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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This guidance is meant to provide general information to help you comply with Colorado's hazardous waste regulations. It cannot cover every situation and is not intended to do so. It does not modify or replace adopted regulations, which undergo periodic revisions. If there is a conflict between the guidance and the regulations, the regulations govern. Some portions of the hazardous waste regulations are complex and this guidance does not go into details of these complex situations. This document is not intended and cannot be relied upon to create any rights, substantive or procedural, enforceable by any party in litigation with Colorado. The Division reserves the right to act at variance with this guidance and to change it at any time.

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1.0 Introduction

This document is intended as a "plain English" guide to give owners and operators of outdoor small arms shooting ranges (.50 caliber or smaller) general 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 cleanup of these sites, but it is not intended as an all-encompassing corrective action guidance document. If you have specific questions or need interpretive guidance on your situation, you should contact the Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division (the Division). Contact information for the Division is provided at the end of this document. Additional guidance on corrective action and hazardous waste compliance cited in this document can be found on the Division's website and in Section 10.0 of this document.

2.0 Impact on Human Health and the Environment

Most contamination at outdoor small arms shooting ranges consists of heavy metals wastes from ammunition fired at the site. The most common contaminant is lead from expended ammunition, though arsenic, cadmium and zinc may also be present. Other wastes such as plugs, casings, target fragments, and abandoned structures may be present, depending on how the range was managed during its operation.

Lead can be introduced into the environment though oxidation of bullets and shot when it is exposed to air. Breakdown of the ammunition may also occur if the materials are allowed to weather and are exposed to freeze/thaw cycles. Lead can dissolve when it is exposed to acidic soil or water. Dissolved lead can then migrate through soil or fractured rock to ground water. The amount of lead that migrates into soil and ground water and the distance it travels will depend on several factors including:

- The amount of lead in soil (source).
- The length of time 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.
- Ground water chemistry.

In addition, lead bullets, shot, 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, neurological disorders, convulsions, coma and death. 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 water. Other environmental effects of elevated lead levels include plant toxicity.

3.0 Best Management Practices at Active Ranges

During the active life of a shooting range, range operators and owners should use a lead management program to reduce the mobility of lead in the environment. The plan should include best management practices (BMPs) such as bullet and shot containment, engineered structures or devices to prevent lead migration, as well as periodic lead removal and recycling. There are many techniques available to achieve these objectives that can be designed to meet the specific needs of individual ranges. In addition to the lead management practices above, active range operators and owners should evaluate whether lead-free shot should be used on the range.

Soil managed at an active range under a best management practice can be placed back on the ground at the shooting range if it is used for a similar purpose. For example, lead contaminated soil used in an earthen backstop may be returned to the backstop after the lead bullets, shot and fragments are recovered from the soil. The removed lead should be sent for recycling or must be disposed of as hazardous waste. Other best management practices may include adding lime, phosphate, or other stabilizers to adjust soil pH or other techniques intended to reduce the amount or mobility of lead in the environment.

Although best management practices at an active range are not considered to be a waste management activity subject to regulation, they may result in the generation of solid or hazardous wastes if the soils or other wastes are treated or disposed of offsite. For example, a mixture of clay target fragments, lead shot and soil generated while screening the soil to remove lead and debris (a best management practice approved activity) is considered to be a solid waste and may also need to be managed and disposed of as a hazardous waste if this screened debris contains lead or other contaminants at levels that would cause it to be regulated as hazardous. Similarly, wastes generated during other activities, such as moving soil during construction that is 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 a clubhouse to be constructed is subject to the waste management requirements of the Colorado Hazardous Waste Act, including the requirement to test the soil to determine if it is a hazardous waste. On the other hand, this soil would not be subject to regulation if it were reused in one of several other firing range backstops that may be present at the same active facility.

Best management practices should take into consideration the site's physical characteristics and operating conditions. Physical characteristics that should be considered include:

- Range size.
- Soil type and pH.
- Annual precipitation.
- Site topography and storm water runoff direction.
- Depth to ground water.
- Location of surface water bodies.

- Location and type of vegetation.
- Accessibility of shot fall and slug impact zones.

Range operations that should be considered include:

- The number of rounds shot annually.
- The size of the ammunition used.
- Shooting directions and patterns.

With these characteristics in mind, range-specific best management practices can be put in place to reduce the potential for lead to impact the environment. EPA Region II's *Best Management Practices for Lead at Outdoor Shooting Ranges* (revised June 2005) and the Interstate Technology and Regulatory Council's *Technical Guidance: Environmental Management at Operating Outdoor Small Arms Firing Ranges* (February 2005) provide additional guidance on techniques used to manage and recover lead at active shooting ranges.

