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FINAL PHASE

IMPLEMENTATION REPORT FOR SMALL-ARMS RANGE D-30 REMEDIATION PROJECT AT MARINE CORPS BASE (MCB) CAMP LEJEUNE, NORTH CAROLINA

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July 25, 1997

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A maintenance activity was conducted to improve the environmental conditions and capabilities of Range D-30 at Marine Corps Base Camp Lejeune, North Carolina. During the maintenance activity, the soils from the existing berm were processed to recover bullet metals and reduce the mobility of metal contaminants, and the length of the existing pistol range was increased. The project demonstrated the feasibility of range maintenance involving screening to collect and recycle oversize material containing high lead concentrations and solidification/stabilization to immobilize lead remaining in the finer soils. About 580 yd^3 of berm material was processed for a total cost of $133,547 or $230/yd^3$, including firing line walkway construction.

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ACRONYMS AND ABBREVIATIONS

BZO	battle sight zero
CFR	Code of Federal Regulations
EPA	Environmental Protection Agency
HAZWOPER	hazardous waste operations
MCB	Marine Corps Base
OSHA	Occupational Safety and Health Administration
QA	quality assurance
SOW	Statement of Work
S/S	solidification/stabilization
TCLP	Toxicity Characteristic Leaching Procedure
TSP	triple super phosphate

FINAL PHASE

IMPLEMENTATION REPORT FOR SMALL-ARMS RANGE D-30 REMEDIATION PROJECT AT MARINE CORPS BASE (MCB) CAMP LEJEUNE, NORTH CAROLINA

July 25, 1997

1.0 SCOPE

This section describes, in general terms, the existing site conditions and work performed during the remediation project.

1.1 General

This remediation project was conducted to improve the environmental conditions and capabilities of Range D-30 at Marine Corps Base (MCB) Camp Lejeune, North Carolina. The location of Range D-30 at MCB Camp Lejeune is shown in Figure 1-1. During the remediation project, the soils from the existing berm were processed to recover bullet metals and reduce the mobility of metal contaminants. The length of the existing pistol range was increased from about 84 ft to about 156 ft and the rest of the range was prepared for use as a battle sight zero (BZO) range. The remediation project involved the following:

- Removing the barricade between the active and intermittently used areas (performed by MCB Camp Lejeune personnel)
- Removing the target stands in front of the active area (performed by MCB Camp Lejeune personnel)
- Excavating soils from the top and front of the impact berm
- Recovering and managing the bullet metals from impact berm soils
- Processing excavated soils with a phosphate binder to reduce the mobility of metal contaminants
- Replacing the processed soil on the impact berm
- Straightening and resurfacing the impact berm
- Preparing a new drainage trench and new firing line walkways in front of the berm
- Replenishing top soil and seeding bare areas at Range D-30 caused by project work.

Soil handling and processing was performed by HEPACO, Inc. of Charlotte, NC. Mike Woolfe served on site as Battelle's project superintendent. The arrangement of the range before and after the project are shown in Figures 1-2 and 1-3, respectively. Photographs showing the range before, during, and after the remediation project are included in the appendix.

