INNOVATIVE TECHNOLOGY
Summary Report

DOE/EM-0481

Lead Paint Analyzer

Deactivation and Decommissioning
Focus Area

Prepared for
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Innovative Technology
Summary Report

Lead Paint Analyzer

OST Reference #2317

Deactivation and Decommissioning
Focus Area

Demonstrated at
Idaho National Engineering and Environmental Laboratory
Idaho Falls, Idaho

INNOVATIVE TECHNOLOGY
Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at http://OST.em.doe.gov under "Publications."

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SECTION 1

SUMMARY

Introduction

The U.S. Department of Energy (DOE) continually seeks safer and more cost-effective technologies for use in decontamination and decommissioning (D&D) of nuclear facilities. To this end, the Deactivation and Decommissioning Focus Area (DDFA) of the DOE's Office of Science and Technology (OST) sponsors Large-Scale Demonstration and Deployment Projects (LSDDP). At these LSDDPs, developers and vendors of improved or innovative technologies showcase products that are potentially beneficial to DOE's projects, and to others in the D&D community. Benefits sought include decreased health and safety risks to personnel and the environment, increased productivity, and decreased cost of operation.

The Idaho National Engineering and Environmental Laboratory (INEEL) LSDDP generated a list of statements defining specific needs or problems where improved technology could be incorporated into ongoing D&D tasks. One of the stated needs was for a Lead Paint Analyzer that would reduce costs and shorten schedules in DOE's Decommissioning Project. The Niton 700 Series Multi-element Analyzer is a hand-held, battery-operated unit that uses x-ray fluorescence spectroscopy (XRF) to analyze 25 elements, including the presence of lead in paint. The baseline technologies consist of collecting field samples and sending the samples to a laboratory for analysis.

This demonstration investigated the associated costs and the required time to take an analysis with the multi-element analyzer with respect to the baseline technology. The Niton 700 Series Multi-element Analyzer performs in situ real-time analyses to identify and quantify lead, chromium, cadmium, and other metals in lead-based paint. Benefits expected from using the multi-element spectrum analyzer include:

- Reduced cost
- Easier use
- Reduced schedules in DOE's decommissioning projects.

Technology Summary

Baseline Technology

In the past, determining the presence of metals in lead-based paint consisted of collecting paint chips and sending the samples to a laboratory for analysis. This method requires 1–3 months to receive the data from the laboratory (see Figure 1).

Figure 1. Baseline sampling technique.

Innovative Technology

The Niton 700 Series Multi-element Analyzer is a hand-held, battery-operated instrument that is 8 x 3 x 2 in., weighs 2.5 lb, and costs approximately $25,000 (see Figure 2). The analyzer uses XRF spectrum analysis to identify and quantify metals and elements in lead-based paint. All eight Resource Conservation and Recovery Act (RCRA) metals and up to 17 other elements can be characterized within seconds. The analyzer uses two radioactive sources: (1) Americium-241 to test for antimony, barium, cadmium, indium, iodine, palladium, silver, and tin; and (2) Cadmium-109 to test for arsenic, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, rubidium, selenium, strontium, titanium, zinc, and zirconium. The unit can be carried, shipped, and transported without exterior labeling, conforming to *49 Code of Federal Regulations (CFR) 173.421*. Batteries provide power for 8 hours and charge in 2 hours. The analyzer stores up to 3,000 data points, including sample locations. Data is easily downloaded to a conventional personal computer.

Figure 2. Niton 700 Series Multi-element Analyzer.

Demonstration Summary

The Niton 700 Series Multi-element Analyzer technology was demonstrated in February 1999 at three INEEL facilities as part of the INEEL LSDDP. The analyzer technology identified and quantified metals in lead-based paint at various points inside each facility. At one facility, paint chip samples were collected and sent to a laboratory for analysis for comparison with the Niton data from the same location (see Figure 3). At the other facilities, the unit was tested against existing laboratory analyses from known locations. Data from the demonstration indicated that the Niton 700 Series Multi-element Analyzer provides data comparable to the laboratory data. Based on cost savings of $18,775 per 14 samples, it would require about 17 samples to recover the capital cost of the Niton 700 Series Multi-element Analyzer of $25,000.

Figure 3. Niton 700 Series Multi-element Analyzer performing multi-element analysis on a wall.

Key Results

The key results of the demonstration are summarized below. Detailed descriptions and explanations of these results are in Section 3.

- The analyzer takes 20 seconds to obtain a reading, compared to an average 2 hours to collect a sample and 1–3 months to receive laboratory data on the samples.
- The analyzer takes reading from all the layers of a painted surface, whereas the baseline cannot acquire samples from all the paint present because of the ineffectiveness of the scraping technique (some paint remains on the wall after intense scraping).
- The data produced by the Niton 700 Series Multi-element Analyzer closely matched the results from the laboratory analysis.
- The Niton 700 Series Multi-element Analyzer provides data that more accurately represents the makeup of the paint. Due to the crude method of collecting samples, the potential exists to obtain an incomplete sample and also contaminate the sample with rust and other foreign materials.
- The analyzer also has the capability to characterize layered paint on curved and flat surfaces. The analyzer has to be placed directly on the painted surface and must remain stationary to get a reliable reading.
- The unit costs are $54.18 per sample for the Niton 700 Series Multi-Element Analyzer and $1,533 per sample for the baseline technology.
- The analyzer is user friendly.

Contacts

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Web Site
The INEEL LSDDP Internet web site address is http://id.inel.gov/lsddp.

Licensing
The Niton Corporation General license number 3G-105-02 was used to support this demonstration.

Permitting
No permitting activities were required to support this demonstration. The Niton 700 Series Multi-element Analyzer meets the Department of Transportation requirements in *49 CFR 173.421* for excepted packages for limited quantities of Class 7 (radioactive) materials. A Class 7 (radioactive) material is one in which the activity per package does not exceed the limits specified in *49 CFR 173.425*. The packaging, marking, labeling and, if not a hazardous substance or hazardous waste, the shipping papers meet the certification requirements of this subchapter and requirements of this subpart if the radiation level at any point on the external surface of the package does not exceed 0.5 mrem/hour.

Other
All published Innovative Technology Summary Reports are available on the OST web site at http://em-50.em.doe.gov under the “Publications” heading. The Technology Management System, also available through the OST web site, provides information about OST programs, technologies, and problems. The OST Reference Number for the Niton 700 Series Analyzer is 2317.

SECTION 2

TECHNOLOGY DESCRIPTION

Overall Process Definition

Demonstration Goals and Objectives

The overall purpose of this demonstration was to assess the benefits that may be derived from using the Niton 700 Series Multi-element Analyzer. The analyzer was compared with the baseline technology, which is laboratory analysis on samples. The primary goal of the demonstration was to collect valid operational data to make a legitimate comparison between the Niton 700 Series Multi-element Analyzer and the baseline technology in the following areas:

- Cost
- Productivity rates
- Ease of use
- Limitations and benefits.

A secondary goal of the demonstration was to provide the D&D program with characterization data in real-time, which would allow the D&D project manager to disposition a room or facility and move forward immediately without waiting 3 months for the data needed for a decision.

Description of the Technology

The Niton 700 Series Multi-element Analyzer is a hand-held, battery-operated unit, which is 8 x 3 x 2 in., weighs 2.5 lb, and costs approximately $25,000 (see Figure 4). The analyzer uses XRF spectrum analysis to identify and quantify metals and elements in lead-based paint. All eight RCRA metals and up to 17 other elements can be characterized within seconds. The analyzer uses two radioactive sources: (1) Americium-241 to test for antimony, barium, cadmium, indium, iodine, palladium, silver, and tin; and (2) Cadmium-109 to test for arsenic, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, rubidium, selenium, strontium, titanium, zinc, and zirconium. The unit can be carried, shipped, and transported without exterior labeling, conforming to *49 CFR 173.421*. Batteries provide power for 8 hours and charge in less than 2 hours. The analyzer stores up to 3,000 data points, including sample locations. Data from the Niton 700 Series Multi-element Analyzer is easily downloaded to a conventional personal computer.

