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QUALITY ASSURANCE PROJECT PLAN FOR SELECTING SITES FOR CHARACTERIZATION OF DUST LEAD LEVELS AFTER RENOVATION, REPAIR, AND PAINTING ACTIVITIES

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Quality Assurance Project Plan for Selecting Sites for Characterization of Dust Lead Levels After Renovation, Repair, and Painting Activities

Version #5

July 17, 2006

Approval for Battelle:

Principal Investigator — Date
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Project Manager — Date
Bruce Buxton

Field Operations Coordinator — Date
Ian MacGregor

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EPA WAM — Date
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EPA Deputy WAM — Date
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Approval for Healthy Housing Solutions:

Field Sampling Coordinator — Date
Jackson Anderson

TABLE OF CONTENTS

Page

Page

LIST OF TABLES

LIST OF FIGURES

1.0 PROJECT MANAGEMENT

1.1 DISTRIBUTION LIST

Individuals who will receive copies of the approved Quality Assurance Project Plan (QAPP) and any subsequent revisions are listed in Table 1-1. Each individual's role on the project and the organization to which he/she belongs are also provided.

Table 1-1. Distribution List for QAPP

Individual	Organization	Project Responsibility/Role
Sineta Wooten	U.S. EPA / OPPT	EPA Project Officer
Barbara Leczynski	U.S. EPA / OPPT	EPA/OPPT QA Manager
John Schwemberger	U.S. EPA / OPPT	Work Assignment Manager (WAM)
Samuel Brown	U.S. EPA / OPPT	Deputy WAM
Bruce Buxton	Battelle	Project Manager
Zachary Willenberg	Battelle	QA Manager
Tim Pivetz	Battelle	Principal Investigator
Warren Strauss	Battelle	Technical Advisor
Ian MacGregor	Battelle	Field Operations Coordinator
Jack Anderson	Healthy Housing Solutions	Field Operations Coordinator - Baltimore
Darrell Joseph	Battelle	Field Operations Coordinator - Pittsburgh
Adam Abbgy	Battelle	Laboratory Manager

1.2 PROJECT/TASK ORGANIZATION

Tim Pivetz will have overall responsibility for this study. Mr. Pivetz will be assisted on this project by Mr. Warren Strauss, who will provide overall technical guidance and specific guidance on study design and data analysis; Mr. Zachary Willenberg, who will serve as the Battelle Quality Assurance (QA) Manager; and Dr. Bruce Buxton, who will provide technical guidance and management oversight. Ian MacGregor of Battelle will serve as Field Operations Coordinator, supporting all field operations and leading field technicians in Columbus. Mr. Jack Anderson of Healthy Housing Solutions will coordinate field operations in Baltimore, Maryland under subcontract to Battelle. The field operations coordinator for experiments performed in Pittsburgh, Pennsylvania is Darrell Joseph from Battelle. Also supporting field operations will be environmental assessment firms hired via subcontract that will conduct X-ray fluorescence inspections. These firms will either report directly to Battelle or to the appropriate organization

coordinating field operations in that location, e.g. Healthy Housing Solutions.. Adam Abbgy of Battelle will serve as the Laboratory Manager for any analysis of paint chip samples, until an external laboratory is hired. John Schwemberger of EPA is the Work Assignment Manager (WAM). Sam Brown of EPA is the Deputy WAM. Sineta Wooten of EPA is the Project Officer. Barbara Leczynski is the EPA QA Manager. Figure 1-1 displays the organizational relationship between these individuals.

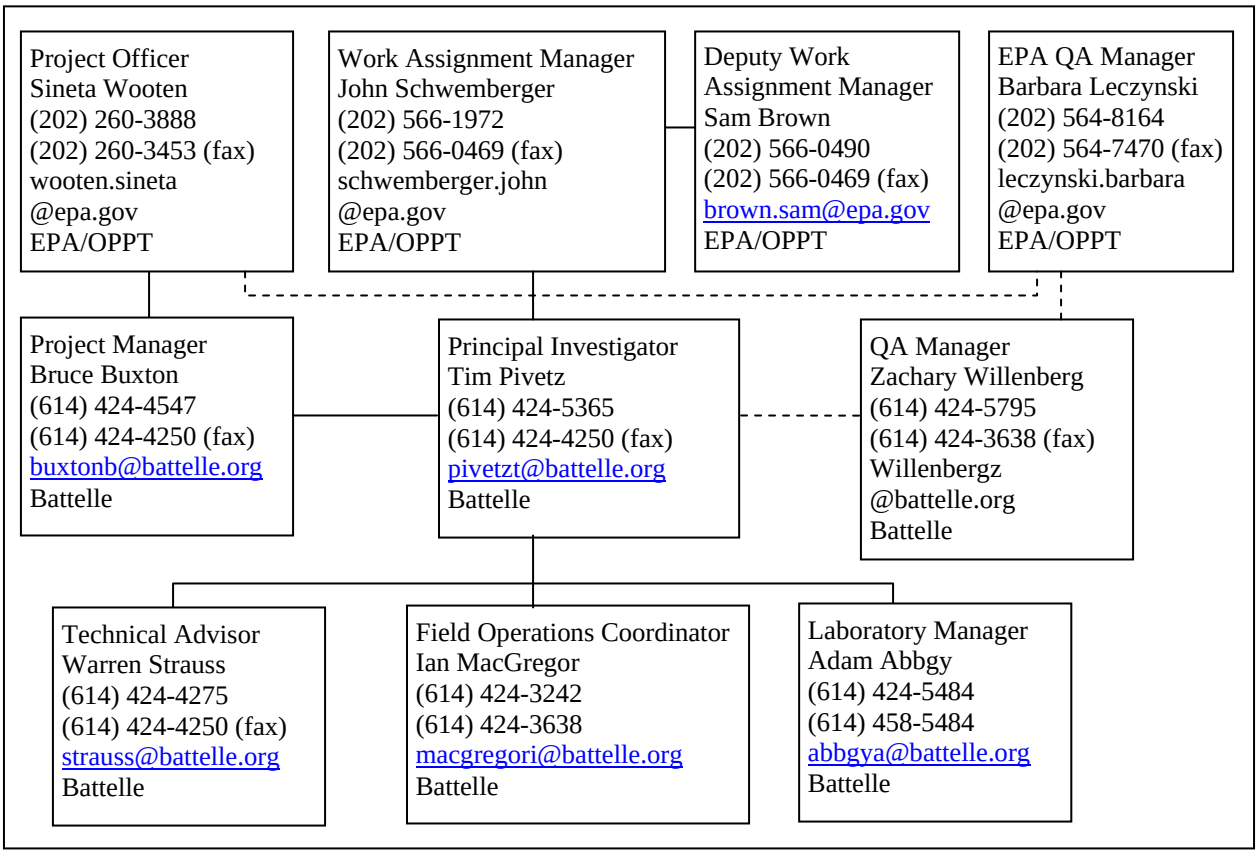


Figure 1-1. Organizational Structure

1.3 PROBLEM DEFINITION/BACKGROUND

EPA's proposed rule for Renovation, Repair, and Painting (RRP) of pre-1978 housing units with lead based paint was published in the Federal Register on January 10, 2006. The summary of the proposed rule included in the Federal Register stated, "EPA is proposing new requirements to reduce exposure to lead hazards created by renovation, repair, and painting activities that disturb lead-based paint. This action supports the attainment of the Federal government's goal of eliminating childhood lead poisoning by 2010. The proposal would establish requirements for training renovators and dust sampling technicians; certifying

renovators, dust sampling technicians, and renovation firms; accrediting providers of renovation and dust sampling technician training; and for renovation work practices. These requirements would apply in ''target housing,'' defined in section 401 of the Toxic Substances Control Act (TSCA) as any housing constructed before 1978, except housing for the elderly or persons with disabilities (unless any child under age 6 resides or is expected to reside in such housing) or any 0-bedroom dwelling. Initially the rule would apply to all renovations for compensation performed in target housing where a child with an increased blood lead level resides, rental target housing built before 1960 and owner-occupied target housing built before 1960, unless, with respect to owner-occupied target housing, the person performing the renovation obtains a statement signed by the owner-occupant that the renovation will occur in the owner's residence and that no child under age 6 resides there. EPA is proposing to phase in the applicability of this proposal to all rental target housing and owner-occupied target housing built in the years 1960 through 1977 where a child under age 6 resides. This proposal is issued under the authority of TSCA section 402(c)(3). EPA is also proposing to allow interested States, Territories, and Indian Tribes the opportunity to apply for and receive authorization to administer and enforce all of the elements of the new renovation provisions."

In order to adequately complete a risk assessment and a cost-benefit analysis of the proposed rule, a characterization of dust lead levels during appropriate stages of RRP activities via a small scale field study will be conducted. The first phase of this project requires identifying and screening of possible sites where the study could be conducted. Sites targeted for inclusion in the study are target housing and child occupied facilities (COF) such as daycare centers or early year kindergartens.

1.4 PROJECT/TASK DESCRIPTION

This project will be conducted to characterize the dust lead levels after Low, Medium, and High renovation, repair, or painting jobs in housing units with lead-based paint. Both interior and exterior jobs will be considered. Interior jobs will be defined as taking place in a primary "work" room in the house. EPA has indicated a preference for homes with three adjacent rooms on a single level so that an additional room may be used for tool storage and a third, unused, room may help characterize the spread of lead dust. Exterior jobs will consist as taking place on a single side of the building, and will require sufficient space in the yard to lay down plastic in accordance with the rule.

The targeted amount of work to be evaluated is 15 interior jobs (12 housing units and 3 COFs) and 15 exterior jobs (12 at housing units and 3 at COFs), although those 15 exterior jobs could be completed at 3 housing units and 1 COF if multiple sides of a building are available. The study will assign each unit or building a high, medium, or low RRP activity in such a way that there are four sets of high, medium, and low activities among the 12 housing units and one set of high, medium, and low for the three COFs. It is possible that a housing unit or building may be able to serve as both an interior and exterior site, as long as the areas to undergo work

will not lead to cross-contamination. Table 1-2 lists the interior and exterior RRP jobs that will be conducted at each of the three levels. High dust-generating work practices prohibited for lead abatement work as per 40 CFR 745.227(e)(6) will be included in the study as they are permitted by the proposed rule. Substitutions to the table may be considered based on the outcome of the initial paint testing.

Table 1-2. Targeted RRP Jobs at Three Levels of RRP Work

Low Level Work	Medium Level Work	High Level Work
INTERIOR JOBS		
• Make three cut-outs, each of a 2 foot+ section of wall with lead-based paint, to perform plumbing or electrical or HVAC work, perform the work inside the wall, and repair and repaint wall sections cut open, disturbing approximately 6 ft^2 of lead-based paint. (Possible Substitute: install recessed lighting in ceiling, disturbing approximately 6 ft^2 of lead-based paint.) • Replace a window from inside the unit, disturbing at least 2 ft^2 of lead-based paint.	• Scrape or plane an interior door to remove paint from 20-40 ft^2 and repaint. • Scrape deteriorating lead-based paint from a flat interior component, scraping 50-75 ft^2 of painted surfaces, and repaint the surfaces which were scraped.	• Remove paint from 75-100 ft^2 of lead-based painted components (trim, window systems, door systems) in a room by using a heat gun at or over 1100 degrees Fahrenheit held at one inch or the distance specified in the instructions from paint, and repaint all components from which paint was removed • Gut out a kitchen, disturbing 100 ft^2 or more of lead-based paint. (Possible substitute: Gut out a bathroom, disturbing 100 ft^2 or more of lead-based paint.)
EXTERIOR JOBS		
• Replace an exterior door and doorway, disturbing 25-50 ft^2 of lead-based paint. • Replace fascia boards, soffits, and other exterior trim on one side of the structure, disturbing approximately 50 ft^2 of lead-based paint.	• Replace siding with lead-based paint on one exterior side of the structure with vinyl (complete replacement of the existing siding, not just nailing over the existing siding), disturbing at least 100 ft^2 of lead-based paint. • Remove lead-based paint from exterior components by dry scraping, disturbing approximately 100 ft^2 of lead-based paint, and repainting areas from which paint was removed.	• Remove paint by power sanding or grinding on at least 100 ft^2 of lead-based paint on exterior wood components on one side of the structure, and repaint components from which paint was removed. • ~~Abrasive-blast or sandblast, without a HEPA exhaust control,~~ lead-based paint on ~~least~~ 75 100 ft^2 of lead-based paint from brick, concrete, stone, ~~or~~ metal on one side of the structure, and repaint areas from which paint was removed.

REMOVE by torching or OPEN FLAME burning

The project considered in this plan is the screening and enrollment of prospective sites into the study. The following questions summarize the characteristics required for inclusion of potential sites in this study:

- Was the prospective site built before 1978?
- Will RRP activities and cleanup be feasible at the prospective site within the timeframe of the study?

- Is lead based paint present in a potential work area of the prospective site?
- Are all required characteristics met?

Current plans require field work to begin in July 2006 and be completed by October 2006 so that the final report can be completed by December 2006.

1.5 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

Potential sites will be required to answer the following three study questions listed in Section 1.4 in order to be included in this study.

1.5.1 STUDY QUESTION #1: Was the prospective site built before 1978?

The RRP rule applies only to housing units and buildings accessible to the public that have lead based paint which implies that the proposed site must have been built prior to 1978. Because pre-1950 homes have a greater probability of containing lead based paint, they will receive higher priority in initial site targeting. The age of prospective sites will be verified with county tax assessor records.

1.5.2 STUDY QUESTION #2: Will RRP activities, data collection, and cleanup be feasible at the potential site?

A potential site needs to be vacant, accessible at some point during July through October of 2006, and have a floor plan conducive to performing the experiment. The following general criteria must be met by a proposed site for inclusion in the study:

- The housing unit or COF must be vacant; preferably most of these will have become vacant within the last 6 months,
- The housing unit or COF must allow for RRP work during the times needed for the study (see below for in-scope RRP activities),
- The housing unit or COF must be in a reasonably cleanable condition so that pre-work cleaning can remove the risk of cross-contamination.

For interior sites, the following criteria with regards to the floor plan must be met:

- EPA has indicated a desire for a “work” room at the end of three sequentially adjacent interior rooms on a single level. The room adjacent to the “work” room must have adequate room to be used for tool storage. The third room furthest from the “work” room will be used as an “observation” room for spatial characterization. See Figure 1-2 for an example of an acceptable study area layout.
- The floors of all three rooms are desired to be smooth and cleanable, i.e. wood, vinyl, or other non-carpeted surface is strongly desired.

- The potential work room must contain at least one window, if window-related RRP activities are to be conducted.

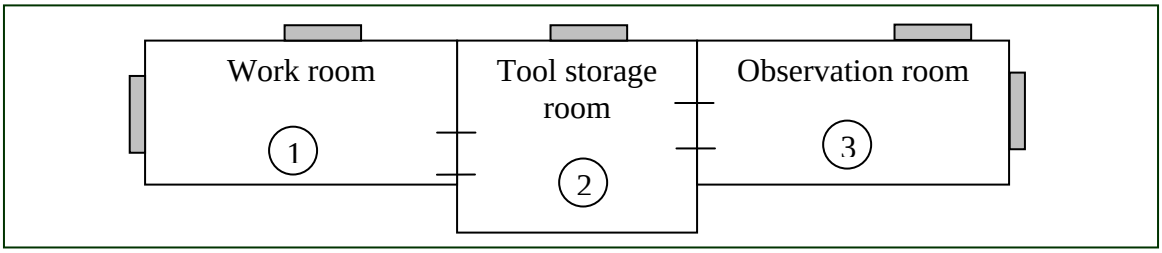


Figure 1-2. Example Study Area Within a Prospective Housing Unit or COF (horizontal lines represent doorways or openings connecting the rooms)

Exterior sites must meet the following criteria:

- There needs to be adequate space in the yard or around the exterior of the building for sample collection and containment of dust and debris.
- Exterior sites must not be contaminated by concurrent interior work, unless this is part of the design.

Additionally, it is highly desirable that electricity be available at all sites. While it would be ideal to have a cross section of housing ages (e.g., 2 pre-1920, 2 built between 1920 and 1950, and 2 built between 1950-1978), this must be balanced by choosing the sites in close proximity (e.g. within a 15 mile radius) to each other and availability for undergoing work according to the study's schedule.

1.5.3 STUDY QUESTION #3: Is lead based paint present on a sufficient area in the work room or on the exterior of the potential site?

Once a potential site has been verified for feasibility in Study Question #2, a lead based paint screening using a portable x-ray fluorescence (XRF) device operated by a certified contractor will be performed in potential "work" rooms (interior) or on walls (exterior) of the RRP activities. Various components including walls, trim, doors, window sills will be tested for the presence of lead paint. Presence of lead based paint is determined when an XRF measurement returns a reading at or above 1.0 mg/cm^2, or when the lead content of a paint chip sample is at or above 0.5% by weight (5,000 µg/g) or 1.0 mg/cm^2. A sufficient quantity of lead based paint for purposes of this study is defined as at least 2 ft^2 or more within the potential work room. As indicated in Table 1-2, minimum requirements for area of lead-based paint on the interior range from 2 ft^2 for one of the low level jobs, to 50-75 ft^2 for the medium level jobs, and over 100 ft^2 for one of the high-level jobs. For the targeted exterior jobs, minimum areas containing lead-based paint range from 25 ft^2 to over 100 ft^2.

1.5.4 Data Quality Objectives

The following objectives must be met regarding the data collected during the site selection process.

- 100% completeness in age of housing (decade built) and building characteristics data;
- 100% completeness in classification of units and housing as suitable or not suitable for the study;
- adherence to HUD PCS Sheets or similar specifications for 95% of the paint measurements taken by portable XRF;
- batch quality control samples in the control range for 95% of the paint measurements done by laboratory analysis.

1.6 SPECIAL TRAINING/CERTIFICATION

Members of the research team or subcontractors gathering XRF measurements will require state certification to conduct a lead-based paint inspection, and must comply with applicable federal, state, or local regulations regarding the safe operation of a portable XRF instrument. Appropriate precautions will be taken when operating the instrument. Data collectors obtaining paint chip samples will receive training on the appropriate collection protocol, following proper chain of custody procedures, maintaining logbooks, and avoiding contamination or damage of samples. Appropriate safety precautions will be taken when collecting the lead based paint chip samples.

For any paint chip samples collected during the site screening process, a laboratory with appropriate qualifications and experience with the required protocols that can meet the schedule for the study will be used, and any applicable federal, state, or local regulations will be followed. The qualifications of any laboratory that analyzed samples utilized for the study will be documented.

Copies of all relevant qualifications and certifications will be obtained from appropriate participants and maintained in files by the PI.

1.7 DOCUMENTATION AND RECORDS

Detailed records will be kept of all field data collection activities. Information to be recorded includes:

- Addresses of prospective housing units and COFs visited with associated information including Year Built, property owner, vacancy status, floor type, and likely ages of children that could or would be at a COF (since children under age 6 are preferred);

- A signed permission form for each property at which XRF measurements are obtained;
- Paint lead levels on various components throughout each prospective unit as registered via the portable XRF device;
- A sketch of each tested property's room layout identifying rooms in which XRF measurements are obtained;
- Location of XRF measurements and paint chip samples identified by level of house (0,1,2,3,…), room (BR1, DR, KI,….), and wall (1,2,3,4);
- Appropriate measurements of the surface area of components with lead-based paint;
- Condition of paint and substrate, where necessary;
- Lead levels found in all paint chip samples; and
- Letters or documents transmitting results to property owners or managers.

If data collectors make or discover errors on their data collection forms, they should cross out the incorrect information with a single line, insert the correct information, and add their initials and the date next to the change. Appendix C contains instructions for conducting inspections whiles Appendix D contains study data collection forms.

Records describing sample receipt, handling, and storage will be prepared and maintained by the designated sample custodian or designee. The documentation will record sample receipt, problems, or anomalies in the samples or shipment conditions, and will provide a record that custody records were received for each sample. The documentation will also identify missing documents or incomplete data.

The laboratory staff will enter all data for sample preparation and analysis into a project record book or electronic database designated for that purpose. Entries will be made promptly and legibly in ink (for paper versions) and will be dated, signed, and initiated by the responsible staff member(s). Any deviations from the QAPP covering the paint chip analysis procedure will be documented by providing copies of the changes/deviations and reason(s) for the deviation to all individuals identified on the distribution list. All error corrections will be made by drawing a single line through the error, initialing and dating the error and adding a short explanation for non-obvious error corrections.

Laboratory staff members will identify and report sample and data collection problems to the Principal Investigator (PI). Corrective action reports that describe the problem and record how the problem was resolved will be prepared. Samples or data that are unusable will be identified and all associated results will be flagged accordingly. Corrective action reports will be maintained by the Principal Investigator and included as part of the prospective site report. In cases where samples or data are lost or compromised, the Principal Investigator will immediately send a copy of the report to the Project Manager who, in turn, will forward it to EPA.

Laboratory results will be returned from the laboratory in electronic spreadsheets, showing all calculations, and on paper forms. The results, including sample identification number and measurement, will be entered into a database at Battelle. The paper forms will be archived and used in verifying the results entered in the database.

QA records from the field audit and any necessary stop work orders will be stored with the QA Manager, and laboratory QC samples will be stored with the Laboratory Manager in a secure location for a period of seven years after the close of Battelle's contract with EPA. The study PI will maintain the original signed version of the QAPP and have responsibility for implementing any necessary revisions or amendments to the QAPP. The PI will also maintain all original copies of data collection forms, QAPPs, and study reports for a period of seven years. Data collection forms will not be included in the final report made available to the public in order to maintain the privacy of individual property owners.

2.0 MEASUREMENT/DATA ACQUISITION

2.1 SAMPLING PROCESS DESIGN (EXPERIMENTAL DESIGN)

2.1.1 Site Selection

The study team has developed a list of potential locations and contacts for identifying prospective housing units and COFs to enroll in the study. Initially, the study will seek to identify locations in or around Columbus, Ohio because of their proximity to Battelle. The table below lists a number of potential contacts in Columbus and in other areas that may have access to information concerning RRP activities.

Table 2-1. Potential Locations for Prospective Sites

#	Potential Location	Lead Detail
1	Columbus, Ohio	City of Columbus LHC program (Lead Safe Columbus - Dept. of Development)
2	Columbus, Ohio	Campus Partners - OSU, City of Columbus alliance
3	Columbus, Ohio	Columbus Housing Partnership
4	Columbus, Ohio	Columbus Lead Poisoning Prevention Program
5	Columbus, Ohio	Columbus Metropolitan Housing Authority
6	Columbus, Ohio	Fort Hays or DSSC DOD sites
7	Columbus, Ohio	City of Columbus Housing Division
8	Columbus, Ohio	Various private developers and property owners
9	Detroit MI	Vacant housing waiting for demolition
10	Milwaukee, WI	Milwaukee Health Department, Childhood Lead Poisoning Prevention Prog.
11	Baltimore, MD	Healthy Housing Solutions & Connor Environmental locating properties
12	Pittsburgh, PA	East Liberty Development, Inc. redeveloping multiple single-family and multi-family properties
13	Marietta, OH	Noble Learning Center converting an armory
14	Various	Military housing, BRAC housing

The site selection process will involve contacting organizations thought to have information on ongoing RRP activities. During the initial contact, study representatives will explain the study to the contact, offer to provide them with a Fact Sheet summarizing the study, and ask whether they know of RRP activities planned for housing in their area or of housing that fits the study requirements that would be good candidates for participating in this study. If they are interested in supporting the study, detailed discussions about potential candidate housing units will be held.

To be considered, candidate housing units must meet the following criteria:

- They must contain lead-based paint (LBP) on 2 square feet (ft^2) or more within a single room that will undergo RRP activity with LBP defined as dried paint film that has a lead content at or exceeding 1.0 mg/cm^2 or 0.5 percent by weight;

- They must contain three sequentially adjacent rooms to allow sampling in a work room, a tool storage room, and an observation room;
- They must be vacant to avoid exposing residents to health hazards;
- They must be accessible during the data collection period;
- They must be cleanable before work begins and at the completion of all study activities;
- If window-related work is required, they must contain an adequate number of windows; and
- If being considered for exterior work, they must contain an adequate amount of yard space to allow for exterior data collection and containment.