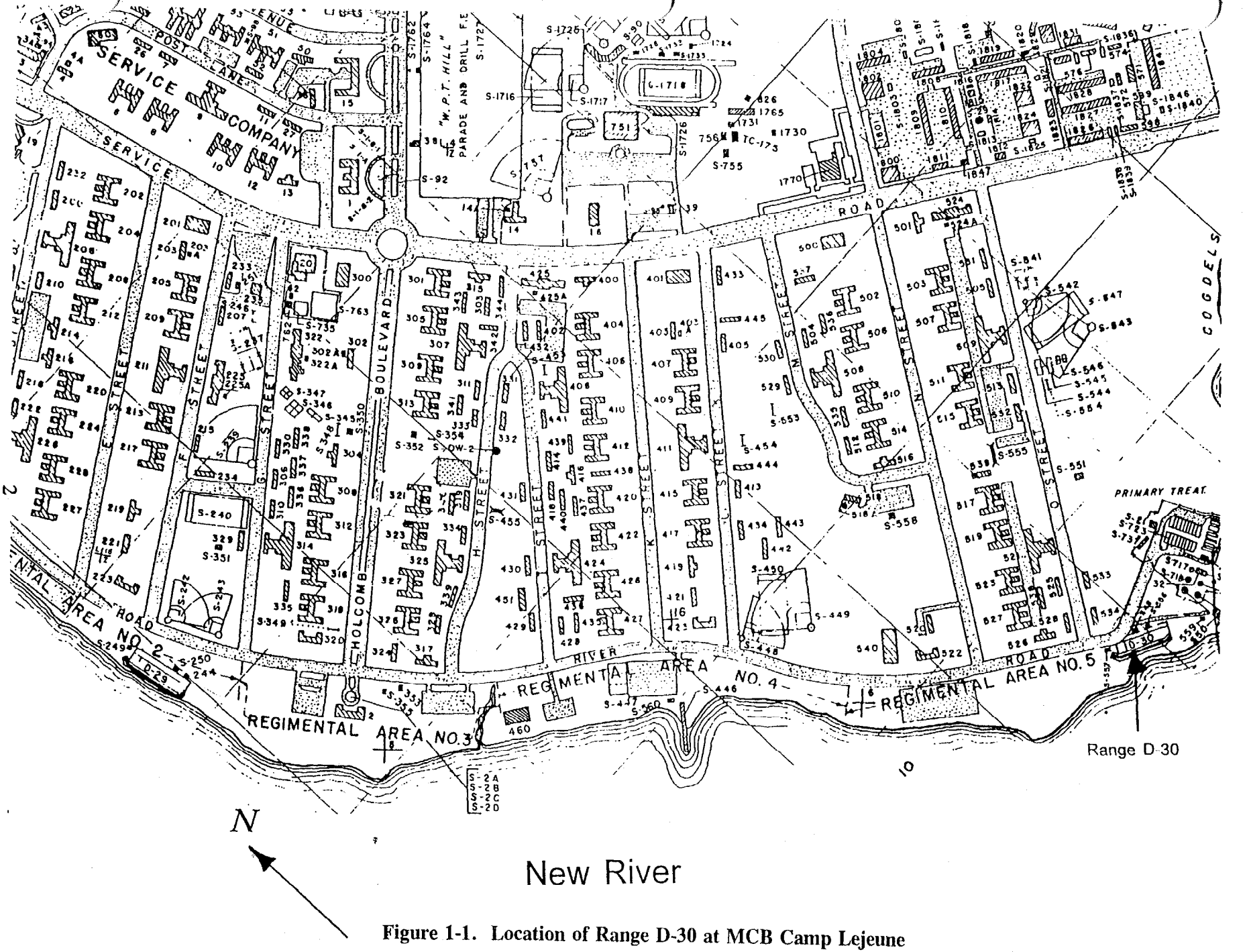

Figure 1-1. Location of Range D-30 at MCB Camp Lejeune

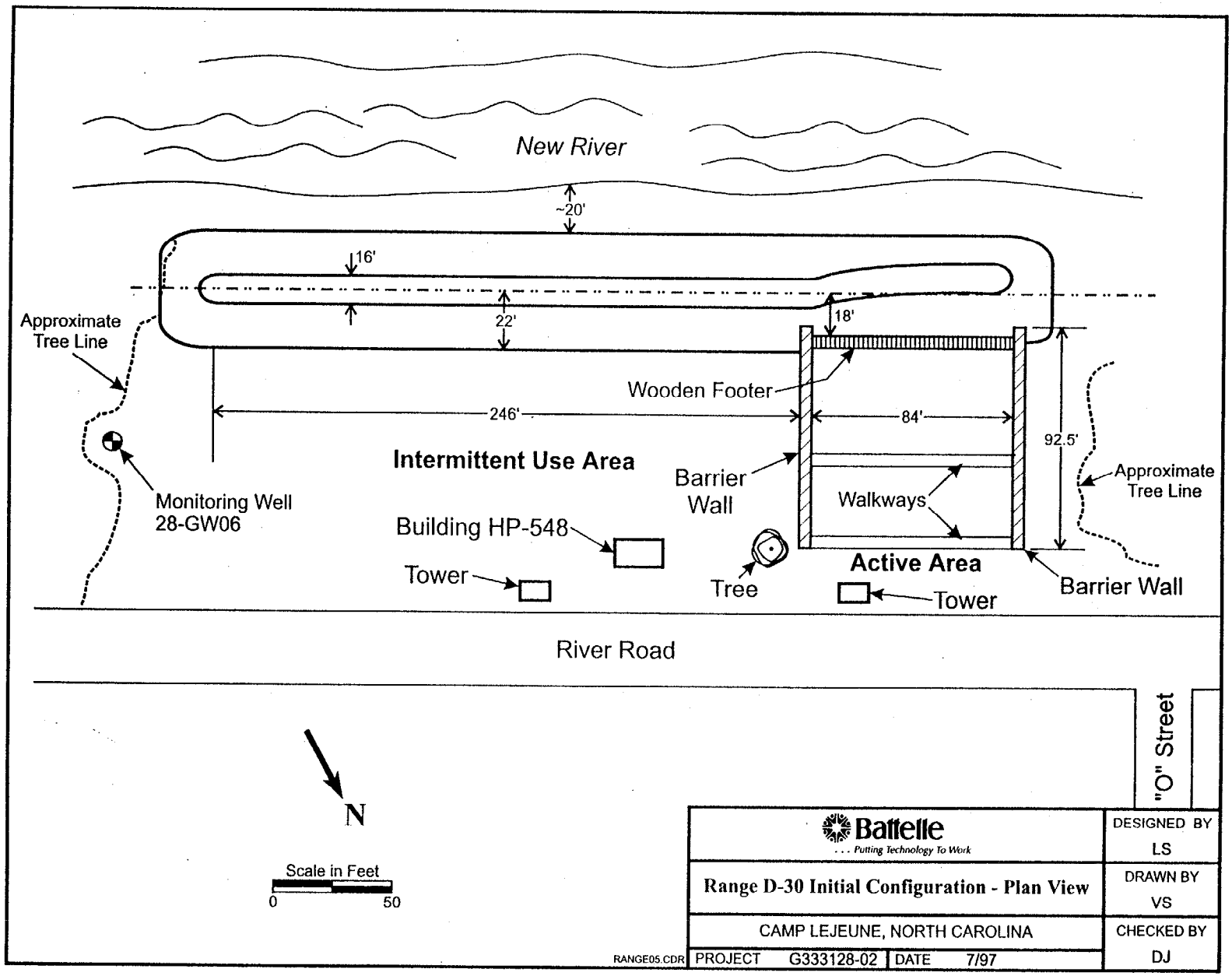

Figure 1-2. Range D-30 Initial Configuration — Plan View

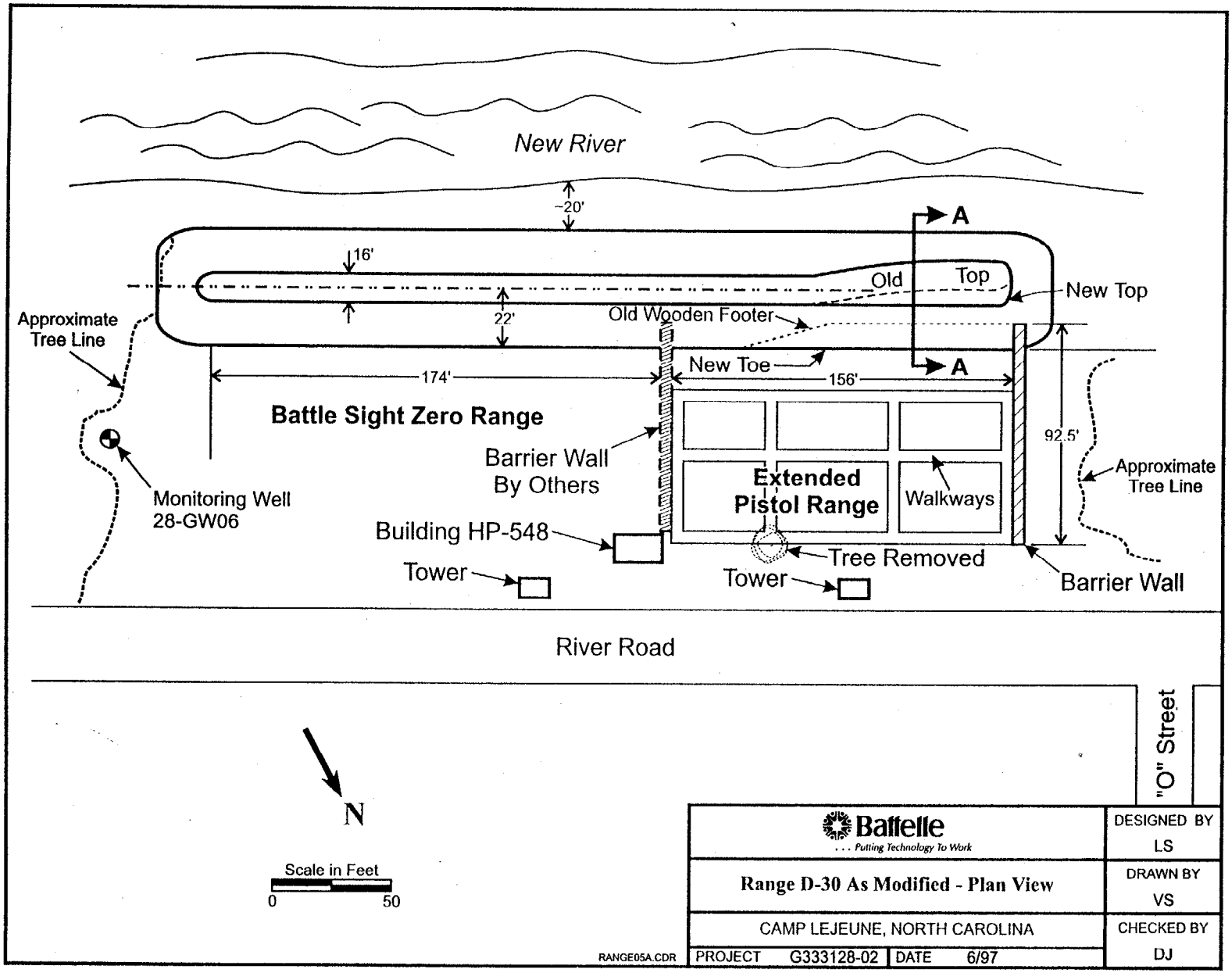

Figure 1-3. Range D-30 as Modified — Plan View

1.2 Background

Range D-30 is an active pistol and rifle BZO range located on the New River at MCB Camp Lejeune, North Carolina. Both high- and low-velocity small arms have been and continue to be fired at this range. Although there is a lack of consistent historical records regarding this site, this range is reported to have been in constant operation since the 1950s. This same source also indicated that there has been one lead removal operation at D-30, during the late 1960s, prior to the 1997 reclamation project.

The portion of the range located to the right when facing the river is about 84 ft long and is actively used for pistol training and qualification. A longer portion of the range, located to the left when facing the river, is used intermittently. There is an earth-filled wooden barricade on the right end of the actively used portion and a second earth-filled wooden barricade between the active and intermittent use portions of the range.

In 1995, an unrelated environmental investigation in the vicinity of Range D-30 revealed sediment samples with high concentrations of lead. Subsequent to this investigation, MCB Camp Lejeune took proactive measures to initiate cleanup activities at Range D-30. This final report is the summation of the D-30 range remediation project.

2.0 WORK ACTIVITIES

The remediation project resulted in processing 570 yd^3 (700 tons) of soil and recycling 19.2 tons (10.7 yd^3) of lead-bearing oversize material. The soil was processed on site by addition of triple super phosphate (TSP) fertilizer to immobilize the lead. The soil processing work is summarized in Table 2-1. Recycling involved shipment to a primary smelter operated by The Doe Run Company in Missouri. The lead-bearing soil was shipped as Class 9 material with a U.S. Department of Transportation designation UN 3077.

Table 2-1. Summary of Soil Processing

Date and Time	Soil Source	Treated Material Batch Size (yd^3)	Binder Addition (% as TSP)
5/15/97 - 09:30	Active area	75	6