Figure 4. Niton 700 Series Multi-element Analyzer with a laptop computer.

System Operation

Table 1 summarizes the operational parameters and conditions of the Niton 700 Series Multi-element Analyzer demonstration.

Table 1. Operational parameters and conditions of the Niton 700 Series Multi-element Analyzer demonstration.

Working Conditions	
Work area locations	• Initial Engine Test (IET) Facility. • Test Reactor Area (TRA) Facility. • Idaho Nuclear Technology and Engineering Center (INTEC).
Work area access	Access controlled by D&D project through use of fencing and posting.
Work area description	• Work area inside IET is cordoned off by fencing and posted as a controlled area and D&D/construction hazard area requiring training, hard hat, safety glasses, and safety shoes for entry. • INTEC and TRA are cordoned off by fencing and posted as a controlled area. • Both IET and INTEC had multiple D&D activities ongoing that were not related to the demonstration. • D&D support trailers were available at the IET job site.
Work area hazards	• Heavy equipment operations. • Tripping hazards. • Temperature extremes.
Equipment configuration	The Niton 700 Series Multi-element Analyzer was transported to the job site by the vendor.
Labor, Support Personnel, Specialized Skills, and Training	
Work crew	• Two sample technicians. • Two Niton vendors. • One IET project manager.
Additional support personnel	• One data taker. • One health and safety observer (periodic). • One test engineer.
Specialized skills/training	No specialized training was provided, but personnel familiarity with equipment setup and operation was helpful.
Waste Management	
Primary waste generated	No primary wastes were generated.
Secondary waste generated	Disposable personal protective equipment (latex gloves).
Waste containment and disposal	Laboratory disposed of secondary waste.
Equipment Specifications and Operational Parameters	
Technology design purpose	To identify and quantify metals and elements in lead-based paint.
Specifications	• 8 x 3 x 2 in. • 2.5 lb.
Portability	The Niton 700 Series Multi-element Analyzer is a hand-held battery operated unit.
Materials Used	
Work area preparation	No specific preparation was necessary for the demonstration. The D&D project already had necessary controls and preparations in place.
Personal protective equipment (PPE)	• Two pair rubber latex gloves. • Two pair safety glasses.
Utilities/Energy Requirements	
Power, fuel, etc.	None required specific to the technology tested.

PERFORMANCE

Problem Addressed

Most DOE facilities characterize and field-screen for lead-based paint by scraping paint chips and sending the samples to a laboratory for analysis. Sample collection can take hours, and analytical results from the laboratory may not be available for months. The Niton 700 Series Multi-element Analyzer provides results in about 20 seconds. The D&D project manager can use these results in making immediate decisions on the appropriate approach to remediate a facility.

Demonstration Plan

Demonstration Site Description

IET was constructed during the1950s for use in the Aircraft Nuclear Propulsion Program, which was terminated in 1961. The facility itself consists of several buildings and structures, both above and below ground level (see Figure 5).

Figure 5. Aerial view of the IET facility before becoming a D&D site.

TRA was constructed in the early 1950s with the development of the Materials Test Reactor (see Figure 6). These facilities have been modified to fit the changing needs of the INEEL and provide five major types of functional space: reactor, laboratory, office, training, and craft support for maintenance.

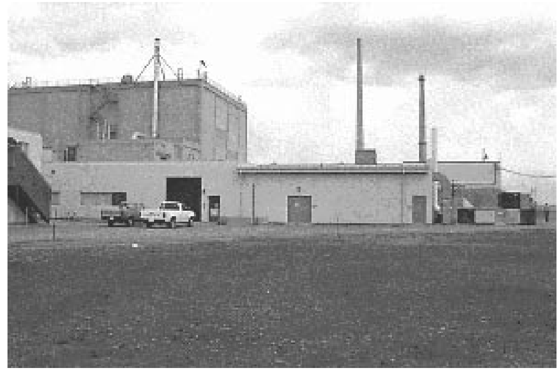


Figure 6. TRA facility site: aerial view of TRA and TRA-661 building.

INTEC (formerly the Idaho Chemical Processing Plant) is located about 3 miles north of the Central Facilities Area (CFA) (see Figure 7). The mission of the facility is to receive and store spent nuclear fuels and radioactive wastes, treat and convert wastes, and develop new, cost-effective waste management technologies for DOE in a manner that protects the safety of INEEL employees, the public, and the environment. Before April 1992, this mission also included nuclear fuel reprocessing; however, reprocessing work was phased out.

Figure 7. INTEC facility site: aerial view of INTEC and INTEC-637 building where the Niton 700 Series Multi-element Analyzer demonstration took place.

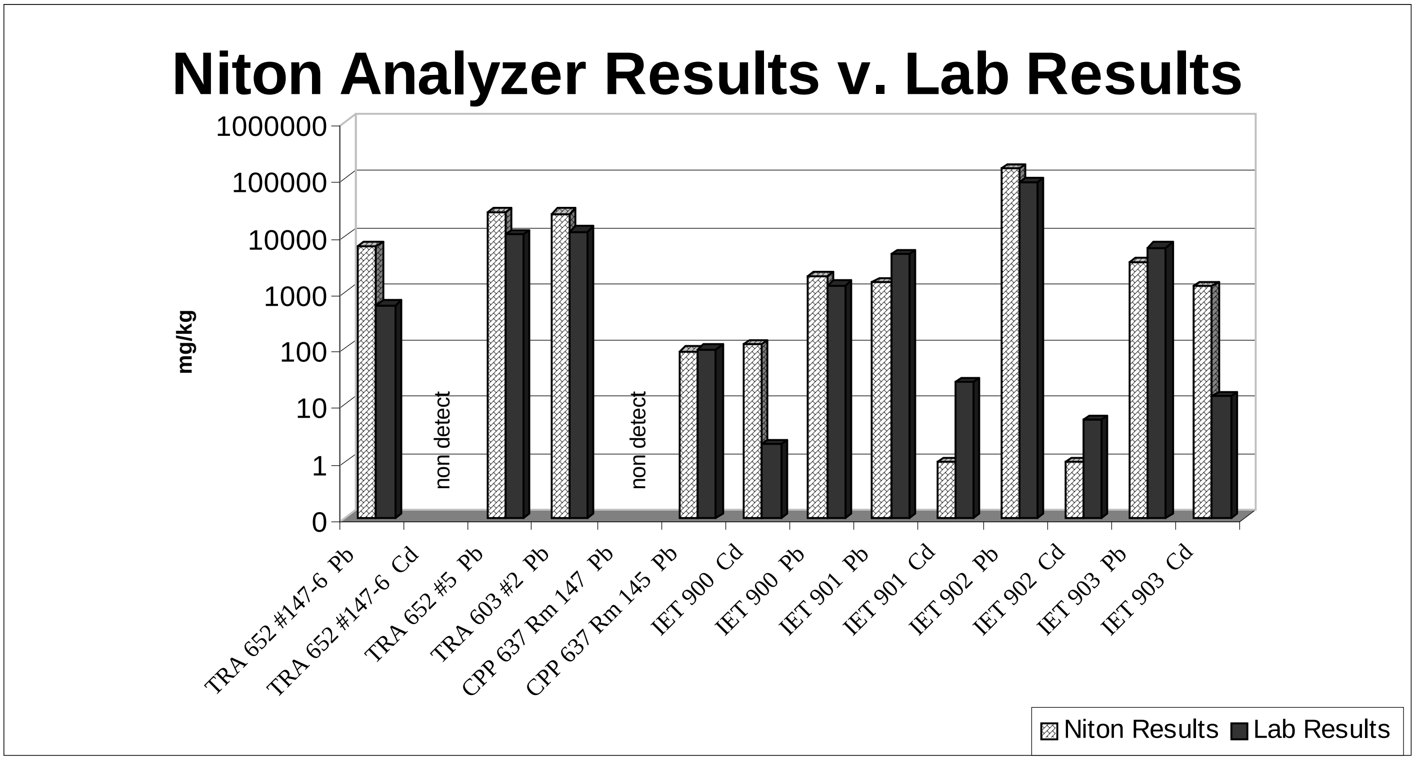
Major Objectives of the Demonstration

The major objectives were to evaluate the Niton 700 Series Multi-element Analyzer against the baseline technology in several areas including:

