TRAINING RANGE SITE CHARACTERIZATION AND RISK SCREENING

REGIONAL RANGE STUDY, JEFFERSON PROVING GROUND, MADISON, INDIANA

Final

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TRAINING RANGE SITE CHARACTERIZATION AND RISK SCREENING REGIONAL RANGE STUDY

Jefferson Proving Ground, Madison, Indiana

August 2003

EXECUTIVE SUMMARY

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REGIONAL RANGE STUDY
JEFFERSON PROVING GROUND (JPG)
MADISON, INDIANA
SEPTEMBER 2002

1 REFERENCES

Appendix A provides a list of general references used in this document. Specific media references are provided in their respective sections.

2 AUTHORITY

The U.S. Army Environmental Center (AEC) has requested that the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) examine several military ranges at JPG for their potential impact (contamination) on soil, ground water, surface water, and sediment resources and plant and stream biota.

3 PURPOSE

To conduct a limited focus investigation of the potential munitions constituents impact of normal, live-fire range training operations at the former Army range of Jefferson Proving Ground. This investigation is to consider ground water, soil, surface water, and sediments. To conduct a screening level human health risk assessment based on U.S. Environmental Protection Agency (USEPA) methods using the data collected from each of the environmental media.

To conduct an ecological assessment, including a site-specific evaluation of biological resources (if necessary) and potential ecological impacts of chemical data collected for each of the environmental medial. This investigation is intended as an assessment of residuals in soil and water and not as an occupational study.

This investigation was conducted using a JPG Quality Assurance Project Plan (QAPP) (See Appendix G). The QAPP was developed in accordance with the *Draft Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP), October 2002*, prepared by the Intergovernmental Data Quality Task Force[1] (IDQTF), a federal consensus organization to document and control sampling and analysis procedures for this project.

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[1] The U.S. Environmental Protection Agency established the Intergovernmental Data Quality Task Force (IDQTF), chaired by the Director, Federal Facilities Restoration and Reuse Office (FFRRO) to address environmental data quality issues across governmental organizations. The IDQTF operates as a partnership, reaching decisions through consensus. While membership in IDQTF is open to any federal agency/department, current consensus members include representatives from the Department of Defense, the Department of energy, and the U.S. environmental Protection Agency.

4 SUMMARY OF FINDINGS

4.1 GROUND WATER

Eight monitoring wells (four in Impact Field 5.3 E, three in Impact Field 3W, and one in the Delta Impact Area) were installed in the surficial aquifer underlying the study area. The wells were installed to collect ground-water quality and ground-water elevation data. In order to better define ground-water conditions in the study area, ground-water quality and elevation data were also collected from seven pre-existing wells. Based on ground-water elevation data, shallow ground water in the study area appears to follow topography.

Ground-water samples were collected from all wells and were analyzed for one or a combination of the following: 15 explosive compounds (explosives and their degradation compounds), 14 metals, depleted uranium, perchlorate, hardness, and total dissolved solids. Due to low recovery rates in some of the pre-existing wells, a full suite of sample analysis could not be completed for each well. All wells were sampled and the samples were analyzed for explosive compounds. Fourteen wells were sampled for perchlorate. Metals samples from twelve wells were collected and analyzed. Samples collected from 13 wells were also analyzed for hardness and dissolved solids.

No explosive compounds or perchlorate were detected in any ground-water sample. Antimony, cadmium, chromium, mercury, silver, and zinc were not detected in any sample. Arsenic, barium, copper, lead, and total uranium were detected in samples collected from one or more wells at concentrations below their respective primary or secondary MCL. Manganese was detected in the majority of samples collected from wells screened in the overburden at concentrations above the secondary MCL and above the mean background concentration. Manganese concentrations in samples collected from wells screened in bedrock were below the secondary MCL. Calcium concentrations exceed the mean background concentration; there is no MCL for calcium. The high concentrations of manganese and calcium in ground water are most likely a result of the parent material of the overburden in the area. Other metals detected in ground water are molybdenum, nickel, and vanadium. Reported concentrations of molybdenum, nickel, and vanadium are below their respective background concentrations; there are no MCLs for these metals.

4.2 SOILS

Approximately 170 soil samples were collected from seven study sites and a reference area.

For the majority of the 13 metal parameter samples that were collected and analyzed, proportions and concentrations of metals in the study sites were not significantly greater than in the reference site.

Four metals, antimony, copper, vanadium, and barium, were significantly greater than the reference in one or more study sites.

None of the metals data sets exceeded the human health screening criteria.

Of the explosives analyzed, only RDX and perchlorate were distributed throughout the impact area. The 99th percentile concentrations for these parameters were less than the human health risk screening criteria.

4.3 SURFACE WATER AND SEDIMENTS

Surface water, sediment, and benthic macroinvertebrate samples were collected from all the significant creeks at JPG from 7-11 October 2002. Creeks were sampled near the entrance and exit points to the installation, and near the midpoint to be closer to the source of possible contamination. A total of eighteen sample sites were sampled from six different stream basins. Samples were analyzed for selected metals and explosives constituents.

4.3.1 Collective Upstream Reference Sampling Locations

Since there was no upstream reference location for two of the watersheds (Middle Fork Creek and Marble Creek), the results from the six reference locations in the other watersheds were averaged to develop a reference background for the metals. This reference value was used to determine if munitions compounds and firing range activities may have impacted surface water quality. Three explosives compounds, HMX, RDX, and 2,4,6-TNT were detected in the upstream sediment samples at higher concentrations than the downstream localities.

4.3.2 Middle Fork Creek Sampling Locations

Based on the surface water, sediment and biological data collected from Middle Fork Creek, the munitions constituents and firing range activities in the Middle Fork Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. There was an increase in several surface water total metals concentrations at sampling location 13 (midstream), but these concentrations were back to reference values at the downstream sampling location 01. There were several increases in sediment metals concentrations over reference values at both sampling locations.

4.3.3 Big Creek Sampling Locations

Based on the surface water, sediment and biological data collected from Big Creek, the munitions constituents and firing range activities in the Big Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. There was an increase in surface water total lead, manganese, and zinc at the downstream sampling location and an increase in surface water total and dissolved uranium at both midstream and downstream sampling locations. At the mid stream sampling location there was an increase in metals sediment concentrations over reference values but all returned to background values by the time Big Creek exited the installation.

4.3.4 Marble Creek Sampling Location

Based on the surface water, sediment and biological data collected from Marble Creek, the munitions constituents and firing range activities in the Marble Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. Marble Creek surface water and sediment results were almost entirely below reference values.

4.3.5 Little Graham Creek Sampling Locations

Based on the surface water, sediment and biological data collected from Little Graham Creek, the munitions constituents and firing range activities in the Little Graham Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. Most of the surface water metals results were below reference values. The sediment metals results indicated that the majority of the metals increased over the watershed reference values but only four of the twelve were higher than the average reference values at the furthest downstream sampling location.

4.3.6 Graham Creek Sampling Locations

Based on the surface water, sediment and biological data collected from Graham Creek, the munitions constituents and firing range activities in the Graham Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. The surface water results indicated an increase in a few of the metals at the midstream sampling location (16) but none were substantial when considering variability between duplicate and split samples and reference locations. There were no substantial increases in sediment metals concentrations compared to reference values.

4.3.7 Otter Creek Watershed Sampling Locations

Based on the surface water, sediment and biological data collected from Otter Creek, the munitions constituents and firing range activities in the Otter Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. None of the surface water metals increased substantially in downstream locations compared to reference locations. Most of the metals sediment concentrations increased in midstream locations compared to reference values. However, only arsenic, barium chromium, and zinc remained substantially higher at the furthest downstream location (06).

4.4 HUMAN HEALTH RISK ASSESSMENT

Environmental field sampling conducted within the former firing points and impact areas at Jefferson Proving Ground indicated several metals and explosives were present in site soils. The substances detected in a relatively high percentage of the samples were antimony, arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, silver, uranium, vanadium, perchlorate, and RDX. Using the sampling data collected, the 95% upper confidence limit of the arithmetic mean was calculated for each substance. These values were used as exposure point concentrations to represent average conditions that an individual may be exposed to over the entire site. Site-specific risk-based screening values were then derived and the risk evaluation was performed by comparing these with the exposure point concentrations for each substance. Screening levels were also derived evaluating dermal absorption of chemicals in surface water. A risk screening for surface water was conducted in a similar manner except the maximum detections of each compound were used as the exposure point concentrations. Each stream was evaluated separately since they could represent discrete areas of exposure.

4.5 ECOLOGICAL RISK ASSESSMENT

Ecological risk assessment was conducted on the basis of rodent sperm analysis, vegetation sampling and a review of the soil sample results. Two study sites and a comparison area were assessed. A total of 80 rodents were trapped and 24 adult males were sacrificed for sperm and organs. Approximately 50 vegetation samples were collected.

The sperm count in *M. pennsylvanicus* was reduced on the impact area study sites. Since the comparison site was more contaminated than the impact area sites, the cause of these reductions are probably not chemically mediated. In addition, the observed reductions in count are below the assumed 80% reduction threshold required before reproductive effects are seen.

M. pennsylvanicus had a lesser incidence of abnormal sperm (morphology) on the DU area than the comparison area, and a greater incidence of abnormal sperm on the HE area than on the comparison area. The lack of consistency in results (increased abnormal sperm on comparison site as compared to HE site) and the fact that the comparison site is more contaminated than impact area sites indicate that the observed abnormalities are due to factors other than chemical stressors. In addition, the observed differences were well below the 4% morphologic difference needed to cause a reproductive effect.

The result trend for sperm motility was similar to sperm morphology (more motile sperm were observed from animals taken from the HE area than on the comparison site, and fewer motile sperm were observed in DU animals than on the comparison site). The lack of consistency in results and the fact that the comparison site is more contaminated than impact area sites indicate that the observed differences in motility are due to factors other than chemical stressors. In addition, the observed differences were well below the 40% difference needed to cause a reproductive effect.

The fact that the comparison area was more contaminated than the impact area sperm counts were reduced on the less contaminated impact areas, the lack of consistency in morphology and motility results, and that any differences seen in sperm parameters did not exceed established thresholds, indicate that rodent populations at JPG are not being negatively impacted by substance of potential concern (SOPC) contamination.

Organ to body weight ratios did not indicate that rodents are exposed to SOPC's

Histpopathological evaluation did not indicate any chemically mediated changes in the histopathology of the organs collected from *M. pennsylvanicus*.

Hazard quotients for rodents and raptors did not exceed one on the impact area, indicating these receptors are not at risk due to SOPC exposure.

5 CONCLUSIONS

5.1 GROUNDWATER

Ground-water sample results show no evidence of ground-water contamination from the past use of munitions or the presence of UXO in the study area.

5.2 SOILS

5.2.1 The sample results indicate the presence of minor amounts of copper, RDX, and perchlorate in the JPG range areas and suggest that these are the result of range activities.

5.2.2 Based on the data collected during sampling, the SOPC's detected in soil within the former range area would not be expected to present a health risk to site workers or recreational users (hunters). All of the exposure point concentrations evaluated were well below the calculated site-specific screening levels.

5.3 SURFACE WATER AND SEDIMENTS

5.3.1 There were no exceedances of Federal Water Quality Criteria or State Water Quality Criteria in the surface water. There were a few sediment quality benchmarks exceeded in the sediment results, to include reference locations. The explosives compounds HMX, RDX, and 2,4,6-TNT were detected at very low levels in the sediment samples to include the reference locations. The aquatic benthic macroinvertebrate community was not adversely impacted by any of the munitions constituents.

5.3.2 Based on the data collected during sampling, the SOPC's detected in surface water within the former range area would not be expected to present a health risk to site workers or recreational users (hunters). All of the exposure point concentrations evaluated were well below the calculated site-specific screening levels.

5.4 HUMAN HEALTH RISK ASSESSMENT

Based on the sampling data collected during this study, the SOPC's detected within the former range area would not be expected to present a health risk to site workers or recreational users. The analytical data were evaluated and used to calculate 95% UCL's for each compound detected at levels above background. These values were then used as the exposure point concentrations, or the average site values that receptors would likely be exposed to. As a point of comparison, site-specific screening levels were developed that evaluated dermal contact, inhalation, and ingestion of soil. Another set of screening levels were calculated for dermal contact with surface water. These screening levels were meant to evaluate a typical receptor's exposure based on what information is available regarding site usage patterns. A direct comparison indicated that all of the calculated exposure point concentrations were below the site-specific screening levels. This indicates that a health risk would not be expected for the receptors evaluated.

5.5 ECOLOGICAL RISK ASSESSMENT

Based on the weight of evidence obtained during the study, it appears that the small mammal population at JPGis not being affected by munitions constituents attributable to test artillery range operations.

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TRAINING RANGE SITE CHARACTERIZATION
AND RISK SCREENING
REGIONAL RANGE STUDY
JEFFERSON PROVING GROUND
MADISON, INDIANA
USACHPPM PROJECT NO. 38-EH-8220-03
SEPTEMBER 2002

1 REFERENCES

Appendix A provides a list of general references used in this document. The soil, surface water and sediment, ground water, vegetation, and rodent investigation sections contain specific references to each respective media.

2 AUTHORITY

The U.S. Army Environmental Center (AEC) has requested that the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) examine several ranges for the potential impact of munition use (contamination) on soil, ground water, and surface water resources and plant and stream biota.

3 PURPOSE

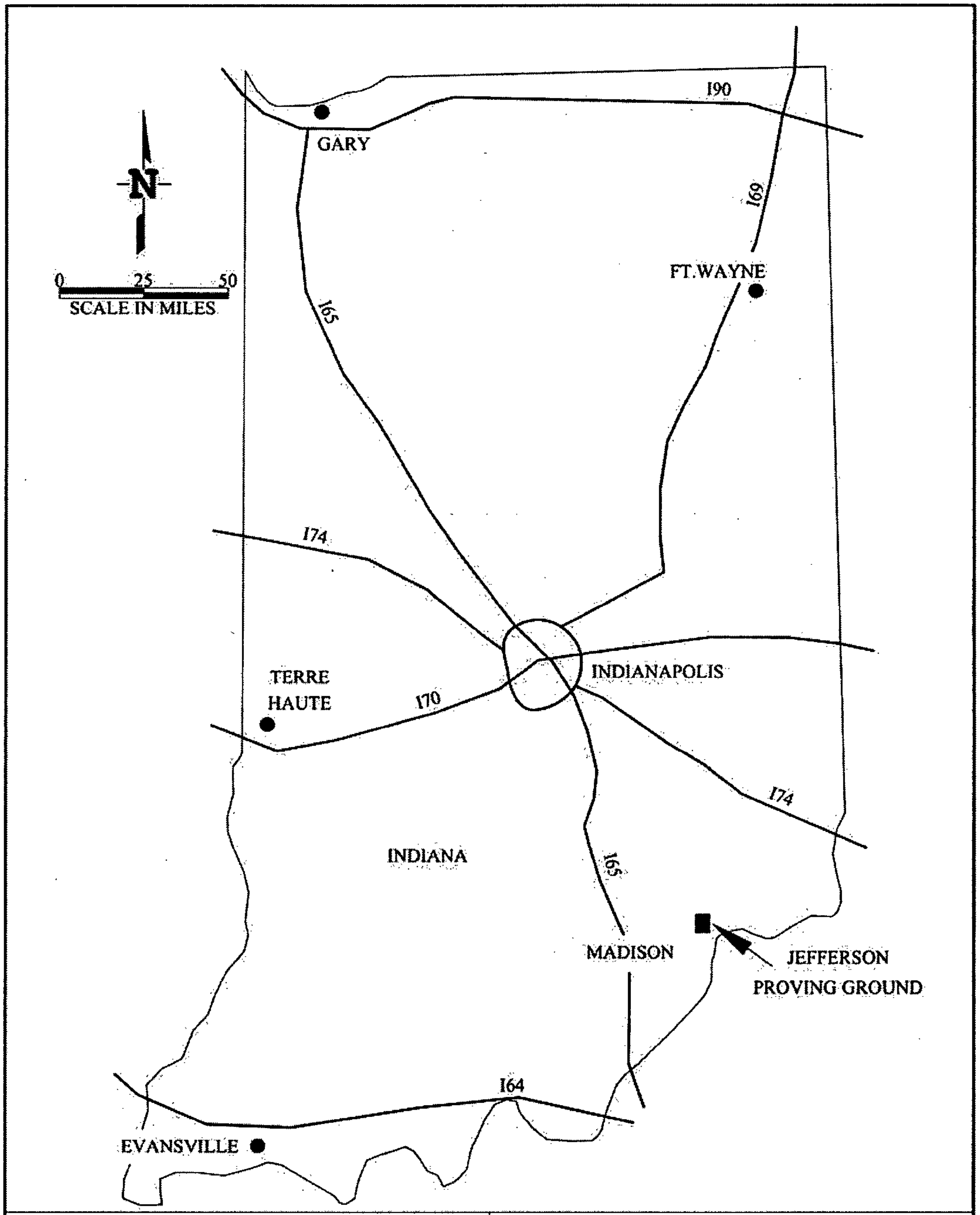
The purpose of this range study was to conduct a limited focus investigation of the potential chemical impact of normal, live-fire range training operations that historically occurred at the JPG impact areas. This investigation consisted of sampling the soils, surface water and sediments, ground water, vegetation, and the sperm of a limited number of small mammals. A screening level human risk assessment based on U.S. Environmental Protection Agency (USEPA) methods was conducted using the data collected from the sampled media. Biological resources were generally characterized to conduct a screening level ecological risk assessment and to identify potential ecological hazards.

4 GENERAL

4.1 LOCATION

Jefferson Proving Ground is located in southeast Indiana (See Figure 4-1). The installation consists of 55,265 acres and is located in portions of Ripley, Jennings, and Jefferson Counties. The installation is 18 miles long (north – south) and varies from 3-6 miles wide (east – west). The area north of the firing line is considered the range, and comprises the majority of the installation. This area is characterized by forests and grasslands and is predominantly devoid of any structures.