5/15/97 - 10:30	Active area	75	6
5/15/97 - 11:00	Intermittent top	100	2
5/15/97 - 13:00	Intermittent top	100	2
5/15/97 - 16:00	Intermittent face	100	2
5/15/97 - 18:00	Intermittent face	100	2
5/15/97 - 19:40	Intermittent face	100	2
5/15/97 - 20:00	Intermittent face	100	2
5/16/97 - 10:00	Intermittent face	100	2
5/16/97 - 10:30	Intermittent face	100	2
	Total	950	

The soil proved to be more cohesive than expected, causing the #5 mesh screen to plug frequently. The active area soil, which contained the highest proportion of bullets and bullet fragments, was screened using the #5 mesh. The intermittent use area soil was screened through a more open mesh (3/8-in. mesh screen) which did not plug with the moist, cohesive soil. The larger screen opening retained lead fragments because of the inclined orientation of the screen and the tendency for the soil to partially fill the openings

The interior of the berm contained an unexpectedly large proportion of fibrous roots. A high organic content is detrimental to smelter operation, so the roots had to be removed by rescreening the oversize material through a 3/4-in. mesh screen. This larger screen allowed metal to pass through but retained the organic debris. Even with several passes through the 3/4-in. screen, the material sent to the smelter contained excessive organic material, resulting in a small additional processing charge.

The front of the active area berm was several feet further from the firing line than the front of the intermittent use berm. The front of active area berm needed to be aligned with the front of the intermittent use berm to allow the planned extension of the active use area. The alignment required the addition of about 160 yd^3 of soil to advance the front of the active area berm into alignment with the intermittent use area berm, as well as construction of a new drainage path at the toe of the berm, removal of the existing concrete walkways that marked firing line locations, and placement of 843 ft of gravel walkways to mark new firing line locations. MCB Camp Lejeune supplied two trucks and operators to move the soil from the borrow pit to Range D-30. Base personnel removed a tree that interfered with the range extension.

A chronological summary of activities is provided in Table 2-2.