- Cost effectiveness
- Ease of use
- Limitations

Major Elements of the Demonstration

Both the baseline technology and the Niton 700 Series Multi-element Analyzer were used to identify and quantify lead, chromium, cadmium and other metals in lead-based paint on walls, doors and handrails. The demonstration occurred on both painted concrete and metal surfaces. The areas sampled on the walls used grids of 2 x 2 ft in diameter. The intent of analysis by the Niton 700 Series Multi-element Analyzer analysis was to gather information that can be used by the D&D project managers in making immediate decisions on the approach to remediate an area of a facility, instead of waiting months for laboratory results. Data from the demonstration indicated that the Niton 700 Series Multi-element Analyzer provides data comparable to the laboratory data as shown in Figure 8. The main value of the analyzer is that it provides results in about 20 seconds.



Sample Location	Niton Results (mg/kg)	Baseline Results (mg/kg)
TRA 652 #147-6 Pb	6,410	574
TRA 652 #147-6 Cd	Non detect	Non detect
TRA 652 #5 Pb	25,641	10,608
TRA 603 #2 Pb	24,359	11,809
CPP 637 Rm 147 Pb	Non detect	Non detect
CPP 637 Rm 145 Pb	91	96
IET 900 Cd	116	2
IET 900 Pb	1,860	1,310
IET 901 Pb	1,512	4,620
IET 901 Cd	0	25
IET 902 Pb	151,282	85,000
IET 902 Cd	0	5
IET 903 Pb	3,419	6,220
IET 903 Cd	1,282	14

Figure 8. Niton Results vs. Lab Results (Chart and Table)

The lower detection limits for the Niton (N) analyzer vs. the Analytical Lab (A) are:

- Lead 40-50 ppm (N) 0.80 ppm (A)
- Cadmium 250 ppm (N) 0.020 ppm (A)
- Chromium 800 ppm (N) 0.175 ppm (A)

The upper detection limits for the Niton (N) analyzer v the Analytical Lab (A) are:

- Lead 15,000-20,000 ppm (N) 10 ppm (A)
- Cadmium 15,000-20,000 ppm (N) 10 ppm (A)
- Chromium 15,000-20,000 ppm (N) 10 ppm (A)

Note: The information above was provided by the Niton Corporation and from the Analytical Laboratory.

Accuracy for Niton instrument is rated at 5% and accuracy for the Analytical Lab is 16%.

Results

Both technologies were evaluated under identical physical conditions. Every attempt was made to allow work to proceed under normal conditions with no bias. All parties involved in the demonstration were requested to perform the work normally with no special emphasis on speed or efficiency. Both technologies were demonstrated on the same paint materials at each facility on February 9, 1999. A performance comparison between the two technologies is listed in Table 2.

Table 2. Performance comparison between the Niton 700 Series Multi-element Analyzer and the baseline technology.

Performance Factor	Baseline Technology Scraping Paint Chips for Laboratory Analysis	Niton 700 Series Multi-element Analyzer
Personnel/equipment/ time required to obtain data or paint chips	Personnel: • Two sample technicians. Equipment: • One pan. • Six sample bottles. • One paint scraper. Time: • 21–22 minutes to collect sample.	Personnel: • Two Niton vendors. Equipment: • 1 Niton 700 Series Multi-element Analyzer. Time: • 11–12 minutes for the analyzer to provide results.
Time required to obtain data	Equipment: • Laboratory. Time: (duration not man-hours worked) • 12 hours to ship samples to the laboratory. • 90 days.	Equipment: • Niton 700 Series Multi-element Analyzer. Time: (duration not man-hours worked) • 2–5 minutes.
Preparation time	Equipment: • One pan. • Six sample bottles. • One paint scraper. • Contract with laboratory. Time: • 24 hours to purchase equipment. • 1 week for the Sample Management Office to set up contract with a laboratory.	Equipment: • 1 Niton 700 Series Multi-element Analyzer. Time: • 10 minutes to check the analyzer out of the Radioactive Material Area (RMA). • 5 minutes for the analyzer to warm up. • 3 minutes to calibrate the analyzer (see Figure 9).
Total time per technology	• 90 days.	• 30 minutes.
PPE requirements	Both technologies required the same level of PPE. The number of workers required to wear PPE is the same for both technologies.	
Superior capability	• Collecting paint chip samples is the preferred method for characterizing lead-based paint. A few confirmation samples are required to be analyzed by a laboratory in order to document RCRA compliance.	• Workers considered the analyzer much easier to use. • The analyzer takes 20 seconds for a reading compared to 90 days for laboratory data (see Figure 10). • The analyzer does not damage painted structures when gathering data. • Data not erroneous due to possible contamination of sample during sample collection.

Figure 9. Calibrating the Niton 700 Series Multi-element Analyzer with standards.

Figure 10. Recording data as collected from the analyzer.

TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

Baseline Technology

The Niton 700 Series Multi-element Analyzer competes with the baseline technology of scraping surfaces for collection of paint samples followed by laboratory analysis.

Other Competing Technologies

Other competing technologies include the Spectrace 9000 Field Portable XRF from Spectrace Instruments and the LPA-1 from Radiation Monitoring Devices (RMD), Inc (see Figure 11).

