CHARACTERIZATION SURVEY AND INTERIM CORRECTIVE MEASURE REPORT

IRP SITE NO. RW-41

TEST AREA C-74L GUNNERY BALLISTIC FACILITY

CONTRACT NO. DACW45-94-D-0002
DELIVERY ORDER NO. 12

Prepared For
Eglin Air Force Base
Air Armament Center
Air Force Materiel Command
Eglin AFB, Florida

Prepared By
Earth Tech Environment & Infrastructure, Inc.
Fort Walton Beach, Florida

Under Contract To
U.S. Army Corps of Engineers
Omaha, Nebraska

March 2000

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I hereby submit that I am currently registered in good standing as a Professional Geologist in the state of Florida. To the best of my knowledge, the investigative methods proposed within this Characterization Survey and Interim Corrective Measure Report are in accordance with applicable state and federal regulations, project Work Plans, and accepted professional practices.

Alexander P. Macbeth, P.G.
Florida P.G. #1933

3/17/00

ALEXANDER P. MACBETH
LICENSE
No 1933
STATE OF FLORIDA
PROFESSIONAL GEOLOGIST

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LIST OF ACRONYMS

AAC	Air Armament Center
bls	below land surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
CompQAP	Florida Comprehensive Quality Assurance Plan
CP	Control Point
CS	Characterization Survey
DCGL	Derived Concentration Guideline Limit
DCGLemc	Derived Concentration Guideline Limit Elevated Measurement Comparison
DOD	Department of Defense
DOE	Department of Energy
dpm	disintegrations per minute
DQO	Data Quality Objectives
DU	Depleted Uranium
Eglin	Eglin Air Force Base
Eglin RSO	Eglin Radiation Safety Officer
EMR	Environmental Management Restoration
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ESOPs No. 1 through 14	Eglin Standard Operating Procedures
ESOP No. 1	Site Access and Clearance
ESOP No. 2	Field Records and Documentation
ESOP No. 3	Sample Nomenclature and Control
ESOP No. 4	Geophysical Investigation Methods
ESOP No. 5	Quality Control Procedures for Field Equipment
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ESOP No. 10	Subsurface Water Investigation
ESOP No. 11	Surveying
ESOP No. 12	Abandonment
ESOP No. 13	Standard Cleaning and Decontamination Procedures
ESOP No. 14	Investigation Derived Material
ESOP No. 15	LLRM Site Investigations
FDOH	Florida Department of Health
FIDLER	Field Instrument for the Detection of Low-Energy Radiation
FSP	Field Sampling Plan
ft/sec	foot per second
g	grams
gpm	gallons per minute
g/cm^3	grams per cubic centimeter
HSP	Basewide Health and Safety Plan
ICM	Interim Corrective Measures
ICP/MS	Inductively Coupled Plasma Mass Spectroscopy

LIST OF ACRONYMS (CONTINUED)

IDM	Investigative Derived Material
IENA	Instrumental Epithermal Neutron Activation
IERA	Institute for Environment, Safety and Occupational Health Risk Analysis
IRP	Installation Restoration Program
IRPIMS	IRP Information Management Systems
^{40}K	Potassium
kcpm	kilocounts per minute
Kg	kilograms
LANL	Los Alamos National Laboratory
LECR	lifetime excess cancer risk
LLRM	Low-Level Radioactive Materials
LUC	Land Use Control
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	Maximum Contaminant Level
$MDCR_{surveyor}$	Surveyor Minimum Detectable Count Rate
MSL	mean sea level
NaI	sodium iodide
NCP	National Contingency Plan
NFA	No Further Action
NRC	Nuclear Regulatory Commission
NWFWMD	Northwest Florida Water Management District
pCi/g	picoCuries per gram
pCi/L	picoCuries per liter
PPE	Personal Protective Equipment
QAPjP	Quality Assurance Project Plan
QAPP	Basewide Quality Assurance Program Plan
RAM	Radioactive Material
RCA	Radiation Control Area
RCRA	Resource Conservation and Recovery Act
REI	Rust Environment & Infrastructure, Inc.
RESRAD	residual radioactivity
RFA	RCRA Facility Investigation
^{222}Rn	Radon
R.R.	Range Road
RSO	Project Radiation Safety Officer
RWP	Radiation Work Permit
scan MDC	Scanning Minimal Detectable Concentration
SI	Site Investigation
S.R.	State Road
SSHP	Site Safety and Health Plan
TERC	Total Environmental Restoration Contract
TLD	Thermoluminescent Dosimeter
^{235}U	Uranium 235
^{235}U HP	Uranium 235HP (See Table 3.2.)
^{238}U	Uranium 238
^{238}U DHP	Uranium 238DHP (See Table 3.2.)
μg/g	micrograms per gram
μg/L	micrograms per liter

LIST OF ACRONYMS (CONTINUED)

UXO	unexploded ordnance
μR/hr	microR per hour
USACE	U.S. Army Corps of Engineers

1.0 INTRODUCTION

The U.S. Army Corps of Engineers, Omaha District (USACE) has retained Earth Tech Environment & Infrastructure, Inc. (Earth Tech), formerly Rust Environment & Infrastructure, Inc. (REI), to perform a Characterization Survey (CS) and Interim Corrective Measure (ICM) for depleted uranium (DU) fragments at Installation Restoration Program (IRP) Site No. RW-41 Test Area C-74L Gunnery Ballistic Facility, located at Eglin Air Force Base (Eglin), Florida. This CS/ICM Report was developed under the Total Environmental Restoration Contract (TERC), Delivery Order No. 12, and the U.S. Air Force IRP.

The CS/ICM was performed at Eglin under the IRP, which was established to meet the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as defined in the National Oil and Hazardous Substances Contingency Plan (NCP). The SI was also conducted to comply with the substantive requirements of a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA), in conjunction with Eglin's RCRA Part B permit.

Radioactively contaminated sites are complex because of the number of regulatory programs governing the cleanup of such sites and the number of agencies involved in releasing the sites for restricted or unrestricted use. For this reason, the U.S. Environmental Protection Agency (EPA), the Nuclear Regulatory Commission (NRC), the Department of Defense (DOD), and the Department of Energy (DOE) developed the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) to provide a nationally consistent approach to conducting radiation surveys and investigations at potentially contaminated sites (NUREG-1575, 1997). Although Eglin must adhere to the IRP (as described in the previous paragraph), the Eglin Low-Level Radioactive Materials (LLRM) Partnering Team determined that, for the best interest of all regulatory agencies involved, the MARSSIM approach should be followed as practical for the investigation and potential cleanup of the LLRM sites identified at Eglin. Therefore, this document incorporates nomenclature and terminology from the RCRA and CERCLA programs, as well as MARSSIM. The Eglin LLRM Partnering Team is composed of the Eglin Environmental Management Restoration (EMR) Project Manager, the Eglin Radiation Safety Officer (Eglin RSO), and representatives of the Eglin 46th Test Wing, the Air Force Radioisotope Committee (RIC), the U.S. Environmental Protection Agency (EPA), the Florida Department of Health (FDOH), USACE, and Earth Tech.

Eglin has performed environmental work from 1976 through 1991 at IRP Site No. RW-41 to evaluate the impact of DU on site soils and groundwater, as well as nearby sediment and surface water. In 1980, limited DU fragment excavation was performed within the approach gun corridor leading from the gun bay building to and including the target butt (Becker and others, 1990; Becker and others, 1994). The results of these activities are summarized in Section 2.3 of this SI Report.

The CS consisted of a walk-over survey of site surface soils using an appropriate field screening instrument (FIDLER) and the collection and laboratory analyses of soil samples. The ICM portion of the work entailed the collection and off-site disposition of discrete DU penetrator fragments on the ground surface and the shallow subsurface (down to approximately 6 inches below land surface [bls]).

These data obtained from the CS/ICM are being used to design appropriate corrective measures (if necessary), which may include the excavation and off-site disposal of DU fragments at the site.

The decision to pursue the SI activities of soil sampling was developed by the Eglin LLRM Partnering Team in the March, June, August, and December 1998 meetings (Eglin, March 1998; Eglin, June 1998; Eglin, August 1998; Eglin, December 1998).

All Environmental Restoration (ER) work discussed in this document was conducted, as applicable, in accordance with the approved Basewide ER scoping documents prepared for Eglin. These include the Basewide ER Work Plan, which includes *Eglin Standard Operating Procedures* (ESOPs; Eglin, October 1997a; Eglin, April 1999a), the *Basewide Quality Assurance Program Plan* (QAPP; Eglin October 1997b; Eglin, April 1999b), the *Basewide Health and Safety Plan* (HSP; Eglin, October 1997c; Eglin, April 1999c), and the *Florida Comprehensive Quality Assurance Plan* (CompQAP), No. 980203 (Earth Tech, December 1998).

The contents of this CS/ICM Report include the following:

- Objectives of the CS/ICM;
- Accepted Release Criteria and Preliminary Derived Concentration Guideline Levels (DCGLs);
- Physical Description of the Site;
- Summary of Historical Environmental Work at the Site;
- Detailed CS/ICM Scope of Work;
- Results of the CS/ICM;
- Data Evaluation; and
- Conclusions and Recommendations for Future Activities.

1.1 OBJECTIVES OF THE CS/ICM

Currently, Test Area C-74L is an active conventional weapons test range, but is closed for DU testing. DU penetrator fragments have been observed on the ground surface at the site. Also, as discussed in Section 2.3, DU has been detected in the soils at the site. Because of these conditions, in the late 1970s Eglin established a radiation control area (RCA), which is fenced off and requires permission/escort from the Eglin RSO to access. A CS/ICM was performed at the site, because the DU penetrator fragments and the soil quality posed a potential risk to the workers at Test Area C-74L and to future potential users of the land.

Therefore, the objectives of the CS/ICM at IRP Site No. RW-41 are as follows:

- Remove from the site the readily accessible DU penetrator fragments located at the ground surface and shallow subsurface (within about 6 inches bls). These removal activities are considered the ICM portion of the field activities.
- Identify the presence or absence of DU in site soils. Use the residual radioactivity (RESRAD) model, along with the LLRM Partnering Team-accepted risk criteria and future land use exposure parameters, to derive preliminary DCGLs. Determine if the level of contamination (if any) at the site is above the release criteria.

- If DU activities are below DCGL, provide enough supporting data for no further action (NFA) or Land Use Controls (LUC) recommendation and acceptance. Use applicable data obtained from the CS/ICM to support a final status survey.
- If DU is present above the DCGL, delineate the lateral and vertical extent of DU at levels that warrant remedial action.

1.2 ACCEPTED RELEASE CRITERIA AND PRELIMINARY DCGL

The DCGL is defined as a derived, radionuclide-specific activity concentration at a site that corresponds to the release criterion. DCGLs were derived from activity/dose relationships through various exposure pathways. For IRP Site No. RW-41, they were calculated using the RESRAD computer code, which was developed to implement DOE requirements for residual radioactive material. RESRAD calculates doses and risk to an on-site individual. Input parameters and exposure pathways (e.g., residential, industrial worker, and construction worker) can be adjusted to simulate site land use scenarios. Input parameters of the RESRAD code for all exposure scenarios were presented to the LLRM Partnering Team during the March 1999 Partnering Meeting (Eglin, March 1999). These input parameters are discussed and presented in *Compilation of RESRAD Input Parameters for Low-Level Radioactive Material Depleted Uranium Investigations* (Earth Tech, March 1999), which is included in Appendix A.

For the CS/ICM at IRP Site No. RW-41, DCGLs have been determined from graphical output of RESRAD to be an approximate Lifetime Excess Cancer Risk (LECR) greater than 3E-04. The DCGL corresponds to an activity of DU in soil in picoCuries per gram (pCi/g) that would result in a LECR of 3E-04 for the following future land use scenarios:

- Industrial Scenario - 600 pCi/g
- Construction Worker - 7,500 pCi/g
- Residential - 500 pCi/g

DCGLs were determined for the industrial scenario, which is considered to be the most likely future land use designation. In addition, the construction scenario was evaluated to determine the DCGLs to be attained to allow future construction activities at the site. This will allow Eglin some flexibility in their future land use decisions. For comparative purposes, the residential scenario was evaluated to determine the most conservative DCGL value. Because of the potential presence of unexploded ordnance (UXO), it is unlikely that IRP Site No. RW-41 will be cleared for residential land use.

Development of the DCGLs for IRP Site No. RW-41 allows the subsequent evaluation of appropriate future investigation/corrective measures at the site.

