CORRECTIVE ACTION AT OUTDOOR SHOOTING RANGES GUIDANCE DOCUMENT

Colorado Department
of Public Health
and Environment

Hazardous Materials and Waste Management Division
Colorado Department of Public Health and Environment

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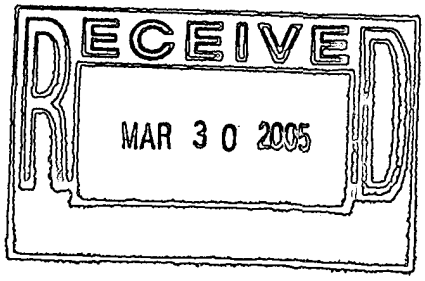

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Introduction

The purpose of this document is to provide owners and operators of outdoor small arms (50 caliber or smaller) shooting ranges with guidance for the closure of active ranges and remediation of closed or abandoned ranges. It is intended to provide a framework for performing assessment and corrective action (cleanup) of these sites, but is not intended as an all-encompassing corrective action guidance document. The reader is directed to additional guidance in the areas of corrective action and hazardous waste compliance, which are referenced at the end of this document.

Impact on Human Health and the Environment

Lead can be introduced into the environment at shooting ranges though oxidation of lead shot when exposed to air, followed by dissolution when exposed to acidic water or soil. This dissolved lead can then migrate through soil or fractured rock to ground water. The rate and distance of migration of lead through soil and ground water is controlled by several factors including:

- The amount of lead in soil (source);
- The length of time that the source has been allowed to oxidize;
- The annual amount of precipitation;
- The pH of rain water, surface water, ground water, and surface and subsurface soils;
- The amount of time the source is in contact with acidic water or soil;
- Soil type and chemistry;
- Depth to ground water; and,
- Ground water chemistry.

In addition, lead shot, lead fragments and dissolved lead can be transported by storm water runoff, which can result in the spread of soil contamination and impacts to surface water.

Once in the environment, lead can have many adverse effects on humans, animals and plants. Human exposure to lead can result in a wide range of health problems in adults, including kidney dysfunction, high blood pressure, reproductive problems, digestive problems, concentration and memory problems, and neurological disorders. Effects on children include headaches, impaired vision and motor skills, behavior and learning problems, hearing problems, damage to brain and nervous system, and a reduced growth rate.

Effects on animals due to excessive lead exposure, primarily from ingestion, include increased mortality rates. Waterfowl are particularly susceptible to lead ingestion, especially in areas where shooting occurs over or near to water. Other environmental effects of elevated lead levels include plant toxicity.

Best Management Practices at Active Ranges

During the active life of a shooting range, steps can be taken to reduce the amount of lead in the environment. A lead management program, which employs a variety of best management

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practices (BMPs), should include bullet and shot containment, prevention of lead migration, and periodic lead removal and recycling. There are many techniques available to achieve these objectives, which can be designed to meet the specific needs of individual ranges. In addition to lead management practices, the use of lead-free shot should also be evaluated.

Soil that is managed at an active range during the implementation of a BMP can be placed back on the ground at the shooting range if it is used for a similar purpose. These BMP activities would include: screening soil for lead fragments, adding lime, phosphate, or other material to adjust soil pH, or any other BMP that is intended to reduce the amount or mobility of lead in the environment. For example, lead contaminated soil may be returned to the earthen backstop following the recovery and recycling of lead shot. Although BMPs are not considered to be a waste management activity subject to regulation, they may result in the generation of solid or hazardous wastes for the purposes of off-site treatment or disposal. For example, a mixture of clay target fragments, lead shot and soil generated while screening the soil to remove lead and debris (a BMP approved activity) is considered to be a solid waste and may also need to be managed and disposed of as a hazardous waste if the lead content of this screened debris is sufficiently elevated. Similarly, wastes generated during other activities, such as moving soil during construction, which are not being conducted as part of normal lead management practices, are not exempt from regulation. For example, a lead contaminated earthen backstop that is removed to allow for the construction of a clubhouse is subject to the waste management requirements of the Colorado Hazardous Waste Act (CHWA), including the requirement to test the soil to determine if it is a hazardous waste. On the other hand, this soil would be exempt from regulation if it were reused in one of several other firing range backstops that may be present at this active facility.