2.1.2 Sampling Locations and Sample Size

To meet current study goals, the study requires the enrollment of 15 units for interior work, 12 housing units and 3 COFs, with the goal of doing 15 interior jobs, i.e., one per unit. At least four units need to be enrolled for exterior work, 3 housing units and 1 COF, with the goal of conducting 15 exterior jobs – 12 at the 3 housing units and 3 at the COF.

To identify and enroll housing units in the study, at least 15 interiors and 4 exteriors will have to undergo screening to ensure that they possess the required characteristics listed in the section above, but it is estimated that as many as 50 units or buildings may need to be screened to locate eligible sites. The exact location of the prospective housing units is unknown at this time, but the study will seek to identify a potential location that presents a high density of prospective units to reduce the logistical complexity and cost of the study. Appendix C contains detailed instructions regarding the process for initiating and completing an inspection of the prospective unit, which will be provided to field coordinators and support staff conducting the site selection.

Permission to inspect and test units or buildings will be obtained from site owners or managers prior to any inspection or testing taking place. The permission will include agreement as to whether and how the results of the inspection and testing should be transmitted to the site owner or manager. Form 6 in Appendix D is a draft form for obtaining the permission of the property owner to conduct the XRF inspection and visual assessment of a property. Each prospective housing unit or COF will first undergo a visual inspection to ensure that it meets the study requirements beyond the presence of LBP – three sequential rooms, vacant, cleanable, etc. If the visual inspection confirms that a prospective housing unit meets those study requirements, a full lead screening inspection will occur with a portable XRF device to measure lead content of various painted components in the house – walls, window sills, trim, doors, etc. Inspectors will obtain a large number of XRF measurements throughout a house, which will be recorded by the field operations coordinator for the area or their representative on the appropriate data collection form.

Following review of the XRF measurements at a prospective housing unit, study planners will determine whether there is one or more rooms that could serve as the work room for an interior job or whether there is more than one exterior side of the house that could serve as the work area for an exterior job. Paint samples will be collected from prospective rooms and exterior sides for laboratory analysis, as necessary. When paint lead levels are required for the interior of a prospective housing unit, the protocol will involve collecting one paint chip sample on each of the possible lead-based paint components in the room, with a duplicate sample on large components such as walls, ceilings, baseboards, and any other large component that spans the room. Exterior paint lead levels will be determined by collecting one paint sample on each lead-based paint component on each side of the house that is a candidate for exterior work, with a second sample collected from large components.

2.2 SAMPLING METHODS

The study will utilize three methods of data collection – visual assessment, XRF measurement, and paint chip collection. These three data collection methods are described separately below.

2.2.1 Visual Assessment

The visual assessment will involve (1) gathering information on a prospective housing unit by viewing the unit, interviewing the property owner or manager, and checking county records and (2) sketching the property and labeling rooms appropriately. Form 1 in Appendix D, the Visual Assessment form, contains the various information that the study inspector will gather on a unit. This information includes:

- Year Built (from county records),
- recent occupancy/vacancy history,
- number of levels,
- number of rooms,
- number of windows per room,
- presence of three sequential adjacent rooms,
- floor type and condition,
- cleanliness rating,
- electricity status, and
- accessibility for RRP activities.

The technician will also complete a property sketch on Form 2, the Floor Plan and Property Sketch form in Appendix D, to support potential subsequent planning for XRF measurements, paint chip samples, and RRP activities. See Appendix C for detailed instructions on how to complete the property sketch and label areas of the prospective unit.

2.2.2 XRF Measurements

Either a full lead-based paint inspection or a partial lead-based paint inspection conducted similarly to a full inspection will occur in prospective sites passing the visual assessment. A portable XRF device that has a HUD/EPA-issued or equivalent *XRF Performance Characteristic Sheet* will be used. Other supplies needed include the XRF Performance Characteristic Sheet (supplied by the operator) and data collection Forms 3 and 4, interior and exterior XRF paint inspection and testing (see Appendix D). The inspector will obtain paint lead content measurements from the major components of various rooms in the housing unit and record measurements according to Forms 3 and 4 in Appendix D.

XRF measurements of lead in paint will follow the 16-step procedure from Chapter 7 of the HUD Guidelines (presented in Appendix E). A certified (licensed) lead-based paint inspector or risk assessor will be utilized for the lead-based paint inspections. The inspector will follow either protocols required by state regulations or the XRF Performance Characteristic Sheets, available from HUD, for conducting the inspections with portable XRF instruments. These sheets specify the ranges where XRF results are positive, negative, or inconclusive; the calibration check tolerances; and other important information. Lead paint results can usually be obtained without damaging the painted surface and should be reported in mg/cm². The method for correcting XRF readings for substrate bias is described in the HUD Guidelines. Measurements at or over 1.0 mg/cm² will be considered as having lead based paint for purposes of this study.

Testing with portable XRF instruments estimates lead loadings (mg/cm^2) present on painted surfaces. Readings from XRF devices must be obtained in accordance with the instrument manufacturer's instructions. The operator of the XRF device must be a trained XRF technician certified in the state in which testing is performed. The technician must also be proficient in all areas of operation for the particular XRF device being utilized. At a minimum, the following guidelines must be followed in operating an XRF device in this study.

- Never point the XRF device at anyone.
- Be certain that no one is on the opposite side of a component being tested.
- While testing a door, the door should be either completely closed or fully open (i.e., immovable).
- Do not use any part of your body to steady the XRF device.
- Be aware of the direction at which radiation is emitted from the XRF device and verify that no one is exposed to this direction. (i.e., the XK3 device emits radiation from the right side and at an angle).
- An XRF device must never be left unattended; the device must be in the possession and total control of the XRF technician. The device must be left "out of sight" when stored in a vehicle.

- If a padlock feature is included on the device to lock the trigger, the feature should be used when the device is not being utilized.
- A suitable distance (i.e., 10 feet) should be heeded between multiple XRF devices being utilized in the same housing unit.
- Proper theft and loss procedures will be followed when the device is missing, including notification of proper authorities (i.e., supervisors).
- Appropriate actions will be taken if the sealed source is believed to be damaged and/or exposed.
- All components of the device will be kept together and stored in a proper container.
- The base of the XRF device will be kept together and stored in a proper container.
- The base of the XRF device must be kept clean of dust, paint chips, and other debris.
- Care will be taken that the device is not dropped or otherwise mishandled.

It is expected that the XRF technician will adhere to any additional guidelines for XRF testing as provided by local ordinances, the XRF manufacturer, and the XRF contractor.

Calibration Check **-** Each XRF device shall be calibrated during field use in accordance with the manufacturer's instructions. The frequency of calibration on each device shall be as follows:

a. Before XRF testing is initiated at a housing unit, after an appropriate warm-up cycle.
b. After XRF testing is completed at a housing unit.
c. After any extended shutdown period (e.g., after lunch breaks), following an appropriate warm-up cycle.
d. After any series of readings are questioned by the XRF technician.
e. XK3 devices only: When a value of 10 mg/cm^2 or higher is obtained, or when a series of readings of 5.0 mg/cm^2 or higher are obtained.
   ML1 devices only: When a value of 15 mg/cm^2 or higher is obtained.

Preventive Maintenance **-** The manufacturer's manual will be followed for operation and maintenance of the analytical and auxiliary equipment. The maintenance program consists of both scheduled (preventive maintenance) and nonscheduled maintenance procedures. It is expected that records of maintenance performed on the instruments will be maintained in the respective instrument logbooks. The scheduled maintenance program involves servicing the instruments at regular intervals.

Substrate Correction - XRF readings are sometimes subject to systematic biases as a result of interference from substrate material beneath the paint. The magnitude and direction of bias depends on the substrate, the specific XRF instrument being used, and other factors such as temperature and humidity. Results can be biased in either the positive or negative direction and may be quite high. All substrates across all room equivalents should be grouped into one of the six substrate categories (brick, concrete, drywall, metal, plaster, or wood) shown on the *XRF*

Performance Characteristic Sheet for the instrument being used. Substrate correction procedures can then be applied for all building component types with the same substrate. For example, the substrate correction procedure for wooden doors and wooden baseboards can use the same substrate correction value.

Some XRF instruments do not need to have their readings corrected for substrate bias. Other instruments may only need to apply substrate correction procedures on specific substrates and/or when XRF results are below a specific value. The *XRF Performance Characteristic Sheet* should be consulted to determine the requirements for a specific instrument and each mode of operation (e.g., nominal time, or time required for intended precision). XRF instruments which do not require correction for any substrate, or require corrections on only a few substrates, have an advantage in that they simplify and shorten the inspection process.

Analytical Method Performance - Analytical method performance for XRF testing will be measured in terms of precision and accuracy of the XRF instrument and through data verification and validation. XRF technology varies by model. The Performance Characteristic Sheets will give the precision and accuracy for each instrument. The extent to which quality XRF paint-lead data are reported in this study will be monitored through applying instrument calibration and other QC techniques. Data completeness will be checked by a study representative after receipt of a complete XRF data packet containing the raw data for a specific housing unit. XRF results will be subject to auditing and verification by the QA Manager during on-site QA activities as well as data audits after the reports have been submitted. Any problems with the measurements or QC data will be reported to the Principal Investigator. Data will be reviewed, and anomalous values will be flagged for further investigation. Errors will be documented and corrected, or, if actual values cannot be determined, values may be flagged and excluded from further analysis.

Corrective Action - Deviations in equipment operation, loss of data, and data that are out of limits will be immediately reported to the Field Operations Coordinator or the Principal Investigator. Types of corrective actions used for these situations involving instrumental response include investigation of instrumental operation, recalibration, and performance of minor or major maintenance.

Documentation of Work - The XRF technician will report all findings (with the exception of discarded readings) to the Principal Investigator in hard-copy format. Forms 3 and 4 in Appendix D are the forms for reporting interior and exterior XRF results in this study. Each cell of the tables on those forms is associated with one measurement taken from a specific component in a specified room. The forms also include space for noting the make and model of the instrument used, whether an instrument calibration is performed, and the range of the instrument.

Data Review **-** Evaluation methods include direct observation, immediate provision of results, and time-and-motion analysis. Direct observations of the XRF testing process should be made whenever possible. Subcontracts established with any XRF testing firms will outline the financial penalties that will occur if an XRF technician fails to perform inspections as contracted during any visit.

An evaluation of a lead-based paint inspection is best made if a knowledgeable observer is present for as much of the XRF testing as possible. If possible, the observer should be someone who is trained in lead-based paint inspection and who is independent of the XRF technician's immediate organization. The independent field auditing team will observe the XRF testing process during site visits. The XRF technician should provide the original data collection form to the study field technician immediately following the completion of the inspection or on a daily basis. Alternatively, the inspector's written results can be reviewed to ensure that they are properly recorded for all surfaces that require XRF testing. If surfaces have been overlooked or recorded incorrectly, the affected housing units should be revisited to complete testing.

If possible, an electronic file of the XRF measurements obtained for each prospective unit will be obtained from the XRF technician. These electronic files will be spot-checked against the data collection forms. If they are accurate, these data will be utilized for subsequent data analyses.

2.2.3 Paint Chip Samples

The study will conduct laboratory analysis of paint-chip samples to confirm the presence of lead based paint measured by the portable XRF device or verify inconclusive XRF results. In some cases, due to the condition of paint an XRF measurement may not be feasible, and a paint chip sample for laboratory analysis will have to be collected. Laboratory analysis is more accurate and precise than XRF but only if great care is used to collect and analyze the paint-chip sample. The method used to collect paint samples will be the cold-scraping method described in ASTM E1729-05, "Standard Practice for Field Collection of Dried Paint Samples for Subsequent Lead Determination" or a comparable method. The size of the samples obtained will be approximately two square inches and will include all paint down to the substrate. After collecting a sample and placing it in the appropriate sample container, the field technician will label it accordingly and record the sample locations and sample number on the Paint Chip Data Collection Form. The SampleID is composed of a series of codes representing UnitID-Experiment-Sample room/wall-Stage and Type-Sample number and will be in the format UUU-EE-RRR-SST-##. Technicians will take appropriate safety precautions when collecting the paint samples, although it is not anticipated that respirators will be necessary.

2.3 SAMPLE HANDLING AND CUSTODY

To ensure sample integrity throughout the collection and analysis process, every paint chip sample container will be labeled with a permanent marker or adhesive label. Identifying information will include the SampleID, date, and time, which will also be recorded on the Paint Chip Data Collection Forms (Forms 7 and 8 in Appendix D). The data collector will store the samples in a cooler or other rigid-walled container until they can be shipped or transported to the laboratory. When the laboratory receives the samples, they will ensure that all samples have been received and sign the appropriate forms verifying this.

After analysis of the samples is completed, any remaining samples or digestate will be stored for at least six months. The Battelle laboratory (or other participating laboratory) will store the samples at their facility. Once the six month storage period has passed, Battelle will dispose of any remaining samples according to state and Federal guidelines, using Battelle's waste disposal program.

2.4 ANALYTICAL METHODS

Because the portable XRF device returns measurements in the field, the only analytical work required will be for providing quantifiable lead levels in the paint chip samples. Sample preparation will be performed according to ASTM E1645-01 and the subsequent analysis will follow ASTM E1613-04. The analysis will provide measurements of lead concentrations in µg/g and $\mu g/cm^2$. The performance of the method will be assessed by evaluation of the QC sample results. If the method does not perform acceptably, according to the QC criteria specified in Section 2.5, the procedures will be reviewed and altered as necessary.

2.5 QUALITY CONTROL

2.5.1 Field Blanks

Field blanks will be used to evaluate the presence of any lead contamination in the collection media during sample collection and handling. One field blank per prospective housing unit will be prepared. The field blank will be prepared by removing the lid of one sampling container, exposing the container to the open air for approximately 15 seconds, then replacing the lid on the container, and labeling the container appropriately. Field blanks should be less than 10 percent of sample levels. If they are higher, the PI and Field Activity Coordinator will review and observe the process of preparing sample collection materials, transporting them to the field, and obtaining samples. Any necessary modifications to the standard procedures will be immediately implemented.

2.5.2 Laboratory Blanks

In order to measure any potential contamination from the laboratory environment or procedures, the laboratory used to analyze the paint chip samples collected in the field will be required to prepare and analyze one laboratory blank for each batch of samples that they analyze (approximately 20 samples per batch). The sampling material used to prepare laboratory blanks will not make the trip to the field. The lab blanks will consist of cleaning out sample containers that did not travel to the field in a manner identical to how an actual sample would be removed from a container. The rinse will then be digested accordingly and analyzed for lead. The laboratory will report the results of the lab blank analysis to the Principal Investigator for review. Lab blanks should be less than twice the detection limit. If they are higher, the QA Manager and Laboratory Manager will review and observe the chemical analysis procedures, and immediately implement any necessary modifications.

2.5.3 Laboratory Spikes

The laboratory analyzing the paint chip samples collected in the field will be required to prepare and analyze one spiked sample for each batch of samples that they analyze (approximately 20 samples per batch). The laboratory will have to report the results of the spiked sample analysis to the study PI for review. The measured values of the spiked samples should average within 20 percent of the true values. Laboratory technicians will use National Institute of Standards and Technology (NIST) SRM 2581, Powdered Paint Nominal 0.5% Lead, for preparing spiked paint samples. If the spiked sample results are beyond 20 percent of the true values, the QA Manager will review the analytical process for deficiencies. Any deficiencies found will be corrected immediately. If none are found, analysis will proceed but a subsequent out-of-range laboratory spike sample result will cause the analysis to be halted and an alternative method to be explored. If spiked sample results are beyond 50 percent of the true values, all samples analyzed in the respective batch will be subsequently flagged in the study database to identify them as potentially inaccurate. The PI, in consultation with EPA, will decide whether additional paint chip samples need to be obtained.

2.5.4 Laboratory Duplicates

The laboratory will be asked to prepare one duplicate measurement per batch to evaluate the precision of the laboratory measurements (approximately 20 samples per batch). The paint chip duplicate should be prepared by homogenizing and splitting one of the field samples. The lab will have to report the results of the duplicate analysis to the study PI for review. Each pair of duplicate measurements should be within 20 percent of each other. If the duplicate results are beyond 20 percent of each other, the QA Manager will review the analytical process for deficiencies. Any deficiencies found will be corrected immediately. If none are found, analysis will proceed but a subsequent out-of-range laboratory duplicate result will cause the analysis to be halted and an alternative method to be explored. If duplicate sample results are beyond

50 percent of the true values, all samples analyzed in the respective batch will be subsequently flagged in the study database to identify them as potentially inaccurate. The PI, in consultation with EPA, will decide whether additional paint chip samples need to be obtained.

2.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Laboratories used to analyze samples collected in the study will be asked to provide or verify appropriate credentials, e.g., their NLLAP recognition if they are an NLLAP-recognized lab. They will also be asked to provide:

- records of their experience using the protocols that they are being asked to implement,
- the written procedures or manuals they follow in conducting all QA/QC work,
- the QC sample results for review by the study team, and
- procedures for implementing corrective action when QC sample limits are exceeded.

They will be asked to ensure that all instruments and equipment are maintained in sound operating condition and are capable of operating at acceptable performance levels. Records will be maintained for each major instrument, including records of in-house preventive maintenance and service. The frequency of calibration/verification for each instrument will be documented. Description of the problem or service, dates and types of repair, organization and person performing repair, and contact phone number will be recorded. The record will identify the instrument by make and model number.

2.7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

The laboratory used for chemical analysis will be asked to provide calibration measurements for the instrument used in analyzing the paint chip samples as specified in the analytical method. The instruments will be calibrated with a minimum of three standards daily prior to use. Calibration coefficients of .0995 or better should be achieved or the instrument will be recalibrated. All calibration curves will be dated and labeled with applicable method, instrument identification, analysis date, analyte concentrations, and instrument response. Measurements used to calculate detection limits will also be requested.

2.8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

All supplies and consumables to be used in the field and laboratory activities will be inspected by qualified staff (under the supervision of the Field Activities Coordinator and Laboratory Manager) and determined to be acceptable for use on the project prior to use. The Field Activities Coordinator and the Laboratory Manager(s) will determine appropriate

acceptance criteria (e.g. expiration dates, certificates of cleanliness or testing) for critical field and laboratory supplies. Results of the inspection will be documented in the study files.

2.9 NON-DIRECT MEASUREMENTS

It is possible that some organizations may have already collected various pieces of information on a prospective housing unit, e.g. a unit targeted for lead hazard control may already have undergone a lead inspection and detailed XRF measurements may be available. If relevant previously collected information is available, the study will seek to obtain it and use it as appropriate. All non-directly collected data will be evaluated to ensure that they meet the standards and requirements for data that are collected directly (see section 1.5) and if used will be noted accordingly.

2.10 DATA MANAGEMENT

The Battelle Principal Investigator and the Laboratory Manager(s) are responsible for the detection and correction of errors and for the prevention of data loss during data entry, reduction, reporting, and other manipulation. Error detection and correction will be properly documented. Battelle will manage the data on the site screening process on computers using MS Excel 2003 and SAS v9.1.

Information gathered on prospective units via the visual assessment form, floor plan and property sketch form, and digital photography form will be data entered into Excel spreadsheets with the appropriate identifying information. Data entry results will be spot-checked by the PI to ensure accurate transfer of data from the hand-written forms to the electronic files. Data managers will transfer all the data from the Excel spreadsheets to SAS datasets.

If possible, XRF measurements obtained in the field using a portable device and recorded on data collection forms will also be obtained from the device in an electronic file. If an electronic file is obtained, the electronic data will be compared to the measurements on the data collection forms to ensure consistency. These data subsequently will be loaded into a SAS dataset. If electronic XRF measurements cannot be obtained from the device, the data captured on the data collection forms will be data entered into Excel spreadsheets with appropriate unit identifying information, checked, and subsequently transferred to SAS datasets. Similarly, paint lead measurements will be obtained from the laboratory in an Excel spreadsheet. Following review, a data manager will read these data into a SAS dataset. Additionally, supporting information for the paint lead samples will be transcribed from the data collection forms into Excel spreadsheets, reviewed for accuracy, and transferred to SAS datasets.

Consistent back-up and data archiving techniques will be used to ensure that data management work products are not subject to computer failure. Daily backups of individual PCs and computers are conducted. Final datasets containing XRF measurements (in mg/cm^2), paint chip lead levels (in µg/g), and other descriptive information for each prospective and enrolled site will be provided to EPA in an agreed upon format that can be made available to the public. A data dictionary describing each data field will also be written and delivered to EPA with the final data. No calculations will be required for this phase of the study.

3.0 ASSESSMENT AND OVERSIGHT

3.1 ASSESSMENTS AND RESPONSE ACTIONS

A field audit will be performed in order to ensure that all elements of the QAPP have been implemented correctly and that data of sufficient quality are generated. The Battelle QA Manager will have the responsibility of reviewing the field data collection process to ensure that sample collection procedures specified in Section 2.2 or referenced methods are being followed. In addition, the sample design and all other specifications related to the field activity specified in this QAPP will be examined for compliance. The Battelle QA Manager will perform one QA audit of the visual assessment, XRF measurement, and paint chip collection process at a single prospective housing unit. If these three types of data collection do not occur in a single visit to a prospective unit, the QA Manager will make multiple trips to the unit, as necessary. If problems are identified with sample collection protocols, the Battelle QA Manager will immediately report these to the Field Activity Coordinator who will ensure that the problems are corrected. Because the site screening process needs to happen over a short period of time, it is critical that any problems be identified and corrected quickly.

Findings of the field audit will be recorded and submitted to the Principal Investigator for immediate corrective action (if needed) in an audit report. The Principal Investigator will then return the field audit report, documenting any corrective actions taken, to the Battelle QA Manager who will confirm that the corrective actions were adequate and completed. Finally, the field audit report will be routed through the Project Manager for review and subsequently provided to the EPA WAM.

The QA Manager also will be responsible for conducting audits of data quality for the various QC samples including blank and spiked samples. The Battelle QA Manager will retain copies of all QA reports in permanent files in a secure location for seven years after the end of Battelle's contract with EPA.

3.2 REPORTS TO MANAGEMENT

Written reports covering the progress made and the results of this study will be delivered to EPA on a regular basis. The schedule for these reports is provided in Table 3-1. In addition, we will keep the EPA WAM informed on weekly progress, problems, etc. via e-mail and/or conference calls. A written progress report will be included in the contract's monthly progress report.

Table 3-1. Schedule of Reports

Report	Due Date
Final QAPP	March 31, 2006
Draft report on prospective sites	April 11, 2006
Final report on prospective sites	April 27, 2006
QA Audit report on screening operations	2 weeks following audit
Assessment and inspection reports	3 days following inspection
Monthly progress reports	20th day of subsequent month

Descriptions of these reports listed in Table 3-1 are as follows.

QAPP - this document.

Draft Report on Prospective Sites – an initial report providing descriptions of all aspects of the screening process and data collection that occurred at the various prospective locations visited and evaluated by April 11th.

Final Report on Prospective Sites – A final report providing descriptions of all aspects of the screening process and data collection that occurred at the various prospective locations.

QA Audit Report on Screening Operations - a report providing the results of the QA audit of the visual assessment, XRF measurement, and paint chip collection data collection efforts. This report will discuss any issues identified during the audits and steps taken to address those issues.

In addition to reporting on findings to EPA, the study will report results of the XRF inspection and paint chip analysis to all property owners who allowed their properties to be assessed for inclusion in the study. Following the inspection, Battelle will generate and provide an environmental disclosure report to participants indicating if and where lead-based paint is located in the housing unit or building. The report will include a statement that the presence of lead-based paint must be disclosed by the seller or owner to potential new buyers (purchasers) and renters (lessees) prior to obligation under a sales contract or lease, based on Federal law. Actual property addresses and associated environmental measurements will not be included in the final reports or any publicly-available documents.