FIGURE 4-1. LOCATION MAP



UNITED STATES ARMY
CENTER FOR HEALTH PROMOTION
AND PREVENTIVE MEDICINE
ABERDEEN PROVING GROUND, MARYLAND

FIGURE 4-1
JEFFERSON PROVING GROUND
MADISON, INDIANA

DRAWN BY:	PROJECT #:	FILE NAME:
GCL	38-EH-8220-02	IN/JPG/8220LOCA

4.2 HISTORY

Jefferson Proving Ground, in operation from 1941 to 1995, was established to meet the need for conducting research and development tests and production acceptance tests during World War II. Prior to being established as a munitions and ordnance testing facility, JPG land use consisted of farmland and woodland. Past activities have included detonation, burning, and disposal of many types of waste propellants, explosives and pyrotechnic substances. The types of munitions and ordnance tested at JPG include: propellants, mines, ammunition, cartridge cases, artillery projectiles, mortar rounds, grenades, tank ammunition, bombs, boosters, and rockets.

JPG became a subcommand of the U.S. Army Test and Evaluation Command (TECOM) in 1962. Identified for Base Realignment and Closure (BRAC) in 1989, JPG ceased operation in 1995. In 1997, TECOM and the U.S. Fish and Wildlife Service (USFWS) signed a Memorandum of Understanding granting the USFWS a 25-year real estate permit. This has enabled the USFWS to establish the Big Oaks National Wildlife Refuge, encompassing approximately 51,000 acres north of the firing line. The USFWS allows limited public access for hunting, fishing, and tours.

The impact area, encompassing 51,000 acres north of the firing line, consists mostly of wooded land and some areas that were chemically (i.e., pesticide application) and physically maintained for certain munitions testing. The firing line, located north of the cantonment area, consisted of 268 gun positions. According to archive reports, there were 50 impact fields with associated safety fans. It is important to note that most of the unexploded ordnance (UXO) contamination is not limited to the impact areas. This is due to the fact that the actual target areas were used only when the detonation and/or impact of the projectile was important to the test. Therefore, many of the munitions tests used for velocity measurements, gun tube proofing, or propellant were not fired into specific impact areas and may be found anywhere north of the firing line. A small portion of the range is still used by the Air National Guard for training missions.

Installation personnel voiced their concern for the possible presence of submunitions. The potential for contamination from submunitions fired into the northern portion of the impact area is largely due to the irregular manner in which this type of weapon discharges. For safety purposes, areas into which submunitions were fired were not considered as potential sample areas.

The USFWS began to manage the natural resources of the installation on October 1, 1996 under a 3-year Memorandum of Agreement (MOA) with the Army. The service expanded its role to make the area a national wildlife refuge through a new MOA in May 2000. The natural resources north of the firing line are managed by the USFWS as the Big Oaks National Wildlife Refuge (USFWS, 2000). While the entire area north of the firing line is considered to be UXO contaminated, there are specifically designated impact areas that received the most use.

5 ENVIRONMENTAL SETTING

The following is a brief, general discussion of the environmental setting. More detailed discussions can be found in the specific media sections.

5.1 CLIMATE

The area has a typical mid-western continental climate, and the weather is quite variable because of the influx of high and low pressure systems and warm moist air from the Gulf of Mexico. Summers are generally quite warm, while the winters are moderately cold. Precipitation is fairly uniform throughout the year, averaging 3 - 4 inches per month. Spring and summer thunderstorms push the monthly average over 4 inches for the March-June period, while the fall of the year sees monthly rainfalls close to 3 inches. Measurable snowfall can be experienced throughout the November-March period, and averages about 16 inches annually. Approximately 39 days per year see temperatures exceeding 90° F, with occasional occurrences in excess of 100 ° F. The record high of 105° F occurred in July 1954. Winter temperatures are mild, with occasional periods of very cold temperatures. Although temperatures less than zero are uncommon, the record low temperature in the area is -25° F occurring in January 1994. Winds vary from about 6 - 10 miles per hour from the south throughout the year, except for the months of February, March, and August when the direction is from the north-northwest. Wind gusts up to 78 miles per hour have been recorded at the Louisville Station, the nearest source of long-term climatological data. The strongest gusts are normally associated with thunderstorms. The area can experience occasional severe weather, including tornadoes.

5.2 TOPOGRAPHY, SOILS, HYDROLOGY, AND GEOLOGY

Ground elevations at the refuge are generally between 850 - 900 feet Net Geodetic Vertical Datum (NGVD), with elevations along the numerous streams flowing through the area being about 30 - 50 feet lower. Site drainage is generally to the west and southwest. The area is in the headwaters of the White River Basin (which includes the Muscatatuck River area), a major tributary of the Wabash River, which in turn is a major tributary of the Ohio River. Small to moderate size streams flowing through JPG include: Otter, Graham, Little Graham, Big and Middle Fork Creeks. The refuge would be located in the Till Plains section of the Central Lowlands physiographic province. The topography is dominated by gently rolling hills as a result of glacial processes. The bedrock exposed in Jefferson and Ripley Counties belongs to the Ordovician, Silurian, and Devonian Systems of the Paleozoic era. These rocks were deposited about 350 to 450 million years ago as fine-grained sediments in shallow marine waters. The strata dip 20 to 25 feet per mile to the west. In the site area the rocks at the surface are the Silurian rocks. The Devonian bedrock is composed predominantly of limestones that exhibit karst features in some areas. The site is underlain by deep, nearly level and gently sloping, poorly drained and somewhat poorly drained soils formed in a thin mantle of loess and in the underlying glacial drift. The surface layer of the soil is generally dark grayish brown or grayish brown, mottled, silty sandy clay, to a depth of 12 inches. The subsoil layer is composed of silty sandy clay that is light gray, yellowish brown, mottled, and friable. The subsoil layer extends below a depth of 6 feet. The available water capacity of the soil is very high and the permeability is slow. There is a perched, seasonal high water table at or near the surface during the winter and spring months.

5.3 VEGETATION AND WILDLIFE

Upland forests comprise 54% of the 50,000-acre refuge. The second most abundant habitat at JPG is grasslands. This habitat type makes up 17% of the area. Other habitat types at JPG include palustrian wetland (10%), woodland (6%), early successional shrubland (12%), open water (0.5%), and bare soil and paved areas (0.5%). A total of 46 state-listed plant species are found on the proposed refuge.

The JPG provides habitats for, and subsequently attracts, an abundance of wildlife species, including freshwater mussels, fish, amphibians, reptiles, mammals, and birds. The state-endangered river otter was reestablished on JPG in 1996.

The wide array of both resident and migratory species found at JPG is due to the grassland/forest/wetland complex found within the landscape of the installation. These large habitat blocks of forests, shrublands, grasslands, forested wetlands, and occasional emergent marsh contribute to the increased biodiversity of the natural communities found at the refuge.

The Big Oaks National Wildlife Refuge was named a Globally Important Bird Area by the American Bird Conservancy due to large Henslow's sparrow populations within the grassland areas. The Indiana Department of Natural Resources states that, "JPG is indeed a natural treasure that contains a full array of the region's natural communities and species assemblages."

5.4 SURFACE WATER

JPG has an extensive system of surface water resources, including ponds, lakes, streams and wetland areas, along with numerous ephemeral streams, ponding sites, and wet areas. These drainages appear to have developed along major fracture lineaments. Surface water at JPG generally flows along northeast to southwest trending stream drainages that eventually join the Muscatatuck River to the west. Four major watersheds traverse JPG from east to west. Starting in the south and heading north; Middle Creek, Big Creek, Little Graham Creek, and Otter Creek. Two important watersheds originate on JPG in the heart of the more significant impact areas. They are Marble Creek and Middle Fork Creek. Middle Fork Creek has an approximate average flow of 50 cubic feet per second.

There are at least 10 ponds or lakes on the installation, varying in size from less than 1 acre to 165 acres. Most are stocked with various kinds of game fish by the Indiana Department of Natural Resources. The largest is Old Timbers Lake in the northeastern corner of JPG at the headwaters of Little Otter Creek, which drains into Otter Creek. This lake covers approximately 165 acres. The second largest lake is Krueger Lake which covers some 8 acres. This lake is also stocked with fish and used for recreation.

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6 GROUND WATER

6.1 PURPOSE AND PROBLEM DEFINITION

6.1.1 Purpose

The purpose of the ground-water sampling was to conduct a limited focus investigation of the potential chemical impact of former normal, live-fire range training operations on ground water. This investigation consisted of installing eight monitoring wells and sampling the ground water near and/or within four impact areas, Impact Field 3W, Impact Field 5.3E, the Delta Impact Area, and Impact Field 7.5CF. A screening level human health risk assessment based on USEPA methods was conducted using the data collected from the ground-water samples. The data from this assessment and from assessments of other select ranges will be compiled to represent the condition of similarly situated ranges throughout the Army.

6.1.2 Problem Statement

Principal study questions were developed for ground water as part of the data quality objective (DQO) development. The questions are as follows:

- Are explosive compounds present in the ground water?
- Are metals present in the ground water at levels that substantially exceed the upgradient or background concentrations?
- Do detected concentrations exceed maximum contaminant levels (MCLs) or Health Advisories (HA)?
- Do detected concentrations pose an unacceptable health risk to future receptors?

6.2 REGIONAL SETTING

6.2.1 Physiography

JPG is located within rural areas of Jefferson, Jennings, and Ripley Counties, Indiana, which are located in the Muscatatuck Regional Slope of the Till Plain Section of the Interior Lowlands Physiographic Province. The Muscatatuck Regional Slope is characterized by till deposits capping a rolling limestone plateau and crossed by deep rocky valleys (USACE, 1991). The region has a westerly slope of approximately 400 feet over 25 miles or 0.17°. The slope is controlled by the regional dip of underlying bedrock. Generally, river valleys in the Muscatatuck Regional Slope are deeply entrenched along joints and fractures zones in the bedrock, and commonly make near-right angle turns (Fenelon & Greeman, 1994).

The southern two-thirds of JPG is relatively flat; the northern third is more rolling, with relatively steep bluffs along many of the major streams. Generally, the land surface at JPG slopes from east to west. Along the eastern boundary of JPG, elevations range from about 925–940 feet above mean sea level (msl). Elevations along the western boundary vary from about 835–850 feet above msl. Relief is greatest along stream channels, where it may exceed 100 feet (TetraTech NUS, 2000). Six almost parallel stream corridors flow across JPG in a generally west-southwesterly direction. Each stream has well-developed drainage and consists of numerous tributaries. With the exception of the two most southern streams, drainages have cut into underlying limestone and formed steep banks (USACE, 1991).

6.2.2 Regional Geology

Located on the western flank of the Cincinnati Arch, a broad structural feature that separates the Illinois and Appalachian Basins, JPG lies within an area characterized by young glacial till plains of the Illinoisan glacial period. The till deposits are composed predominantly of silts and clays with minor amounts of gravel and rock fragments. These deposits have an average thickness of 25 feet but in some areas thicknesses of 50 feet is common. At JPG the till deposits are generally not present in the incised stream valleys where bedrock has been breached (Earth Technology, 1994). Till deposits are underlain by carbonate units from the Ordovician, Silurian, and Devonian Periods. The carbonate units dip west-southwest at about 20 feet per mile (Earth Technology, 1994).

In the northern portion of JPG, Ordovician-aged limestones are exposed in the incised valleys formed by Otter Creek and Graham Creek. The oldest exposed unit is the Black River, Middle Ordovician Limestone. The Black River Limestone is fine grained and thickens to the south. The Black River Limestone underlies the Trenton Limestone. The Trenton Limestone is fine to medium-grained, includes extensive dolomite, and thins toward the south. Overlying the Trenton Limestone are interbedded shales and limestones of the Middle to Late Ordovician Maquoketa Group (USACE, 1991).

In Jennings County, Silurian-aged limestones and dolomites can be grouped into an upper and lower sequence. Shale, that can be as much as 12 feet thick, separates the two sequences. The upper limestone sequence has been eroded along the extreme eastern boundary of Jennings County and from all of JPG. A fine-grained, thick-bedded dolomite unit, containing numerous chert nodules, forms a resistant protective cover for the lower sequence. The lower limestone sequence ranges in thickness from 60-120 feet (Earth Technology, 1994) and jointing is prominent (Greeman, 1981).

At JPG, the oldest of the Silurian carbonates is the Brassfield Limestone. The Brassfield is a compact crystalline limestone, which unconformably overlies Ordovician Units, and underlies the Salamonie Dolomite. The Salamonie Dolomite is a fine-grained, light gray, porous dolomite and dolomitic limestone. The Laurel Member of the Salamonie Dolomite is a hard, light-dark gray limestone with zones of porous brown limestone. The Laurel Member of the Salamonie Dolomite is the most widespread unit at JPG. The Salamonie Dolomite underlies the Louisville Limestone. The Louisville Limestone is described as a light gray to brown, fine-grained dolomite or dolomitic limestone (USACE, 1991).

The Devonian Shaly dolomite of the Muscatatuck Group underlies glacial till in a small area near JPG's southwestern boundary. Mineralization in the bedrock at JPG includes pyrite and galena in the Trenton Limestone and fluorite and galena in the Muscatatuck Group. Sphalerite is also found in most Ordovician, Silurian, and Devonian units underlying JPG (USACE, 1991).

6.2.3 Regional Hydrogeology

6.2.3.1 Glacial Deposits

The direction of ground-water flow in the glacial till is roughly the same as the surface water drainage, which is to the west-southwest over most of JPG. The matrix hydraulic conductivity of the tills at JPG range from 1.1 x 10^{-5} to 8.4 x 10^{-5} inches/second. Small-scale fractures and sand lenses within the till contribute to the higher hydraulic conductivity (SBCCOM, 2002). Much of the hydrogeological and geological information pertaining to JPG was collected from studies performed at sites located south of the firing line at JPG.

6.2.3.2 Bedrock

In the JPG vicinity, the Silurian and Devonian-aged bedrock units are aquifers. These aquifers are poor sources of ground water, with well yields of less than 25 to 50 gallons per minute (gpm) (Rust, 1994b). Most inadequate bedrock well yields were reported in areas where the upper limestone-dolomite sequence has been removed; leaving the dense, thick-bedded, lower limestone sequence. The permeability of the lower limestone sequence is low because the siliceous dolomite capping the lower sequence is resistant to dissolution along vertical fractures and horizontal bedding planes. The higher well yields of 50 gpm may be obtained from the lower sequence along lineaments and fracture traces in the zone of high permeability associated with most perennial streams in the area (Greeman, 1981).

The shallow bedrock aquifer is confined to semiconfined. In areas where the overlying till is not fractured, the bedrock aquifer appears to be confined. The bedrock aquifer is recharged by infiltration and precipitation concentrated along fractures within the glacial till and in areas where the creek channels lose water to the ground-water system (SBCCOM, 2002). Generally, ground-water flow in the shallow bedrock aquifer is to the west-southwest. Many bedrock features such as interconnecting joints, fractures, solution channels, and other influences could alter flow directions (Ebasco, 1990). Water-level elevation data from wells screened in bedrock at JPG, loosely mimic surface topography. In the vicinity of incised surface drainages, the potentiometric surface slopes toward streams at roughly the same gradient as the surface topography. Therefore, on a local scale, ground water in shallow bedrock tends to discharge to surface streams (SBCCOM, 2002).

6.2.4 Ground Water Use

There are no sole source aquifers on or in the vicinity of JPG (SBCCOM, 2002). Public and private utilities provide water services to practically all households in the rural area surrounding JPG. Most of the utilities' water supply is pumped from the city of Madison well field, which yields approximately 8.3 million gallons per day from the sand and gravel alluvial aquifer of the Ohio River Valleys. There are limited numbers of private wells in the area surrounding JPG (Ebasco, 1990).

6.3 RATIONALE OF SELECTED SAMPLING LOCATIONS AND SAMPLE ANALYSES

6.3.1 Sampling Design Rationale

As stated in section 6.2.3.1, the direction of ground-water flow in glacial till is roughly the same as the surface drainage. In the vicinity of incised surface drainages, the potentiometric surface in shallow bedrock tends to slope toward streams at roughly the same gradient as the surface topography (SBCCOM, 2002). Seven streams and their tributaries drain JPG, and bedrock exposures are present along many of the stream channels. Due to the size of JPG, the number of streams, the fact that some streams are incised, and because ground water in glacial till and shallow bedrock tend to discharge to surface drainages, there are probably multiple ground-water basins.