1.3 APPROACH

The approach adopted to meet the objectives presented in Section 1.1 includes conducting a field survey/investigation to assess the presence or absence of and delineate, if necessary, DU fragments at the site. This section summarizes these activities. A detailed description of the scope of work is presented in Section 3.0. The CS/ICM at IRP Site No. RW-41 included the following activities:

- Performed a walk-over survey of the site using a Field Instrument for the Detection of Low-Energy Radiation (FIDLER) detector and rate meter/scaler. This walk-over survey was performed in a north-south orientation over the entire site. The survey was also performed in an east-west orientation around approximately 10% of the site.
- Removed discrete DU penetrators from the ground surface using hand-held tools, containerize the fragments, and transport them to Test Area C-64, a licensed holding facility at Eglin. This activity entailed the ICM portion of the work at IRP Site No. RW-41.
- Collected surface (zero to six inches bls) and subsurface (six inches to approximately 48 inches bls) soil samples from selected locations based on the results of the FIDLER survey and the historical data for the site. Use the results from these samples to help determine a correlation factor between the FIDLER readings and the laboratory analytical results, and to determine the presence or absence of DU fragments at concentrations above the DCGL. Submit the soil samples to an off-site laboratory for gamma spectroscopy analysis.
- Collected one groundwater sample from the production well located on site. Submit the sample to an off-site laboratory for gross alpha analysis.

2.0 BACKGROUND INFORMATION

2.1 SITE DESCRIPTION AND HISTORY

The following background information has been compiled from previous investigations performed at Test Area C-74L Gunnery Ballistic Facility and a survey report generated by USACE, St. Louis District entitled *Low-Level Radioactive Material Eglin AFB Archives Search Report* (USACE, 1999). As noted in Section 1.0, the area is currently referred to as IRP Site No. RW-41.

IRP Site No. RW-41 is located in Walton County, Florida, within the north-central part of the Eglin Reservation, approximately 14 miles northeast of the city of Niceville (Figures 2.1 and 2.2). The site occupies an area east-northeast of Auxiliary Field No. 1. To reach the site from the East Gate of Eglin Main Base, travel east on State Route (S.R.) 20 for 3.6 miles. Turn left (north) onto S.R. 285, and travel approximately 11.6 miles. Turn right (east) on Range Road (R.R.) 213. Proceed on R.R. 213 4.8 miles, past R.R. 214, and turn right (south) at the next road. Travel approximately 0.75 miles. The control building for C-74L Test Area (Building No. 9372) is on the right side of the road.

IRP Site No. RW-41 is located within the Test Area C-74 Complex on the Eglin Reservation. The Test Area C-74L Gunnery Ballistics Facility is an active facility comprised of two gun bays used to test the damage potential and terminal ballistics of various ammunitions (Figure 2.3; Becker and others, 1994). The test area has been in operation since at least 1963 as a gunnery ballistics facility. From late 1974 to 1978, Test Area C-74L was used for pre-production testing of the GAU-8/A gun system, which uses DU in the ammunition. In late 1978, all testing involving DU was transferred to Test Area C-64, and the mission at C-74L was changed to include only the firing of high incendiary explosives. An estimated 16,315 pounds (7,400 kilograms [Kg]) of DU was expended at Test Area C-74L. Approximately 9,257 pounds (4,199 Kg) was disposed of, off site, in remediation activities (Section 2.3) between March 1978 and June 1987 (Becker and others, 1994).

The spatial boundaries of the physical area under consideration for release (in other words, the site boundaries) include the RCA and the Former Drum Storage Area. The CS/ICM also addressed the soils in the two drainage ditches that lead away from the RCA, one draining northeastward from the eastern edge of the RCA and the other leading southeastward down toward Rocky Creek (Figure 2.3).

2.2 PHYSICAL SETTING

This section presents a brief description of the local physiography, geology, and hydrogeology at the site. A detailed discussion of regional physiography, geology, hydrogeology, and water use is presented in Section 2.0 of the Basewide ER Work Plan (Eglin, October, 1997a).

2.2.1 Physiography

IRP Site No. RW-41 is located within the Western Highlands Physiographic District of the Gulf Coastal Plain Physiographic Province (Northwest Florida Water Management District [NWFWMD], December 1996). The area surrounding the site is characterized by flat to rolling uplands with elevations ranging from 200 to 250 feet above mean sea level (MSL). The uplands are dissected by perennial creeks within relatively steep ravines. The relief between the bottom of the ravines and the surrounding uplands is generally between 50 and 90 feet.

Rocky Creek is located about 700 feet south of the site. A tributary to Rocky Creek is located about 1800 feet west of the site. A small dammed pond is located within the western tributary (Figure 2.2).

Presently, the site has a sparse vegetative cover of brush and grasses over sandy soils. The area within the gun corridor is cleared and covered with an approximately six-inch clay layer. An asphalt-covered earthen berm bounds the site on the southern edge to inhibit runoff into Rocky Creek. The asphalt covering the berm is cracked in many places. A shallow drainage ditch trending northeast has been constructed to draw storm water away from the eastern part of the RCA (Figure 2.3).

The site itself exhibits little relief, although the terrain around the site is wooded and slopes steeply to the southeast, south, and southwest toward Rocky Creek and its tributaries (Figures 2.2 and 2.3). Dominant trees are slash pine and turkey oak with isolated stands of live oak. Palmettos, beach sage, and grasses constitute the underbrush. A moderately well developed erosion gully leading down toward Rocky Creek has developed along a dirt road extending southeast of the site (Figure 2.3).

2.2.2 Hydrogeology

Specific hydrogeologic conditions were estimated from site conditions and regional hydrogeologic maps.

Geologic literature indicates that the surficial aquifer beneath this site extends to an approximate depth of 125 feet bls (Hayes and Barr, 1983). The Pensacola Clay, which acts as an aquiclude and separates the sand and gravel (surficial) aquifer from the underlying Floridan aquifer system, is about 160 feet thick and extends to a depth of approximately 285 feet bls (Maslia and Hayes, 1988). The sand and gravel aquifer occurs under water-table conditions. On the basis of site topography, the groundwater is approximately 50 to 60 feet bls. Groundwater flow directions within the sand and gravel aquifer at the site are anticipated to have a southward component towards the Rocky Creek tributaries.

Two Eglin water supply wells, Well Nos. 37 and 38, are located at the main Test Area C-74 facility, located approximately 0.5 miles northwest of Test Area C-74L. Well Nos. 37 and 38 are associated with Building Nos. 9352 and 9373, respectively. Well No. 37 has been abandoned (Robeen, 1998). Well No. 38 is used only during training missions and is completed within the Floridan aquifer system at a depth of 644 feet bls. Both the thickness of the Pensacola Clay (160 feet) and the likely direction of groundwater flow at Test Area C-74L (eastward) preclude Well No. 38 from being considered a potential target for contaminant migration from IRP Site No. RW-41. One supply well is located on site just across the asphalt road from Building No. 9372 (Figure 2.3). The well is installed within the sand and gravel aquifer at a depth of 58 bls and has a capacity of 1800 gallons per minute (gpm) (Becker and others, 1990). Again, based on the anticipated direction of groundwater flow, this well is located hydraulically upgradient of the RCA. However, the well's effect on the hydraulic gradient (i.e., its zone of influence) when it is pumping is unknown. No other water supply wells are known to exist within a one-mile radius of the site (USACE, 1994).

2.2.3 Surface Waters

Rocky Creek and its associated tributaries are classified as Class III bodies of water, designated for use for recreation and the propagation and maintenance of a healthy, well-balanced population of fish and wildlife (FDEP, FAC 62-302.400 and 62-302.600).

Because of the relatively low site relief and the site's sandy soils, most storm water run-off at the site would percolate into the subsurface or be subjected to evapotranspiration. During heavy precipitation, some storm water run-off may enter nearby drainage ditches and be transported to the upper tributaries of Rocky Creek.

2.3 PREVIOUS INVESTIGATIONS AND ACTIVITIES

Several soil sampling events have been performed at Test Area C-74L to monitor and evaluate the soil quality at the site with regard to uranium. Section 2.3.1 summarizes the sampling activities and results. Section 2.3.2 outlines the conclusions of the investigations.

2.3.1 Results of the Previous Investigations

2.3.1.1 Initial Soil Sampling 1976 - 1978

An initial soil sampling program was performed from June 1976 to August 1978. Surface soil samples were collected along a polar grid with radiating sampling lines extending out to beyond the RCA (Figure 2.4). The sample collection method consisted of compositing approximately 500 grams (g) of soil collected from the inside of a 10 centimeter (cm) square by 5 cm deep stainless steel form pushed into the ground. Samples were collected along this grid approximately twice a year for the duration of the sampling program. Samples collected in the early part of the program were analyzed using Instrumental Epithermal Neutron Activation (IENA). Later samples were analyzed using Gamma Spectroscopy. Comparison of laboratory analyses of split samples using both methods shows good correlation between the two methods. The results of the sampling are presented in detail in Becker and others (1990). The maximum concentration detected at each sampling point during the sampling program is presented in Table 2.1. Uranium background values from this study ranged from less than 1 to 2.4 micrograms per gram (μg/g; 0.06 picoCuries per gram [pCi/g] to 0.7 pCi/g) (Becker and others, 1990).

2.3.1.2 Soil Sampling Event 1979 - 1980

Between October 1979 and September 1980, the Los Alamos National Laboratory (LANL) performed research at Eglin that emphasized sampling at Test Area C-74L to determine areas needing cleanup because of DU contamination. Samples were collected along an expanded grid, using the existing polar grid as a basis. The samples were analyzed using IENA, and the uranium concentrations were evaluated using a Kriging statistical technique and plotted accordingly (White, 1981). The outline of the area of the site showing concentrations above 100 μg/g (30 pCi/g) is shown on Figure 2.4.

In 1986, nine additional soil samples were collected from inside the RCA, and two background samples were collected from near Indigo Pond located approximately 1.1 miles north of the site (Figure 2.2). These samples were analyzed using Inductively Coupled Plasma/Mass Spectroscopy (ICP/MS) and Beta Radiation. Uranium concentrations in the background samples were less than

3 µg/g (0.9 pCi/g). Uranium concentrations detected using the ICP/MS method are shown on Figure 2.4 (Becker and others, 1990).

2.3.1.3 Soil Excavation within Approach Corridor

In 1980, after evaluating the analytical results from the soil samples collected at the Test Area C-74L, Eglin cleaned the approach corridor of the facility leading from the gun bay building to the target butt (Figure 2.3). The upper 6 inches of the surface soil was removed and stockpiled outside and just east of the corridor, within the RCA. The approximate location of this stockpile is shown on Figure 2.3. The target butts at Test Area C-74L were also cleaned during this time frame. The contaminated sand from the target butts was sealed in 55-gallon drums and placed within the drum storage area, located north of the RCA (Figure 2.3; Becker and others, 1990). Drums containing gun butt sands from Test Area C-64 were also staged at this drum storage area during the early 1980s (Eglin, March 1999). The drums remained in the drum storage area until the middle 1980s, when they were transported to a receiver facility in Barnwell, South Carolina. A total of 1,252 55-gallon drums were sent for disposal due to this cleanup (Becker and others, 1994). According to Mr. Rick Crews, an Eglin Wright Laboratory physical scientist involved with the soil sampling and soil excavation activities described in these sections, in contrast to Becker and others (1990), the soil from the target butts was stockpiled within the RCA, while the excavated upper six inches of soil from the corridor ground surface was contained in the drums (Crews, 1998). Efforts to clarify this discrepancy have been unsuccessful. It should not affect this CS/ICM and future environmental work at the site, because the primary concern is characterizing the present DU concentrations at the stockpile and drum storage area, rather than determining the DU source.

After the excavated area was monitored to determine that radioactivity was near the background values, clay from an off-site borrow location was back-filled onto the excavated area.

2.3.1.4 Soil Sampling Event 1988

In 1988, soil samples were collected in three to six-inch intervals at depths ranging from zero to 36 inches below land surface (bls) to measure the magnitude of remaining DU contamination and assess the potential for uranium transport downgradient of the RCA. Soil samples were collected from inside the former drum storage area, within a drainage ditch inside the RCA extending northeastward from the target butt, the target butt, the soil stockpile location, and the steep slope south of the RCA. These samples were analyzed using either Delayed Neutron Activation or ICP/MS. Both the concentration of uranium in soils and the isotopic ratio of uranium 238 (^{238}U) to uranium 235 (^{235}U) were measured. Natural uranium consists predominantly of ^{238}U (99.3 %) and ^{235}U (0.7 %). If uranium in soils had an isotopic ratio of ^{235}U to ^{238}U between 0.0064 and 0.0080 %, the uranium was naturally occurring. If the ratio was between 0.0028 and 0.0064 %, then a mixture of naturally occurring uranium and DU existed. If the ratio was less than 0.0028 %, then the uranium detected in the sample was DU (Becker and others, 1994). The vast majority of these results indicated that the uranium detected was DU.

The samples collected from within the RCA (near the soil stockpile) indicated that DU concentrations decreased with depth, with the maximum concentrations of DU detected in the surface (zero to 3 inches bls) sample. The results of this sampling effort are shown on Table 2.2 and Figure 2.5.

2.3.1.5 Fate and Transport Investigation

Additional soil sampling was performed in 1990 and 1991. Samples were collected from three locations within the northeast-trending drainage ditch (Northeast Ditch). Samples were collected from zero to six inches bls just inside the RCA, from zero to 43 inches bls at the second location 150 feet outside of the RCA, and from zero to 2 inches bls, at the third location about 400 feet outside of the RCA. Samples were also collected within the drainage ditch on the slope south of the RCA (South Ditch; Figure 2.5). Naturally occurring uranium was detected in the South Ditch at concentrations less than background. The Northeast Ditch showed DU concentrations ranging from 60 μg/g (18 pCi/g) at the surface to 1.2 μg/g (0.36 pCi/g) at a depth of 38 inches. Naturally occurring uranium was detected at a concentration of 0.76 μg/g (0.22 pCi/g) from 38 to 43 inches bls (Becker and others, 1994). Refer to the Table 2.2 for a summary of laboratory analytical results.

