to filter out sediment and heavy metals; and detention basins to temporarily capture runoff.

Stormwater Channels and Buffer Strips

During storms, gullies will often form at the base of a backstop as rainwater carries large amounts of soil and lead off site. Gullies can often undermine target frames and the backstop itself (Figure 8). To prevent this type of erosion, vegetated stormwater channels (Figure 9) should be constructed at the foot and rear of the backstop to capture rain-generated surface water, reduce the water's velocity and direct it off the range. Although the width and depth of the channel will vary depending on site conditions (rainfall and soil), banks should be kept at a maximum slope of 3:1 to ensure stability and ease of maintenance. (Assistance in designing a stormwater channel can be obtained from local Conservation Districts, NRCS or the Directorate of Public Works.)

FIGURE 8

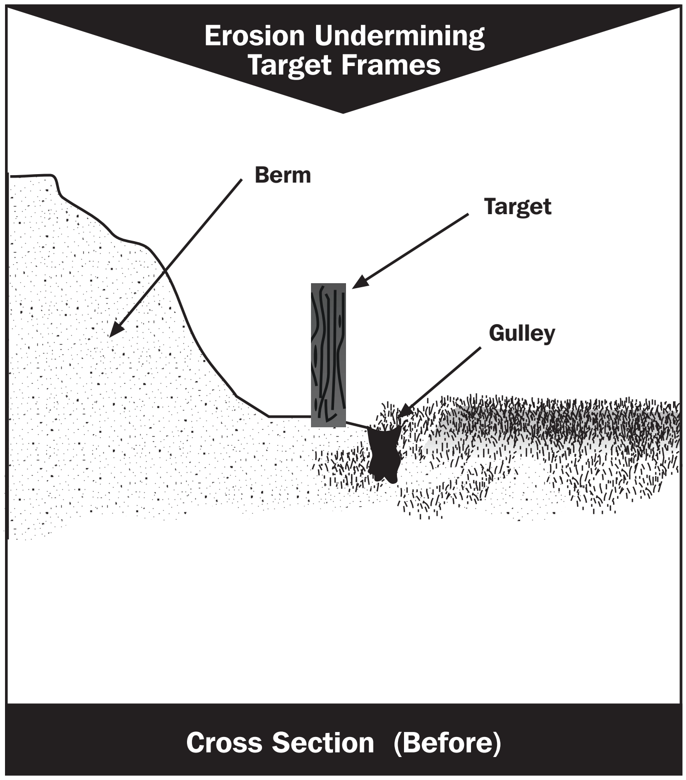
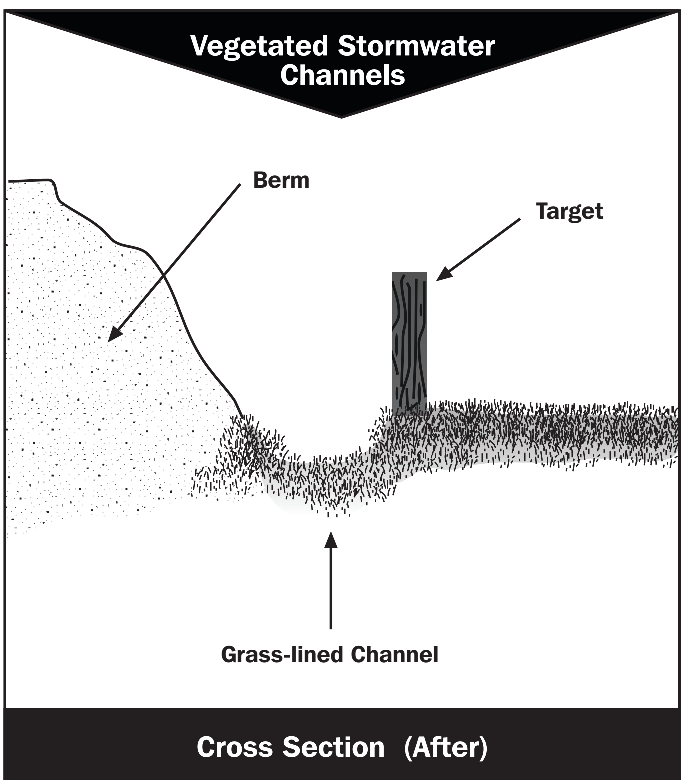


FIGURE 9



> The Conservation Districts work closely with the NRCS, providing service to land owners/operators on the layout and design of detention basins, sediment ponds, stormwater channels, buffer strips, terraces and windbreaks.