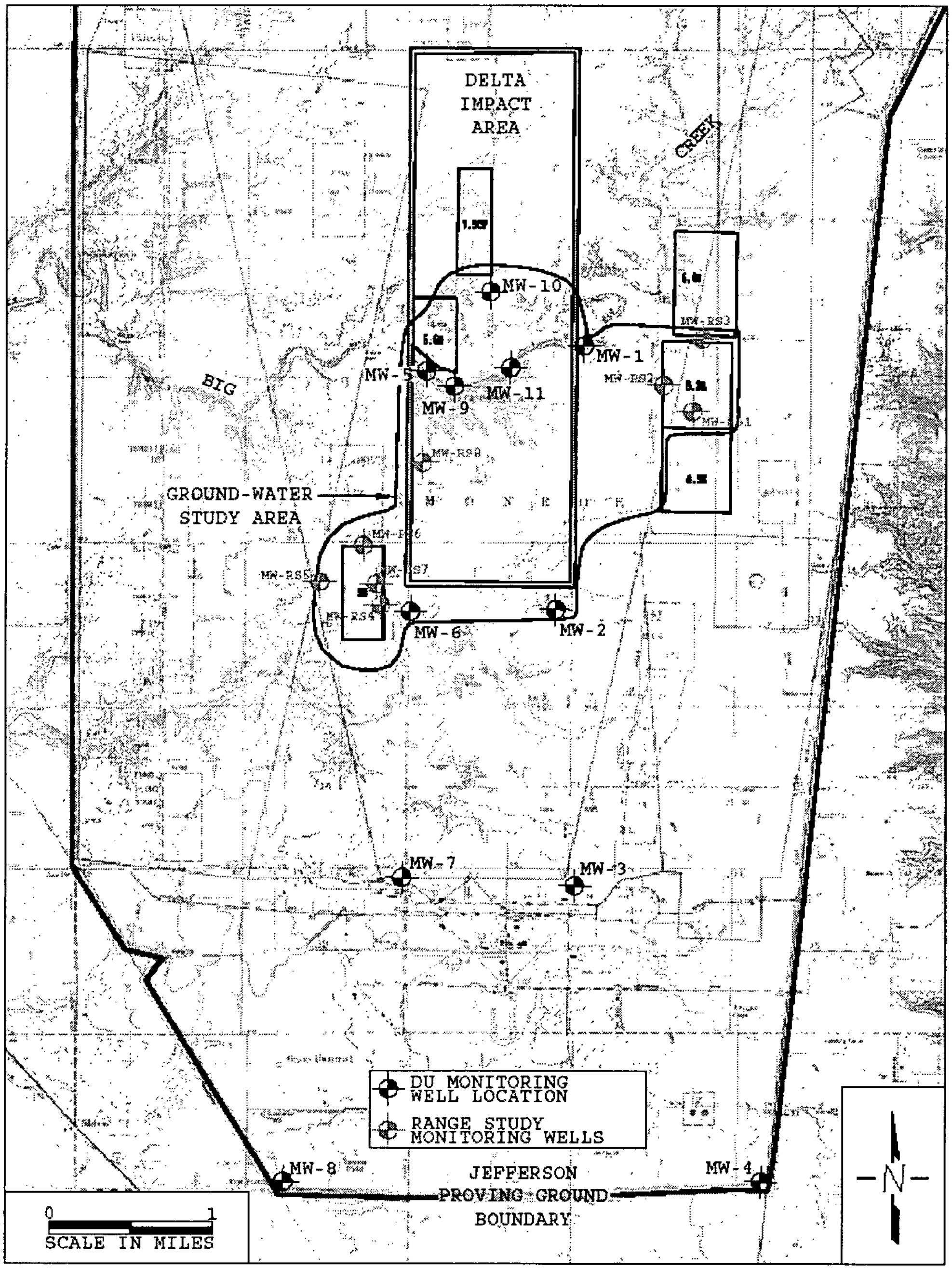
Due to the size of JPG, the presence of multiple ground-water basins, and budgetary constraints, one general area was examined to evaluate the potential impact of live-fire training operations on ground-water quality. The selected study area (Figure 6-1) is within or in close proximity to the Delta Impact Area. The selected area contains four discreet units; Impact Field 3W, Impact Field 5.3E, Impact Fields 5.6W and 7.5CF (both are within the Delta Impact Area north of Big Creek and are considered one unit), and the Delta Impact Area south of Big Creek. All units selected for ground-water evaluation lie within an area that was delineated as contaminated with high explosives in the *Archives Search Report* (ASR) *for Ordnance and Explosive Waste, Chemical Warfare Materials* (USACE, 1995).

Impact Field 3W was selected for ground-water evaluation based on its location southwest of the Delta Impact Area. Impact Field 5.3E was selected for evaluation because of its location east of the Delta Impact Area and between two other impact fields (6.4E and 4.5E), and its probable upgradient or sidegradient location relative to the Delta Impact Area.

Impact Fields 5.6W and 7.5CF were selected based on their probable location within a different ground-water basin, and because three monitoring wells [MW-9, MW-10, and MW-11 (Figure 6-2)] were located hydraulically downgradient and/or sidegradient from the impact fields. The monitoring wells were installed during previous characterization surveys and Environmental Radiation Monitoring (ERM) for depleted uranium (DU) in and near the Delta Impact Area.

The unit within the Delta Impact Area south of Big Creek was selected to help further define ground-water quality and ground-water conditions south of Big Creek. Four ERM wells located near the perimeters of the Delta Impact Area south of Big Creek were incorporated into this study. The ERM wells are MW-1, MW-2, MW-5, and MW-6 (Figure 6-2).

FIGURE 6-1 GROUND-WATER STUDY AREA

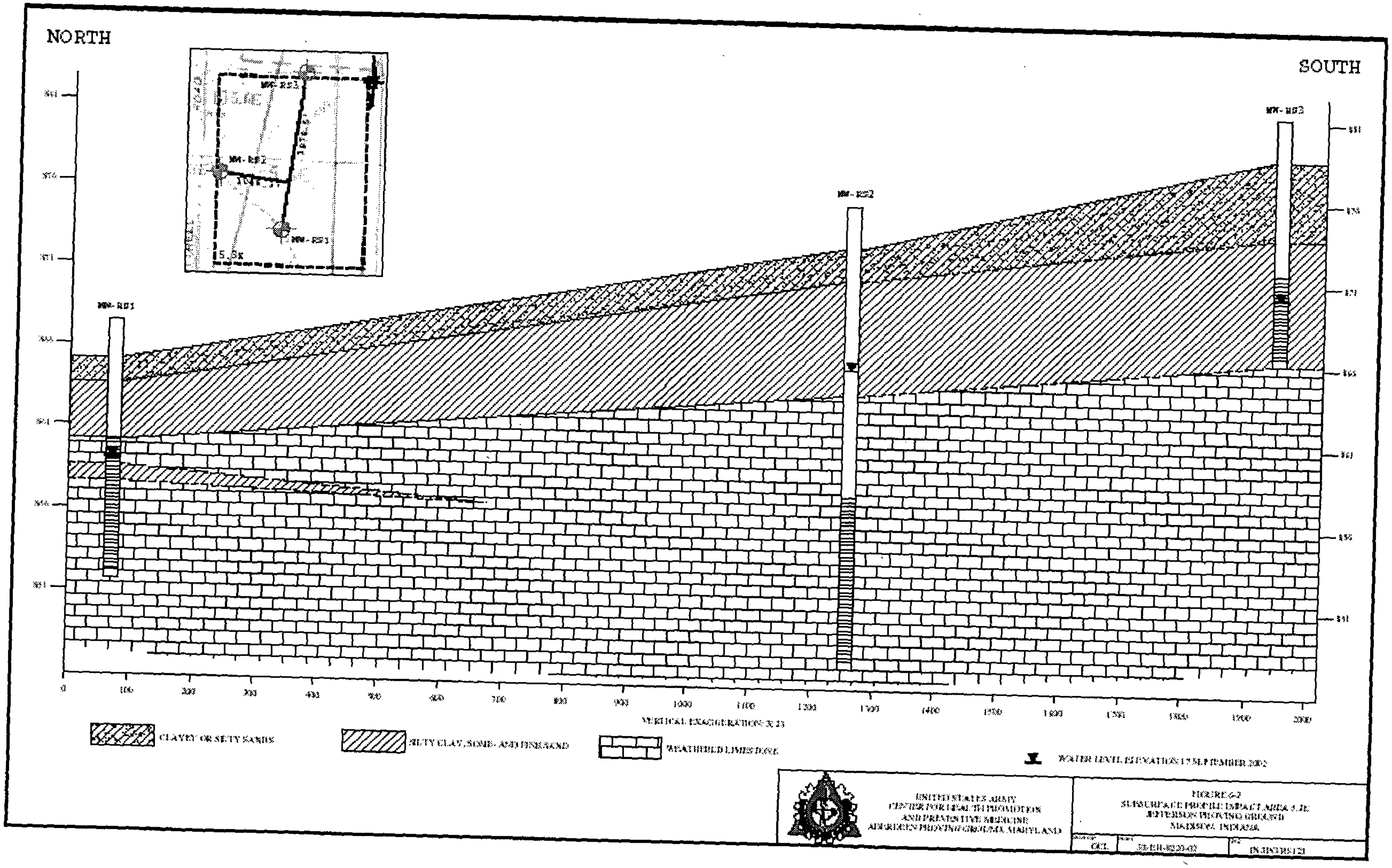


UNITED STATES ARMY
CENTER FOR HEALTH PROMOTION
AND PREVENTIVE MEDICINE
ABERDEEN PROVING GROUND, MARYLAND

FIGURE 6-1
RANGE STUDY MONITORING WELL LOCATIONS
JEFFERSON PROVING GROUND
MADISON, INDIANA.

GCL | 38-EH-8220-02 | IN/JPG/8220PROP

FIGURE 6-2 SUBSURFACE PROFILE IMPACT AREA 5.3E



6.3.2 Sampling Network

6.3.2.1 Monitoring Wells

Seven wells used in the DU monitoring program at JPG were incorporated into this range study. The wells are: MW-1, MW-2, MW-5, MW-6, MW-9, MW-10 and MW-11. Monitoring well MW-1 has two screened intervals; each screened interval is located in limestone. Monitoring wells MW-2, MW-5, and MW-9 are also screened in limestone. MW-6 is screened in a silty clay, and MW-10 and MW-11 are screened in glacial till.

Eight wells were installed by USACHPPM. Four wells were installed within or near the perimeter of Impact Field 3W. Three wells were installed near the perimeter or within Impact Field 5.3E. One well was installed inside the Delta Impact Area. Access to planned drilling locations shown in the QAPP was not feasible at some locations due to the presence of extensive UXO and topographical features, which precluded vehicle access to locations.

6.3.2.2 Springs

Three springs, each located near stream channels, were identified at JPG. Springs were sampled in conjunction with surface water sample collection. The spring sampling results are summarized in Section 8.4.8.

6.3.3 Analyses

Ground-water samples were collected from 15 wells (7 existing wells within and near the Delta Impact Area, and 8 monitoring wells installed by USACHPPM). The QAPP required that samples be analyzed for 15 explosive compounds (explosives and their degradation products), 14 metals (filtered and unfiltered), DU, perchlorate, hardness, and total dissolved solids. Analytes, analyses methods, reporting limits, and the significant contamination levels are listed in Tables 6-1, 6-2, and 6-3. The significant levels for the explosive compounds are indicated by the USEPA HA, and for the metals by the USEPA drinking water standards.

TABLE 6-1 CONTAMINANTS OF CONCERN IN GROUND WATER

Explosives	**Acronym**	**CAS Number**
Nitrobenzene	NB	98-95-3
2-Nitrotoluene	2-NT	88-72-2
3-Nitrotoluene	3-NT	99-08-1
4-Nitrotoluene	4-NT	99-99-0
Nitroglycerin (e)	NG	55-63-0
4-Amino-2,6-dinitrotoluene	4-A-2, 6-DNT	1946-51-0
1,3-Dinitrobenzene	1,3-DNB	99-65-0
2,4-Dinitrotoluene	2,4-DNT	121-14-2
2,6-Dinitrotoluene	2,6-DNT	606-20-2
2-Amino-4,6-dinitrotoluene	2-A-4, 6-DNT	355-72-78-2
Hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-Trinitrobenzene	1,3,5-TNB	99-35-4
Methyl-2,4,6-trinitrophenyinitramine	Tetryl	479-45-8
2,4,6-Trinitrotoluene	2,4,6-TNT	118-96-7
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	HMX	26-41-0
Metals	**Acronym**	**CAS Number**
Antimony	Sb	7440-36-0
Arsenic	As	7440-38-2
Barium	Ba	7440-39-3
Cadmium	Cd	7440-43-9
Calcium	Ca	7440-70-2
Chromium	Cr	7440-47-3
Copper	Cu	7440-50-8
Lead	Pb	7439-92-1
Manganese	Mn	7439-96-5
Magnesium	Mg	7439-95-4
Mercury	Hg	7439-97-6
Molybdenum	Mo	7439-98-7
Nickel	Ni	7440-02-0
Silver	Ag	7440-22-4
Uranium	U	7440-61-1
Vanadium	V	7440-62-2
Other Inorganics	**Acronym**	**CAS Number**
Perchlorate	ClO_4	14797-73-0
Hardness	N/A	N/A
Total Dissolved Solids	TDS	N/A

N/A –Not Available

TABLE 6-2 EXPLOSIVES ANALYTE LIST, ANALYTICAL METHOD, REPORTING LIMITS, AND USEPA HEALTH ADVISORIES FOR GROUND WATER

ANALYTE	ANALYTICAL METHOD	LABORATORY SOP	PERFORMING LABORATORY	MRL (ug/L)	USEPA HEALTH ADVISORY
1,3,5-TNB	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.03	N/A
1,3-DNB	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.09	1.0 [2]
2,4,6-TNT	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.03	2.0[2]
2,4-DNT	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.02	5.0 [1,3]
2,6-DNT	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.01	5.0 [1,3]
2-A-4,6-DNT	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.1	N/A
2-NT	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.09	N/A
3-NT	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.09	N/A
4-A-2,6-DNT	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.1	N/A
4-NT	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.09	N/A
HMX	USEPA 8095M	CAD 13.2	USACHPPM-CAD	3.0	400.0 [1]
NB	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.03	N/A
Nitroglycerin	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.09	N/A
RDX	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.1	2.0 [1]
TETRYL	USEPA 8095M	CAD 13.2	USACHPPM-CAD	0.5	N/A

NOTES:

MRL – Method Reporting Limit

N/A – Not Available

A health advisory is an estimate of acceptable drinking water levels for a chemical substance based on health effects information. It is not a legally enforceable Federal standard, but serves as technical guidance to assist Federal, State, and local officials. Unless otherwise noted, health advisories are for chronic lifetime exposures to a 70 kilogram adult that drinks about 2 liters of water per day. Health advisories will be used in this study for comparison purposes only.

1 – Source: U.S. Environmental Protection Agency, Summer 2000, Drinking Water Standards and Health Advisories, USEPA 822-B-00-001, Office of Water, Washington, D.C.

2 – Source: Roberts, Welford C., and William R. Hartley, editors, 1992, Drinking Water Health Advisories: Munitions, U.S. Environmental Protection Agency Drinking Water Health Advisories, Lewis Publishers, Boca Raton, Ann Arbor, London, Tokyo, 535 pp.

3 – This chemical is classified in USEPA cancer group B2. This means that there is sufficient evidence of carcinogenicity in animals and inadequate or no evidence in humans.

TABLE 6-3 METALS AND INORGANICS ANALYTE LIST, ANALYTICAL METHOD, REPORTING LIMITS, AND USEPA HEALTH ADVISORIES FOR GROUND WATER

ANALTYE	ANALYTICAL METHOD	LABORATORY SOP	PERFORMING LABORATORY	MRL (ug/L)	CURRENT DRINKING WATER STANDARDS[1]	
					MCL (ug/L)	SECONDARY STANDARDS
Antimony	USEPA 200.8	MET 21.4	USACHPPM-ASD	5	6	N/A
Arsenic	USEPA 200.8	MET 21.4	USACHPPM-ASD	4	10	N/A
Barium	USEPA 200.8	MET 21.4	USACHPPM-ASD	5	2000	N/A
Cadmium	USEPA 200.8	MET 21.4	USACHPPM-ASD	2	5	N/A
Calcium	USEPA 200.7	MET 41.5	USACHPPM-ASD	100	N/A	N/A
Chromium	USEPA 200.8	MET 21.4	USACHPPM-ASD	4	100	N/A
Copper	USEPA 200.8	MET 21.4	USACHPPM-ASD	5	N/A	1000
Lead	USEPA 200.8	MET 21.4	USACHPPM-ASD	4	15	N/A
Manganese	USEPA 200.8	MET 21.4	USACHPPM-ASD	4	N/A	50
Magnesium	USEPA 200.7	MET 41.5	USACHPPM-ASD	N/A	N/A	N/A
Mercury	USEPA 245.1	MET 17.4	USACHPPM-ASD	0.2	2	N/A
Molybdenum	USEPA 200.8	MET 21.4	USACHPPM-ASD	4	N/A	N/A
Nickel	USEPA 200.8	MET 21.4	USACHPPM-ASD	10	N/A	N/A
Silver	USEPA 200.8	MET 21.4	USACHPPM-ASD	2	N/A	100
Vanadium	USEPA 200.8	MET 21.4	USACHPPM-ASD	5	N/A	N/A
Uranium	USEPA 6020	RAD U_006.0	USACHPPM-RCCCD	20*	N/A	N/A
OTHER INORGANICS						
Perchlorate	USEPA 314.0	IC-EP314.0	DATACHEM	2	N/A	N/A
Hardness	SM2340B	656	USACHPPM ASD	N/A	N/A	N/A
TDS.	USEPA 160.1	GR-07-101	TriMatrix	25,000	N/A	N/A
Conductivity	Field	N/A	USACHPPM DEHE	None	N/A	N/A
DO	Field	N/A	USACHPPM DEHE	None	N/A	N/A
PH	Field	N/A	USACHPPM DEHE	None	N/A	N/A
Temperature	Field	N/A	USACHPPM DEHE	None	N/A	N/A
Turbidity	Field	N/A	USACHPPM DEHE	None	N/A	N/A

DO – Dissolved oxygen
MRL - Method Reporting Limit
N/A – Not Available
TDS – Total Dissolved Solids
*MCL is for uranium and will be changed to 30 µg/L effective 8 December 2003.

Metals samples preparation - USEPA 200.2

[1] Internet Web Page http://www.epa/safewater/mcl.html

6.4 FIELD ACTIVITIES AND SAMPLING PROCEDURES

6.4.1 Drilling and Monitoring Well Installation

USACHPPM mobilized personnel, a direct push probing machine, and a drill rig to JPG to conduct drilling operations and monitoring well installations. The direct push soil probing machine, mounted on the bed of a 1-ton truck, was used to complete downhole surveys and to advance direct push soil core samplers. The drill rig, a truck-mounted Mobile B-80, was used for hollow stem augering and air rotary drilling for the installation of monitoring wells. Drilling and well installation activities began on 13 August 2002 and were completed on 23 August 2002.

Explosive Ordnance Technologies, Inc. (EOTI) was contracted by USACHPPM to provided onsite UXO support. Personnel from EOTI were onsite with USACHHPM personnel during drilling, well installation and sampling, and surveying activities.

A geologist from USACHPPM monitored drilling operations, and collected borehole lithologic data and well construction information. Soil was logged in accordance with the Unified Soil Classification System. Water level data and any other pertinent remarks concerning drilling and well installation activities were also noted on boring logs and in the field notebook in accordance with Section 5.3.1 of the QAPP (USACHPPM, 2002). Boring and well constructions logs are included in this report as Appendix E. Soil and rock cuttings generated during drilling were left at the drill site from which they were generated.

