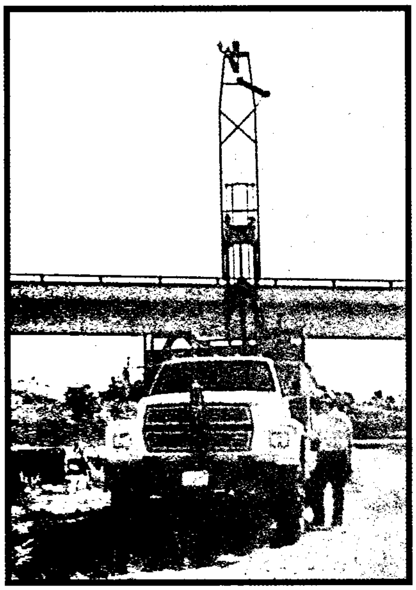
CORRECTIVE MEASURES STUDY
MARICOPA COUNTY SHERIFF'S SHOOTING RANGE
NEAR MCMICKEN DAM
SURPRISE, ARIZONA
CONTRACT FCD 2004C029
WORK ASSIGNMENT NO. 3



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Ninyo & Moore

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PREPARED FOR:
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January 30, 2006
Project No. 600996003

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Mr. Michael Greenslade, P.E.
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

Subject: Corrective Measures Study
Maricopa County Sheriff's Shooting Range
Near McMicken Dam
Contract FCD 2004C029
Work Assignment No. 3

Dear Mr. Greenslade:

In accordance with your authorization, Ninyo & Moore is pleased to provide this Corrective Measures Study regarding the Maricopa County Sheriff's Shooting Range located near the McMicken Dam in Surprise, Arizona. The activities were performed under Flood Control District of Maricopa County Contract No. 2004C029, Work Assignment No. 3, and in general accordance with Ninyo & Moore's revised proposal dated June 30, 2005.

Ninyo & Moore appreciates this opportunity to be of service to Flood Control District of Maricopa County. If you have any questions or comments regarding this report, please call the undersigned at your convenience.

Respectfully submitted,
NINYO & MOORE

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EXECUTIVE SUMMARY

Ninyo & Moore was retained by the Flood Control District of Maricopa County to perform a Corrective Measures Study for the Maricopa County Sheriff's Office Shooting Range, located near the McMicken Dam in Surprise Arizona. The Sheriff's Shooting Range consists of an approximately 19.72-acre area located in Section 24 of Township 4 North, Range 2 West, Gila and Salt River Meridian and is in Maricopa County Assessor's Parcel Number 503-75-016. The range is situated just east of McMicken Dam and north of the principal spillway. The current shooting range configuration consists of five bays. Bay 1 is used as a rifle range, Bay 2, Bay 3, and Bay 4 are used as pistol and shotgun ranges, and Bay 5 is used for Special Weapons and Tactics training. In addition, approximately four open burning treatment units (burn pits) were reportedly used for the demilitarization of small arms ammunition. Additionally, a dumpster (bin) used to burn fireworks and chemical irritants, such as chloroactonphenone, o-chlorobenzlylidenemalononitrile, and pepper spray, was previously operated at the site.

The corrective measures study also presents several methods of reducing the potential for environmental impacts at the facility.

1. INTRODUCTION

Ninyo & Moore was retained by the Flood Control District of Maricopa County to perform a Corrective Measures Study (CMS) for the Maricopa County Sheriff's Shooting Range, located near the McMicken Dam, Surprise, Arizona.

The Sheriff's Shooting Range consists of an approximately 19.72-acre area located in Section 24 of Township 4 North, Range 2 West, Gila and Salt River Meridian and is a portion of Maricopa County Assessor's Parcel Number 503-75-016. The range is situated just east of McMicken Dam, north of the principal spillway. The current shooting range configuration consists of five bays. Bay 1 is used as a rifle range, Bay 2 through Bay 4 are used as pistol and shotgun ranges and Bay 5 is used for Special Weapons and Tactics (SWAT) training. At the time of this report remediation of the burn pits was in progress with approximately 80 cubic yards of material excavated being disposed of as a hazardous waste because the material failed the toxicity characteristic leaching procedure (TCLP) test for lead. Additionally, a dumpster (bin) previously used to burn fireworks and chemical irritants, such as chloroactonphenone (CN), o-chlorobenzlylidenemalononitrile (CS), and pepper spray was removed from the site in December of 2005 according to the Maricopa County Department of Risk Management.

This study utilized the data presented in the following reports to assess the site-specific impacted soil and methodology for remediation:

- *Final Phase I / II - Environmental Site Assessments of Sheriff's Shooting Range, Surprise Arizona, EEC Project No. 203169.01,* dated June 28, 2004.
- *Historical Records Review Maricopa County Sheriff's Range, near McMicken Dam, Surprise Arizona, Ninyo & Moore Project No. 600996003,* dated January 24, 2006.
- *Regulatory Analysis Report Maricopa County Sheriff's Range, near McMicken Dam, Surprise Arizona, Ninyo & Moore Project No. 600996003,* dated January 30, 2006.
- *Initial Limited Site Characterization Report Maricopa County Sheriff's Range, near McMicken Dam, Surprise Arizona, Ninyo & Moore Project No. 600996003,* dated January 30, 2006.

To aid in further assessment of the site, Ninyo & Moore developed a conceptual site model presented in Figure 2 and a simplified soil decision matrix presented in Figure 3.

2. SCOPE OF THE CORRECTIVE MEASURES STUDY

2.1. Corrective Measures Study Background

On October 7, 1999, the United States Environmental Protection Agency (USEPA) announced its decision to withdraw many of the provisions of the July 27, 1990, Notice of Proposed Rulemaking (NPRM) for corrective action for solid waste management units (SWMUs) at hazardous waste management facilities (64 FR 54604). Commonly known as the Subpart S proposed rule, this rule would have created a comprehensive set of requirements under 40 CFR Part 264, Subpart S of the Resource Conservation and Recovery Act (RCRA) regulations, for conducting corrective action at RCRA facilities. To implement RCRA corrective action, USEPA is deferring instead to:

- The February 16, 1993, final rule on Corrective Action Management Units (CAMUs) and Temporary Units (TUs) (58 FR 8658) and the January 22, 2002, CAMU Amendments (67 FR 2962);
- The May 1, 1996, Advance Notice of Proposed Rulemaking (ANPR) on RCRA corrective action (61 FR19432);
- The November 30, 1998, final rule on Hazardous Remediation Waste Management Requirements (HWIR-Media) (63 FR 65874);
- Completion of Corrective Action Activities at RCRA Facilities (68 FR 8757); and
- Various policy and guidance documents that USEPA has issued since the 1990 Subpart S proposal.