4.0 Corrective Actions at Closing, Closed or Abandoned Ranges

The Division 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 Colorado Hazardous Waste Act and its implementing regulations. In addition, if soil containing lead or debris at a shooting range is in some way "managed," including being excavated, moved without being excavated, or buried, it is considered to be a solid waste. Once a solid waste, the material is considered to be 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 if soil will not be managed using a best management practice at an active range, corrective action to address impacted soil may be necessary.

In general, corrective action is made up of two primary components: assessment and remediation. Assessment is conducted to determine the full nature and extent of contamination present, while remediation consists of actions taken to mitigate or limit the potential for the contamination to cause harm to humans and the environment. If you are conducting corrective action at your site, you have the option of performing the work first and then seeking Division approval or you can involve the Division at key points in the corrective action process to ensure all requirements and technical expectations are met along the way. Seeking Division approval before beginning corrective actions will allow for agreement on the process and help avoid the unnecessary waste of time and money correcting any problems identified later.

The Hazardous Materials and Waste Management 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 identified in those documents. If the shooting range was operating after 1980 and its closure is not subject to requirements of a permit, administrative order or consent decree, the Division's Hazardous Waste Corrective Action Unit would typically oversee the cleanup under a corrective action plan in accordance with Section 100.26 of the Colorado Hazardous Waste Regulations (6

CCR 1007-3). The only exception to this is if testing reveals that no pellets, bullets or lead fragments are present and the soil found on site does not exhibit the characteristics of a hazardous waste, in which case shooting ranges that were active after 1980 are eligible for cleanup under the Division's Voluntary Cleanup Program or the Solid Waste and Materials Management Program. Where a shooting range ceased operation prior to 1980, the Voluntary Cleanup Program or the Solid Waste and Materials Management Program would oversee the cleanup.

5.0 Site Assessment

The main goal of any site assessment at a small arms shooting range is to determine the location and vertical and horizontal extent of contamination present. While there are many methods that can be used to characterize a site, the data generated from the assessment must be able to give you enough information to determine what areas need to be remediated and to what extent.

General information about the facility should be gathered as part of the initial site assessment. This information should include the physical location and the approximate limits of the range; physical features on or adjacent to the range that may affect shot or slug fall patterns such as berms and backstops, outcrops, hilly terrain or stands of trees; any valleys or bodies of water (ephemeral or flowing) draining the area that could potentially contain contaminated sediment; and the types and sizes of ammunition that may have been used at the range. Additional information such as the number of years the range was in operation, locations of firing lines and targeting areas, and the types of weapons used on the range may also be helpful in determining the locations of potential contamination zones. Where possible, the types and methods of targeting used at the range (e.g., clay targets or other materials, aerial or ground targets) should also be identified. If they are available, owners and operators familiar with the facility's historic operation should be interviewed as they may be able to provide this information.

A thorough visual site inspection is critical to verify the site's terrain, to find the approximate locations of firing lines, target and shot fall zones and slug impact areas, and to identify any other wastes present. If firing lines and target zones can be identified, areas suspected to be fall or impact zones should be flagged and inspected to determine their visible extent. If there is no specific information available on the location of the target zones and firing lines, the soils in the area must be systematically examined for the presence of shot, slugs and targets using a grid system, transects or other method.

Contaminant transport can be a concern with sites that are adjacent to water bodies and which do not have engineering controls such as berms or backstops to prevent expended shot, slugs and other wastes from being transported off site. If the site is adjacent to an ephemeral or flowing body of water or is located in a floodplain, sediments associated with these features should be evaluated for evidence of range-associated wastes.

Questions may arise on whether soil samples must be sieved or whether un-sieved samples should be used in the assessment process. While many current analytical methods rely on using only soil that has been passed uncrushed through a 30-mesh or 60-mesh (250µm) sieve as the source for analytical tests, some controversy exists in the field as to the best method(s). Different sample preparation protocols have been proposed and approved by other regulatory agencies.

Differences in sample preparation protocols include the designation of the size of sieve or whether to use a sieve at all and on the degree of disaggregation prior to sieving. Therefore, to recommend a specific sample preparation method may be misleading. No matter which method is finally selected, however, it should result in a sample that is representative of the area being tested and yields data that accurately quantifies the degree to which it may be contaminated.

5.1 Site-Specific Issues for Shotgun and Multipurpose Ranges

Outdoor shotgun practice ranges such as trap, skeet and sporting clays ranges and ranges used for both smooth-bore and rifled weapons shooting, can be problematic when compared to small arms rifle and pistol ranges for assessment and remediation. These ranges may be located on variable terrain, may sit adjacent to intermittent or flowing water bodies, and/or may not have backstops or other manmade or natural structures to prevent or limit expended ammunition from leaving the range. Shotgun ammunition contains small diameter pellets rather than a single slug. Because of its size, this smaller ammunition can scatter and disseminate more readily through sandy or rocky soils and be more readily mobilized off of the original range limits by weathering processes or wildlife.