Eight borings (labeled MW-RS1 through MW-RS8, inclusive) were advanced for the installation of temporary monitoring wells (Figure 6-2). Several boring locations shown on Figure 5-3 and discussed in Section 5.2.11 of the QAPP were changed in the field because planned drilling locations were not accessible. Three borings, instead of the four specified in the QAPP, were installed along the perimeter of or within Impact Field 5.3E. The planned boring on the east side of Impact Field 5.3E was deleted because extensive UXO on the ground surface precluded vehicular access. Due to topographical features (steep slopes, ruts, and gullies) and the presence of UXO, the planned western and southern boring locations at Impact Field 3W were adjusted. Boring MW-RS5 was located as close to the western perimeter of Impact Field 3W as site conditions allowed. The southern section of Impact Field 3W was inaccessible to vehicles; so a boring location (MW-RS4) was selected at the southern most point of a former vehicle trail that crosses into Impact Field 3W. Because only three of the four borings planned for advancement in Impact Field 5.3E were completed, a boring (MW-RS8) was advanced inside the Delta Impact Area to aid in evaluating ground-water quality conditions in the area.

USACHPPM personnel purged and sampled 15 monitoring wells 17 –23 September 2002. Purge and sample data were recorded on field forms (Appendix E). Water purged from monitoring wells was not containerized.

6.4.1.1 Surface and Downhole UXO Surveys

EOTI conducted a UXO surface sweep at each drilling location and the vehicular ingress/egress to each drill location. The UXO sweep was necessary to identify potential UXO on or near the surface, which might present a hazard to onsite workers. Magnetometers were used to locate metallic objects on the surface and in the shallow subsurface (within 4 feet of ground surface). UXO located on the surface was identified and marked for avoidance. Following surface UXO avoidance sweeps, the upper 2 – 3 feet of each boring was hand augered by EOTI personnel and a gradiometer was lowered into the hole to scan for metallic objects. Following hand augering, borings were advanced with a direct-push soil probing machine. Direct-push borings were advanced in 4-foot increments so a gradiometer could be lowered down the borehole to survey for metallic objects in the subsurface. UXO personnel requirements, procedures, and descriptions are provided in Section 5.2.2 and Annex A of Appendix K of the QAPP (USACHPPM, 2002). Although not required by the QAPP, soil core samples were collected from borings MW-RS2 – MW-RS8 to aid in describing the subsurface material.

6.4.1.2 Drilling Procedures

After direct-push soil borings were deemed clear of metallic objects, the drill rig was used to ream borings for the installation of monitoring wells. Borings were reamed/overdrilled with 7.25-inch outside diameter (OD) by 4.25-inch inside diameter (ID) hollow-stem augers (HSAs). Borehole depths were dependent on several factors including, downhole clearance depths for UXO avoidance, depth to auger refusal, or the presence of dry zones underlying saturated zones.

Auger refusal was encountered at 9 feet below ground surface (bgs) in boring MW-RS2. Due to auger refusal, air rotary drilling techniques were required to advance the boring to its total depth. A 5.6-inch diameter air hammer, attached to 4.5-inch air rods, was lowered through 10 feet of HSAs to advance the boring to its terminal depth.

Downhole equipment and the back of the drill rig were cleaned prior to use at each boring location. Cleaning consisted of the physical removal of soil, and rinsing with potable water and a power washer. Equipment was cleaned at select locations near, but outside, each impact area where borings were installed. Water used to rinse equipment was obtained from a fire hydrant on the south side of the firing line, and was transported to each impact field in a water tank mounted on a trailer.

6.4.1.3 Monitoring Well Construction Procedures

USACHPPM attempted to screen the uppermost ground water at each impact field. With the exception of MW-RS1 and MW-RS2, monitoring wells installed by USACHPPM were screened in the overburden. Although the screen of MW-RS1 was placed in limestone, the sand pack does extend into the overburden. Because the overburden at MW-RS2 ranged from moist-to damp-to dry, with moisture content decreasing with depth, the well was screened in weathered limestone. When the HSAs were at a depth of 8 feet in boring MW-RS2, the HSAs were pulled from the boring to check for the presence of ground water. After remaining open for approximately 1-1/2 hours no ground water was detected in boring MW-RS2 and drilling was resumed.

Monitoring wells were constructed through HSAs. This method was used to reduce sloughing in the borehole, and to ensure that all screens were properly centered for sand pack placement. At boring MW-RS2, the HSAs extended from above ground surface to approximately 9.5 feet bgs.

All wells were constructed of 2-inch ID, Schedule 40, flush-threaded, factory-wrapped, polyvinyl chloride (PVC) riser pipe and screen. Screens consist of 0.010-inch factory slotted pipe and range in length from 5 – 10 feet. Due to relatively shallow ground water and shallow boring depths at some locations, 10 feet of screen could not be set in each well and allow for an effective surface seal. Screen lengths were selected to screen across the greatest saturated interval while maintaining enough vertical space above the well screen so the sand pack could extend at least 1 foot above the screen, and a minimum 1.5-foot bentonite seal could be placed on the sand pack, with enough space remaining to set the protective casing without breaching the seal. Some 10-foot well screen sections were cut to shorter lengths in the field before well construction depending on subsurface conditions at a site. The screened interval in MW-RS2 was selected so there would be enough vertical space above the well screen and sand pack to seal the annular space below the contact of the overburden and limestone.

A well point, typically 0.5 feet in length, or a slip cap were placed at the bottom of each well screen. Slip caps were placed on the bottom of screens that were cut in the field. The PVC riser pipe extends from the top of the screen to approximately 2.5 – 3 feet above ground surface. Each well was fitted with a vented PVC cap. Well construction logs are contained in Appendix E and well construction details are summarized on Table 6-4.

An artificial sand pack was placed in the annular space around the well from the base of the borehole to at least 1 foot above the well screen. The sand pack in each well consists of commercially purchased silica sand. The sand pack was placed by pouring sand through the augers, and gradually withdrawing the augers in stages. The annular space above the sand pack was sealed with bentonite pellets. Bentonite pellets were poured from ground surface, through the augers and formed at least a 1.5-foot seal. Bentonite pellets were hydrated with distilled water.

The remaining annular space was grouted. An upright steel protective casing with a hinged, locking cap was installed over each PVC riser pipe and grouted into place. The protective casings extend to a depth of approximately 2 feet bgs. A drain hole was drilled into the protective casing near the ground surface.

TABLE 6-4 MONITORING WELLS CONSTRUCTION DETAILS

Well No.	Northing	Easting	Date Installed	Ground Surface Elevation (Ft msl)	TOC Elevation (Ft msl)	Total Depth (Ft bgs)	Screen Length (Ft)	Slot Size (in.)	Screen Interval (Ft msl)	Sand Pack Interval (Ft msl)	Seal Interval (Ft msl)	Open Interval Formational Material (Ft msl)
MW-RS1	503005.2707	577855.4394	20/Aug/02	865.1	867.43	13.5	8	0.010	851.6 - 859.6	851.6 - 860.8	860.8 - 862.2	limestone & clayey silt
MW-RS2	503847.0441	576944.9146	16/Aug/02	872.8	875.43	25.7	10	0.010	847.1 - 857.6	847.6 - 859.9	859.9 - 868.7-	limestone
MW-RS3	505381.7919	578161.3596	17/Aug/02	878.7	881.25	12.5	5	0.010	866.2 - 871.2	866.2 - 872.7	872.7 - 874	silty clay
MW-RS4	496416.5607	567877.9056	19/Aug/02	858.1	860.72	14.8	9	0.010	843.3 - 852.3	843.3 - 853.3	853.9 - 853.9	silty clay & fine sand
MW-RS5	497351.9896	565862.4473	18/Aug/02	851.2	853.72	13.1	8	0.010	838.1 - 846.2	838.1 - 847.4	847.4 -848.7	silty clay & fine sand
MW-RS6	498493.3647	567297.3022	18/Aug/02	857.9	860.17	14.8	9	0.010	843.1 - 852.5	843.1 - 853.9	853.9 -855.4	silty clay & sand
MW-RS7	467243.6429	567739.7984	19/Aug/02	859.2	861.72	12.5	5	0.010	846.7 - 851.7	846.7 - 854.2	854.2 - 855.7	silty clay & sand
MW-RS8	501278.9558	569046.8177	21/Aug/02	864.0	866.93	15.7	10	0.010	848.3 - 858.3	848.3 – 860.1	860.1 - 861.1	silty clay & sand
MW-1	504983.4695	573987.2719	06/Dec/83	851.7	853.49	33.2	4.8	0.006	818.5 - 823.3	818.5 - 848.49	848.49 -847.7	limestone
							4.8	0.006	838.6-843.420	"	"	limestone
MW-2	496877.0486	573990.6136	13/Dec/83	848.0	850.18	23.7	10	0.006	824.3 - 834.3	824.3 - 835.5	835.5 - 836.5	limestone
MW-5	504375.1632	568636.2430	07/Dec/83	801.6	804.05	33.4	10	0.006	768.2 - 778.2	768.2 - 779.6	779.6 - 780.6	limestone
MW-6	496603.1512	568641.3525	17/Dec/83	858.4	861.12	40	10	0.006	818.4 - 828.4	818.4 - 830.4	830.4 - 831.9	silty clay
MW-9	504716.6247	572005.9329	09/Sept/88	819.6	819.58	38.2	20	UK	781.4 - 801.6	781.6 - 801.6	801.6 - 804.6	limestone & shale
MW-10	506791.1421	571247.2907	18/Sept/88	860.8	865.75	41.3	20	UK	819.5 - 839.5	819.5 - 839.8	839.8 - 843.3	sandy to clayey silt
MW-11	504032.1293	570131.3331	19/Sept/88	809.4	809.56	41.9	30	UK	767.5 - 797.5	767.5 - 797.4	797.4 - 806.9	limestone & shale

Notes:

No. – number.
Ft msl – feet mean sea level.
Ft bgs – feet below ground surface.
TOC – Top of casing.
UK – Unknown.

6.4.1.4 ERM Wells

The seven existing wells incorporated into this range study were installed during the 1980's. Construction details are included in Table 6-4. Wells MW-1, MW-2, MW-5, and MW-6 were installed in 1983 by T.M Gates, Inc. These wells were constructed from PVC riser pipes and screens and were fitted with steel protective covers. Well caps and locks were missing from each well. The protective casing lids were also partially or completely open at each well allowing the introduction of vegetation and precipitation into the well pipes. Wells MW-9, MW-10, and MW-11 were installed in 1988 by ATEC Associates, Inc. These wells were all flush mounted and only MW-10 was fitted with a well cap and lock. Wells MW-9 and MW-10 were not capped, making the introduction of vegetation, debris, precipitation, and surface runoff into the wells possible. Although riser pipe and screen materials were not specified on boring and well installation logs, the riser pipes of MW-9, MW-10, and MW-11 were PVC.

6.4.1.5 Monitoring Well Development

Newly constructed wells were developed to remove fines associated with well installation, and to enhance hydraulic communication of the well screen with the formation material. Wells were developed by manually bailing and surging with decontaminated stainless steel bailers. Bailers were decontaminated in accordance with Section 5.4.1 of the QAPP. Ground water purged from wells was not containerized. Wells were developed until a minimum of three standing water columns was evacuated, or until the well was purged dry. The pH, conductivity, and temperature of purged ground water were measured periodically during well development and recorded on well development forms (Appendix E). Visual descriptions of turbidity were also recorded on well development forms. Prior to and after development, water level data were also collected.

6.4.1.6 Surveying

Classickle, Inc., professional surveyors licensed in the State of Indiana, surveyed the horizontal location and the elevation of the 15 monitoring wells sampled during this study. Elevations to the nearest 0.01 foot were provided for the reference mark at the top of each PVC riser pipe. The ground surface elevation was also surveyed at each well. Horizontal locations and elevation data were referenced on the Indiana State Plane East Zone and the North American datum 1927. Survey data are included on boring logs in Appendix E and on Table 6-4.

6.4.1.7 Water Level Measurements

The water level in each well was measured to the nearest 0.01 foot with a decontaminated water level indicator in accordance with Section 5.3.5.1 of the QAPP. Measurements were made from the reference mark on the top of the PVC riser pipe. Water levels are included in Table 6-5. The water level probe and cable were cleaned between uses following decontamination methodology presented in Section 5.4.1 of the QAPP.

TABLE 6-5 STATIC WATER LEVEL MEASUREMENT

Well No.	Date	Time	Water Level (btoc)	TOC Elevation (ft msl)	Water Elevation (ft msl)	Comments
MW-RS1	17-Sept-02	1140	8.36	867.43	859.07	
	23-Sept-02	1000	8.63	867.43	858.80	
MW-RS2	17-Sept-02	1125	10.04	875.43	865.39	
	23-Sept-02	1005	10.33	875.43	865.10	
MW-RS3	17-Sept-02	1119	11.00	881.25	870.25	
	23-Sept-02	950	11.47	881.25	869.78	
MW-RS4	17-Sept-02	1430	10.56	860.72	850.16	
	23-Sept-02	844	11.04	860.72	849.68	
MW-RS5	17-Sept-02	1345	10.65	853.72	843.07	
	23-Sept-02	908	11.28	853.72	842.44	
MW-RS6	17-Sept-02	1400	10.28	860.17	849.89	
	23-Sept-02	916	11.74	860.17	848.43	
MW-RS7	17-Sept-02	1450	8.99	861.72	852.73	
	23-Sept-02	856	9.59	861.72	852.13	
MW-RS8	17-Sept-02	---	NM	---	---	
	23-Sept-02	925	12.51	866.93	854.42	
MW-1	17-Sept-02	1104	13.59	853.49	839.9	
	23-Sept-02	1016	18.11	853.49	835.38	
MW-2	17-Sept-02	1045	13.35	850.18	836.83	
	23-Sept-02	1030	13.48	850.18	836.70	
MW-5	17-Sept-02	1330	17.45	804.05	786.6	
	23-Sept-02	930	17.2	804.05	786.85	
MW-6	17-Sept-02	1440	21.59	861.12	839.53	
	23-Sept-02	849	41.37	861.12	819.75	Not static
MW-9	17-Sept-02	1250	33.55	819.58	786.03	
	23-Sept-02	---	NM	---	---	Not static
MW-10	17-Sept-02	1240	9.88	865.75	855.87	
	23-Sept-02	---	NM	---	---	
MW-11	17-Sept-02	1315	30.62	809.56	778.94	
	23-Sept-02	---	NM	---	---	Not static

Notes:

btoc – below top of casing.
ft msl – feet mean sea level.
TOC – Top of casing.
NM – Not measured.
-- - No data.

6.4.2 Ground-Water Purging and Sampling Procedures

6.4.2.1 Ground-Water Purging and Sample Collection footnotes

Monitoring wells were purged to ensure that water representative of the ground-water system was collected for analysis. Wells were purged by one of the following methods; low-flow purging with a peristaltic pump or an electric submersible pump, or by bailing. Wells were purged following methodologies outlined in Section 5.3.5.2 of the QAPP. The selected purge method was based on one or more of the following; a low recharge rate, a short water column, a small well volume, depth, or other factor. Wells purged by pumping generally followed procedures outlined in the USEPA Region I Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells, July 30, 1996, revision 2. Tubing and bailers were dedicated to a single well and disposed of after a well was purged and sampled.

Monitoring wells MW-1, MW-2, MW-5, MW-10, MW-RS1, MW-RS2, MW-RS4, MW-RS5, MW-RS6, MW-RS7, and MW-8 were purged and sampled with a peristaltic pump. Due to a slow recovery rate, monitoring well MW-RS3 was purged with a factory cleaned Teflon®[®] bailer and sampled the following day with a peristaltic pump. The intake of the peristaltic pump was set at the mid-point of the screen if the screen was completely below the water table, or at a depth equal to the middle of the water column within the well if the top of the water level was below the top of the screen. The peristaltic pump was fitted with a controller to regulate the flow rate (discharge). Low-flow procedures were followed during purging and sampling. Flow rates ranged from 180 milliliters per minute (mL/min) to 300 mL/min. Flow rates were recorded on Sampling Field Logs (Appendix E).

A multiprobe flowcell sampling system was used to monitor indicator parameters during well purging and/or sampling. Ground water was pumped through the intake tubing to the surface where it flowed into and through a 250-milliliter capacity cell fitted with probes that monitored pH, conductivity, temperature, and dissolved oxygen. An in-line bypass valve was located upstream of the flowcell to allow periodic withdrawal of water for turbidity measurements. The indicator parameters were monitored for stabilization. When the indicator parameters had stabilized, or 3-5 standing well volumes were purged, samples were collected directly from the tubing into the laboratory-supplied sample containers. Water samples were collected upstream of the flowcell to prevent cross-contamination between monitoring wells. Field parameters and other information relative to purging and sampling were recorded on Sample Field Logs (Appendix E). All tubing used with the peristaltic pump was disposed of after each use.

Monitoring wells MW-6 and MW-9 were purged with stainless steel bailers decontaminated in accordance to Section 5.4.1 of the QAPP. Bailers were used because each well had a very slow recovery rate and the depth to ground water was too great to use a peristaltic or whale pump. The static water levels in MW-6 and MW-9 on 17 September 2002 were 21.59 feet btoc and 33.6 feet btoc, respectively. The depth of well MW-6 was 42.5 feet btoc. The depth of MW-9 was 38.6 feet btoc. Monitoring well MW-6 was purged dry after one standing well pipe volume

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[®] Teflon is a registered trademark for E.I. Dupont de Nemours & Company, Inc., Wilmington, Delaware.

(3.6 gallons) was evacuated. Monitoring well MW-9 was purged dry after approximately 3 standing well pipe volumes (2.5 gallons) were evacuated. Due to low water volumes in both wells, only two readings of field indicator parameters were obtained. The indicator parameters were measured by placing the pH, temperature, and conductivity probes directly into a beaker that contained purged water. Dissolved oxygen was not measured during purging because the flow through cell could not be used due to insufficient water volumes.