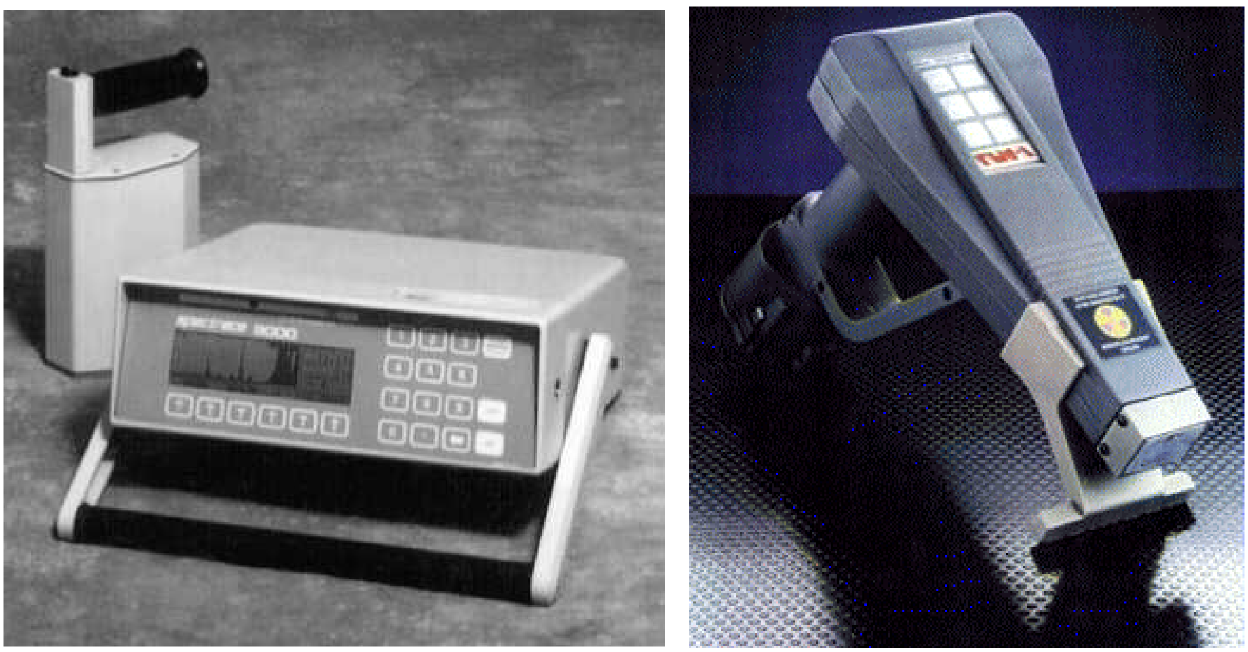


Figure 11. Photos of the Spectrace 9000 Instrument (left) and the (RMD) LPA-1 Instrument (right).

Technology Applicability

The Niton 700 Series Multi-element Analyzer is a fully developed technology that is now commercially available for field testing lead-based paint, paint chips, dust wipes, and air monitoring filters. Its superior performance over the baseline in almost all areas makes it a prime candidate for deployment throughout the DOE complex. It has the potential to reduce costs for field screening and characterization on any D&D project. The INEEL has also deployed the RMD LPA-1 on INEEL projects for field screening on lead-based paint. The RMD LPA-1 only detects lead in paint.

Patents/Commercialization/Sponsor

The Niton 700 Series Multi-element Analyzers are commercially available from the Niton Corporation of Bedford, Massachusetts.

SECTION 5

COST

Introduction

This section compares the characterization costs for the Niton 700 Series Multi-element Analyzer technology with the sampling and laboratory analysis cost of the baseline method. In this demonstration, the cost to use the analyzer is approximately 4% of the baseline technology cost. This cost analysis is based on observations from approximately 1 day of work consisting of mobilizing to the demonstration site, grid and marking of various sample areas, and taking characterization readings with the analyzer and manually scraping surface areas (baseline).

Methodology

The costs for the Niton 700 Series Multi-element Analyzer and baseline technology are derived from the observed duration of the work activities. These activities were recorded as the demonstration progressed. The demonstration was performed using INEEL workers and Niton vendors. Government ownership of the equipment and site personnel operation was assumed. The cost analysis for the analyzer is for a field-screening level of characterization and includes costs for moving the equipment from storage area to the work area, setup, sample collection, sample analysis, data downloading, and return to the storage area. The cost analysis for the baseline technology is for providing characterization data that can serve as evidence in court. The baseline technology costs include preparation for work (checklists, chain of custody, sample labels, etc.), sample collection, sample shipping, laboratory analysis, and data validation.

The amount of characterization work performed with the analyzer varied from the baseline's amount (i.e., fourteen areas sampled using the analyzer and six using the baseline). This cost analysis assumes 14 sample areas for both the analyzer and the baseline technologies and uses the average production rate observed during the demonstration to compute production rates for the sampling.

In the actual performance of the demonstration, a crew of two people performed the baseline sample collection while two Niton vendors operated the Niton 700 Series Multi-element Analyzer. The cost analysis varies from the demonstration (to match typical work situations), by assuming a crew of two industrial hygienists for the innovative technology costs and a crew of two engineering technicians for the baseline technology costs. Both technologies include a job supervisor for the pre-job safety meeting. Labor rates for crew members are based on standard rates for the INEEL site. Specific labor classifications for surface characterization work may vary at other sites.

The equipment rates are based on the amortized purchase price and maintenance costs (reference Appendix A). The baseline technology equipment calculation is an allowance for small tools not covered by overhead or included in the labor rates. Small tools comprised of a metal basin, scrapers, heat gun, tape measure, and pedestal. Ownership and operating costs for the Niton 700 Series Multi-element Analyzer include repairs, maintenance, source replacements, manufacturer calibrations, software upgrades, parts inspections, cleaning, and preventive upkeep.

The estimated costs include work delays and inefficiencies that are typical for real work situations. An example of a work delay/inefficiency observed for this demonstration occurred when the work was interrupted while a worker went to the tool storage area (Test Area North tool crib) to acquire a tape measure and a heat gun for the paint chip sample removal. These costs are identified in this cost analysis as productivity loss and consist of the accumulated duration of the delays and inefficiencies observed during the demonstration.

Additional details of the basis of the cost analysis are described in Appendix B.

Costs to Purchase, Rent, or Procure Vendor Provided Services

The analyzer equipment is available from the vendor with optional components. The purchase prices of the basic equipment and optional features used in the demonstration are shown in Table 3. Rental of the equipment is not considered.

Table 3. Niton 700 Series Multi-element Analyzer acquisition costs.

Acquisition Option	Item Description	Cost
Equipment purchase	Niton 700 Series Multi-element Analyzer	$25,000
Equipment rental	Rental – 3 months (per month rate)	14% of purchase
	Rental – 6 months (per month rate)	10% of purchase
	Rental – 1 year (per month rate)	6.5% of purchase
Equipment leasing*	Leasing – 2 years (per month rate)	4.5% of purchase
	Leasing – 3 years (per month rate)	3.15% of purchase
	Leasing – 4 years (per month rate)	2.5% of purchase
	Leasing – 5 years (per month rate)	2.1% of purchase
Vendor provided service		Not available

* The lease payments apply toward ownership of the equipment. The leaseholder receives title to the equipment at the end of the leasing period.

Operation of the analyzer will require periodic factory calibration. This calibration cost is not included in the purchase, rental, or leasing rates shown in Table 1. The calibration is required every 24 months at a cost of approximately $2,600.

Unit Costs

Figure 12 shows the unit cost of $54.18 per sample for the analyzer and Figure 13 shows the unit cost of $1,533 per sample for the baseline technologies. The unit costs are based on the costs summarized in Tables B-2 and B-3 in Appendix B and include amortization of the equipment purchase and productivity loss. The figures also show a relative contribution to the total for each of the work activities. Activities that occur once per job or once per day have been divided by 14 (the number of samples used in this cost analysis) to determine an average unit cost for that activity. The relative contribution to the unit cost of the once per job type of activities will be smaller than shown here for jobs having more than 14 samples and will have a larger percentage for jobs having fewer than 14 samples. Additionally, the site-specific conditions that can significantly affect the cost of the activity are identified in Figures 12 and 13 under the title “Site Specific Conditions.” This section describes the conditions encountered for this demonstration. The percentage information and the condition information provide some indication of the variation in unit cost that may occur at other sites. The activities that are 1% to 5% of the total cost have little affect on the total cost, even if these activities have the potential for large variation. But, a moderate variation in cost of those activities that are 15% or more of the total unit cost will have a significant impact on the total cost. For example, a change in sample analysis unit cost from $1,034 to $300 (due to different analysis requirements) would decrease the total cost by approximately 53% for the baseline technology.