The RCRA corrective action program was mandated by the Hazardous and Solid Waste Amendments of 1984 (HSWA). Congress requested USEPA to require "corrective action for all releases of hazardous waste or constituents from any solid waste management unit..." [HSWA 3004(u)] and, where necessary, "that corrective action be taken beyond the facility property boundary..." [HSWA3004(v)].

A CMS involves the identification and evaluation of remedial alternatives (i.e., remedies) for performing corrective action at one or more solid waste management units (SWMUs) at a facility. The CMS is prepared by the facility owner/operator, in this case the Flood Control District of Maricopa County the land owner. Typically, this process would be conducted with the guidance or oversight from the Arizona Department of Environmental Quality (ADEQ), the authorized state program. In a CMS, the owner/operator identifies, evaluates, and recommends one or more specific remedies that will remediate releases based on an evaluation of applicable data and available corrective measures technologies. In the proposed Subpart S rule (July 1990), which was withdrawn by USEPA (64 FR 54604, October 7, 1999), the CMS was proposed as the third phase in the execution of corrective action under RCRA. The ANPR (61 FR 19432, May 1996); however, stresses that in some cases, CMSs do not need to be performed (i.e., where the choice of a remedial alternative is relatively clear), or that the CMS can be tailored to focus on a limited set of plausible remedies only. In addition, the ANPR stresses that the CMS should not be viewed as an isolated step in a linear process, and that the CMS can be performed concurrent with other activities (e.g., the RCRA facility investigation [RFI]). A CMS is analogous to a feasibility study (FS) conducted for remedial actions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

2.2. Purpose

The purpose of this CMS is to develop, evaluate, and discuss potential corrective action alternative(s) to be considered at the Sheriff's Shooting Range. The CMS consisted of the following tasks:

1) Identification and development of the corrective measures alternative(s); and
2) Evaluation of the corrective measures alternative(s)
    a) Long-term effectiveness
    b) Reduction in the toxicity, mobility or volume of wastes
    c) Short-term effectiveness

d) Implementability

e) Community acceptance

f) State acceptance

g) Cost

3. CURRENT SITE CONDITIONS

As noted in the site characterization report, the site contains several areas with visible metals on the ground surface and in the near subsurface. The site characterization data used in this analysis was obtained from the reports titled *Final Phase I / II - Environmental Site Assessments of Sheriff's Shooting Range, Surprise Arizona, EEC Project No. 203169.01,* dated June 28, 2004 and *Initial Limited Site Characterization Report Maricopa County Sheriff's Range, Near McMicken Dam, Surprise Arizona, Ninyo & Moore Project No. 600996003*, dated January 30, 2006. Currently the site has noted concentrations of the following constituents of concern (COCs) above the residential and non-residential Arizona Soil Remediation Levels (SRLs), minimum Groundwater Protection Levels (GPLs), and other regulatory action levels:

Table 1 – Ranges of Concentrations

COC	Range of Concentrations (mg/kg)	Action Level Exceeded
Lead	17 - 17,000	Residential SRL (400 mg/kg) Non-residential SRL (2,000 mg/kg) Minimum GPL (290 mg/kg)
Arsenic	5.8 - 48	Residential SRL (10 mg/kg) Non-Residential SRL (10 mg/kg)
Antimony	8.2 - 78	Residential SRL (31 mg/kg) Minimum GPL (35 mg/kg)
Benzo(a)pyrene	8.5	Residential SRL (0.61 mg/kg)

Notes:
mg/kg = milligrams per kilogram
SRL = Soil Remediation Level
GPL = Groundwater Protection Level

It is expected that lead will be the primary risk "driver" for clean-up actions. Additionally, the methods that remove the lead hazard will likely treat the other metals below the acceptable risk levels. The benzo(a)pyrene impacts were noted inside of one area in the facility and are limited to that area.

The lead speciation in a representative sample from the range contained the following amounts of total lead by X-ray fluorescence (XRF):

Table 2 – Lead Speciation in Particle Fractions

Particle Size Fraction	Lead by XRF (mg/kg)	Total lead by USEPA Method 6010 (mg/kg)
> #4 mesh (0.187 inches)	6,600	Not Analyzed
#4 - #8 mesh (0.0937 inches)	3,770	Not Analyzed
#8 - #30 mesh (0.0234 inches)	837	Not Analyzed
#30 - #100 mesh (0.0059 inches)	1,450	Not Analyzed
#100 - #200 mesh (0.0029 inches)	1,700	Not Analyzed
< #200 mesh	3,590	7,100

Notes:
mg/kg= milligrams per kilogram

4. ASSUMPTIONS

For the purposes of this report, the action levels that are applicable are assumed as follows:

- For the range closure scenario, an action level of 290 milligrams per kilogram (mg/kg) for total lead, the Arizona groundwater protection level, and 5 milligrams per liter for Toxicity Characteristic Leaching Procedure (TCLP) lead was applied.
- The earthen berms and McMicken Dam are impacted with metals in the particle size less than #30 mesh sieve in a nearly homogeneous manner.

5. ALTERNATIVES CONSIDERED

The alternatives considered for implementation at the Sheriff's Shooting Range include:

1) Removal and disposal of soil impacted above action levels. Some soil above TCLP action levels will be required to be stabilized or solidified.
2) Physical separation of soil impacted above action levels. Some soil above TCLP action levels will be required to be stabilized or solidified for disposal.

3) Soil washing of soil impacted above action levels. Some soil above TCLP action levels will be required to be stabilized or solidified for disposal.

4) Stabilization or solidification.

5) Electrokinetic separation.

6) Phytoremediation.

5.1. Removal and Disposal

Removal and disposal is the simplest of the treatment technologies. This technology simply removes the impacted soil, separates the soil through physical separation or soil washing, and if necessary, stabilizes it, followed by disposal off site. The disposal of materials in a landfill off site will create a long term liability for the generator of the waste materials being disposed, as a responsible party. It is assumed that the soil can be segregated into soils for stabilization and those not being stabilized.