Table 2-2. Summary of Work Activities

Time Period	Activities
5/5/97 - all day	• Arrived on site, established site boundary, and began equipment setup
5/6/97 - 09:00 to 12:00	• Continued setup
5/6/97 - 12:30	• Started soil excavation
5/6/97 - 14:30	• Started screening with #5 mesh screen
5/6/97 - 16:00	• Noted slow screening throughput due to soil consistency and moisture content
5/7/97 - all day	• Continued soil screening with use of compressed air jet to help clear screen
5/8/97 - 07:00 to 11:00	• Continued soil screening until screening plant breakdown
5/8/97 - 11:00 to 12:00	• Performed general site cleanup and then shutdown for screen repair
5/12/97 - 18:30	• Completed soil excavation and repaired screen
5/13/97 - 07:45	• Met with Gilmar Swenson at borrow pit to identify soils for use at Range D-30
5/13/97 - 09:20 to 17:00	• Continued screening; problems with plugging persist
5/14/97 - 09:00	• Decided to switch to 3/8-in.-mesh size screen for intermittent use area soils • The larger opening increased throughput without a significant reduction in quality because the intermittent use area soils contained a much lower proportion of bullets in comparison to the active area
5/15/97 - all day	• Used screening plant to mix soil and TSP
5/16/97 - 05:30 to 11:00	• Screened and processed soils • Processing completed; treated soils sampled; awaiting analytical results

Table 2-2. Summary of Work Activities (continued)

Time Period	Activities
5/19/97 - all day	• Rescreened oversize with 3/4-in.-mesh size screen to remove organic debris
5/20/97 - 13:30	• Received analytical results showing that the leachable lead concentrations in the treated soil were much lower than the Toxicity Characteristic Leaching Procedure (TCLP) criterion, indicating effective immobilization of the lead.
5/21/97 - 08:00	• Finished grading berm
5/27/97 - 14:00	• Developed new range layout with Camp Lejeune, HEPACO, and Battelle personnel • The new layout allowed 30 firing points and required removal of existing concrete firing line walkways and replacement with gravel firing lines
5/29/97 - 10:00	• Truck with 19.2 tons of lead-bearing soil departs for The Doe Run Company primary smelter
5/30/97 - 06:00 to 14:00	• Performed final grading of berm and excavation of drainage ditch at base of berm
6/3/97 - all day	• Continued firing line installation until delayed by stormy weather
6/4/97 - all day	• Base personnel removed tree • Finished firing line installation and rough grading
6/5/97 - all day	• Disposed of debris from concrete firing lines • Performed final site grading and seeding
6/6/97 - 15:00	• Completed final site inspection

Table 2-3 provides a summary of the cost for the Phase I characterization and treatability testing performed in preparation for the maintenance activity, and the cost for the maintenance work at Range D-30.

Table 2-3. Summary of Project Costs by Task

Task	Cost ($)
Phase I	
Site characterization, treatability testing, and planning	$56,389
Phase I total	$56,389
Phase II	
Work plan preparation	$5,000
On-site management	$24,700
Implementation report	$8,847
Planning and mobilization	$8,385
Soil excavation and treatment	$43,035
Toll fee for lead recycling	$6,360
Berm reconstruction	$19,238
Firing line walkway construction	$11,237
Demobilization	$6,745
Phase II total	$133,547
Project total	$189,936

3.0 SAMPLING ACTIVITIES

This section reports the results of project monitoring activities.

3.1 Soil Sampling

Samples of treated soil were collected by compositing materials from treatment batches and were tested to ensure effective immobilization of any lead remaining after physical separation. One sample of treated soil was collected for every 75 to 100 yd^3 of treated soil produced for analysis by the TCLP. The results of the TCLP test for the 10 batches and one duplicate analysis are shown in Table 3-1. The leachable lead content of all samples was well below the TCLP criteria for lead of 0.5 mg/L, indicating successful immobilization of the lead.

Table 3-1. Range D-30 Processed Soil Leaching Results

Sample	TCLP Leachable Lead (μg/L)[(a)]
1	0.147
2	0.086
3	0.174
4	0.114
5	0.111
6	0.199
7	0.057
8	0.356
9	0.020
10	0.052
10 Duplicate	0.048

(a) TCLP limit for lead is 500 μg/L.

3.2 Air Monitoring

Air monitoring for particulate dust was conducted using two Miniram™ model PDM-3 air monitors. Monitor 1 was placed near the screening site and monitor 2 was placed downwind near the site boundary. The results for the air monitoring are shown in Table 3-2. Monitoring results indicate that, as expected, dust generation was minimal due to the dampness of the soil.

Table 3-2. Air Monitoring During Maintenance at Range D-30

Date and Time	Monitor 1 Results (mg/m^3)	Monitor 2 Results (mg/m^3)
5/6/97 - 15:00	1.84	1.97
5/12/97 - 12:00	1.84	1.92
5/12/97 - 17:00	1.90	1.97
5/13/97 - 10:00	1.62	1.62
5/13/97 - 17:00	1.62	1.70
5/15/97 - 9:30	1.62	1.62
5/15/97 - 10:30	1.62	1.67
5/15/97 - 18:00	1.62	1.67

4.0 SUMMARY AND CONCLUSIONS

The project demonstrated the feasibility of small-arms range remediation and maintenance. The demonstration project included screening to collect oversize material containing high lead concentrations, recycling of that material, and solidification/stabilization (S/S) to immobilize lead remaining in the screened soils. The S/S treated soil was used to rebuild the berm for continued use as a small-arms range. About 580 yd^3 of berm material was processed for a total cost of $133,547 or $230/$yd^3$, including firing line walkway construction. Although some unexpected conditions were encountered, HEPACO demonstrated superior ability to adapt while maintaining technical, schedule, and budget goals. The program highlights the importance of obtaining representative samples of the material to be processed. Sampling activities in preparation for future range maintenance or remediation activities should use a skid steer loader (Bobcat™), backhoe, or similar excavator to cut narrow trenches allowing access to a full cross section of the berm.

5.0 RECOMMENDATIONS

This section describes lessons learned during the Range D-30 remediation project.

5.1 Site Characterization

It is important to have complete information about the chemical and physical condition of the berm when planning a range maintenance or remediation project. Small-arms range berms often contain inhomogeneities such as pockets of buried lead or the network of fibrous roots encountered in the berm at Range D-30. Conventional soil sampling using hand scoops or bucket augers does not expose significant volumes of the berm to investigation, so buried features can be missed.

Sampling in preparation for future range remediation or maintenance activities should include exploratory excavations into the berm. A skid steer loader (Bobcat™), backhoe, or similar excavator can be used to cut one or more narrow trenches allowing access to a cross section of berm soils. Samples can be collected with conventional hand tools for measuring metal content of soils in areas around the berm or for determining the need for soil amendments (see Section 5.2), but berm sampling should be done on a larger scale to expose more of the interior soils.