Targets used on these ranges may contain other regulated hazardous constituents such as polycyclic aromatic hydrocarbons (PAHs) depending on the manufacturer of the target clays and the dates of manufacture. Other solid wastes such as plastic shell liners, casings and plugs may also be present if the range was not regularly maintained during its operation. A systematic approach and thorough assessment is necessary to properly characterize and remediate these sites.

Multipurpose ranges often have a greater number of shooting days when compared to single purpose ranges, and ammunition types should be expected to vary widely in size and distribution. In this case, the range should initially be examined using methods suitable for shotgun ranges until additional information can be gathered on targeting locations and firing lines.

Shotgun or Multipurpose Range Site Assessment

Shotgun and multipurpose ranges usually must be characterized using a site wide approach as the expended ammunition may be more widely distributed than at a rifle range. Gridding off the range into smaller sections to delineate and examine specific areas, along with qualitative sampling to identify shot or slug presence/absence, may need to be conducted during the initial site assessment to identify these areas. In this case, the sampling should be done on a dry basis, with samples sieved to determine the presence or absence of pellets. When soil samples are obtained, samples should be taken at specific depths at each sampling point to determine the approximate vertical distribution of the expended ammunition.

In general, individual grid dimensions should be no greater than 50 feet by 50 feet; these may be smaller depending on the size of the range. One method that can be used to help characterize the soil contamination and to potentially limit the number of soil samples necessary to characterize the site is to determine the threshold level (what amount of pellets per unit weight of soil) that would cause the sample to be regulated as solid waste and/or hazardous waste. This threshold

level may be based on risk-based values such as those found in the *Colorado Soil Evaluation Values* (July 2011 and updates) or on values specifically approved by the Division for the site. The *Colorado Soil Evaluation Values* table is available on the Division's website.

To minimize wasted time and effort, the method used to characterize an area should be discussed with the Division beforehand and submitted in a work plan for review and approval. Various approaches are available, including everything from collecting multiple samples from a grid or transect and analyzing each individually to compositing several samples and analyzing as one sample. The first approach may provide sufficient detail to allow you to limit remediation to small areas within a particular grid or transect. Basing a remedial decision on a single composite sample limits you to a "pass/fail" determination for the entire grid, requiring additional sampling if you want to further refine and reduce the area where remediation may be required. The decision on which approach to employ will be dependent on the competing costs of collecting and analyzing soil samples versus the cost of remediating and disposing of the lead contaminated soil.

An example protocol for field sampling and testing for macroscopic pieces of lead (based on Carter Burgess, 2002) is provided below. This method is preferred over others that rely on the collection and laboratory analysis of what is presumed to be a representative sample. The method described below results in a more representative total lead concentration that is (a) based on a much larger volume of soil and (b) is not subject to the problem of getting a representative sample in a situation where the contaminant may not be uniformly distributed in the soil matrix (which can lead to either under or over reporting the contaminant concentration). This method also minimizes the number of samples that need to be submitted for laboratory analysis, and is capable of being implemented in the field with real-time decisions being made on what further characterization is necessary.

1. Determine the average weight of soil in a full 8-ounce jar based on weighing six individual samples and calculating the average soil weight. These soil samples should be collected from a non-impacted area of the site where soils adequately reflect the types of soils found in the range area.

2. Mark the locations to be sampled in and around the shotgun pellet fallout zone with survey flags and note the position of each sample location using either global positioning system (GPS) technology or detailed site maps.

3. At each sample location in the shotgun pellet fallout zone, collect enough soil from the 0 to 2-inch depth interval to fill an 8-ounce sample jar. If the initial site investigation indicates contamination may be present at greater than 2 inches in depth, additional soil samples should be taken to delineate the vertical extent.

4. Each sample should then be sieved separately using a sieve with a 2-millimeter opening. This mesh size reflects the smallest pellet size commercially available (Size 9) which is 2.03 millimeters in diameter. Once the lead shot and bullet fragments are separated from the sample, these lead particles should be weighed to the closest 0.01 grams.

5. Using the average weight of soil from Step 1 and the weight of the lead shot and bullet fragments from Step 4, calculate the milligrams of lead per kilogram of soil in each sample.

Based on this information, a determination can be made on what amount of lead in the soil (either by weight or by number of pellets) would cause the soil to contain total lead at greater than the unrestricted (residential) use guidelines in the *Colorado Soil Evaluation Values* (July 2011 and updates) or other value approved for this site. This threshold value can then be used to compare information from other soil samples taken at the range to identify areas needing further investigation or remediation. An example of grid characterization for a shotgun range is provided in Figure 1.