5.2. Physical Separation

This method of metals removal is also appropriate for the routine maintenance of ranges. The process consists of the removal of the top soil or media in the berms and other impacted areas to a depth deep enough to gather the metal bullets and fragments. The data gathered during the *Initial Limited Site Characterization Study* suggests that the top 2 feet of berms will be subject to routine maintenance and the top 0.5 feet of the range floor will be subject to maintenance. The soil or media is then screened to remove the bullets and bullet fragments using wet or dry screening methods. The screening is preferably done wet to minimize dust, when the clay fraction in the soil is limited. The wet screening will also disaggregate more soil from the lead, increasing the purity of the collected lead. Wet screening can result in collected lead purities ranging from 74 to 95 percent, with the lower purities more likely in soils with higher rock content. Dry screening results in lower lead purity, potentially creating problems with the recycling of the lead. This type of activity is recommended on a routine basis to mitigate the detrimental metal build-up in the soil, but it will not reduce the leachable metals from the soil matrix. Additionally, as noted above, the larger fractions of metals will be removed using these methods; therefore, they are appropriate for routine removal activities. Subsequent screening events after the first operation will be more efficient because larger rocks will be removed and no longer commingling with the metals.

One method of physical separation includes the use of a "Rotar" bucket on an excavator or front end loader. The machine has a closable bucket in place of the typical bucket found on machinery. The bucket has a screening material placed in the cavity, and the bucket closes around it. The bucket then, upon operator command, rotates around separating the soil from the oversize materials. The fine materials can be allowed to fall back into the berm area. This machine will travel to the berm and scoop the soil, rotate and separate the fraction desired. This operation may be used as an initial screen while moving the materials for additional treatment.

5.3. Soil Washing

The soil washing process is a more aggressive method for the removal of metals from the soil or berm media. This method employs removal and initial screening in a similar manner as the Physical Separation wet methods. The soil is then further separated using gravity and chemical reagents. This method is appropriate as part of a long term metals reclamation program for a range, and is performed on an infrequent basis.

Unlike stabilized or landfilled soil, the site incurs no liability when returning the washed soil to the site provided the soil meets TCLP requirements, and the recovered metals can be recycled. Some state regulators have selected the physical separation/acid leaching soil washing process as the technology of choice for small arms range remediation. In addition, this technology is cost-effective for the maintenance of ranges with low clay content.

5.4. Stabilization or Solidification

For solidification/stabilization (S/S) contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization). This process can be performed either in-situ or ex-situ. Ex-situ S/S; however, typically will involve the disposal of the resultant materials.

Examples of the applicable different types of stabilization and solidification technology are:

5.4.1. Bituminization

In the bituminization process, wastes are embedded in molten bitumen and encapsulated when the bitumen cools. The process combines heated bitumen and a concentrate of the waste material, usually in slurry form, in a heated extruder containing screws that mix the bitumen and waste. Water is evaporated from the mixture to about 0.5% moisture. The product is a homogenous mixture of extruded solids and bitumen. This process may be limited by the letting and vaporization of lead at elevated temperatures.

5.4.2. Emulsified Asphalt

Asphalt emulsions are very fine droplets of asphalt dispersed in water that are stabilized by chemical emulsifying agents. The emulsions are available as either cationic or anionic emulsions. The emulsified asphalt process involves adding emulsified asphalts having the appropriate charge to hydrophilic liquid or semiliquid wastes at ambient temperature. After mixing, the emulsion breaks, the water in the waste is released, and the organic phase forms a matrix of hydrophobic asphalt around the waste solids. In some cases, additional neutralizing agents, such as lime or gypsum, may be needed. After given sufficient time to set and cure, the resulting solid asphalt has the waste distributed within it and is much less permeable.

5.4.3. Pozzolan/Portland Cement

Pozzolan/Portland cement process consists primarily of silicates from pozzolanic-based materials like fly ash, kiln dust, pumice, or blast furnace slag and cement-based materials like Portland cement. These materials chemically react with water to form a solid cementious matrix which improves the handling and physical characteristics of the waste. They also raise the pH of the water which may help precipitate and immobilize some heavy metals. Pozzolanic- and cement-based binding agents are typically appropriate for inorganic contaminants.

5.4.4. Soluble Phosphates

The soluble phosphates process involves the addition of various forms of phosphate and alkali for control of pH as well as for formation of complex metal molecules of low-solubility to immobilize (insolubilize) the metals over a wide pH range. Unlike other stabilization processes, soluble phosphate processes do not convert the waste into a hardened, monolithic mass. One application of soluble phosphates and lime is in stabilizing fly ash by immobilizing the lead and cadmium in the ash.

5.5. Electrokinetic Separation

The principle of electrokinetic remediation relies upon application of a low-intensity direct current through the soil between ceramic electrodes that are divided into a cathode array and an anode array. This mobilizes charged species, causing ions and water to move toward the electrodes. Metal ions, ammonium ions, and positively charged organic compounds move toward the cathode. Anions such as chloride, cyanide, fluoride, nitrate, and negatively charged organic compounds move toward the anode. The current creates an acid front at the anode and a base front at the cathode. This generation of acidic condition in situ may help to mobilize sorbed metal contaminants for transport to the collection system at the cathode.

Removal of contaminants is achieved by electrokinetic transport of contaminants toward the polarized electrodes to concentrate the contaminants for subsequent removal and ex-situ treatment. Removal of contaminants at the electrode may be accomplished by several means among which are: electroplating at the electrode; precipitation or co-precipitation at the electrode; pumping of water near the electrode; or complexing with ion exchange resins.

5.6. Phytoremediation

Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment. The mechanisms of phytoremediation include enhanced phyto-extraction (also called phyto-accumulation), phyto-degradation, and phyto-stabilization. The applicable mechanism to the Sheriff's Shooting Range is phyto-accumulation. Phyto-accumulation is the uptake of contaminants by plant roots and the translocation/accumulation (phytoextraction) of contaminants into plant shoots and leaves.

Phytoremediation is limited by the influence the plants can have on the contaminants, which extends to depths slightly deeper than the root system. The processes have been field tested to a limited extent and have not gained full acceptance by the regulatory community. The arid conditions in Surprise, Arizona would limit the effect of phytoremediation because the copious amounts of water to be applied to sustain some types of vegetation may cause downward migration of COCs.