To be effective, stormwater channels must be vegetated. The purpose of the vegetation is threefold:

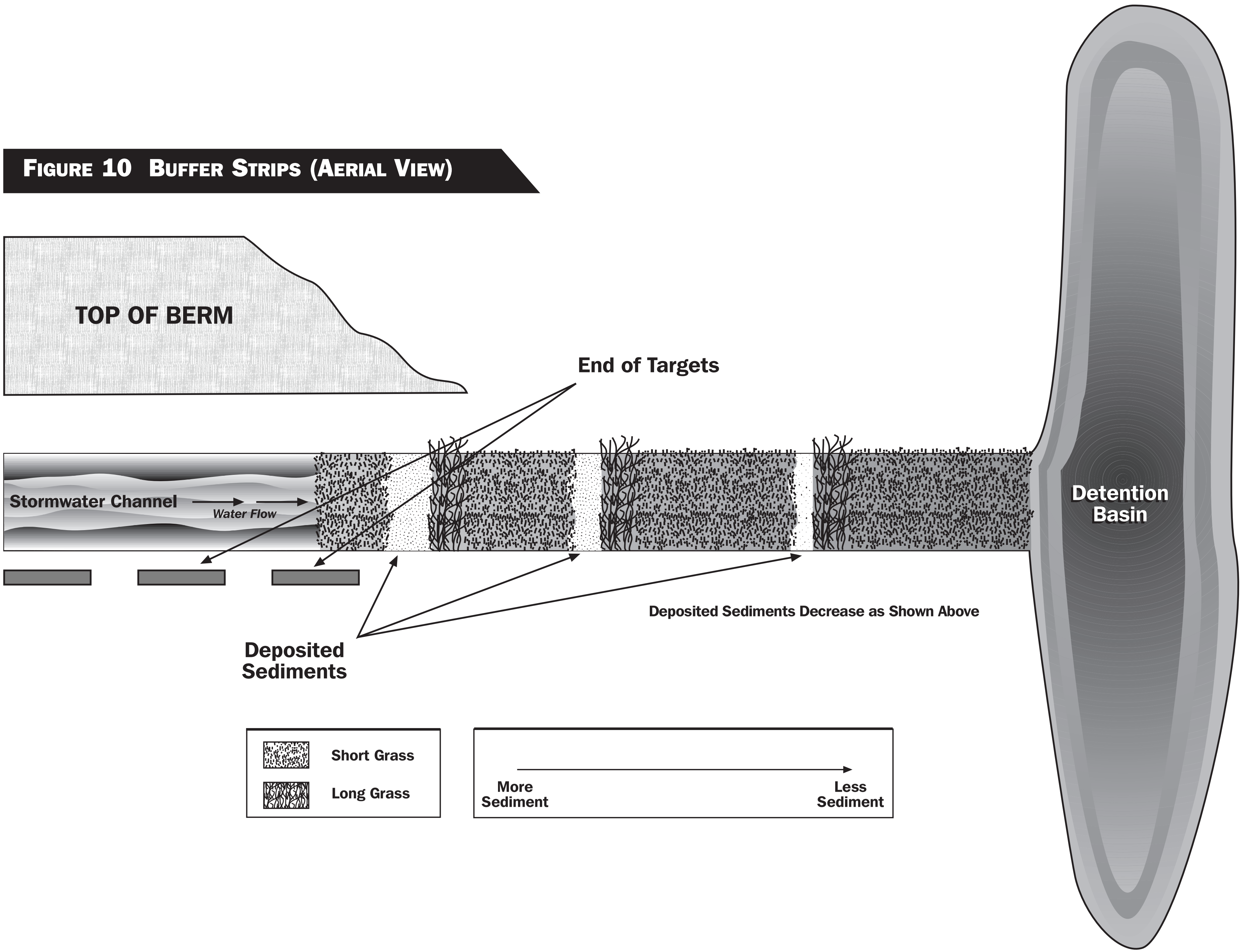
1. Control erosion in the channel.
2. Slow the velocity of the runoff.
3. Filter out sediment which may contain lead or other heavy metals.