After initial samples have been taken and a general outline of the shotgun pellet fallout zone has been established, additional site sampling should be done to more thoroughly define the full magnitude of lead contamination. Sampling may be done in one of two ways:

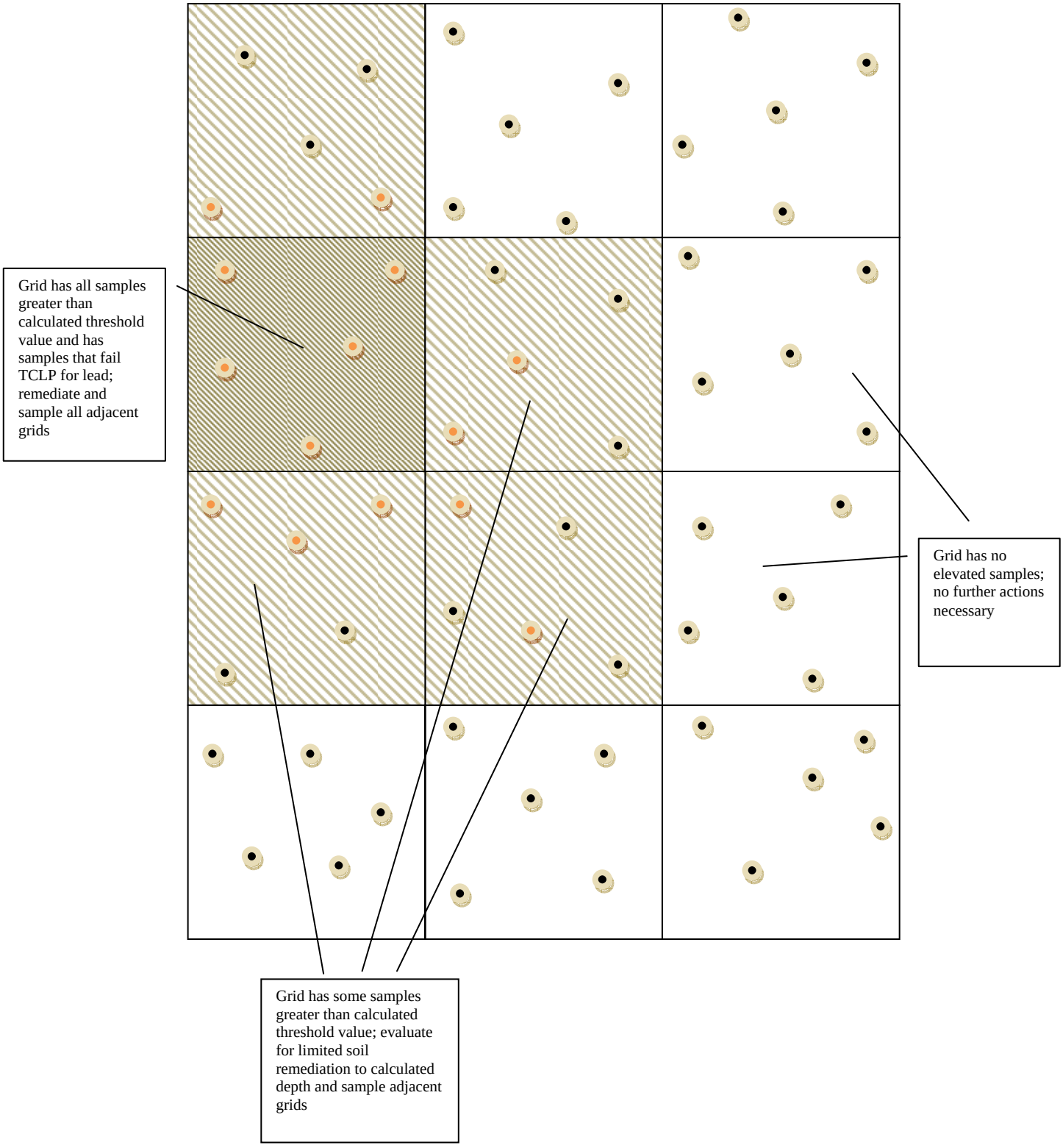
- Establishing multiple transects throughout the observed shotgun pellet fallout zone along which data is collected.
- Conduct additional sampling in grids around areas previously identified as having contamination above the threshold level to further delineate the lateral extent of the fallout area.