5.2 Turf Maintenance

Maintaining good turf conditions helps reduce metal mobility at the range. Healthy vegetation provides physical stabilization that minimizes metal transport due to wind and water erosion. Soil chemistry that promotes healthy turf can also help immobilize metals. Sever (1993) and Cohen and Lindstrand (1997) provide more detailed information about using soil amendments to reduce metal mobility at small-arms ranges. Avoiding an acidic condition in the soil helps to reduce the mobility of cationic metals such as lead, copper, and zinc. Strongly acidic or basic conditions also are detrimental to vegetation. A variety of grasses and similar ground-covering plants prefer a soil pH in the range of 5.5 to 7.0. Free phosphate in the soil is essential for plant health and can help immobilize lead by precipitating insoluble lead-phosphate minerals. The pH and phosphate levels in soil should be adjusted to the maximum level consistent with healthy turf conditions.

The pH, nitrogen, phosphorus, and potassium levels should be measured at least twice a year in the spring and fall and adjustments made, as needed. The soil pH can be increased by spreading finely ground agricultural lime on the soil surface. Phosphorus concentration can be increased by surface application of a high phosphate fertilizer such as bone meal, super phosphate, or triple superphosphate. Fertilizers that combine nitrogen and phosphorous should be used only when the nitrogen levels are low. Excess nitrogen can produce high nitrate concentrations in the soil which may tend to mobilize lead. The county extension agent or a local landscaping service should be consulted for specific information about the recommended pH and nutrient conditions for the vegetation in the area and methods for adjusting the pH and nutrient conditions.

5.3 Soil Screening and Bullet Recycling

Metallic lead in the form of bullets or shot is a recoverable metal and can be reclaimed from impact berms at rifle and pistol ranges and shotfall areas at trap and skeet ranges. The frequency of bullet recovery depends on the amount of bullets fired at the range. Screening and recycling should be done before ricochet problems develop and often enough to reduce losses of lead resulting from oxidation. The National Rifle Association suggests that recycling annually is appropriate for heavily used ranges and that the time between recycling should not be more than five years for ranges with minimal use to avoid converting a large proportion of lead metal to lead compounds (Whiting, 1989).

Environmental Turf Services, Inc. recommends that recycling be done once every two to ten years, depending on the volume of fire (Cohen and Lindstrand, 1997). Scheduling of routine recycling on a three year cycle, with provision of more frequent processing of berms at ranges that develop ricochet problems, would appear to be adequate for the berms at MCB Camp Lejeune.

6.0 REFERENCES

Cohen, S.Z., and L. Lindstrand. 1997. *EPA and OSHA Compliance Guide for Small-Arms Ranges: A Focus on Lead*. Environmental Turf Services, Wheaton, MD.

Sever, C.W. 1993. "Lead and Outdoor Ranges." *National Shooting Range Symposium*. pp. 87-98. U.S. Fish and Wildlife Service, Washington, DC. October 17-19.

Whiting, R.C. 1989. *Range Manual*. National Rifle Association, Fairfax, VA.