Sampling of sediments associated with Rocky Creek located south of the RCA indicated no DU in the sediment at concentrations above its detection limit. To assess the potential and occurrence of DU transport away from the RCA at Test Area C-74L, Eglin installed a cumulative sampler in 1990 along the Northeast Ditch that begins within the RCA. A total of 14 run-off samples were detected between October 1990 and November 1992. The results from these analyses and the evaluation of the data indicate that, when run-off occurs, DU is present in both the dissolved and suspended sediment phases. Generally, the DU concentrations detected ranged from below detection limits to 14.7 micrograms per liter (μg/L) in the dissolved phase, and from 4.5 μg/g (1.3 pCi/g) to 291.0 μg/g (87 pCi/g) (202 μg/g [61 pCi/g] average) in the suspended sediment phase (Becker and others, 1994). Refer to the Table 2.2 for a summary of laboratory analytical results.

2.3.1.6 Groundwater Sampling

Results of laboratory analysis of a groundwater sample taken in May 1983, from the shallow supply well located just outside the RCA indicated a gross alpha concentration of less than 1 picoCurie per liter (pCi/L). The maximum contaminant level (MCL) for gross alpha activity in groundwater, of which uranium can be a major contributor, is 15 pCi/L. Based on this analysis, it appears that DU has not impacted groundwater near the RCA. It should be noted that the proposed MCL for total uranium is 20 μg/L; however, the detected gross alpha activity cannot be directly compared to this limit.

2.3.2 Conclusions of the Previous Investigation

The following summarizes the conclusions of the previous work:

- Background total uranium concentrations in sandy soils at Eglin range from 0.2 to 2.4 μg/g (0.06 to 0.7 pCi/g; Berven and others, 1987).
- In 1980, the upper six inches of soil was removed from the gun corridor. After a surface scan indicated that the radioactivity of the soils from the bottom of the excavation was below background, clay from an off-site borrow location was backfilled onto the excavated area.

- Soil containing a maximum DU concentration of 3,379 µg/g (1014 pCi/g) has been detected within the RCA. At one location, near the stockpile inside the RCA, DU was detected at a concentration of 40.1 µg/g (12 pCi/g) at a depth of 12 to 15 inches bls and 4.5 µg/g (1.4 pCi/g) at 24 to 27 inches bls (Figures 2.4 and 2.5). The concentration of DU decreases with depth.
- Suspended sediment transported off site by stormwater runoff may have concentrations of DU as high as 291 µg/g (87 pCi/g; Becker and others, 1994).
- Groundwater appears to have not been impacted by DU weapons testing.
- The fate and transport study performed by LANL in the early 1990's (Becker and others, 1994) concluded that uranium is believed to be migrating vertically by dissolved phase transport. Lateral redistribution may occur after heavy subsequent rainfall events via overland runoff. It should be noted that the results of the current CS/ICM performed in 1999 and discussed in this document demonstrate very limited vertical or lateral migration of DU.

3.0 SCOPE OF WORK

This section presents the sampling activities and associated tasks pertaining to the CS/ICM that was conducted at IRP Site No. RW-41 Test Area C-74L Ballistics Gunnery Testing Facility. The general outline of the scope of work described in the following subsections was developed during the December 1998 and March 1999 LLRM Partnering Team Meetings (Eglin, December 1998; Eglin, March 1999).

3.1 SITE GRIDDING

Prior to surveying and sampling, the area of the FIDLER survey, as discussed in Section 3.2, was cleared of extraneous vegetation and swept for unexploded ordnance (UXO) as necessary. Eglin Explosive and Ordnance Disposal (EOD) performed the UXO sweep. Care was taken in all cases to avoid contamination of workers and/or any material being removed as part of this process. To this end, vegetation was cut even with, or slightly above, ground level.

The grid used for the CS/ICM at IRP Site No. RW-41 was established and surveyed by Gustin, Cothern & Tucker, Inc., (GCT) a professional surveyor licensed in the state of Florida. A reference point for the FIDLER survey grid was established in the northwestern part of the site. A baseline was surveyed bearing north-south from this reference point. This baseline is defined by the easting 7060. After establishing the baseline, a grid was laid out on a 30-foot by 30-foot spacing. The baseline and the grid intersections (nodes) were marked by flagged wooden stakes in the field by the professional surveyor. The grid locations were designated by northing and easting coordinates.

On the basis of a discussion with the EPA and FDOH in June 1999, Eglin expanded the FIDLER survey grid by an approximately 60-foot radius for every DU fragment detected near the edge of the original grid. The extents of the original and the extended FIDLER survey areas are denoted in Figure 3.1.

The overall accuracy of the grid intersection points for the CS/ICM were plus or minus 1.0 foot.

3.2 FIDLER FIELD SCREENING SURVEY

A walk-through scanning survey of the site was performed using a Bicron G-5 FIDLER Detector Probe attached to an Eberline ASP-2e rate meter/scaler. In this CS/ICM, the term "FIDLER" means the FIDLER detector and its associated rate meter/scaler, cables, and any other associated appurtenances. Figure 3.1 presents the area of the FIDLER survey.

The objectives of the survey were as follows:

- To locate "hot spots" which likely were caused by discrete DU penetrator fragments in the surface or near-surface soil. As part of the ICM, these fragments along with associated soil were removed with a hand shovel when readily accessible. The DU fragments and soil were placed into lined 22-gallon, 30-gallon or 55-gallon metal drums temporarily staged in the former drum storage area of Test Area C-74L (Figure 2.3). If fragments were not located or removed, the hot spots were marked with pin flags for potential sampling and/or remediation.

- To provide an organized data set to map the radiological contours of the site (grid intersection readings combined with the above hot spot readings). This information was used to guide the locations of the biased surface and subsurface soil samples.

The FIDLER was operated in a gross, low-energy gamma detection mode; therefore, the readings are considered relative or qualitative. The use of FIDLER readings to determine the presence of DU penetrators was performed with great caution, as elevated readings could be caused by other radionuclides in the environment, notably naturally occurring radon (^{222}Rn), its progeny, and potassium (^{40}K). Additionally, the instrument responses varied greatly with the concentration, depth, and spatial distribution of the radioactive material.

3.2.1 Prerequisites

The following prerequisites were met before beginning the FIDLER survey at IRP Site No. RW-41:

- Ensure that the FIDLER was properly calibrated and normalized to detect DU. This included performing a high voltage plateau (E^2/B) determination with a DU source. The FIDLER was assigned a dedicated DU check source for this purpose. The instrument was checked with that source, in a reproducible geometry, at the time of, or immediately following calibration of the instrument. Daily, this same source was used to check the instrument (as described in the following bullets).
- A preliminary walk-through survey was performed to determine the average background count rate to be used to identify hot spots based on an investigation level of twice the average background readings. This walk-through survey was performed close to the site prior to the field work to establish a site specific background level.
- Daily check source readings and background determinations were performed before starting any scanning in the morning. Daily check source readings were also performed at the end of field activities. These background readings were taken within a controlled environment (e.g., the field trailer). This is discussed further in Section 4.1.1.
- If any of the daily check source readings varied by more than 10% from the initial calibration value, the test was repeated. If the second test continued to show a deviation of greater than 10% from the initial calibration value, the instrument was not used until the reason for the change was corrected or the instrument was recalibrated (Table 3.1).
- Site preparations were completed in accordance Section 3.1.
- Ensure that a properly equipped Control Point (CP) was established to facilitate entry and egress into the RCA. A daily Radiation Work Permit (RWP) and safety briefing was prepared by the RSO and utilized for the scanning survey. All personnel read, signed, and adhered to the requirements of the RWP and safety briefing.

Until actual radiological conditions were documented by Radiological Survey, personnel utilized modified Level D protective clothing, lapel air samplers, and thermoluminescent dosimeters (TLDs), which were worn in accordance with the Basewide HSP, Addendum No. 1 (Eglin, April 1999b). The results of the personnel TLDs were 0.0 μR per quarter (Earth Tech, November 3, 1999).

3.2.2 Procedure

Prior to this systematic scanning survey, a random walk-through was performed to establish the relative background for the area, detect major hot spots, remove selected DU fragments on the ground surface, and determine what increase of count rate could be detected by the surveyor. The average background reading of the FIDLER was 5 kilocounts per minute (kcpm). Therefore, a FIDLER reading above 10 kcpm (twice background) was considered the investigation level during the fieldwork of this CS/ICM. Locations that exhibited a FIDLER reading above the investigation are referred to as a hot-spot (Figure 3.2).

Two types of FIDLER surveys were performed. The first type was conducted along the north-south gridlines over the entire site. It was also performed along east-west gridlines over approximately 10% of the site to attain a higher level of confidence for attaining 100% coverage of the area (Figure 3.2). The FIDLER operator started at the corner of the grid and followed the line walking at a relatively slow pace (approximately one foot per second [ft/sec]). The FIDLER was swung side to side keeping the probe approximately four to six inches above the ground.

At each of the grid intersections (30-foot centers), the FIDLER was switched to the scaler mode and an integrated reading of 95% confidence level was performed (at ground contact). These data were recorded in the field log book. At the end of the line, the survey team reversed direction, moved approximately six feet right or left of the line (as appropriate) and returned in the opposite direction. A total of five lines were therefore surveyed in this fashion at 6-foot intervals (grid line and four intermediate "lines") within each 30-foot by 30-foot survey grid (Figure 3.1).

The area of this type of walk-over survey is shown in Figure 3.1. The area of the survey originally included the RCA (with an approximately 100-foot buffer to the northwest and a 10-foot buffer along its remaining boundaries), the gun butt corridor, the former drum storage area, and the two ditches emanating from the RCA. As discussed in Section 3.1, because DU fragments were identified near the edges of this area, the survey was expanded in all directions, particularly to the north, southeast, south, and northwest.

In addition to the grid nodes, scaler readings were collected at the detected hot spots. As part of an ICM, the FIDLER surveyors attempted to locate and remove DU fragments and associated soil at these hot spots using a hand shovel. Hot-spots were identified as the surveyor detected an increase in the audible output of the FIDLER and verified that the audible level corresponded to a measurement of greater than 10 kcpm. In the event that a measurement exceeded 10 kcpm, the surveyor located the area of highest activity, performed a pre-DU/soil removal FIDLER scaler measurement, and noted the location and pre-DU/soil removal reading in the field logbook. Figure 3.2 shows the locations of these hot-spots.

After this information had been documented, the surveyor began manually removing soil to a depth of less than or equal to one foot bls. (The operation was performed only after Eglin EOD had previously cleared the area for subsurface penetration to a depth of one foot bls.) Once a shovel of soil was removed, a FIDLER measurement was taken at the hot-spot to determine if the DU fragment had been removed. If the point continued to indicate elevated activity, then additional soil was removed until the FIDLER readings were below the investigation level (10 kcpm) or a maximum of three shovels-full of DU/soil had been removed. After the removal of the DU fragment, a second, post-DU/soil removal scaler measurement was taken at the flagged location to determine the post DU/soil removal activity (these readings indicate the current FIDLER readings at that location).

The DU fragment and the immediately surrounding soil was collected, managed, and disposed of as radioactive waste. The material was contained in lined 22-gallon, 30-gallon, and 55-gallon drums and turned over to Test Area C-64 for storage under Eglin's existing Radioactive Material (RAM) License for future disposition (Eglin, March 1999).

The second type of FIDLER survey was performed within the RCA in the areas where the presence of the DU fragments were too concentrated to warrant identifying and manually removing each individual fragment. In this area, which is delineated in purple in Figure 3.1, scaler readings were taken at six-foot centers (rather than 30-foot centers) and logged in the field book. These scaler readings were collected using the same methodology as described in the previous paragraph. It should be noted that, over most of the area of six-foot centers readings, hot-spots were not identified, because of the high concentration of DU fragments on the ground surface. Therefore, hot-spot stations are not noted in this part of the site in Figure 3.2.

3.3 SOIL SAMPLING

Following the removal of the DU penetrator fragments from the site and the performance of the FIDLER field screening, soil samples were collected during the month of August, 1999 and submitted off site for laboratory analyses using gamma spectroscopy, as discussed in Section 3.4. On the basis of the FIDLER screening results, three types of soil samples were collected at IRP Site No. RW-41, as follows:

- *Correlation Sampling*: Surface soil samples collected over the extent of the site to help determine a correlation between FIDLER readings in kcpm and laboratory results in pCi/g (Figure 3.3 and Table 3.2).
- *Ditch Sampling*: Soil samples collected in the two ditches emanating from the RCA to characterize the lateral and vertical extent of DU fragments at concentrations exceeding the DCGL (Figure 3.3 and Table 3.2).
- *Vertical Extent Sampling*: Surface and subsurface samples collected at locations which exhibited relatively high FIDLER readings under current conditions. The purpose of these samples was to evaluate the vertical extent of DU fragments under the areas of relatively high surface contamination. Downhole logging was performed with a 1-inch by 1-inch sodium iodide (NaI) detector at each of these boreholes (Figure 3.3 and Table 3.3).