The design of BMPs should take into account the physical characteristics and operation conditions at the site. The physical characteristics that should be considered include: range size, soil type and pH, annual precipitation, topography and storm water runoff direction, depth to ground water, location of surface water bodies, location and type of vegetation, and accessibility of shotfall zones. The operational aspects of a range that should be considered include: the number of rounds shot annually, the size of the shots that are used, and shooting directions and patterns. With these characteristics in mind, range-specific BMPs can be put in place to reduce the potential for lead to impact the environment. Guidance on the use of techniques to manage and recover lead at active shooting ranges is provided in EPA Region II's *Best Management Practices for Lead at Outdoor Shooting Ranges* (January 2001) and the Interstate Technology and Regulatory Cooperation Work Group's *Technical Guidance: Environmental Management at Operating Outdoor Small Arms Firing Ranges* (December 2004).

Corrective Action

The Department considers lead shot at closing, closed, or abandoned shooting ranges to be solid waste. Spent lead shot that is left in the environment long after it has served its intended purpose poses a threat to human health and the environment and is therefore subject to the broader statutory definition of solid waste under the CHWA and its implementing regulations. In addition, if soil containing lead or debris at either an active or closed range is in some way "managed", including being excavated, moved without being excavated, or buried, it is

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considered a solid waste. Once a solid waste, the material is considered a hazardous waste if it exhibits the toxicity characteristic for lead when analyzed by the Toxicity Characteristic Leaching Procedure (TCLP) using EPA Test Method 1311.

If a shooting range has closed or is closing, or soil is to be managed in a way that does not constitute a BMP to reduce lead levels at an active range, cleanup action of impacted soil may be necessary. In general, corrective action is made up of two primary components: assessment and remediation. The party conducting corrective action has the option of performing the work and then seeking Department approval, or involving the Department at key points in the corrective action process to ensure all requirements and technical expectations are met. The preferred method is to seek Department approval in advance of planned activities so that agreement can be reached on how to conduct the cleanup, thereby avoiding the unnecessary waste of time and money having to correct deficiencies identified at a later date.

The Department's Hazardous Materials and Waste Management Division (the Division) is responsible for overseeing corrective action at sites with solid and hazardous wastes. Shooting ranges identified as solid waste management units in hazardous waste permits or subject to corrective action under a compliance order must be remediated in accordance with the applicable legal requirements. Otherwise, if the shooting range ceased operation prior to 1980, the Division's Voluntary Cleanup Program or Solid Waste Program will oversee the cleanup. If the shooting range was active after 1980 and its closure is not subject to requirements of a permit or order, the Division's Hazardous Waste Corrective Action Unit would typically oversee the cleanup under a corrective action plan in accordance with 6CCR 1007-3, Section 100.26 of the Colorado Hazardous Waste Regulations. The only exception to this is if testing reveals that no soil found on-site exhibits the characteristic of a hazardous waste, in which case even those shooting ranges that were active after 1980 are eligible for cleanup under the Voluntary Cleanup Program or Solid Waste Program.

Assessment of Impacted Soils

Areas with significant exposure to lead shot or with a potential for lead impact, such as the area between the firing line and impact berm, the impact berm itself, shot-fall zones, and runoff collection areas, should be assessed to determine if lead contamination is present and whether cleanup is necessary. The Department recommends characterizing the presence, extent, and magnitude of lead contamination according to the following steps:

1. Sample and analyze the soil to determine if there are levels of total lead above the Department's unrestricted (residential) use level of 400 mg/kg, and/or levels of leachable lead in the soil at or above the toxicity characteristic (TC) limit of 5 mg/l. A sample grid pattern can be used for initial assessment, with biased samples collected in areas of suspect high levels of contamination. The initial grid spacing will depend on the total area to be assessed, but should generally be no greater than 50 feet. A smaller grid spacing may be necessary depending on the activity.