APPENDIX

PHOTOGRAPHS OF RANGE D-30

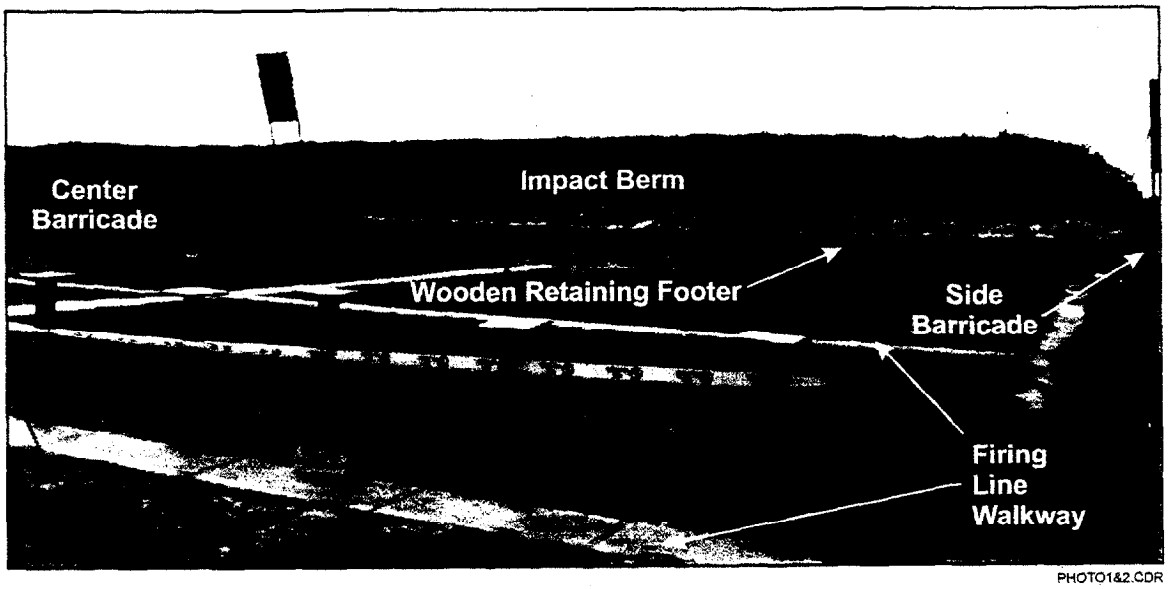

Photo 1. General Features of the Active Area - Range D 30

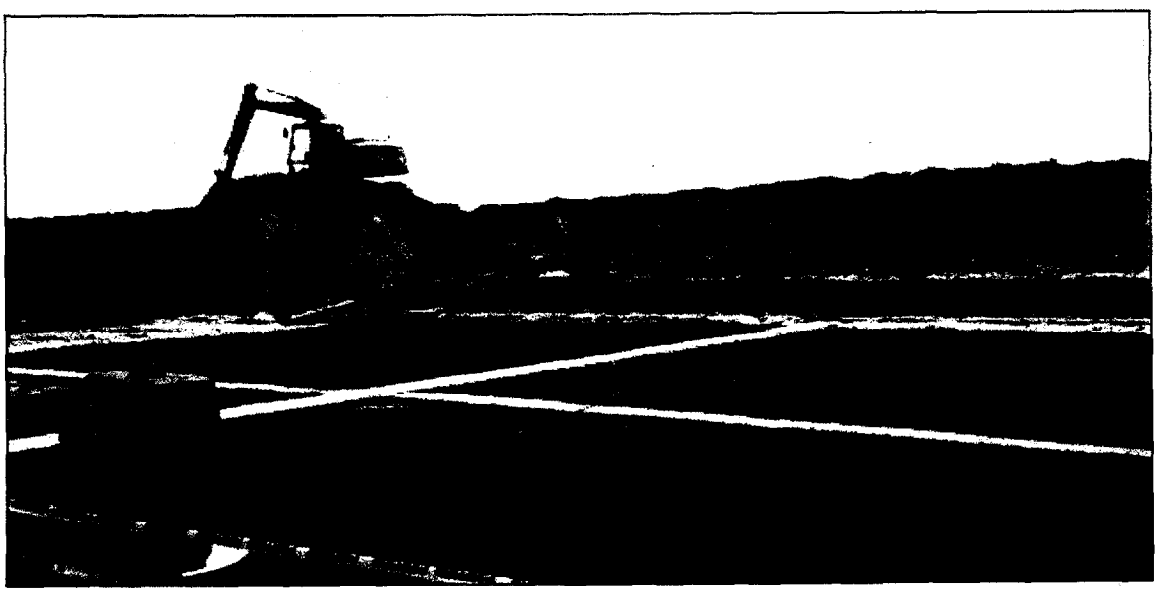

Photo 2. Soil Excavation in the Active Area

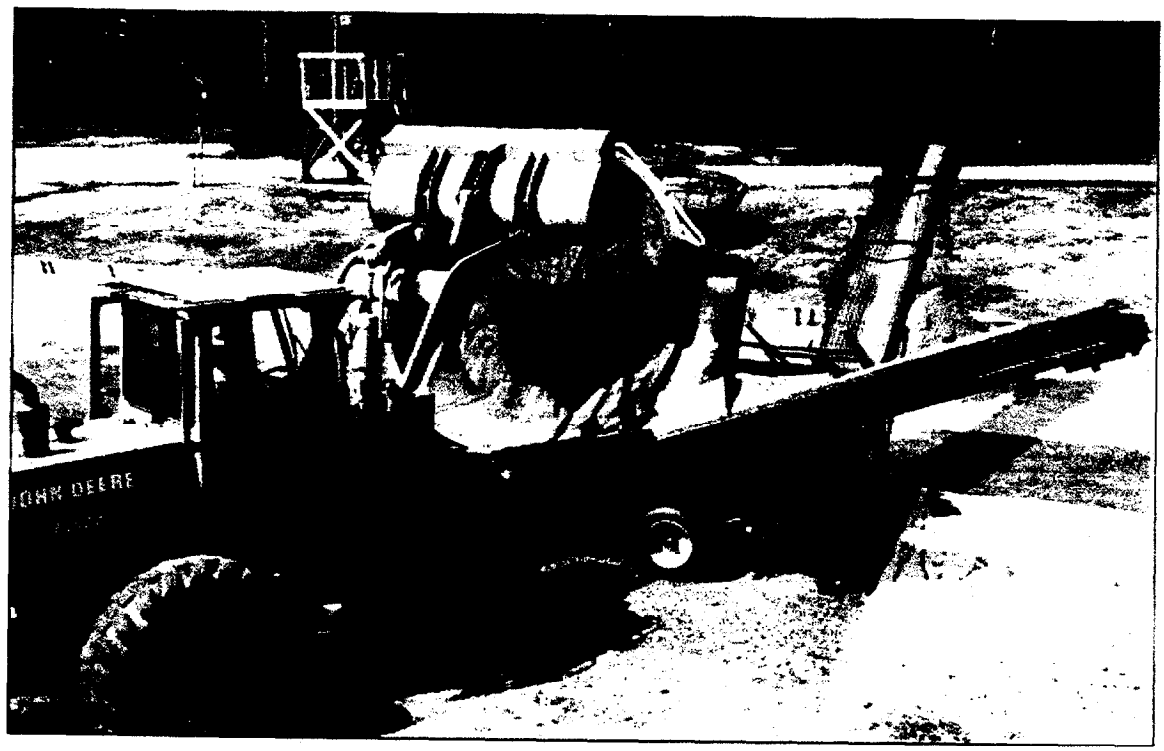

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Photo 3. Rotating Screening Plant Operation