3.3.1 Correlation Sampling

On August 11 through 13, 1999, Earth Tech advanced 21 soil borings (RW-41-SB-01 through RW-41-SB-20 and RW-41-SB-40) at IRP Site No. RW-41 to help determine a correlation between the FIDLER readings in kcpm to the laboratory results in pCi/g. The borings were advanced to 0.5 feet bls with a stainless steel hand auger. A discrete soil sample was collected from each boring at zero to 0.5 feet bls. The locations of these borings were based on the FIDLER readings. Five of the borings (RW-41-SB-01 through RW-41-SB-05) were collected where FIDLER readings were relatively low and reflected essentially background conditions. Attempts were made to advance the remaining borings (RW-41-SB-06 through RW-41-SB-20) at locations of relatively low to medium to high FIDLER readings. Two duplicate samples (RW-41-SB-04-0.5-a and RW-41-SB-40-0.5-a) were also collected. The corresponding ground surface FIDLER readings for each of these soil borings are presented in Table 3.2.

All soil samples were collected with a stainless steel hand auger and homogenized in a stainless steel bowl. The soil sampling collection methods conformed to those presented in ESOP No. 8, Section 8.5 and ESOP No. 15, Section 15.4.3.2.1. Field documentation, sample nomenclature, and sample management was in accordance with ESOP No. 2, Sections 2.3 and 2.4; ESOP No. 3, Sections 3.3, 3.4, and 3.5; ESOP No. 15, Section 15.4.5. All sampling equipment was decontaminated as specified in ESOP No. 13, Sections 13.3, 13.4, and 13.5; and the Basewide HSP Addendum 1, Section 13.0. Specific sample management and handling procedures, as discussed in the QAPjP, were followed for the samples to be submitted for radioisotopic analyses. All investigative derived material (IDM) generated during the sampling activities were managed in accordance with Section 3.8.

3.3.2 Ditch Sampling

On August 16 through 20, 1999, Earth Tech advanced 25 hand auger soil borings to a depth of 1.5 feet bls within the two ditches emanating away from the RCA (Figure 3.3). In the ditch leading southward down to Rocky Creek (South Ditch), soil sample borings were located on approximately 30-foot centers within the FIDLER grid area (RW-41-SB-30 through RW-41-SB-37) and on approximately 60-foot centers from the edge of the FIDLER grid area to Rocky Creek (RW-41-SB-22 through RW-41-SB-29, and RW-41-SB-45). In addition to these systematically located borings, three soil borings (RW-41-SB-21, RW-41-SB-24, and RW-41-SB-26) were advanced at the locations of relatively elevated FIDLER readings within the ditch. These South Ditch samples were collected at zones of obvious sediment deposition if such a zone was present within about a 5-foot radius of the measured soil sampling location. In the ditch leading northeastward from the RCA (Northeast Ditch), the soil borings were located on approximately 75-foot centers from the RCA to the edge of the FIDLER grid (RW-41-SB-41 through RW-41-SB-44). In addition to these soil samples, five duplicate samples (RW-41-SB-25-0.5-a, RW-41-SB-26-0.5-a, RW-41-SB-28-0.5-a, RW-41-SB-36-0.5-a, and RW-41-SB-43-0.5-a) were collected. The locations of all these ditch soil sampling borings are presented on Figure 3.3.

Discrete soil samples were collected from each of these soil borings at depths of zero to 0.5 feet bls, 0.5 to 1.0 feet bls, and 1.0 to 1.5 feet bls. Only the surface soil sample from these borings was submitted to the laboratory for gamma spectroscopy analyses. The subsurface samples were not submitted, because of their relatively low FIDLER readings and the laboratory results for the associated surface sample.

The soil samples associated with the ditches were collected and managed similar to the methods referenced in Section 3.3.1. The subsurface soil samples were collected in accordance with ESOP No. 8, Section 8.6.

3.3.3 Vertical Extent Sampling

On August 25 and 26, 1999, Earth Tech advanced seven hand auger soil borings (RW-41-SB-16, RW-41-SB-38, RW-41-SB-39, RW-41-SB-46, and RW-41-SB-49 through RW-41-SB-51) to evaluate the vertical extent of DU fragments at locations that exhibited relatively elevated FIDLER readings. The locations of these soil sampling locations are presented in Figure 3.3. Except for soil borings RW-41-SB-38 and RW-41-SB-39, discrete soil samples were collected from each of these soil borings at depths of zero to 1.0 feet bls, 1.0 to 2.0 feet bls, 2.0 to 3.0 feet bls, and 3.0 to 4.0 feet bls and screened with the FIDLER. Discrete soil samples were collected from borings RW-41-SB-38 and RW-41-SB-39 from depths of zero to 0.5 feet bls, 0.5 to 1.0 foot bls, and 1.0 to 1.5 feet bls. Each of the discrete soil samples down to 3 feet bls was submitted to the laboratory for gamma spectroscopy analysis. Two duplicate samples (RW-41-SB-16-1.0-a and RW-41-SB-51-0.5-a) and two field blanks (RW-41-SB-46-0.5-e and RW-41-SB-49-0.5-e) were also collected.

The soil samples associated with these borings were collected and managed similar to the methods referenced in Section 3.3.2.

Earth Tech also performed downhole logging from zero to four feet bls at these hand auger boreholes (except for RW-41-SB-38 and RW-41-SB-39), as well as four hand auger borings (RW-41-SB-47, RW-41-SB-48, RW-41-SB-52, and RW-41-SB-53) from which no samples were submitted to the laboratory. This logging entailed lowering a 1-inch by 1-inch SPA-8 NaI probe connected to an Eberline ASP-2e rate meter/scaler into the borehole to monitor gamma count rates with depth. After each borehole was completed, the probe was lowered into the hole, and readings (in kcpm) were recorded at 0.5-foot increments down to 4.0 feet bls.

All of the soil samples submitted to the laboratory were analyzed for isotopic uranium, using gamma spectroscopy.

3.4 GROUNDWATER SAMPLING

On February 23, 2000, on the basis of discussions during the LLRM Partnering Meeting on February 17 and 18, 2000, one groundwater sample (RW-41-GW-01) was collected from the production well located at IRP Site No. C-74L (Figure 2.3; Eglin, February 2000). This well is screened in the sand and gravel aquifer and is used for washing and drinking by the workers at the test area. The sample was collected directly from the spigot discharging the water, which is located against the wall of the well house. To purge the water from the eductor pipe within the well, the spigot was allowed to run for five minutes at a flow rate of approximately five gallons per minute (gpm) before collecting the sample.

This groundwater was submitted to the laboratory for gamma spectroscopy for isotopic uranium.

3.5 LABORATORY RADIOISOTOPIC ANALYSIS

This section describes the laboratory chemical analyses performed on the samples associated with IRP Site No. RW-41. All sampling and analyses were conducted in accordance with the Basewide QAPP, Addendum 1 (Earth Tech, April 1999b) and the site-specific FSP and QAPjP (Earth Tech, April 1999). Quanterra Laboratories (Quanterra) in Richland, Washington, a USACE-approved laboratory, performed the laboratory radioisotopic analyses of the soil samples and generated the radioisotopic data. The analytical methods which Quanterra used, RICHRC5013 and RICHRC5017, meet the QA/QC standards of the HASL 300 methods. Quanterra participants in the EPA Radiochemistry Laboratory Intercomparison study. Their QA/QC policy is consistent with USACE and EPA policy and guidance. Ten split soil samples were also submitted to Brooks AFB IERA Laboratory for gamma spectroscopy analysis.

The soil samples were analyzed in accordance with the following methodologies:

SOIL SAMPLES

Laboratory	Analytical Suite	Methodology
Quanterra	Isotopic Uranium (U-235 and U-238)	Gamma Spectroscopy by HPGE (Gamma Scan by Quanterra Method RICHRC5013 and RICHRC5017)
Brooks AFB IERA	Isotopic Uranium (U-235 and U-238)	Gamma Spectroscopy by HPGE

The groundwater sample was analyzed using the following methodology:

GROUNDWATER

Laboratory	Analytical Suite	Methodology
Quanterra	Isotopic Uranium (U-235 and U-238)	Gamma Spectroscopy by Quanterra Method RICHRC5017)

3.6 DECONTAMINATION PROCEDURES

All sampling equipment was decontaminated in accordance with the applicable sections of ESOP No. 13 and ESOP No. 15 prior to and after its use at each sampling location.

3.7 SURVEYING

GCT, a surveying firm licensed in the state of Florida, surveyed the field screening grid intersections and sampling locations, as well as important site features (such as the centerline of the asphalt berm, the North Ditch, and the South Ditch; and building and fence corners) associated with IRP Site No. RW-41. Both vertical and horizontal control surveying was performed at each grid intersection and soil sampling point. The elevation of the ground surface was surveyed for these points

Both latitude and longitude coordinates and the state plane coordinates were calculated. Both of these coordinate systems are based on the North American Datum (NAD) 1983 Geographic Coordinates. The vertical datum is the National Geodetic Vertical Datum (NGVD) of 1929. The surveyor certified that the positions meet or exceed Third-order, class I (1:10,000) Horizontal accuracy and Third-order Vertical accuracy. A summary of the survey data is included in Appendix B.

3.8 QUALITY ASSURANCE/QUALITY CONTROL

The analytical program requirements established for the CS/ICM conducted at IRP Site No. RW-41 were met in accordance with the *Basewide QAPP* (Eglin, October 1997b), *Basewide QAPP, Addendum 1* (Eglin, April 1999b), and the Earth Tech CompQAPP (Earth Tech, December 1998). Specific CS/ICM quality assurance (QA) requirements were met in accordance with the site-specific FSP and the QAPjP (REI, April 1999).

Analytical data validation was conducted by Earth Tech and reviewed by the Earth Tech QA Manager. Supporting QA documents including Chain of Custody (COC) Records, Laboratory Logbooks, Internal QC Records, and Laboratory Certifications are maintained by Quanterra. Standard Operating Procedures and Field QC Records are maintained at the Earth Tech-Fort Walton Beach office. All records are available for review upon request.

The QA/QC program addresses all field and laboratory activities and was implemented on a program-wide, as opposed to a site-specific, basis. Therefore, some sites may not have QA/QC samples associated with samples from that particular site.

The QC program was implemented by conforming to the QAPP and ESOP requirements regarding standard preparation, equipment decontamination, sample collection, field measurements, and equipment calibration, maintenance and corrective action. Laboratory QC results are presented in Appendix C. The number of field QC samples (duplicate and field blanks) was calculated at a quantity of approximately 10% of all samples collected, per matrix, per analytical method, for the CS/ICM program. All QC samples were submitted to Quanterra. The reports for the field QC samples are presented in Appendix C.

The QA program was implemented by the analyses of split samples by the U.S. Air Force Institute for Environment, Safety and Occupational Health Risk Analysis (IERA) at Brooks Air Force Base, Texas (Brooks) to corroborate the subcontractor laboratory data. The percentage of QA samples was approximately 5% of all samples collected, per matrix, per analytical method for a total of 10 samples. Table 3.4 summarizes the analytical results from the two laboratories. The measurement of QA for all CS/ICM data (as described in Section 3.0 of the QAPP) included the following parameters: precision, accuracy representativeness, comparability, and completeness. The reliability and credibility of the subcontract laboratory were corroborated by the inclusion of replicate and field blanks.

3.9 MANAGEMENT OF INVESTIGATION DERIVED MATERIAL

Consumable equipment (e.g., PPE) was treated as radioactive material and was not removed from the RCA until off-site disposal was arranged. Such items were handled and disposed of in accordance with Section 3.4 of the Basewide HSP, Addendum 1 (Eglin March 1999b) under the supervision of the RSO.

Equipment was treated as radioactive material and was not removed from the RCA when measurements of removable or total (removable plus fixed) uranium and its associated decay products exceeded 1,000 disintegrations per minute per 100 square centimeters (dpm/100 cm^2) and 5,000 dpm/100 cm^2, respectively, or when prior use suggested that contamination levels on inaccessible surfaces were likely to exceed the referenced removal and total levels. Equipment was surveyed and decontaminated in accordance with Sections 12.0 and 13.0 of the *Basewide HSP, Addendum 1* (Eglin, March 1999b).

Small items of equipment (e.g., hand-held items such as hand tools and air monitoring instruments) were surveyed by radiological workers and decontaminated, as necessary, by hand wiping or tape pressing under the supervision of the RSO. Small items were protected from contacting contamination to the extent possible through practices such as bagging instruments (if applicable/possible) and avoiding the placement of items on potentially contaminated surfaces. Exceptions to these requirements may include:

- Items made of absorbent materials (e.g., wooden handles on tools) were frisked out or discarded and not subjected to decontamination efforts.
- Items that required special decontamination procedures, such as samples and/or sampling apparatus.

