The Decontamination and Characterization Challenges of Legacy Material

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ABSTRACT

The legacy project at Lovelace Respiratory Research Institute (LRRI) was an opportunity to work with decades worth of research. LRRI was founded in 1963 to provide inhalation research using radioactive nuclides. Over the next 35 years, scientists at the institute researched the effects of radioactivity on the lungs and the effects of inhaled radiation on the body. There were two outcomes of the research. First, the studies provided valuable information regarding radiation safety and the prevention of the inhalation of radioactive material. Second, the studies created a large amount of legacy waste that is now being cleaned up.

Overall, the legacy materials project at LRRI was an interesting challenge. It provided opportunities to the team of LRRI and SEC to engineer solutions to remove and release material. It involved unique ALARA engineering to minimize dose exposure to the project team. And finally, it provided an opportunity to minimize low-level radioactive waste. This paper will expand on the waste management challenges and lessons learned.

INTRODUCTION

The Lovelace Respiratory Research Institute (LRRI) 2002 Decommissioning Project consisted of two tasks. The first task is called the Castle Project. The second task is called the Alpha Wing Project.

CASTLE PROJECT

The Castle Project consisted of a radioactive materials storage area located in Building 9222 on the LRRI complex. A wall that is 12 inches thick and 10 feet high surrounds the area. The general radiation field inside the storage area ranged from 200 mR/hr to 400 mR/hr, while the background outside the wall is 0.02-0.06 mR/hr. Figure 1 shows how the storage area held approximately 30 drums/containers of radioactive material that ranged from 6 to 20 years old. Content information and individual dose rates of the drums were insufficient to ship for disposal. The isotopes of concern are Sr-90, U-232/Th-228, Ra-226. The objectives of the project was to:

1. Obtain dose rates of the individual drums

2. Determine and calculate the activities of the drums
3. Determine the contents of containers and drums
4. Determine what drums can be safely shipped for disposal

The first step in the project was to remove the drums from the storage area and obtain dose rates for the individual drums. The background within the storage area was too high to give an accurate reading of the individual drums. The crew set up additional high-density block shielding walls to reduce individual exposures.

Each drum was removed from the area and placed on a balance for weight determinations. After gathering the information, the drums were measured for dose rate and activity. The crew used a SAM instrument (sodium iodide detector) to measure the amount of signal coming from the drums. Any additional documents that were found on the container were gathered and placed in the project file.

Figure 1. Overview of Castle Radioactive Material Storage

The second step was to estimate the activities of the radioisotopes. All the information (dose rate, SAM measurements, and documents) was used to estimate the Becquerel (Curie) quantities of the radionuclides. Even with all the information that was gathered, some assumptions had to be made to estimate the quantities. The assumptions were:

1. Contents of the container based on the information
2. The type of outer container, steel versus polyethylene
3. The number of inner containers and type
4. The type of shielding used in the packaging of the material.

Upon review of the initial calculations, LRRI continued to have additional questions regarding the characterization and activity quantities of the material. The estimated activities were above the Department of Transportation (DOT) A_2 values, which indicated that the drums might need to repackaged or placed in special shipping containers.

The third step was to work with Sandia National Laboratories (SNL) to take real-time-radiography (RTR) pictures of the inside of the containers. SNL brought a portable 300 KeV X-ray source to the LRRI complex. The X-ray was pointed into a loading dock to provide shielding for the beam. A 4-layer high 2 column deep wall of high-density block was erected on top of the loading dock to provide additional shielding. The drum was placed on a turntable with the forklift between the X-ray and the camera inside the box. The purpose of bringing SNL to shoot pictures of the drums is to verify contents, configuration, and look for prohibited items. Figure 2 provides an example of prohibited items.

