Reclamation Manual

Directives and Standards

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Lead on Outdoor Firing Ranges

By Charles W. Sever
CEO and Environmental Consultant
Best Environmental Services and Technology, Inc.

Background

Lead on outdoor firing ranges is not currently considered by USEPA as an environmental contaminant unless it becomes waste lead by being discarded or abandoned. Lead shot deposited on soils and in berms at firing ranges is not considered a "waste" because it has been used for its intended purpose. Lead shot fired at upland and other game is not a "waste" for the same reason. However, beware! If you sell, close, or otherwise abandon a shooting range, the lead deposited on the range may become a waste because it has been abandoned and/or discarded. To the best of my knowledge, the only way you can ever remove lead shot from a range without it becoming a waste is for recycling purposes. Recycling is encouraged by EPA and NRA.

If lead from a firing range is allowed to enter waters of the State, either on or off range property, it may violate any of several laws including, but not limited to, the Clean Water Act, the Safe Drinking Water Act, and the Resource Conservation and Recovery Act. All fresh groundwater is considered property of the State. All water in flowing streams (and in some cases, even ditches and small private lakes) is water of the State (or Federal government).

A recent court ruling made it illegal to shoot lead shot directly into waters of the United States without first obtaining a National Pollution Discharge Elimination System permit for the shooting range. The Seventh Circuit Court of Appeals has ruled that EPA has the power to issue lead disposal regulations for completely isolated intrastate wetlands and small ponds (less than one acre) under the Clean Water Act (see Hoffman Homes, Inc. v. EPA, CA 7 No. 90-3810 [July 19, 1993]).

Bullets are often fragmented upon impact and the fragments may move suspended in moving water or air. Also, lead is soluble in even a mild acid, and most rainfall contains carbon dioxide and nitric oxide both of which in water solution form acids. At times, sulfuric and other acids are also present in "acid rain."

Pathways for Movement

There are four movement pathways whereby lead deposited on firing ranges may cause a risk for violating federal and state environmental laws and appear to cause a risk to human health or to the environment. These pathways are:

1. *as airborne dirt particles,*
2. *as waterborne particulates in storm runoff,*
3. *in solution in storm runoff, and*
4. *in solution in ground water.*

1. Airborne Dust Particles

Wind is unlikely to move heavy lead particles very far; therefore, airborne dust is generally considered a potential threat only to persons shooting upwind and using the range on a windy day. Under such conditions, the hygiene and other practices proposed by NRA for indoor ranges are applicable to outdoor ranges. Further discussion of airborne dust is outside the scope of this paper.

2. Lead in Suspension in Storm Runoff

The ability of water to transport lead is influenced by two factors: velocity of the water and weight or size of the lead fragment. Water's particulate carrying capacity is proportional to the square of the water's velocity. Clear water moving at 100 feet per minute can carry a lead particle 10,000 times heavier than water moving at a velocity of 10 feet per minute. Muddy water can carry even larger particles. The five factors that most influence velocity of runoff are described below and shown on Table 1.

Transport of Lead Particles in Suspension					
Risk	*Safe*	*Slight Risk*	*Moderate Risk*	*High Risk*	*Very High Risk*
Annual Precipitation (inches)	*Less than 20*	*21-30*	*31-45*	*46-60*	*60 plus*
Topographic Slope (in feet/100 feet)	*Flat*	*5'/100'*	*10'/100'*	*15'/100'*	*20'/100'*

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Soil Type	*Coarse Sand or Gravel*	*Fine Sand*	*Fractured Rock*	*Silt*	*Clay*
Distance to Surface Stream (miles)	*1+*	*½ to 1*	*¼ to ½*	*Less than ¼*	*Shooting into water*
Vegetative Cover and Barriers	*Dams & Dikes*	*Forested*	*Grass*	*Sparse Weeds*	*Bare*

a. *Rainfall Intensity. The greater the volume of rainfall during a short period of time, the faster the velocity created to carry the rainfall off-site. The higher the annual rainfall, the greater the number of periods of heavy rainfall.*

b. *Geographic Slope. The steeper the topographic slope, the faster will be the velocity of storm water runoff, other things being equal.*

c. *Soil Type. More rainfall will soak into sandy soils than into clay soil. Hence, for a given rainfall intensity, the volume of runoff will be greater from areas underlain by clays or other low permeable soils than from permeable sandy soils.*