All equipment underwent a contamination release survey prior to unrestricted release from the site. All decontamination waste associated with the sampling effort was managed in accordance with Section 3.4 of the *Basewide HSP, Addendum 1* (Eglin, March 1999b).

4.0 INVESTIGATION ACTIVITIES AND RESULTS

4.1 FIELD SCREENING SURVEY

This section presents the FIDLER survey results as they pertain to the CS/ICM that was conducted at IRP Site No. RW-41 Test Area C-74L Ballistics Gunnery Testing Facility.

The FIDLER results are summarized in Figures 4.1 and 4.2. The field data were recorded in the field book and compiled in an Excel spreadsheet. This spreadsheet is very large and therefore is not included in this report. A copy of the spreadsheet, as well as the field book are available upon request from Earth Tech-Fort Walton Beach Office.

4.1.1 Systematic Survey

In order to verify the statistical validity of the FIDLER data, daily pre and post source checks were completed using a DU source with a known activity level in a reproducible geometry. Daily, before using the instrument, it was confirmed that measurements were within± 10% of the initial calibration value, or within two standard deviations (± 2σ). The methodology used to calibrate the instrument included:

- One background measurement taken per day within a controlled environment (field trailer) to determine if probe was contaminated prior to source check calibration;
- Measurements taken in the scaler mode;
- Measurements taken with an approximately 0.25-inch thick plastic cover over the instrument probe face (for protection purposes, field measurements were taken with a plastic cover over the instrument probe face);
- Measurements taken at an invariable distance and geometry;
- Ten individual counts (e.g., one count is completed when the rate meter reaches the 95% confidence level) performed and the average used as the calibration measurement.

During the survey of IRP Site No. RW-41, the FIDLER identified numerous areas of elevated activity (≥ 10 kcpm) distributed throughout the site (Figure 3.2). The contamination was present in small areas of elevated and diverse activity.

Based on the collected FIDLER data from the site, approximately 70% of the surface FIDLER measurements were less than the recognized investigation level of 10 kcpm, while only 30% were greater than or equal to the investigation level. As shown on Figure 4.1, the FIDLER measurements that were greater than or equal to the investigation level were primarily located in three areas:

- Gun corridor;
- Stockpile area/eastern part of RCA; and
- Former drum storage area.

The surface pre-DU/soil removal FIDLER measurements in these three areas ranged from 10 kcpm to 336 kcpm, while the average measurement was 67.40 kcpm.

4.1.2 Hot-Spot Identification/DU Fragment and Soil Removal

Areas of elevated activity or hot-spots were identified throughout the site, with the highest measurements located in the gun corridor, the stockpile and surrounding area within the eastern RCA, and the northwest part of the drum storage area. As stated in Section 3.2.2, in most cases no effort was made to perform ICM activities (that is, remove the DU/soil that represent a hot spot) in the eastern part of the RCA, because of the extensive presence of DU fragments on the ground surface. Figure 4.1 illustrates the FIDLER results before the DU/soil was removed. This figure also shows the FIDLER results at locations where no DU/soil was removed. Figure 4.2 shows the FIDLER results after the DU/soil removal as well as the FIDLER results at locations where no DU/soil was removed. The data on Figure 4.2 therefore represents the current conditions at the site.

As shown in Table 4.1, the ICM methodology used at IRP Site No. RW-41 to remove the contamination (manual shovel method) proved effective in reducing the initial level of activity at each location. Of the 471 locations where post DU/soil removal measurements were taken (primarily outside of the gun corridor), only 46 locations (or approximately 10% of the measurements) maintained an activity level of greater than 10 kcpm. Another way to view the effectiveness of the shovel methodology is the percent reduction of the existing activity at locations identified in Table 4.1 as illustrated in Figures 4.1 and 4.2.

The average reduction in activity was approximately 60%. However, the activity at some locations actually increased. The probable cause for this increased activity is related to the depth of the DU fragments (e.g., shielding provided by the surrounding soil), where the surface FIDLER measurements were significantly lower than the measurements taken after the DU/soil removal activities (as indicated by the yellow bars in Table 4.1). These locations, which were pin flagged, may require further efforts to mitigate the elevated activity levels.

After the flagged locations had been cleared and the activity reduced to less than the investigation level, the investigation derived material was placed into radioactive waste storage drums and stored at the Eglin AFB permitted radioactive waste storage facility, located at Test Area C-64. A total of approximately 106 cubic feet (4 cubic yards) of soil and DU fragments were transported to Test Area C-64. This material was contained in seven 22-gallon drums, eighteen 30-gallon drums, and two 55-gallon drums (these largest drums also contained some personal protective equipment [PPE]). The transfer is documented in Earth Tech (November 1999).

4.1.3 Down-Hole Logging

Soil borings were performed at nine different locations at IRP Site No. RW-41. Each soil boring was hand augured to a depth of 4.0 feet bls, while activity measurements were taken at intervals of 0.5 feet. The measurements were taken using an ASP-2e rate meter connected to a 1-inch x 1-inch SPA-8 NaI probe. The results of the down-hole logging are included in Table 3.3.

Based on the down-hole logging effort, the majority of the measured activity is present within the upper one foot of the soil. The activity significantly decreases with depth indicating the unlikelihood of DU fragments reaching more than 1.0 to 1.5 feet bls. Based on the downhole measurements, activity levels are considered to be at background levels below three feet bls. Elevated activity levels were measured at four feet bls in soil borings RW-41-SB-49 and RW-41-SB-50; however, contamination at this depth is interpreted to result from contaminated soil at the surface or shallow depths falling into the boring.

As shown in Table 3.3, the two highest activity levels were observed at soil borings RW-41-SB-46 and RW-41-SB-50. These two locations produced peak FIDLER readings greater than 100 kcpm, while maintaining readings of greater than 10 kcpm at 1.5 feet bls. The downhole logging results from these soil borings indicate that contamination at IRP Site No. RW-41 is mainly confined to the gun corridor and the RCA and limited to shallow depths less than 1.0 foot bls.

4.2 SOIL QUALITY

This section presents the laboratory analytical data for the soil samples collected at IRP Site No. RW-41. The results are presented in Table 3.2 and posted on Figure 3.3. Laboratory reports are presented in Appendix B.

4.2.1 Correlation Sampling Event

As described in Section 3.3.1, the correlation sampling was an attempt to determine if any direct comparison could be made between the FIDLER measurements and the soil sample results. Surface soil samples (zero to 0.5 feet bls) were collected from soil borings RW-41-SB-01 through RW-41-SB-20 and RW-41-SB-40 for this purpose. Total uranium activities ranging from 0.21 pCi/g to 358.33 pCi/g were detected in these samples. The associated FIDLER scaler readings, taken on the ground surface at the sample location prior to sample collection, ranged from 3.48 kcpm to 155.60 kcpm. These results are shown in Table 3.2. The laboratory analytical data for these samples are posted on Figure 3.3.

Table 3.2 shows that the FIDLER is capable of finding small isolated areas of elevated activity and should continue to be used to direct soil sampling efforts at other LLRM DU sites. However, a problem with comparing the FIDLER measurements directly to the soil sample results is that the soil sampling method might not represent the small DU fragment that the FIDLER is detecting. Also, in some parts of the site (for example, the gun corridor) the native soil was mixed or covered with a red clay. The red clay in some cases provided shielding for DU fragments. (This may account for some post-DU/soil FIDLER measurements being higher than pre-DU/soil FIDLER measurement, as discussed in Section 4.1.2).

Eglin considers the development of a correlation factor between FIDLER results and laboratory analytical results, using the results (FIDLER and laboratory analytical) from the samples described in this section, to be inconclusive. Therefore, DU fragment testing with red clay and modeling (using the MARSSIM-suggested Micro-Shield™ modeling program) was conducted to clarify this issue of correlating FIDLER results to activity of DU in the soil. The results of this testing are presented in Sections 4.2.4, 4.2.5, and 4.2.6. Based on the outcome of these tests, the Eglin LLRM Partnering Team agreed to a $DCGL_{emc}$ which reflects the non-uniform distributed small areas of elevated activity found below the ground surface.

4.2.2 Ditch Sampling Event

The two drainage ditches at IRP Site No. RW-41 represent the potential for migration of DU off site. One drainage ditch extends northeastward from the RCA (Northeast Ditch), while the other drainage ditch extends south-southeastward from the southern section of the site to Rocky Creek (South Ditch). As described in Section 3.3.2, soil sampling was performed along the centerline of both ditches to determine the extent of, if any, contamination that had been transported off site via the drainage ditches. Only the surface soil samples (zero to 0.5 feet bls) from the ditch borings were submitted for laboratory analysis. No subsurface samples were submitted to the laboratory for analysis, because the surface samples exhibited low activities of uranium.

In the Northeast Ditch (defined as the part of the ditch that is outside of the RCA), the total uranium activities detected in the surface samples ranged from 5.68 pCi/g to 10.89 pCi/g (Figure 3.3).

In the South Ditch, which extends from the RCA to Rocky Creek, the total uranium activities ranged from 0.15 pCi/g to 2.76 pCi/g (Figure 3.3). Although some of the soil sampling results from the Northeast Ditch and the South Ditch were above background, they were all well below the DCGL.

The laboratory analytical data for the ditch samples indicate that the existing DU at IRP Site No. RW-41 has not been transported off site through erosion or surface water runoff via the drainage ditch extending southeastward off site. The average DU concentration of the samples taken from the South Ditch was 0.73 pCi/g or almost three orders of magnitude below the recognized DCGL. In addition, these results correspond to background levels (0.7 pCi/g) of uranium in the soil at Test Area C-74L (Becker and others, 1990).

Figure 3.3 indicates that the existing DU has not been transported off site through erosion or surface water runoff via the Northeast Ditch. The average DU concentration of the samples taken from the drainage ditch was 8.49 pCi/g or approximately 72 times below the DCGL for the industrial scenario.

4.2.3 Vertical Extent Sampling Event

As discussed in Section 3.3.3, vertical extent soil sampling was performed to evaluate the vertical extent of DU contamination in the soil at IRP Site No. RW-41. The primary goals of the subsurface soil sampling were as follows:

- Determine the status/compliance with the DCGL;
- Identify DU concentration hot-spots; and
- Identify areas where DU concentrations require remedial action.

Subsurface soil samples were taken along the centerline of the Northeast Ditch within the RCA, at elevated surface FIDLER measurements, and randomly throughout areas where DU concentrations were anticipated to potentially be in excess of the DCGL (Figures 3.2 and 3.3.).

The detected activities from these samples ranged from 6.22 pCi/g to 1,191.76 pCi/g. Commonly, the activities decreased sharply with depth. Soil samples from borings RW-41-SB-38, RW-41-SB-46, and RW-41-SB-50 in or near the gun corridor and eastern part of RCA exhibited the highest detected DU concentrations. Soil samples from the remainder of the site had concentrations below the DCGL, with the exception of the drum storage area where RW-41-SB-49 indicated contamination at zero to 0.5 feet bls.

In summary, the soil samples collected at IRP Site No. RW-41 indicate that the zones of elevated DU activity are located in the eastern part of the RCA and the drum storage area generally from zero to 0.5 feet bls and locally down to depths of 1.5 feet bls. In addition, DU contamination also exists within the gun corridor below the clay cap. These areas showed the highest DU soil concentrations were observed (e.g., highest measurement was 1,191.3 pCi/g or almost twice the DCGL). The northwestern part of the drum storage area and parts of the gun corridor and eastern RCA may require further mitigation in reducing the DU concentrations to less than or equal to the DCGL.

4.2.4 Particle Size Distribution Laboratory Results

On the basis of the LLRM Partnering Team discussion in December 1999, Earth Tech has submitted two samples to the laboratory to evaluate the DU activities in the respirable size fraction (less than 10 microns) of the soil at IRP Site No. RW-41. The analytical results from this analysis will be available in late March 2000 and will be submitted as an attachment to this report in early April 2000.

4.2.5 White Sand/Red Clay DU Testing

The purpose of this study was to describe and quantify the sensitivity of the ASP2e/G5 FIDLER (rate meter and probe) in detecting DU fragments in white sand and red clay found on Eglin. The results of this study were also used to recommend a Derived Concentration Guideline Limit Elevated Measurement Comparison ($DCGL_{emc}$) based on FIDLER measurements. The results and conclusions of this study were presented to the Eglin LLRM Partnering Team in February 2000 (Eglin, February 2000).

The study concludes that the FIDLER is capable of detecting DU fragments at ten percent to fifty percent of the DCGL as recommended in the MARSSIM (NRC, NUREG-1575, December 1997). The FIDLER is capable of detecting average size fragments (greater than 50 grams) in the upper 12 inches of soil within 10 to 50% of the DCGL.

The DU test also confirmed the Surveyor Minimum Detectable Count Rate ($MDCR_{surveyor}$) scan calculation value of 1078 cpm for use during field surveys. This value is the recommended scan MDCR that should be used during future FIDLER field surveys.

4.2.6 MicroShield™ Modeling Evaluations

A total of 72 models were calculated using MicroShield™ at various depths, geometry, soils, densities, dose points and fragment sizes to determine an average Scanning Minimum Detectable Concentration (scan MDC) for the FIDLER.