    a. To determine the vertical extent of total lead contamination above the 400 mg/kg unrestricted use level:

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i. Collect soil samples at 6-inch intervals, beginning at the ground surface and extending downwards to a depth where contamination is not anticipated (e.g., sample 1 from the 0-6 inch depth interval, sample 2 from 6 to 12 inches, sample 3 from 12 to 18 inches, etc.). Professional judgment should be used to decide if different sample intervals are more appropriate (e.g., sample 1 from the 0-6 inch depth interval, sample 2 from 12 to 18 inches, sample 3 from 24 to 30 inches, etc. in an area such as the backstop where shot penetration is expected to be greater).
ii. Analyze the 0-6 inch sample for total lead using EPA Method 6010B.
iii. If the total lead concentration is greater than 400 mg/kg, analyze the next deepest sample.
iv. Continue to analyze progressively deeper samples until the analytical result is below the 400 mg/kg unrestrictive use level.

c. Repeat step (a) at each location in the sampling grid to delineate the horizontal extent of contamination.

d. Additional sampling points may be necessary to delineate contamination detected during initial grid sampling.

e. To evaluate the presence and extent of leachable lead contamination above the TC limit, analyze (by TCLP) a sufficient number of representative samples that exceed 400 mg/kg to determine a threshold total concentration above which soil will generally be a hazardous waste.

2. If soil sampling results indicate that there is impacted soil near or in contact with ground water, or if shallow ground water is present, monitoring wells should be installed to evaluate the presence and extent of ground water contamination. If levels of lead in ground water exceed the Colorado ground water standard of 50 ug/l, then ground water impact must also be delineated and addressed during site remediation.

3. After soil remediation activities have been performed, as discussed below, confirmation samples should be collected to demonstrate that all soil above TC limits and the unrestricted use level (or an approved site-specific cleanup level) has been excavated and disposed of or treated to below appropriate levels. This step may not be necessary if the initial investigation adequately delineated the vertical extent of the lead contamination and the depth below which the cleanup standard is not exceeded has already been established (i.e., the site investigation test results substitute for the confirmation samples).

Remediation of Impacted Soil

Depending on assessment results, remediation or proper management of impacted soil may be necessary. While evaluating options for handling impacted soil, the following should be considered:

1. Soil with leachable lead concentrations exceeding the TC limit of 5 mg/l is considered to be a characteristic hazardous waste and must be managed accordingly (e.g., the soil is placed in containers

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and disposed of by established deadlines at a permitted hazardous waste facility). This soil may either be excavated and disposed of at a hazardous waste landfill or treated onsite (in compliance with Section 100.21(d) of the Colorado Hazardous Waste Regulations) to below the TC limit and managed as a solid waste in accordance with the Colorado Solid Waste Regulations (6 CCR 1007-2). Examples of available treatment technologies are discussed later in this document. A waste determination must be conducted on all newly generated waste (contaminated soil that is disturbed or actively managed during the cleanup activity), regardless of when the shooting range ceased operating or which program within the Department is overseeing the cleanup.

2. If there is a potential for impact to ground water or surface water (i.e., contaminated soil is in contact with or within 5 feet of ground water or within 100 feet of surface water), the concentration of leachable lead remaining on-site may not exceed 1.1 mg/l, a leachate extract concentration believed to be protective of underlying ground water quality. Leachability is characterized using the TCLP method or some other Department approved leach test. A cleanup that leaves behind lead contamination at concentrations greater than the 400 mg/kg unrestricted use level should also be tested in a similar fashion to verify that the residual contamination will not be sufficiently mobile to degrade ground water quality at a later date.