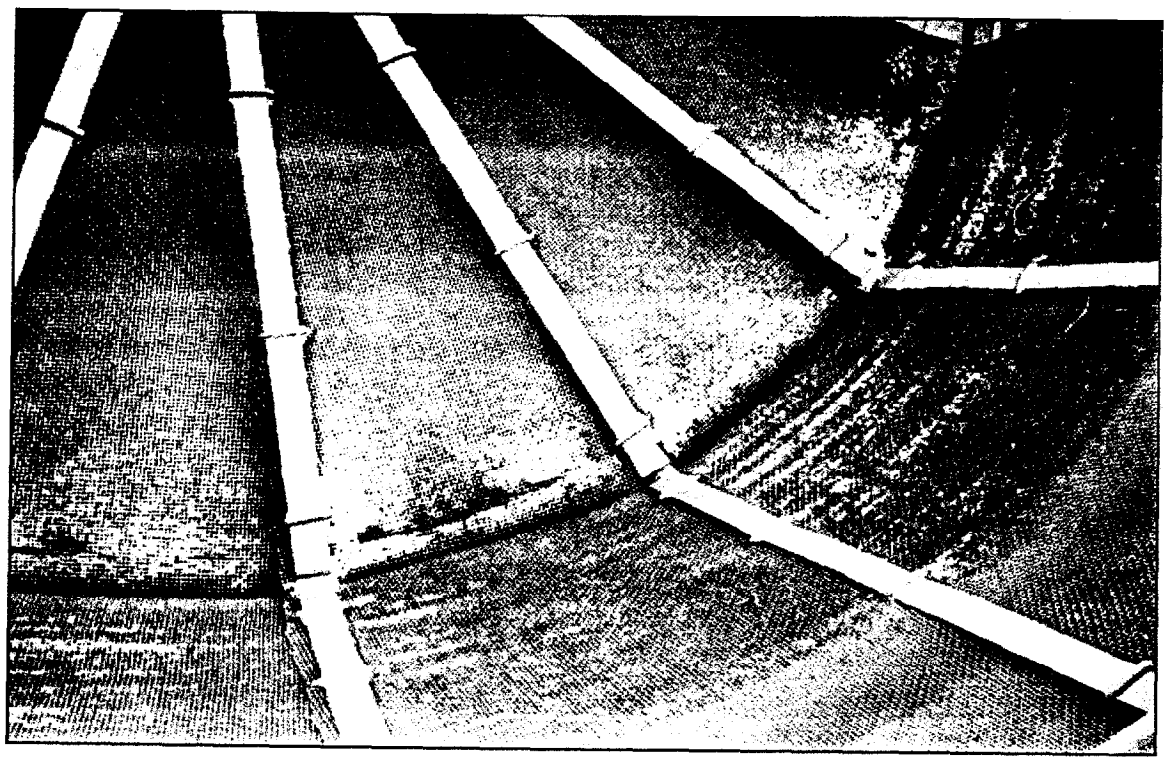

Photo 4. Screen Showing Soil Accumulation in Openings

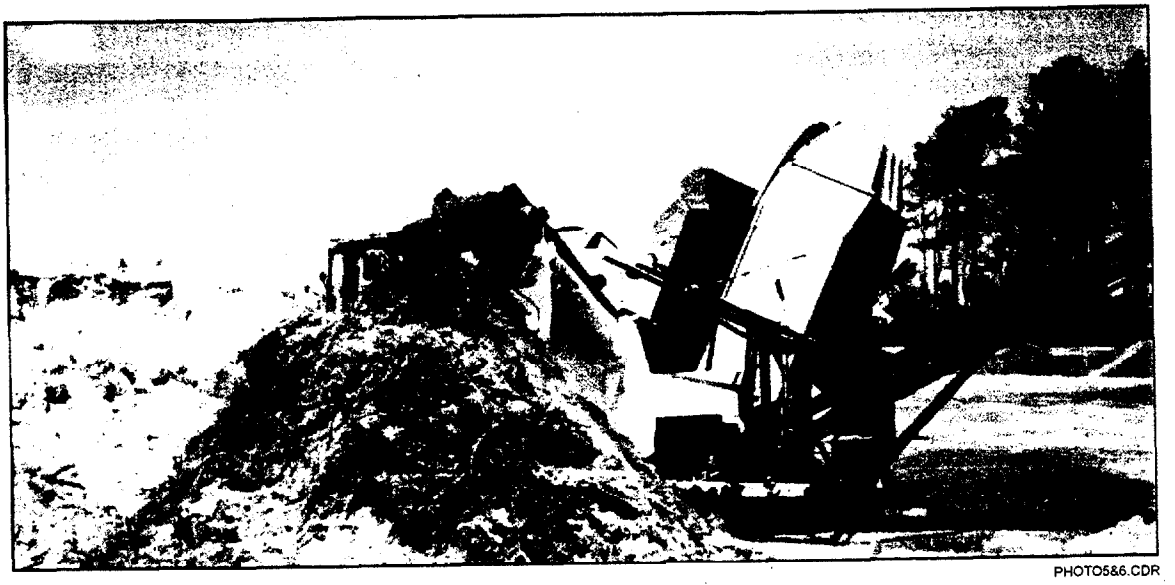

PHOTO5&6.CDR

Photo 5. Organic Debris Removed from Lead-Bearing Material Prior to Recycling

Photo 6. Soil Treatment Operation

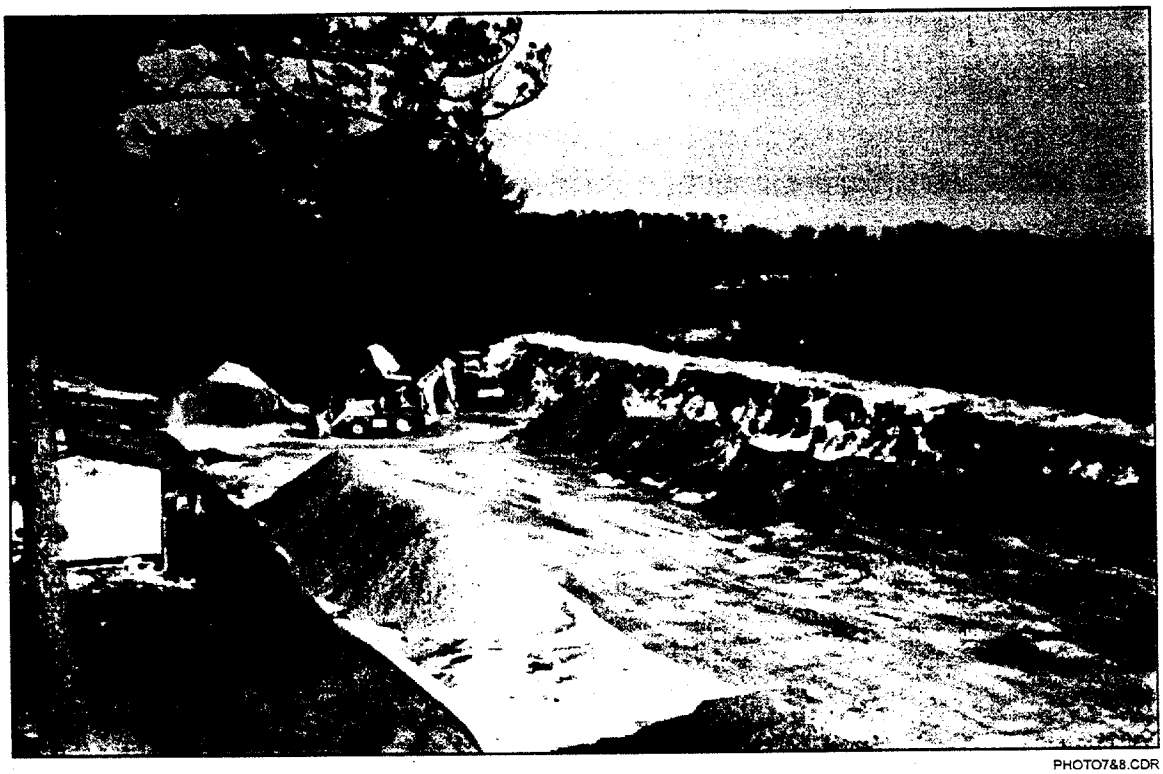

PHOTO7&8.CDR