Water levels in MW-6 and MW-9 did not recover sufficiently over a 5-day period to provide enough water volume to collect a full sample set. The water level in MW-6 the day after purging was only 41.51 feet btoc, a recovery of approximately 1 foot. On 20 September 2002, a sample for explosives analysis was collected from MW-6. After filling the sample bottle the well was dry. On 22 September 2002, a sample for perchlorate analysis was collected from MW-6. After collection of the perchlorate sample the well was again dry. MW-9 was purged dry on 17 September 2002. On 22 September 2002, only 0.5 feet of standing water was measured in the well. The standing water (less than 1 liter) was collected for explosives analysis. Samples for the other analytical parameters were not collected from MW-9.

Samples from MW-6 were collected with a factory cleaned Teflon bailer. The sample collected from MW-9 was collected with the stainless steel bailer used during purging. Water contained in bailers during sampling was emptied directly into the appropriate, laboratory-supplied sample containers. The Teflon bailer and the line used to collect samples from each well was disposed of after each use.

Monitoring well MW-11 was purged and sampled with an electrical submersible pump. On 18 September 2002, the pump intake was set at the middle of the water column and the well was purged at a rate of approximately 300 mL/min. The water column was lowered to a depth equal to the pump intake. On 19 September 2002, the pump was turned on to purge the tubing extending from the pump to the surface, and to attempt to collect samples. The water column was lowered to the pump intake. The pump was then set at a depth of 40 feet btoc, approximately 2 feet from the bottom of the well. The water column was pumped at flow rates varying from 200 – 500 mL/min, and was pumped dry. On 20 September 2002, approximately 5 feet of water was standing in the well; the pump was turned on and samples for filtered metals, filtered mercury, and unfiltered mercury analysis were collected before the well was pumped dry. On 21 September 2002, samples for explosives, perchlorate, and total dissolved solids were collected for analysis. After collection of these samples, the well was dry and a sample for unfiltered metals analysis could not be collected. Field parameters were collected during purging on 18-19 September 2002. Because of the low water volume the field parameters were not measured during sample collection in an attempt to collect as much water as possible for laboratory analysis. A summary of samples submitted for laboratory analyses is provided in Table 6-6.

TABLE 6-6 SUMMARY OF GROUND-WATER SAMPLES COLLECTED FOR ANALYSES

Well Number	Explosives	TDS	Perchlorate	Total Metals	Total Hg	Dissolved Hg	Dissolved Metals
MW-RS1	X	X	X	X	X	X	X
MW-RS2	X	X	X	X	X		
MW-RS3	X	X	X	X	X	X	X
MW-RS4	X	X	X	X	X	X	X
MW-RS5	X	X	X	X	X		
MW-RS6	X	X	X	X	X	X	X
MW-RS7	X	X	X	X	X	X	X
MW-RS8	X	X	X	X	X	X	X
MW-1	X	X	X	X	X		
MW-2	X	X	X	X	X		
MW-5	X	X	X	X	X		
MW-6	X		X				
MW-9	X						
MW-10	X	X	X	X	X		
MW-11	X	X	X	X	X	X	

Notes:
TDS – Total dissolved solids.
Hg – Mercury.

6.4.2.2 Ground-Water Sample Filtering

Section 5.2.3 the QAPP required the collection of filtered samples for metals analysis. Due to low turbidity measurements during well purging, samples for filtered metals analysis were only collected if the turbidity of the ground water was greater than 5 nephelometric turbidity units (NTUs). Samples were filtered in the field by attaching an in-line, 0.45-micron, acrylic copolymer-pleated membrane filter housed in a polyethylene capsule to the outlet of the pumps' discharge tubing or to the outlet of a bailer.

6.4.2.3 Ground-Water Sample Preservation, Labeling, Storage, and Shipment

The USACHPPM Directorate of Laboratory Sciences (DLS) provided clean sample containers. All ground-water samples were placed into the appropriate laboratory-supplied sample containers. Nitric acid was added to samples collected for metals and mercury analysis immediately after sample collection. The pH adjustments were checked in the field by pouring a small volume of sample over a pH strip to ensure the pH was lowered to a pH of 2 or less.

Ground-water samples were labeled, documented, and handled in a manner consistent with Sections 8.1.3, 8.2, 8.3, and 8.5 of the QAPP. All samples were placed into ice-filled coolers after collection and preservation. At the end of each work day, samples were transferred to sample custodians for refrigeration and repackaging for shipment to the analytical laboratories.

6.4.3 Field Sampling Quality Control (QC)

To assure the validity and reliability of the sampling data, QC samples were collected as required by Section 5.3.5.7 of the QAPP. QC samples include equipment blank/field blanks, a blind duplicate sample, and cooler temperature blanks. The QAPP required that duplicate samples and equipment blanks be collected at a minimum frequency of 5 percent per parameter. The blind duplicate sample, labeled MW-RS9, was collected from monitoring well MW-RS7. An equipment blank was collected by pumping distilled water through new tubing attached to a peristaltic pump. Temperature blanks were supplied by the laboratory and were included in each cooler containing samples shipped to the analytical laboratory. The number of ground-water samples collected during this study, including QC samples, is summarized on Table 6-7.

TABLE 6-7 NUMBER OF GROUND-WATER AND QC SAMPLES

Analyte*	**Analytical Method**	**Number of Normal Samples****	**QC Samples*****		**Total**
			Blind Duplicate	Field Blank	
Explosives	USEPA 8095M	15	1	1	17
Metals (Unfiltered)	USEPA 200.8	12	1	1	14
Metals (Filtered)	USEPA 200.8	7	1	0	8
Perchlorate	USEPA 314.0	14	1	1	16
Total Dissolved Solids	USEPA 160.1	13	1	1	15

Notes:

* See Table 6-1 for specific analytes of concern.

** Normal samples are non-QC samples collected from monitoring wells.

*** Duplicate samples and field blanks were collected on a frequency of 5% of normal samples.

6.4.4 Field Equipment Calibration Maintenance, Testing, and Inspection

The accuracy of the field measurements of pH, temperature, specific conductance, dissolved oxygen, and turbidity were addressed through pre-measurement calibrations and post-measurement verifications. Field instruments were checked daily for proper operation. The dissolved oxygen, pH, specific conductance, temperature, and turbidity meters were calibrated and inspected daily prior to use following guidelines detailed in Sections 5.5.1 and 5.5.2 of the QAPP. Calibrations were documented on field calibration forms (Appendix E). Post-measurement verifications were performed at the end of the sampling workday and documented in the field notebook. No maintenance was required on field instrumentation during the field program.

6.4.5 Investigation-Derived Wastes

Soil cuttings generated during drilling were spread on the ground near the boring from which the cuttings were generated. Ground water evacuated from each well during purging and sampling was discharged to the ground surface. Solid wastes such as rubber gloves and paper towels used during this study were placed in plastic bags and disposed as municipal solid waste.

6.5 GROUND-WATER INVESTIGATION RESULTS

6.5.1 Analytical Results

6.5.1.1 Explosives

No explosive compound was detected in any ground-water sample. Laboratory data sheets are included in Appendix B. DLS method CAD SOP 13.2 was used to analyze ground-water samples. A summary of the method reporting limits is provided in Table 6-8. Seven reporting limits for two compounds 1,3,5-TNB and 2Am46DNT were above the method reporting limits specified in Section 1 of the QAPP. Method reporting limits for 1,3,5-TNB (in samples from MW-9, MW-RS1, MW-RS4, MW-RS5, MW-RS7, and MW-RS8) and 2Am46DNT (MW-RS4) were raised due to interferences in the samples that could not be resolved on any of the analytical columns.

6.5.1.2 Perchlorate

Perchlorate was not detected in any ground-water sample. Samples were analyzed by USEPA Method 314.0; a summary of the method detection limits are presented in Table 6-9. Laboratory data sheets are included in Appendix B. All detection limits were below the 2 μg/L method reporting limit specified in Section 1 of the QAPP. The method detection limits for samples MW-5 and MW-11 (0.67 and 3.4 μg/L, respectively) are higher than the method detection limit of 0.337 μg/L for all other samples. The method detection limits for samples from MW-5 and MW-11 were raised since the samples had to be diluted because the samples' conductivities were above the established maximum conductivity threshold (MCT). MW-5 was diluted by a factor of two and MW-11 was diluted by a factor of 10 to bring the conductivities below the MCT.

6.5.1.3 Metals

The unfiltered sample results of the metals analyses are shown in Table 6-9. Laboratory data sheets are included in Appendix B. The filtered sample results of the metals analyses are shown in Table 6-10. When available, metals results are compared to the primary and secondary MCLs contained in the National Primary Drinking Water Regulations (USEPA, 2002). Metals that do not have an MCL are compared to mean background concentrations of metals in ground water south of the firing line.

TABLE 6-8 RESULTS OF EXPLOSIVES ANALYSES

Compound	USEPA Health Advisory µg/L	Method Reporting Limits Specified in QAPP	MW-1 µg/L	MW-2 µg/L	MW-5 µg/L	MW-6 µg/L	MW-9 µg/L	MW-10 µg/L	MW-11 µg/L	MW-RS1 µg/L	MW-RS2 µg/L	MW-RS3 µg/L	MW-RS4 µg/L	MW-RS5 µg/L	MW-RS6 µg/L	MW-RS7 µg/L	MW-RS9 (Duplicate Sample of MW-RS7) µg/L	MW-RS8 µg/L
Nitrobenzene	NHA	0.03	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
2-Nitrotoluene	NHA	0.09	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090
3-Nitrotoluene	NHA	0.09	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090
4-Nitrotoluene	NHA	0.09	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090
Nitroglycerin	NHA	0.09	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090
1, 3-Dinitrobenzene	1.0	0.09	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090	< 0.090
2, 6-Dinitrotoluene	5.0	0.01	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
2, 4-Dinitrotoluene	5.0	0.02	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020	< 0.020
1, 3, 5-Trinitrobenzene	NHA	0.03	< 0.030	< 0.030	< 0.030	< 0.030	< 0.23*	< 0.030	< 0.030	< 0.060*	< 0.030	< 0.030	< 0.17*	< 0.15*	< 0.030	< 0.13*	< 0.030	< 0.10*
2, 4, 6-Trinitrotoluene	2.0	0.03	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030	< 0.030
RDX	2.0	0.1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
4-Amino-2,6-dinitrotoluene	NHA	0.1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
2-Amino-4,6-dinitrotoluene	NHA	0.1	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.15*	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Tetryl	400.0	0.5	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
HMX	NHA	3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0

Notes:

NHA – No Health Advisory.
<0.300 – indicates the compound was not detected at the indicated method reporting level.
* - Reporting limit raised due to interference in samples that could not be resolved on any of the analytical colums.

TABLE 6-9 INORGANIC ANALYSES RESULTS OF UNFILTERED SAMPLES

Compound	Drinking Water Standard	Mean Back-ground	MW-1	MW-2	MW-5	MW-6	MW-9	MW-10	MW-11	MW-RS1	MW-RS2	MW-RS3	MW-RS4	MW-RS5	MW-RS6	MW-RS7	MW-RS8	MW-RS9 (D. S.)
Perchlorate			<0.337	<0.337	<0.67	<0.337	NA	<0.337	<3.4	<0.337	<0.337	<0.337	<0.337	<0.337	<0.337	<0.337	<0.337	<0.337
Metals																		
Antimony, (g/L	6P	30.0	<2.00	<2.00	<2.00	NA	NA	<2.00	NA	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Arsenic, (g/L	10 P	4.00	<1.00	3.69	1.12	NA	NA	<1.00	NA	7.42	<1.00	6.88	5.43	1.14	<1.00	2.02	1.06	<1.00
Barium, (g/L	2,000 P	263	48.4	154	82.4	NA	NA	245	NA	33.8	38.6	285	128	15.8	159	74.0	158	73.8
Cadmium, (g/L	5P	3.39	<1.00	<1.00	<1.00	NA	NA	<1.00	NA	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Calcium, (g/L	NS	96,041	111,000	81,900	157,000	NA	NA	88,700	NA	80,900	172,000	**81,200**	**115,000**	**74,100**	**83,800**	**73,100**	**97,700**	**74,700**
Chromium, µg/L	100^{P}	11.1	<2.00	<2.00	<2.00	NA	NA	<2.00	NA	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Copper, µg/L	$1,300^{Su}$	9.40	**2.16**	<2.00	<2.00	NA	NA	**6.15**	NA	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	**2.06**	<2.00	<2.00
Lead, µg/L	15^{Pu}	2.24	<2.00	<2.00	<2.00	NA	NA	<2.00	NA	<2.00	<2.00	**2.44**	<2.00	<2.00	<1.00	<2.00	<2.00	<2.00
Magnesium, µg/L	NS	39,516	**29,700**	**36,200**	**56,700**	NA	NA	**34.200**	NA	**70,600**	**18,400**	**31,900**	**39,400**	**28,100**	**30,600**	**45,400**	**34,200**	**46,400**
Manganese, µg/L	50^{S}	311.2	<2.00	**17.8**	**15.4**	NA	NA	**19.4**	NA	**72.0**	**28.1**	**2,690**	**1,210**	**252**	**150**	**799**	**2,060**	**800**
Mercury, µg/L	2^{P}	0.05	<0.200	<0.200	<0.200	NA	NA	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Molybdenum, µg/L	NS	26.4	<2.00	<2.00	<2.00	NA	NA	**6.06**	NA	**7.63**	**3.64**	**22.2**	**16.6**	**8.36**	<1.00	**17.9**	**7.60**	**17.7**
Nickel, µg/L	NS	17.8	<2.00	<2.00	<2.00	NA	NA	<2.00	NA	<2.00	<2.00	**3.70**	**4.68**	<2.00	**2.18**	**3.34**	**15.4**	**3.19**
Silver, µg/L	100^{S}	0.17	<1.00	<1.00	<1.00	NA	NA	<1.00	NA	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Vanadium, µg/L	NS	13.8	<1.00	<1.00	<1.00	NA	NA	<1.00	NA	<1.00	<1.00	**2.55**	**1.78**	**1.18**	<1.00	**1.92**	**1.66**	**2.02**
Zinc, µg/L	$5,000^{S}$	12.8	<100	<100	<100	NA	NA	<100	NA	<100	<100	<100	<100	<100	<100	<20	<100	<100
Uranium (Total), µg/L	30^{P}*	NS	**0.632**	**1.15**	**0.430**	NA	NA	**2.42**	NA	**3.28**	**0.856**	**14.0**	**10.9**	**8.12**	**1.68**	**22.4**	**6.36**	**24.6**
Uranium, U235/U238 ratio	NS	NS	0.00627	0.00713	0.00702	NA	NA	0.00720	NA	0.00724	0.00708	0.00727	0.00722	0.00720	0.00720	0.00725	0.00727	0.00725
Uranium ratio uncertainty	NS	NS	0.000190	0.000110	0.000450	NA	NA	0.000100	NA	0.0000900	0.00021	0.0000600	0.0000700	0.0000400	0.000100	0.0000500	0.0000400	0.0000500
Calculated Hardness, µg/L	NS	NS	**399,000**	**354,000**	**626,000**	NA	NA	**362,000**	NA	**493,000**	**172,000**	**334,000**	**449,000**	**301,000**	**335,000**	**369,000**	**385,000**	**378,000**
Total Dissolved Solids, µg/L	$500,000^{S}$		**394,000**	**382,000**	**3,120,000**	NA	NA	**456,000**	**13,800,000**	**540,000**	**232,000**	**518,000**	**496,000**	**388,000**	**562,000**	**1,150,000**	**486,000**	**1,110,000**

NOTES:

D.S. Duplicate sample, sample was collected from MW-RS7.
NA – Not analyzed.
NS - No drinking water standard.
P –Maximum Contaminant Level. National Primary Drinking Water Regulations, USEPA.
Pu – Primary MCL at point of use.
S – National Secondary Drinking Water Regulation or secondary standards, USEPA.
Su – Secondary MCL at point of use.
* Uranium MCL as of 8 December 2003
<0.300 – indicates the compound was not detected at the indicated method reporting level.
Due to inadequate water volume, samples were not collected from MW-6 and MW-9, and only mercury was collected from MW-11.

TABLE 6-10 INORGANIC ANALYSES RESULTS OF FILTERED SAMPLES

Compound	**Drinking Water Standard**	**Mean Background**	**MW-11 Dissolved**	**MW-RS1 Dissolved**	**MW-RS3 Dissolved**	**MW-RS4 Dissolved**	**MW-RS6 Dissolved**	**MW-RS7 Dissolved**	**MW-RS8 Dissolved**	**MW-RS9 (D. S.) Dissolved**
Metals										
Antimony, µg/L	6^P	30	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Arsenic, µg/L	10^P	4	**6.24**	**7.40**	**7.97**	**5.47**	<1.00	**1.71**	<1.00	**1.83**
Barium, µg/L	$2{,}000^P$	263	**264**	**32.4**	**274**	**141**	**147**	**84.9**	**148**	**78.5**
Cadmium, µg/L	5^P	3.39	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Calcium, µg/L	NS	96,041	**343,000**	**71,200**	**78,500**	**111,000**	**85,100**	**73,700**	**95,800**	**72,700**
Chromium, µg/L	100^P	11.1	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
Copper, µg/L	$1{,}300^{Su}$	9.40	**4.25**	**2.21**	<2.00	<2.00	<2.00	2.00	<2.00	<2.00
Lead, µg/L	15^{Pu}	2.24	<2.00	<2.00	<2.00	<2.00	<200	<2.00	<2.00	<2.00
Magnesium, µg/L	NS	39,516	**202,000**	**65,100**	**31,000**	**38,100**	**30,700**	**45,500**	**33,500**	**45,100**
Manganese, µg/L	50^S	311.2	**159**	**59.5**	**2,450**	**1,260**	**140**	**786**	**1,980**	**749**
Mercury, µg/L	2^P	0.05	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200	<0.200
Molybdenum, µg/L	NS	26.4	<2.00	**7.80**	**16.8**	**17.6**	<2.00	**17.6**	**6.80**	**17.7**
Nickel, µg/L	NS	17.8	**2.79**	<2.00	**3.32**	**3.55**	**2.09**	**3.21**	**13.2**	**2.87**
Silver, µg/L	100^S	0.17	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Vanadium, µg/L	NS	13.8	<1.00	<1.00	**2.53**	**1.16**	<1.00	**1.92**	<1.00	**1.99**
Zinc, µg/L	$5{,}000^S$	12.8	<100	<100	<100	<100	<100	<100	<100	<100
Uranium (Total), µg/L	30*	NA	**0.254**	**3.30**	**12.0**	**10.4**	**1.69**	**21.4**	**5.86**	**21.8**
Uranium, U235/U238 ratio	NS	NA	0.00608	0.00720	0.00724	0.00721	0.00727	0.00725	0.00721	0.00727
Uranium ration uncertainty	NS	NA	0.000240	0.0000500	0.0000600	0.0000700	0.000120	0.0000600	0.0000500	0.0000400
Calculated Hardness, µg/L	NS	NA	**1,690,000**	**446,000**	**324,000**	**434,000**	**339,000**	**371,000**	**377,000**	**367,000**

NOTES:

D.S. Duplicate sample, sample was collected from MW-RS7.
NA – Not analyzed.
NS - No drinking water standard.
P –Maximum Contaminant Level. National Primary Drinking Water Regulations, USEPA.
Pu – Primary MCL at point of use.
S – National Secondary Drinking Water Regulation or secondary standards, USEPA.
Su – Secondary MCL at point of use.
* Uranium MCL as of 8 December 2003
<0.300 – indicates the compound was not detected at the indicated method reporting level.
Due to inadequate water volume, samples were not collected from MW-6 and MW-9, and only mercury was collected from MW-11.