3. Any cleanup that leaves soil contamination at a level greater than 400 mg/kg and/or that poses a risk to ground water (yields a TCLP leachate concentration equal to or above 1.1 mg/l) will require that use restrictions and appropriate access controls be put in place. These controls would be incorporated into an environmental covenant in accordance with Sections 25-15-317 through 25-15-327 of the Colorado Revised Statutes. The only exception to this requirement for a covenant is for cleanups occurring under the oversight of the Voluntary Cleanup Program, where the designated land use will be noted in the Department's approval letter, the violation of which voids that approval. More information on the use of environmental covenants may be found at http://www.cdphe.state.co.us/hm/envcovenants.asp.

4. Soil with leachable lead concentrations below the TC limit, but with total lead concentrations above the Department's unrestricted use level of 400 mg/kg and/or that poses a threat to ground water (yields a TCLP leachate concentration equal to or above 1.1 mg/l), can be managed in one of the following ways:

    a. The soil can be excavated and disposed of at a licensed solid waste landfill.

    b. The soil may be treated to stabilize the lead in order to reduce its mobility, thereby protecting ground water and allowing it to be managed in accordance with paragraph c below.

    c. The soil may be left on-site as a solid waste, but only if it is i) managed in accordance with the Colorado Solid Waste Disposal Site and Facilities Act and the Colorado Solid Waste Regulations at 6 CCR 1007-2, ii) it poses no risk to the current and future users of the property and iii) it does not leach into and contaminate ground water. As stated above, any cleanup that leaves behind lead contamination at concentrations that exceed the unrestricted use level will result

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in a requirement that use restrictions and appropriate access controls be put in place under an environmental covenant.

5. Prior to soil remediation, the Department recommends that lead shot and fragments be screened from the impacted soil. These materials can be recycled in accordance with 6CCR 1007-3, Section 261.6 of the Colorado Hazardous Waste Regulations. Screening out lead fragments is not required as long as the treatment process used during remediation successfully stabilizes both the soil and the lead fragments, resulting in a mixture that is no longer a characteristic hazardous waste. However, separating and recycling lead shot and fragments from the soil may reduce the total volume of waste requiring treatment and/or disposal.

6. During the remediation of soil that is a hazardous waste, no stockpiles may be created unless they are strictly meant to facilitate remediation (staging piles for the purpose of preparing for treatment or disposal), in which case the temporary stockpiles must be eliminated within 72 hours of creation. Such piles should be limited to areas of known contamination that will be remediated and where confirmation samples will be collected to verify that no residual contamination is being left behind. Movement of contaminated soil into clean areas is discouraged; however, if necessary, the temporary stockpile should be placed on plastic sheeting, covered with weighted plastic sheeting, and confirmation samples collected afterwards to verify that clean soil around and beneath the stockpile has not been impacted.

7. Prior to remediation of soil that is a hazardous waste, the Department recommends that bench scale tests be performed on materials with the highest lead concentrations. Successful elimination of the hazardous waste characteristic in this material will reduce the need for subsequent testing of the treated soil for waste determination purposes. If the chosen treatment method is of questionable reliability (e.g., the hazardous waste characteristic may not always be eliminated), the treated soil will need to be tested routinely for waste determination purposes. In the event that the bench scale tests are successful and the characteristic is consistently eliminated, a few samples will still need to be collected, at least initially, to verify the continued success of the stabilization effort following full scale field implementation of the treatment process. This verification testing may cease entirely if it is demonstrated early on that the lead contaminated soil is successfully treated during the full scale operation of the treatment system.

In some instances it may be necessary to retrieve lead contaminated soil that may be found on adjoining properties. This soil may be recovered and returned to the site where the cleanup is taking place. Once it is brought back onsite, the lead contaminated soil should be managed in accordance with its waste classification (e.g., in containers if it is a characteristic hazardous waste).