Table 3 – Corrective Measures Comparison

Alternative	Long-term effectiveness	Reduction in the toxicity, mobility or volume of wastes	Short-term Effectiveness	Implementability	Community Acceptance	Regulatory Acceptability
Removal and Disposal	Very effective	No reduction	Very effective	Easily implemented with readily available equipment, means and methods	Well accepted to remove the hazards from the area	Easily acceptable
Removal and Physical Separation	Moderately effective as a part of a hazard reduction program	Significant volume reduction for larger particles, will not reduce volume of leachable metals	Effective for operational ranges between other aggressive removal actions	Easily implemented with readily available equipment, means and methods	May cause citizen complaints from dust or noise	Acceptable as a part of a hazard reduction program
Removal and Soil Washing	Very effective	Significant volume reductions	Very effective	Easily implemented with readily available equipment, means and methods	Well accepted to remove the hazards from the area	Easily acceptable
Stabilization or Solidification	Very effective	Volume may increase	Very effective	Easily implemented with readily available equipment, means and methods	Well accepted to remove the hazards from the area	Easily acceptable
Electrokinetic Separation	Some success in field scale studies	Significant volume reductions	Some success in field-scale studies	Low soil moisture may cause problems with implementation.	Unknown process may complicate public involvement	Can be acceptable if developed with performance-based standards
Phytoremediation	Some success in field scale studies	Significant volume reductions	Some success in field-scale studies	Low precipitation may cause problems with implementation.	Unknown process may complicate public involvement	Can be acceptable if developed with performance-based standards

6. COSTS

To provide the user of this document with summary costs in a consistent format, Ninyo & Moore is providing the following section in general accordance with our proposal. The costs displayed in this section are dated to the year of the cost data available. To aid in the comparison of cost data, Ninyo & Moore has normalized the cost data using mg/kg, ppm, yards (yd), square yards (yd^2), cubic yards (yd^3), and tons. The normalization used the high recorded site soil density of approximately 110 pounds per cubic foot (ft^3) or 1.49 tons/yd^3. The normalization efforts will allow for the review of the cost data in a cost per yd^3 of soil.

6.1. Unit Costs

The following sections supply the unit cost data for portions of the work required, and total costs where they may be applied. For example the excavation costs for removal of the soil will be relatively stable in all technologies that employ excavation, and the disposal costs will be relatively stable for solid and hazardous wastes.

6.1.1. Excavation

In general, the excavation costs for the removal and stockpiling of the impacted soil from the berms and range floor will be consistent among the remediation technologies in which excavation is used. This section will provide the basis for the costs of soil removal using the document titled *Interim Measures Cost Compendium*, USEPA, September 2004. The costs represent 2004 dollars and are not adjusted for inflation. These costs are to remove the soil from the berms and other impacted areas and stockpile them on site covered with plastic sheeting.

Ninyo & Moore developed a proposed scenario for the removal of the soil from the Sheriff's Shooting Range. The scenario involves the limited removal of the areas with visibly heavy impacts based on our limited characterization (Ninyo & Moore, 2005c) and will need additional site characterization. The areas of removal are depicted in Figure 4.

The removal of the areas with visible impacts is based on our limited characterization; the following provides the basis for the estimate. The areas designated as berm areas and the McMicken Dam structure materials subject to direct fire are based on removal of soil to a depth of 2 feet (0.667 yd) over the berm area, which is treated as a horizontal surface for ease of calculations, and the areas designated as range floor and surface soil outside the range subject to indirect fire are based on the removal of soil to a depth of 0.5 feet (0.167 yd). The areas for soil removal were further delineated as area within the shooting range and area outside the shooting range. Cost estimate breakdowns for each are provided below.

For the area within the range the estimated volume of the impacted berm material to be excavated is approximately 9,205 yd^3. This estimate is based on approximately 13,800 yd^2 of impacted surface area. The volume of range floor soil assumed to be excavated is approximately 1,461 yd^3. This estimate is based on approximately 8,750 yd^2 of impacted surface area. The total to be excavated inside the range is approximately 10,666 yd^3. The unit rate for the excavation cost is \$5.78/yd^3, plus one-time mobilization costs of \$2,056, for a total estimated excavation cost of \$63,705.

For the area outside the range the estimated volume of the impacted McMicken Dam structure materials to be excavated is approximately 867 yd^3. This estimate is based on approximately 1,300 yd^2 of impacted surface area. The volume of surface soil outside the range was assumed to be excavated is approximately 192 yd^3. This estimate is based on approximately 1,150 yd^2 of impacted surface area. The total to be excavated outside the range is approximately 1,059 yd^3. The unit rate for the excavation cost is \$5.78/yd^3, plus a one-time mobilization cost of \$2,056, for a total estimated excavation cost of \$8,177.

These costs assume that no backfill will be used to restore the range berms or soil removed from the range floor and surface outside the range. Costs for replacement of the McMicken Dam structure materials are presented separately. In development of these costs, Ninyo & Moore considered the calcification of the soils within the berms. However, this is a rough estimate and detailed estimations should be made by the appropriate parties prior to any cost estimations for proposal purposes.

6.1.2. Transportation and Disposal

The costs for transportation and disposal of soil will be generally constant for the type of waste that it is (i.e., hazardous waste [RCRA] or solid waste [exceeding SRLs]). Minor variances in cost may be incurred for different waste forms; however, these are not considered for the purposes of this document.

The average rate for transportation and disposal of solid waste to local landfills is computed based on similar projects performed by Ninyo & Moore in 2005. These costs are based on end dump trucks with capacity of 13 yd^3. The average transportation cost is approximately $95.00/hour, with the average round trip to the landfill (Northwest Regional in Surprise, Arizona) being 2 hours. The transportation costs are approximately $14.62/$yd^3$. The transportation times may vary greatly depending on several factors including; loading time on site, traffic and road construction, landfill distance, and landfill operating schedule.

Disposal costs are provided on a tonnage basis and can vary widely. For large projects a typical landfill cost per ton of material can range from $19.50 to $25.60 for an average cost of $22.55/ton. This cost includes a standard markup of 15% on the disposal fees. The soil at the Sheriff's Shooting Range has a bulk density of approximately 1.49 tons/yd^3. This will allow the use of the figure of $33.60/$yd^3$ for the materials to be disposed as soil. If the treatment type increases the density of the materials, this should be accounted for in the total cost calculations.

The costs for hazardous waste disposal are not presented because the treatment to gain acceptance into a solid waste landfill is well below the anticipated costs of transportation and disposal at the two nearest hazardous waste disposal facilities, Kettleman City, California and Beatty Nevada. Each of those facilities would incur an additional 14 hours of transportation, for an estimated cost of $102/$yd^3$. Hazardous waste landfills generally have much higher disposal fees, approximately 4 times higher, for an approximate disposal fee of $\$120/yd^3$ including the special taxes imposed, compared with estimates of approximately $\$100/yd^3$ to stabilize or solidify the soil making it acceptable for disposal in the local landfill. This provides a basis for not disposing of the waste as hazardous unless it can not be treated otherwise.

The overall composite cost for transportation and disposal of solid waste used in the estimates is $\$48.22/yd^3$, including the standard markup of 15% for other direct costs.