4.0 DATA VALIDATION AND USABILITY

4.1 DATA REVIEW, VERIFICATION, AND VALIDATION

In order to determine if data collected during the project achieve the criteria on data quality specified in Section 1.5, the Principal Investigator will subject all data to a verification and validation process. Data will be reviewed using the criteria specified below, and any data that fail to meet any of the criteria will be investigated as described in Section 4.2. If data errors cannot be corrected (i.e., errors other than calculation errors, data entry errors, transcription errors, etc.), those data will be flagged and excluded from final analyses.

4.2 VERIFICATION AND VALIDATION METHODS

Data verification and validation will be performed to ensure that the criteria specified below have been met. Methods for verifying the compliance, correctness, consistency, and completeness of the data are described below.

Compliance and Correctness – The characteristics of selected sites will be documented to show that they meet the required criteria for inclusion. Presence of lead based paint is determined when an XRF measurement returns a reading at or above 1.0 mg/cm^2, or when the lead content of a paint chip sample is at or above 0.5% by weight (5,000 µg/g) or 1.0 mg/cm^2. A sufficient quantity of lead based paint for purposes of this study is defined as 2 ft^2 or more within the potential work room. Data collector and laboratory log books will be reviewed to determine if data collection and analysis protocols were followed and basic operations and calculations were performed correctly.

Consistency - The range of the XRF measurements obtained at each prospective housing unit will be evaluated to determine whether they appear to be reasonable and consistent.

Completeness – Completion of this study is determined by enrollment of a sufficient number of qualified housing units willing to meet the requirements of the study. Completeness of the specific data collection methods will be evaluated based on the successful completion of visual assessments, XRF measurement protocols, and paint lead testing.

Once it is determined that the data have successfully passed the data verification elements above, data validation will take place. This process will ensure that the data can be used as intended to make decisions and address project objectives. The PI will review that all targeted housing units or other enrolled facilities contain the required characteristics for use in this study.

When data problems are found, the Principal Investigator will notify the responsible person for the data (e.g., Field Operations Coordinator, Laboratory Manager, etc.). This individual will attempt to resolve the data problem. Possible solutions include correcting a

mistake in a spreadsheet formula, correcting a calibration curve, and correcting data entry errors. Corrected data will be re-submitted to the Principal Investigator for validation and verification again.

Data that are confirmed to be in error but cannot be corrected (e.g., sample was contaminated in laboratory) will be removed from the study database and replaced with a flag indicating the specific problem. Data that appear suspicious but have no reason for which to invalidate them will be reported in the database accompanied by a flag that indicates their possible outlier status. Analysts and users of the data will need to consider how to include these data points in their analyses.

4.3 RECONCILIATION WITH USER OBJECTIVES

Data results will be compiled, and the Battelle Principal Investigator will determine if the results fall within the acceptable limits defined in this QAPP. Reconciliation with the data quality objectives specified in Section 1.5 will be performed once all data problems have been resolved. If criteria on data quality are not achieved, reanalysis will be required until these criteria are met or until Battelle and EPA determine that the data cannot be improved. If a sufficient number of housing units or other facilities with the required characteristics are not identified at the completion of the data collection process, additional prospective units will have to be identified and screened according to the procedures in this plan. The number of samples obtained in the prospective site screening phase is a function of timing and ability to conduct the study in a reasonable timeframe.

APPENDIX A

SAMPLING PROTOCOLS

ASTM E1729-05 - Standard Practice for Field Collection of Dried Paint Samples for Subsequent Lead Determination

The ASTM standard in this appendix was deleted from this electronic version of the Quality Assurance Project Plan because the standard is copyrighted by ASTM International.

APPENDIX B

ANALYTICAL METHODS

ASTM E1645-01 - Standard Practice for Preparation of Dried Paint Samples by Hotplate or Microwave Digestion for Subsequent Lead Analysis

ASTM E1613-04 - Standard Test Method for Determination of Lead by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES), Flame Atomic Absorption Spectrometry (FAAS), or Graphite Furnace Atomic Absorption Spectrometry (GFAAS) Techniques

ASTM standards in this appendix were deleted from this electronic version of the Quality Assurance Project Plan because the standards are copyrighted by ASTM International.

APPENDIX C

INSTRUCTIONS FOR INSPECTION OF PROSPECTIVE UNITS

INSTRUCTIONS FOR
INITIAL INSPECTION AND XRF TESTING
OF PROSPECTIVE UNITS FOR EPA RRP STUDY

After a property has been identified as a possible unit for Renovation, Repair, and Painting (RRP), an initial inspection of the property must take place. Please follow the steps outlined below for the initial inspection and XRF testing.

1. Contact the project manager to get a UNIT ID assigned to the property. This will be a unique three-character identifier consisting of a letter and two integers *(e.g. H15 for a housing unit or C04 for a child occupied facility)* that will be carried throughout the study.

2. Organize the forms and gather equipment needed to complete the inspection. The following is a list of the forms that should be emailed or mailed to the inspector. The second column corresponds to the number of copies that should be printed or copied for each form. Be sure to put the UNIT ID on every page of every form for identification.

FORM	No. OF COPIES
FORM 1 : Visual Assessment of Unit	1
FORM 2 : Property Sketch and Floor Plans	1 for each 4 floors of unit
FORM 3 : Interior XRF Paint Inspection and Testing	1 for each room of unit
FORM 4 : Exterior XRF Paint Inspection	1 for each exterior wall of unit
FORM 5 : Digital Photography Record	As many as needed
FORM 6 : Permission for XRF Inspection of a Privately-Owned Property	1
EQUIPMENT	
Compass, XRF Device, Clipboard and Pen, Digital Camera, 30 ft. Measuring Tape	

3. Acquire signature of property owner on FORM 6, granting permission to access the property for XRF inspection of lead-based paint.

4. Complete items 1-11 on FORM 1 to the best of your ability using information on the unit from tax assessor websites, the property owner, and from the visual assessment, itself.

5. ITEM 12 on FORM 1: If inspector has experience with housing/RRP, please provide recommendations throughout the inspection for Renovation, Repair and Painting work that is feasible or of use to the unit. Input may also be acquired from discussions with the property owner as to what work they want to have completed or what level of work they would accept.

6. While performing the inspection, please use a digital camera to capture external images of the unit, as well as interior items of disrepair, representative pictures of possible rooms to be used, and matters of cleanliness.

7. Prepare a property sketch on FORM 2, including the exterior outline of the unit and the yard, as well as any detached buildings found on the property.

    a. Please indicate North on the sketch.
    b. Be sure to label all exterior walls, with the wall facing the road/street used in Address of Residence as WALL 1 and increase the wall number CLOCKWISE around the building.
    c. Include distance measured from all exterior walls/out buildings to the property line or other defining boundary (*e.g. fence, road, sidewalk, etc*.).

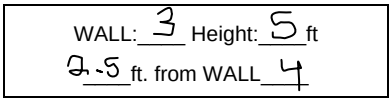
8. Prepare floor plans on FORM 2 for each floor of the unit, beginning with the basement, if present.

    a. Label each room on the plan and indicate the TYPE of room in the table to the right of the sketch. Please follow the numbering convention provided, where the first digit indicates the floor number and the next two digits identify the room (*e.g. 001 is the first room on the lowest floor, 103 is the third room on the second floor, etc*.)
    b. Hallways and stairs are to be labeled as rooms and assigned a number.
    c. Please note the location of closets, doors and windows in each room.
    d. In addition, label each interior wall of each room with the same convention used for the exterior (*WALL 1 is the interior wall that is closest to the road/street used in Address of Residence, and the wall number increases CLOCKWISE around the room*).
    e. If there are more than four (4) floors in a unit, please print or copy the floor plan sheet, as needed, and continue the room numbering convention from the previous floors (*401 would be the first room on the fifth floor*)

f. NOTE: It is not necessary at this point to include all interior room measurements.

9. Perform interior XRF inspection and testing. Please use one form per room and be sure to indicate UNIT ID and ROOM # (*from floor plan*) on form.

    a. For each component listed on FORM 3, record the final lead content (mg/cm^2) from the XRF instrument.
    b. For large components (*floor, ceiling, walls, trim, etc*.), please obtain additional samples at different locations on the component. These will be recorded in the columns for sample numbers 2, 3, and 4 (*as needed*).
    c. Please record the locations of the samples by filling in the measured distances requested for each component. Note that the same distances are not requested for each component; this is done to minimize the amount of measuring required. An example is given below:



10. Perform exterior XRF inspecting and testing. Please use one form per exterior wall and be sure to indicate UNIT ID and WALL # on form.
    a. For each component listed on FORM 4, record the final lead content (mg/cm^2) from the XRF instrument.
    b. For large components (*wall, trim, etc*.) please obtain additional samples at different locations on the component. These will be recorded in the columns for sample numbers 2, 3, and 4 (*as needed*).
    c. Please record the locations of the samples by filling in the measured distances requested for each component. Note that the same distances are not requested for each component; this is done to minimize the amount of measuring required.

11. Please be sure to remove all items and instruments from the unit and clean up any mess caused by this inspection. If the floors are carpeted, consider removing shoes upon entry.

12. Remember to sign, initial and date the bottom of all forms and add any appropriate notes or comments.

13. Make a copy of all forms for your records and send originals to:

    Timothy Pivetz
    Battelle
    505 King Ave.
    Columbus, OH 43201

APPENDIX D

FIELD DATA COLLECTION FORMS

Form 1: Visual Assessment Form

Form 2: Floor Plan and Property Sketch

Form 3: Interior XRF Paint Inspection and Testing

Form 4: Exterior XRF Paint Inspection and Testing

Form 5: Digital Photography Record

Form 6: Permission for XRF Inspection of a Privately-Owned Property

Form 7: Interior Paint Chip Sample Data Collection Form

Form 8: Exterior Paint Chip Sample Data Collection Form

FORM 1: VISUAL ASSESSMENT OF UNIT

UNIT ID

Unit Information:

Street No. _____ Street Name _____ Apt. No. _____

City _____ State _____ Zip Code _____

Property Owner Information:

Name _____

Street No. _____ Street Name _____ Apt. No. _____

City _____ State _____ Zip Code _____

Phone # _____

Unit Information:

☐ 01. Is this unit vacant or occupied?
Code: 1 = Vacant, 2 = Occupied, 3 = Other

02. If unit is vacant, when was the unit last occupied? ☐

☐ 03. Type of building:
Code: 1 = Single detached, 2 = Single-attached, 3 = Two-family, 4 = Triplex, 5 = Four-plex,

6 = More than 4 units/building (Specify) ☐

7 = Other (Specify) ☐

04. Year that dwelling was constructed: ☐

☐ 05. Type of exterior:
Code: 1 = Masonry, 2 = Wood, 3 = Aluminum or vinyl siding, 4 = Stucco, 5 = Non-wood shingles,

6 = Other (Specify) ☐

06. Approximate square feet of yard? ☐ Sq. ft.

☐ 07. Are there 3 sequentially adjacent interior rooms on a single level?
Code 1 = Yes, 2 = No

If yes, what types of flooring are in the rooms? (select all that apply)

☐ Wood ☐ Vinyl ☐ Other (Non-carpeted) ☐ Carpet

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

UNIT ID

☐ 08. Does the unit have electricity?
Code: 1 = Yes, 2 = No

☐ 09. Does the unit have running water?
Code: 1 = Yes, 2 = No

☐ 10. Condition of unit's interior:
Code: 1 = Serious deterioration, 2 = Mild deterioration, 3 = No significant deterioration

☐ 11. Condition of unit's exterior:
Code: 1 = Serious deterioration, 2 = Mild deterioration, 3 = No significant deterioration

12. Recommendations for Renovation, Repair and Painting work to be performed:

	INTERIOR		EXTERIOR	
Low Level Work	☐	Remove three (3) 2 ft. wall sections, perform plumbing, electrical and HVAC work, repair and repaint	☐	Replace an exterior door and doorway, disturbing 25-50 ft^2 of lead-based paint
	☐	Install recessed lighting in ceiling, disturbing approximately 6 ft^2 of lead-based paint	☐	Replace fascia boards, soffits, and other exterior trim on one side of the structure, disturbing approximately 50 ft^2 of lead-based paint
	☐	Replace a window from inside the unit, disturbing at least 2 ft^2 of lead-based paint	☐	OTHER (INTERIOR/EXTERIOR):
Medium Level Work	☐	Scrape deteriorating lead-based paint from a flat interior component, scraping 50-75 ft^2 of painted surfaces, and repaint	☐	Replace siding with lead-based paint on one exterior side of the structure with vinyl disturbing at least 100 ft^2 of lead-based paint
	☐	Scrape or plane 20-40 ft^2 of an interior door, and repaint	☐	Remove lead-based paint from exterior components by dry scraping, disturbing approximately 100 ft^2 of lead-based paint, and repaint
	☐	OTHER (INTERIOR/EXTERIOR):		
High Level Work	☐	Remove paint from 75-100 ft^2 of lead-based painted components in a room by using a heat gun at or over 1100°F held at 1" or the distance specified in the instructions from paint, and repaint	☐	Remove paint by power sanding or grinding on at least 100 ft^2 of lead-based paint on exterior wood components on one side of the structure, and repaint
	☐	Gut out a kitchen, disturbing 100 ft^2 or more of lead-based paint	☐	~~Abrasive-blast or sandblast, without a HEPA exhaust control,~~ lead-based paint on ~~least~~ 25 100 ft^2 of lead-based paint from brick, concrete, stone, ~~or~~ metal on one side of the structure, and repaint
	☐	OTHER (INTERIOR/EXTERIOR):		

(REMOVE by Torching or open flame burning)

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

FORM 2: PROPERTY SKETCH AND FLOOR PLANS

UNIT ID	Street Address
Date	

PROPERTY SKETCH

Note: Sketch one plan for the perimeter of the property, showing the exterior outline of the building and any out-buildings as well as yard. Label exterior walls, with the wall facing road/street used in Address of Residence as WALL 1 and increase CLOCKWISE around the building. Please indicate North and provide distance measurements from exterior walls to property line or other defining boundary (*e.g. fence, road, sidewalk,etc.*).

Symbols
Exterior
E = Exterior (building)
G = Garage
O = Other
OB = Out Building
P = Porch
Y = Yard

Road/Street used in Address of Residence

Notes:

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID

INTERIOR FLOOR PLANS

Note: Sketch a separate plan for each floor of the unit beginning with the Basement. Label each room/location on sketch. Note location of windows and doors. Stairs and hallways are numbered as rooms. Label interior walls of each room, with the wall closest to the road/street used in Address of Residence as WALL 1 and increase CLOCKWISE around the room.

FLOOR : _____

Room	Type
001	

Symbols
Interior
B = Bath
BA = Basement
BL = Balcony
BR = Bedroom
D = Dining Room
H = Hall
K = Kitchen
L = Lobby
LR = Living Room
O = Other Room
PA = Pantry
PL = Playroom
S = Stairs

Road/Street used in Address of Residence

FLOOR : _____

Room	Type
101	

Symbols
Interior
B = Bath
BA = Basement
BL = Balcony
BR = Bedroom
D = Dining Room
H = Hall
K = Kitchen
L = Lobby
LR = Living Room
O = Other Room
PA = Pantry
PL = Playroom
S = Stairs

Road/Street used in Address of Residence

Notes:

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

INTERIOR FLOOR PLANS

Note: Sketch a separate plan for each floor of the unit beginning with the Basement. Label each room/location on sketch. Note location of windows and doors. Stairs and hallways are numbered as rooms. Label interior walls of each room, with the wall closest to the road/street used in Address of Residence as WALL 1 and increase CLOCKWISE around the room.

FLOOR : _____

Room	Type
201	

Symbols
Interior
B = Bath
BA = Basement
BL = Balcony
BR = Bedroom
D = Dining Room
H = Hall
K = Kitchen
L = Lobby
LR = Living Room
O = Other Room
PA = Pantry
PL = Playroom
S = Stairs

Road/Street used in Address of Residence

FLOOR : _____

Room	Type
301	

Symbols
Interior
B = Bath
BA = Basement
BL = Balcony
BR = Bedroom
D = Dining Room
H = Hall
K = Kitchen
L = Lobby
LR = Living Room
O = Other Room
PA = Pantry
PL = Playroom
S = Stairs

Road/Street used in Address of Residence

Notes:

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

FORM 3: INTERIOR XRF PAINT INSPECTION AND TESTING

UNIT ID	Street Address
ROOM #	Date of Testing

XRF Measurements: Instrumentation

01. Please specify make and model of instrument used to collect readings? ____
02. Was an instrument calibration performed? ____
    Code: 1 = Yes, 2 = No, 3 = Not Applicable If yes, specify the date of the calibration: ____
03. What instrument range is being used? ____

Record final lead content (mg/cm^2) if component is painted and tested and location on component where sample was taken. For components not listed, please use added space for additional components and indicate the type and location.

Component Type	Sample #1:	Lead Content (mg/cm^2) / Location	Sample #2	Lead Content (mg/cm^2) / Location	Sample #3	Lead Content (mg/cm^2) / Location	Sample #4	Lead Content (mg/cm^2) / Location
Floor								
	____ft. from WALL 1 ____ft. from WALL 2		____ft. from WALL 1 ____ft. from WALL 2		____ft. from WALL 1 ____ft. from WALL 2		____ft. from WALL 1 ____ft. from WALL 2	
Ceiling								
	____ft. from WALL 1 ____ft. from WALL 2		____ft. from WALL 1 ____ft. from WALL 2		____ft. from WALL 1 ____ft. from WALL 2		____ft. from WALL 1 ____ft. from WALL 2	
Wall #1								
	Height: ____ft. ____ft. from WALL		Height: ____ft. ____ft. from WALL		Height: ____ft. ____ft. from WALL		Height: ____ft. ____ft. from WALL	
Wall #2								
	Height: ____ft. ____ft. from WALL		Height: ____ft. ____ft. from WALL		Height: ____ft. ____ft. from WALL		Height: ____ft. ____ft. from WALL	
Wall #3								
	Height: ____ft. ____ft. from WALL		Height: ____ft. ____ft. from WALL		Height: ____ft. ____ft. from WALL		Height: ____ft. ____ft. from WALL	

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

UNIT ID	ROOM #

Component Type	Sample #1:	Lead Content (mg/cm^2) Location	Sample #2	Lead Content (mg/cm^2) Location	Sample #3	Lead Content (mg/cm^2) Location	Sample #4	Lead Content (mg/cm^2) Location
Wall #4								
	Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___	
Baseboard								
	WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___	
Door Casing								
	WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___	
Door								
	WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___	
Window Sill								
	WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___	
Window Trough								
	WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___	
Window Sash								
	WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___	
Window Casing								
	WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___		WALL:____ Height:____ft ____ft. from WALL___	

Otherwise code: A - Component Not Present B - Component Not Painted C - Component Painted but not tested

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

UNIT ID	ROOM #

ADDITIONAL COMPONENTS

Please use similar location descriptions as above

Component Type	Sample #1:	Lead Content (mg/cm^2) / Location	Sample #2	Lead Content (mg/cm^2) / Location	Sample #3	Lead Content (mg/cm^2) / Location	Sample #4	Lead Content (mg/cm^2) / Location

Notes:

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

FORM 4: EXTERIOR XRF PAINT INSPECTION AND TESTING

UNIT ID	Street Address
WALL #	Date of Testing

XRF Measurements: Instrumentation

01. Please specify make and model of instrument used to collect readings? ____

02. Was an instrument calibration performed? ____

Code: 1 = Yes, 2 = No, 3 = Not Applicable If yes, specify the date of the calibration: ____

03. What instrument range is being used? ____

Record final lead content (mg/cm^2), if component is painted and tested, and location on component where sample was taken. For components not listed, please use added space for additional components and indicate the type and location.

Component Type	Sample #1:	Lead Content (mg/cm^2) / Location	Sample #2	Lead Content (mg/cm^2) / Location	Sample #3	Lead Content (mg/cm^2) / Location	Sample #4	Lead Content (mg/cm^2) / Location
Wall (Siding)								
	Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___	
Trim								
	Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___	
Door								
	Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___	
Door Casing								
	Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___	
Window Sill								
	Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___	
Window Sash								
	Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___	

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

UNIT ID	WALL #

Component Type	Sample #1:	Lead Content (mg/cm^2) / Location	Sample #2	Lead Content (mg/cm^2) / Location	Sample #3	Lead Content (mg/cm^2) / Location	Sample #4	Lead Content (mg/cm^2) / Location
Window Casing	Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___		Height: ____ft. ____ft. from WALL___	

Otherwise code: A - Component Not Present B - Component Not Painted C - Component Painted but not tested

ADDITIONAL COMPONENTS

Please use similar location descriptions as above

Component Type	Sample #1:	Lead Content (mg/cm^2) / Location	Sample #2	Lead Content (mg/cm^2) / Location	Sample #3	Lead Content (mg/cm^2) / Location	Sample #4	Lead Content (mg/cm^2) / Location

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

FORM 5: DIGITAL PHOTOGRAPHY RECORD

UNIT ID	Street Address
Date	

Digital Photos:

Please use Photo ID convention: **UNIT-ROOM*-COMPONENT-PHOTO#** (*ex. 12-204-FL-01*)
*NOTE: For exterior photographs, use ROOM 999

Component Codes:

FL → Floor	BB → Baseboard	W1 → Wall #1
W2 → Wall #2	W3 → Wall #3	W4 → Wall #4
CE → Ceiling	DC → Door Casing	DR → Door
WS → Window Sill	WT → Window Trough	WH → Window Sash
WC → Window Casing	IN → General Interior	EX → Exterior
OB → Out Building		

Photo ID	Room/Location Photographed	Photo Description

1. Date Photographs downloaded from camera: [ ]

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

Form 6. Permission for XRF Inspection of a Privately-Owned Property

Purpose of the Study

The U.S. Environmental Protection Agency's (EPA) proposed rule for Renovation, Repair, and Painting (RRP) of pre-1978 housing units with lead based paint was published in the Federal Register on January 10, 2006. EPA has contracted with Battelle Memorial Institute to conduct a study (the "Study") to collect data that is intended to be used to develop a final rule. This Study involves screening housing units or other buildings for lead-based paint and other characteristics necessary for the conduct of the Study; selecting units or other buildings for the Study; conducting renovation, repair, and painting (RRP) jobs under different scenarios to obtain comparative environmental data on the benefits of the EPA proposed rule; and cleaning units and buildings when Study work is completed.

I. Participation in XRF Paint Inspection for the Study

The property that I own at _____ has been identified as a potential Study location because it potentially meets the minimum housing criteria—it was built prior to 1978, is currently vacant, may have a sufficient area of lead based paint present, and is available to undergo RRP work in the appropriate timeframe. Study representatives will schedule one or more visits with me at the property I own (listed above) to conduct a brief interview; conduct a lead screening via x-ray fluorescence (XRF) methods; and perform a visual assessment of the property. If the property is assessed and found to meet all minimum criteria, I may be asked to participate in the Study, and to allow paint chip sampling, RRP jobs, cleaning, and environmental testing to be conducted at the property listed above. The only paint chip sampling that will be done at this time is minor sampling necessary to complete an XRF paint inspection.

II. Benefits to Me

I will be notified of the results of the visual assessment, lead inspection, and environmental sampling in a timely manner. I will receive a report on the results of the XRF inspection, which will identify the location of any lead-based paint found by the XRF testing. Federal regulation requires sellers, landlords, and agents to warn prospective home buyers and tenants of lead-based paint and lead-based paint hazards in pre-1978 housing at the time a home is sold or rented.

III. Confidentiality of Information

Battelle, EPA, and other Study representatives will keep all my personal identifiers for the study private and confidential. Data may be may be published in a report or shared with other researchers only after my personal identifiers—such as my name and the street address of my residence or the home I own—have been removed.

IV. Availability of Information

Any questions that I may have concerning any aspect of this Study will be answered by Tim Pivetz of Battelle at (614) 424-5365.

V. Fiscal Responsibility

All environmental tests and activities that are conducted as part of this Study will be done at no charge to me. The XRF inspection and any subsequent Study activities are not intended to abate existing lead-based paint or existing lead-based paint hazards.

VI. Signatures

I, _____, consent to allow an XRF inspection for lead based paint in my property for the EPA RRP Evaluation being conducted in _____.