d. *Velocity tends to decrease as stream width increases. Merging streams, eddy currents, and curves in streams are other factors that may reduce the velocity. Generally, the shorter the distance from the lead deposit to the property line, the more likely it is that lead fragments in suspension will be transported off-site. Shooting directly over a water body ensures that the lead reaches the water.*

e. *Vegetative cover and man made structures like dams and dikes reduce the water's velocity and greatly reduce the size and weight of the lead particles the water can carry. Since lead particles are heavy compared to the other suspended particles of similar size, they are more likely to be deposited under the influence of anything that reduces velocity of the storm runoff. Grass and other vegetation reduce runoff velocity and acts as a filter to remove suspended solids from the water.*

3. *Dissolved in Surface Runoff*

When lead is exposed to air and/or water, it breaks down by weathering into lead oxides, carbonates, and other soluble compounds. With each rainfall, these compounds are dissolved and the lead moves in solution in the storm runoff waters. Water is a chemical solution in which decreases in water acidity, or increased in its pH, will cause the dissolved lead to precipitate out of solution. Lead concentrations in solution are reduced by this precipitation. At pH's above 7.5, very little lead remains in solution. Increased time of contact between lead and acidic water generally results in an increase in the amount of lead dissolved in a given unit of water. The factors that influence the amount of dissolved lead in the storm runoff water are summarized below.

a. *Annual Precipitation Rate. The higher the annual precipitation rate, the faster lead weathers. Also, during prolonged rains, the contact time between water and lead is increased. In general, the higher the precipitation rate, the higher the risk of lead migration off-site in solution.*

b. *pH of the Rain and Surface Water. The acidity of the rainwater decreases as basic minerals in the soils are dissolved; and if sufficient minerals, such as calcium, magnesium, and iron are present in local soils, then the lead may within a few feet of its origin precipitate out of solution entirely as these other minerals are dissolved. The pH of shallow surface water is an indicator of the presence or absence of basic minerals in the local soil and in gravel within the stream beds through which the water has moved. The water in deeper streams and lakes is more likely to be composed of unneutralized acidic rainwater.*

c. *Contact Time. The contact time between acidic surface water and lead shot is a factor in the amount of lead that is dissolved. For example, lead shot deposited directly into lakes has a longer contact time than lead shot deposited in upland areas.*

d. *Soil Cover. Organic material will absorb lead and remove it from a water solution. The thicker the organic leaf and peat cover on the soil, the lower the lead content in solution in water leaving the shot area. Organic carbonations material has a strong ability to extract lead out of solution in water.*

e. *pH of Groundwater. During periods of no rainfall, the water flowing within most streams comes from groundwater discharging into the stream channel. Therefore, the acidity of the groundwater affects the acidity of the surface water, and hence, affects the solubility of any lead particles carried into the stream during storm runoff.*

Dissolved in Surface Runoff					
Risk	*Safe*	*Slight Risk*	*Moderate Risk*	*High Risk*	*Very High Risk*
Annual Precipitation (inches)	*Less than 20*	*21-30*	*31-45*	*46-60*	*60 plus*
Acidity of Surface Water (pH)	*8.0*	*7.5-8.0*	*6.5-7.5*	*6.0-6.5*	*Less than 6*
Contact Time with Water	*None*	*Very Short*	*Short*	*Moderate*	*Continuous (shot falls into water)*
Soil Cover	*Organic Peat*	*Heavy Leaves*	*Grass*	*Other*	*None*
Acidity of Groundwater (pH)	*8.0+*	*7.5-8.0*	*6.5-7.5*	*6.0-6.5*	*Less than 6*

4. <u>Dissolved in Groundwater</u>

Acidic rainwater will dissolve weathered lead compounds. A portion of the lead is then transported in solution in groundwater beneath land surfaces. Groundwater will transport lead in solution from the higher topographic areas to the lower areas such as stream valleys, where it is discharged and becomes part of the surface water flow. If the water flowing underground passes through rocks containing calcium, magnesium, iron, or other minerals more soluble than lead, or minerals that raise the pH of the water, then the lead in solution may be replaced (removed) from solution by these other metals.