6.1.3. Physical Separation

The costs for physical separation can vary widely depending on the type of separation desired. The separation costs are in addition to the excavation and the replacement of the soil. The disposal can be off set by the recycling of the metals from the separation. The costs for screening the soil are derived from *Prevention of Lead Migration and Erosion from Small Arms Ranges*, United States Army Environmental Center, August 1998. This costing does not account for disposal or sale of lead to a recycler, as it is not reliably quantifiable due to market fluctuations. Lead recycling, however, can recoup a portion, if not a large portion, of the cost difference for separation using the wet methods for the higher purities.

Dry screening costs are approximately \$30.00/ton or $\$44.70/yd^3$. Wet screening costs are approximately \$40.00/ton or $\$59.60/yd^3$. The costs do not include the excavation of soil.

The Sheriff's Shooting Range soil, based on the results discussed in the *Initial Limited Site Characterization Report,* contains particles sized approximately 19% > #4 mesh, approximately 19% > #30 mesh < #4 mesh, and approximately 60% < #30 mesh. An estimate of the bullets and bullet fragments in the fraction > #4 mesh is approximately 40% for the surface soil; however, it is expected to be significantly lower for the underlying soils. The metals recovery for physical separation may apply to the total volume of soil in the limited removal noted above (11,725 yd^3) for the areas inside and outside of the range. This soil will have a gross weight of approximately 17,470 tons, and could yield approximately 3,319 tons of soil and debris > #4 mesh including 1,328 tons of lead. The remaining soil (14,151 tons) could contain approximately 3,666 ppm lead, or 0.37% lead. If separated with an estimated 75% removal rate and 75% purity, there would be 52 additional tons of lead removed and available for recovery.

By using this method as routine maintenance for a shooting range, several assumptions can be made. First, it can be assumed that the soil will not contain more than 5% over-size particles such as rocks and other debris. Secondly, it can be assumed that the soil will be returned to the locations it came from in the berms. Lastly, it can be assumed that the metals removed will be acceptable for recycling at a cost comparable to the transportation.

Table 4 – Physical Separation Costs

Dry Screening with Rotar Bucket only	Costs assumed to be similar to excavation costs or $5.78/yd^3$
Dry Screening	$44.70/yd^3$
Wet Screening Costs with 75% purity, 75% efficiency	$59.60/yd^3$

6.1.4. Soil Washing

Soil washing costs are variable in the type and size of plant to be used. Several references acknowledge differing costs.

The costs noted in the USEPA technology report for a demonstration project at a small arms range in Louisiana stated that the full scale implementation at $170/ton including excavation. This would be $253.30/yd^3$ based on the assumed soil density. These costs are assumed to be inclusive of excavation and the solidification and subsequent disposal of both hazardous and solid wastes.

The *Interim Measures Cost Compendium* states a cost of $\$51/yd^3$ of loose materials, plus mobilization costs. This cost does not include excavation of the soil, or the solidification and disposal of the resultant waste stream.

6.1.5. Stabilization or Solidification

Stabilization costs from the document titled *Interim Measures Cost Compendium*, USEPA, September 2004 for soil in 2004 dollars is stated as $84/ton or $\$125.2/yd^3$ in the site soil. This cost does not include the excavation of soil from the berms. The Federal Technology Roundtable website indicates a project on a small arms range at Mayport Naval Station, Florida was performed for $490/ton with on-site disposal (http://www.frtr.gov/matrix2/section3/table3_8_fr.html). This cost is assumed to be inclusive of excavation and disposal of the resulting materials.

The amount of soil to be stabilized is difficult to quantify without further analysis. However, stabilization is typically used to follow other treatments such as physical separation, soil washing or electrokinetic separation.

Some solidification methods can be achieved with off the shelf equipment and supplies at a reduced cost.

6.2. Removal and Disposal

To develop a cost estimate for removal and disposal assumptions are made on the type of treatment process selected. A typical treatment process would include the excavation of the soil in lifts, the physical separation or soil washing to consolidate the soil for treatment and disposal, the sampling of processed soils, the solidification of leachable soils to mitigate a hazardous waste stream, the transportation and disposal of solid waste. The cost structures used to develop these costs are assumed to contain the costs for the routine engineering services related to the removal actions. The costs are presented in the table below.

In addition, the cost to replace the materials removed from the McMicken Dam Structure would be approximately \$7.96/yd^3 for the 867 yd^3 removed from the dam structure, for an estimated cost of approximately \$6,901. The engineering costs to support the replacement effort are estimated at \$12,500, for a total cost of \$19,401. This cost has a high uncertainty due to construction requirements for flood control structures and should be escalated 100% to account for the uncertainty. The total cost would then escalate to \$38,802 for the rebuild of the McMicken Dam Structure.

6.2.1. Physical Separation

The costs presented assume the following conditions:

1. Physical separation wet screening processes are used for removal within the range and that 5% of the soil volume processed will require further treatment (i.e., solidification, and that 15% of the soil volume removed will be disposed as a solid waste). The volumes solidified include assumptions on the water from the process being treated and solidified as required.

2. Physical separation dry screening processes are used for the removal outside the range and that 5% of the soil volume processed will require further treatment (i.e. solidification, and that 10% of the soil volume removed will be disposed as a solid waste).

Table 5 – Removal and Disposal with Physical Separation

Area	Item	Total Cost
Removal within the range	Excavation	\$63,705
	Physical separation	10,666 yd^3 @ \$59.60/ yd^3 = \$635,693
	Solidification	533 yd^3 @ \$ 125.20/ yd^3 = \$ 66,732
	Transportation and disposal	1,600 yd^3 @ \$48.22/ yd^3 = \$77,152
	Sub-Total Cost	**\$843,282**
Removal outside the range	Excavation	\$8,177
	Physical separation	1,059 yd^3 @ \$44.70/ yd^3 = \$47,337
	Solidification	53 yd^3 @ \$ 125.20/ yd^3 = \$ 6,636
	Transportation and disposal	106 yd^3 @ \$48.22/ yd^3 = \$5,111
	Sub-Total Cost	**\$67,261**
Replacement of McMicken Dam Structure Materials		**\$38,802**
	Grand Total	**\$949,375**

6.2.2. Soil Washing

The costs presented assume the following conditions:

1. Soil washing processes are used for removal within the range and that 5% of the soil volume processed will require further treatment (i.e., solidification, and that 10% of the soil volume removed will be disposed as a solid waste). The volumes solidified include assumptions on the water from the process being treated and solidified as required.