_____ Date: _____

Property Owner

_____ Date: _____

Witness (Study representative)

Original to: ***** _____ *****

FORM 7: INTERIOR PAINT CHIP COLLECTION

UNIT ID	Street Address
ROOM #	Date of Sample

Paint Chip Collection

Collect one paint chip sample on each of the possible lead-based paint components in each room, with a duplicate sample on large components (walls, ceilings, baseboards, etc.). For components not listed, or additional samples taken, please use space for additional components and be sure to record the type and location of the sample. Place one Sample ID label on collection centrifuge and the corresponding Sample ID label here. Please describe the location of the sample and the sample size.

Otherwise code: A - Component Not Present B - Component Not Painted C - Component Painted but not tested

Component Type	Sample #1:	SAMPLE ID		Sample #2	SAMPLE ID	
		Location	Sample Size		Location	Sample Size
Floor						
	____ft. from WALL 1 ____ft. from WALL 2		_____" x _____"	____ft. from WALL 1 ____ft. from WALL 2		_____" x _____"
Ceiling						
	____ft. from WALL 1 ____ft. from WALL 2		_____" x _____"	____ft. from WALL 1 ____ft. from WALL 2		_____" x _____"
Wall #1						
	Height: ____ft. ____ft. from WALL___		_____" x _____"	Height: ____ft. ____ft. from WALL___		_____" x _____"
Wall #2						
	Height: ____ft. ____ft. from WALL___		_____" x _____"	Height: ____ft. ____ft. from WALL___		_____" x _____"
Wall #3						
	Height: ____ft. ____ft. from WALL___		_____" x _____"	Height: ____ft. ____ft. from WALL___		_____" x _____"

Notes:

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID	ROOM #

Component Type	Sample #1:	SAMPLE ID		Sample #2	SAMPLE ID	
		Location	Sample Size		Location	Sample Size
Wall #4						
	Height: ____ft. ____ft. from WALL___	_____" x _____"		Height: ____ft. ____ft. from WALL___	_____" x _____"	
Baseboard						
	WALL:____Height:____ft ____ft. from WALL___	_____" x _____"		WALL:____Height:____ft ____ft. from WALL___	_____" x _____"	
Door Casing						
	WALL:____Height:____ft ____ft. from WALL___	_____" x _____"		WALL:____Height:____ft ____ft. from WALL___	_____" x _____"	
Door						
	WALL:____Height:____ft ____ft. from WALL___	_____" x _____"		WALL:____Height:____ft ____ft. from WALL___	_____" x _____"	
Window Sill						
	WALL:____Height:____ft ____ft. from WALL___	_____" x _____"		WALL:____Height:____ft ____ft. from WALL___	_____" x _____"	
Window Trough						
	WALL:____Height:____ft ____ft. from WALL___	_____" x _____"		WALL:____Height:____ft ____ft. from WALL___	_____" x _____"	
Window Sash						
	WALL:____Height:____ft ____ft. from WALL___	_____" x _____"		WALL:____Height:____ft ____ft. from WALL___	_____" x _____"	
Window Casing						
	WALL:____Height:____ft ____ft. from WALL___	_____" x _____"		WALL:____Height:____ft ____ft. from WALL___	_____" x _____"	

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

UNIT ID	ROOM #

ADDITIONAL COMPONENTS

Please use similar location descriptions as above

Component Type	Sample #1:	SAMPLE ID		Sample #2	SAMPLE ID	
		Location	Sample Size		Location	Sample Size
			____" x ____"			____" x ____"
			____" x ____"			____" x ____"
			____" x ____"			____" x ____"
			____" x ____"			____" x ____"
			____" x ____"			____" x ____"
			____" x ____"			____" x ____"
			____" x ____"			____" x ____"

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

FORM 8: EXTERIOR PAINT CHIP COLLECTION

UNIT ID	Street Address
WALL #	Date of Sample

Paint Chip Collection

Collect one paint chip sample on each of the possible lead-based paint components on each exterior wall, with a duplicate sample on large components (walls, ceilings, baseboards, etc.). For components not listed, or additional samples taken, please use space for additional components and be sure to record the type and location of the sample. Place one Sample ID label on collection centrifuge and the corresponding Sample ID label here. Please describe the location of the sample and the sample size.

Otherwise code: A - Component Not Present B - Component Not Painted C - Component Painted but not tested

Component Type	Sample #1:	Sample ID		Sample #2	Sample ID	
		Location	Sample Size		Location	Sample Size
Wall (Siding)						
	Height: ____ft. ____ft. from WALL___	_____" x _____"		Height: ____ft. ____ft. from WALL___	_____" x _____"	
Trim						
	Height: ____ft. ____ft. from WALL___	_____" x _____"		Height: ____ft. ____ft. from WALL___	_____" x _____"	
Door						
	Height: ____ft. ____ft. from WALL___	_____" x _____"		Height: ____ft. ____ft. from WALL___	_____" x _____"	
Door Casing						
	Height: ____ft. ____ft. from WALL___	_____" x _____"		Height: ____ft. ____ft. from WALL___	_____" x _____"	
Window Sill						
	Height: ____ft. ____ft. from WALL___	_____" x _____"		Height: ____ft. ____ft. from WALL___	_____" x _____"	

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

UNIT ID	WALL #

Component Type	Sample #1:	Sample ID		Sample #2	Sample ID	
		Location	Sample Size		Location	Sample Size
Window Sash						
	Height: ____ft. ____ft. from WALL___	_____" x _____"		Height: ____ft. ____ft. from WALL___	_____" x _____"	
Window Casing						
	Height: ____ft. ____ft. from WALL___	_____" x _____"		Height: ____ft. ____ft. from WALL___	_____" x _____"	

ADDITIONAL COMPONENTS

Please use similar location descriptions as above

Component Type	Sample #1:	SAMPLE ID		Sample #2	SAMPLE ID	
		Location	Sample Size		Location	Sample Size
		_____" x _____"			_____" x _____"	
		_____" x _____"			_____" x _____"	
		_____" x _____"			_____" x _____"	
		_____" x _____"			_____" x _____"	
		_____" x _____"			_____" x _____"	

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

APPENDIX E

HUD Guidelines for the Evaluation and Control of Lead-based Paint Hazards in Housing

Chapter 7: Lead-Based Paint Inspection

U.S. Department of Housing and Urban Development

Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing

Chapter 7: Lead-Based Paint Inspection

1997 Revision

Chapter 7: Lead-Based Paint Inspection
Table of Contents

Step-by-Step Summary

Lead-Based Paint Inspection: How to Do It

Note: This 1997 Revision replaces Chapter 7 of the 1995 *HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing*

1. See Chapters 3, 5 and 16 for guidance on when a lead-based paint inspection is appropriate. A lead-based paint inspection will determine:

   - Whether lead-based paint is present in a house, dwelling unit, residential building, or housing development, including common areas and exterior surfaces; and

   - If present, which building components contain lead-based paint.

   The U.S. Department of Housing and Urban Development (HUD) and the U.S. Environmental Protection Agency (EPA) define an inspection as a surface-by-surface investigation to determine the presence of lead-based paint (see 40 CFR part 745 and Title X of the 1992 Housing and Community Development Act). The sampling protocols in this chapter fulfill that definition.

2. The client should hire a certified (licensed) lead-based paint inspector or risk assessor (see 40 CFR part 745). Lists of inspectors and laboratories can be obtained by calling 1-888-LEADLIST or through the Internet at www.leadlisting.org. Lists are also available through State agencies (call 1-800-LEAD-FYI for the appropriate local contact). More than half of all States now require a license or certification to perform a lead-based paint inspection. If the State does not yet have a certification law, an inspector or risk assessor certified under another State's law should be used. By the fall of 1999, all lead-based paint inspections must be performed by a certified lead-based paint inspector or risk assessor in accordance with 40 CFR part 745, section 227.

3. The inspector should use the HUD/EPA standard for lead-based paint of 1.0 mg/cm² or 0.5% by weight, as defined by Title X of the 1992 Housing and Community Development Act. If the applicable standard in the jurisdiction is different, the procedures in this chapter will need to be modified. For the purposes of the HUD/EPA lead-based paint disclosure rule, 1.0 milligrams per square centimeter (mg/cm²) or 0.5% by weight are the standards that must be used.

4. Obtain the *XRF Performance Characteristic Sheet* for the X-Ray Fluorescence (XRF) lead paint analyzer to be used in the inspection. It will specify the ranges where XRF results are positive, negative or inconclusive, the calibration check tolerances, and other important information. Contact the National Lead Information Center Clearinghouse (1-800-424-LEAD) to obtain the appropriate *XRF Performance Characteristic Sheet*, or download it from the Internet at www.hud.gov/lea/leahome.html. *XRF Performance Characteristic Sheets* have been developed by HUD and EPA for most commercially available XRFs (see Addendum 3 of this chapter).

5. Report lead paint amounts in mg/cm² because this unit of measurement does not depend on the number of layers of non-lead-based paint and can usually be obtained without damaging the painted surface. All measurements of

lead in paint should be in mg/cm², unless the surface area cannot be measured or if all paint cannot be removed from the measured surface area. In such cases, concentrations may be reported in weight percent (%) or parts per million by weight (ppm).

6. Follow the radiation safety procedures explained in this chapter, and as required by the U.S. Nuclear Regulatory Commission and applicable State and local regulations when using XRF instruments.

7. Take at least three calibration check readings before beginning the inspection. Additional calibration check readings should be made every 4 hours or after inspection work has been completed for the day, or according to the manufacturer's instructions, whichever is most frequent. Calibration checks should always be done before the instrument is turned off and again after it has been warmed up (calibration checks do not need to be done each time an instrument enters an automatic "sleep" state while still powered on).

8. When conducting an inspection in a multifamily housing development or building, obtain a complete list of all housing units, common areas, and exterior site areas. Determine which can be grouped together for inspection purposes based on similarity of construction materials and common painting histories. In each group of similar units, similar common areas, and similar exterior sites, determine the minimum number of each to be inspected from the tables in this chapter. Random selection procedures are explained in this chapter.

9. For each unit, common area, and exterior site to be inspected, identify all testing combinations in each room equivalent. A testing combination is characterized by the room equivalent, the component type, and the substrate. A room equivalent is an identifiable part of a residence (e.g., room, house exterior, foyer, etc.). Painted surfaces include any surface coated with paint, shellac, varnish, stain, paint covered by wallpaper, or any other coating. Wallpaper should be assumed to cover paint unless building records or physical evidence indicates no paint is present.

10. Take at least one individual XRF reading on each testing combination in each room equivalent. For walls, take at least four readings (one reading on each wall) in each room equivalent. A different visible color does not by itself result in a separate testing combination. It is not necessary to take multiple XRF readings on the same spot, as was recommended in the 1990 Interim Guidelines for Public and Indian Housing.

11. Determine whether to correct the XRF readings for substrate interference by consulting the *XRF Performance Characteristic Sheet*. If test results for a given substrate fall within the substrate correction range, take readings on that bare substrate scraped completely clean of paint, as explained in this chapter.

12. Classify XRF results for each testing combination. Readings above the upper limit of the inconclusive range are considered positive, while readings below the lower limit of the inconclusive range are considered negative. Readings within the inconclusive range (including its boundary values) are classified as inconclusive. Some instruments have a threshold value separating ranges of readings considered positive from readings considered negative for a given substrate. Readings at or above the threshold are considered positive, while readings below the threshold are considered negative.

13. In single-family housing inspections, all inconclusive readings must be confirmed in the laboratory, unless the client wishes to assume that all inconclusive results are positive. Such an assumption may reduce the cost of an inspection, but it will probably increase subsequent abatement, interim control, and maintenance costs, because laboratory analysis often shows that testing combinations with inconclusive readings do not in fact contain lead-based paint. Inconclusive readings cannot be assumed to be negative.

14. In multifamily dwelling inspections, XRF readings are aggregated across units and room equivalents by component type. Use the flowchart provided in this chapter (Figure 7.1) to make classifications of all testing combinations or component types in the development as a whole, based on the percentages of positive, negative, and inconclusive readings.

15. If the inspector collected paint-chip samples for analysis, they should be analyzed by a laboratory recognized under the EPA's National Lead Laboratory Accreditation Program (NLLAP). Paint-chip samples are collected when the overall results for a component type are inconclusive. They may be collected by a properly trained and certified inspector, client, or third party, if permitted by State law. Paint-chip samples should contain all layers of paint (not just peeled layers) and must always include the bottom layer. If results will be reported in mg/cm^2, including a small amount of substrate with the sample will not significantly bias results. Substrate material should not, however, be included in samples reported in weight percent. Paint from 4 square inches (25 square centimeters) should provide a sufficient quantity for laboratory analysis. Smaller surface areas may be used, if the laboratory indicates that a smaller sample is acceptable. In all cases, the surface area sampled must be recorded.

16. The client or client's representative should evaluate the quality of the inspection using the procedures in this chapter.

17. The inspector should write an inspection report indicating if and where lead-based paint is located in the unit or the housing development (or building). The report should include a statement that the presence of lead-based paint must be disclosed to potential new buyers (purchasers) and renters (lessees) prior to obligation under a sales contract or lease, based on Federal law (see 24 CFR part 35, subpart H or 40 CFR part 745, subpart F). The suggested language below may be used. The inspection report should contain detailed information on the following:

    - Who performed the inspection;
    - Date(s);
    - Inspector's certification number;
    - All XRF readings;
    - Classification of all surfaces into positive or negative (but not inconclusive) categories, based on XRF and laboratory analyses;
    - Specific information on the XRF and laboratory methodologies;
    - Housing unit and sampling location identifiers;
    - Results of any laboratory analyses; and
    - Additional information described in Section IV of this chapter.

This chapter also contains language that may be used in an inspection report in the case where no lead-based paint has been identified (see the suggested language below).

Recommended Report Language On Disclosure For Use In Lead-Based Paint Inspections

"A copy of this summary must be provided to new lessees (tenants) and purchasers of this property under Federal law (24 CFR part 35 and 40 CFR part 745) before they become obligated under a lease or sales contract. The complete report must also be provided to new purchasers and it must be made available to new tenants. Landlords (lessors) and sellers are also required to distribute an educational pamphlet approved by the U.S. Environmental Protection Agency and include standard warning language in their leases or sales contracts to ensure that parents have the information they need to protect their children from lead-based paint hazards."

(See Section IV of Chapter 7 of the HUD *Guidelines* for further details)

Recommended Report Language for Inspections Where No Lead-Based Paint Was Identified

"The results of this inspection indicate that no lead in amounts greater than or equal to 1.0 mg/cm^2 in paint was found on any building components, using the inspection protocol in Chapter 7 of the *HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing (1997 Revision)*. Therefore, this dwelling qualifies for the exemption in 24 CFR part 35 and 40 CFR part 745 for target housing being leased that is free of lead-based paint, as defined in the rule. However, some painted surfaces may contain levels of lead below 1.0 mg/cm^2, which could create lead dust or lead-contaminated soil hazards if the paint is turned into dust by abrasion, scraping, or sanding. This report should be kept by the inspector and should also be kept by the owner and all future owners for the life of the dwelling."

(See Section IV of Chapter 7 of the HUD *Guidelines* for further details)

Chapter 7: Lead-Based Paint Inspection

Note: This 1997 Revision replaces Chapter 7 of the 1995 *HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing*

I. Introduction

A. Purpose

This chapter explains methods for performing lead-based paint inspections in housing to determine:

- Whether lead-based paint is present in a house, dwelling unit, residential building, or housing development, including common areas and exterior surfaces; and
- If present, which building components contain lead-based paint.

The information presented here is intended for both inspectors and persons who purchase inspection services (clients). Both an inspection protocol and methods for determining the quality of an inspection are provided. Means for locating certified lead inspectors are also described.

1. Disclosure of Inspections

Federal law now requires that the results of lead-based paint inspections and risk assessments be disclosed to prospective renters (lessees, tenants) entering into a new lease and renters renewing an old lease, and to prospective purchasers prior to obligation under a sales contract, if lead-based paint is found. If the inspection described in this chapter finds that lead-based paint is not present in units which are to be leased, the dwelling unit and, for multifamily housing, all other dwelling units characterized by the inspection are exempt from disclosure requirements. However, for dwelling units which are being sold (not leased), the owner still has certain legal responsibilities to fulfill under Federal law *even if no lead-based paint is identified*. See the HUD and EPA regulations in 24 CFR part 35 or 40 CFR part 745, respectively, for additional details.

You may contact the National Lead Information Center Clearinghouse (1-800-424-LEAD) to obtain HUD and EPA brochures, question-and-answer booklets, the regulations mentioned above (and the descriptive preamble to those regulations), and other information on lead-based paint disclosure. See Section IV for recommended inspection report language regarding these disclosure requirements.

2. Limitation of this Inspection Protocol

The protocol described here is not intended for investigating housing units where children with elevated blood lead levels are currently residing. Such a protocol can be found in Chapter 16 or may be available from a State or local health department.

3. Documentation of Results

The complete set of forms provided at the end of this chapter may be used in single-family and multifamily housing. Equivalent forms or computerized reports may also be used to document the results of inspections.

B. Qualifications of Inspectors and Laboratories

1. Where to Find Inspectors and Laboratories

Lists of State-licensed (certified) inspectors and accredited laboratories recognized under the U.S. Environmental Protection Agency (EPA) National Lead Laboratory Accreditation Program (NLLAP) are often available from State or local agencies. Call the National Lead Information Center Clearinghouse (1-800-424-LEAD) to locate the appropriate local contact.

A nationwide listing of certified inspectors, risk assessors, and accredited laboratories is also available on the Internet at www.leadlisting.org. The lists are

also available through an automated telephone system by calling 1-888-LEADLIST (1-888-532-3547).

2. Qualifications of Inspectors

The inspector must be certified (licensed) in lead-based paint inspection by the State where the testing is to be done if it has an inspection certification program; if the State does not have such a program, the inspector should be certified by another State. Currently, more than half of all States have such licensing laws. By the fall of 1999, all lead-based paint inspections must be performed only by a certified lead-based paint inspector or risk assessor in accordance with the work practices of 40 CFR part 745, section 227 (see the regulation for specific effective dates for States and Indian Tribes).

C. Other Sources of Information Required to Use This Protocol

The other sources of information and materials needed for using this protocol include an *XRF Performance Characteristic Sheet*, U.S. Nuclear Regulatory Commission and State radiation protection regulations, and standards issued by the American Society for Testing and Materials (ASTM). The National Institute of Standards and Technology (NIST) produces Standard Reference Materials (SRMs) and provides supporting documentation for these materials.

1. XRF Performance Characteristic Sheet

An *XRF Performance Characteristic Sheet* defines acceptable operating specifications and procedures for each model of X-Ray Fluorescence (XRF) lead-based paint analyzer. An inspector should follow the *XRF Performance Characteristic Sheet* for all inspection activities. For most commercially available XRFs, *XRF Performance Characteristic Sheets* are available from the National Lead Information Center Clearinghouse or through the Internet at www.hud.gov/lea/leahome.html. They are also included in a new, easy-to-use format in Addendum 3 to this chapter.

2. XRF Radiation Protection Regulations

Regulations that govern radioactive sources used in XRFs are available from State radiation protection agencies, and the Nuclear Regulatory Commission (301-415-7000).

3. ASTM and NIST Standards

Other helpful information and standards are available from ASTM (610-832-9585), including:

- ASTM E 1583 on evaluating laboratories used to determine lead levels
- ASTM E 1605 on terminology
- ASTM E 1613 on determining lead by atomic emission or atomic absorption spectroscopy
- ASTM E 1645 on laboratory preparation of paint-chip samples
- ASTM E 1729 on collecting paint-chip samples
- ASTM E 1775 on-site extraction and field-portable stripping voltammetry analysis for lead
- ASTM PS 53 on identifying and managing lead in facilities
- ASTM PS 87 on ultrasonic extraction for later analysis for lead
- ASTM PS 88 on determining lead by portable electroanalysis

NIST (301-975-6776) has developed series of paint films that have known amounts of lead-based paint and can be used for calibration check purposes. NIST Standard Reference Material 2579 is available as of mid-1997; NIST is planning to release additional series of paint films in late 1997 or early 1998 (see Section IV.D, below).

D. Paint Testing for Inspections and Risk Assessments

Risk assessments determine the presence of lead-based paint *hazards*, while inspections determine the presence of lead-based paint. The paint-chip sampling and measurement techniques used for paint inspections are similar to the techniques used for risk assessment. However, the number of paint measurements or samples taken for a paint inspection is considerably greater than the number of paint samples required for a risk assessment, because risk assessments measure lead only in deteriorated paint (risk assessments also measure lead in dust and soil). Inspections measure lead in both deteriorated and

intact paint, which involves many more surfaces. Risk assessments always note the condition of paint films; inspections may not. For dwellings in good condition, a full risk assessment may be unnecessary, and a lead hazard screen risk assessment may be conducted. In a lead hazard screen or risk assessment, the certified risk assessor tests only painted surfaces in "deteriorated" condition for their lead content, either by XRF or laboratory analysis. See Chapter 5 for methods to determine the condition of paint films when conducting a risk assessment.

E. Most Common Inspection Method

Portable XRF lead-based paint analyzers are the most common primary analytical method for inspections in housing because of their demonstrated abilities to determine if lead-based paint is present on many surfaces and to measure the paint without destructive sampling or paint removal, as well as their high speed and low cost per sample. Portable XRF instruments expose a building component to X rays or gamma radiation, which causes lead to emit X rays with a characteristic frequency or energy. The intensity of this radiation is measured by the instrument; the inspector must then compare this displayed value (reading) with the inconclusive range or threshold specified in the *XRF Performance Characteristic Sheet* for the specific XRF instrument being used, and the specific substrate beneath the painted surface (see Section IV.G, below). If the reading is less than the lower boundary of the inconclusive range, or less than the threshold, then the reading is considered negative. If the reading is greater than the upper boundary of the inconclusive range, or greater than or equal to the threshold, then the reading is considered positive. Readings within the inconclusive range, including its boundary values, are considered inconclusive. Because the inconclusive ranges and/or thresholds shown in the Performance Characteristic Sheet are based on 1.0 mg/cm^2, positive and negative readings are consistent with the HUD definition of lead-based paint for identification and disclosure purposes.

F. XRF Performance Characteristic Sheets and Manufacturer's Instructions

Only XRF instruments that have a HUD/EPA-issued or equivalent *XRF Performance Characteristic Sheet* should be used. XRFs must be used in accordance with the manufacturer's instructions and the *XRF Performance Characteristic Sheet*. The *XRF Performance Characteristic Sheet* contains information about XRF readings taken on specific substrates, calibration check tolerances, interpretation of XRF readings (see section I.E, above), and other aspects of the model's performance. If discrepancies exist between the *XRF Performance Characteristic Sheet*, the HUD *Guidelines* and the manufacturer's instructions, the most stringent guidelines should be followed. For example, if the *XRF Performance Characteristic Sheet* has a lower (more stringent) calibration check tolerance than the manufacturer's instructions, the *XRF Performance Characteristic Sheet* should be followed. These *Guidelines* and the *XRF Performance Characteristic Sheets* are applicable to all XRF instruments that detect K X rays, L X rays, or both.[1]

G. Inspection by Paint Chip Analysis

Performing inspections by the sole use of laboratory paint chip analysis is not recommended because it is time-consuming, costly, and requires extensive repair of painted surfaces. Laboratory analysis of paint-chip samples *is* recommended for inaccessible areas or building components with irregular (non-flat) surfaces that cannot be tested using XRF instrumentation. Laboratory analysis is also recommended to confirm inconclusive XRF results, as specified on the applicable *XRF Performance Characteristic Sheet*. Some newer laboratory analytical methods can provide results within minutes (see section I.H, below). Only laboratories recognized under the EPA NLLAP should be used. Laboratory analysis is more accurate and precise than XRF but only if great care is used to collect and analyze the paint-chip sample. Laboratory results should be reported as mg/cm^2. Appendix 1 of these *Guidelines* explains why units of mg/cm^2 are not dependent on the number of overcoats of lead-free paint and why such units of measure are therefore more reliable than weight percent. The dimensions of the area from which a paint-chip sample is removed must be measured as accurately as possible (to the nearest millimeter or 1/16th of an inch).