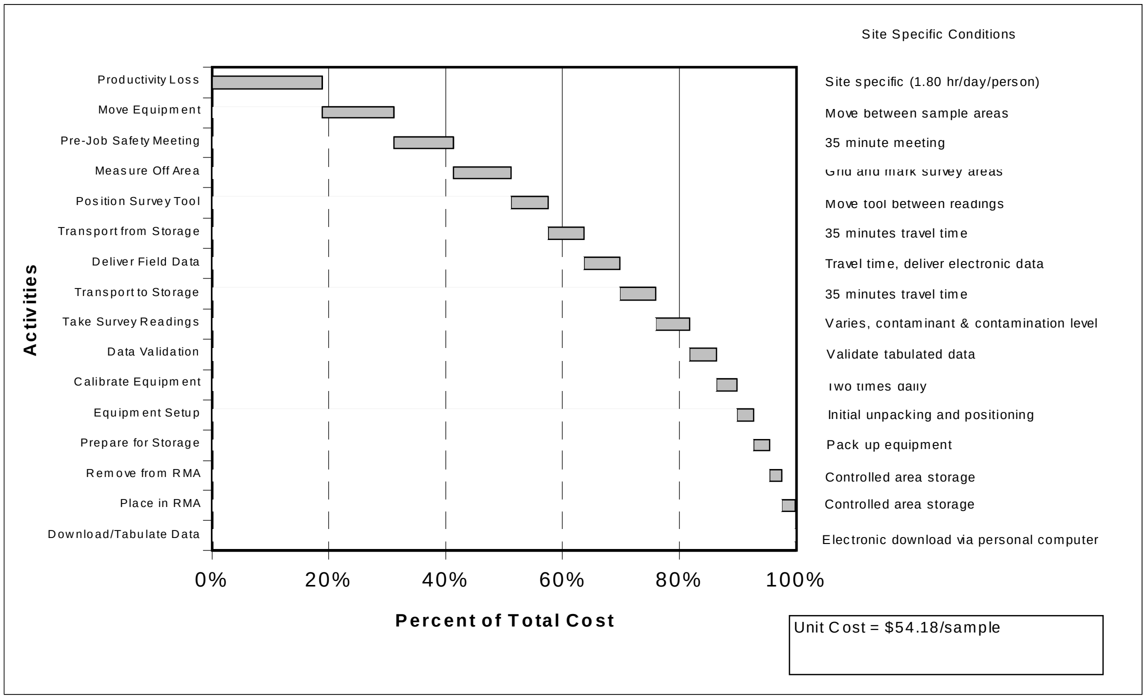


Figure 12. Breakdown of Niton 700 Series Multi-element Analyzer unit cost.

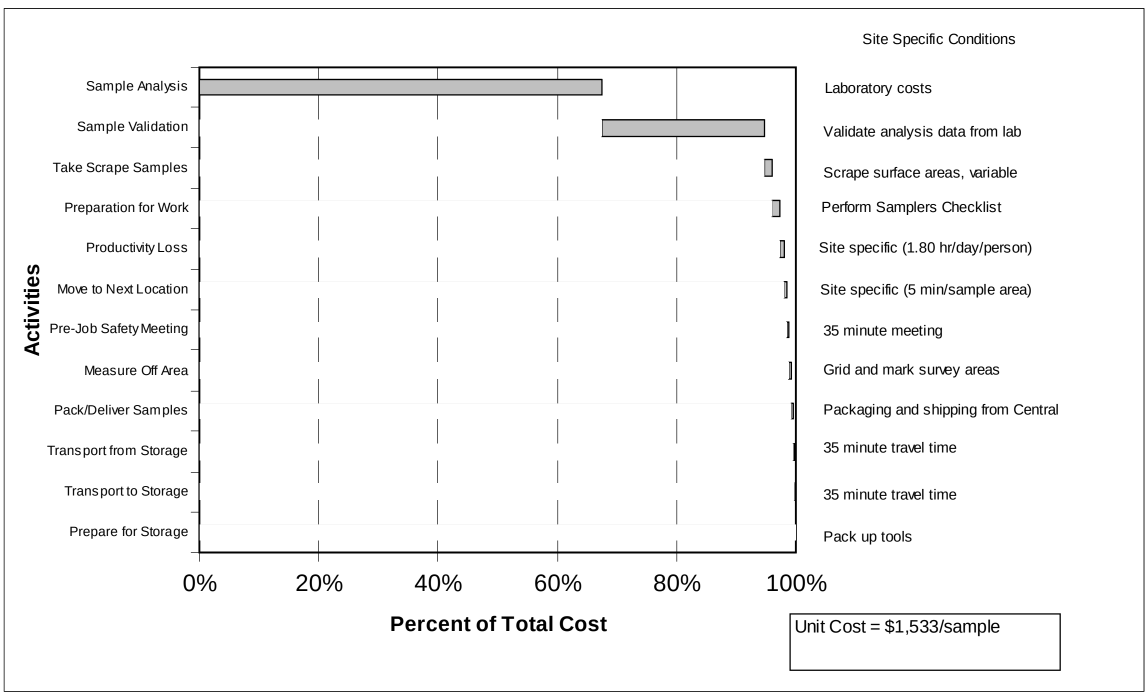


Figure 13. Breakdown of baseline technology unit cost.

Payback Period

For this demonstration, the innovative technology saves approximately $20,708 per job over the baseline for a job size of 14 sample areas or approximately $1,479 per sample (amount will vary depending on site-specific conditions). At this rate of savings, the purchase cost is recovered after approximately 17 samples.

Observed Costs for Demonstration

Figure 13 summarizes the costs observed for the analyzer and baseline technologies for 14 sample areas. The details of these costs are shown in Appendix B and include Tables B-2 and B-3, which can be used to compute site-specific costs by adjusting for different labor rates, crew makeup, laboratory costs, etc.