The white sand exposure rate from 6 inches to 12 inches bls ranged from 0.0008 microR per hour (μR/hr) to 6.2850 μR/hr at a dose point of 10 centimeters above the surface of the ground. This dose rate equals scan MDCs ranging from 0.1846 pCi/g to 1386.89 pCi/g. This range of contamination is the scanning minimum detectable concentration level for fragments ranging in size from one gram to 300 grams.

The red clay exposure rate from 6 inches to 12 inches ranged from 0.0020 μR/hr to 4.66 μR/hr at a dose point of 10 centimeters above the surface of the ground. This dose rate equals scan MDCs ranging from 0.2488 pCi/g to 568.90 pCi/g. This range of contamination is the scanning minimum detectable exposure rate of 1.16 μR/hr for fragments ranging in size from 1 gram to 300 grams.

The MicroShield™ calculation with 12 inches of red clay, a 50 gram DU fragment and with an average density of 2.0 grams per cubic centimeter (g/cm^3) produced an exposure rate of 0.0818 μR/hr at 10 centimeters (cm) above the surface. This is equal to a scan MDC of 14.17 pCi/g needed to yield the minimum detectable exposure rate of 1.16 μR/hr.

After completion of the DU test, and completion of the MicroShield™ modeling program, the FIDLER is capable of detecting average size fragments (less than 50 grams) in 12 inches of soil within 10 to 50% of the DCGL. Therefore, it is recommended that a FIDLER based $DCGL_{emc}$ value of 44 kcpm be used for a 1-meter area. This value should be used as a direct comparison value for hot spots risk determination.

This information was presented and discussed during the February 2000 LLRM Partnering Meeting. The LLRM Partnering Team reached consensus on a scan MDC of 14.17 pCi/g and a $DCGL_{emc}$ of 44 kcpm (Eglin, February 2000). This $DCGL_{emc}$ is considered the investigation level for future field work at Eglin LLRM DU sites and will be used as the action level during remediation at IRP Site No. RW-41.

4.3 GROUNDWATER QUALITY

The detected activity of total uranium in groundwater sample RW-41-GW-01, collected from the production well at IRP Site No. C-74L, was –24.41 pCi/L. The laboratory results for this sample are presented in Appendix C.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF RESULTS

The following summarizes the results of the CS/ICM at IRP Site No. RW-41 Test Area C-74L Gunnery Ballistics Facility.

- The FIDLER survey indicated numerous isolated occurrences of DU fragments (hot-spots), identified by FIDLER readings above the investigation level used during the field work (10 kcpm).
- The results of this CS confirmed that the DU fragments are the source of the DU contamination. Furthermore, the DU remains as discrete fragments of the DU penetrators. That is, the DU contamination is not adsorbed to soil particles.
- The majority of these DU fragments range in size from tiny specks to full rounds and weigh less than 1 gram to approximately 50 grams.
- The DU fragments were deposited onto the ground surface and the very shallow subsurface (generally less than 0.5 feet bls) from ricocheting off of steel and concrete targets during ground to ground test firing.
- The ICM activities, which entailed removing up to three shovels-full of the DU fragment and surrounding soil and collecting pre- and post-DU/soil removal FIDLER readings, proved very effective in mitigating the hot-spots (Figures 4.1 and 4.2). A total of approximately 106 cubic feet (4 cubic yards) of soil and DU fragments were transported to Test Area C-64 under Eglin's existing RAM permit. This material was contained in seven 22-gallon drums, eighteen 30-gallon drums, and two 55-gallon drums (these largest drums also contained some personal protective equipment).
- The soil sampling results indicate that the total uranium decreases sharply with depth and that DU contamination is not being transported off site within the Northeast or South Ditches.
- The FIDLER survey down-hole logging survey, and soil sample results indicate that areas with elevated DU are currently primarily located in the gun corridor, the eastern part of the RCA, and the northwest corner of the drum storage area, generally from 0 to 0.5 feet bls (locally down to 1.5 feet bls).
- Extensive DU fragments are currently visible on the surface of the ground in the eastern parts of the RCA and the northwestern part of the former drum storage area.
- The findings of this CS/ICM are generally consistent with the historical investigative work performed at the site (Becker and others, 1990; Becker and others, 1994; White, 1981).
- During this CS/ICM, the FIDLER survey grid was extended for a radius of 60 feet for every DU fragment that was detected near the edge of the grid (Section 3.1). This criterion proved to be impracticable. Eglin is currently developing more scientifically valid criteria for extending the survey grid during future LLRM investigative activities.

- Total uranium was detected in the groundwater sample collected from the production well on site at a very low activity (-24.42 pCi/L). This indicates that the groundwater has not been impacted with the DU.

5.2 DATA QUALITY ASSESSMENT

Data Quality Assessment (DQA) is a scientific and statistical evaluation that determines if the data are of the right type, quality, and quantity to support the intended use. MARSSIM recommends several steps for reviewing data to meet the document's required 95% confidence level (NUREG-1575, 1997). This process was designed primarily for the final status survey and should be applied with care to the CS phase where initial assumptions, instrument selection, and procedures might change as knowledge is gained during the survey effort. However, the following DQA is presented here to ensure that the data and procedures used to collect that data during the CS can support No Further Investigative Action recommendations for some areas of the site without going through a formal MARSSIM final status survey process.

First the data was reviewed to ensure that no errors were made. Then a statistical test was selected to verify the assumptions of the Data Quality Objectives (DQO) process. Finally conclusions from the plots and statistical test used in the survey were made. There were two primary types of data used in this survey: soil sample results and the FIDLER readings. The FIDLER data were used to delineate the horizontal extent of the contamination and to select soil sampling locations.

5.2.1 Soil Data Quality Assessment

The review of the soil sample results relied primarily on the QA/QC program. The QA/QC program addressed in the QAPP and ESOP for all laboratory activities and field surveys was followed. Laboratory and field QC results are presented in Appendix C. The number of field QC samples (field duplicates and field blanks) was calculated at a quantity of approximately 10% of all samples collected, per matrix, per analytical method, for the LLRM investigation program. All QC samples were submitted to Quanterra.

The QA program was implemented by the analyses of split samples by the U.S. Air Force IERA at Brooks Air Force Base, Texas to corroborate the subcontractor (Quanterra) laboratory data. The percentage of QA samples was approximately 5% of all samples collected, per matrix, per analytical method for a total of 10 samples.

The soil sampling results revealed that all of the measurements, except for four out of 51 samples, were below the DCGL. Although the DCGL was exceeded in such a small percentage of the samples, there are isolated areas of elevated activity. Further testing with DU fragments and modeling (as summarized in Sections 4.2.4 through 4.2.6) was performed as part of the DQA process. This included the development of a $DCGL_{emc}$ for use during the final status survey.

5.2.2 FIDLER Data Quality Assessment

The review of the FIDLER data began with the performance of the equipment. The performance of the FIDLER was monitored daily and recorded on a performance control chart. The control charts document instrument performance on a regular basis and identify conditions requiring corrective actions on a real time basis. All pre/post source checks were within the established 10% QC checks as recommended by MARSSIM (NUREG-1575, 1997).

The statistical test used for evaluating the FIDLER data involved the use of nonparametric statistical techniques. Nonparametric statistical methods are appropriate for data that does not fit a normal distribution, as is the case with non-uniform small areas of elevated activity. Based on the recommendations of NUREG-1505, the Quantile test was selected (NRC, 1995). The Quantile test performs well at identifying smaller areas with somewhat higher contamination concentrations. The Quantile test is better when excess radioactivity is concentrated in a few areas within a site, assuming an adequate number of samples were taken. For this reason the test was applied to the FIDLER readings within the RCA to support the null hypothesis that the site contains non-uniform small areas of elevated activities above the investigation level and requires remediation. The test also was used on the South Ditch to show that the site was below the investigation level of 10 kcpm; and could be recommended for No Further Investigative Action. But until the modeling program (MicroShield^{TM}) and the DU test were completed, the data could not be fully evaluated.

The histogram and Quantile Plot for the RCA FIDLER readings support the DQO statements that this area contains small areas of elevated activity (Tables 5.1 and 5.2). The histogram revealed 1,781 measurements between 6.3 and 630.0 kcpm (anti log of 0.8 to 2.8). The Quantile plot (Table 5.1) is an indication of the amount of data in a given range of values. A small amount of data in a range results in a large slope. A large amount of data in a range of values results in a more horizontal slope. A sharp rise near the bottom or the top is an indication of asymmetry. Sudden changes in slope, or notably flat or notably steep areas may indicate peculiarities in the survey unit data needing further investigation. A useful aid to interpreting the Quantile plot is the addition of boxes containing the middle 50% and middle 75% of the data. The 50% box has its upper right corner at the 75th percentile and it lower left corner at the 25th percentile.

The results of the Quantile plot for the RCA FIDLER readings support the histogram and the FIDLER data evaluation section of this report. The plot of the FIDLER data indicates that 50% of the FIDLER readings fall between 5.62 and 15.84 kcpm, 75% of the readings in the range of 5.0 to 19.95 kcpm and a median of 10 kcpm (Tables 5.1 and 5.2).

The histogram and Quantile Plot for the South Ditch FIDLER readings support the DQO statements that this area contains small areas of elevated activity less than the investigation levels of 10 kcpm (Tables 5.3 and 5.4). The histogram shows 115 FIDLER measurements between 3.3 and 8.50 kcpm (anti log of 0.51 through 0.9) which is consistent with the previous evaluation done of the FIDLER data (section 5.2.1).

The Quantile chart shows that 50% of the FIDLER readings fall between 3.98 and 5.0 kcpm, 75% of the FIDLER readings in the range of 3.98 to 6.30 kcpm and a median of 4.46 kcpm. The statistical test supports the DQO statement that the Southeast Ditch area receives a recommendation of No Further Investigative Action (Tables 5.3 and 5.4).

5.3 FIDLER EVALUATION

The FIDLER survey was conducted over approximately 100% of the site in a north-south direction with over 3,900 FIDLER scaler readings, 1,139 of which were two times the background of 10 kcpm. The survey identified the following three areas that may be considered survey units based on levels of contamination: the RCA and gun corridor, the former drum storage area and the South Ditch.

Within the RCA and gun corridor, the FIDLER identified 1,139 hotspots greater than 10 kcpm, or two times background. This area contains extensive DU fragments on the ground surface. Therefore it was not conducive to manually remove each fragment which was visible. Using the preliminary FIDLER DU test results (as mentioned in Section 4.2.5), the FIDLER can detect DU fragments of greater than 50 grams, one foot bls, with detector readings of greater than 11 kcpm. This would indicate that most of the contamination is either in small fragments on the surface or larger fragment within one foot bls. The average FIDLER readings of the 1,139 hotspots within the RCA were 15.57 kcpm.

The second area identified by the FIDLER and soil sample results as having surface contamination is the northwest corner of the drum storage area. The FIDLER survey identified 95 scaler readings slightly above background with several small isolated areas of elevated activity. These areas had an average measurement of 66 kcpm and were primarily confined to the northwest corner of the drum storage area (Figures 4.1 and 4.2). These areas are currently marked with white pin flags and require remediation to reach the DCGL.

The FIDLER results for the South Ditch indicates readings slightly above background but less than the investigation level of 10 kcpm. These results are correlated with the soil boring samples and down hole logging results from this area. The data collected in the South Ditch area should enable this part of the site to receive a recommendation of No Further Investigative Action as long as there is not cross-contamination during remediation of the RCA.

5.4 SOIL SAMPLE DATA EVALUATION

The Eglin LLRM Partnering Team decided that soil sampling would not be used solely for delineation and characterization purposes, because discrete DU fragments are the source of the contamination (Eglin, August 1999). Rather, soil samples were collected for three reasons: 1) evaluate a correlation between FIDLER and laboratory analytical results; 2) evaluate soil quality in the Northeast and South Ditches; and 3) evaluate DU impacted soil at depth. This sampling strategy resulted in a total of 51 samples collected, in addition to the duplicate samples sent to Quanterra and the 11 split samples sent to the Institute for Environment, Safety and Occupational Health Risk Analysis, Surveillance Division Radioanalytical Branch at Brooks Air Force Base for Quality Assurance analysis.

Twenty surface soil samples were collected to determine if a correlation factor could be established between the FIDLER readings and the laboratory analytical results. Although a trend of increasing activity (laboratory analytical results) with gamma count rate (FIDLER readings) was discerned the data could not be used to establish a specific correlation factor. Therefore, Eglin is pursuing collecting FIDLER readings of DU fragments at varying depths in both sandy and clayey soil, as described in Section 4.2.5.

The soil samples from the Northeast and South Ditches exhibited activities that were slightly lower than expected, based on the FIDLER readings. Again, the DU testing should clarify the relationship between the FIDLER readings and the laboratory analytical results. It is anticipated that these ditches will not warrant remedial activities.

Biased surface and subsurface soil samples were collected at locations of elevated FIDLER detections, to determine the approximate vertical extent of DU fragments and help evaluate the lateral and vertical extent of soil potentially requiring remediation. These soil sample results indicated that contamination is confined mainly to the upper 0.5 feet of soil.