Although laboratory results can also be reported as a percentage of lead by weight of the paint sample, percents should only be used when it is not feasible to use mg/cm^2. These two units of measure are not interchangeable. Laboratory results should be reported as mg/cm^2 if the surface area can be accurately measured and if all paint within that area is collected.

In mg/cm² measurements, collecting small amounts of substrate material with the sample does not bias the results significantly, although having any amount of substrate in the sample can result in less precise results. In weight percent measurements, however, no substrate may be included because the substrate will "dilute" the amount of lead reported. Regardless of the units of measurement selected, the bottom layer of paint must always be included in the sample. If a visual examination shows that the bottom layer of paint appears to have "bled" into the substrate, a very thin upper portion of the substrate should be included in the sample to ensure that all lead within the sample area has been included in the sample. In cases where significant amounts of substrate are included in the sample, the results should always be reported in mg/cm².

See Section VI for additional information on laboratory analysis.

H. Additional Means of Analyzing Paint

Methods of analyzing lead in paint are available in addition to XRF and laboratory paint chip analysis, including transportable instruments and chemical test kits. Because these methods involve paint removal or disturbance, repair is needed after sampling, unless the substrate will be removed, encapsulated, enclosed, or repainted before occupancy (see Section VI), or if analysis shows that the paint is not lead-based paint, and leaving the damage is acceptable to the client and/or the owner.

1. Mobile Laboratories

Portable instruments that employ anodic stripping voltammetry and potentiometric stripping voltammetry are now available. Their use is described in ASTM Provisional Standard Practice PS 88. Also, ASTM Standard Guide E 1775 may be used as a basis for evaluating the performance of on-site extraction and electrochemical and spectrophotometric analyses. If the organization using a portable instrument is recognized under the EPA NLLAP and used that type of instrument to obtain the laboratory's recognition, they can be used in the same way as any other NLLAP-recognized laboratory. In short, both fixed-site and mobile laboratories may be used, provided they are recognized under NLLAP.

2. Chemical Test Kits

Chemical test kits are intended to show a color change when a part of the kit makes contact with the lead in lead-based paint. One type of chemical test kit is based on the formation of lead sulfide, which is black, when lead in paint reacts with sodium sulfide. Another is based on the formation of a red or pink color when lead in paint reacts with sodium rhodizonate.

EPA did not find that chemical spot test kits are sufficiently reliable for use in lead-based paint inspection, and recommended that they not be used (EPA 1995). HUD and EPA may recommend them in the future for inspections if chemical test kit technology is demonstrated to be equivalent to XRF or laboratory paint chip analysis in its ability to properly classify painted surfaces into positive, negative, and inconclusive categories, with appropriate estimates of the magnitude of sampling and analytical error. *XRF Performance Characteristic Sheets* currently provide such estimates for XRFs, and analytical error is well-described for laboratory analysis. HUD is currently funding the National Institute for Standards and Technology (NIST) and other researchers to evaluate commercially available chemical test kits and provide the basis for improved chemical test kits. Information on test kits or other new technologies for testing for lead in paint can be obtained from the National Lead Information Center Clearinghouse (1-800-424-LEAD).

II. Summary of XRF Radiation Safety Issues

Radiation hazards associated with the use of XRFs are covered in detail in Section VII. The shutter of an XRF must never be pointed at anyone, even if the shutter is closed. Inspectors should wear radiation dosimeters to measure their exposure, although excessive exposures are highly unlikely if the instruments are used in accordance with the manufacturer's instructions. If feasible, persons should not be near the other side of a wall, floor, ceiling, or other surface being tested.

III. Definitions

Definitions of several key terms used in this chapter are provided here. Some additional definitions may be found in ASTM Standard E 1605, Standard Terminology Relating to Abatement of Hazards from Lead-based Paint on Buildings and Related Structures, and in other standard chemical, statistical, architectural and engineering dictionaries and texts. For terms discussed both here and in the ASTM document, the definitions and descriptions in this chapter should be used.

Lead-based paint - Lead-based paint means paint or other surface coatings that contain lead equal to or greater than 1.0 mg/cm^2 or 0.5 percent by weight (equivalent units are: 5,000 µg/g, 5,000 mg/kg, or 5,000 ppm by weight). Surface coatings include paint, shellac, varnish, or any other coating, including wallpaper which covers painted surfaces.

Lead loading - The mass of lead in a given surface area on a substrate. Lead loading is typically measured in units of milligrams per square centimeter (mg/cm^2). It is also called area concentration.

Room equivalent - A room equivalent is an identifiable part of a residence, such as a room, a house exterior, a foyer, staircase, hallway, or an exterior area (exterior areas contain items such as play areas, painted swing sets, painted sandboxes, etc.). Closets or other similar areas adjoining rooms should not be considered as separate room equivalents unless they are obviously dissimilar from the adjoining room equivalent. Most closets are not separate room equivalents. Exteriors should be included in all inspections. An individual side of an exterior is not considered to be a separate room equivalent, unless there is visual or other evidence that its paint history is different from that of the other sides. All sides of a building (typically two for row houses or four for freestanding houses) are generally treated as a single room equivalent if the paint history appears to be similar. For multifamily developments or apartment buildings, common areas and exterior sites are treated as separate types of units, not as room equivalents (see section V.C.1 for further guidance).

Substrate - The substrate is the material underneath the paint. Substrates should be classified into one of six types: brick, concrete, drywall, metal, plaster, or wood. These substrates cover almost all building materials that are painted and are linked to those used in the *XRF Performance Characteristic Sheets*. For example, the concrete substrate type includes poured concrete, precast concrete, and concrete block.

If a painted substrate is encountered that is different from the substrate categories shown on the *XRF Performance Characteristic Sheet*, select the substrate type that is most similar in density and composition to the substrate being tested. For example, for painted glass substrates, an inspector should select the concrete substrate, because it has about the same density (2.5 g/cm^3) and because the major element in both is silicon.

For components that have layers of different substrates, such as plaster over concrete, the substrate immediately adjacent to (underneath) the painted surface should be used. For example, plaster over concrete block is recorded as plaster.

Testing Combination - A testing combination is a unique combination of room equivalent, building component type, and substrate. Visible color may not be an accurate predictor of painting history and is not included in the definition of a testing combination. Table 7.1 lists common building component types that could make up distinct testing combinations within room equivalents. The list is not intended to be complete. Unlisted components that are coated with paint, varnish, shellac, wallpaper, stain, or other coating should also be considered as a separate testing combination.

Certain building components that are adjacent to each other and not likely to have different painting histories can be grouped together into a single testing combination, as follows:

- Window casings, stops, jambs and aprons are a single testing combination
- Interior window mullions and window sashes are a single testing combination--do not group interior mullions and sashes with exterior mullions and sashes
- Exterior window mullions and window sashes are a single testing combination
- Door jambs, stops, transoms, casings and other door frame parts are a single testing combination
- Door stiles, rails, panels, mullions and other door parts are a single testing combination

- Baseboards and associated trim (such as quarter-round or other caps) are a single testing combination (do not group chair rails, crown molding or walls with baseboards)
- Painted electrical sockets, switches or plates can be grouped with walls

Each of these building parts should be tested separately if there is some specific reason to believe that they have a different painting history. In most cases, separate testing will not be necessary.

Table 7.1: Examples of Interior and Exterior Building Component Types

Commonly Encountered Interior Painted Components That Should Be Tested Include:	
Air Conditioners	Fireplaces
Balustrades	Floors
Baseboards	Handrails
Bathroom Vanities	Newel Posts
Beams	Other Heating Units
Cabinets	Radiators
Ceilings	Shelf Supports
Chair Rails	Shelves
Columns	Stair Stringers
Counter Tops	Stair Treads and Risers
Crown Molding	Stools and Aprons
Doors and Trims	Walls
Painted Electrical Fixtures	Window Sashes and Trim

Exterior Painted Components That Should Be Tested Include:	
Air Conditioners	Handrails
Balustrades	Lattice Work
Bulkheads	Mailboxes
Ceilings	Painted Roofing
Chimneys	Railing Caps
Columns	Rake Boards
Corner boards	Sashes
Doors and Trim	Siding
Fascias	Soffits
Floors	Stair Risers and Treads
Gutters and Downspouts	Stair Stringers
Joists	Window and Trim

Other Exterior Painted Components Include:	
Fences	Storage Sheds & Garages
Laundry Line Posts	Swing sets and Other Play Equipment

Table 7.2 provides six examples of different testing combinations. The first example is a wooden bedroom door. This is a testing combination because it is described by a room equivalent (bedroom), component (door), and substrate (wood). If one of these variables is different for another component, that component is a different testing combination. For example, if a second door in the room equivalent is metal, two testing combinations, not one, would be present.

For doors separating rooms, each side of the door is assigned to the room equivalent it faces and is tested separately. The same is true of door casings. For prefabricated metal doors where it is apparent that both sides of the door have the same painting history, only one side needs to be tested.

Table 7.2: Examples of Distinct Testing Combinations

Room Equivalent	Building Component	Substrate
Master Bedroom (Room 5)	Door	Wood
Master Bedroom (Room 5)	Door	Metal
Kitchen (Room 3)	Wall	Plaster
Garage (Room 10)	Floor	Concrete
Exterior	Siding	Wood
Exterior	Swing set	Metal

Building Component Types - A building component type consists of doors, windows, walls, and so on that are repeated in more than one room equivalent in a unit and have a common substrate. If a unique building component is present in only one room, it is considered to be a testing combination. Each testing combination may be composed of more than one building component (such as two similar windows within a room equivalent). Component types can be located inside or outside the dwelling. For example, typical component types in a bedroom would be the ceiling, walls, a door and its casing, the window sash, window casings, and any other distinct surface, such as baseboards, crown molding, and chair rails. If trends or patterns of lead-based paint classifications are found among building component types in different room equivalents, an inspection report may summarize results by building component type, as long as all measurements are included in the report. For example, the inspection may find that all doors and door casings in a dwelling unit are positive.

Test Location - The test location is a specific area on a testing combination where either an XRF reading or a paint-chip sample will be taken.

IV. Inspections in Single-Family Housing

Single-family housing inspections should be conducted by a State- or EPA-certified (licensed) lead-based paint inspector using the following seven steps, some of which may be done at the same time:

- List all testing combinations, including those that are painted, stained, shellacked, varnished, coated, or wallpaper which covers painted surfaces.
- Select testing combinations.
- Perform XRF testing (including the calibration check readings).
- Collect and analyze paint-chip samples for testing combinations that cannot be tested with XRF or that had inconclusive XRF results.
- Classify XRF and paint-chip results.
- Evaluate the work and results to ensure the quality of the paint inspection.
- Document all findings in a plain language summary and a complete report; include language in both the summary and the report indicating that the information must be disclosed to tenants and prospective purchasers in accordance with Federal law (24 CFR part 35 or 40 CFR part 745).

A. Listing Testing Combinations

Develop a list of all testing combinations in all interior rooms, on all exterior building surfaces, and on surfaces in other exterior areas, such as fences, playground equipment, and garages. The "Single-Family Housing LBP Testing Data Sheet" (see Form 7.1 at the end of this chapter) or a comparable data collection instrument may be used for this purpose. An inventory of a house may be completed either before any testing or on a room-by-room basis during testing.

1. Number of Room Equivalents to Inspect

Test all room equivalents inside and outside the dwelling unit. The final report must include a final determination of the presence or absence of lead-based paint on each testing combination in each room equivalent.

For varnished, stained, or similar clear-coated floors, measurements in only one room equivalent are permissible if it appears that the floors in the other room equivalents have the same coating.

2. Number of Testing Combinations to Inspect

Inspect each testing combination in each room equivalent, unless similar building component types with identical substrates (such as windows) are all found to contain lead-based paint in the first five interior room equivalents. In that case, testing of that component type in the remaining room equivalents may be discontinued, *if and only if* the purchaser of the inspection services agrees beforehand to such a discontinuation. The inspector should then conclude that similar building component types in the rest of the dwelling unit also contain lead-based paint. See item 6 entitled, "Conditions for Abbreviation of Testing," later in this section for additional details.

Because it is highly unlikely that testing combinations *known* (and not just presumed) to have been replaced or added to the building after 1977 will contain lead-based paint, they need not be tested. If the age of the testing combination is in doubt, it should be tested.

Some testing combinations have multiple parts. For example, a window testing combination could theoretically be broken down into the interior sill (stool), exterior sill, trough, sash, apron, parting bead, stop bead, casing, and so on. Because it is highly unlikely that all these parts will have different painting histories, they should not usually be considered separate testing combinations. (Inspectors should regard parts of building components as separate testing combinations if they have evidence that different parts have separate, distinct painting histories). See the definition of testing combination (Section III, above) for guidance on which building component parts may and which may not be grouped together.

3. Painted Furniture

Painted furniture that is physically attached to the unit (for example, a desk or dresser that is built-in) should be included in the inspection as a testing combination. Other painted furniture may also be tested, depending on the client's wishes. Children's furniture (such as cribs or playpens), especially if built before 1978, may contain lead-based paint and can be tested, subject to the client's wishes.

4. Building Component Types

Results of an inspection may be summarized by classifying component types across room equivalents if patterns or trends are supported by the data.

5. Substrates

All substrates across all room equivalents should be grouped into one of the six substrate categories (brick, concrete, drywall, metal, plaster, or wood) shown on the *XRF Performance Characteristic Sheet* for the instrument being used. Substrate correction procedures can then be applied for all building component types with the same substrate. For example, the substrate correction procedure for wooden doors and wooden baseboards can use the same substrate correction value (see Section IV.E, below).

6. Conditions for Abbreviation of Testing

If lead-based paint is determined to be present (a "positive" finding) for a building component type with

the same substrate in all of the first five room equivalents inspected, further testing of that component type may be discontinued in the remaining room equivalents within that dwelling unit, *if and only if* the purchaser of inspection services agrees beforehand to such a discontinuation. The inspector should then conclude that the similar building component types in the rest of the dwelling unit also contain lead-based paint. For example, if an inspector finds that baseboards in the first five room equivalents are all positive, the inspector -- with the client's permission -- may conclude that all remaining room equivalents in the unit contain positive baseboards.

B. Number and Location of XRF Readings

1. Number of XRF Readings for Each Testing Combination

XRF testing is required for at least one location per testing combination, except for interior and exterior walls, where four readings should be taken, one on each wall. Previous editions of this chapter stated that three readings for each testing combination were needed to control for spatial variation and other sources of error. Recent analysis[2] of EPA data show a median difference in spatial variation of only 0.1 mg/cm² and a change in classification (positive, negative, or inconclusive) occurs less than 5 percent of the time as a result of different test locations on the same testing combination. Multiple readings on the same testing combination or testing location are, therefore, unnecessary, except for interior and exterior walls.

Because of the large surface areas and quantities of paint involved, and the possibility of increased spatial variation, take at least four readings (one reading on each wall) in each room equivalent. (For room equivalents with fewer than four walls, test each wall.) For each set of walls with the same painting history in a room equivalent, test the four largest walls. Classify each wall based on its individual XRF reading. If a room equivalent has more than four walls, calculate the average of the readings, round the result to the same number of decimal places as the XRF instrument displays, and classify the remaining walls with the same painting history as the tested walls, based on this rounded average. When the remaining walls in a room equivalent clearly do not have the same painting history as that of the tested walls, test and classify the remaining walls individually. For exterior walls, select at least four sides and average the readings (rounding the result as described above) to obtain a result for any remaining sides. If there are more than four walls and the results of the tested walls do not follow a classification pattern (for example, one is positive and the other three are negative), test each wall individually.

2. Location of XRF Readings

The selection of the test location for a specific testing combination should be representative of the paint over the areas which are most likely to be coated with old paint or other lead-based coatings. Thus, locations where the paint appears to be thickest should be selected. Locations where paint has worn away or been scraped off should not be selected. Areas over pipes, electrical surfaces, nails, and other possible interferences should also be avoided if possible. All layers of paint should be included and the XRF probe faceplate should be able to lie flat against the surface of the test location.

If no acceptable location for XRF testing exists for a given testing combination, a paint-chip sample should be collected. The sample should include all paint layers and should be taken as unobtrusively as possible. Because paint chip sampling is destructive, a single sample may be collected from a wall and used to characterize the other walls in a room equivalent (see section VI for additional details on paint chip sampling).

3. Documentation of XRF Reading Locations

Descriptions of testing combinations should be sufficiently detailed to permit another individual to find them. While it is not necessary to document the *exact* spot or the *exact* building component on which the reading was taken, it is necessary to record the *exact* testing combination measured. Current room uses or colors can change and should not be the only way of identifying them. A numbering system, floor plan, sketch or other system may be used to document which testing combinations were tested. While HUD does not require a standard identification system, one that could be used is as follows:

a. Side identification

Identify perimeter wall sides with letters A, B, C, and D (or numbers or Roman numerals). Side A for single-family housing is the street side for the address. Side A in multifamily housing is the apartment entry door side.

Side B, C, and D are identified clockwise from Side A as one faces the dwelling; thus Wall B is to the left, Wall C is across from Side A, and Side D is to the right of Side A.

Each room equivalent's side identification follows the scheme for the whole housing unit. Because a room can have two or more entries, sides should not be allocated based on the entry point. For example, giving a closet a side allocation based on how the room is entered would make it difficult for another person to make an easy identification, especially if the room had two closets and two entryways.

b. Room Equivalent Identification

Room equivalents should be identified by both a number and a use pattern (for example, Room 5-Kitchen). Room 1 can always be the first room, at the A-D junction at the entryway, or it can be the exterior. Rooms are consecutively numbered clockwise. If multiple closets exist, they are given the side allocation: for example, Room 3, Side C Closet. The exterior is always assigned a separate room equivalent identifier.

c. Sides in a Room

Sides in an interior room equivalent follow the overall housing unit side allocation. Therefore, when standing in any four-sided room facing Side C, the room's Side A will always be to the rear, Side B will be to the left, and Side D will be to the right.

d. Building Component Identification

Individual building components are first identified by their room number and side allocation (for example, the radiator in Room 1, Side B is easily identified). If multiple similar component types are in a room (for example, three windows), they are differentiated from each other by side allocation. If multiple components are on the same wall side, they are differentiated by being numbered left to right when facing the components. For example, three windows on Wall D are identified as windows D1, D2, and D3, left to right. If window D3 has the only old original sash, it is considered a separate testing combination from the other two windows.

A sketch of the dwelling unit's floor plan is often helpful, but is not required by this protocol. Whatever documentation is used, a description of the room equivalent and testing combination identification system must be included in the final inspection report.

C. XRF Instrument Reading Time

The recommended time to open an XRF instrument's shutter to obtain a single XRF result for a testing location depends on the specific XRF instrument model and the mode in which the instrument is operating. The *XRF Performance Characteristic Sheet* provides information on this issue.

To ensure that a constant amount of radiation is delivered to the painted surface, the open-shutter time must be increased as the source ages and the radiation source weakens. Almost all commercially available XRF instruments automatically adjust for the age of the source. (Some instruments adjust for source decay in some but not all modes; operators should check with the manufacturers of their instruments to determine whether these differences need to be accommodated). The following formula should be employed for instruments requiring manual adjustment of the open-shutter time:

$$\text{Open-Shutter Time} = 2^{(\text{Age}/\text{Half-life})} \times \text{Nominal Time}$$

where:

Age is the age (in days) of the radioactive source, starting from the date the manufacturer says the source had its full radiation strength;

Half-life is the time (in days) it takes for the radioactive material's activity to decrease to one-half its initial level; and

Nominal Time is the recommended nominal number of seconds for open-shutter time,

when the source is at its full radiation strength, and is obtained from the *XRF Performance Characteristic Sheet.*

For example, if the age of the source is equal to its half-life, the open-shutter time should be twice the nominal time. Thus, if the recommended nominal time is 15 seconds, the open-shutter time should be doubled to 30 seconds.

XRFs typically use Cobalt-57 (with a half life of 270 days) or Cadmium-109 (with a half life of 464 days).

XRF Performance Characteristic Sheets typically report different inconclusive ranges or thresholds (see section IV.G, below) for different nominal times and different substrates. This may affect the number of paint-chip samples that must be collected as well as the length of time required for the inspection. Some XRF devices have different modes of operation with different nominal reading times. Inspectors must use the appropriate inconclusive ranges and other criteria specified on the *XRF Performance Characteristic Sheet* for each XRF model, mode of operation and substrate. For example, inconclusive ranges specified for a 30-second nominal reading cannot be used for a 5-second nominal reading, even for the same instrument and the same substrate.

D. XRF Calibration Check Readings

In addition to the manufacturer's recommended warm up and quality control procedures, the XRF operator should take the quality control readings recommended below, unless these are less stringent than the manufacturer's instructions. Quality control for XRF instruments involves readings to check calibration. Most XRFs cannot be calibrated on-site; actual calibration can only be accomplished in the factory.

1. Frequency and Number of Calibration Checks

For each XRF instrument, two sets of XRF calibration check readings are recommended at least every 4 hours. The first is a set of three nominal-time XRF calibration check readings to be taken before the inspection begins. The second occurs either after the day's inspection work has been completed, or at least every 4 hours, whichever occurs first. To reduce the amount of data that would be lost if the instrument were to go out of calibration between checks, and/or if the manufacturer recommends more frequent calibration checks, the calibration check can be repeated more frequently than every 4 hours. If the XRF manufacturer recommends more frequent calibration checks, the manufacturer's instructions should be followed. Calibration should also be checked before the XRF is turned off (for example, to replace a battery or before a lunch break) and after it is turned on again. For example, if an inspection of a large house took 6 hours, there would be three calibration checks: one at the beginning of the inspection, another after 4 hours, and a third at the end of the inspection.

If the XRF is not turned off as the inspector travels from one dwelling unit to the next, calibration checks do not need to be done after each dwelling unit is completed. For example, in multifamily housing, calibration checks do not need to be done after each dwelling unit is inspected; once every 4 hours is usually adequate.

Some instruments automatically enter a "sleep" or "off" state when not being used continually to prolong battery life. It is not necessary to perform a calibration check before and after each "sleep" state episode, unless the manufacturer recommends otherwise.

2. Calibration Check Standard Materials

XRF calibration check readings are taken on the Standard Reference Material (SRM) paint film nearest to 1.0 mg/cm^2 within the National Institute of Standards and Technology (NIST) SRM used. These films can be obtained by calling (301) 975-6776 and referencing SRM 2579 (NIST is planning to release additional series of paint films in late 1997 or early 1998; the film nearest to 1.0 mg/cm^2 should be used for XRF calibration checks). The cost as of September 26, 1997, for the SRM 2579 set of five films, was $320, including 2-day delivery. Calibration checks should be taken through the SRM paint film with the film positioned at least 1 foot (0.3 meters) away from any potential source of lead. The NIST SRM film should not be placed on a tool box, suitcase, or surface coated with paint, shellac, or any other coating to take calibration check readings. Rather, the NIST SRM film should be attached to a solid (not plywood) wooden board or other nonmetal rigid

substrate such as drywall, or attached directly to the XRF probe. The SRM should be positioned so that readings of it are taken when it is more than 1 foot (0.3 meters) away from a potential source of error. For example, the NIST SRM film can be placed on top of a 1 foot (0.3 meter) thick piece of Styrofoam or other lead-free material, as recommended by the manufacturer before taking readings.

3. Recording and Interpreting Calibration Check Readings

Each time calibration check readings are made, three readings should be taken. These readings should be taken using the nominal time which will be used during the inspection, selected from among those specified in the XRF's Performance Characteristic Sheet. The open shutter time should be adjusted, if necessary, to reflect the age of the radioactive source (see section IV.C, above). The readings can be recorded on the "Calibration Check Test Results" form (Form 7.2), on a comparable form, or stored in the instrument's memory, and printed out or transferred to a computer later. The average of the three calibration check readings should be calculated, rounded to the same number of decimal places as the XRF instrument displays, and recorded on the form.