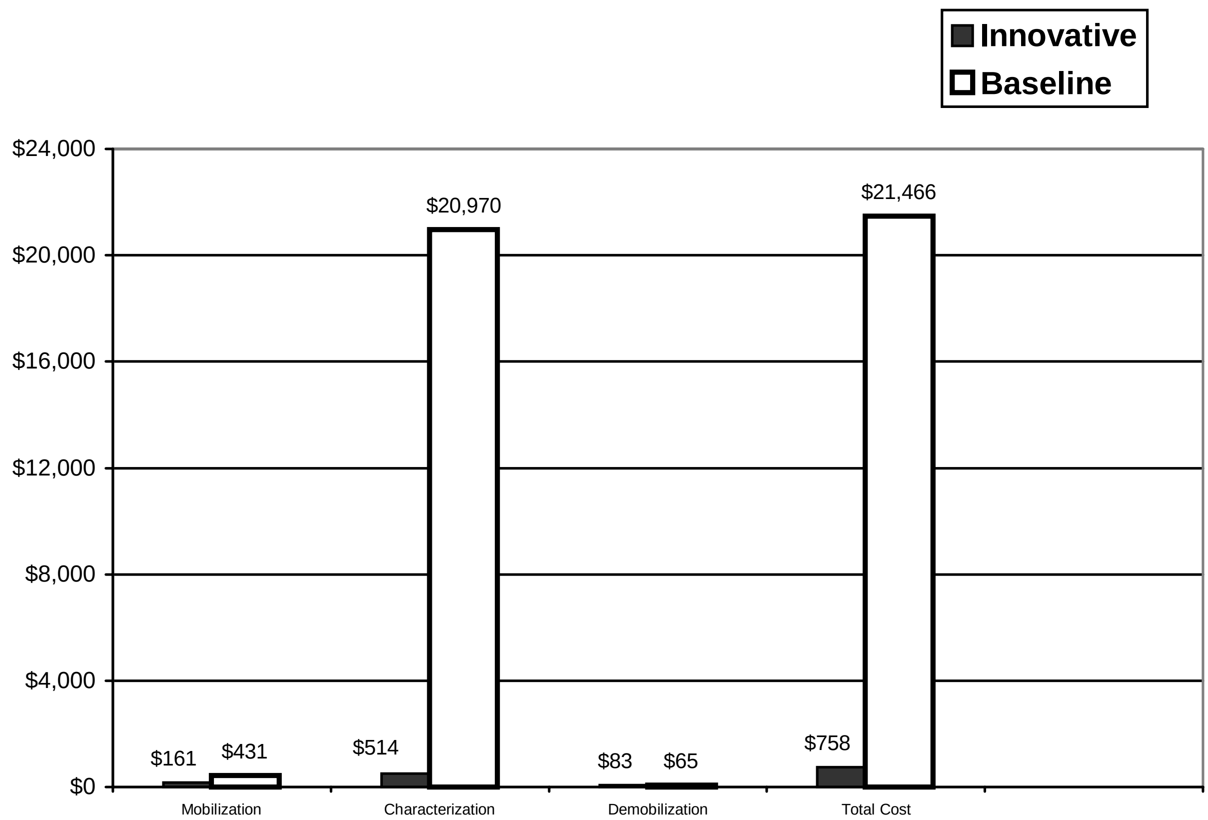


Figure 14. Summary of Technology Costs.

Cost Conclusions

The analyzer is approximately 4% of the cost of the baseline technology for this demonstration.

The single most significant difference for this demonstration is the laboratory analysis cost. The scenario used in this demonstration would be typical for field characterization work. Different types of analyses such as field screening or confirmatory sampling may be associated with other situations. Job-specific criteria should be considered when pricing this activity, if required for the type of analysis prescribed. Use of the Niton 700 Series Multi-element Analyzer eliminated the need for laboratory analysis in this demonstration.

Differences exist in the labor categories at INEEL used for the demonstration. The baseline requires engineering technicians at a rate of $38.67 while the analyzer uses industrial hygienists at $34.32. This may not be representative of other DOE sites.

The production rates for the analyzer and the baseline technologies are significantly different, with the analyzer being more efficient in this demonstration. The observed duration for sampling in each area was used to calculate a production rate per area. The analyzer measured an average of 4.9 sample areas per hour while the baseline measured an average of 2.8 sample areas per hour. These production rates were broken down to lower level activities (such as Position Survey Tool, Take Survey Readings, etc.) based on some of the field observations and the judgement of the test engineer. Complete records of duration for the subactivities were not available for direct computation of production rates at the subactivity level. The difference in production rates reflects inherent differences in the technologies. The analyzer requires using a hand-held device (the Niton 700 Series Multi-element Analyzer) over the sample area and taking electronic readings. In this demonstration, sampling of survey areas ranged from 9 to 19 minutes for the analyzer. The range or variability reflects differences in the number of readings taken per area, the elements being analyzed, and the level of contamination. For example, analyzing for chromium takes longer. Also, lower levels of contamination require more time to achieve a confident reading. The number of readings per area ranged from 2 to 5 during this demonstration.

Conversely, the baseline technology requires manual scraping of the sample area and collecting the droppings. In this demonstration, sampling of survey areas ranged from 11 to 54 minutes for the baseline technology. The wider range or variability in the baseline technology reflects the uncertainty in surface area condition. Certain areas can be labor intensive.

Moving equipment between sample areas will vary depending on distance. In this demonstration, the average distance between sample areas was 30 yards. The Daily Field Log did not specifically account for this activity. But, based on the log information and discussions with the test engineer, an average time of 5 minutes was used to move between sample areas. This activity is included in the measurement of production rates. However, in the baseline estimate, it is not listed as a separate activity from taking scrape samples. Job-specific criteria (distance between sample areas) should be incorporated for determining duration of moving equipment between sample areas.

Mobilization and demobilization costs will depend upon the distance that the equipment must be moved between the storage area and the work area. In this cost analysis, both the analyzer equipment and the baseline technology equipment were assumed to be stored in areas away from the job site, thus requiring travel time.

Field-screening methods used at other DOE sites may vary from the baseline technology assumed in this cost analysis. This baseline cost analysis included costs for procedures that ensure accurate records (sampling plans, sample labels, field journals, laboratory data packages, etc.), control of the samples (chain of custody, shipping manifests, etc.), and a high degree of certainty of the quality of the analysis (laboratory's quality assurance program for precision, accuracy, and repeatability, and validation of the sample data packages). Other baseline methods for field screening may not include these procedures and their costs would compare differently to the analyzer. For example, one of the commonly used field test kits, such as LeadCheck™, requires less than 30 minutes to perform a field analysis of a sample and the kit costs less than $10 per sample. A field-screening method that uses this test kit would be much closer to the analyzer's cost than the Contact Laboratory Program laboratory analysis costs used in this analysis.

SECTION 6

REGULATORY AND POLICY ISSUES

Regulatory Considerations

The Niton 700 Series Multi-element Analyzer meets the Department of Transportation requirements for *49 CFR 173.421* excepted packages for limited quantities of Class 7 (radioactive) materials. The analyzers are approved for field testing lead-based paint and paint chips at the INEEL's CFA, TRA, and INTEC. A test plan and a safe work permit covered their use under the INEEL LSDDP.

Safety, Risks, Benefits, and Community Reaction

The safety issue associated with the use of the Niton 700 Series Multi-element Analyzer is primarily radiation hazards. The risks are mitigated by use of proper monitoring, storage, transport, and training. The risks associated with the use of the Niton 700 Series Multi-element Analyzer are routinely acceptable to the public.

SECTION 7

LESSONS LEARNED

Implementation Considerations

The Niton 700 Series Multi-element Analyzer is a mature technology that performed well during the INEEL LSDDP demonstration. The analyzer required no special skills to use, and the workers found the analyzer to be much easier than the baseline technology. Items that should be considered before implementing the Niton 700 Series Multi-element Analyzer include:

- The Niton 700 Series Multi-element Analyzer needs to be returned to the manufacturer (Niton Corporation) every 4 years for routine maintenance to have the Cadmium-109 source replaced and software upgraded.
- The INEEL's Radioactive Source Coordinator and Radiological Safety Engineers requires the Niton 700 Series Multi-element Analyzer (which contains two radioactive sources inside the instrument) to be controlled and accounted for at all times.
- In some instances it may be necessary to supplement the Niton analysis with confirmatory laboratory analysis.

Technology Limitations and Needs for Future Development

The Niton 700 Series Multi-element Analyzer performed well during this demonstration. There were no significant technology limitations. This technology is currently not approved by the regulators as an alternative to laboratory analysis. Until approved by the regulators as an alternative to laboratory analysis, the potential benefit of this technology will be limited to screening activities that will in some cases require confirmatory sample analysis.

Technology Selection Considerations

Based on the INEEL LSDDP demonstration, the Niton 700 Series Multi-element Analyzer is a better choice than the baseline technology for most lead-based paint and field testing activities. The analyzer is easier to use and more cost effective. The analyzer can provide the field data to support making immediate decisions on the appropriate approach to remediate an area of a facility.

APPENDIX A

REFERENCES

Fred E. Stoll, April 1987, Idaho National Engineering and Environmental Laboratory Document EGG-2468, *Final Report of the Decontamination and Decommissioning of the Initial Engine Test Facility and the IET Two-Inch Hot-Waste Line*.