The vegetation on the bottom of the channel must be maintained at a height of no less than six inches. Vegetative buffer strips should be installed at various intervals along the length of the channel. Buffer strips are sections of vegetation that are allowed to grow taller than the surrounding vegetation to aid in filtering sediment (Figure 10). Assistance in designing, installing and maintaining buffer strips, as well as selecting the most appropriate plant species to vegetate the channel, can be obtained from local NRCS or Cooperative Extension agents.

> The Cooperative Extension (also referred to as the Extension Service) specializes in agricultural information and services related to the land owner/operator. The Extension agent can provide services that include soil testing for nutrients and pH, information on weed control and fertilizers, as well as lawn and garden information within the local area.

Help in choosing the appropriate plant species can also be obtained by using VegSpec, a decision support tool that allows users to identify species for specific uses (in this case filtering and erosion control). VegSpec can be accessed on the Internet at http://plants.usda.gov.

Figure 10 Buffer Strips (Aerial View)



Sediment should be removed from buffer strips before they become clogged and non-functional. Raking is a good way to remove the sediment, but it also may remove the vegetation as well. If vegetation is lost during this process, it must be replaced by reseeding or sodding. It is important to remember that the filtering efficiency of the buffer strips is reduced during this time so it is not advisable to remove the sediment from every buffer strip in the channel at the same time. Staggering the maintenance of the buffer strips will ensure that there are enough functioning strips to filter out sediment during storm events.

Once the sediment has been raked out of the buffer strips, there are three options for handling it:

1. Use it to fill in eroded areas on the range or backstop.
2. Add it evenly across the floor of the range.
3. Remove it from the range.

The first two options do not require testing or handling the soil as a hazardous waste under RCRA. Contact the installation environmental directorate for guidance on regulatory requirements and technical assistance if choosing this option.

Detention Basins

When creating stormwater channels, it is advisable to construct a detention basin to capture the filtered runoff. The basin serves to provide additional settling of residual sediment before the runoff is released from the range. Adding vegetation to the detention basin in addition to the stormwater channel will help to further reduce stormwater velocity as well as aid in the final filtering of the sediment coming off the range. Detention basins must be able to retain runoff long enough to settle out solids, but short enough not to create a habitat for waterfowl or other species that may find ponds or wetlands attractive. Make sure that the detention basin drains completely, so there is no standing water to attract wildlife. Wildlife should be discouraged from developing the area as a habitat because of the possibility of introducing lead into the food chain.

A properly working stormwater channel will greatly reduce the amount of sediment build-up in the detention basin. Under normal conditions, removal of excess sediment will not be necessary. If excess sediment does accumulate in the basin, its effectiveness to settle out solids will decrease. Sediment build up in the basin, particularly around the outlet pipe, should be monitored on a regular basis and removed to ensure efficient operation. Sediment removed from the basin can be returned to the range floor or backstop. If the sediment is to be removed from the range, it must first be tested to determine if it is a hazardous waste and disposed of according to federal/state regulations. Contact the installation Environmental Division for guidance and technical assistance if choosing this option.

Vegetative Cover

In addition to contouring and stormwater controls, maintaining vegetative cover on backstops is critical to reducing off-site transport of lead and sediment. It is important to maintain as much vegetative cover on the entire backstop as possible. Maintaining vegetation on the top and rear slope of the backstop will greatly reduce erosion. Although maintaining vegetation on the front slope is difficult because of continuous firing, plant selection combined with fertilizing, liming, and soil amendments to increase soil moisture content will increase the chance for vegetative growth.

Backstops devoid of vegetation, even with gentle front slopes, are subject to severe erosion. There are a number of elements for maintaining vegetation on backstops, excluding the bullet pockets:

- Test the soil for nutrients and pH.
- Fertilize and lime according to soil test results.
- Plant low-growing, sod-forming vegetation.
- Mowing is not required. However, never mow to a height of less than three inches. There is no maximum height restriction.
- Correct erosion immediately by filling, seeding and fertilizing.
- Add soil amendments, if necessary, to promote stability.