Remedial Alternatives

Lead contaminated soil can easily be treated to eliminate the hazardous waste characteristic, allowing for its disposal more economically as a solid waste. Several examples of available remediation and treatment technology alternatives for lead contaminated soil are presented below. Treatment of hazardous waste must be conducted in accordance with 6CCR 1007-3, Section 100.21(d) of the Colorado Hazardous Waste Regulations. Among other things, this rule requires that treatment occur in tanks or containers and that a plan outlining the process and

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method used to verify the success of the stabilization effort be submitted to the Department for review. Once the determination is made that the material is no longer a hazardous waste, the soil may be managed in accordance with the solid waste regulations (6 CCR 1007-2). In the event that the material remains characteristically hazardous, the soil must be further treated or disposed of within 90 days of when it was excavated, in accordance with Part 262 of the Hazardous Waste Regulations. The reader is referred to the Department's *Treatment of Hazardous Waste by Generators Guidance Document* (CDPHE, April 2000) for further guidance regarding treatment of hazardous waste.

Most Commonly Used Remedial Alternatives

1. Excavation and disposal at a licensed hazardous waste landfill, if leachable lead concentrations exceed the TC limit of 5 mg/l, or disposal at a licensed solid waste landfill if concentrations are below the TC limit. As discussed previously, soil with leachable lead levels below the TC limit, but above the health-based unrestricted use concentration (400 mg/kg) and/or above a concentration that poses a risk to ground water (1.1 mg/L leachate concentration) can be left onsite, requiring on-going land use restrictions that must be ensured long-term through an environmental covenant or some other Department approved control mechanism (Voluntary Cleanup Program).

2. Stabilization/solidification to immobilize contaminants in the soil. This is accomplished by adding a treatment agent, such as Portland cement or a phosphate-based stabilization compound, to reduce contaminant solubility, decrease the exposed contaminant surface area, and reduce matrix porosity and permeability resulting in a reduced exposure to fluids that could transport contaminants. Following appropriate testing to ensure effective treatment, the non-hazardous stabilized soil may then be disposed of at a local solid waste landfill. An alternative is to dispose of the treated soil on-site, requiring the property owner to manage this waste in accordance with the design and operating requirements of a solid waste disposal facility.

Less Frequently Used Remedial Alternatives

1. Vitrification is a high temperature technology that reduces the mobility of metals by incorporation into a chemically durable, leach resistant, vitreous material. Vitrification can be applied either ex-situ or in-situ.

1. Soil washing is an ex-situ technology that uses a combination of physical and aqueous based separation techniques to remove contaminants from soil. Because soil washing transfers contaminants to the washing fluid, the fluid must be treated for reuse or disposed of as hazardous waste.

2. Soil Flushing is the in-situ extraction of contaminants from soil through the use of a washing fluid. As with soil washing, because contaminants are transferred to the washing fluid, the fluid must be treated or disposed of as hazardous waste.

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3. Phytoremediation is an in-situ technology in which plants are used to remove contaminants from soil and/or ground water, or to degrade contaminants to more desirable by-products.

4. Electrokinetic remediation is a relatively new technology that uses low intensity direct current between electrodes placed in soil. The current mobilizes contaminants allowing for consolidation and removal of the contaminant from soil.

Confirmation sampling is necessary to demonstrate the effectiveness of the chosen treatment technology. Soil that remains hazardous after treatment must undergo additional treatment to below the TC limit, or must be disposed of at a hazardous waste landfill.

Land Disposal Restrictions

In the event a decision is made to stabilize lead contaminated soil that exhibits the characteristic of a hazardous waste on-site in accordance with 6CCR 1007-3, Section 100.21(d) of the Colorado Hazardous Waste Regulations, the party performing the treatment must ensure that the resulting lead concentrations in the treated material have been reduced to the extent necessary to satisfy the Land Disposal Restrictions (LDRs) outlined in Part 268 of the regulations. The alternative treatment standards for contaminated soil, specified in 6CCR 1007-3, Section 268.49 of the regulations, only apply to contaminated soil that is classified as a hazardous waste (exceed TCLP regulatory limits).

Two things must be done in order to satisfy the LDR requirements. They are:

- First, the soil must be treated in order to remove the hazardous waste characteristic (i.e., the TCLP leachate for the treated soil must contain lead below a concentration of 5 mg/L). This is easily done using standard stabilization techniques.