The mean background concentrations were derived from ground-water sample and analysis during several studies and investigations conducted by others south of the firing line. Three clusters of three wells each were installed south of the firing line to formulate a conceptual model for ground-water flow by collecting data from the wells with respect to regional variability in general ground-water chemistry, geology, and potentiometric head (Rust, 1994a). Two wells in each cluster are screened in bedrock, and the shallow well is screened at the bedrock-glacial till contact. All nine wells were sampled for general water chemistry parameters, including total metals, anions, pH, dissolved oxygen, and conductivity. Additionally, at each Remedial Investigation/Feasibility Study site south of the firing line, one well (thought to be upgradient) was selected and sampled for general water quality data. This provided general water quality data for any additional wells used in the evaluation of background water chemistry across the installation south of the firing line (Rust, 1994a). Analytical data from the background wells is summarized in Table 6-11. As shown on Table 6-11, the mean background concentrations for some metals are below the certified reporting limit.

Antimony, cadmium, chromium, mercury, silver, and zinc were not detected in any filtered or unfiltered sample collected during this range study. Arsenic was detected in unfiltered samples collected from five wells; all concentrations are below the primary MCL. Arsenic concentrations in filtered samples are also below the MCL and show close similarity to the arsenic concentrations in unfiltered samples. Barium was detected in all filtered and unfiltered ground-water samples. Barium concentrations are at least one order of magnitude below the primary MCL. Lead was only detected in the unfiltered sample collected from MW-RS3. The reported lead concentration, 2.44 µg/L, is less than the primary MCL of 15 µg/L.

Total uranium was detected in all filtered and unfiltered samples at concentrations below the primary MCL of 30 µg/L. Concentrations of total uranium in unfiltered samples range from 0.632 µg/L – 22.4 µg/L. The lowest total uranium concentrations (0. 632 µg/L – 1.15 µg/L) are reported for wells screened in limestone. Total uranium results for unfiltered samples are similar to the filtered results. Filtered sample concentrations range from 0.254 µg/L – 21.4 µg/L. A U235/U238 uranium ratio of 0.00720 or less and within a measurement uncertainty of +/- 0.0001 is indicative of potential DU content with in sample. This ratio suggests the presence of some DU in the sample MW-1 unfiltered. The U235/U238 sample for MW-11 filtered sample is also less than the 0.000720 ration but the measurement uncertainty is greater that 0.0001. The U235/U238 ratio in all other samples does not indicate the presence of DU (Falo, 2002).

Copper was detected in two unfiltered samples (MW-1 and MW-10) and in two filtered samples (MW-11 and MW-RS1) at concentrations ranging from 2.21 µg/L – 21.6 µg/L. The highest concentration is at least two orders of magnitude below the secondary MCL of 1,300 µg/L.

Manganese was detected in all samples with the exception of the sample collected from MW-1. Manganese concentrations in unfiltered samples collected from wells screened in bedrock only (wells MW-1, MW-2, MW-5, and MW-RS2) range from less than the detection limit to 28.1 µg/L. All manganese concentrations in these wells are less than the secondary MCL of 50 µg/L.

TABLE 6-11 METALS DATA FOR BACKGROUND MONITORING WELLS SOUTH OF THE FIRING LINE

	Number of Detections	**Number of Samples**	**CRL**	**Low**	**High**	**MEAN**
Unfiltered Metals						
Antimony, µg/L	0	9	60.0	30.0	60.0	30.0
Arsenic, µg/L	4	12	2.35	1.18	17.0	4.00
Barium, µg/L	12	12	2.82	34.5	967	263
Cadmium, µg/L	0	12	6.78	3.39	6.78	3.39
Calcium, µg/L	12	12	105	74,700	119,000	96,041
Chromium, µg/L	1	12	16.8	8.40	41.0	11.1
Copper, µg/L	0	12	18.8	9.40	18.8	9.40
Lead, µg/L	0	12	4.47	2.24	4.47	2.24
Magnesium, µg/L	12	12	135	18,600	59,700	39,516
Manganese, µg/L	12	12	9.67	63.1	1380	311.2
Mercury, µg/L	0	12	0.10	0.05	0.10	0.05
Molybdenum, µg/L	0	9	52.7	26.4	52.7	26.4
Nickel, µg/L	1	12	32.1	16.0	37.6	17.8
Silver, µg/L	0	12	0.333	0.17	0.333	0.17
Vanadium, µg/L	0	12	27.6	13.8	27.6	13.8
Zinc, µg/L	1	12	18.0	9.00	26.1	12.8
Filtered Metals						
Antimony, µg/L						
Arsenic, µg/L	4	12	2.35	1.175	15.70	3.71
Barium, µg/L	12	12	2.820	26.20	934.0	262.5
Cadmium, µg/L	0	12	6.780	3.390	6.780	3.39
Calcium, µg/L	12	12	105.00	72,500	119,000	96,858
Chromium, µg/L	0	12	16.80	8.400	16.80	8.40
Copper, µg/L	0	12	18.80	9.40	18.80	9.40
Lead, µg/L	0	12	4.470	2.235	4.470	2.24
Magnesium, µg/L	12	12	135.0	17,500	60,000	39,925
Manganese, µg/L	12	12	9.67	50.20	864	272.56
Mercury, µg/L	0	12	0.100	0.050	0.10	0.050
Molybdenum, µg/L	0	9	52.7	26.35	52.7	26.35
Nickel, µg/L	0	12	32.1	16.05	32.1	16.05
Silver, µg/L	0	12	0.333	0.1665	0.333	0.1665
Vanadium, µg/L	0	12	27.6	13.80	27.6	13.8
Zinc, µg/L	2	12	18.0	9.0	42.0	12.8

Notes:

CRL – certified reporting limit.

Data from: Data Summary Report, Jefferson Proving Ground, Madison, Indiana, January 1994 by Rust Environment and Infrastructure, Grand Junction, Colorado, Prepared Under DAAA15-90-D-0007.

Manganese was detected in the filtered sample collected from MW-11, which is screened in bedrock, at a concentration of 159 µg/L. This concentration exceeds the secondary MCL but is less than the mean background concentration of 272.6 µg/L for filtered samples. Manganese concentrations in filtered and unfiltered samples collected from wells screened in the overburden (wells MW-10, MW-RS3, MW-RS4, MW-RS5, MW-RS6, MW-RS7, and MW-RS8) and in a well screened in limestone and silty clay (MW-RS1) range from 19.4 µg/L – 2,690 µg/L. With the exception of the manganese concentration in MW-10 (19.4 µg/L), manganese concentrations exceed the secondary MCL.

Calcium was detected in all filtered and unfiltered samples. There is no MCL for calcium. Concentrations in unfiltered samples range from 74,100 µg/L – 172,000 µg/L. The mean background concentration for unfiltered samples is 96,041µg/L. In unfiltered samples, calcium concentrations range from 71,200 µg/L – 343,000 µg/L. The mean background concentration for filtered samples is 96,858 µg/L.

Magnesium was detected in all filtered and unfiltered samples. There is no MCL for magnesium. Magnesium concentrations in unfiltered samples range from 28,100 µg/L – 70,600 µg/L. Three magnesium concentrations (70,600 µg/L in MW-RS1, 45,400 µg/L in MW-RS7 and 46,400 µg/L in MW-RS7's duplicate) exceed the mean background concentration for unfiltered samples (39,516 µg/L) but are within the same order of magnitude. Magnesium concentrations in filtered samples range from 30,700 µg/L – 202,700 µg/L. Four magnesium concentrations (including a normal and its duplicate sample results) exceed the mean background concentration for filtered samples (39,925 µg/L).

Molybdenum was detected in nine unfiltered samples collected from eight wells at concentrations that range from 6.06 µg/L – 22.2 µg/L. There is no MCL for molybdenum. Molybdenum was detected in six filtered samples, including the duplicate sample, at concentrations of 6.80 µg/L – 17.8 µg/L. All concentrations are below the mean background concentration of 26.4 µg/L for filtered and unfiltered samples.

Nickel was detected in six unfiltered samples, including the duplicate sample, at concentrations of 2.18 µg/L – 15.4 µg/L. There is no MCL for nickel. Nickel was not detected in any unfiltered sample collected from wells screened in limestone. Nickel was detected in seven of the eight filtered samples, including the duplicate sample and the only filtered sample collected from a well screened in limestone (MW-11). Nickel detections in filtered samples range from 2.09 µg/L – 13.2 µg/L. All nickel concentrations are below the mean background concentrations for filtered and unfiltered samples, 16.05 µg/L and 17.8 µg/L, respectively.

Vanadium was detected in six unfiltered samples (including the duplicate sample) at concentrations of 1.18 µg/L – 2.55 µg/L. There is no MCL for nickel. Vanadium was detected in four filtered samples (including the duplicate sample) at concentrations that range from 1.16 µg/L – 2.53 µg/L. All reported concentrations are below the mean background concentration of 13.8 µg/L for filtered and unfiltered samples.

6.5.1.4 Hardness and Total Dissolved Solids

Calculated hardness in unfiltered samples ranges from 172,000 µg/L – 626,000 µg/L (Table 6-9). In filtered samples (Table 6-10) hardness ranges from 324,000 µg/L – 1,690,000 µg/L. The highest calculated hardness was measured in the unfiltered sample collected from MW-11. An unfiltered sample was not collected from this well. Total dissolved solids concentrations were measured for unfiltered samples only. The highest concentration of total dissolved solids was measured in the sample from MW-11, the sample that had the highest calculated hardness. Excluding monitoring well MW-11, total dissolved solids concentrations range from 232,000 µg/L – 3,120,000 µg/L.

6.5.2 Geology and Hydrology of Areas of Investigation

6.5.2.1 Impact Field 5.3E

6.5.2.1.1 Geology

The majority of the ground surface across the Impact Field 5.3E was vegetated with grasses. Impact craters and UXO were sporadically located across the ground surface of this impact field. A generalized subsurface profile (Figure 6-2) was drawn to illustrate subsurface materials encountered during this range investigation. Boring logs in Appendix E were used to develop the subsurface profile. As shown on Figure 6-3, ground surface gently slopes from the north to the south toward the northwest side of an intermittent creek located in the southern half of the impact field. The slope direction changes on the southeast side of the unnamed intermittent stream. No flow was observed in the intermittent stream during field activities associated with this study.

Subsurface materials observed within the impact field are composed of fines, sand, and weathered limestone. Surface and near surface soils are primarily clayey or silty sands. The clayey and silty sands overlie a silty clay, which contains some fine sand. The silty clay overlies a weathered limestone. Boring MW-RS3 was terminated before encountering limestone (see boring log). Based on the location of weathered limestone in borings MW-RS1 and MW-RS2 and interpolation between these wells and MW-RS3, the location of limestone at MW-RS3 is approximated. It is also estimated that limestone like ground surface has a slope of approximately 1 percent to toward the south. A discontinuous layer (both horizontally and vertically) of silty clay is present within the limestone near MW-RS1. The thickness of the unconsolidated materials, which overlies the weathered limestone, decreases in the down-slope direction.

6.5.2.1.2 Hydrogeology

The open intervals of the wells extend across one or more types of subsurface material (see well logs in Appendix E). MW-RS1 is screened in weathered limestone and a clayey silt layer within the weathered limestone. The well's sand pack extends into the overlying clayey silt. MW-RS2 is screened in the weathered limestone, and the sand pack extends into the overlying material. More than 2 feet of bentonite is located below the top of the limestone and the top of the sand pack. The open interval in MW-RS3 extends across a silty clay.

FIGURE 6-3. IMPACT FIELD 5.3E WATER LEVEL ELEVATIONS

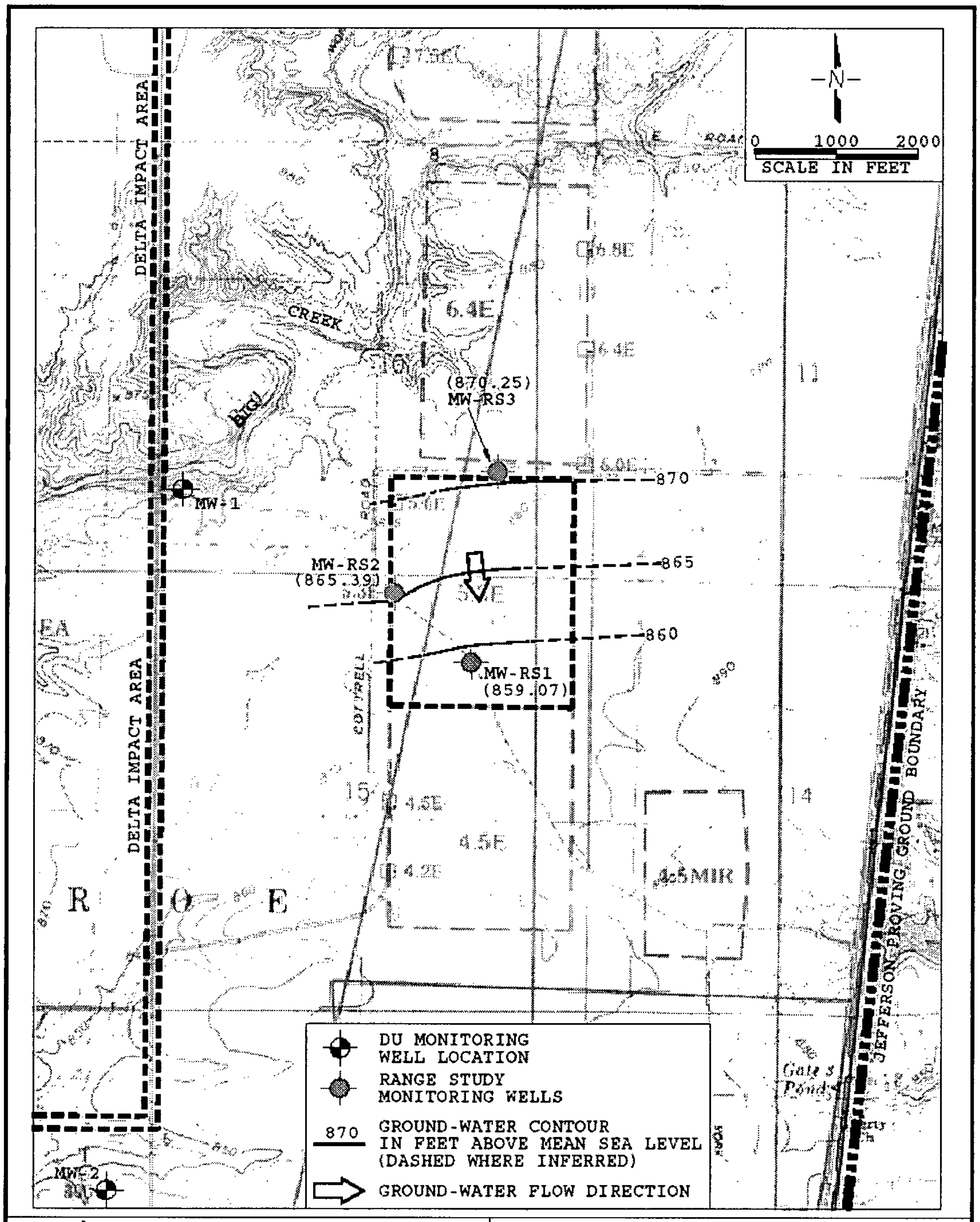

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FIGURE 6-3
IMPACT FIELD 5.3E WATER LEVEL ELEVATIONS
17 SEPTEMBER 2002, JEFFERSON PROVING GROUND
MADISON, INDIANA.

GCL	38-EH-8220-02	IN/JPG/8220F53E

Ground-water levels were obtained from wells MW-RS1, MW-RS2, and MW-RS3 on 17 and 23 September 2002 (Table 6-5). A water level elevation contour map was constructed based on water level measurements made on 17 September 2002 (Figure 6-3). Based on water level data and site stratigraphy, the upper weathered limestone and the overburden function as one hydrologic unit. As shown on Figure 6-4, the estimated direction of ground-water flow is to the south. Ground-water elevations ranged from 858.80 feet msl (6.3 feet bgs) within the impact field to 869.78 (8.9 feet bgs) in the topographically higher area on the north side of the impact field. Monitoring well MW-RS3 is located hydraulically upgradient, and wells MW-RS1 and MW-RS2 are hydraulically downgradient and sidegradient of Impact Field 5.3E. Upgradient well MW-RS3 is probably hydraulically downgradient of Impact Field 6.4E. The average lateral hydraulic gradient, based on water level differences and horizontal differences between the wells installed at Impact Field 5.3 E is approximately 0.005 ft/ft.