2. Physical separation dry screening processes are used for the removal outside the range and that 5% of the soil volume processed will require further treatment (i.e. solidification, and that 10% of the soil volume removed will be disposed as a solid waste).

Table 6 – Removal and Disposal with Soil Washing Option

Area	Item	Total Cost
Removal within the range	Excavation	$63,705
	Soil washing	10,666 yd^3 @ $51.00/ yd^3 = $543,966
	Solidification	533 yd^3 @ $ 125.20/ yd^3 = $ 66,732
	Transportation and disposal	1,067 yd^3 @ $48.22/ yd^3 = $51,451
	Sub-Total Cost	**$725,845**
Removal outside the range	Excavation	$8,177
	Physical separation	1,059 yd^3 @ $44.70/ yd^3 = $47,337
	Solidification	53 yd^3 @ $ 125.20/ yd^3 = $ 6,636
	Transportation and disposal	106 yd^3 @ $48.22/ yd^3 = $5,111
	Sub-Total Cost	**$72,372**
Replacement of McMicken Dam Structure Materials		**$38,802**
	Grand Total	**$837,028**

6.3. Electrokinetic Separation

Recent studies cited in the Federal Technology Roundtable website (http://www.frtr.gov/matrix2/section4/4-4.html) stated an estimated full-scale cost of $117/cubic meter for metals removal from soil. The conversion factor of 1 cubic meter equals 1.31 yd^3, with a project total of 11,725 yd^3, will yield an approximate project cost of $1,047,195 to remove the lead from the Sheriff's Shooting Range.

6.4. Phytoremediation

Recent studies cited in the Federal Technology Roundtable website (http://www.frtr.gov/matrix2/section4/4-3.html) stated the United States Army Environmental Center estimated that the cost for phytoremediation of one acre of lead-impacted soil to a depth of 50 cm was $60,000 to $100,000, whereas excavating and landfilling a similar soil volume was $400,000 to $1,700,000.

The Sheriff's Range impacted areas is approximately 25,000 yd^2, which is approximately 5.17 acres (1 acre is 4,840 yd^2). Using the estimated cost given above the project total cost will range from approximately $309,600 to $516,000. However, this cost estimate is anticipated to be inappropriately low given the water requirements and maintenance needed for some types of vegetation for the climate of Surprise, Arizona.

7. RECOMMENDATIONS

In developing recommendations Ninyo & Moore cautions that multiple combinations of actions will achieve the remediation goals at the project site. A detailed site characterization and either bench or pilot scale studies will be needed to assess the effectiveness and implementation of the selected process parameters.

The following combination of remedial alternatives provides an outline of the recommended course of action:

1. Additional site characterization should be performed to improve our understanding of the extent of the impacted soil. As the site is an active facility in which conditions can change and lead is continually being deposited, a portion of the site characterization consisting of the additional site effort is assigned an estimated cost of $50,000, with 20% uncertainty. This yields a budgetary estimate of $60,000.

2. A comprehensive work plan for the removal, testing, and processing of the site soils in lifts should be developed. Development of the work plan will require the performance of bench or pilot scale testing to evaluate the strategies for processing the soil. Ninyo & Moore further recommends the evaluation of multiple vendors to find the appropriate process parameters. This effort is assigned an estimated cost of $125,000, with 50% uncertainty. This yields a budgetary estimate of $187,500.

3. To remediate lead-impacted soil, Ninyo & Moore recommends the implementation of excavation and soil processing that includes sieving and stabilization. Solidified treatment residues would be assumed to be disposed at Northwest Regional Landfill in Surprise, Arizona. The methodology and costs presented in Section 6.2.2 of $837,028 may be used for this estimate. This effort is assigned an uncertainty factor of 50% which yields a budgetary estimate of $1,255,542. The uncertainty factor is based on the unknowns of the operations and inflation of the 2004 cost data used.

4. Total project costs including the recommendations for additional site characterization and work plan development are estimated to be $1,503,042.

8. REFERENCES

Arizona Administrative Code, 1999, Title 18, Environmental Quality Chapter 7, Department of Environmental Quality Remedial Action, Appendix A, Soils Remediation Levels.

Arizona Administrative Code, 1999, Title 18, Environmental Quality Chapter 8, Department of Environmental Quality Waste Management, Appendix A, Soils Remediation Levels.

Code of Federal Regulations, 2004, Title 40, Part 261 through 264, Hazardous Waste Management System.

Code of Federal Regulations, 2004, Title 33, Part 328, Definition of Waters of the United States.

EEC, 2001, Final Phase I / II - Environmental Site Assessments of Sheriff's Shooting Range, Surprise Arizona, EEC Project No. 203169.01: dated June 28, 2004.

Ninyo & Moore, 2005a, Historical Records Review Maricopa County Sheriff's Range, near McMicken Dam, Surprise Arizona, Ninyo & Moore Project No. 600996003: dated January 24, 2006.

Ninyo & Moore, 2005b, Regulatory Analysis Report Maricopa County Sheriff's Range, near McMicken Dam, Surprise Arizona, Ninyo & Moore Project No. 600996003: dated January 30, 2006.

Ninyo & Moore, 2005c, Initial Limited Site Characterization Report Maricopa County Sheriff's Range, near McMicken Dam, Surprise Arizona, Ninyo & Moore Project No. 600996003: dated January 30, 2006.