APPENDIX B

COST COMPARISON DETAILS

Basis of Estimated Cost

The activity titles shown in this cost analysis come from observation of the work. In the estimate, the activities are grouped under higher level work titles per the work breakdown structure shown in the *Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary* (HTRW RA WBS) (U.S. Army Corps of Engineers 1996). The HTRW RA WBS, developed by an interagency group, is used in this analysis to provide consistency with the established national standards. The costs shown in this analysis are computed from observed duration and hourly rates for the crew and equipment. The following assumptions were used in computing the hourly rates:

- The analyzer and the baseline equipment are assumed to be owned by the government.
- The equipment rates for government ownership are computed by amortizing the purchase price of the equipment, plus a procurement cost of 5.2% of the purchase price, and the annual calibration costs.
- The equipment hourly rates assume a service life of 10 years for the analyzer equipment. A 1-year service life is assumed for the baseline's miscellaneous small tools allowance. An annual usage of 500 hours per year is assumed for both the analyzer and baseline equipment.
- The equipment hourly rates for the government's ownership are based on general guidance contained in Office of Management and Budget (OMB) Circular No. A-94, *Cost Effectiveness Analysis*.
- The standard labor rates established by the INEEL are used in this estimate and include salary, fringe, departmental overhead, material handling markups, and facility service center markups.
- The equipment rates and the labor rates do not include the Lockheed Martin general and administrative (G&A) markups. The G&A are omitted from this analysis to facilitate understanding and comparison with costs for the individual site. The G&A rates for each DOE site vary in magnitude and in the way they are applied. Decision makers seeking site-specific costs can apply their site's rates to this analysis without having to first back-out the rates used at the INEEL.

The analysis does not include costs for oversight engineering, quality assurance, administrative costs for the demonstration, or work plan preparation costs and assumes a 10-hour workday.

Activity Descriptions

The scope, computation of production rates, and assumptions (if any) for each work activity is described in this section.

Mobilization (WBS 331.01)

Remove from RMA—The Niton 700 Series Multi-element Analyzer will be stored in a RMA, because of containment of radioactive source. Because the RMA is a controlled and secured area, it takes time to remove it. The estimated time is based on the judgement of the test engineer.

Transport from Storage—The baseline equipment will be stored in a sample equipment/supplies storage area. The time required to transport the equipment to the work area is based on the judgement of the test engineer. The transport for the analyzer equipment is assumed to be the same as for the baseline. The baseline equipment includes miscellaneous small tools such as a metal basin, wall scrapers, heat gun, tape measure, and a pedestal. The analyzer equipment includes only the analyzer (small tools are negligible).

Pre-Job Safety Meeting—The duration for the pre-job safety meeting is based on the judgement and experience of the test engineer. The labor costs for this activity are based upon an assumed crew rather than the actual demonstration participants. All subsequent activities are also based on the assumed crews. The crew members reflect anticipation of actual field performance for the INEEL site.

Equipment Setup—This activity consists of unpacking the equipment and assembling the components for the analyzer. The duration is based on the observed time for the demonstration.

Preparation for Work—The baseline activity accounts for performing the "Sampling Checklist" at the supply shop prior to traveling to the job site. It includes chain-of-custody requirements, paper work, label preparation, tool organization, etc. The duration is based on the judgement and experience of the test engineer.

Characterization (WBS 331.17)

Move Equipment—This activity accounts for moving the Niton 700 Series Multi-element Analyzer between sample areas. In the demonstration, the average distance between sample areas was 30 yards. The Daily Field Log did not specifically account for this activity. But based on the log information and discussions with the test engineer, an average time of 5 minutes was used to move between sample areas. Job-specific criteria (distance between sample areas) should be incorporated for determining duration of this activity.

Measure Off Area—This activity is relevant to both the analyzer and baseline technologies. It accounts for grid and marking the precise area to be sampled. For this demonstration, sampled areas were marked in 2- x 2-ft squares for walls and otherwise for handrails and other situations. The production rate of 15 per hour was based on information in the Daily Field Log as confirmed by the test engineer.

Position Survey Tool—This activity accounts for repositioning the Niton 700 Series Multi-element Analyzer between each reading, within the specific sample area. In this demonstration, an average of 3.5 readings was taken in each sample area. The range of values was from 2 to 5 readings per area. The Daily Field Log did not specifically account for this activity. In the judgement of the test engineer, repositioning the equipment accounts for approximately 3 minutes per four readings, or 45 seconds per positioning of the survey tool.

Take Survey Readings—Based on the Daily Field Log information, survey readings with the hand-held Niton 700 Series Multi-element Analyzer range from 20 to 120 seconds duration. This duration variability depends on the contaminant being analyzed and the level of contamination. For example, analyzing for chromium takes longer. Also, lower levels of contamination require more time to achieve a confident reading. In actual field use, reading duration should be conservatively estimated and practiced to achieve a high level of confidence for the data recorded, as was the case in this demonstration. Based on the Daily Field Log and judgement of the test engineer, an average of 40 seconds per reading was used for this demonstration estimate. Job-specific criteria should be incorporated for determining duration of this activity.

Take Scrape Samples—This activity accounts for the labor and material costs involved in scraping surface areas to collect sample substance. It includes moving the scrape sampling tools between sample areas. Material costs are for sample jars at $36.00 per dozen. The Daily Field Log included acquiring five samples ranging in duration from 11 to 22 minutes and a sixth sample at 54 minutes. The test engineer indicated that the 54-minute data point should *not* be eliminated from the average. The point is representative of difficulties often encountered in manual sample collection and thus should be considered a recurring event. To account for the activity "Measure Off Area," 24 minutes was deducted from the total before calculating the average production rate of 3.24 sample areas per hour.

Calibrate Equipment—This activity accounts for calibrating adjustments being made to the Niton 700 Series Multi-element Analyzer. The test engineer indicated that typically the equipment is calibrated twice daily, once in the morning and once after lunch. The duration of 10 minutes per calibration is based on the Daily Field Log information.

Deliver Field Data—Although a personal computer was used in the field in conjunction with the Niton 700 Series Multi-element Analyzer during this demonstration, the test engineer stated that it typically would not be used; rather the crew will deliver the collected data back to an office. Subsequently, the information will be electronically downloaded and tabulated for review. This activity accounts for delivery of that data. The duration equal to transporting equipment to the storage area was assumed at 35 minutes.

Pack/Deliver Samples—This activity applies to the baseline technology. It includes delivering the manually collected samples to a central shop, packaging the samples, and shipping. The shipping cost for the samples is $13.17. The time required to travel to the central shop and package the samples is based on the Daily Field Log.

Download/Tabulate Data—This activity accounts for one industrial hygienist to electronically download the data collected in the field from the Niton 700 Series Multi-element Analyzer. The data will be downloaded to a database format and tabulated. The duration used in the cost analysis is based on the observed duration from the demonstration.

Data Validation—The task duration for the innovative is based on the judgement and experience of the test engineer. The baseline is based on information provided by the sample management staff at the INEEL. The baseline cost assumes a Level B validation that consists of $220 per sample cost for subcontractor validation and 4 hours per sample of quality assurance review by in-house reviewers.

Sample Analysis—Laboratory costs apply only to the baseline technology. The type of analysis performed for this demonstration was a Contact Laboratory Program List of Metals. This would be typical for a field characterization scenario. Different types of analyses may be associated with other scenarios, such as field screening or confirmatory sampling. Job-specific criteria should be considered when pricing this activity.

Sample Validation—Once the laboratory analysis comes back from the laboratory for the baseline technology, the data requires validation. The Sample Management Office at the INEEL performs validation. The duration of one chemist full time for 10 days is based on information received by the test engineer from that office. The duration is a typical requirement for sample validation of organic contaminants.