However, if the soil is a clean silica sand and gravel, fractured granite, or similar acidic type material, then the lead may move long distances in solution. The factors most likely to affect the amount of lead carried by groundwater in solution are discussed below:

a. <u>Annual Precipitation Rate</u>

Generally, high precipitation rates result in heavy dew, more frequent rainfall, numerous streams, shallow depth to groundwater, shorter distances of travel, and more rapid rates of groundwater flow.

Also, the greater volumes of rainfall over geologic time probably have reduced the amount of calcium and other soluble basic minerals that could raise the water pH and cause lead to precipitate out of solution from the groundwater.

b. Soil Types

Clays have a high ionic lead bonding capacity and more surface area to which lead can bond. Also, groundwater movement in clay is very slow which increases the contact time for lead to bond to the clay. Low permeability reduces the amount of historical leaching and increases the probability of the presence of basic (+pH) minerals that can precipitate lead out of solution in groundwater or cause the lead to bond to the clay.

All of the basic calcium and related minerals will generally have been removed from clean silica sand and gravel soils, so the lead in solution in groundwater in these type soils can move long distances (miles) through the ground relatively unchanged.

c. Soil Chemistry

The more basic minerals like calcium and magnesium that are present in soils along the pathways through which the groundwater moves, the greater the lead precipitation (removal) rate. Lead should move in solution only short distances (a few feet) through a sand composed of calcium shell fragments, but could move in solution long distances (miles) through clean quartz sand.

d. Depth to Groundwater

In areas of groundwater discharge such as river flood plains, and most flat areas, the groundwater surface is often only a few feet below land surface. Remember, the shorter the distance traveled, the greater the risk that lead will migrate into the environment. Shallow depth to groundwater is indicative of higher risk for lead to reach "waters of the State."

e. pH of Groundwater

Although other factors influence solubility of lead in water, a good rule of thumb is that lead will precipitate out of solution when the pH or alkalinity of water is greater than about 7.5. But, lead dissolved in acid groundwater may travel many miles without change.

Dissolved in Groundwater					
Points	*Safe*	*Slight Risk*	*Moderate Risk*	*High Risk*	*Very High Risk*
Annual Precipitation (inches)	*Less than 20*	*21-30*	*31-45*	*46-60*	*60 plus*
Soil Type	*Clay*	*Silt*	*Fine Sand*	*Fractured Rock*	*Coarse Sand or Gravel*
Soil Chemistry	*Basic Rock (Dolomite)*	*Calcareous Sand (+pH)*	*Neutral*	*Acidic Soil*	*Acidic Rock (Granite)*
Depth to Shallowest Groundwater (feet)	*200+*	*50-200*	*30-50*	*10-30*	*Less than 10*
pH of Groundwater	*8.0*	*7.5-8.0*	*6.5-7.5*	*6.0-6.5*	*Less than 6*

Solving the Lead Problem

Since virtually all of the groundwater beneath ranges in non-coastal areas and all surface water in perennial streams is considered to be waters of the State, lead on outdoor ranges becomes a problem when it is allowed to enter groundwater or surface waters of the State in concentrations considered by law to be a threat to public health or the environment.

Once lead enters the water environment in concentrations that exceed regulatory limits, the costs for removal of this lead can become enormous. Preventing the lead from moving off-site is much less expensive. The saying that an ounce of prevention is worth a pound of cure certainly applies to lead on outdoor ranges. Methods for prevention of migration include, but should not be limited to, implementing the following concepts where practical.