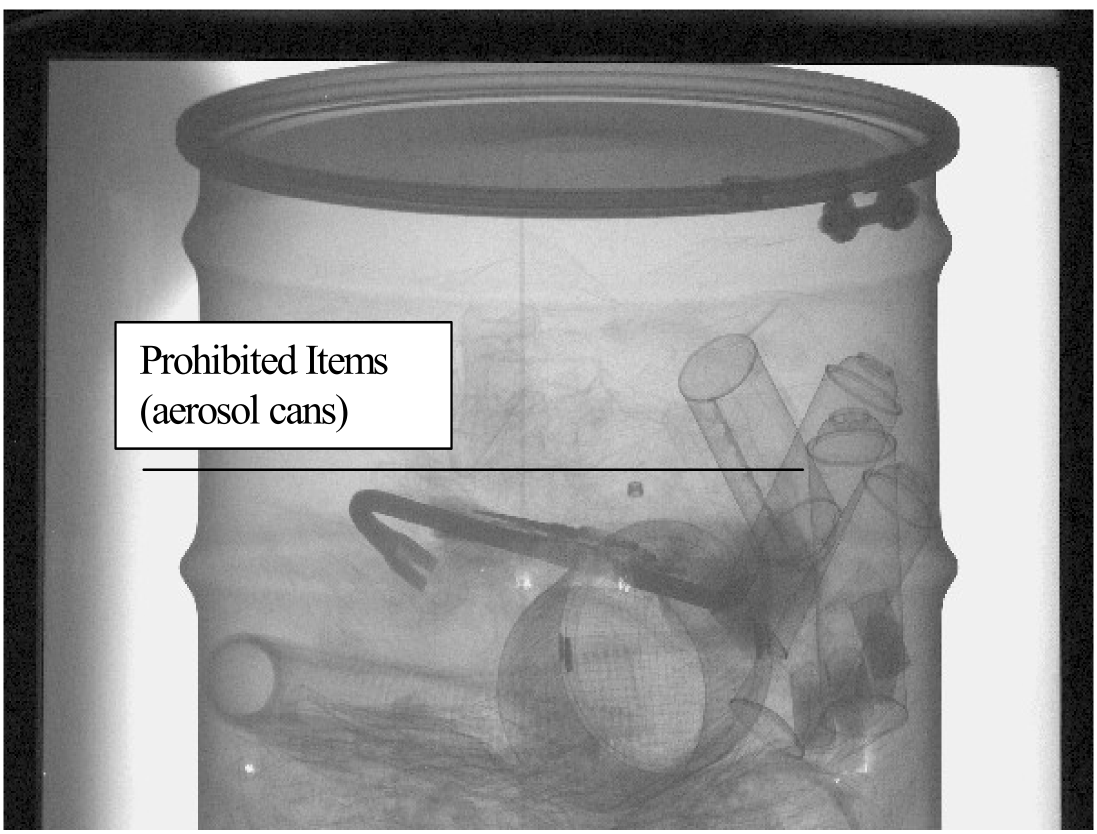

Figure 2. Prohibited items in a drum.

SNL provided pictures of 27 drums. The pictures verified the following:

1. Drums that meet the DOT Type B container definition for shipment of radioactive material.
2. Containers that had dirt used as packaging to reduce the dose.
3. Containers that contained low density material
4. The location of questionable or prohibited items (i.e. aerosol cans or lead) for disposal.

The final step of the project was to determine what containers could be shipped for disposal. After gathering the information, estimating the activities, and verifying the contents, LRRI arrived at the following conclusions:

1. Some drums would require repackaging due to questionable or prohibited items.
2. Some containers would require repackaging to decrease the quantity of radioisotopes.
3. Special shipping containers would have to be used for disposal, due to DOT requirements.

At the conclusion of the project, the containers were stored back in the Castle in an array that minimized as much as possible the background radiation inside the storage area. The results of the dose rate measurements and activity estimates are as follows:

1. Dose rates of the containers ranged from 200 mSv/hr to 270 Sv/hr.
2. The calculated radioisotope activities are shown in Table I.

Table I. Calculated Radioisotope Activities For The Castle Drums

Isotope	**Low**	**High**
U-232/Th-228	4.81e-1 GBq	6.41 GBq
Sr-90	1.79e-1 GBq	3.39e+2 GBq
Ra-226	2.22e-1 GBq	6.70 GBq

THE ALPHA WING PROJECT

The Alpha Wing Project consisted of the decontamination and decommission of approximately 4,000 square feet consisting of 11 rooms. Figure 3 shows the floor plan of the area to be decontaminated. The rooms had been used for 30 years in exposing animals to particles of radioactive materials to determine biological and respiratory effects. The rooms are located in Buildings 9202C and 9202D on the LRRI complex. The rooms held a variety of glove boxes, fume hoods, laminar flow hoods, animal chambers, and muffle furnaces. The isotopes of concern were Pu-238, Pu-239, U-232, Am-241, Th-228, Th-232, and Am-243.