Demobilization (WBS 331.21)

Prepare for Storage—This activity includes breaking down the equipment, cleaning as needed, and stowing it in the equipment cases. The duration is based on the test engineer's judgement.

Transport to Storage—Similar "Transport from Storage."

Place in RMA—Similar to "Remove from RMA."

Cost Estimate Details

The cost analysis details are summarized in Tables B-2 and B-3. The tables break out each member of the crew, each labor rate, each piece of equipment used, each equipment rate, each activity duration, and all production rates so that site-specific differences in these items can be identified and a site-specific cost estimate may be developed.

Table B-2. Niton 700 Series Multi-element Analyzer cost summary.

Work Breakdown Structure	Unit	Unit Cost $/unit	Quan-tity	Total Cost	Computation of Unit Cost: Pro-duction Rate	Duration (hr)	Labor Item	$/hr	Equipment Items	$/hr	Other $	Comments
Facility Deactivation, Decommissioning, & Dismantlement								**TOTAL COST FOR DEMONSTRATION =**				**$ 758.45**
Mobilization (WBS 331.01)										Subtotal =		$ 161.13
Remove from RMA	ea	16.62	1	$ 16.62		0.208	2IH	68.64	MEA on standby	11.24		Controlled area
Transport from Storage	ea	46.57	1	$ 46.57		0.583	2IH	68.64	MEA on standby	11.24		Travel Time
Pre-Job Safety Meeting	ea	76.61	1	$ 76.61		0.583	2IH + 1JS	120.17	MEA on standby	11.24		
Equipment Setup	ea	21.33	1	$ 21.33		0.267	2IH	68.64	MEA	11.24		
Characterization (WBS 331.17)										Subtotal =		$ 514.17
Move Equipment	ea	6.63	14	$ 92.82		0.083	2IH	68.64	MEA on standby	11.24		
Measure Off Area	ea	5.33	14	$ 74.55	15		2IH	68.64	MEA on standby	11.24		Grid and Mark
Position Survey Tool	ea	1.00	49	$ 48.93	80		2IH	68.64	MEA	11.24		
Take Survey Readings	ea	0.89	49	$ 43.71	89.55		2IH	68.64	MEA	11.24		Variable, see details
Calibrate Equipment	ea	13.31	2.00	$ 26.63	6		2IH	68.64	MEA	11.24		Morning and after lunch
Deliver Field Data	ea	46.57	1.00	$ 46.57		0.583	2IH	68.64	MEA on standby	11.24		
Download/Tabulate Data	ea	2.86	1	$ 2.86		0.083	1IH	34.32				
Data Validation	ea	34.32	1.00	$ 34.32		1	1IH	34.32				
Productivity Loss	man day	143.78	1.00	$ 143.78		1.800	2IH	68.64	MEA on standby	11.24		Assume 10 hour man day
Demobilization (WBS 331.21)										Subtotal =		$ 83.16
Prepare for Storage	ea	19.97	1	$ 19.97		0.250	2IH	68.64	MEA on standby	11.24		
Transport to Storage	ea	46.57	1	$ 46.57		0.583	2IH	68.64	MEA on standby	11.24		
Place in RMA	ea	16.62	1	$ 16.62		0.208	2IH	68.64	MEA on standby	11.24		
Disposal (WBS 331.18)										Subtotal =		$ -

Labor and Equipment Rates used to Compute Unit Cost

Crew Item	Rate $/hr	Abbrev-eation	Crew Item	Rate $/hr	Abbreveation	Equipment Item	Rate $/hr	Abbrev-eation	Equipment Item	Rate $/hr	Abbrev-eation
Job Supervisor	51.53	JS				Multi-Element Analyzer	11.24	MEA			
Industrial Hygienist	34.32	IH									

Notes:

1. Unit cost = (labor + equipment rate) × duration + other costs, or = (labor + equipment rate)/production rate + other costs.
2. Abbreviations for units: ea = each, hr = hour.
3. Other abbreviations not identified: RMA = Radioactive Material Area, WBS = Work Breakdown Structure, JS = Job Supervisor, and IH = Industrial Hygienist.

Table B-3. Baseline Technology Cost Summary

Work Breakdown Structure	Unit	Unit Cost $/unit	Quan-tity	Total Cost	Computation of Unit Cost: Pro-duction Rate	Duration (hr)	Labor Item	$/hr	Equipment Items	$/hr	Other $	Comments
Facility Deactivation, Decommissioning, & Dismantlement							**TOTAL COST FOR DEMONSTRATION =**				**$**	**21,465.63**
Mobilization (WBS 331.01)										Subtotal =	$	431.29
Preparation for Work	ea	310.68	1	$ 310.68		4	2ET	77.34	ST on standby	0.33		
Transport from Storage	ea	45.28	1	$ 45.28		0.583	2ET	77.34	ST on standby	0.33		Travel Time
Pre-Job Safety Meeting	ea	75.32	1	$ 75.32		0.583	2ET + 1JS	128.87	ST on standby	0.33		
Characterization (WBS 331.17)										Subtotal =	$	20,969.64
Move to Next Location	ea	6.4725	14	$ 90.62		0.0833	2ET	77.34	ST	0.33		5 min
Measure Off Area	ea	5.18	14	$ 72.49	15		2ET	77.34	ST	0.33		Grid and Mark
Take Scrape Samples	ea	20.49	14	$ 286.91	4.44		2ET	77.34	ST	0.33	3.00	Sample Jars @ $36/dozen
Pack/Deliver Samples	ea	71.42	1	$ 71.42		0.750	2ET	77.34	ST	0.33	13.17	Includes shipping cost
Sample Analysis	ea	1,034.00	14	$ 14,476.00							1,034.00	Laboratory costs
Sample Validation	ea	416.60	14	$ 5,832.40		4	1CH	49.15			220.00	$220 & 4 hrs QC review
Productivity Loss	man day	139.81	1.00	$ 139.81		1.800	2ET	77.34	ST	0.33		Assume 10 hour man day
Demobilization (WBS 331.21)										Subtotal =	$	64.70
Prepare for Storage	ea	19.42	1	$ 19.42		0.250	2ET	77.34	ST on standby	0.33		
Transport to Storage	ea	45.28	1	$ 45.28		0.583	2ET	77.34	ST on standby	0.33		
Disposal (WBS 331.18)										Subtotal =	$	-

Labor and Equipment Rates used to Compute Unit Cost

Crew Item	Rate $/hr	Abbrev-eation	Crew Item	Rate $/hr	Abbreveation	Equipment Item	Rate $/hr	Abbrev-eation	Equipment Item	Rate $/hr	Abbrev-eation
Job Supervisor	51.53	JS				Small Tools	0.33	ST			
Engineering Technician	38.67	ET									
Chemist	49.15	CH									

Notes:

1. Unit cost = (labor + equipment rate) duration + other costs, or = (labor + equipment rate)/production rate + other costs.
2. Abbreviations for units: ea = each, hr = hour.
3. Other abbreviations not identified: WBS = Work Breakdown Structure.

APPENDIX C

ACRONYMS AND ABBREVIATIONS

CFA	Central Facilities Area
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
D&D	Decontamination and Decommissioning
DDFA	Deactivation and Decommissioning Focus Area
G&A	General and Administrative
HTRW RA WBS	Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure
IET	Initial Engine Test
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LPA	Lead Paint Analyzer
LSDDP	Large-Scale Demonstration and Deployment Project
OMB	Office of Management and Budget
OST	Office of Science and Technology
PPE	Personal Protective Equipment
RCRA	Resource Conservation and Recovery Act
RMA	Radioactive Material Area
RMD	Radiation Monitoring Devices, Inc.
TRA	Test Reactor Area
XRF	X-ray Fluorescence