Regression data analysis is used for the purpose of prediction and ultimately to use that knowledge to show a correlation between two variables. Such a regression data analysis was performed using the FIDLER readings and the laboratory analytical results as the variables.

An assumption was made that the laboratory analytical result (pCi/g) is dependent on an independent variable (FIDLER reading; kcpm). Regression analysis examines the strength of this dependency and yields a statistic R to confirm the relationship. If $R=0$, there is no relationship. If $R=1$ then a perfect relationship exists, and the independent variables in the equation perfectly explain the value of the dependent variable.

Tables 5.4 and 5.5 show that the relationship is a linear relationship in the models' prediction, but further analysis of the regression data shows that R is less than one (0.941), which is less than the desired perfect relationship. This is due to the fact that the DU fragments are of unpredictable size and concentration in the soil, as shown by the outliers in both tables. But the model prediction does indicate that a strong relationship does exist between the soil concentration (pCi/g) data and the FIDLER (kcpm) readings. The FIDLER readings do increase linearly as the DU soil concentration increase.

A secondary analysis is required to determine the exact nature of the relationship. A typical method is to calculate the chi square (x^2) and determine what percentage of the perceived relationship is explainable by the independent variables (FIDLER readings). When comparing the relationship between pCi/g to kcpm, the percentage is 88.7%. It should be noted that Eglin used the information on the correlation samples (FIDLER readings compared to laboratory results, as discussed in Section 4.2.1), as well as this percentage, to determine that the DU testing, as described in Sections 4.2.4 through 4.2.6, was necessary to establish a correlation between FIDLER readings and laboratory analytical results.

5.5 RECOMMENDATIONS FOR FURTHER ACTION

The results of this CS/ICM at IRP Site No. RW-41 Test Area C-74L indicate that the DU contamination is present in the eastern part of the RCA, the gun corridor, and the northwestern part of the former drum storage area. The laboratory analytical data from subsurface samples and preliminary results from the DU Testing indicate that the DU fragments are generally confined to the upper six inches of soil.

Therefore, it is recommended that remedial action be performed in these parts of the site. This remedial action should entail excavation and off-site disposal of the DU fragments currently at the site. Some of the details of this recommendation are as follows:

- The approximate areas to be excavated are shown on Figure 5.1. The depth of the excavation is estimated to be six inches bls in the RCA and the former drum storage area. Within the gun corridor, the total depth of the excavation is estimated to be approximately one footbls, because of the presence of the 0.5-foot clay layer covering this part of the site. This estimate of lateral and vertical extent is based on the DCGL for the industrial scenario of 600 pCi/g for laboratory analytical results of soil samples and the corresponding $DCGL_{emc}$ of 44 kcpm for the FIDLER readings (Eglin, February 2000).
- FIDLER readings and confirmation soil samples should be collected during and after the excavation, using 44 kcpm and 600 pCi/g, respectively, as the excavation action levels. The presence of DU fragments should also be used to guide the excavation.
- On the basis of the excavation zone described above, the estimated volume of soil to be excavated and transported/disposed off-site as radioactive waste is approximately 1,200 cubic yards. This estimated volume of soil does not warrant a feasibility study of on site treatment technologies (Eglin, December 1999).
- Substantial UXO support will be needed for this remedial action. The IRP prime contractor performing this work will need to subcontract this support.

A detailed description of the remedial action (RA) activities at IRP Site No. RW-41 will be presented in an RA work plan scheduled for submittal in middle 2000.

After the remedial action has been completed, Eglin intends to perform a Final Status Survey to recommend the site for no further investigative action with industrial LUC. The applicable data from this CS/ICM will be used for this Final Status Survey. It is anticipated that very little post-remediation data will need to be collected from the parts of the site not affected by the excavation. These non-impacted parts of the site include the Northeast Ditch, the South Ditch, the west part of the RCA, and the area of the site surrounding the RCA.

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DETAILED REMEDIAL ACTION PLAN – ITEM 9A

1. Objective Of Decommissioning Action

The objective of the decommissioning of IRP Site No. RW-41 is to remediate the depleted uranium present (land or building) to the extent that any residual radioactivity does not result in a total effective dose equivalent to the average member of a critical population that exceeds 15 mrem (0.15 mSv) per year from all exposure pathways or present an excess cancer risk greater than 1×10^{-6}. The remedial actions described in this section have been approved by the Eglin Low Level Radioactive Material (LLRM) Partnering Team which consists of the following voting members: USAF Radioactive Isotopes Committee, Eglin's Base Radiation Safety Officer, US Environmental Protection Agency, Florida Department of Health, Office of Radiation Control, 46th Test Wing Permit Certifying Official, the Army Corp of Engineers Health Physicist, and the contractor (Earth Tech) Project Manager. Adjunct members of the team consists of the Eglin Alternant Base RSO, USACE Contract Manager, Earth Tech Senior Health Physicist, and members of the Air Force Radioactive and Mixed Waste Office.

2. Critical Population

The critical population for IRP Site No. RW-41 is the range worker. The site is currently being used to test conventional munitions. The industrial use criteria (600 pCi/g or 44 kcpm) has been approved by the Eglin (LLRM) Partnering Team. Test Area C-74L is closed to all activities except testing of conventional munitions. Hunting and other recreational activities are not allowed. Range workers are present on site only during testing of munitions.

3. Activities and Tasks

A. MOBILIZATION AND TRAINING

Mobilization includes procurement and installation of necessary facilities, equipment, and materials to perform the Remedial Action. Mobilization activities also include the assignment of personnel to the job site; personnel radiation safety and site-specific construction safety training; and regulatory permitting and notifications, as required.

Site-specific radiological and general training will be provided by Earth Tech for all employees at the commencement of the project. Health and safety training details are provided in Appendix "A of the Site Specific SSHP (The SSHP will be approved by the Eglin LLRM Partnering Team prior to beginning of decommissioning activities at the site). Site personnel training certification and its documentation will be maintained by the site QAO.

B. SITE PREPARATION

Site preparation will consist of the initial radiological survey of the RCA, land survey of the remediation area, and installation of environmental control systems.

1.) Initial Radiological Survey

Prior to any field activities within the EZ/RCA, an initial walkover radiological survey will be conducted to determine the boundaries of the soil excavation and to confirm the results of the previous CS investigation.

2.) Land Surveying

The perimeter of the excavation area and the soil sampling locations associated with IRP Site No. RW-41 remediation will be surveyed by a surveying firm licensed in the state of Florida. Both vertical and horizontal control surveying will be performed at each soil sampling location. The corners, and other boundary locations of the remediation area will also be surveyed.

Both latitude and longitude coordinates and the state plane coordinates will be calculated. Both of these coordinate systems are based on the North American Datum (NAD) 1983 Geographic Coordinates. The vertical datum is the National Geodetic Vertical Datum (NGVD) of 1929. The surveyor will certify that the positions meet or exceed Third-order, class I (1:10,000) Horizontal accuracy and Third-order Vertical accuracy.

3) Environmental Control Systems and Monitoring Program

Prior to excavation activities and throughout the remedial action, environmental controls will be implemented to control erosion and sedimentation, manage stormwater runoff, and minimize dust emissions, as determined by the RC.

a) Erosion and Sedimentation Controls

Prior to performing any intrusive work at the site, erosion and sedimentation controls shall be installed as required. Silt fencing will be utilized to minimize the transport of sediment in storm water runoff. The silt fence shall be installed down-slope of all areas where intrusive work is to occur, and down-slope of all soil stockpile areas. In addition, a silt fence shall be installed and maintained in active work areas and down-slope of re-vegetated areas until an adequate stand of vegetation is established.

b) Dust Suppression

Throughout remediation, all exposed areas will be watered if necessary to minimize dust emissions. Water used for dust suppression will be obtained from the on-site shallow well and stored in a mobile water tank. Dust suppression will occur, as needed, at the discretion of the RSO, based on visual observation and air monitoring results. A temporary storage tank will be used to store dust suppression water in the EZ.

c) Perimeter RAD Airborne Contaminant Monitoring

Air samplers will be installed at locations around the perimeter of the remediation area in order to assess the levels of airborne radioactive particulates that have potential for migrating off site.

Filters will remove particulates from the air pumped through each sampler. The filters will be surveyed in accordance with the site RPP (Appendix B). If the radiation levels detected are significant, further laboratory analysis will be conducted and work will stop until resolution. If radioisotope activities in the air samples are deemed excessive, then corrective steps will be taken immediately to further reduce dust levels in the work area. The radiological airborne contaminant monitoring will be under the direct supervision of the Site RSO, and will be conducted by HPTs (HPTs will be Earth Tech or other).

d) Environmentally Sensitive Areas

No threatened or endangered plants or animals have been observed at the remediation site.

e) Decontamination Pad

The location and construction of the vehicle/equipment decontamination pad located within the EZ will be determined by the Site RSO during site preparation activities. The decontamination pad will be constructed using 40-mil liner and 8-inch by 8-inch wood posts, and splash walls will be constructed along both sides of the pad using lumber and corrugated sheeting if a power washer will be used for decontamination. A sump pit will be installed for the removal of the water from the decon pad. Decontamination by high or low pressure washers will be the last resort.

If a power washer is not used for decontamination of equipment, part of the existing concrete pad in the EZ will be used for decontamination of equipment using wet wipes and other decon materials. The decon techniques used will not result in any quantity of potentially contaminated water being generated. Decontamination techniques will be determined by the RC and decontamination procedures will be approved by the Eglin RSO and the Site RSO.

f) Excavation Soil Stockpile Areas

Excavation stockpile areas will be designated for contaminated soils as determined by the radiological surveying during excavation activities. All excavated soils will be considered contaminated with DU and will be transferred to the contaminated stockpile area via a front-end loader. The soil stockpile area will be lined on the bottom with 10-mil plastic and on the sides with plastic sheeting and sandbags. Contaminated stockpiles will be limited to 500 cubic yards. The total contaminated stockpile size will not exceed 1,000 cubic yards during the course of the excavation. The on-site Certified Broker will coordinate with the RC for the removal of the contaminated soils in order to minimize the amount of soils stockpiled on site. Soil characterization and radiological surveying of the stockpiles will be conducted periodically as required by the disposal facility, the RC, or the Certified Broker.

g) Transportation Container Load-out Area

The container load-out area will be located at the contaminated soil stockpiles. The load-out area is where the transportation containers will be loaded with contaminated soils and debris by a front-end loader. Prior to the soil being placed in the disposal containers, EOD personnel will survey the soil for UXOs. Any UXO found in the soil will be removed by EOD personnel and stored in a safe location.

C. SITE REMEDIATION OPERATIONS

This section discusses the various procedures, equipment, and personnel to be used in the dismantling of any fencing, the present controlled entry shack, and excavation of the radiologically contaminated soils. The general scope of work includes the removal and off-site disposal of radioactive contaminated soil and building debris. Segregation of the soils and building debris during excavation and dismantlement activities will be based on radiological surveys and on-site soil sampling results.

1) Radiological Surveys and Laboratory Analysis

Radiological surveys will be performed during excavation to ensure compliance with appropriate regulatory guidelines with respect to personnel and equipment release from the site, to determine excavation boundaries, and to document compliance with the cleanup goals. In addition, on-site and off-site laboratory analysis will be performed as discussed below:

The off-site laboratory used for characterization of the waste for disposal purposes must be validated by the USACE – Omaha District.

Four different types of radiological surveys of soils will be performed during the course of this project:

1. A walk-over survey of the perimeter of the excavation will be conducted prior to the start of remedial activities, and during the excavation activities;
2. Routine surveys of roads, load-out areas, decon pads, and soil stockpile areas during remedial activities to ensure that radioactive materials are not being spilled or dispersed around the site as a result of the remedial activities;
3. Release surveys of equipment, materials, tools, and personnel, which will be exiting the exclusion zone, and contamination reduction zone; and
4. FSS of the site following remedial activities, prior to backfilling.

2) Personnel Surveying

Prior to leaving the EZ, all personnel will be surveyed for contamination using hand held radiological meters; this procedure is called "frisking." Frisking will be conducted within the EZ and CRZ prior to entering the SZ. Details regarding personnel monitoring are presented in the SSHP (Appendix A) and the site RPP (Appendix B).

As personnel leave the EZ, PPE, such as Tyveks®, latex gloves, air-purifying respirator with HEPA filter cartridges, and other used PPE will be discarded within the EZ. These items will be disposed of in accordance with the Waste Management, Transportation and Disposal Plan (Appendix C).

3) Decontamination

As a means of controlling radiological contamination, removable contamination will be addressed first. The waste generated by decontamination activities will be contained in drums and stored with other material low level radioactive waste for transportation to the LLRM waste disposal site. The site Radiation Protection Plan (RPP) contains additional information on decontamination of personnel. The Site Radiation Protection Plan will be approved by the Eglin LLRM Partnering Team prior to the beginning of decommissioning activities at the site.