Due to the complexity of the rooms to be decontaminated, the project was broken down into three phases outlined in Table II and displayed in Figure 3.

Table II. Phases of the Alpha Wing Decontamination Project

Phase	Rooms	Use
I (Blue)	440, 441, 442, 443, 444, 445	Exposure rooms, labs, control room
II (Green)	431, 432, 448, 449	Radiochemistry labs, muffle furnace room
III (Yellow)	446, 447	Radon Generator room, Health Physics Lab

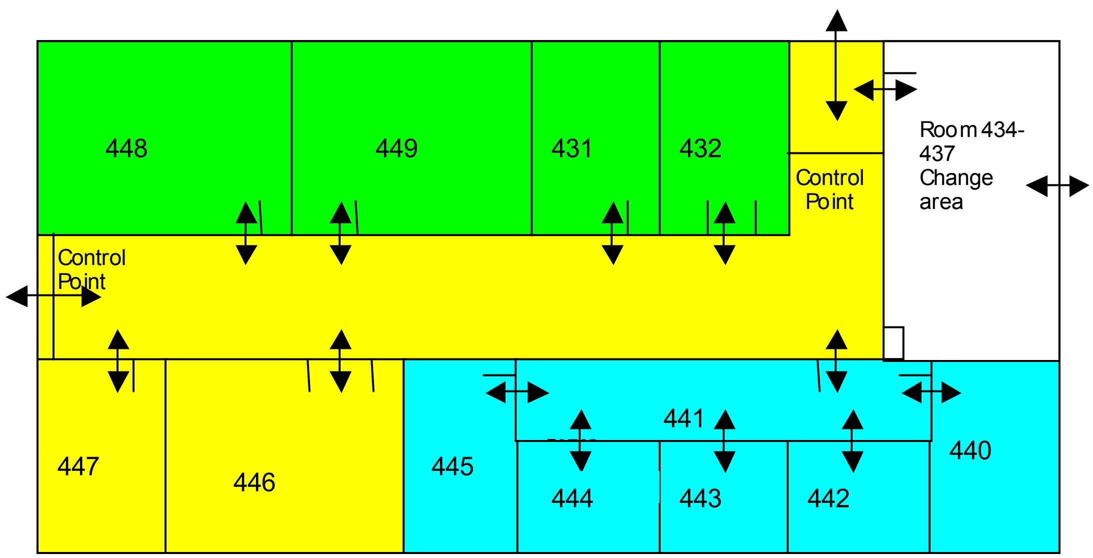

Figure 3. Layout of the Alpha Wing

The objective of the project was to remove all material, including cabinetry and countertops, from the ceiling to the floor and wall-to-wall and dispose of the material. To increase the floor space area and eliminate unnecessary safety hazards during all three phases, at the beginning of each phase, miscellaneous items were removed from the floor, hoods, cabinets, walls, and ceilings. These items were placed in 55-gallon steel drums or aluminum boxes for disposal.

Alpha Wing - Phase I

Due to the nature of the work performed in rooms for Phase I and III, LRRI decided to dispose of all items in those areas. It was not cost effective to perform a release survey on every item that was removed from the rooms. The decontamination crew containerized all the loose items into 55-gallon steel drums or into 5' x 2.5' x 2.5' aluminum lined with plastic. For items that did not fit into the containers, the crew wrapped them in shrink-wrap and moved them to storage on pallets. Once the material was packaged, it was placed in storage for further characterization.

During Phase I, the crew removed two large glove box lines (14 feet and 16 feet long) without having to break apart the glove boxes. LRRI and SEC decided that the surface contamination and airborne hazard to the employees was too high to dismantle the glove boxes. Therefore, loose or questionable material was removed for packaging. After the material was removed, the crew sealed all the openings with caulking material to prevent leakage of material. A non-hazardous fire-dam spray was applied to the surface of the material to fix any external contamination and the glove boxes were wrapped in plastic for transport to storage.

When the time came to remove the glove boxes, LRRI established a temporary radiation work area and limited access to authorized employees only. The glove boxes were taken down the hall to the outside where a forklift was waiting to transport to the storage area. The two glove box lines were 14 feet and 16 feet long respectively and weighed about 800 pounds apiece. During the forklift transport, personnel acted as spotters for the driver and walked on either end of the glove box to prevent any accidents which might lead to a release.