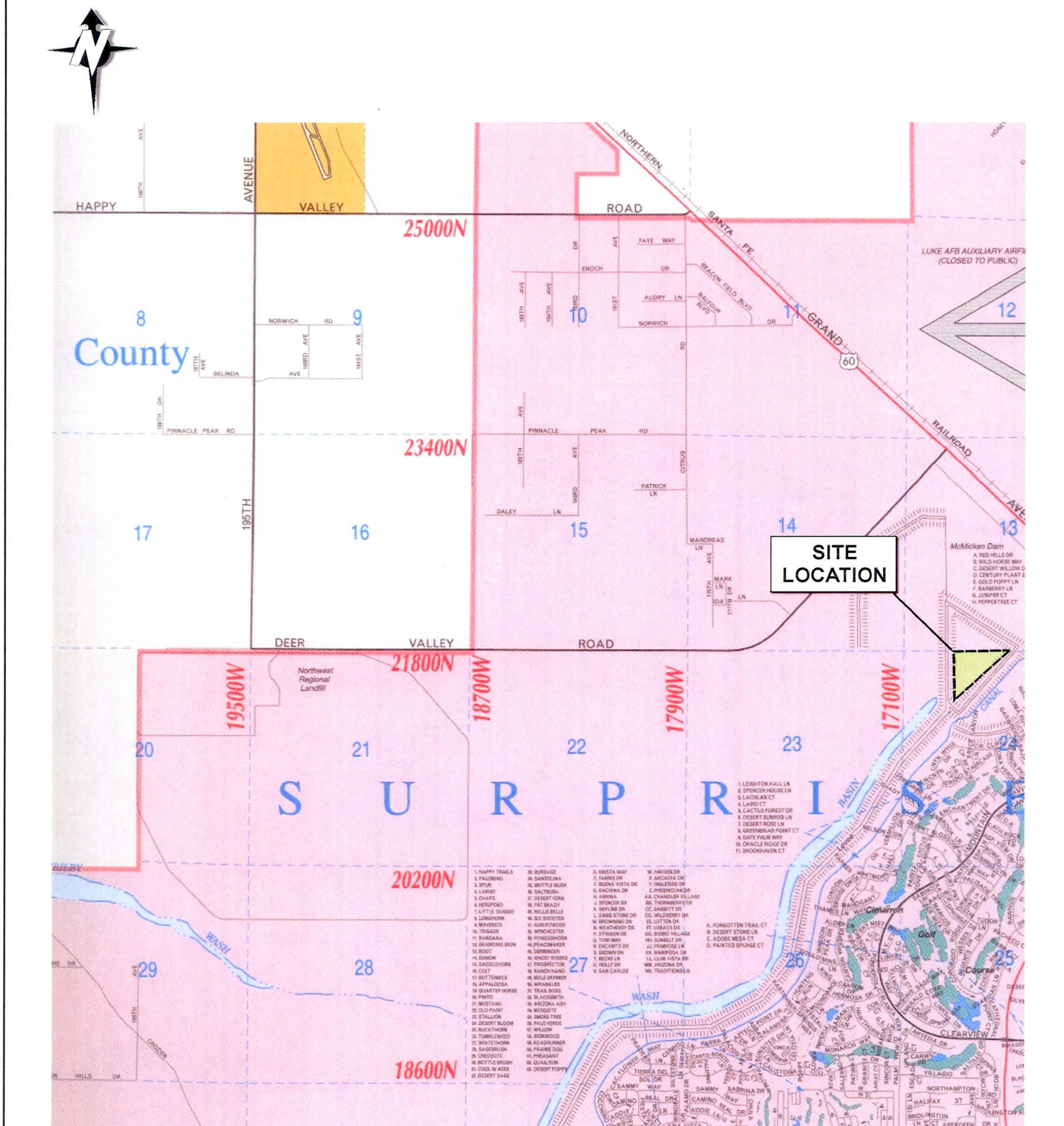
Resource Conservation and Recovery Act, 1976, Public Law 94-580, As Amended (1984, 1988).

United States Code, 2005, Title 33, Section 1362, Clean Water Act.

United States Department of Energy, 2003, RCRA Information Brief, RCRA Corrective Action Corrective Measures Study, DOE/EH-413-047r, August 2003, Office of Pollution Prevention and Resource Conservation Policy and Guidance.

United States Environmental Protection Agency, Best Management Practices for Lead at Outdoor Shooting Ranges, USEPA-902-B-01-001, January 2001, Region 2.

FIGURES

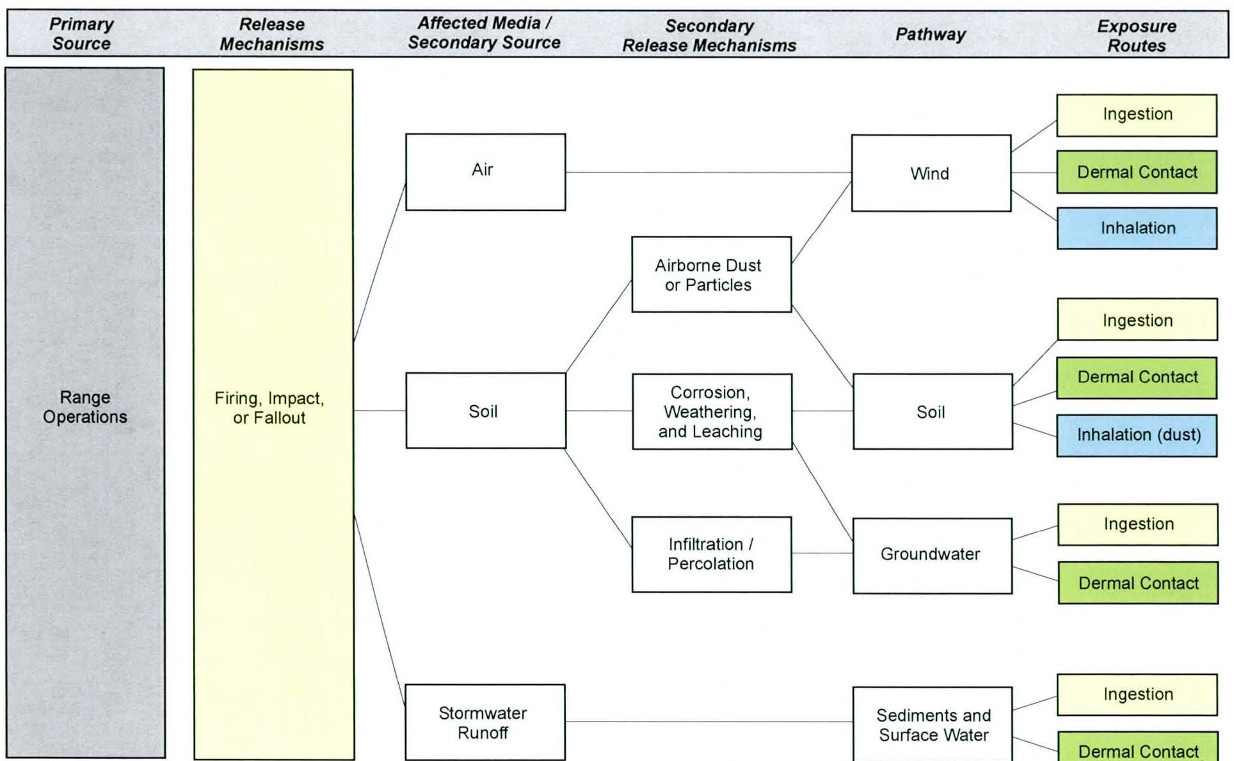


0 3300
Approximate Scale:
1 inch = 3300 feet

Source: Phoenix Mapping Service, Phoenix Metro 2005

Ninyo & Moore	SITE LOCATION MAP	
MARICOPA COUNTY SHERIFF'S SHOOTING RANGE		FIGURE 1
PROJECT No: 600996003	FILE No: 0996slm1105	DATE: 01/06