- Second, Section 268.49(c)(1)(ii) of the regulations requires the treatment to reduce constituent concentrations by 90 percent, as measured in leachate from the treated soil. For example, if the TCLP test on the soil from the backstop contained 40 mg/L lead, treatment would have to get the TCLP leachate concentration down to at least 4 mg/L in the treated soil. In a second example, if the original soil yields a TCLP leachate with 6 mg/L lead, the treated soil must produce a TCLP leachate with .6 mg/L or better. Experience suggests that this too is achievable.

With regard to the second point above, Section 268.49(c)(1)(iii) of the regulations says that treatment is not required if the 90 percent reduction standard would result in a concentration less than 10 times the Universal Treatment Standard (10 x 0.37mg/L = 3.7 mg/L for lead). In the first example described above, the 90 percent reduction observed from 40 to 4 mg/L results in an extract concentration that is still above 10 times the UTS (4.0 vs 3.7 mg/L). The LDRs are satisfied because a 90 percent reduction was achieved and the lead concentration in the leachate has fallen below the 5 mg/L regulatory limit. In the second example, the change from 6 to .6 mg/L is well below 10 times the UTS (0.6 vs 3.7 mg/L). In this case, treatment is not necessary to satisfy the 90 percent reduction requirement. However the LDRs say you must still eliminate the hazardous waste characteristic (TCLP lead concentration below 5 mg/L). This again was

accomplished without doing anything extra beyond the standard stabilization process. Problems arise when the treatment activity fails to achieve the required 90 percent reduction or 10 times the UTS, whichever applies, and eliminate the hazardous waste characteristic, in which case treatment will need to continue or an entirely new treatment method applied to achieve the necessary contaminant reductions before land disposing the soil.

Our experience suggests that the routine stabilization of lead contaminated soil to eliminate the hazardous waste characteristic will for all practical purposes satisfy the LDR requirements.

TABLE 1

SUMMARY OF CONCENTRATION BASED SOIL MANAGEMENT REQUIREMENTS

INCREASING LEAD CONCENTRATION ↑

RELATIVE CONCENTRATION	MANAGEMENT REQUIREMENTS	TREATMENT OPTIONS
Lead concentration in the TCLP leachate extract exceeds the TC regulatory limit of 5 mg/L.	Excavated soil must be managed as a hazardous waste.	Soil may be treated in accordance with §100.21(d) of the Colorado Hazardous Waste Regulations in order to stabilize the lead and render the entire mixture non-hazardous to allow for its disposal as a solid waste at the local landfill.
Lead concentration in the TCLP leachate extract exceeds the 1.1 mg/L leachate reference concentration.	Excavated soil must be managed as a solid waste.	Soil may be treated to stabilize the lead, reducing the opportunity for lead to leach out and contaminate ground water, either at the solid waste landfill or onsite if this soil is allowed to remain behind.
Total lead concentration exceeds the 400 mg/kg unrestricted use value.	Excavated soil must be managed as a solid waste.	No treatment necessary.
Total lead concentration is equal to or below the 400 mg/kg unrestricted use value.	No specific management requirements for this low level contaminated soil.	No treatment necessary.
Total lead concentrations are above background levels.	No specific management requirements for this low level contaminated soil.	No treatment necessary.
Total lead concentrations are equal to or below background levels.	Assumed to be naturally occurring lead and the soil is presumed to be clean and unaffected by site activities.	No treatment necessary.

NOTE: Based on past experience, it is assumed that lead concentrations greater than 400 mg/kg are required in order to fail the toxicity characteristic ($\geq$ 5 mg/L via TCLP) or leach sufficient lead to potentially impact ground water (> 1.1mg/L via TCLP). In the event the lead is a more soluble form (e.g., lead concentrations in the TCLP leachate extract is > 1.1mg/L for soil below the health-based unrestricted use value of 400 mg/kg), manage the soil in accordance with the more stringent of the two criteria (e.g., excavated soil is managed as a hazardous waste because it failed the toxicity characteristic, even though the total lead concentration may be $\leq$ 400/mg/kg).

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