Alpha Wing - Phase II

For Phase II, the LRRI and SEC team determined it was cost effective to perform release surveys on as many items as necessary. These four rooms consisted of large muffle furnaces, counters, cabinets, and fume hoods.

The muffle furnaces were wiped down using a 50% Radiac™ Wash solution and cheese clothes, surveyed, and disposed of as clean waste. The furnaces were also checked for PCB and asbestos containing materials.

The counters and cabinets were also wiped down using a 50% Radiac™ Wash solution. These items were surveyed and reviewed for recycling possibilities. For those cabinets that were not rusted or discolored, the crew placed them in a designated room for re-use in laboratory build-outs. For those cabinets that were significantly rusted or discolored, the crew placed them in the clean waste for disposal. For cabinets that had contamination, the crew wrapped the cabinet in plastic and placed it in radioactive waste storage for characterization.

After using direct readings and swipe surveys, all the fume hoods were disposed of as radioactive waste. Using hoisting and rigging techniques, the hoods were removed from the base and lowered to the floor. The hood weights ranged from 200 pounds to 800 pounds and in size from five (5) feet to eight (8) feet wide. Once lowered, the internal hood space was filled with PPE used during the project and the sashes secured closed. The hood was shrink-wrapped and moved to the storage area for characterization.

During phase II, many of the labs contained chemicals and radioactive solutions. The chemicals were analyzed for radioactivity and released as hazardous waste if no activity was detected. For the radioactive solutions, the crew took an inventory of the material and determined what activities were written on the containers. For those solutions that were unknown, small aliquots were taken to determine total activity. To meet Low Level Waste disposal criteria, the solutions were then solidified using plaster of paris and ensuring that the material did not meet TRU waste criteria. If a possibility of creating TRU waste existed, the solution was solidified and set aside for further characterization.

Alpha Wing - Phase III

Phase III, which consisted of rooms 446 and 447 present different challenges than did Phases I or II. Room 446 had been used as a Radon gas generator room and was known to still contain residual material of Radium 226 solutions from the studies. The room had a glove box, a 6-foot stainless steel aging tank, and 350-400 high-density block used for shielding. It was not cost effective to decontaminate the stainless steel materials, so, the objective was to remove all the material as radioactive material.

During Phase III, the Radium-226 glove box posed a significant health hazard. The last activity that was recorded for the glove box was 1996. Since the last experiment, material remained in the glove box. This included lead shielding, laboratory equipment, and residual Ra-226 solutions. The crew measured approximate dose rates of 60 mR/hr on the outside of the glove box.

LRRI and SEC established a radiation work permit for removal of the material from the glove box. A second pass-through box, with gloves, was installed on the primary pass-through to control contamination. Material was moved into the secondary containment, surveyed and removed to an appropriate waste container. The lead and other hazardous waste was separated from radiological [radiological waste? You repeat "hazardous" in sentence which confused me.] waste. The dose rates on the items coming from the original glove box ranged from background to 200 mR/hr on contact. Acidic radioactive Ra-226 solutions were neutralized, solidified, and placed in R2 containers for storage and characterization. Overall, Ra-226 contamination was minimized, however, there was measurable amounts in the room, therefore, the crew worked in respirators while removing material.

At the conclusion of the material removal, the glove box was surveyed to determine the residual dose rate, which was 12 mR/hr. The crew built a wooden box for the glove box so that it could be moved without the potential of spreading contamination.

Room 446 also had a significant safety hazard with the high-density shielding block. The block was manufactured to look like a regular concrete block. However, the block weighed approximately 70-80 pounds, whereas, the regular block weighs 30-40 pounds. The blocks were surveyed while in place, and then a plan was developed to remove the non-contaminated blocks. LRRI and SEC personnel designed a process that used conveyor belts to remove the block to a staging area for transport to storage. By using the conveyor belt, the risk of injury was minimized and the work was completed in 1.5 days. After the clean blocks were removed, the contaminated blocks were removed in a similar fashion.

The last challenge for Phase III was a 5-foot tall 47-inch diameter stainless steel tank with internal contamination, which stood upright. The tank was designed as an aging tank for the radon gas used in the experiments. A plug was removed to verify that the tank did not contain any liquids and to experiment with how to verify contamination. A slight amount of liquid came out. This was collected and analyzed for activity, which verified that contamination did exist.