6.5.2.2 Impact Field 3W

6.5.2.2.1 Geology

The majority of the ground surface across the Impact Field 3W was vegetated with grasses. Impact craters and UXO were sporadically located across the ground surface. Although field activities were conducted during a drought period, standing water and cattails were observed in some impact craters. A generalized subsurface profile, which illustrates subsurface materials at Impact Field 3W, is presented as Figure 6-5. Boring logs in Appendix E were used to develop the subsurface profile. As shown on Figure 6-5, ground surface is relatively flat but does slope slightly toward the northwest and the southeast from MW-RS7.

Subsurface materials are composed of fines and sand. Surface and near surface soils are primarily silty to clayey sands. The upper silty to clayey sand is underlain by a silty clay at well locations MW-RS4, MW-RS5, and MW-RS7, and the silty clay is underlain by clayey sand. At the northern most well location, MW-RS6, the silty clay is absent and silty to clayey sands extend the entire length of the boring.

6.5.2.2.2 Hydrogeology

Ground-water levels were obtained from wells MW-RS4, MW-RS5, MW-RS6, and MW-RS7 on 17 and 23 September 2002 (Table 6-5). A water level elevation contour map was constructed based on the 17 September water level measurements (Figure 6-6). As shown on Figure 6-6, the estimated direction of ground-water flow is to the southeast and the northwest. A ground-water divide is present at the impact field and the divide corresponds to the impact field's topographical high. Ground-water elevations range from 852.73 feet msl (6.47 feet bgs) at or near the divide, or topographical high, at MW-RS7 to 843.07 feet msl (8.11 feet bgs) on the north side of the impact field. Although monitoring well MW-RS7 is located within Impact Field 3W it is the hydraulically upgradient well. MW-RS4 and MW-6 are located downgradient, and wells MW-RS5 and MW-RS6 are hydraulically downgradient and sidegradient of the impact field.

FIGURE 6-4 Subsurface Profile Impact Field 3W

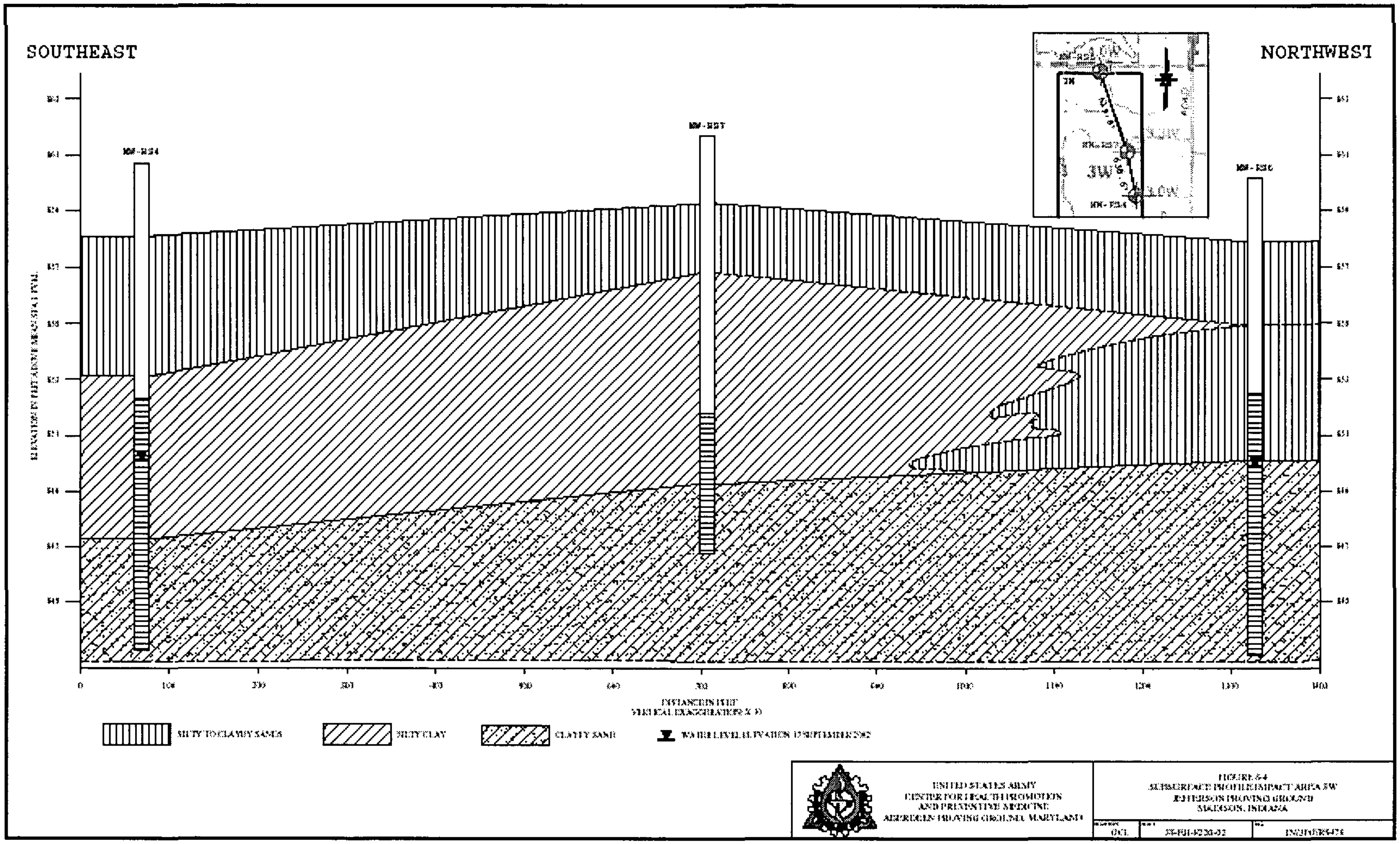

Figure 6-5 Impact Field 3W Water Level Elevations Contour Map

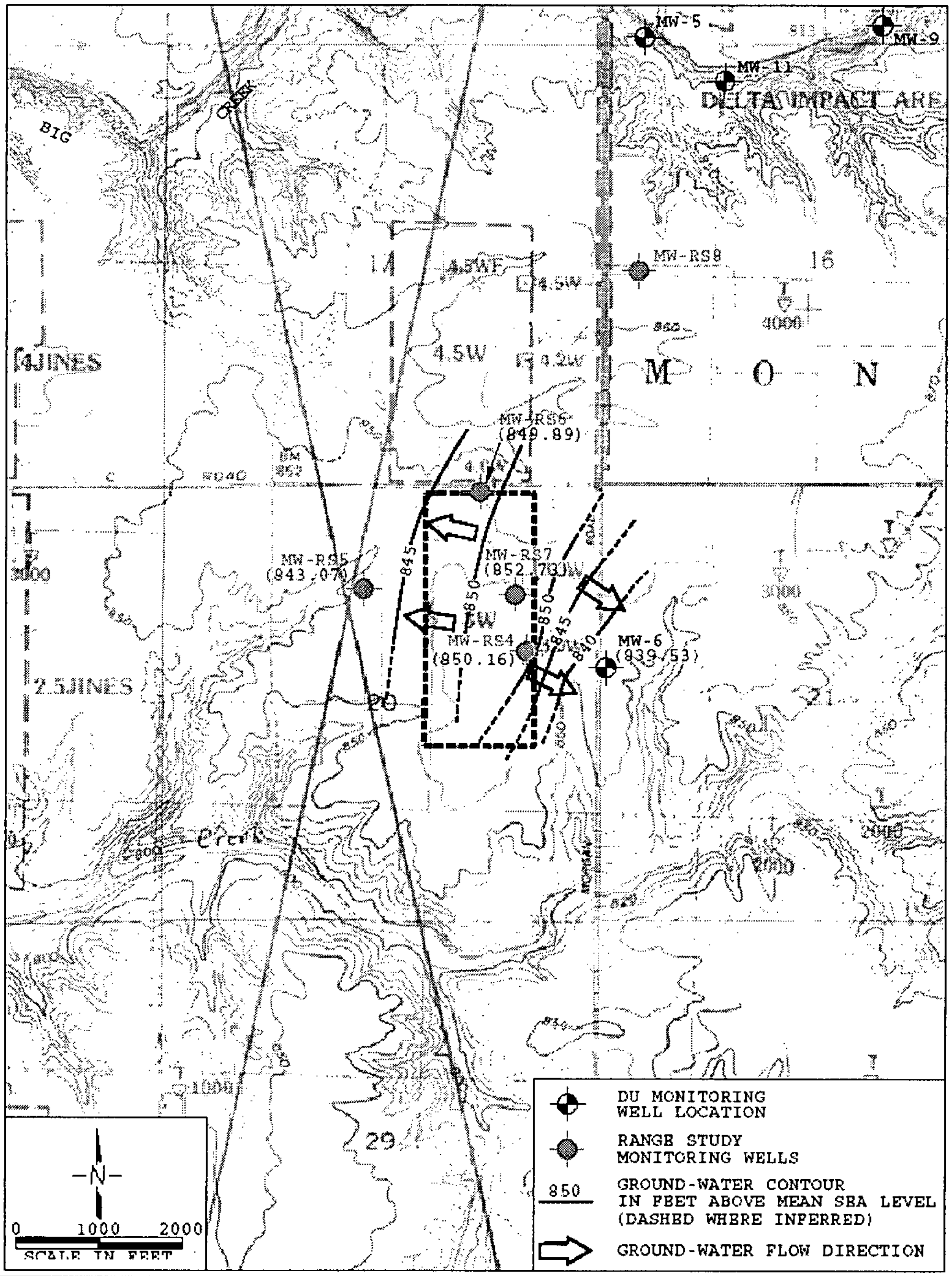

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FIGURE 6-5
IMPACT FIELD 3W WATER LEVEL ELEVATIONS
17 SEPTEMBER 2002. JEFFERSON PROVING GROUND
MADISON, INDIANA.

GCL	38-EH-8220-02	IN/JPG/8220F3W

Figure 6-6 Impact Field 7.5CF and 5.6W Water Level Elevations

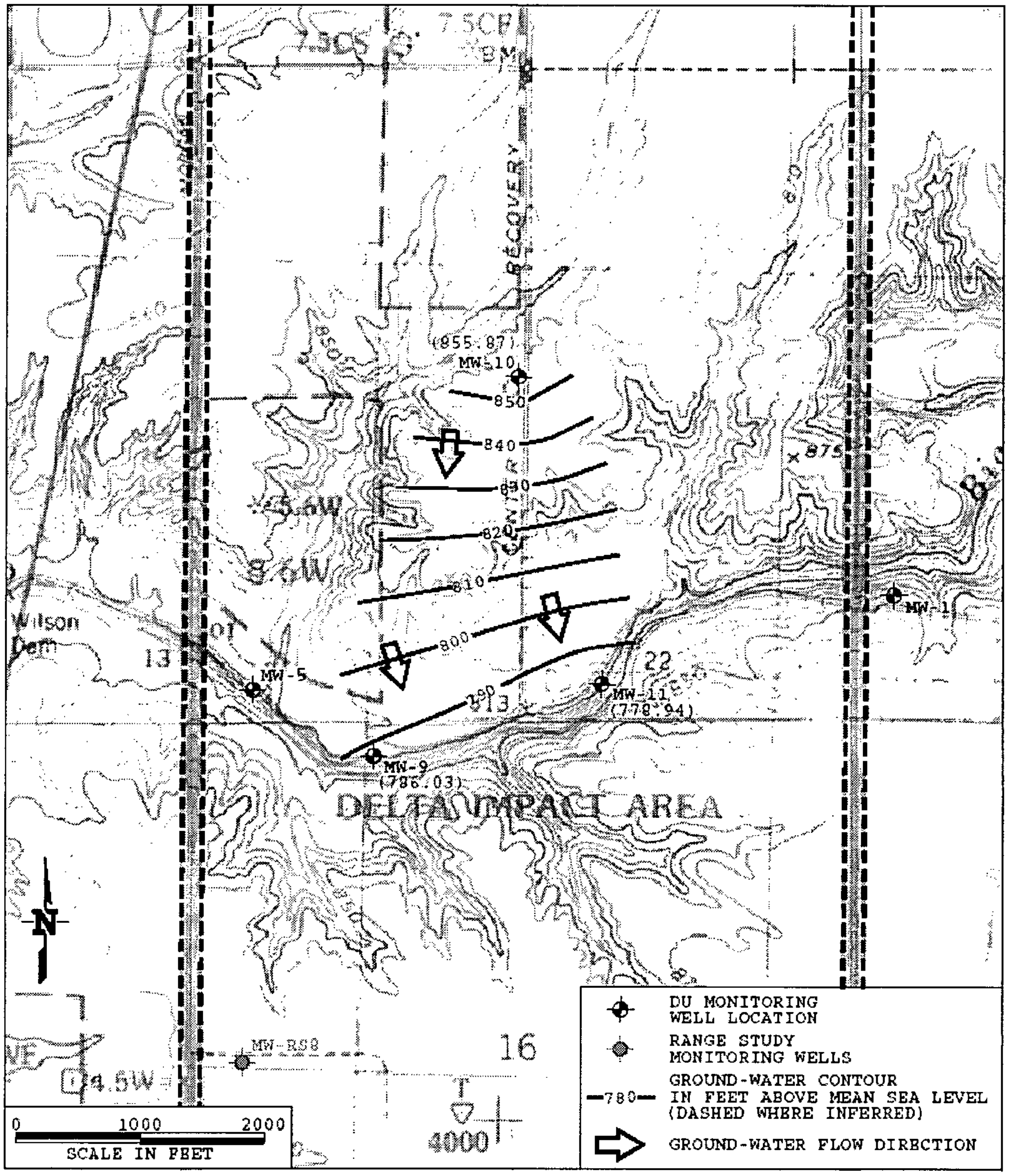

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FIGURE 6-6
IMPACT FIELD 7.5CF AND 5.6W
WATER LEVEL ELEVATIONS, 17 SEPTEMBER 2002
JEFFERSON PROVING GROUND, MADISON, INDIANA

GCL | 38-EH-8220-02 | IN/JPG/8220CF75

The average lateral hydraulic gradient to the southeast, based on water level and horizontal differences, is approximately 0.17 ft/ft. The average lateral hydraulic gradient on the northwest side of the ground-water divide is approximately is 0.006 ft/ft.

6.5.2.3 Delta Impact Area South of Big Creek

6.5.2.3.1 Geology

Monitoring wells MW-1, MW-2, MW-5, and MW-6 were installed near the Delta Impact Area by others as part of the ERM program. The well borings were advanced to various depths that ranged to 40 feet bgs with an average depth of 32.6 feet. Limestone was encountered at well locations MW-1, MW-2, and MW-5 at 4.5 feet bgs (847.2 feet msl), 7.0 feet bgs (840.96 feet msl), and 5.6 feet bgs (795.97 feet msl), respectively. The overburden at each of these locations was described as silty clay. MW-6 was drilled to 40 feet bgs (818.44 feet msl), and limestone was not encountered in the boring. The subsurface material at MW-6 was described as a silty clay. MW-RS8 was advanced to 15.7 feet bgs (848.3 feet msl) and like MW-6 limestone was not encountered. The subsurface material at MW-RS8 was described as a silty clay with sands. Additional data points are needed in the Delta Impact Area South of Big Creek to construct a meaningful subsurface profile.

6.5.2.3.2 Hydrogeology

Water levels in the area range from 786.85 feet msl at MW-5 to 854.42 feet msl at MW-RS8. Monitoring wells near and within the Delta Impact Area south of Big Creek are too widely spaced to construct a meaningful ground-water elevation contour map. Based on water level data collected from MW-6 and wells in Impact Field 3W, MW-6 is located hydraulically crossgradient (Figure 6-6) of the Delta Impact Area. Monitoring well MW-2 is located near the southeast channel of a tributary of Middle Fork Creek that cuts across the southeast corner of the Delta Impact Area. Near incised surface drainages at JPG, ground water in shallow bedrock tends to discharge to surface stream (see Section 6.2.3.2). Based on this, shallow ground water in the MW-2 area southeast of the unnamed tributary probably has a different flow direction than ground water northwest of the creek.

6.5.2.4 Delta Impact Area North of Big Creek

6.5.2.4.1 Geology

Monitoring wells MW-9, MW-10, and MW-11 were installed within the Delta Impact Area north of Big Creek (Figure 6-6). The boring advanced for monitoring well MW-10 is topographically more than 40 feet higher than MW-9 and MW-10. The subsurface material at boring MW-10 was described as a clayey to sandy silt. The boring was terminated at a depth of 41.3 feet bgs (819.5 feet msl). Bedrock, described as limestone and shale, was encountered at MW-9 at 3.7 feet bgs (815.9 feet msl) and at MW-11 at 2 feet bgs (807.4 feet msl). The overburden at MW-9 and MW-11 is clayey silt.

6.5.2.4.2 Hydrogeology

Ground-water levels were obtained from wells MW-9, MW-10, and MW-11 on 17 September 2002 (Table 6-5). Water levels were not measured on 23 September 2002 because water levels had not recovered to static conditions after sampling activities. Monitoring wells MW-9 and MW-11 are screened in bedrock and MW-10 is screened in a sandy to clayey silt. Measured ground-water elevations are below the top of screens in MW-9 and MW-11, and the open intervals in both wells is sealed below the contact between the overburden and the bedrock.

6.6 PROBLEMS ENCOUNTERED AND DEVIATIONS FROM THE QAPP

6.6.1 Well Installations

Three wells, instead of the four wells specified in the QAPP, were installed around Impact Field 5.3E. The reasons only three wells were installed are discussed in Section 6.4.1 of this report.

6.6.2 Sample Identification

The DLS laboratory report for total dissolved solid analyses lists one sample identification as MW-S. The correct sample identification is MW-5.