CONCEPTUAL SITE MODEL
SMALL ARMS FIRING RANGE



Pathway	Exposure Route	Range Worker	Recreational User	Remediation Worker	Trespasser
Wind	Ingestion	Partially completed pathway	Completed pathway	Incomplete pathway	Completed pathway
Wind	Dermal Contact	Completed pathway	Completed pathway	Incomplete pathway	Completed pathway
Wind	Inhalation	Completed pathway	Completed pathway	Incomplete pathway	Completed pathway
Soil	Ingestion	Incomplete pathway	Completed pathway	Incomplete pathway	Completed pathway
Soil	Dermal Contact	Partially completed pathway	Completed pathway	Incomplete pathway	Completed pathway
Soil	Inhalation (dust)	Incomplete pathway	Completed pathway	Incomplete pathway	Completed pathway
Groundwater	Ingestion	Incomplete pathway	Incomplete pathway	Incomplete pathway	Incomplete pathway
Groundwater	Dermal Contact	Incomplete pathway	Incomplete pathway	Incomplete pathway	Incomplete pathway
Sediments and Surface Water	Ingestion	Incomplete pathway	Completed pathway	Incomplete pathway	Completed pathway
Sediments and Surface Water	Dermal Contact	Completed pathway	Completed pathway	Incomplete pathway	Completed pathway

Receptors

KEY

- Completed pathway
- Partially completed pathway
- Incomplete pathway

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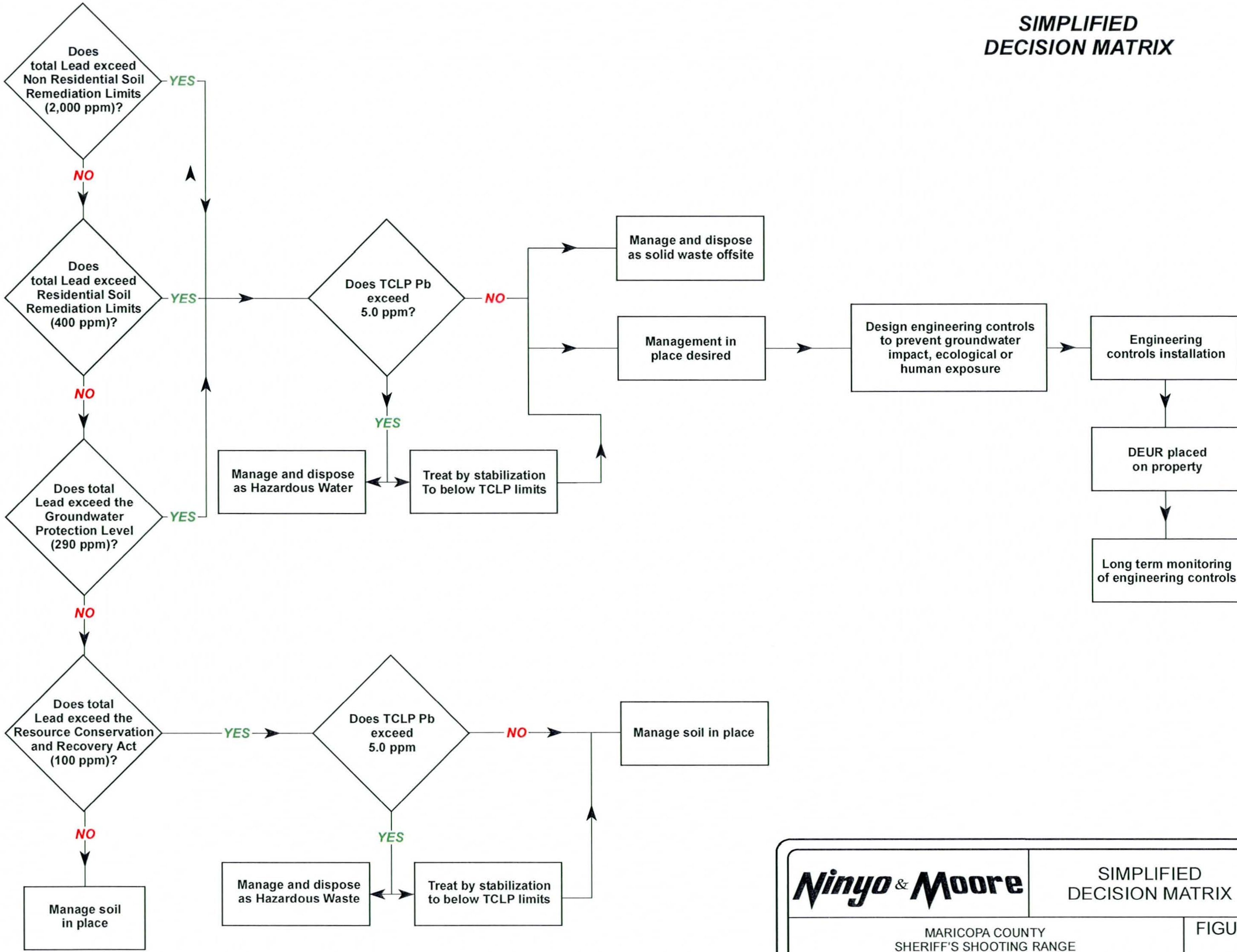
CONCEPTUAL SITE MODEL
SMALL ARMS FIRING RANGE

MARICOPA COUNTY
SHERIFF'S SHOOTING RANGE

PROJECT No:	FILE No:	DATE:	FIGURE
600996003	996chrt1205e2	01/06	2

SIMPLIFIED DECISION MATRIX



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SIMPLIFIED DECISION MATRIX

MARICOPA COUNTY
SHERIFF'S SHOOTING RANGE

PROJECT No:	FILE No:	DATE:	FIGURE
600996003	996chrt1205d	01/06	3

Sheriff's Shooting Range Soil Remediation Estimation

Within Shooting Range Boundary

- Berm material - 13,800 square yards
- Non-berm material - 8,750 square yards

Outside Shooting Range Boundary

- Berm material - 1,300 square yards
- Non-berm material - 1,150 square yards

Approximate Scale

0 50 yds

N W E S

Ninyo & Moore		REMEDIATION AREA ESTIMATE
Sheriff's Shooting Range		FIGURE
PROJECT No: 600996003	FILE No: McMickenDam	DATE 01/06	4