The characterization of the areal and vertical extent should proceed using steps 4 and 5 noted above until the full extent of the contamination is defined down to the unrestricted (residential) use guidelines or other value specifically approved by the Division for the site. At the same time, samples of the sieved soil should be submitted for laboratory analysis to determine whether fragments smaller than 2 millimeters in size may have contaminated the soil to levels above the unrestricted (residential) use guidelines. If testing reveals that the sieved soil meets the unrestricted (residential) use guidelines, the need for remediation may only be triggered by the presence of the whole shotgun pellets. This knowledge may allow for unrestricted use of the soil after the pellets are removed, without further testing.

If the sieved soil sample contains lead at levels greater than the unrestricted (residential) use guidelines, an additional soil sample should be collected for laboratory analysis to verify whether the soil passes or fails TCLP for lead to determine whether it needs to be managed as a solid or hazardous waste.

Representative soil samples should also be collected from the firing lines for laboratory analysis if the location of these areas is known since microscopic particles of lead and other metals can be of concern in these areas. Representative samples of shotgun target debris should be collected from the range and analyzed using the TCLP to determine whether this waste material may be characteristically hazardous for lead. The target fragments should also be tested for other constituents (metals, polycyclic aromatic hydrocarbons) to determine whether they too are regulated and therefore need to be analyzed for in soil samples during the site characterization process.

Figure 1 – Example of Grid Characterization for Shotgun Range Remediation



In some instances, you may find that some samples in a given grid have constituent concentrations greater than the unrestricted (residential) use value, while other samples in that grid are lower than the value. In this instance, you should determine whether the entire grid section should be remediated or if only portions of it should be remediated. You will need to include this determination and the supporting justification for making the decision in your documentation of the processes you went through when selecting your remediation alternative.

5.2 Site-Specific Issues for Rifle and Pistol Ranges

Ranges used solely for rifled weapons can be somewhat easier to assess and remediate. Since rifled weapons fire ammunition at higher velocities, these ranges will often have backstops and side walls to help prevent ammunition from leaving the range and expended ammunition may be more concentrated rather than disseminated over a large area. However, bullets fired into backstops and berms can shatter and create finer lead particles. In addition, lead particles from weapons firing may be present at firing lines and some rifle ranges may have remnants from clay targets, shell casings, and plugs.

Areas with significant exposure to ammunition or with a potential for impact, such as the area between the firing line and impact berm, the impact berm itself and runoff collection areas, should be assessed to determine if lead contamination is present and whether cleanup is necessary.

Rifle and Pistol Range Site Assessment

In general, ranges for rifled weapons will have contamination concentrated in several distinct areas: at the firing line, near target zones and in backstops or berms. Soil samples should be collected from the berms and backstops first; the rest of the shooting range should be characterized based on the results from these areas. An example methodology follows.

1. Sample and analyze the soil to determine if there are levels of total lead above the Division's unrestricted (residential) use guidelines in the *Colorado Soil Evaluation Values*, (July 2011 and updates) and/or levels of leachable lead in the soil at or above the toxicity characteristic limit of 5 mg/L. If necessary, a randomized sample grid pattern can be used for initial assessment, with more samples collected in areas of suspected high levels of contamination such as backstops. The initial grid spacing will depend on the total area to be assessed, but should generally be no greater than 50 feet by 50 feet; smaller grid spacing may be necessary depending on the area being sampled. If structures such as impact berms and sidewalls are not present, the range should be evaluated in the same manner as a shotgun or multipurpose range. Unless the lead-bearing bullets have been or are scheduled for removal and recycling, a sampling approach similar to what is used for shotgun or multipurpose ranges may be needed to factor in this lead content when making a hazardous waste determination for soil in the impact zone.

    a. To determine the vertical extent of total lead contamination above the residential use guidelines:

i. Collect soil samples at set intervals, beginning at the ground surface and extending downwards to a depth where contamination is no longer anticipated (e.g., sample 1 from the 0-2 inch depth interval, sample 2 from 2-6 inches, sample 3 from 6-12 inches, etc.). Professional judgment should be used to decide if different sample intervals are more appropriate (e.g., sample 1 from the 0-2 inch depth interval, sample 2 from 6-12 inches, sample 3 from 18-24 inches, etc. in an area such as the backstop where shot penetration is expected to be greater).
ii. Analyze the 0-2 inch sample for total lead using EPA Method 6010B.
iii. If the total lead concentration is greater than the Colorado unrestricted (residential) use guidelines, analyze the next deepest sample.
iv. Continue to analyze progressively deeper samples until the analytical result is below the Colorado unrestricted (residential) use guidelines.

b. Repeat step (a) at each location to delineate the horizontal extent of contamination.

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

d. To evaluate the presence and extent of leachable lead contamination above the toxicity characteristic limit, analyze a sufficient number of representative samples that exceed the Colorado unrestricted (residential) use guidelines by using the TCLP to determine the total lead concentration level (threshold level) 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 contamination in ground water exceeds established Colorado ground water standards, the extent of impacts to ground water must be delineated and addressed during site remediation.