Since the tank was stainless steel and did not offer a good place to dismantle it without personal safety or health at risk, LRRI and SEC decided to remove the tank as a whole. All the lines were disconnected from the tank and the holes plugged with caulking material. The 300-pound tank was laid down on the floor and then placed on a flat cart and secured. Just as with Phase I, LRRI established a temporary radioactive materials area to remove the tank to the outside. Fortunately, the doorways were 48 inches wide and the crew was able to squeeze the tank through the openings. The crew used a forklift to transport the item to the storage area. This concluded the movement of material from the Alpha Wing to the storage area.

FACILITY DECONTAMINATION

During each phase, after the loose material, ductwork, and large items were removed, the rooms were decontaminated. This involved wiping down walls, light fixtures, and girders; removing contaminated tile or linoleum; and removal of surface concrete.

Data was collected to determine radioactive contamination and areas to be decontaminated. Areas were scanned before and after decontamination attempts to determine if efforts were successful and whether more aggressive techniques would be required.

Decontamination efforts were initiated at the level of the girders that at the ceiling. Ceiling and walls were decontaminated using the "top-to-bottom approach" so that the floor was the last to be cleaned. Wipes dampened with Radiac solution were used to remove surface contamination. Care was taken to not create significant amounts of contaminated liquid waste. Brushes and scrub pads were used if more aggressive techniques were necessary. For concrete surfaces, contamination that could not be removed using the previously mentioned techniques was removed using a needle gun and electrical grinder. This removed less than an inch of concrete down to the decontamination limits. Dust and removed contamination were collected using a high-efficiency particulate air vacuum.

RADIOLOGICAL STATUS SURVEY APPROACH

The objective for the Alpha Wing Project was to release the area from radioactive contamination and to free release the area for use. The release survey followed the guidance provided in Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). The Nuclear Regulatory Commission, Environmental Protections Agency, Department of Energy, and Department of Defense collaborated to develop the MARSSIM process. The focus of the process is to demonstrate compliance of a site or facility with criteria established for future use without radiological restrictions. This type of survey is known as a "Final Status Survey". LRRI expected that several of the areas in Alpha Wing to be contaminated above the allowable limits established by policy.

Many aspects of MARSSIM are intended for application with dose-based guideline levels of residual contamination, implemented by averaging over an entire "survey unit." This dose-based guideline approach also incorporates provisions for establishing additional limitations for small isolated areas of elevated concentrations of the contaminant. For the Alpha Wing, the release criteria were not dose-based, therefore limiting applications of the MARSSIM to this survey. However, the survey design provided a level of thoroughness and technical support that equals or exceeds that of MARSSIM.

LRRI and SEC developed a “Final Decon Verification Survey” to release the rooms from radiological contamination requirements in accordance with accordance to LRRI policies.

RADIOLOGICAL SURVEY IMPLEMENTATION

Following removal of equipment, fume hoods, cabinets, and general surface cleaning, the room surfaces were surveyed for removable and fixed contamination. Surfaces were designated “clean” if contamination levels were less than:

- Fixed alpha contamination <300 dpm/100 cm^2
- Removable alpha contamination < 20 dpm/100 cm^2

Fixed contamination measurements were based on a combination measurements that were based on combination of surface scanning and fixed point measurements based on grids and at biased locations determined from process knowledge and scan results. Removable contamination was assessed using smears to wipe 100 cm^2 areas. Residual activity associated with difficult geometries, such as wall-floor intersections, floor cracks, etc., was surveyed directly using a Fidler/Ludlum 221 detector to measure the presence of Am-241 (60 KeV gamma) that is normally associated with the presence of Pu-239.

The floor (100% of accessible floor surface) was scanned using the Ludlum 43-37 floor monitor. The floor was scanned at a rate of 7.5 cm/s. If a count was indicated, the scanning stopped for one second to verify whether the spot was above background. If no further counts were recorded, then there was a 90% probability that it was an indication of background. If additional counts were recorded, the spot was marked and biased measurements were performed.

The survey crew scanned 100% of the accessible wall space up to 7 feet using a Ludlum 43-89 α/β Scintillator instrument. The forward velocity of the scan was 3.5 cm/s. If a count was indicated, then the survey was stopped for approximately 5 seconds. If no further counts were registered, then the initial indication of the count was background with a probability of 90%. If additional counts were registered, then the area was marked and biased measurements were performed.