Because the front face is normally steep and constructed with engineered soil, stability on backstops and vegetative cover are difficult to maintain. Compounded with high throughput, this may seem impossible. Stabilizing the front face of the backstop is the first requirement before vegetating the slope. Soil amendments, such as clay, can be used to increase or decrease infiltration of rainwater, increase soil moisture holding capacity and bind soil particles — all of which will increase the stability of the soil and reduce erosion. *(See the section on Soil Amendments under Section 4.1.1, Whole Backstop Management Measures, for more information.)*

5.0 Range Siting

Siting of new ranges is often limited by the availability of training land assets, topography, surface danger zone requirements, noise and other factors. When evaluating potential locations for small arms ranges, avoid wetlands, floodplains or surface water where lead could easily be introduced by weapons firing, erosion or stormwater runoff. Depth to groundwater and soils conducive to vertical transport should also be considered when location options are available. When site options are limited, preventive measures must be taken to mitigate erosion and vertical transport of lead before they become a problem.

6.0 Regulatory Considerations

The environmental regulatory climate surrounding small arms ranges in the Continental United States (CONUS) is complex and confusing. With the number of environmental regulations that have been promulgated over the last 20 years, it is often difficult to decipher under what circumstances they are to be applied to active small arms ranges. This section provides a brief discussion of the laws and regulations applicable to small arms ranges. Prior to the promulgation of the U.S. Environmental Protection Agency's (EPA) Military Munitions Rule, no federal regulations specifically addressed military munitions or ranges. However, federal laws such as the Clean Water Act (CWA), Safe Drinking Water Act, the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and others can be applied to active small arms ranges. The law, however, remains unresolved as to the extent to which federal and state regulators can directly affect range activities. While the Army continues to assert that environmental authority does not reach active ranges, prevention is the best course of action in an uncertain regulatory climate.

6.1 Federal Laws and Regulations

EPA Military Munitions Rule (MR) and Resource Conservation and Recovery Act (RCRA)

The Environmental Protection Agency's Munitions Rule (MR) defines when military munitions become waste and how RCRA applies to waste munitions. As such, munitions, which include small arms ammunition, are not a RCRA waste when used for their intended purpose (training, research and development, testing, or destruction during range maintenance). It is important to remember that because not all states have adopted the MR, the Army has no national standard for applying RCRA to military munitions. States with RCRA authority that have not adopted the MR could promulgate more stringent regulations.

Application of the MR to handling, storage and transportation of waste military munitions can be found in the **DoD Munitions Rule Implementation Policy (MRIP)**, being developed by a joint service working group. The MRIP interprets the requirements of the MR into specific DoD procedures and establishes an overarching policy for the management of waste munitions that is consistent among the services. Staffing of the policy is being conducted through the respective service logistics, operational, explosive safety, environmental and legal chains of command. The final MRIP is expected to be disseminated by the end of 1998.

DoD Range Rule

The proposed DoD Range Rule (RR) establishes procedures for evaluating and responding to explosives safety, human health and environmental concerns on closed, transferring, and transferred military ranges based upon reasonable anticipated future land use. Closed ranges include ranges within military control that have been put to a use incompatible with range activities. Transferring ranges include those associated with Base Realignment and Closure (BRAC) activities and other property transfers to nonmilitary entities. Transferred ranges include those in the Formerly Used Defense Sites (FUDS) program. The RR does not apply to active ranges being upgraded, modified or converted to other training activities such as maneuver areas.

Clean Water Act

The Clean Water Act of 1977 (CWA), an amendment to the 1972 Federal Water Pollution Control Act, regulates the discharge of pollutants into U.S. waters, making it illegal to discharge pollutants without a permit. The intent of the CWA is to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." Enforcement actions under the CWA can be applied to Army installations where water quality has been substantially reduced by erosion, and could be applied where lead has migrated to surface water via stormwater runoff or erosion from ranges. Munitions, as a class of items, are defined as a "pollutant" under the CWA, Section 502 (6).