Large deviations from the NIST SRM value will alert the inspector to problems in the instrument's performance. If the observed calibration check average is outside of the acceptable calibration check tolerance range specified in the instrument's *XRF Performance Characteristic Sheet*, the manufacturer's instructions should be followed to bring the instrument back into control. A successful calibration check should be obtained before additional XRF testing is conducted. Readings not accompanied by successful calibration checks at the beginning and end of the testing period are unreliable and should be repeated after a successful calibration check has been made. If a backup XRF instrument is used as a replacement, it must successfully pass the initial calibration check test before retesting the affected test locations.

This procedure assumes that the HUD/EPA lead-based paint standard of 1.0 mg/cm^2 is being used. If a different standard is being used, other NIST SRMs should be used to determine instrument performance against the different standard. At this time, however, no method for determining performance characteristics using different standards has been developed.

E. Substrate Correction

XRF readings are sometimes subject to systematic biases as a result of interference from substrate material beneath the paint. The magnitude and direction of bias depends on the substrate, the specific XRF instrument being used, and other factors such as temperature and humidity. Results can be biased in either the positive or negative direction and may be quite high.

1. When Substrate Correction Is Not Required

Some XRF instruments do not need to have their readings corrected for substrate bias. Other instruments may only need to apply substrate correction procedures on specific substrates and/or when XRF results are below a specific value. The *XRF Performance Characteristic Sheet* should be consulted to determine the requirements for a specific instrument and each mode of operation (e.g., nominal time, or time required for intended precision). XRF instruments which do not require correction for any substrate, or require corrections on only a few substrates, have an advantage in that they simplify and shorten the inspection process.

2. Substrate Correction Procedure

XRF results are corrected for substrate bias by subtracting a correction value determined separately in each house for each type of substrate where lead paint values are in the substrate correction range indicated on the *XRF Performance Characteristic Sheet.* In single-family housing, the substrate correction value is determined using the specific instrument(s) used in that house. The correction value (formerly called "Substrate Equivalent Lead" or "SEL") is an average of six XRF readings, with three taken from each of two test locations that have been scraped visually clean of their paint coating. The locations selected for removal of paint should have an initial XRF reading on the painted surface of less than 2.5 mg/cm², if possible. If all initial readings on a substrate type are greater than 2.5 mg/cm², the locations with the lowest initial reading should be chosen. Because available data indicate that surfaces with XRF readings in excess of about 3.0 mg/cm² or 4.0 mg/cm² are almost always coated with lead-based paint, and since bleed-through of lead into the substrate may occur, or pipes and similarly interfering building components may be behind the material being evaluated, locations with such high readings should be avoided for substrate correction.

After all XRF testing has been completed but before the final calibration check test has been conducted, XRF results for each substrate type should be reviewed. If any readings fall within the range for substrate correction for a particular substrate, obtain the substrate correction value.

On each selected substrate requiring correction, two different testing combinations must be chosen for paint removal and testing. For example, if the readings are inconclusive for some wooden baseboards, select two baseboards, each from a different room. If some wooden doors also require substrate correction, the inspector should take substrate correction readings on one door and one baseboard. Selecting the precise location of substrate correction should be based on the inspector's ability to remove paint thoroughly from the substrates, the similarity of the substrates, and their accessibility. The XRF probe faceplate must be able to be placed over the scraped area, which should be completely free of paint or other coatings.

The size of the area from which paint is taken depends on the size of the analytical area of the XRF probe faceplate; normally, the area is specified by the manufacturer. To ensure that no paint is included in the bare substrate measurement, the bare area on the substrate should be slightly larger than the analytical area on the XRF probe faceplate.

In all, six readings must be taken for each substrate type that requires correction. All six must be averaged together. Take three readings on the first *bare* substrate area. Record the substrate and XRF readings on the "Substrate Correction Values" form (Form 7.3) or a comparable form. Repeat this procedure for the second *bare* substrate area and record the three readings on the same form. Substrate correction values should be determined using the same instrument used to take readings on the painted surfaces. If more than one XRF model was used to take readings, apply the substrate correction values as specified on each instrument's *XRF Performance Characteristic Sheet.*

Compute the correction value for each substrate type that requires correction by computing the average of all six readings as shown below and recording the results on the "Substrate Correction Values" form. The formula given below should be used to compute the substrate bias correction value for XRF readings taken on a bare substrate that is not covered with NIST SRM film. A different formula should be used when SRM film must be placed over the bare substrate. The *XRF Performance Characteristic Sheet* specifies when this correction is necessary and provides the formula for computing the correction value.

For each substrate type requiring substrate correction, transfer the correction values to the "Single-Family Housing LBP Testing Data Sheet" (Form 7.1). Correct XRF readings for substrate interference by subtracting the correction value from each XRF reading.

Example: Suppose that a house has 50 testing combinations with wood substrates. The *XRF Performance Characteristic Sheet* states that a correction value for XRF results taken on those wood testing combinations that have values less than 4.0 mg/cm² must be computed. Select two test locations from the testing combinations that had uncorrected XRF results of less than 2.5 mg/cm².

Completely remove the paint from these two test locations and take three nominal-time XRF readings on the bare substrate at each location. The six XRF readings at the two random locations are:

Selected Location	Reading (mg/cm^2)		
	First	Second	Third
Wood Master Bedroom Door	1.32	0.91	1.14
Kitchen Wood Baseboard (Room 4)	1.21	1.03	1.43

The correction value is the average of the six values:

Correction value = $(1.32 + 0.91 + 1.14 + 1.21 + 1.03 + 1.43)\ mg/cm^2 / 6 = 1.17\ mg/cm^2$

In this same house, three different wood testing combinations were inspected for lead-based paint and the XRF results are: 1.63 mg/cm^2, 3.19 mg/cm^2, and 1.14 mg/cm^2. Correcting these three XRF measurements for substrate bias produces the following results:

First corrected measurement =
1.63 mg/cm^2 - 1.17 mg/cm^2 = 0.46 mg/cm^2

Second corrected measurement =
3.19 mg/cm^2 - 1.17 mg/cm^2 = 2.02 mg/cm^2

Third corrected measurement =
1.14 mg/cm^2 - 1.17 mg/cm^2 =-0.03 mg/cm^2

The third corrected result shown above is an example of how random error in XRF measurements can cause the corrected result to be less than zero. (Random measurement error is present whenever measurements are taken). Note that correction values can be either positive or negative. In short, negative corrected XRF values should be reported if supported by the data.

Finally, suppose an XRF result of 1.24 mg/cm^2 has a correction value of negative 0.41 mg/cm^2. Subtracting a negative number is the same as adding its positive value. Therefore, the corrected measurement would be:

Corrected result = 1.24 mg/cm^2 - (-0.41 mg/cm^2) =
1.24 mg/cm^2 + 0.41 mg/cm^2 = 1.65 mg/cm^2

3. Negative Values

If more than 20 percent of the corrected values are negative, the instrument's lead paint readings and/or the substrate readings are probably in error. Calibration should be checked and substrate measurements should be repeated.

F. Discarding Readings

If the manufacturer's instructions call for the deletion of readings at specific times, *only* readings taken at those specific times should be deleted. Similarly, readings between a successful calibration check and a subsequent unsuccessful calibration check must be discarded. Readings should not be deleted based on any criteria other than what is specified by the manufacturer's instructions or the *HUD Guidelines*. For example, a manufacturer may instruct operators to discard the first XRF reading after a substrate change. If so, *only* the first reading should be discarded after a substrate change.

G. Classification of XRF Results

XRF results are classified as positive, negative, or inconclusive.

A *positive* classification indicates that lead is present on the testing combination at or above the HUD/EPA standard of 1.0 mg/cm^2. A positive XRF result is any

value greater than the upper bound of the inconclusive range, or greater than or equal to the threshold, as specified on the applicable *XRF Performance Characteristic Sheet.*

A *negative* classification indicates that lead is not present on the testing combination at or above the HUD/EPA standard. A negative XRF result is any value less than the lower bound of the inconclusive range, or less than the threshold, specified on the performance characteristic sheet.

An *inconclusive* classification indicates that the XRF cannot determine with reasonable certainty whether lead is present on the testing combination at or above the HUD/EPA standard. An inconclusive XRF result is any value falling within the inconclusive range on the performance characteristic sheet (including the boundary values defining the range). In single-family housing, all inconclusive results should be confirmed by laboratory analysis, unless the client wishes to assume that all inconclusive results are positive.

Positive, negative, and inconclusive results apply to the actual testing combination and to any repetitions of the testing combination that were not tested in the room equivalents. Positive results also apply to similar component types in room equivalents that were not tested. For example, suppose that one baseboard in a room equivalent is tested, and that the inspector decided that all four baseboards are a single testing combination. The single XRF result applies to all four baseboards in that room equivalent.

When an inconclusive range is specified on the *XRF Performance Characteristic Sheet*, XRF results are classified as positive if they are greater than the upper boundary of the inconclusive range, negative if they are less than the lower boundary of the inconclusive range, or inconclusive if in between. The inconclusive range on the *XRF Performance Characteristic Sheets* in Addendum 3 of these *Guidelines* includes its upper and lower bounds. Earlier editions of this guide and earlier *XRF Performance Characteristic Sheets* did not include the bounds of the inconclusive range as "inconclusive." This 1997 edition of Chapter 7 of the HUD Guidelines changes that system, but the specific XRF readings that are considered positive, negative, or inconclusive for a given XRF model and substrate remain unchanged, so previous inspection results are not affected.

For example, if the inconclusive range given in the *XRF Performance Characteristic Sheet* is 0.51 mg/cm² to 1.49 mg/cm², an XRF result of 0.50 mg/cm² is considered negative, because it is less than 0.51; a result of 0.6 mg/cm² is inconclusive; and a result of 1.5 mg/cm² is positive. A result of 0.51 mg/cm², 1.00 mg/cm², or 1.49 mg/cm² would be inconclusive.

Different XRF models have different inconclusive ranges, depending on the specific XRF model and the mode of operation. The inconclusive range may also be substrate-specific.

In some cases, the upper and lower limits of the inconclusive range are equal; that value is called the *threshold.* If the reading is less than the threshold, then the reading is considered negative. If the reading is equal to or greater than the threshold, then the reading is considered positive.

Use of the inconclusive range and threshold is detailed in the performance characteristic sheet. The categories include substrate-corrected results, if substrate correction is indicated. XRF's with *only* threshold values listed on the *XRF Performance Characteristic Sheet* are advantageous in that classifications of results are either positive or negative (no XRF readings are inconclusive).

H. Evaluation of the Quality of the Inspection

The person responsible for purchasing inspection services -- the homeowner, property owner, housing authority, prospective buyer, occupant, etc.; also known as the client -- should evaluate the quality of the work using one or more of the methods listed below. Evaluation methods include direct observation, immediate provision of results, repeated testing, and time-and-motion analysis. Direct observation of the inspection should be used whenever possible. The inspection contract should outline the financial penalties that will occur if an inspector fails to perform as contracted during any visit.

1. Direct Observation

An evaluation of a lead-based paint inspection is best made if a knowledgeable observer is present for as much of the XRF testing as possible. This is the only way to ensure that all painted, varnished, shellacked, wallpapered, stained, or other coated testing combinations are actually tested, and that all XRF

readings are recorded correctly. If possible, employ as the observer someone who is trained in lead-based paint inspection and who is independent of the inspection firm.

If it is not feasible for the client or the client's representative to be present throughout the inspection, that person should conduct unannounced and unpredictable visits to observe the inspection process. The number of unannounced visits will depend on the results of prior visits. When observing ongoing XRF testing, review the test results for the room equivalent currently being tested and for the previously inspected room equivalent. Even if the first visit is fully satisfactory, follow-up visits should be conducted throughout the inspection.

2. Immediate Provision of Results

The client, or a representative, should ask the inspector to provide copies or printouts of results on completed data forms immediately following the completion of the inspection or on a daily basis. Alternatively, visually review the inspector's written results to ensure that they are properly recorded for all surfaces that require XRF testing. If surfaces have been overlooked or recorded incorrectly, the inspection process should be stopped and considered deficient. Clients should retain daily results to ensure that the data in the final report are the same as the data collected in the home.

3. Repeated Testing of 10 Surfaces

Data from HUD's private housing lead-based paint hazard control program show that it is possible to successfully retest painted surfaces without knowing the exact spot which was tested.

Select 10 testing combinations at random from the already compiled list in the "Single-Family Housing LBP Testing Data Sheet" for retesting (see forms in Addendum 2 of this chapter). Observe the inspector during the retesting. If possible, the same XRF instrument used in the original inspection should be used in the retesting. If the XRF instrument used in the original inspection is not available and cannot be returned to the site, use an XRF of the same model for retesting. Use the same procedures to retest the 10 testing combinations. The 10 repeat XRF results should be compared with the 10 XRF results previously made on the same testing combinations. The repeat readings and the original readings should not be corrected for substrate bias for the purpose of this comparison. The average of the 10 repeat XRF results should not differ from the 10 original XRF results by more than the retest tolerance limit. The procedure for calculating the retest tolerance limit is specified in the *XRF Performance Characteristic Sheet*. If the limit is exceeded, the procedure should be repeated using 10 different testing combinations. If the retest tolerance limit is exceeded again, the original inspection is considered deficient.

4. Time-and-Motion Analysis

Anyone who contracts for a lead-based paint inspection can also perform a simple check to determine if the inspector had sufficient time to complete the number of housing units reported as being tested in the time allotted. Usually, inspections require at least 1 to 2 hours per unit using existing technology. If the inspector's on-site time is significantly less than that, further investigation should be conducted to determine if the inspector actually completed the work in the report.

I. Documentation in Single-Family Housing

1. Data Forms

Data can be recorded on hand written forms, electronically, or by a combination of these two methods. XRF readings can be entered on handwritten forms, such as the set of forms (7.1, 7.1A, 7.2, and 7.3) provided at the end of this chapter (or comparable forms). Because handwriting can result in transcription errors, handwritten forms should be examined for missing data and copying errors.

2. Electronic Data Storage

Electronic data storage is recommended only if the data recorded are sufficient to allow another person to find the testing combination that corresponds to each XRF reading. Electronically stored data should be printed in hard copy either daily or at the completion of the inspection. The printout should be examined for extraneous symbols or missing data, including missing test location identification. In most cases, electronic data storage is supplemented by manual data recording of sampling location, operator name, and other information.

3. Final Report

The final report must include both a summary and complete information about the site, the inspector, the inspection firm, the inspection process, and the inspection results. The full report should include a complete data set, including:

- Housing unit identifiers;
- Date of the inspection;
- Identity of the inspector and the inspection firm and any relevant certifications or licenses held by the inspector and/or the firm;
- Building component and room equivalent identification or numbering system or sketches;
- All XRF readings (including calibration check readings);
- All paint chip analyses;
- Testing protocol used;
- Instrument manufacturer, model, serial number, mode(s) of operation and age of radioactive source;
- Information on the owner's legal obligation to disclose the inspection results to tenants and/or purchasers before obligation under 24 CFR part 35 and 40 CFR part 745 (published in the *Federal Register,* Volume 61, Number 45, March 6, 1996, starting on p. 9064; copies of the regulations and related materials can be obtained from the National Lead Information Center Clearinghouse, 1-800-424-LEAD); and
- Final classification of all testing combinations into positive or negative categories, including a list of testing combinations, or building component types and their substrates, that were classified but not individually tested. *(Note that the final report should not list inconclusive readings as a third category. If the client wishes to assume all inconclusive readings are positive, the report should state that assumption and present all readings and testing combinations for which the readings were inconclusive. It is not permissible to assume all inconclusive readings are negative. The report should include the actual readings for any testing combinations for which readings were inconclusive, but were classified as positive. Also note that final classifications are needed for building component types and their substrates that were not actually tested. For example, if the client wants to suspend testing on testing combinations that were found to be positive in the first five room equivalents and are assumed to be positive in the remaining rooms, the final report should list those testing combinations that are assumed to be positive).*

The report should also contain a summary that answers two questions:

(1) Is there lead-based paint in the house? *and*
(2) if lead-based paint is present, where is it located?

The summary report should also include the house address where the inspection was performed, the date(s) of the inspection, the name, address and phone numbers of the inspector and inspection firm, any appropriate license or certification numbers, and the starting and ending times for each day when XRF testing was done. The summary should also contain language regarding disclosure, such as:

> "A copy of this summary must be provided to new lessees (tenants) and purchasers of this property under Federal law (24 CFR part 35 and 40 CFR part 745) before they become obligated under a lease or sales contract. The complete report must also be provided to new purchasers and it must be made available to new tenants. Landlords (lessors) and sellers are also required to distribute an educational pamphlet and include standard warning language in their leases or sales contracts to ensure that parents have the information they need to protect their children from lead-based paint hazards."

Although 24 CFR part 35 and 40 CFR part 745 do not require that inspectors and owners keep copies of inspection reports for any specified period of time, future buyers are entitled to all available inspection reports, should the property be re-sold.

If no lead-based paint has been detected in the house, the summary should say so. The following language may be used:

"The results of this inspection indicate that no lead in amounts greater than or equal to 1.0 mg/cm² in paint was found on any building components, using the inspection protocol in Chapter 7 of the *HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing (1997)*. Therefore, this dwelling qualifies for the exemption in 24 CFR part 35 and 40 CFR part 745 for target housing being leased that is free of lead-based paint, as defined in the rule. However, some painted surfaces may contain levels of lead below 1.0 mg/cm², which could create lead dust or lead-contaminated soil hazards if the paint is turned into dust by abrasion, scraping, or sanding. This report should be kept by the inspector and should also be kept by the owner and all future owners for the life of the dwelling."

Detailed documentation of the XRF testing should also be provided in the full report, including the raw data upon which it was based. The single-family housing forms provided at the end of this chapter or comparable forms would serve this purpose.

For a leased home, where no lead-based paint is identified during an inspection, the building owner is exempt from the requirements of the disclosure rule. However, when a housing unit with no lead-based paint is being sold, the owner still has responsibilities under the disclosure rule (e.g., providing a lead hazard information pamphlet to potential buyers). For selling and leasing properties where no lead-based paint is identified, it is strongly recommended that owners and inspectors retain inspection reports for the life of the building.

V. Inspections in Multifamily Housing

This section emphasizes the differences between single-family and multifamily housing paint inspections. The protocols mentioned in earlier sections are not repeated here. It will be necessary to read Section IV on single-family housing to implement the protocol for multifamily housing.

Use of the multifamily protocol is less time-consuming and more cost effective than inspecting all units in a given housing development or building because in most instances a pattern can be determined after inspecting a fraction of the units. The number of units tested is based on the date of construction and the number of units in the housing development.

For purposes of this chapter only, multifamily housing is defined as any group of units that are similar in construction from unit to unit, with:

- 21 or more units, if any were built before 1960 or are of unknown age, or
- 10 or more units, if they were all built from 1960 through 1977.

Developments with fewer units should be treated as a series of single-family housing units.

A. Statistical Confidence in Dwelling Unit Sampling

The number of similar units, similar common areas or exterior sites to be tested (the sample size) is based on the total number units, similar common areas or exterior sites in the building(s), as specified in Table 7.3. Use the table for sampling each set of similar units, each set of similar common areas and each set of exterior sites. For pre-1960 or unknown-age buildings or developments with 1,040 or more similar units, similar common areas or exterior sites, test 5.8 percent of them, and round up any fraction to the next whole number. For 1960-77 buildings or developments with 1,000 or more units, test 2.9 percent of the units, and round up any fraction to the next whole number. For reference, the table shows entries from 1500 to 4000 in steps of 500. For example, in a development built in 1962, with 200 similar units, 20 similar common areas, and 9 similar exterior sites, sample 27 units, 16 common areas, and all 9 exterior sites.

If lead levels in *all* units, common areas or exterior sites tested are found to be below the 1.0 mg/cm² standard, these sample sizes provide 95 percent confidence that:

- For pre-1960 housing units, less than 5 percent or fewer than 50 (whichever is less) units, common areas or exterior sites, have lead at or above the standard; and
- For 1960 to 1977 housing units, less than 10 percent or fewer than 50 (whichever is less) units, common areas or exterior sites, have lead at or above the standard.

Refer to Appendix 12 of these Guidelines for the statistical rationale for this table. The Appendix shows the details of the calculation for pre-1960 housing; the calculation is the same for 1960-1977 housing, except for using the 10 percent criterion for 1960-1977 housing, rather than the 5 percent used for older housing.[3]

Table 7.3: Number of Units to be Tested in Multifamily Developments

Number of Similar Units, Similar Common Areas or Exterior Sites in a Building or Development	Pre-1960 or Unknown-Age Building or Development: Number to Test	1960-1977 Building or Development: Number to Test
1-9	All	All
10-13	All	10
14	All	11
15	All	12
16-17	All	13
18	All	14
19	All	15
20	All	16
21-26	20	16
27	21	17
28	22	18
29	23	18
30	23	19
31	24	19
32	25	19
33-34	26	19
35	27	19
36	28	19
37	29	19
38-39	30	20
40-48	31	21
49-50	31	22
51	32	22
52-53	33	22
54	34	22
55-56	35	22

Number of Similar Units, Similar Common Areas or Exterior Sites in a Building or Development	Pre-1960 or Unknown-Age Building or Development: Number to Test	1960-1977 Building or Development: Number to Test
57-58	36	22
59	37	23
60-69	38	23
70-73	38	24
74-75	39	24
76-77	40	24
78-79	41	24
80-88	42	24
89-95	42	25
96-97	43	25
98-99	44	25
100-109	45	25
110-117	45	26
118-119	46	26
120-138	47	26
139-157	48	26
158-159	49	26
160-177	49	27
178-197	50	27
198-218	51	27
219-258	52	27
259-279	53	27
280-299	53	28
300-279	54	28
380-499	55	28
500-776	56	28
777-939	57	28

Number of Similar Units, Similar Common Areas or Exterior Sites in a Building or Development	Pre-1960 or Unknown-Age Building or Development: Number to Test	1960-1977 Building or Development: Number to Test
940-1004	57	29
1005-1022	58	29
1023-1032	59	29
1033-1039	59	30
1500	87	44
2000	116	58
2500	145	73
3000	174	87
3500	203	102
4000	232	116

Although the data set used to develop sample sizes in multifamily housing[4] was not randomly selected from all multifamily housing developments in the nation (no such data set is available), analyses drawn from the data are likely to err on the side of safety and public health for at least two reasons: First, the prevalence and amounts of lead-based paint are highest in pre-1960 housing developments. The sampling approach used here focuses inspection efforts on buildings where a greater chance of lead-based paint hazards exist.

Second, and perhaps more important, none of the 65 developments had lead-based paint in 5 to 10 percent of the units. That indicates lead-based paint in this range is likely to be quite rare and that plausible increases in sampling to improve detection in this range will fail to improve confidence in the results significantly. Most painting follows a pattern: Property owners or managers often paint all surfaces, all components within a room, or similar components in all rooms in a unit when there is tenant turnover. It is unlikely that lead-based paint distributions are completely random, as assumed in the 1995 edition of the *Guidelines*. From the available data, there appears to be no significant benefit to increasing the number of units to be sampled to detect a prevalence rate of 5 to 10 percent, because few developments are likely to be in that range. In short, the sampling design presented here will yield a more targeted, cost-effective approach to identifying lead-based paint where it is most likely to exist.

B. Selection of Housing Units

The first step in selecting housing units is to identify buildings in the development with a common construction based on written documentation or visual evidence of construction type. Such buildings can be grouped together for sampling purposes. For example, if two buildings in the development were built at the same time by the same builder and appear to be of similar construction, all of the units in the two buildings can be grouped for sampling purposes. Units can have different sizes, floor plans, and number of bedrooms and still be grouped.

The specific units to be tested should be chosen *randomly* from a list of all units in each building or buildings. The "Selection of Units" form (Form 7.4) or a comparable form may be used to aid in the selection process. A complete list of all units in each group should be used and a separate identifying sequential number must be assigned to each unit. For

example, if apartment addresses are shown as 1A, 1B, 2A, 2B etc., they must be given a sequence number (1, 2, 3, 4, etc.).

Obviously, units without identifiers could not be selected for inspection and would thus bias the sampling scheme. The list of units should be complete and verified by consulting building plans or by a physical inspection of the development.