Photo 7. Soil Being Treated and Stockpiled

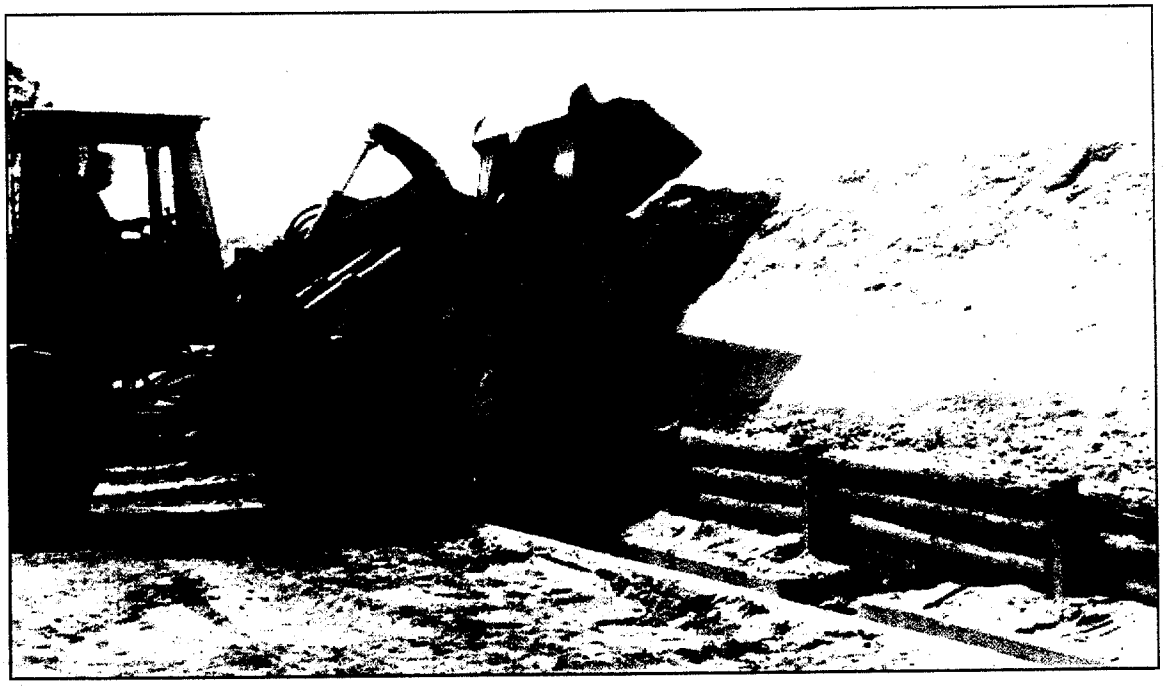

Photo 8. Rebuilding Berm Face

PHOTO9&10.CDR

Photo 9. Gravel-Lined Drainage Channel at the Base of the Completed Berm

Photo 10. Forming Gravel Walkways

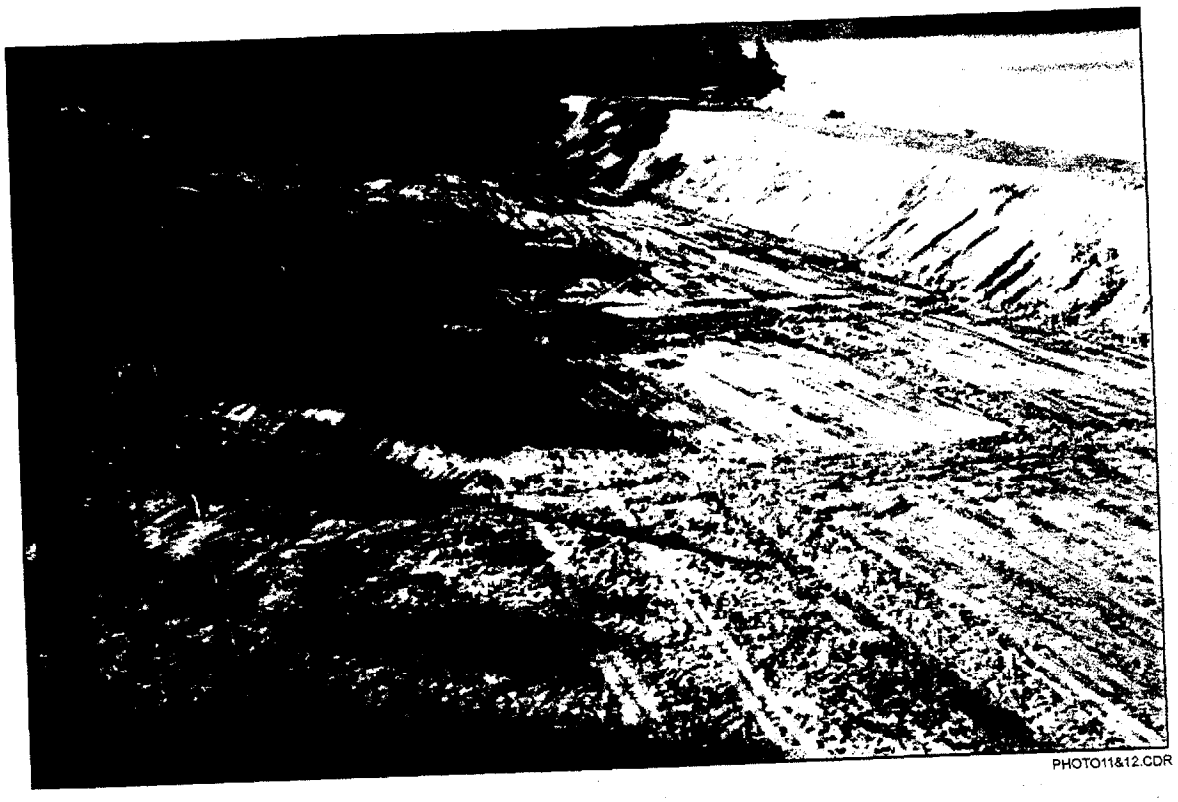

Photo 11. Layout of Completed Walkways

Photo 12. Site Restoration