6.0 Soil Remediation Considerations

Depending on assessment results and future potential land uses, remediation or proper management of impacted soil may be necessary. Remediation will likely be necessary at former ranges that are planned for development or are currently used for activities that could result in exposure to human and ecological receptors. If contaminated soils are left in place, administrative controls such as an environmental covenant or environmental use restriction will be required, limiting future uses of the site.

As you evaluate remedial options for handling contaminated soil from an outdoor range, these issues must be considered:

- A hazardous waste determination must be made on all newly generated waste, including contaminated soil that is disturbed or actively managed (e.g., excavated, tilled, or scraped) during the cleanup activity, regardless of when the shooting range ceased

operating or which program within the Division is overseeing the cleanup. Soil with leachable lead concentrations exceeding the toxicity characteristic limit of 5 mg/L is considered to be a characteristic hazardous waste and must be managed accordingly.

- If there is a potential for impact to ground water or surface water (for example, 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 onsite should not exceed 1.1 mg/L, a leachate extract concentration believed to be protective of underlying ground water quality. A cleanup that leaves behind lead contamination at concentrations greater than the Division's unrestricted (residential) use guidelines must be tested to verify that the residual contamination will not be sufficiently mobile to degrade ground water quality at a later date.

- Any cleanup that leaves soil contamination at a level greater than the Division's unrestricted (residential) use guidelines 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 the requirement for a covenant is for cleanups occurring under the oversight of the Voluntary Cleanup Program where the designated land use is noted in the Division's approval letter. Violation of the designated land use voids that approval. More information on the use of environmental covenants and use restrictions can be found on the Division's website.

- Where possible, the Division recommends that lead slugs, shot and fragments be screened from the impacted soil before any other treatments are used. These materials can be recycled as scrap metal in accordance with the Colorado Hazardous Waste Regulations (6 CCR 1007-3, Section 261.6). Separating and recycling lead shot and fragments from the soil may reduce the total volume of waste requiring treatment and/or disposal, or may eliminate the need altogether depending on sieved sample results. Screening out lead fragments is not required if the waste is treated during remediation as long as the treatment process thoroughly stabilizes both the soil and the lead fragments, resulting in a mixture that is no longer a characteristic hazardous waste.

- During the remediation of soil that is a hazardous waste, no stockpiles may be created unless they are strictly meant to facilitate site cleanup (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. Placing contaminated soil in clean areas is strongly discouraged. However, if it is necessary to do this, the temporary stockpile should be placed on plastic sheeting and covered with weighted plastic sheeting. Confirmation samples must also be collected once the soil is removed to verify that clean soil around and beneath the stockpile has not been impacted.

- The Division recommends that bench scale tests be performed on materials with the highest lead concentrations prior to remediating soil that is a hazardous waste. 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, some samples will still need to be collected to verify the continued success of the stabilization effort following full scale field implementation of the treatment process. This verification testing may be discontinued if it is demonstrated early on that the lead contaminated soil is successfully treated during the full scale operation of the treatment system.

Additional factors to consider include:

- Establishing onsite treatment operations within the confines of the shooting range facilitates the timely excavation and hauling of soils destined for treatment, as well as the return and placement of treated soil. When fieldwork is confined to one location, the project is more efficient and overall project costs are reduced.

- Many shotgun ranges may not be good candidates for a single type of remediation because the associated contamination is often widely disseminated. Multi-pronged approaches such as offsite disposal of heavily contaminated soils and onsite treatment of less contaminated soil may be used.

- In some instances, it may be necessary to retrieve lead contaminated soil that may have washed onto adjoining properties. This soil may be recovered and moved 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).

- Targets, casings and other range wastes present a different concern. Since these wastes are usually surface deposits, hand-picking or surface soil scraping of fall areas can be performed. Once collected, these wastes should be characterized to determine if they are hazardous and then recycled or disposed of based on that determination. Since the fall zones can overlap with bullet or shot fall zones, care should be taken to avoid comingling different types of waste. It may be helpful to separate shot and bullet fragments from other wastes where possible to aid in reducing the volume of hazardous waste and disposal costs.

7.0 Soil Remediation Alternatives

Lead contaminated soil can often be treated onsite to eliminate the hazardous waste characteristic, allowing for its disposal more economically as a solid waste. Treatment of hazardous waste by the generator must be conducted in accordance with Section 100.21(d) of the Colorado Hazardous Waste Regulations (6CCR 1007-3). Among other things, this rule requires that treatment occur in tanks or containers and that a waste analysis plan describing the treatment

procedure and methods used to verify the success of the treatment effort be developed before the treatment process is put in place. Confirmation sampling is necessary to demonstrate the effectiveness of the selected treatment technology(ies). If the determination is made that the material has been treated to meet the Land Disposal Restriction treatment standards (see Section 8.0 below) and is no longer a hazardous waste, the soil may be managed in accordance with Colorado's solid waste regulations (6 CCR 1007-2).