Specific units to be tested should be selected randomly using the formula below, and a table of random numbers or the random number function on a calculator. Tables of random numbers are often included in statistics books. Calculators with a random number function key can be obtained for less than $20 and are easier to use than tables. Inspectors are, therefore, advised to use them to obtain the random numbers, which can then be used to select the specific numbered units. A unit number is selected by rounding up the product of the random number times the total number of units in the development to the *next* whole number. That is:

Housing Unit number = Random number *times* Total number, rounded *up*,

where:

Housing Unit number = the identification number for a unit in a list;
Random number = a random number between 0 and 1; *and*
Total number = the total number of units in a list of units.

The same unit may be selected more than once by this procedure. Because each unit should be tested only once, duplicate selection should be documented and then discarded. The procedure should be continued until an adequate number of units has been selected.

The "Selection of Units" form (Form 7.4) is completed by filling in as many random numbers as are needed in the appropriate column. Numbers for the third column are obtained by multiplying the total development size by each random number. Numbers for the fourth column are obtained by rounding up from the previous calculation to the next whole number. If the whole number in the fourth column has already been selected, that selection should not be entered again. The notation "DUP" should be entered to show that the selection was a duplicate. This process should continue until the required number of distinct sample numbers have been selected. Common areas and exterior room equivalents should be identified at this time, but they are not considered to be separate units.

C. Listing Testing Combinations

The "Multifamily Housing LBP Testing Data Sheet" form (Form 7.5) -- or a comparable form -- should be used to list the testing combinations in each unit, common area and exterior site that was selected for inspection. In multifamily housing, the inventory of testing combinations often will be similar for units that have the same number of bedrooms. The inspector should, however, list testing combinations that are unique to each tested unit. For example, some units may contain built-in cabinets while others do not. The selection of testing combinations should, therefore, be carried out independently in each inspected unit.

As in single family housing, take readings on all testing combinations in all room equivalents in each unit selected for testing.

1. Common Areas

Similar common areas and similar exterior sites must always be tested, but in some cases they can be sampled in much the same way that dwelling units are. Common areas and building exteriors typically have a similar painting history from one building to the next. In multifamily housing, each common area (such as a building lobby, laundry room, or hallway) can be treated like a dwelling unit. If there are multiple similar common areas, they may be grouped for sampling purposes in exactly the same way as regular dwelling units are. However, dwelling units, common areas and exterior sites cannot all be mixed together in a single group.

All testing combinations within each common area or on building exteriors selected for testing must be inspected. This includes playground equipment, benches and miscellaneous testing combinations located throughout the development. The specific

common areas and building exteriors to test should be randomly selected, in much the same way as specific units are selected using random numbers. (See Section IV.B, above).

The number of common areas to test should be taken from Table 7.3. In this instance, common areas and building exteriors can be treated in the same way as housing units (although they are not to be confused with true housing units).

D. Number of Readings on Each Testing Combination

The method for collecting XRF readings is identical for multifamily and single-family housing (see Section IV).

E. XRF Calibration Check Readings

The method for collecting and evaluating XRF calibration check readings is identical for multifamily and single-family housing (see Section IV.D).

F. Substrate Correction in Multifamily Housing

The method for correcting XRF readings for substrate bias is identical for multifamily and single-family housing (see Section IV.E) with one exception: For multifamily housing, randomly select two housing units to be used to collect substrate measurements for all substrates within the development that need correction, and use the results from those two units to perform substrate correction calculations in all tested units within the development or building. If substrates exist in common areas or on exterior sites that do not exist in residential areas, select two locations from these areas for substrate correction. Otherwise, the same substrate correction readings can be applied to dwelling units, common areas and exterior sites.

G. Classification of XRF Results in Multifamily Housing

The inspector should record each XRF reading for each testing combination on the "Multifamily Housing LBP Testing Data Sheet," (Form 7.5) or a comparable form, and indicate whether that testing combination was classified as positive, negative, or inconclusive as described previously for single-family housing.

When the inspection is completed in all of the selected units and the classification rules have been applied to all XRF results, the "Multifamily Housing: Component Type Report" form (Form 7.6) or a comparable form should be completed. Building component types -- groups of like components constructed of the same substrate in the multifamily housing development -- are aggregated on this form. For example, grouping all interior walls would create an appropriate component type if all walls are plaster. Grouping all doors would not be appropriate, however, if some doors are metal and some are wood. At least 40 testing combinations of a given component type in a multifamily housing development must be tested to obtain the desired level of confidence in the results. (Refer to Appendix 12 of these *Guidelines* for the statistical rationale for this minimum number of component types to test.) If fewer than 40 testing combinations of a given component type were tested, test additional combinations of that component type. If less than 40 components of a given type exist in the units to be tested, test all of the components that do exist.

In some cases additional sampling of the specific component may not be necessary. If no lead at or above the standard is found on that component type, additional measurements should be taken in other units to increase the sample size to 40. However, if all or most of the sampled component types are positive, no further sampling is needed, provided that the building owner agrees with this reduction of testing. For example, if 20 out of 60 doors are tested, and the majority are positive for lead-based paint, all similar doors in the buildings may be presumed positive. Note, however, that all required XRF testing and laboratory analysis, if necessary, must be completed to conclude that all components included in a given component type are negative.

On the "Multifamily Housing: Component Type Report" form, the substrate, and component for each component type should be recorded under the heading "Description" (for example, wooden interior doors) as well as the total number of testing combinations included in the component type. In addition, for each component type, the aggregated positive, negative, and inconclusive classifications should be recorded as

described below. Record the number and percentage of testing combinations classified as:

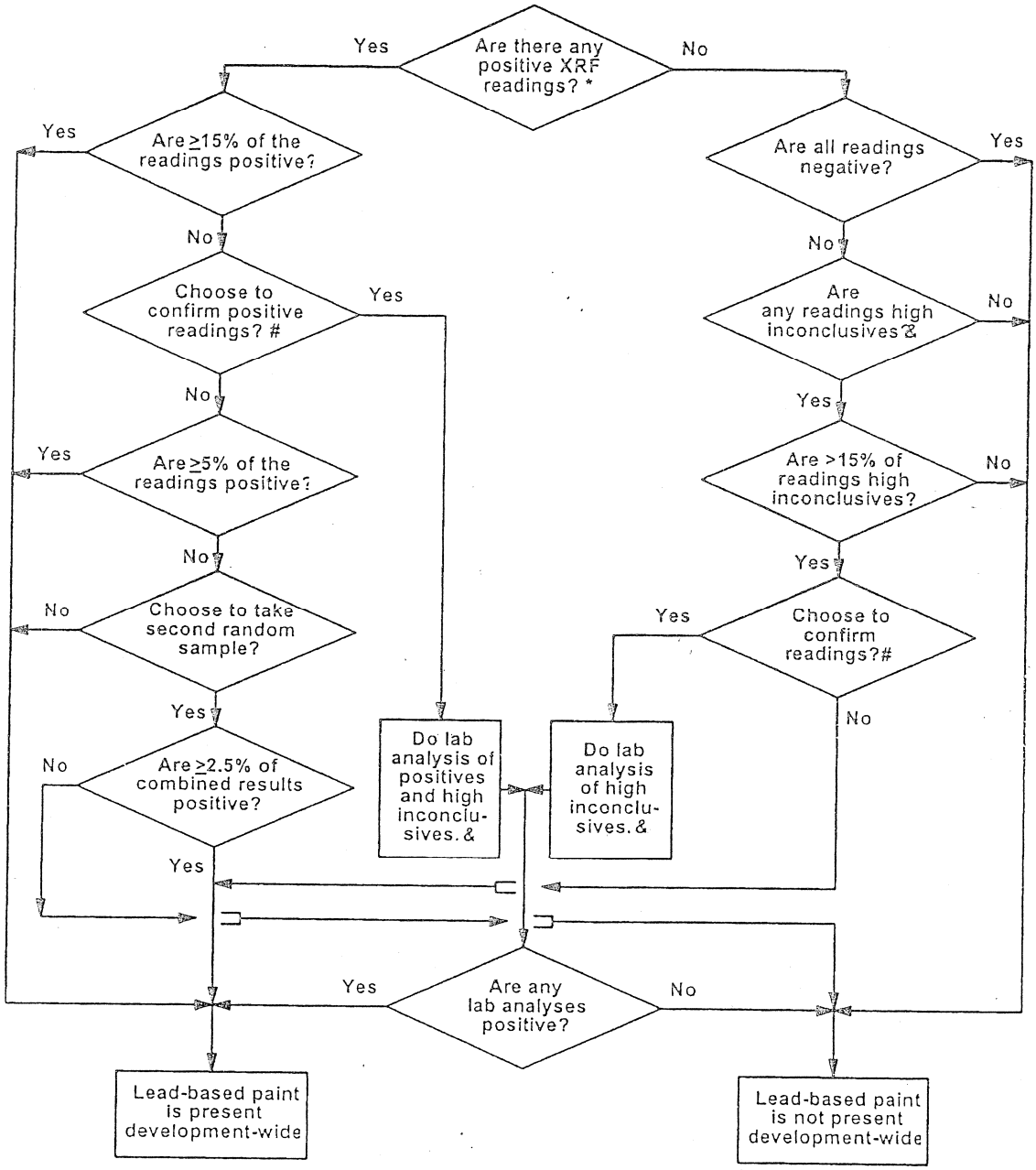
- Positive for lead-based paint. This is based upon a positive XRF reading in accordance with the XRF's Performance Characteristic Sheet;
- Inconclusive and having XRF readings less than the midpoint of the XRF's inconclusive range ("low inconclusive");
- Inconclusive and having XRF readings equal to or greater than the midpoint of the XRF's inconclusive range ("high inconclusive"); and
- Negative for lead-based paint.

The "Multifamily Decision Flowchart" (Figure 7.1) should be used to interpret the aggregated XRF testing results in the "Multifamily Housing: Component Type Report" form. The flowchart is applied separately to each component/substrate type (wood doors, metal window casings, etc.) and shows one of the following results:

- **Positive**: Lead based-paint is present on one or more of the components.
- **Negative**: Lead based-paint is not present on the components throughout the development. (Lead may still be present at lower loadings and hazardous leaded dust may be generated during modernization, renovation, remodeling, maintenance, or other disturbances of painted surfaces.)

These results are obtained by following the flowchart. The decision that lead-based paint is present is reached with 99 percent confidence if 15 percent or more of the components are positive. (Refer to Appendix 12 for the statistical rationale for this percentage.) The decision that lead-based paint is not present throughout the development is reached if: (1) 100 percent of the tested component types are negative, or (2) 100 percent of the tested component types are classified as either negative or inconclusive *and* all of the inconclusive classifications have XRF readings less than the midpoint of the inconclusive range for the XRF in use. Note that the midpoint of the inconclusive range is *not* a threshold; it is used only for classifying XRF readings in multifamily housing in conjunction with information about other XRF readings as described here. (See section 2 below for guidance on what to do when the percentage of positive readings is less than 5%). For cases with greater than or equal to 5% positives *and* less than 15% positives, as well as no positives but greater than 15% high inconclusives, some confirmatory laboratory testing may be needed to reach a final conclusion, unless the client wishes to assume the validity of the XRF results and that all inconclusives are positive. For each testing combination with an inconclusive XRF reading at or above the midpoint of the inconclusive range, a paint-chip sample should be analyzed by a laboratory recognized by the EPA National Lead Laboratory Accreditation Program. If all the laboratory-analyzed samples are negative, it is not necessary to test inconclusive XRF results below the midpoint of the inconclusive range. If, however, *any* laboratory results are positive on a component type, all inconclusives equal to or above the midpoint of the inconclusive range should be analyzed. Once all laboratory results have been reported, the "Multifamily Housing: Component Type Report" form should be updated to include the laboratory results and classifications (either positive or negative).

The "Multifamily Decision Flowchart" is based on data collected by EPA in a large field study of XRF instruments (EPA 1995). Percentages were chosen so that, for each component type, there is a 98 percent chance of correctly concluding that lead-based paint is either absent on all components or present on at least one component of a given



* *"Positive," "negative," and "inconclusive" XRF readings are determined in accordance with the XRF instrument's Performance Characteristics Sheet as described in the HUD Guidelines for the Evaluation and Control of Lead Hazards in Housing, chapter 7.*

& *A high inconclusive reading is an XRF reading at or above the midpoint of the inconclusive range. For example, if the inconclusive range is 0.41 to 1.39, its midpoint (average) is 0.90; a reading in the range from 0.90 to 1.39 would be a high inconclusive reading.*

\# *Any paint or coating may be assumed to be lead-based paint, even without XRF or laboratory analysis. Similarly, any XRF reading may be confirmed by laboratory analysis.*

Figure 7.1 Multifamily Decision Flowchart

type. Thus, the probability that a tested component type will be correctly classified is very high.

Percentages of positive or inconclusive results are computed by dividing the number in each classification group by the total number of testing combinations of the component type that were tested. For example, if 245 wooden doors in a multifamily housing development were tested and 69 were classified as inconclusive with XRF readings less than the midpoint of the inconclusive range, 28 percent [(69 / 245) x 100 percent = 28.2 percent] should be recorded on the form in the "<1.0 percent" columns under the heading "Inconclusive."

1. Unsampled Housing Units

If a particular component type in the sampled units is classified as positive, that same component type in the unsampled units is also classified as positive. For those cases where the number of positive components is small, further analysis may determine if there is a systematic reason for the specific mixture of positive and negative results.

For example, suppose that a few porch railings tested negative, but most tested positive. Examination of the sample results in conjunction with the building records showed that the porch railings classified as positive were all original and the railings classified as negative were all recent replacements. The records did not reveal which units had replaced railings, and due to historic preservation requirements, the replacement railings were identical in appearance to the old railings. Thus, all unsampled original porch railings could be classified as positive, and all unsampled recently replaced porch railings could be classified as negative if at least 40 of the replaced porch railings had been tested.

2. Fewer than 5% Positive Results

Where a small fraction of XRF readings, less than 5 percent, of a particular component type are positive, several choices are available:

- First, the inspector may confirm the results by laboratory analysis, which is considered definitive when performed as described in Section VI, below; a laboratory lead result of 1.0 mg/cm^2 or greater (or 0.5 percent by weight or greater) is considered positive.

- Second, the inspector may select a second random sample (using unsampled units only) and test the component type in those units. If less than 2.5% of the combined set of results is positive, the component type may be considered as not having lead-based paint development-wide, but, rather, having lead-based paint in isolated locations, with a reasonable degree of confidence. Individual components that are classified positive should be considered as being lead-based painted and managed or abated appropriately.

- Finally, if the client chooses not to confirm the results by laboratory analysis and not to take a second set of measurements, then the component type should be considered as having lead-based painted development-wide.

The inspector may wish to advise the client that the cost of additional XRF testing or laboratory analysis is usually much less than the cost of lead abatement or interim control projects, and that this is of particular interest in the situation where few results are positive, because there is a significant chance that the paint, development-wide, may not be lead-based.

Whatever approaches are used, all painted individual surfaces found to be positive for lead must be included in the inspection report, regardless of development-wide conclusions.

H. Evaluation of the Inspection

The methods for evaluating inspection services in multifamily housing are identical to those described for single-family housing (see Section IV.H) except for the retesting option: In multifamily housing, a total of 10 testing combinations should be selected for retesting in two units.

I. Documentation in Multifamily Housing

The method for documentation is identical for multifamily and single-family housing (see Section IV.I), with the following exception: Use forms 7.2

through 7.6 for multifamily housing (see Addendum 2) or comparable forms, not the single-family housing forms.

When lead-based paint has been found in some units it must be managed or treated as such in those units, even if the inspection indicates that it is not present development wide.

VI. Laboratory Testing for Lead in Paint

For inconclusive XRF results and areas that cannot be tested using an XRF instrument, a paint-chip sample should be collected using the protocol outlined here and in Appendix 13.2 of these *Guidelines*. The sample should be analyzed by a laboratory recognized under the EPA National Lead Laboratory Accreditation Program (NLLAP) using the analytical method(s) it used to obtain the laboratory's recognition. If a paint chip sample cannot be collected, the inspection report should include a list of surfaces where paint chip samples were needed but not taken (in this case, the client would assume that inconclusives requiring confirmation by laboratory analysis are positive).

A. Number of Samples

Only one paint-chip needs to be taken for each testing combination. Additional samples can be collected as a quality control measure, if desired.

B. Size of Samples

The paint-chip sample should be taken from a 4-square-inch (25-square-centimeter) area that is representative of the paint on the testing combination, as close as possible to any XRF reading location and, if possible, unobtrusive. This area may be a 2 by 2 inch (5 by 5 centimeter) square, or a 1 by 4 inch (2½ by 10 centimeter) rectangle, or have any other dimensions that equal at least 4 square inches (25 square centimeters). Regardless of shape, the dimensions of the surface area must be accurately measured (to the nearest millimeter or 1/16th of an inch) so that laboratory results can be reported in mg/cm². Results should be reported as percent by weight if the dimensions of the surface area cannot be accurately measured or if all paint within the sampled area cannot be removed. In these cases, lead should be reported in ppm or percent by weight, *not* in mg/cm². Smaller surface areas can be used if acceptable to the laboratory.

The 4-square-inch (25-square-centimeter) area practically guarantees that a sufficient amount of paint will be collected for laboratory analysis. As a result, samples will sometimes weigh more than required for some laboratory analysis methods. Smaller-sized paint chips may be collected if permitted by the laboratory. (See ASTM E 1729). In all cases, the inspector should consult with the NLLAP recognized laboratory selected regarding specific requirements for the submission of samples for lead-based paint analysis.

C. Inclusion of Substrate Material

Inclusion of small amounts of substrate material in the paint-chip sample will result in minimal error if results are reported in mg/cm², but including any amount of substrate can result in less precise results, with worse effect as the amount of substrate increases. Substrate material may not be included if results are to be reported in weight percent (or ppm).

D. Repair of Sampled Locations

Areas from which paint-chip samples are collected should be repaired and cleaned, unless the area will be removed, encapsulated, enclosed, or repainted before occupancy. Repairs can be completed by repainting, spackling, or any other method of covering that renders the bare surface inaccessible. Cleanup should be done with wet wiping and rinsing, and it should be done on both the surface and the floor underneath the surface sampled. The new covering or coating should have the same expected longevity as new paint or primer. Repair is not necessary if analysis shows that the paint is not lead-based paint and leaving the damage is acceptable to the client and/or the owner.

E. Classification of Paint-Chip Sample Results

Any paint inspections may be carried out using only paint-chip sampling and laboratory analysis at the option of the purchaser of the inspection services. This option is not recommended because it is time consuming, costly, and requires extensive repairs. Paint-chip sampling also has opportunities for errors,

such as inclusion of substrate material (for results in weight percent), failure to remove all paint from an area (including paint that has bled into a substrate) and laboratory error. Nevertheless, paint-chip sampling generally has a smaller error than does XRF and is, therefore, appropriate as a final decisionmaking tool. Laboratory results of 1.0 mg/cm² or greater, or 0.5 percent or greater, are to be considered positive. If the laboratory reports both mg/cm² and weight percent for a sample, use whichever result is positive (if any) for final classification. In the rare situation where more than one paint-chip sample from a single testing combination is analyzed, the combination is considered positive if any of those samples is positive. All other results are negative. No inconclusive range is reported for laboratory measurements.

F. Units of Measure

Results should be reported in mg/cm², the primary unit of measure for lead-based paint analyses of surface coatings. Results should be reported as percent by weight only if the dimensions of the surface area cannot be accurately measured or if not all paint within the sampled area can be removed. In these cases, results should not be reported in mg/cm², but in weight percent.

Weight measurements are usually reported as micrograms per gram (μg/g), milligrams per kilogram (mg/kg), or parts per million (ppm) by weight. For example, a sample with 0.2 percent lead may also be reported as 2,000 μg/g lead, 2,000 mg/kg lead, or 2,000 ppm lead.

G. Sample Containers

Samples should be collected in sealable rigid containers such as screw-top plastic centrifuge tubes, rather than plastic bags which generate static electricity and make quantitative transfer of the entire paint sample in the laboratory impossible. Paint-chip collection should include collection of all the paint layers from the substrate, but collection of actual substrate should be minimized. Refer to ASTM E 1729 and Appendix 13 of these *Guidelines* for further details on collection of paint-chip samples.

H. Laboratory Analysis Methods

Several standard laboratory technologies are useful in quantifying lead levels in paint-chip samples. These methods include, but are not limited to, Atomic Absorption Spectroscopy (AAS), Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES), Anodic Stripping Voltammetry (ASV), and Potentiometric Stripping Voltammetry (PSV).

For analytical methods that require sample digestion, samples should be pulverized so that there is adequate surface area to dissolve the sample before laboratory instrument measurement. In some cases, the amount of paint collected from a 4-square-inch (25-square-centimeter) area may exceed the amount of paint that can be analyzed successfully. It is important that the actual sample mass analyzed not exceed the maximum mass the laboratory has successfully tested using the specified method. If subsampling is required to meet analytical method specifications, the laboratory must homogenize the paint-chip sample (unless the entire sample will eventually be analyzed and the results of the subsamples combined). Without homogenization, subsampling would likely result in biased, inaccurate lead results (see ASTM E 1645). See ASTM PS 87 for an ultrasonic extraction method for preparing paint samples for subsequent analysis for lead.

If the sample is properly homogenized and substrate inclusion is negligible, the result can be reported in either milligrams per square centimeter (mg/cm²; the preferred unit), percent by weight, or both. The following equation should be used to report the results in milligrams per square centimeter:

$$\text{mg/cm}^2 = \frac{\text{weight of lead from subsample (in mg)} \times \frac{\text{total sample weight (in g)}}{\text{subsample weight (in g)}}}{\text{sample area (in cm}^2\text{)}}$$

To report results in weight percent, the following equation should be used:

Weight percent = weight of lead in the subsample/weight of subsample x 100.

To report results in micrograms per gram (μg/g), the following equation should be used:

$$\mu g/g = \frac{\text{weight of lead from subsample (in } \mu g)}{\text{subsample weight (in g)}}$$

If the laboratory reports results in both mg/cm² and weight percent, and if one result is positive and the other negative, the sample is classified as positive.

Whatever the preparation techniques of paint-chip samples (including homogenization, grinding, and digestion), and instrument selection and operation selected, the inspector should verify, prior to the collection and submission of samples, that the laboratory is approved to perform the appropriate analytical methodologies. Methods should be applied to paint-chip materials of approximately the same mass and lead loading (also called area concentration, measured in mg/cm²) as those samples anticipated from the field.

Because of the potential for sample mass to affect the precision of lead readings, laboratory analysis reference materials processed with field samples for quality assurance purposes should have close to the same mass as those used for paint-chip samples. Refer to ASTM E 1645 or equivalent methods for further details on laboratory preparation of paint-chip samples, and refer to ASTM E 1613, ASTM E 1775, ASTM PS 88, or equivalent methods on analysis of samples for lead.

I. Laboratory Selection

Only a laboratory recognized under EPA's National Lead Laboratory Accreditation Program (NLLAP) should be used for lead-based paint analysis. Such a laboratory is required to use the same analytical methods that it used to obtain accreditation. EPA established NLLAP to provide the public with laboratories that have a demonstrated capability for analyzing lead in paint chip, dust, and soil samples at the levels of concern stated in these *Guidelines*. In some states, an NLLAP laboratory *must* be used. To participate in NLLAP, a laboratory must:

- Participate successfully in the Environmental Lead Proficiency Analytical Testing Program (ELPAT). ELPAT is administered by the American Industrial Hygiene Association (AIHA) in cooperation with the Centers for Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH), and EPA. The proficiency testing samples used in ELPAT consist of variable levels of lead in paint, dust, and soil matrices.

- Undergo a systems audit, including an on-site visit. The systems audit must be conducted by an accrediting organization with a program recognized by EPA through a Memorandum of Understanding (MOU). Laboratory accrediting organizations participating in NLLAP have accrediting program requirements that meet or exceed NLLAP laboratory quality system requirements stated in the MOU.