Safe Drinking Water Act

The Safe Drinking Water Act of 1974 (amended in 1996), the primary law used to protect the nation's drinking water supply, sets drinking water standards that safeguard the public health against pollutants and contaminants. In April 1997, EPA Region I relied on the Safe Drinking Water Act to stop training (the firing of large and small caliber ammunition as well as the use of pyrotechnics and smoke) at the Massachusetts Military Reservation. This was based on allegations that ongoing training activities caused an imminent and substantial threat of contamination to the sole source aquifer under the impact area.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA, enacted in 1980 and extensively amended in 1984, primarily requires remediation at inactive hazardous waste sites. CERCLA, however, is triggered by the release or substantial threat of a release into the environment of a hazardous substance, pollutant or contaminant that presents an imminent and substantial danger to the public health or welfare. Military munitions, as a class, are not designated as CERCLA hazardous substances. However, some constituents of munitions are listed as CERCLA hazardous substances. Examples include ammunition that contains lead, mercury, cadmium, nitroglycerin, ammonium picrate and phosphorous. DoD is currently evaluating how CERCLA can be applied at military ranges.

Appendix A

Recycling Questions and Answers

Lead recycling is done by secondary smelters, which obtain lead from manufactured material such as TV screens, lead paint, batteries and small arms rounds. Although recycled lead does provide a payback, smelters often find it more lucrative to recycle TV screens rather than lead fragments and bullets. This may determine whether a secondary smelter will want to take the lead fragments from a small arms range.

Secondary smelters are located across the country and are more likely to "want" lead fragments that have been screened, rather than a combination of fragments and soil. This depends on whether the smelter has the capacity and need for both the fragments and/or soil. If one smelter does not want to recycle the material, try another. Contact the smelter far in advance to make sure the material will be accepted.

Because smelters operate under different state regulatory guidelines, it is necessary to contact the Raw Materials Manager at the smelting operation to obtain specific procedures. The smelter generally will ask questions concerning the material to determine how it should be handled. Below is a list of questions and answers that may serve as a guide in handling range material.

Question

Does the RCRA recycling exemption apply when lead fragments are recovered at an active range and the lead sent off to a smelter?

Answer

Yes. Under the Military Munitions Rule, fired military munitions are solid waste when transported off range for reclamation. RCRA regulations define a solid waste as material that is abandoned, inherently waste-like, or recycled. Because the lead fragments need processing to recover the usable product, "reclamation" is applicable. Reclaimed scrap metal is completely exempt from RCRA Subtitle C requirements under 40 CFR 261.6 (a) (3) (ii).

Question

Will DoD policy on Ammunition, Explosives, and Dangerous Articles (AEDA) affect how expended small arms brass is handled?

Answer

Yes. DoD may implement new controls and restrictions on the removal and sale of AEDA scrap. Under the Military Munitions Rule, environmental regulators may view the services' current practice of policing up residue, certifying it as free from explosives, and recycling it either by processing it through the Defense Reutilization and Marketing Office or selling it to a recycler who manages uncharacterized solid waste. DoD is taking steps to determine if it is necessary to make a waste characterization of recyclable residue resulting from range operations. It is therefore imperative that installations verify current DoD and Army policy on recycling and sale of AEDA before contacting smelters.

Question

Is it always necessary to screen the lead from the soil or will the lead be accepted with the soil from the backstop?

Answer

Screened expended small arms ammunition and fragments have the most value and, depending on the quality of the lead, may be a payable item. The smelter will most likely take the material as a recyclable item and therefore it will be exempt under RCRA. Smelters will sometimes take unscreened lead fragments. Smelters who will take the soil and lead fragments under the RCRA recycling exemption are looking for soil that is made up primarily of sand. That is because they need the sand along with the lead to clean their furnaces of impurities. Some smelters will also take any type of soil with the lead fragments, but it will be handled as a hazardous waste and must be manifested. All in all, smelters like to see the fragments screened.

Question

When is it more cost-effective to screen the lead from the soil and when is it more cost-effective to send the lead fragments with the range soil?

Answer

There are two different screening techniques: wet screening and dry screening. Wet screening separates the lead from the soil and washes the lead fragments to remove any attached soil — a task usually performed by a contractor. The typical costs range from $40-$60 per ton. The purity rate of the lead after wet screening will be between 74%-95%, depending on the size of the soil grain size.