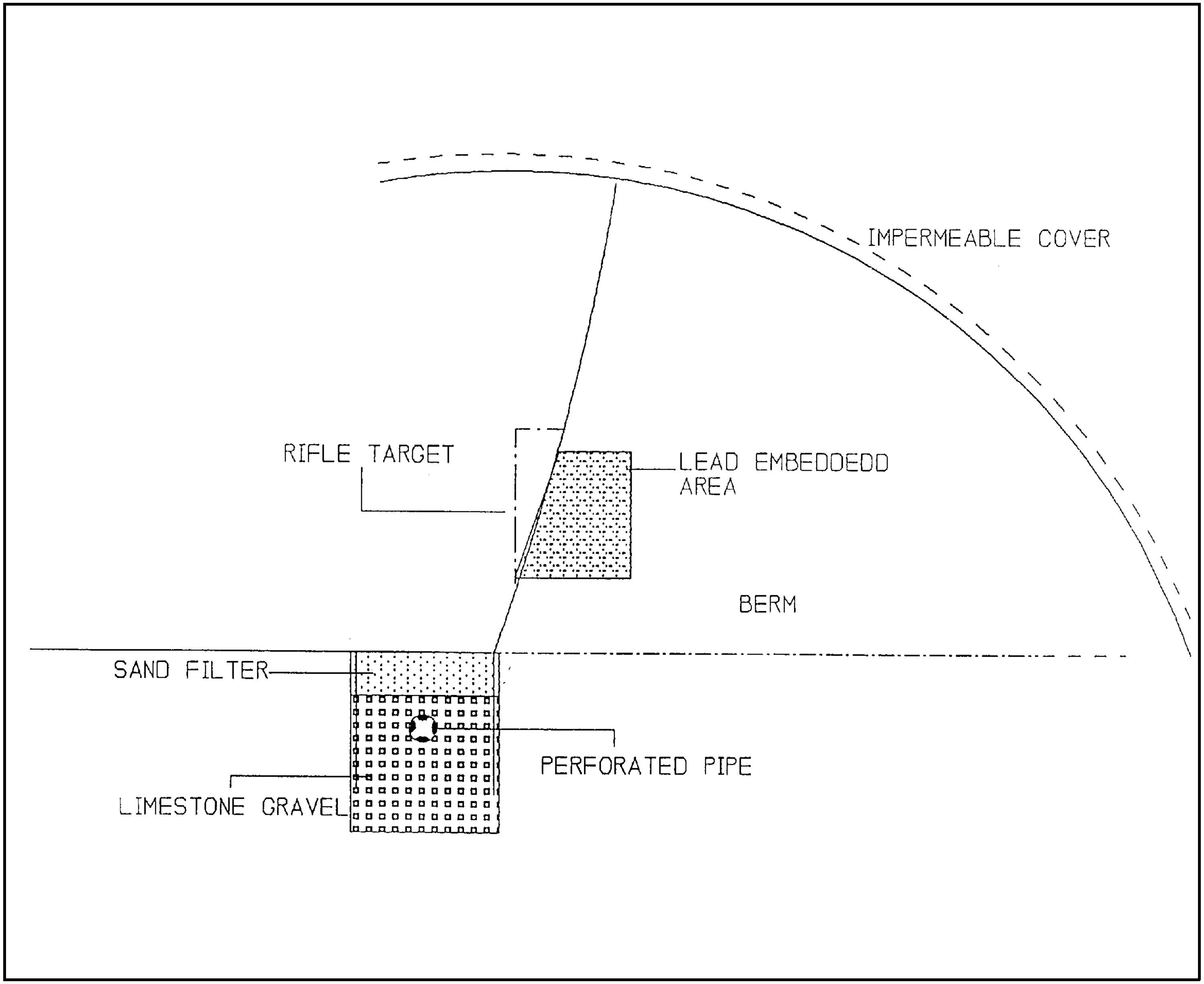
1. *Prevent acidic rainwater (and snow melt) from coming in contact with the lead bullets in berms by covering the berms with impermeable material as illustrated on a following page.*

2. *Separate the acidic rainwater from the lead as quickly as possible. Filter out the particulate lead and raise the pH of the water by causing it to pass through a filter bed of fine grained sand underlain by limestone gravel or some other acid neutralizing material at or near the berm as illustrated on a following page.*

3. *Reduce the velocity of water exiting skeet shooting areas by use of terraces or other water flow retarding structures. Use drainage ditches filled with sand and limestone gravel above the terraces to filter lead shot and raise the pH of the water to precipitate the dissolved lead. See the illustration on a following page.*

4. *Use impoundments, traps, or other structures to catch lead in sediment transported away from the shooting area by storm runoff.*