Soil that remains hazardous after treatment must undergo additional treatment to meet the applicable treatment standards, or must be disposed of at a hazardous waste landfill within 90 days of when it was first excavated, in accordance with Part 262 of the Colorado Hazardous Waste Regulations. Refer to the Division's *Treatment of Hazardous Waste by Generators Guidance Document* (August 2010 and updated) for additional information regarding treatment of hazardous waste.

7.1 Commonly Used Remediation Alternatives

The following remedies are frequently used at shooting ranges because they are effective and relatively simple to put in place.

- Excavation and disposal: This involves mechanical removal of contaminated soils and disposal of those soils offsite. If leachable lead concentrations meet or exceed the toxicity limit of 5 mg/L, the soils must be disposed of at a permitted hazardous waste landfill where they will be treated prior to disposal. Untreated soils with leachable lead concentrations below the 5 mg/L toxicity limit are not hazardous waste and may be disposed of at a permitted solid waste landfill. As discussed in Section 6.0, soil with leachable lead levels below the 5 mg/L toxicity limit, but above the health-based unrestricted (residential) use guidance level and/or above the leachate extract concentration protective of ground water (1.1 mg/L for lead) can be left onsite. However, this would require ongoing land use restrictions that must be ensured long term through an environmental covenant, environmental use restriction or other Division-approved control mechanism. Approval from the local governing authority may also be required.

- Stabilization/solidification: This treatment process involves mixing a treatment agent such as Portland cement or a phosphate-based stabilization compound with the excavated soil to reduce contaminant solubility, decrease the exposed contaminant surface area, and reduce matrix porosity and permeability. This reduces the potential for the contamination to be exposed to fluids that could transfer it out of the soil into surface or ground water. After appropriate testing to ensure effective treatment to meet the land disposal restriction standards (see Section 8.0), the non-hazardous stabilized soil may be disposed of at a permitted solid waste landfill. An alternative is to dispose of the treated soil onsite, but this requires the property owner manage this waste in accordance with the design and operation requirements of a permitted solid waste disposal facility. Engineering controls to limit or prevent treated soils from moving offsite and administrative controls such as an environmental covenant would also be required in this instance. Local governing authority approval for onsite disposal would be required.

7.2 Less Common Remediation Alternatives

The remedies below have been used at sites with soil contamination for stabilization and cleanup. However, these are rarely used for outdoor shooting ranges.

- Vitrification is a high temperature technology that reduces the mobility of metals by incorporating them into a chemically durable, leach resistant, glass-like material. Contaminated soil can be excavated and treated above ground or can be treated in place.

- Soil washing is a technology that uses a combination of agitation and water based washing fluid to remove contaminants from excavated soil. Because soil washing transfers contaminants to the washing fluid, the fluid must be treated for reuse or disposed of as hazardous waste.

- Soil flushing is the in place extraction of contaminants from soil by flooding the contaminated soil with a washing fluid to move contaminants to an area where they are removed from the ground. As with soil washing, the fluid must be treated or disposed of as hazardous waste because contaminants are transferred to the washing fluid.

- Phytoremediation is an in place technology where plants are used to remove contaminants from soil and/or ground water, or to degrade contaminants to more desirable by-products. Plants can remove contaminants when their roots take in water and nutrients from the soil and ground water or when contaminants stick to (or sorb) to the plant's roots. Some contaminants are stored in the leaves and stem of the plant while others can be changed into less harmful chemicals within the plant or by bugs or microbes that live near the plant's roots. Afterward, the plants are usually harvested and destroyed.

Additional information on remediation options based on contaminant concentration can be found in Table 1.

8.0 Land Disposal Restrictions

If you decide to stabilize lead contaminated soil that exhibits the characteristic of hazardous waste onsite in accordance with Section 100.21(d) of the regulations, you must ensure that the resulting lead concentrations in the treated soil have been reduced to the extent necessary to satisfy the Land Disposal Restrictions (LDRs) in Part 268 of the regulations. The waste code-specific treatment standard for characteristic wastes destined for land disposal requires removal of the hazardous characteristic plus treatment of the underlying hazardous constituents present in the waste to meet the universal treatment standards. Underlying hazardous constituents are contaminants present in the waste, but do not themselves cause the waste to exhibit a hazardous characteristic. When determining what universal treatment standards apply to a waste, you are not required to analyze for or treat all 257 constituents in the universal treatment standards table in Section 268.48 of the regulations. You are only required to identify and treat underlying hazardous constituents which can reasonably be expected to be present at a concentration above the constituent-specific universal treatment standard. Underlying hazardous constituents may

include metals such as arsenic, cadmium, zinc and antimony associated with weapons firing or polycyclic aromatic hydrocarbons (PAHs) associated with some clay targets.