Dry screening is less effective in cleaning the lead, which reduces payback. But it costs much less at $30 per ton. Efficiency is reduced and difficulties are normally encountered if using this method on clay/loam soils, soils with a high moisture content, or in the presence of root matter or vegetation.

Although the cost of wet screening is greater, in certain cases, the payback from the smelter may make it worthwhile. A simple, inexpensive treatability study can help determine the most effective screening technique. (See Appendix B for a list of companies.)

Below are examples that show the cost differentiation between wet and dry screening and disposal of the fragments along with the soil as a hazardous waste.

EXAMPLE: Excavating two feet into the face of a backstop 110 meters across and 10 feet high yields:

SCENARIO 1

Cost to recycle the lead fragments after wet screening to 95% pure lead:

266 cubic yards of soil containing 23 tons of bullets

Cost to wet screen soil @ $40/ton	=	$10,640.00
Payback from smelter @ $0.11/lb or $220/ton	=	($5,060.00)
Net cost of lead recycling	=	$5,580.00

SCENARIO 2

Cost to recycle the lead fragments assuming dry screening to 75% pure lead is achievable:

266 cubic yards of soil containing 23 tons of bullets

Cost to dry screen soil @ $30/ton	=	$7,980.00
Payback from smelter @$0.05/lb or $100/ton	=	($2,300.00)
Net cost of lead recycling	=	$5,680.00

SCENARIO 3

Cost to recycle lead fragments after dry screening to 50% pure lead:

266 cubic yards of soil containing 23 tons of bullets

Cost to dry screen soil @ $30/ton	=	$7,980.00
Cost to recycle @ $0.04/lb or $80/ton	=	$1,840.00
Net cost of lead recycling	=	$9,820.00

SCENARIO 4

Cost to dispose of soil and lead fragments as a hazardous waste:

266 cubic yards of soil containing 23 tons of bullets

Waste disposal cost @ $200/ton	=	$53,200.00

Question

How much notice must be given to the smelter to ensure that the lead fragments will be accepted?

Answer

The more notice the better. Some smelters offer approval within 48 hours while others require two months. Contact the smelter as far in advance as possible (30-60 days in advance is ideal) to arrange a shipment date. Once arranged, it is crucial to deliver the material on the agreed date or the material may not be accepted upon delivery.

Question

Will the secondary smelter pick up the material?

Answer

Most smelters will not pick up the material, however, it is best to inquire with each smelter. The cost to pick up the material depends on the quantity of material, miles to travel and the make-up of the material (whether it is lead fragments or lead fragments and soil). Most smelters work with logistics companies that provide profiling and transportation services.

Question

Are there times when a smelter accepts the range material (such as lead fragments and soil) for disposal rather than recycling? If so, how will the material be transported?

Answer

Generally, materials with low lead content (mostly soil with a limited amount of lead) and no appreciable silica content are likely be disposed of as a hazardous waste. The material must be packaged and transported as a hazardous waste. Contact the environmental division for assistance.

Question

UNDER WHAT CIRCUMSTANCES WILL A PAYBACK BE RECEIVED FROM THE SMELTER?

Answer

It depends on the quality of the material being sent and how much it costs to ship it to the smelter. The cost to transport the material to a secondary smelter is typically $0.02 to $0.05/lb. The quality of material needs to be greater than 75% lead in order to realize a payback.

How it Works

Lead is a commodity traded daily on the London Metal Exchange (LME). The price credit depends on the LME rate. Generally, the break-even point is 70% metal. Below 70% metal, the facility pays for recycling. Above 70% metal, the facility receives a credit. Below is an example of how the sliding scale* works:

% Metal	Army Pays for Recycling (Debit)	Recycling Pays Army (Credit)
5%	$0.15/lb or $300/ton	
25%	$0.10/lb or $200/ton	
50%	$0.04/lb or $80/ton	
75%		$0.02/lb or $40/ton
95%		$0.07/lb or $140/ton

At approximately 35% lead, the cost to recycle is the same as the cost to dispose of the material as a hazardous waste. If the recycle option is chosen, the installation will receive a recycling certificate. At approximately 50% lead, the cost to recycle is the same as the cost to dispose. At approximately 70%, the installation will break even (the cost to recycle equals the payback from smelter).