4) RCRA Soil Remediation

a) Safety

The excavation activities discussed in this section can be conducted only if proper procedures and practices are instituted to ensure the safety and health of personnel from radiological exposure, and physical and/or mechanical hazards. An SSHP (Appendix A) has been developed in accordance with the Occupational Safety and Health Administration (OSHA) Code of Federal Regulations 29 CFR 1910.120, 29 CFR 1926, and the Hazard Communication Standard 29 CFR 1910.1200. The purpose of the Safety and Health Plan is to establish safe procedures and practices for the personnel engaged in field activities associated with the remedial action.

b) Soil Excavation

The scope of work for the remediation of soils includes the excavation and loading into disposal containers of approximately 1,500 cubic yards of soil contaminated with DU penetrators or DU fragments. These soils are located within the RCA, which surrounds three sides of the gun corridor. The excavation depth is six inches for the entire excavation area. The depth to groundwater on the site is approximately 50 to 60 feet bls. Therefore, groundwater should not be encountered during excavation activities.

Excavation of radiologically contaminated soil will commence after the area of excavation has been delineated and marked on the ground surface.

c) Excavation Storm Water Control

The excavated area will be covered with plastic sheeting at the end of each day to prevent precipitation from entering the excavation. The plastic (liner) will be secured with sandbags at the outer limits of the liner and set in place either manually or with the excavator at regular intervals within the excavation. The liner will be disposed of with other remedial waste at the end of the project.

d) Excavation Soil Management

The stockpile areas are dedicated to the materials they are storing. On the basis of the surveying and sampling effort, the excavated material will be segregated into four separate, dedicated stockpiles, as follows:

- Contaminated soils for off-site disposal,
- Contaminated debris for off-site disposal
- Contaminated PPE for off-site disposal
- Clean debris stockpile

All contaminated stockpiles will be staged on 10-mil plastic and will be covered with sheeting and sandbags. Sampling and surveying of the stockpiles will be conducted periodically at the discretion of the RSO.

The size of the stockpiles will be maintained at 500 cubic yards to reduce the difficulties in covering and uncovering stockpiles. As soil stockpiles (clean and contaminated) reach the 500 cubic yard limit, a composite soil sample will be collected for analysis. Composite samples will be collected in accordance with the disposal site and Certified Broker requirements.

e) Personnel

Experienced personnel will be required to implement these excavation activities. Equipment operators will be utilized for front-end loaders, dozers, forklifts, and cranes. The number of operators required will depend on the quantity of equipment on site and the tasks being completed. Operators will be required to comply with the PPE and radiological procedures established in the SSHP.

Experienced personnel will also be required to oversee activities in a non-operator capacity. Spotters will be required to assist in the excavation and loading activities.

f) Quality Control and Oversight

As excavation proceeds, it will be necessary to document conditions prior to excavation, during excavation, after excavation, and after backfilling is completed.

Decontamination, surveying, and sampling activities will be supported by a team of HPTs under the direct supervision of the RM and Site RSO.

Except for general employee training at the site, all subcontractor personnel will be properly trained to perform their primary duties.

E. TRASNPORTATION AND DISPOSAL OPERATIONS

1) Load-Out and Transport to Rail Facility

The load-out area will be located adjacent to the full contaminated soil disposal containers, just outside the EZ. Although the disposal containers are located within the EZ, the truck used for the transport of the disposal containers will be located outside the EZ, but within the CRZ.

After loading of the containers to capacity, the containers will be sampled, sealed, inspected, and cleaned of loose material, and surveyed in accordance with the instructions from the Certified Broker. A crane or a forklift will be used to lift and store the containers until ready for shipment. A suitable scale mounted to the crane will be used to determine the actual container weight.

After the completion of the appropriate manifest and disposal facility documentation by the Certified Broker, the containers will be loaded onto trucks for delivery to the rail facility determined by the Certified Broker. The maximum number of days the disposal containers will be stored at the rail facility (on the rail cars) is five days.

Trucks will arrive on site and will be directed to the loading station, which will be adjacent to the EZ. A general survey of the truck will be conducted prior to loading to confirm the absence of off-site contamination. Wipe samples will also be collected, as determined by the Certified Broker.

The crane will load the containers onto the trucks. The flat bed trucks will deliver the containers to the radioactive material storage area located at Test Area C-64.

Daily surveying of the truck loading area during load-out days will be conducted to confirm the absence of contamination within the clean zone used by the transport trucks.

2) Quality Control and Oversight

As excavation proceeds, it will be necessary to document conditions prior to excavation, during excavation, after excavation, after backfilling, and after final cover is completed. Documentation activities may include, but not be limited to, the following:

- Quantity of contaminated soils removed from excavation areas,
- Location of soils removed from excavation areas (using elevation and planar coordinates),
- Soil sample locations, survey locations and associated results,

- Air monitoring results,
- Quantity and quality of backfill materials delivered and placed, and
- Transportation documentation and tracking.

These activities will be documented by appropriate field personnel assigned to each task, and tracked by the on-site QAO.

F. FINAL STATUS SURVEY SAMPLING AND ANALYSIS

FSS sampling and analyses will be performed following excavation of contaminated soils and prior to backfilling, in accordance with the guidelines specified in NUREG 1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM; August 2000). The FSS design will be determined by the Site Certified Health Physicist (CHP).

The FSS process will determine whether the data demonstrates compliance with the cleanup goal (600 pCi/g). If not, the site will be evaluated for additional remediation at areas that fail to meet the criteria.

If the results demonstrate compliance, the results of the analysis along with FSS data will be presented to the Eglin RSO, USACE, State, and Federal officials for review and approval. After approval is received, the excavations will be back filled.

The final recommendation for the site is anticipated to be No Further Investigative Action (NFIA) with current Land Use Restrictions (LURs).

G. BACKFILLING AND SITE RESTORATION

Backfilling of the excavations will commence after the FSS sampling program has confirmed that soils containing DU penetrators and DU fragments above the $DCGL_w$ have been removed from the remediated area and has been approved by Eglin, USACE, the Statae of Florida, and EPA.

The front-end loader used during loading of contaminated soils will be decontaminated using approved procedures. The front-end loader will then be used to bring clean backfill to the excavation area. Backfilling of soils will be performed using native soils or clay backfill. The area may be seeded if required by Eglin Environmental Management.

H. RADIATION CONTROL OPERATIONS

A monitoring program will be implemented in order to:

- Ensure that all contaminated soil materials exceeding the $DCGL_{emc}$ are removed from the site.
- Verify that all items leaving the RCA are surveyed and meet the requirements of NRC Regulatory Guide 1.86.

- Verify that all shipping containers meet the DOT (49 CFR 173.421) criteria before leaving the site.
- Monitor and verify that exposure of workers to external gamma radiation and airborne alpha emitters is within an acceptable limit and is As Low As Reasonably Achievable (ALARA).
- Confirm that the site meets the cleanup requirements stated in the project Scope of Work through an FSS.

The quantitative analytical data generated as a result of these activities will be sufficient in type, quantity, and quality such that the cleanup of the site is verified, minimization of exposure to on-site workers can be quantified, and migration of radioactive materials to adjacent properties and roads is proven to be negligible. Each aspect of on-site monitoring, sample collection, and field laboratory operations including laboratory Data Quality Objectives are presented in the site Quality Assurance Project Plan (Appendix D).

I. SUPPORTING OPERATIONS

1) Safety and Health, and Radiation Protection

The SSHP and RPP will be implemented to ensure both worker and public protection throughout the remediation effort. This plan establishes requirements in regard to medical surveillance, bioassays, PPE, air monitoring, stop-work authority, restricted work areas, hazardous and radiation work permits, training requirements, emergency response and notifications, and waste minimization and pollution prevention. The provisions of this plan are mandatory for all on-site personnel, including subcontractor personnel.

The ALARA Program is a commitment on the part of the management of this project to closely monitor all exposures and seek methods or techniques to further reduce the radiation exposure personnel may receive. All reasonable efforts will be made to keep radiation exposures, as well as releases of radioactive material to unrestricted areas, to levels that are ALARA. Toward this end, several ALARA principles will be used:

- The site RSO will have sufficient delegated authority to enforce regulations and administrative practices concerning all aspects of the SSHP and the site RPP.
- Personnel will be trained in safety procedures and ALARA philosophies to a level commensurate with their work.
- Safety inspections will be conducted.
- Radiation Work Permits will be required.
- Radiation exposures will be minimized where practical, by the use of time, distance, shielding, administrative controls and engineering controls as specified in 10 CFR 20.1101(b).

The site RSO, as the site safety representative, in consultation with the PM and applicable Earth Tech safety professionals, will establish environmental health and safety policies and conduct independent inspections of the implementation of those policies.

Access to the site will be controlled to protect workers from unnecessary radiation exposure and to minimize the potential for the spread of radiation. Each area will be divided into three zones:

- Exclusion Zone - Actual areas of contamination. Represents any area that has the highest inhalation exposure potential and/or presents a high probability of skin contact.
- Contamination Reduction Zone - Areas immediately surrounding the exclusion zone, including the personnel and equipment decontamination facilities.
- Support Zone - Areas outside the contamination reduction zone where radiological exposures are unlikely.

These zones are discussed in more detail in Section 3.2. Access to these areas will be controlled for people, vehicles, and equipment by fencing and proper posting of the area, or by using other methods to prevent inadvertent entrance. Smoking, drinking, eating, or other activities that would enhance the transfer of radionuclides into the human body will be prohibited within the exclusion and contamination reduction zones.

Air samples will be collected and analyzed in accordance with the RSO's requirements. High volume samplers will typically be used for area monitoring. Data from the high volume monitors will be used to assess releases due to excavation operations. Air filters will be analyzed for radioisotope identification and quantification to ascertain the airborne concentration.

Generally, work at the site will be performed under Level D or modified Level D protection (Appendix A). Level C protection is not anticipated. Level C protection would only be required for activities where the potential for airborne particulates (in excess of the action level as specified in the SSHP) exists. This includes decontamination and material loading areas. If required, full-face, cartridge-type air purifying respirators will be utilized, as directed by the site RSO.

2) Quality Control

The site Quality Assurance Project Plan (QAPjP; Appendix D) will be implemented and monitored to ensure that all sampling, surveying, and construction quality objectives are met.

The site QAO will work directly with the site RSO and RM and will have the authority to enforce the requirements and administrative practices concerning any aspect of the quality control requirements depicted in this plan and its appendices. A three-phase control process will be implemented which includes:

- Preparatory Phase Inspection - Review and document applicable requirements and verify that the necessary resources, conditions, and controls are in place;
- Initial Phase Inspection - Check and document preliminary work for compliance with procedures and plans, and
- Follow-Up Phase Inspection - On-site monitoring and documentation of the practices and operations taking place, and verifying continued compliance with the project requirements and applicable regulations. Outstanding and nonconforming items or practices will be identified, along with corrective measures.

Upon conclusion of work, a review will be completed to verify that all documentation is in order prior to close out and transfer of files to the Earth Tech Fort Walton Beach Office.

3) Decontamination and Release Operations

All equipment leaving a radiologically controlled area will be decontaminated and surveyed to demonstrate compliance with NRC Regulatory Guide 1.86, a summary of which follows:

Surface Contamination Guidelines

Allowable Total Residue Surface Contamination (dpm/100cm^2)a

Radionuclides (b)	Average (b, c)	Removable (d, f)	Maximum (d, e)
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission)	5,000 (Beta-gamma)	1,000 (Beta-gamma)	15,000 (Beta-gamma)

a. As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

b. Where surface contamination by both alpha- and beta-gamma-emitting radionuclides should apply independently.

c. Measurements of average contamination should not be averaged over an area of more than 1 meter squared. For objects of less surface area, the average should be derived for each such object.

d. The average and maximum dose rate associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr and 1.0 mrad/hr, respectively, at 1 cm.

e. The maximum contamination level applies to an area of not more than 100 cm^2.

f. The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with a dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less then 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

The use of solvents may be necessary to strip outer layers of porous rubber parts (e.g., tires). This procedure will be used only as a last resort. Other porous parts (seals, wiper blades), which cannot be readily decontaminated, will be removed and treated in the same manner as contaminated soil material.

Rail transportation will be regulated by DOT 49 CFR 173.421.

All equipment will be dedicated for single use for the duration of the project (as practical) and will remain within the EZ until decontaminated, surveyed, and verified in conformance with release limits.

All equipment will be dry brushed/scraped before transport to the site decon facility to retain contamination within the EZ. At the decon pad, the equipment will be dry brushed until the equipment is verified clean. Use of water or high or low pressure washers will be used as a last resort and will require containment of the potentially contaminated runoff water.

J. PERSONNEL, EQUIPMENT, AND FACILITIES DEMOBILIZATION

At the conclusion of remedial activities, the project will demobilize from the remediation site. All equipment will have been decontaminated and equipment tested and cleared through the site RSO. Decontamination and testing details are provided in the SSHP (Appendix A) and Quality Assurance Project Plan (Appendix E).

Additional radiological surveys of roads and decontamination facilities will be performed to meet the requirements of the Site RPP. After completion of the remediation all records, including all post work submittals, will be moved to the Earth Tech Fort Walton Beach Office.