An up-to-date list of fixed-site and mobile laboratories recognized by the EPA NLLAP for analysis of paint-chip samples may be obtained from the National Lead Information Center Clearinghouse by calling 1-800-424-LEAD or from the Lead Listing at http://www.leadlisting.org. Since December 1993, the American Association for Laboratory Accreditation (A2LA) and AIHA have been recognized as laboratory-accrediting organizations participating in NLLAP. NLLAP specifies quality control and data reporting requirements, as described in "Laboratory Quality System Requirements," which can be found in Appendix A of the NLLAP Model MOU. The MOU can also be obtained by calling the National Lead Information Center Clearinghouse, at the number above. The evaluation approach in ASTM E 1583 may be considered in selecting laboratories to use

from among available NLLAP-recognized laboratories.

J. Laboratory Report

The laboratory report for analysis of paint samples for lead should include both identifying information and information about the analysis. At a minimum, this should include:

- Laboratory identifying information: including the laboratory's name, address, and phone number, and NLLAP and other applicable certification and accreditation information; similarly, the client and/or project's name and address should be provided.

- Analytical method information: including the information provided in accordance with NLLAP procedures, and ASTM E 1613, ASTM PS 88 or equivalent method(s) for analysis for lead.

- Sample information: including field sample number and any information (e.g., sample type and/or location) given to the laboratory about the sample, unique laboratory sample number, analytical method (including a description of any variations from the standard method), quality control/quality assurance results, date of analysis, operational or testing problems or unusual occurrences.

VII. Radiation Hazards

Portable XRF instruments used for lead-based paint inspections contain radioactive isotopes that emit X rays and gamma radiation. Proper training and handling of these instruments is required to protect the instrument operator and any other persons in the immediate vicinity during XRF usage. The XRF instrument should be in the operator's possession at all times. The operator should never defeat or override any safety mechanisms of XRF equipment.

A. XRF Use Licenses and Certification

In addition to training and certification in lead-based paint inspection, a person using a portable XRF instrument for inspection must have valid licenses or permits from the appropriate Federal, State, and local regulatory bodies to operate XRF instruments because of radioactive materials they contain. All portable XRF instrument operators should be trained by the instrument's manufacturer (or equivalent). XRF operators should provide related training, licensing, permitting, and certification information to the person who has contracted for their services before an inspection begins. Depending on the State, operators may be required to hold three forms of proof of competency: manufacturer's training certificate (or equivalent), a radiation safety license, and a State lead-based paint inspection certificate or license. To help ensure competency and safety, HUD and EPA recommend that clients hire only those inspectors who hold all three.

The regulatory body responsible for oversight of the radioactive materials contained in portable XRF instruments depends on the type of material being handled. Some radioactive materials are Federally regulated by the U.S. Nuclear Regulatory Commission (NRC); others are regulated at the State level. States are generally categorized as "agreement" and "non-agreement" States. An agreement State has an agreement with NRC to regulate radioactive materials that are generally used for medical or industrial applications. (Most radioactive materials found in XRF instruments are regulated by agreement States). For non-agreement States, NRC retains this regulatory responsibility directly. At a minimum, however, most State agencies require prior notification that a specific XRF instrument is to be used within the State. Fees and other details regarding the use of portable XRF instruments vary from State to State. Contractors who provide inspection services must hold current licenses or permits for handling XRF instruments, and must meet any applicable State or local laws or notification requirements.

Requirements for radiation dosimetry by the XRF instrument operator (wearing dosimeter badges to monitor exposure to radiation) are generally specified by State regulations, and vary from State to State. In some cases, for some isotopes, no radiation dosimetry is required. Because the cost of dosimetry is low, it should be conducted, even when not required, for the following four reasons:

- XRF instrument operators have a right to know the level of radiation to which they are exposed during the performance of the job. In virtually all cases, the exposure will be far below applicable exposure limits.

- Long-term collection of radiation exposure information can aid both the operator (employee) and the employer. The employee benefits by knowing when to avoid a hazardous situation; the employer benefits by having an exposure record that can be used in deciding possible health claims.

- The public benefits by having exposure records available to them.

- The need for equipment repair can be identified more quickly.

B. Safe Operating Distance

XRF instruments used in accordance with manufacturer's instructions will not cause significant exposure to ionizing radiation. But the instrument's shutter should never be pointed at anyone, even if the shutter is closed.

The safe operating distance between an XRF instrument and a person during inspections depends on the radiation source type, radiation intensity, quantity of radioactive material, and the density of the materials being surveyed. As the radiation source quantity and intensity increases, the required safe distance also increases. Placing materials, such as a wall, in the direct line of fire, reduces the required safe distance. According to NRC rules, a radiation dose to an individual in any unrestricted area must not exceed 2 millirems per hour. One of the most intense sources currently used in XRF instruments is a 40-millicurie ^{57}Co (Cobalt-57) radiation source. Other radiation sources in current use for XRF testing of lead-based paint generally produce lower levels of radiation. Generally, an XRF operator conducting inspections according to manufacturer's instructions would be exposed to radiation well below the regulatory level (State of Wisconsin 1994). Typically, XRF instruments with lower gamma radiation intensities can use a shorter safe distance provided that the potential exposure to an individual will not exceed the regulatory limit.

Persons should not be near the other side of a wall, floor, ceiling or other surface being tested. Verify that this is indeed the case prior to initiating XRF testing activities, and check on it during testing.

If these practices are observed, the risk of excessive exposure to ionizing radiation is extremely low and will not endanger any inspectors or occupants present in the dwelling.

VIII. REFERENCES

EPA 1995. "A Field Test of Lead-Based Paint Testing Technologies: Technical Report, EPA 747-R-95-002b, U.S. Environmental Protection Agency, Washington DC, May 1995.

EPA and HUD 1996. 24 CFR 35, subpart H, and 40 CFR 745, subpart F. Requirements for Disclosure of Known Lead-Based Paint and/or Lead-Based Paint Hazards in Housing. Published, along with their preamble, in the *Federal Register,* volume 61, pp. 9064-9088, March 6, 1996. Implements Section 1018 of Title X.

EPA 1996. 40 CFR 745, subparts L and Q. Requirements for Lead-Based Paint Activities in Target Housing and Child-Occupied Facilities. Published, along with its preamble, in *Federal Register*, volume 61, pp. 45777-45830, August 29, 1996. Implements Sections 402 and 404 of the Toxic Substances Control Act.

State of Wisconsin 1994. Wisconsin Department of Health and Social Services, memo from Mark Chamberlain dated April 28, 1994. Measurements showed that exposures to radiation during operation of a Scitec MAP 3 XRF were 132 µrem/day, which can be compared to about 1,400 µrem/day from natural background radiation.

Addendum 1

Examples of Lead-Based Paint Inspections

A. Example of a Single-Family Housing Inspection

The inspector completed the "Single-Family Housing LBP Testing Data Sheet," recording "bedroom (room 5)" as the room equivalent and listing "plaster" as the first substrate. The completed inventory of testing combinations in the bedroom indicated the presence of wood, plaster, metal, and drywall substrates. Brick and concrete substrates were not present in the bedroom. Descriptions of all testing combinations in the bedroom were recorded. Completed Form 7.1 shows the completed inventory for all testing combinations in the bedroom. (Completed Forms are found in Addendum 3, after the blank forms.)

Before any XRF testing, the inspector performed the manufacturer's recommended warm up procedures. The film was placed more than 12 inches (0.3 meters) away from a painted or other surface. The inspector then took three calibration check readings (1.18 mg/cm^2, 0.99 mg/cm^2, and 1.07 mg/cm^2) on the NIST SRM with a lead level of 1.02 mg/cm^2. Results of the first calibration check readings were recorded on the "Calibration Check Test Results" form (see Completed Form 7.2).

The inspector then averaged the three readings (1.08 mg/cm^2), and computed the calibration difference (1.08 mg/cm^2 - 1.02 mg/cm^2 = 0.06 mg/cm^2) and compared this to the calibration check tolerance shown in the *XRF Performance Characteristic Sheet* (see Completed Form 7.2). The calibration difference was not greater than the 0.20 calibration check limits around the NIST SRM standard of 1.02 mg/cm^2, that is, the difference was within the range of 0.82 mg/cm^2 to 1.22 mg/cm^2, inclusive. The instrument was considered in calibration, and XRF testing could begin.

The inspector recorded the results from the XRF testing in the bedroom on the "Single-Family Housing LBP Testing Data Sheet." At that point, the inspector was able to complete this form only through the XRF Reading column (see Completed Form 7.1). The remainder of the form was completed after the testing combinations in the house were inspected and correction values for substrate bias were computed. The inspector then moved on to inspect the next room equivalent.

The other bedroom, the kitchen, a living room, and a bathroom were also inspected. Three substrates -- wood, drywall, and plaster -- were found in these room equivalents. XRF testing for lead-based paint was conducted, using the same methodology employed in the first bedroom (room 5). After these five room equivalents were tested, the inspector noticed that all baseboards and all crown molding of the same substrate had XRF values of more than 5.0 mg/cm^2. The client had agreed earlier that testing could be abbreviated in this situation, so no further baseboard and crown molding testing combinations were tested in the remaining room equivalents. All similar remaining untested baseboard and crown molding with identical substrates were classified as positive in the final report based on the results of those tested. The raw data for the tested baseboards and crown moldings were also included in the final report.

Four hours after the initial calibration check readings, the inspector took another set of three calibration check readings. (If the inspection had taken less than 4 hours, as is common, the second calibration check test would have been conducted at the end of the inspection.) The readings were 1.45 mg/cm^2, 1.21 mg/cm^2, and 1.10 mg/cm^2; the inspector recorded the results on the "Calibration Check Test Results" form (Completed Form 7.2). The inspector then averaged the three readings (1.25 mg/cm^2), and computed the calibration difference (1.25 mg/cm^2 - 1.02 mg/cm^2 = 0.23 mg/cm^2) and compared this to the calibration check tolerance shown in the *XRF Performance Characteristic Sheet* on Completed Form 7.2. The calibration difference exceeded the 0.20 calibration check tolerance. The inspector then marked "Failed calibration check" on the data sheets for those room equivalents that had been inspected since the last

successful calibration check test, and consulted the manufacturer's recommendations. After trying, the instrument could not be brought back into control. Consequently, the inspector began using a backup instrument, after performing a calibration check and manufacturer's warm up and quality control procedure. The calibration check test showed that the backup instrument was operating acceptably. The inspector used the backup instrument to reinspect the room equivalents checked with the first instrument, and then all the other room equivalents in the home. Next, because substrate correction was required for all results on wood and metal below 4.0 mg/cm² as specified in the *XRF Performance Characteristic Sheet* for the XRF model in use, the inspector prepared to take readings for use in the substrate correction computations. Using the random number function on a calculator and the list of sample location numbers, the inspector randomly selected two testing combinations each with wood and metal substrates where initial readings were less than 2.5 mg/cm², removed the paint from an area on each selected testing combination slightly larger than the faceplate of the XRF instrument, took three readings on the bare substrates, and recorded the readings on the "Substrate Correction Values" form (Completed Form 7.3). The inspector calculated the correction values for each substrate by averaging the six readings from the two test locations, rounded the result to the 2 places after the decimal point that the XRF instrument displayed, and recorded the information in the Correction Value row. The inspector then transferred the correction values to the "Single-Family Housing LBP Testing Data Sheet" for each corresponding substrate.

After the inspector had finished taking the readings needed to compute the substrate correction values, the inspector took another set of three calibration check readings. The inspector recorded the results on the "Calibration Check Test Results" form, under Second Calibration Check, for readings taken by the backup XRF instrument (Completed Form 7.2). The second (and final) calibration check average did not exceed the 0.20 calibration check tolerance. The inspector, therefore, deemed the XRF testing to be complete.

The inspector then calculated the corrected readings by subtracting the substrate correction value from each XRF result taken on a wood or metal substrate. The substrate correction value was obtained by averaging readings on bare surfaces that had initially measured less than 2.5 mg/cm² with the paint still on the surface (Completed Form 7.3). The inspector also used the inconclusive ranges obtained from the XRF Performance Characteristic Sheet (0.41 mg/cm² to 1.39 mg/cm²) for all substrates except plaster (inconclusive range 1.01 mg/cm² to 1.09 mg/cm²). Based on the valid window sill XRF readings, including substrate corrections for wood, there were initially 10 positive results, 2 inconclusive results, and 3 negative results in the bedroom. The two inconclusive results required paint-chip sampling with laboratory confirmation; this resulted in one positive and one negative result. The inspector then filled out the "Single-Family Housing: Component Type Report" (Completed Form 7.1A). A description of each component type was recorded in the first column, the total number of each tested component type was entered in the second column, and the number of testing combinations classified as positive for each component type from the "Single-Family Housing LBP Testing Data Sheet" (Completed Form 7.1) was calculated and entered in the third column. The inspector then did the same for the testing combinations classified as negative. Based upon the XRF results as modified by the laboratory confirmation of the two inconclusive samples, Completed Form 7.1A shows 11 positive and 4 negative results for wood window sills. The remaining component types were entered in a similar fashion.

B. Example of Multifamily Housing Inspection

This section presents a simple example of a multifamily housing development inspection. An actual inspection would have many more testing combinations than are provided here.

The inspector's first step was a visual examination of the development to be tested. During this pretesting review, buildings with a common construction and painting history were identified and the date of construction -- 1948 -- was determined. The construction and painting history of all the units was found to be similar, so that units in the development could be grouped together for sampling purposes. The inspector determined that the development had 55 units, and by consulting Table 7.3, determined that 35 units should be inspected.

The inspector used the "Selection of Housing Units" form (Completed Form 7.4) to randomly select units to inspect. The total number of units, 55, was entered into the first column of the form. The random numbers generated from a calculator were entered into the second column. The first random number, 0.583, was multiplied by 55 (the total number of units), and the product, 32.065, was entered in the third column. The product was rounded up from 32.065 to 33, and 33 was written in the fourth column, indicating that the 33rd unit would be tested. Other units were selected using the same procedure. When a previously selected unit was chosen again, the inspector crossed out the repeated unit number and wrote "DUP" (for duplicate) in the last column. The inspector continued generating random numbers until 35 distinct units had been selected for inspection. (In this case, it would have been faster to randomly determine the 20 units that would *not* be inspected (55 - 35 = 20) and then to select the remaining 35 units for inspection).

After identifying units to be inspected, the inspector conducted an inventory of all painted surfaces within the selected units. The inspector completed the "Multifamily Housing LBP Testing Data Sheet" for every testing combination found in each room equivalent within each unit. Completed Form 7.5 is an example of the completed inventory for the bedroom of the first unit to be inspected. The inventory showed that the bedroom was composed of four substrates and eight testing combinations of the following components: (1) one ceiling beam, (2) two doors, (3) four walls, (4) one window casing, (5) two door casings, (6) three shelves, (7) two support columns, and (8) one radiator. Where more than one of a particular component was present, except walls, one was randomly selected for XRF testing. Component location descriptions were recorded in the "Test Location" column. Drywall and brick substrates were not present in the bedroom.

Testing combinations not common to all units were added to the inventory list. The inspector also noted which types of common areas and exterior areas were associated with the selected units, identified each of these common and exterior areas as a room equivalent, and inventoried the corresponding testing combinations.

The inspector inventoried the remaining 34 units selected and their associated types of common areas and exterior areas before beginning XRF testing in the development. Alternatively, the inspector could have inventoried each room equivalent as XRF testing proceeded.

After completing the inventory, the inspector performed the XRF manufacturer's recommended warm up and quality control procedures successfully. Then the inspector took three calibration check readings on a 1.02 mg/cm² NIST SRM film. The calibration check was accomplished by attaching the film to a wooden board and placing the board on a flat wooden table. Readings were then taken with the probe at least 12 inches (0.3 meters) from any other potential source of lead. The following readings were obtained: 1.12, 1.00, and 1.08 mg/cm². These calibration check results were recorded on the "Calibration Check Test Results" form (Completed Form 7.2). The difference between the first calibration check average and 1.02 mg/cm² (NIST SRM) was not greater than the 0.3 mg/cm² calibration check tolerance limit obtained from the *XRF Performance Characteristic Sheet*, indicating that the XRF instrument was in calibration and that XRF testing could begin. (See the single-family housing example, in Section A, above, of this Addendum, for a description of what to do when the calibration check tolerance is exceeded).

The inspector began XRF testing in the bedroom by taking one reading on each testing combination listed on the inventory data sheet. XRF testing continued until all concrete, wood, and plaster component types were inspected in the bedroom. The XRF readings were recorded on the "Multifamily Housing LBP Testing Data Sheet" form (Completed Form 7.5). According to the *XRF Performance Characteristic Sheet*, the XRF instrument in use did not require correction for substrate bias for any of the substrates encountered in the development, so the XRF classification column was completed at that time. The inspector used single-family housing rules for classifying the XRF readings as positive, negative, or inconclusive. The inspector also used the inconclusive ranges obtained from the *XRF Performance Characteristic Sheet* (0.41 mg/cm² to 1.39 mg/cm²). The midpoint of the inconclusive range was then calculated to be 0.90 mg/cm² ([0.41 mg/cm² + 1.39 mg/cm²]/2 = 0.90 mg/cm²). The results of the classifications were recorded in the Classification column of the "Multifamily Housing LBP Testing Data Sheet" form. Classifications for all testing combinations within the unit were computed in the same manner as for the bedroom.

Once inspections were completed in all of the 35 selected units of the development, the inspector completed the "Multifamily Housing: Component Type Report" form (Completed Form 7.6). A description of each component type was recorded in the first column, the total number of each tested component type was entered in the second column, and the number of testing combinations classified as positive for each component type from the "Multifamily Housing LBP Testing Data Sheet" (Completed Form 7.5) was calculated and entered in the third column. The inspector then did the same for the testing combinations classified as negative, that is, XRF readings up to and including 0.40 mg/cm², and for inconclusive classifications with XRF readings less than the midpoint of the inconclusive range, that is, XRF readings from 0.41 mg/cm² to 0.89 mg/cm², and for inconclusive classifications with XRF readings equal to or greater than the midpoint of the inconclusive range, that is 0.90 mg/cm² to 1.39 mg/cm². Using these readings and the total number of the component type sampled, the inspector computed and recorded the percentages of positive, negative, and inconclusive classifications for each component type.

After entering the number of testing combinations for each component type in the "Multifamily Housing Component Type Report" form, the inspector noticed that only 34 wood door casings had been inspected. Because it is necessary to test at least 40 testing combinations of each component type, the inspector arranged with the client to test six more previously untested door casings. Additional units were randomly selected from the list of unsampled units. An initial calibration check test was successfully completed and the six door casings were tested for lead-based paint. Another calibration check test indicated that the XRF instrument remained within acceptable limits. The inspector then updated the "Multifamily Housing: Component Type Report" form by crossing out with one line the row of the form that showed the original, insufficient number of component types for testing; the inspector then wrote the information on the full 40 wood door casings in a new row.

The inspector used the "Multifamily Decision Flowchart" (Figure 7.1) to evaluate the component type results. Because 100 percent of the plaster walls and metals baseboards tested negative for lead, the inspector concluded that no lead-based paint had been detected on any walls or baseboards in the development, including those in uninspected units, and entered "NEG" in the Overall Classification column. The inspector also observed that shelves, hall cabinets, and window casings had no positive results. For all of the other component types, 15% or more of the readings for each type were positive; after choosing *not* to perform additional XRF readings or laboratory analysis on those components, that is, to rely on the XRF readings, the inspector entered "POS" in the Overall Classification column for them. For the shelves, all the XRF results were negative or inconclusive and less than 0.90 mg/cm² ("low inconclusive") so the inspector, in accordance with the flowchart, entered "NEG" in the Overall Classification column. The hall cabinets and window casings were classified as inconclusive with some readings greater than or equal to 0.90 mg/cm² ("high inconclusive"). The inspector determined that over 15 percent of the readings taken on these component types were high inconclusives. The inspector chose to take additional samples for laboratory analysis, to see if any or all of the samples would be determined to be negative by laboratory analysis.

The inspector collected paint-chip samples from the inconclusive component types, but only from testing combinations where XRF readings were equal to or greater than 0.90 mg/cm², the midpoint of the inconclusive range. Paint-chip samples were taken from 32 sampling locations: 12 hall cabinets, 7 window casings and 13 metal radiators. The paint-chip samples were collected from a 4-square-inch (25-square-centimeter) surface area on each component. Each paint-chip sample was placed in a hard-shelled plastic container, sealed, given a uniquely-numbered label, and sent to the laboratory for analysis.

The laboratory returned the results to the inspector, who entered the laboratory results and classifications on the appropriate "Multifamily Housing LBP Testing Data Sheet" (Form 7.5). Laboratory results of all 5 paint-chip samples taken from the window casings were classified as negative. The laboratory results of 5 samples from the hall cabinets were classified as positive, and 7 as negative. The metal radiator results were classified as 9 positives and 4 negatives.

The "Multifamily Decision Flowchart" was applied to the results shown in the "Multifamily Housing: Component Type Report" to determine the appropriate classification for each component type. The inspector classified all shelves and

window casings as negative, based either on the XRF substrate-corrected readings or on laboratory confirmation analysis, respectively. Therefore, no further lead-based paint testing was required for the shelves and window casings. About 9.1 percent (none positive by XRF analysis and 5 positive by lab analysis of the 55 that were inspected) of all hall cabinets in the housing development had lead-based paint.

Final decisions made by the development client regarding the hall cabinets were based on various factors, including:

- The substantially lower cost of inspecting all hall cabinets in the development versus replacing all of those cabinets;
- Future plans, including renovating the buildings within three years; and
- The HUD/EPA disclosure rule requirements regarding the sale or rental of housing with lead-based paint.

In this case, the client arranged for testing hall cabinets in all of the unsampled units to determine which were positive, and which were negative. To verify the accuracy of the inspection services, the client asked the inspector to retest 10 testing combinations. The retest was performed according to instructions obtained from the *XRF Performance Characteristic Sheet*. The client appointed an employee to randomly select 10 testing combinations from the inventory list of 2 randomly selected units. The employee observed the inspector retesting the 10 selected testing combinations, using the same XRF instrument and procedures used for the initial inspection. A single XRF reading was taken from each of the 10 testing combinations. The average of the 10 repeat XRF results was calculated to be 0.674 mg/cm^2, and the average of the 10 previous XRF results was computed to be 0.872 mg/cm^2. The absolute difference between the two averages was computed to be 0.198 mg/cm^2 (0.872 mg/cm^2 minus 0.674 mg/cm^2). The Retest Tolerance Limit, using the formula described in the *XRF Performance Characteristic Sheet* , was computed to be 0.231. Because 0.198 mg/cm^2 is less than 0.231 mg/cm^2, the inspector concluded that the inspection had been performed competently. The final summary report also included the address of the inspected units, the date(s) of inspection, the starting and ending times for each inspected unit, and other information described in Section V.I of Chapter 7.

At the end of the work shift, the inspector took a final set of three calibration check readings using the same procedure as for the initial calibration check. The following readings were obtained: 0.86, 1.07 and 0.94 mg/cm^2. The average of these readings is 0.97 mg/cm^2. The difference between 0.97 mg/cm^2 and the NIST SRM's 1.02 mg/cm^2 is -0.08 mg/cm^2, which is not greater in magnitude than the 0.30 mg/cm^2 calibration check tolerance for the instrument used. The inspector recorded that the XRF instrument was in calibration, and that the measurements taken between the first and second calibrations could be used.

Endnotes

1. Most XRF instruments detect K-shell fluorescence (X-ray energy), some L-shell fluorescence, and some K and L fluorescence. In general, L X rays released from greater depths of paint are less likely to reach the surface than are K X rays, which makes detection of lead in deeper paint layers by L X rays alone more difficult. However, L X rays are less likely to be influenced by substrate effects.

2. Westat, Inc. An Analysis and Discussion of the Single Family Inspection Protocol Under the 1995 HUD Guidelines: Draft Report. 1996.

3. Dixon, S., National Center for Lead-Safe Housing, Sample Size as a Function of Multifamily Development Size. 1997.

4. The statistical rationale and calculations used to develop sample sizes in multifamily housing is based on a data set which contains approximately 164,000 XRF readings from 23,000 room equivalents in 3,900 units located in 65 housing developments. Statistical and theoretical analyses completed for HUD are available through the Lead Clearinghouse and on HUD's World Wide Web Home Page.