* This sliding scale is based on the March 1998 London Metal Exchange rate for lead of $0.24/lb. At times, the LME rate for lead has been as high as $0.54/lb. In other words, as the LME rate increases, the credit increases and as the LME rate decreases, the credit decreases.

Appendix B

Service Providers

The following contractors offer services such as secondary smelting, treatability studies, maintenance and equipment rentals. This is not a comprehensive list and in no way promotes the use of one contractor over another. Additional contractor names and addresses can be obtained from various resources including the World Wide Web. For assistance on your particular range needs, contact the Army Environmental Hotline at 1-800-USA-3845 or t2hotline@aec.apgea.army.mil.

Secondary Smelters

Below is a list of secondary smelters known to handle lead waste from small arms ranges.

American Waste Transport & Recycling, Inc.
12-B The Ellipse Building Suite 216
Mt. Laurel, NJ 08054
Telephone: 609-985-7300
Fax: 609-985-1778
** Other locations in Indiana, Pennsylvania, Missouri, Louisiana and Tennessee.*

Doe Run Recycling
HC1 Box 1395
Boss, MO 65440
Telephone: 573-626-3476
Fax: 573-626-3304

ECS Refining
2711-C Pinedale Road
Greensboro, NC 27408
Telephone: 336-851-1113

Encycle
5500 Up River Road
Corpus Christi, TX 78407
Telephone: 512-289-0300

Louis Padnos Iron & Metal Company
ATTN: Mr. Bob Klenk or non-ferrous buyer
PO Box 1979
Holland, MI 49422-1979
Telephone: 616-396-6521
* *9 Locations in Michigan*

This company is not a secondary smelter. However, as traders, they will take any volume of lead and provide it to a recycling smelter. They prefer clean lead (no soil) and will offer $0.08-0.10 per pound of lead. Depending on the amount of soil with the lead, the payback will be less. The company will only pick up the lead if there is a volume greater than 10,000 pounds. Upon delivery, they will inspect the quality of the lead and offer a payback accordingly as well as a certificate of recycling.

Treatability Studies

A treatability study performed prior to finalizing an approach or contracting the work for maintenance operations will cost $3,000 to $5,000. A treatability study involves obtaining a sample of range soil and performing laboratory tests to determine how the soil will respond to field-scale operations. If funding is available, a treatability study will provide the most cost-effective maintenance procedure for removing lead from the range. There are a number of small business/specialty contractors that provide this service. One such company is:

Brice Environmental Services Corporation (BESCORP)
PO Box 73520
3200 Shell Street
Fairbanks, AK 99707
Telephone: 907-456-1955
* *Offices in Alaska and New Jersey*

Maintenance Contractors

The following contractors provide services such as dry and wet screening as well as soil washing for more aggressive lead removal.

BESCORP
PO Box 78
554 Route 31
Ringoes, NJ 08551
Telephone: 908-806-3655

Bristol Environmental Services Corporation
201 E. 56th Avenue, Suite 301
Anchorage, AK 99518-1241
Telephone: 302-292-8995

Enviro/Consultants Group, LTD.
262 Chapman Road
Bellevue Building, Suite 103-A
Newark, DE 19702
Telephone: 302-292-8995

Rotar Bucket

Rotar Buckets are cylindrical screening devices that can manage soil volumes ranging from 1/2 cubic yard to 4 cubic yards. The smallest Rotar Bucket is designed to attach to a small front end loader and may be rented for approximately $1,500 per month, $500 per week or $125 per day. The largest Rotar Bucket can be attached to a large front end loader and may be rented for approximately $7,000 per month, $2,333 per week or $583 per day. Rotar Buckets are available with different screen sizes and essentially pick up the soil, rotate on a central axis, and allow soil to pass through the screen and back onto the backstop. The remaining lead can then be moved to a storage compartment until it is shipped to the smelter for recycling. The advantage of the Rotar Bucket over a power screen is the screening efficiency and mobility. Rotar Buckets can be driven from backstop to backstop.

Wright Equipment Corporation
PO Box 2333
5039 Industrial Road
Farmingdale, NJ 07727
Telephone: 732-751-1760