5. *Add liberal amounts of limestone, dolomite, or gypsum periodically to skeet ranges and to wooded shotfall areas to raise the pH of rainwater after it falls in these areas. The amount needed will vary with average rainfall volumes and acidity of the local precipitation, but it is easily calculated.*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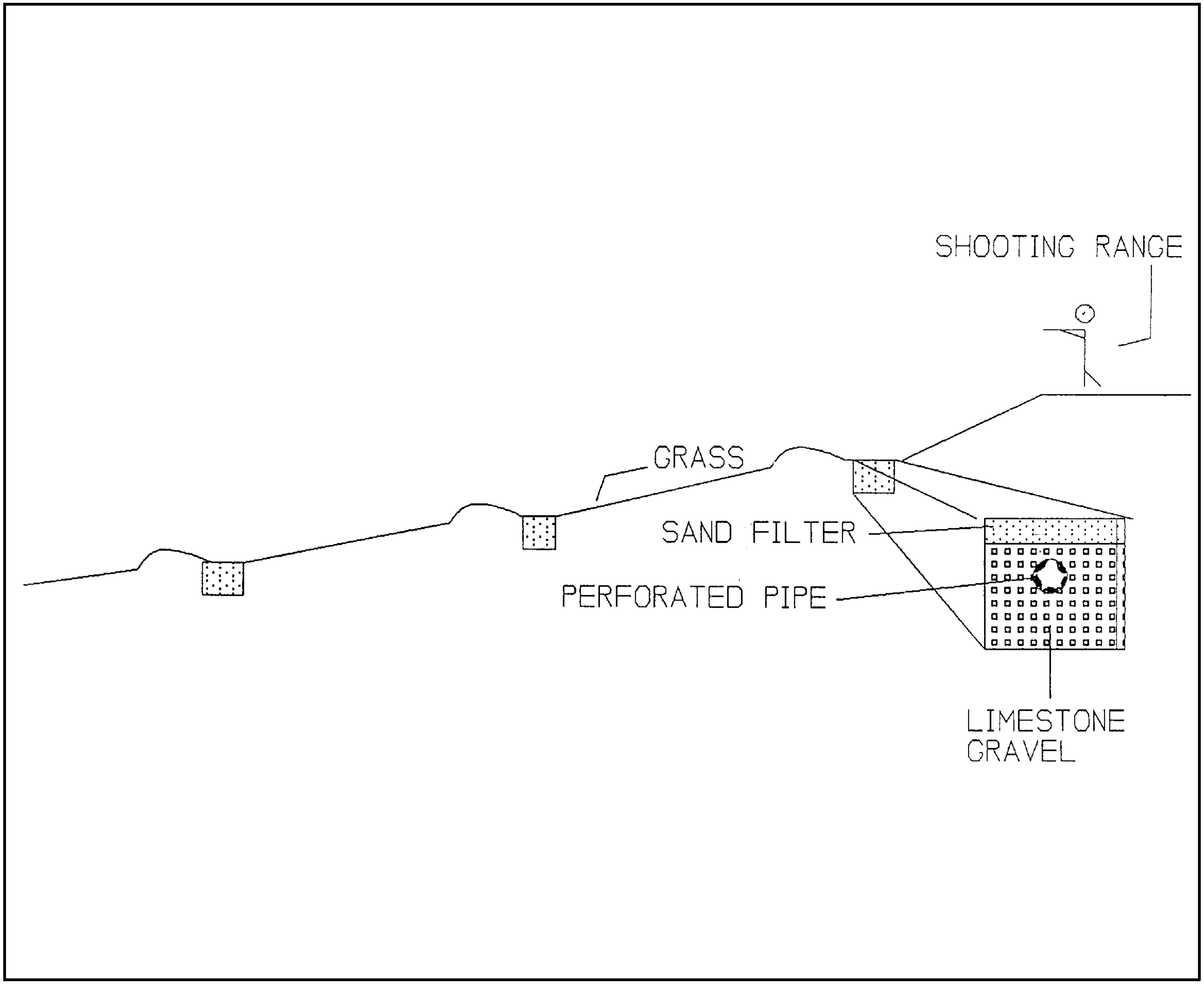
RIFLE TARGET
LEAD EMBEDDEDD
AREA
BERM
SAND FILTER
PERFORATED PIPE
LIMESTONE GRAVEL


SHOOTING RANGE
GRASS
SAND FILTER
PERFORATED PIPE
LIMESTONE GRAVEL

<u>Summary</u>

In summary, think prevention!

1. *Recycle the lead to reduce its volume.*

2. *Prevent precipitation from coming in contact with the lead.*

3. *Separate lead splatter suspended in storm runoff by filtration, impoundment, or another method.*

4. *Reduce the velocity of storm runoff.*

5. *Increase the pH of water and soil by addition of limestone or dolomite.*

6. *Increase vegetative cover – plant grass or native flowering plants.*

7. *Minimize costs by performing these tasks as near the lead deposit areas as is practical.*