Land disposal of hazardous soils is generally prohibited unless the soils have been treated to meet the waste code-specific treatment standards developed for the hazardous waste. Yet remediation wastes, due to either their large volume or unique characteristics, are not always amenable to the same type of treatment. Therefore, alternative treatment standards were developed for contaminated soils. The alternative treatment standards for contaminated soils are in Section 268.49 of the Colorado Hazardous Waste regulations.

The alternative treatment standards for contaminated soil allow you to choose among three types of treatment:

- Treat the soil to meet the existing treatment standards for lead.
- If the soil contains really low levels of lead, manage the soil in accordance with the contained-out policy (see Appendix 2 of the *Corrective Action Guidance Document*, available on the Division's website).
- Treat the soil using the alternative treatment standards in Section 268.49.

The alternative soil treatment standards in Section 268.49 require that all constituents subject to treatment present in the soil at 10 times the universal treatment standard or higher be treated to reduce the concentration by 90%. You are not required to treat the soil to less than 10 times the universal treatment standard or beyond normal background levels. For example, a contaminated soil contains 40 mg/L lead. Reducing this by 90 percent would mean treating the waste to 4 mg/L. However, the universal treatment standard for lead is .75 mg/L, so 10 times the universal treatment standard would be 7.5 mg/L. Therefore, this soil would require treatment to 7.5 mg/L to meet the alternative soil treatment standard. In this example, however, the soil would still exhibit a characteristic of hazardous waste if treated to this level since 10 times the universal treatment standard is above the toxicity characteristic level of 5 mg/L. As long as the soil still exhibits a hazardous characteristic, it would require disposal in a hazardous waste disposal facility. It may be worth your while to treat the soil to below the toxicity limit of 5 mg/L so that it may be disposed of at a municipal or industrial solid waste landfill as long as all of the underlying hazardous constituents are also treated. Treated wastes cannot be land disposed until all applicable treatment standards have been met, even if the waste itself no longer exhibits a characteristic.

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 toxicity characteristic regulatory limit of 5 mg/L.	Excavated soil must be managed as a hazardous waste.	• Excavate and dispose at a hazardous waste landfill. • Treat onsite to meet the land disposal restrictions and dispose at a solid waste landfill. • Treat in place using techniques that do not actively disturb or manage the soil to meet the land disposal restrictions and leave onsite; may require Division approval.
Lead concentration in the TCLP leachate extract exceeds the 1.1 mg/L leachate reference concentration but is less than the toxicity characteristic regulatory limit of 5 mg/L.	Excavated soil must be managed as a solid waste.	• Excavate and dispose at a solid waste landfill. • Treat onsite to immobilize the contaminants and leave onsite; may require Division approval.
Total lead concentration exceeds the 400 mg/kg unrestricted (residential) use value and TCLP leachate extract is less than the 1.1 mg/L leachate reference concentration.	Excavated soil must be managed as a solid waste.	• Excavate and dispose at a solid waste landfill. • No treatment necessary to leave onsite; may require Division approval.
Total lead concentration is less than the 400 mg/kg unrestricted (residential) use value [1].	No specific management requirements for this low level contaminated soil.	• No treatment necessary to leave onsite.

[1]Generally, lead concentrations greater than 400 mg/kg are required to fail the toxicity characteristic (≥ 5 mg/L via TCLP) or to leach sufficient lead to potentially impact ground water (> 1.1mg/L via TCLP). If the lead is in a more soluble form, the soil must be managed as a hazardous waste if it fails the toxicity characteristic even though the total lead concentration may be less than or equal to the unrestricted use value. Contaminated soils left onsite may require Division and local governing authority approval and/or an environmental covenant or environmental use restriction.

9.0 Additional Resources

For additional information please contact:

Colorado Department of Public Health and Environment
Hazardous Materials and Waste Management Division
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530

Customer Technical Assistance
(303) 692-3320
or
(888) 569-1831 ext. 3320 (toll-free outside of 303/720 area codes)

Fax: (303) 759-5355
OR
E-mail: comments.hmwmd@state.co.us

Please provide as much detail as possible concerning your question and the waste or process to which it applies.

Websites

Hazardous Materials and Waste Management Division
http://www.colorado.gov/cdphe/hm

U. S. Environmental Protection Agency
www.epa.gov

Interstate Technology and Regulatory Council
http://www.itrcweb.org/

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