Once the areas were scanned, the crew performed direct measurements consisting of fixed-point and biased locations. At the fixed-point locations, a one-meter grid system on the floor and walls was established. Measurements were taken for one-minute intervals based upon the grid system. For biased locations (areas identified to have higher than background measurements), the area was deconned, and then one-minute counts were obtained. For those areas located above 7 feet, a survey was conducted at 10% of the random locations on the wall and ceiling.

For removable activity measurements, a 100 cm^2 smear sample was obtained using 47 mm filter paper discs and analyzing the alpha activity using the Ludlum 2929 sample counter. A smear was obtained at each location where a direct measurement was performed (fixed or biased).

The results of the surveys determined that 99% of the rooms could be release without radiological restrictions. Only the ceiling in room 446 did the contamination have to be fixed in place using two coats of paint. With all the contamination eliminated through decontamination, there were no restrictions placed on the areas allowing the facility to be released for reuse. As a result of the surveys, personnel were allowed to move freely throughout the areas that were previously had restricted access.

LESSONS LEARNED

As with any project, there are lessons learned that can be applied to on-going or future projects. These to tasks provided their own lessons learned that are useful and beneficial. For example, the significant use of ALARA and project planning minimized exposures and injuries. Another example of a lesson learned is the use of real time radiography technology to minimize exposure to employees. A third lesson learned is the method of waste characterization that will be used in future projects.

Castle Project

The castle project offered a number of lessons learned. One would be the good practice of ALARA. The teamwork between LRRI and SEC minimized the exposure to the workers to the radiation. Not once during the project did the team exceed the project administrative limit of 0.1 mSv/week. There were several opportunities of high exposure to employees.

One was the removal of the drums from the castle. Personnel had to be in the area for several minutes as they retrieved the drums. The second opportunity was the dose rate determinations. Personnel had to handle the drums using forklifts, drum holders, and hooks to measure all sides (including top and bottom), to weigh, and to gather spectrum information from SAM. The third opportunity for exposure was handling the drums during the RTR portion of the project. Each drum had to be placed in a certain configuration using a forklift, drum holders, or hooks with a tether line.

Another lesson learned is the verification of drum contents. By using RTR, the team was able to verify contents, look for prohibited or questionable items, and determine the configuration of the waste. The RTR allowed the team to focus on the next step of the project due to the pictures of the contents. Using the pictures, the team can determine what drums can be repackaged, what drums need additional shielding, and how to plan the work to minimize contamination and exposure.

A third lesson learned from Castle is proper planning is the key. Through the planning of the project, personnel did receive significant doses and were not injured. The project had no accidents or radiological releases.

The Alpha Wing Project

The Alpha Wing Project also offered several lessons learned. The best lesson learned from the project was the characterization of the waste. The team found it difficult to characterize the waste from thirty years of research. Preliminary research was able to provide the isotopes of concern, however, it could not provide the sufficient support data for the radioisotope activities of the waste material. It was very difficult to indicate that the contamination came from a single study through process knowledge. Therefore, a number of techniques had to be used to characterize the material.

Direct instrument readings and swipe data provide some information as to estimated activities; however, it could not provide the isotope. As the areas were decontaminated and loose material was removed, any research logbooks, procedures, or protocols were reviewed to identify isotopes. Finally, Non-Destructive Analysis (NDA) was used to determine isotopes and estimate activities. In all over 65 items were counted to determine isotopes for the alpha areas. After the NDA, a sufficient number of waste drums from each room were counted to provide a representative sample of the total waste volume. These counted values were used to extrapolate activities for those items that were not counted. In the end, the use of the NDA, direct readings, and swipes was more cost effective than trying to just use process knowledge.

In the future, the decontamination of legacy projects will include the characterization of the waste as the project progresses. This may include using all three methods of *in situ* gamma spectrometry, completing direct readings to locate contaminated areas, and swipes to determine removable and possible isotope analysis.

CONCLUSIONS

As a result of the cooperation between LRRI and SEC, the project was able to take an old area of LRRI that had not been used since 1996, remove everything from the rooms, decontaminate the floors, walls, and ceilings, and prepare the area for renovations within 5.5 months. The team was able to free release approximately $100,000 of lab cabinetry to be reused in new laboratories and facilities. Through the constant communication, plan of the week meetings, and clear objectives, the project was completed on time, within budget costs, and with no recordable injuries or illnesses or accidents.