6.6.3 Data Quality Indicators

6.6.3.1 Duplicate Samples

The QAPP called for duplicate samples equal to at least 5 percent of the number of normal ground-water samples. One split sample, labeled as MW-RS9, more than 5 percent, was collected from MW-RS7. The results for the normal and duplicate samples indicate precision as measured by the relative percent difference (RPD). Only metals were detected in samples, nine metals in MW-RS7 and eight metals in MW-RS9. Among the detected metals, the RPDs ranged from 1 - 133. The RPD was less than the objective of 50 (Section 7.3.7 of the QAPP) for all but 2 of the calculated RPDs. The two high RPDs (68 & 133) are skewed by nondetects. Since the RPD is intimately linked to the magnitude of the results, it works best when detectable levels of contaminants are present. Table 6-12 shows RPD results for metals.

TABLE 6-12 RELATIVE PERCENT DIFFERENCES

Metal	A	B	(A-B)	2(A-B)	(A+B)	RPD
Antimony	<2	<2	0	0	4	0
Arsenic	2.02	<1	1.02	2.04	3.02	68
Barium	74	73.8	0.2	0.4	147.8	0.3
Cadmium	<1	<1	0	0	2	0
Calcium	73.1	74.7	1.6	3.2	147.8	2
Calculated Hardness	369	378	9	18	747	2
Chromium	<2	<2	0	0	4	0
Copper	2.06	<2	0.06	0.12	4.06	3
Lead	<2	<2	0	0	4	0
Magnesium	45.4	46.4	1	2	91.8	2
Manganese	799	800	1	2	1599	0.1
Mercury	<0.2	<0.2	0	0	0.4	0
Molybdenum	17.9	17.7	0.2	0.4	35.6	1
Nickel	3.34	3.19	0.15	0.3	6.53	5
Silver	<1	<1	0	2	2	0
Vanadium	1.92	2.02	0.1	0.2	3.94	5
Zinc	<0.02	<0.1	0.08	0.16	0.12	133

6.6.3.2 Equipment Rinsate Blanks

Most samples were collected directly from the discharge tubing of a pump. Tubing was dedicated to a single well. One equipment rinsate blank was collected by pumping distilled water through a peristaltic pump fitted with new tubing. The rinsate blank was analyzed for total metals, perchlorate, and explosives. Calcium was the only analyte detected in the rinsate blank. A rinsate blank was not collected from a bailer used.

6.6.3.3 Representativeness

Representativeness is the degree to which data accurately characterize a population, parameter variations at a sampling point, a process condition, or an environmental condition. The degree of representativeness is dependant on the thoroughness and proper design of the QAPP and Sampling Plans (SP) and adherence to its prescribed procedures, especially regarding the assumptions made during the development and the statistical soundness of the sampling design. Representativeness in this ground-water investigation was maintained through the careful application of industry accepted procedures in the sampling as defined in the JPG QAPP and with the use of quality assurance (QA) audits.

6.6.3.4 Comparability

Comparability is an expression of the confidence with which one data set can be compared with another. Comparability is also dependent on similar QA objectives. There are no numerical values that can be placed on this concept. This involves a subjective review and evaluation process, and the use of the appropriate field and analytical methodologies.

6.6.3.5 Completeness

Field completeness is based on the number of samples collected versus the number of samples planned. Fifteen wells were planned to be sampled for metals, perchlorate, explosives, hardness, and total dissolved solids. Completeness for sample analyses is summarized in Table 6-13. Ninety percent completeness was the standard established by the QAPP and this standard was met for explosives and perchlorate samples. Due to slow recovery rates at several wells (MW-6, MW-9, and MW-11) the full suite of samples could not be collected, which lowered the percent complete for unfiltered and filtered metals and total dissolved solids analyses. Further adding to the low percentage for filtered metals was a field decision not to collect samples for filtered metals if the ground water was below 5 Nephelometric Turbity Units (NTU).

TABLE 6-13 SAMPLE COMPLETENESS

Analyte	Number of Samples Planned for Collections	Number of Samples Collected	Percent Complete
Explosives	15	15	100
Metals (Unfiltered)	15	12	80
Metals (Filtered)	15	7	47
Perchlorate	15	14	93
Total Dissolved Solids	15	13	87

6.6.4 Analytical QC

Field analysis of pH, specific conductance, dissolved oxygen, and temperature was made at each well prior to collecting the samples. Monitoring wells MW-6 and MW-9 were purged dry and had very slow recovery rates which limited the number of field parameters that could be collected. The primary purpose of these analyses was to determine when the wells were sufficiently purged to provide samples representative of the ground water.

6.7 SUMMARY

Eight monitoring wells (three in Impact Field 5.3 E, four in Impact Field 3W, and one in the Delta Impact Area) were installed in the surficial aquifer underlying the study area. The wells were installed to collect ground-water quality and ground-water elevation data. In order to better define ground-water conditions in the study area, ground-water quality and elevation data were also collected from seven pre-existing wells. Based on ground-water elevation data, shallow ground water in the study area appears to follow topography.

Ground-water samples were collected from all wells and were analyzed for one or a combination of the following: 15 explosive compounds (explosives and their degradation compounds), 14 metals, DU, perchlorate, hardness, and total dissolved solids. Due to low recovery rates in some of the pre-existing wells, a full suite of sample analysis could not be completed for each well. All wells were sampled and the samples were analyzed for explosive compounds. Fourteen wells were sampled for perchlorate. Metals samples from 12 wells were collected and analyzed. Samples collected from 13 wells were also analyzed for hardness and dissolved solids.

No explosive compounds or perchlorate were detected in any ground-water sample. Antimony, cadmium, chromium, mercury, silver, and zinc were not detected in any sample. Arsenic, barium, copper, lead, and total uranium were detected in samples collected from one or more wells at concentrations below their respective primary or secondary MCL. Manganese was detected in the majority of samples collected from wells screened in the overburden at concentrations above the secondary MCL and above the mean background concentration. Manganese concentrations in samples collected from wells screened in bedrock were below the secondary MCL. Calcium concentrations exceed the mean background concentration; there is no MCL for calcium. The high concentrations of manganese and calcium in ground water are most likely a result of the parent material of the overburden in the area. Other metals detected in ground water are molybdenum, nickel, and vanadium. Reported concentrations of molybdenum, nickel, and vanadium are below their respective background concentrations; there are no MCLs for these metals.

6.8 CONCLUSIONS

Ground-water sample results show no evidence of ground-water contamination from the past use of munitions or the presence of UXO in the study area.

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7 SOILS INVESTIGATION

7.1 BACKGROUND

7.1.1 Purpose and Problem Definition

The purpose of this investigation was to determine the presence of munitions constituents (e.g., explosives, heavy metals, perchlorate, and depleted uranium) from range-related activities in surficial soils located within the Jefferson Proving Ground (JPG) Impact Area and an area identified as a Reference/Background Site. Data collected was used to assess the following study questions: 1) Are munitions-related constituents present in surficial soils? 2) Is there a human or ecological health risk associated with munitions constituents at the levels determined to be present? This section describes the soil sampling strategy and rationale and reports the results. Subsequent sections will describe the human health and ecological risk assessments.

7.1.2 Site Description

Jefferson Proving Ground, a 55,265-acre facility in operation from 1941 to 1995, was established to meet the need for conducting research and development tests and production acceptance tests during World War II. Prior to being established as a munitions and ordnance testing facility, JPG land use consisted of farmland and woodland. The types of munitions and ordnance tested at JPG include: propellants, mines, ammunition, cartridge cases, artillery projectiles, mortar rounds, grenades, tank ammunition, bombs, boosters, and rockets. JPG became a subcommand of the U.S. Army Test and Evaluation Command (TECOM) in 1962. Identified for Base Realignment and Closure (BRAC) in 1989, JPG ceased operation in 1995. In 1997, TECOM and the U.S. Fish and Wildlife Service (USFWS) signed a Memorandum of Understanding granting the USFWS a 25-year real estate permit. This has enabled the USFWS to establish the Big Oaks National Wildlife Refuge, encompassing approximately 51,000 acres north of the firing line. The USFWS allows limited public access for hunting, fishing, and tours. JPG is located on portions of Jefferson, Ripley, and Jennings Counties. JPG is approximately 18 miles long and 5 miles wide. The impact area, encompassing 51,000 acres north of the firing line, consists mostly of wooded land and some areas that were chemically (i.e., pesticide application) and physically maintained for certain munitions testing. The firing line, located north of the cantonment area, consisted of 268 gun positions. According to archive reports, there were 50 impact fields with associated safety fans. It is important to note that most of the unexploded ordnance (UXO) contamination is not limited to the impact areas. This is due to the fact that the actual target areas were used only when the detonation and/or impact of the projectile was important to the test; therefore, many of the munitions tests used for velocity measurements, gun tube proofing, or propellant were not fired into specific impact areas and may be found anywhere north of the firing line. Installation personnel voiced their concern for the possible presence of submunitions. The potential for contamination from submunitions fired into the northern portion of the impact area is largely due to the irregular manner in which this type of weapon discharges. For safety purposes, areas into which submunitions were fired were not considered as potential sample areas.

7.2 INVESTIGATION NARRATIVE

7.2.1 Rationale

Soil sampling project personnel performed an initial walkthrough of the JPG impact area March 20 – 22, 2002 and a more extensive site visit May 6 – 10, 2002. The number and type of similar areas, termed strata and substrata, to be sampled was determined through an extensive review of JPG Archive Search Reports, topographical maps, aerial photography, and personal interviews.

7.2.2 Strategy

A stratified random sampling scheme (USEPA, 1989a and 2000) was used to assess the presence of substances of potential concern (SOPC) within surficial soils located within the JPG impact area and reference site. Using this sampling scheme, the area to be studied was divided into two strata. Each stratum is defined as possessing like characteristics (e.g., terrain, soil type, vegetation, location, accessibility, usage patterns, and type/size of munitions fired in to the area) throughout the defined sample area. The two strata consisted of a depleted uranium stratum and a nondepleted uranium stratum. The two strata were further divided into substrata based upon area usage patterns, munitions fired into the area, and topography. Project personnel determined the number of areas to be sampled by identifying sample areas that were representative of the entire impact area north of the firing line. Time and funding constraints also influenced the final number of sample areas that were sampled as part of this assessment.

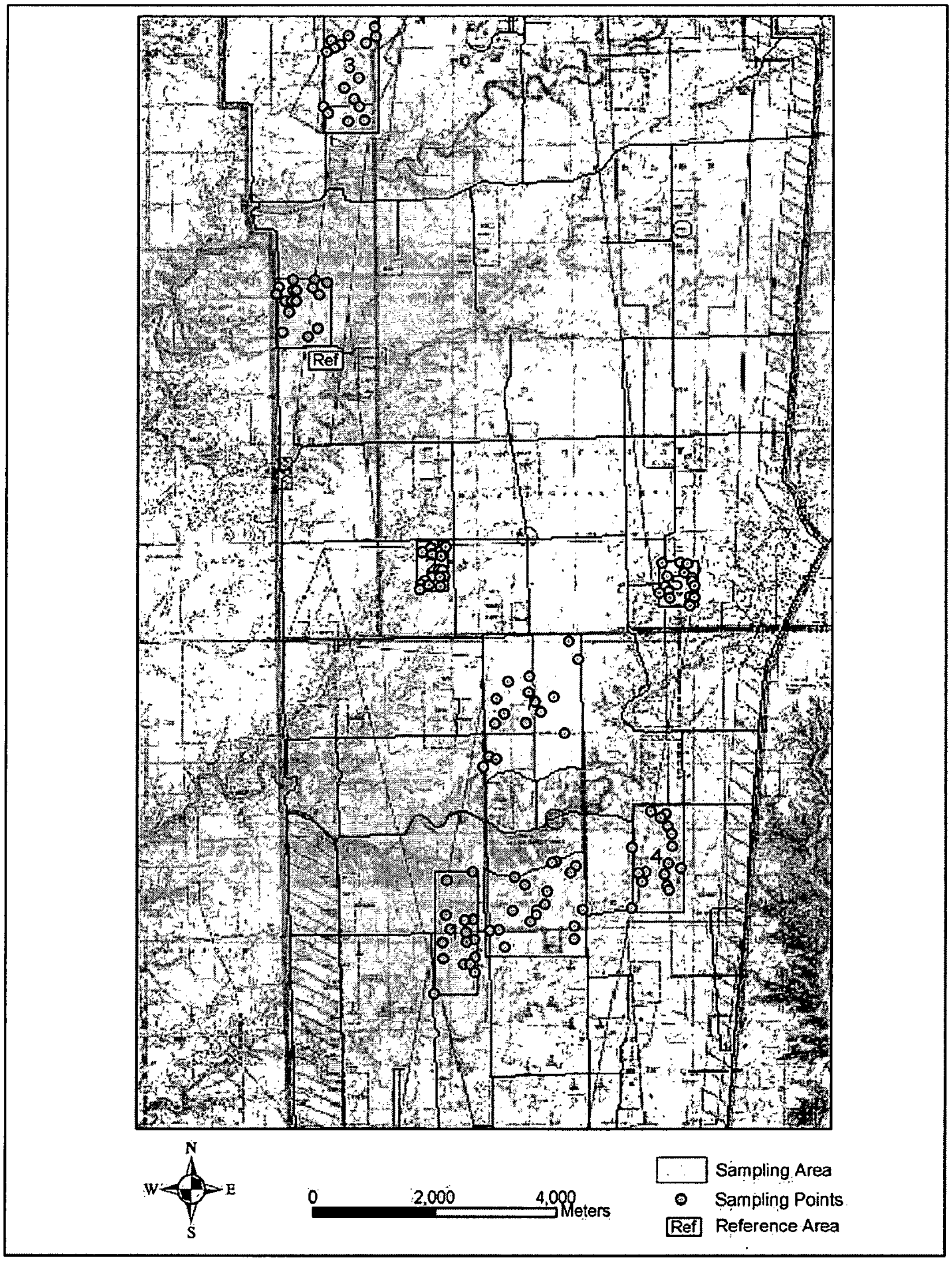
7.2.2.1 Substrata

The following eight substrata were chosen based upon characteristics that were representative of the impact area north of the firing line: five nondepleted uranium sample areas; two depleted uranium sample areas; and a reference site (See Figure 7-1). Impact areas to the north, east, south, and west were chosen to represent the entire range. The reference site was identified as one with similar terrain, soil, and vegetation to that of the impact areas. This site was also identified as an area not having been impacted by munitions-related activities, or any other activities that would result in the deposition of SOPC (e.g., heavy metals, explosives, perchlorate, depleted uranium) that are being assessed as part of this site investigation. Certain impact areas were not chosen for study due to a lack of accessibility and proximity to submunitions impact areas.

7.2.2.2 Sample Locations

Sample locations were randomly selected prior to initiating sampling activities. Sample numbers collected within each stratum were determined based on the following assumptions: Confidence Level (80%), Power (95%), Minimum detectable difference (20%), and Coefficient of Variation (30%). These parameters coincide with those recommended by the USEPA in the "Soil Sampling Quality Assurance User's Guide" (USEPA, 1989b) for sites undergoing preliminary investigations for determining potential risks to human health and the environment. Twenty samples, consisting of sixteen study samples and four quality control/quality assurance (QA/QC) samples, were collected within each study area. A number of bias samples were also collected.

FIGURE 7-1 SOIL SAMPLING POINTS



7.2.3 Composite samples

A composite sampling design approach was used to collect analytical data for this site investigation. Composite sampling is a mechanism for investigating large study sites where time and monetary limitations are sample issues (USEPA, 1989a, 1992, and 2000). Time limitations reflect how much time the study team has access to the site due to range training schedules, and money limitations reflect how many samples/analyses can be performed.

Five point composite samples were collected and used to evaluate each of the defined strata. Using a Geographic Information System (GIS), sample locations were randomly selected prior to initiating sampling activities. To determine the random location, each stratum was subdivided into 5 m^2 mini-grids, 100 per km^2, with a unique number assigned to each mini-grid. Random numbers were generated for sample identification until 16 unique mini-grids were selected. The coordinates for these samples were then entered into handheld Global Positioning Satellite (GPS) units that were used to navigate the sample teams to the predetermined sample locations. The Universal Transverse Mercator (UTM) coordinates for each sample location were recorded in field notebooks.

7.2.4 QA/QC Samples

QA/QC samples were collected to assess field precision objectives. Two field duplicate samples and two split samples were collected within each of the strata. Field duplicate samples were collected adjacent (1.5 ft to the west) to each of the five point sub-sample locations for two sample locations within each of the strata. Field split samples were taken as subsamples of two original field samples within each strata. Collection and analysis of these samples were identical to that of original field samples.

7.3 DATA EVALUATION

Samples were analyzed for parameters using methodologies shown in the JPG Quality Assurance Project Plan (QAPP) (USACHPPM, 2002).

7.3.1 Statistical Evaluation

Statistical tests used to evaluate study data were selected according to the number/percentage of non-detects; sample distribution within each study area (e.g., normality or lognormality); equality of sample variances (e.g., equal or unequal); and criteria with which each parameter of interest is to be compared (e.g., comparison data from a reference/background site or health risk based screening value). The following statistical software packages were utilized to perform various statistical analyses required to assess the JPG data: USEPA *Data Quality Evaluation Statistical Toolbox* (DataQUEST) software (USEPA, 1996); and SPSS® (SPSS Inc., 2000).

7.3.2 Nondetects

Percentage of nondetects was determined for each parameter of interest for the reference site and each study site in order to determine the type of statistical analysis method needed to analyze data that fell below the method detection limit (MDL). Table 7-1 outlines statistical methods used to analyze data according to the percentage of nondetects within the dataset for each study site (USEPA, 2000).

TABLE 7-1 GUIDELINES FOR ANALYZING DATA WITH NONDETECTS

Percentage of Nondetects	Statistical Analysis Method
< 15%	Replace nondetects with DL/2, DL, or a very small number.
15 % - 50 %	Trimmed mean, Cohen's adjustment, Winsorized mean and standard deviation
> 50 % - 90 %	Tests for proportions (i.e., Fisher's exact test or Chi Square)
> 90 %	Poisson method

7.3.3 Parametric/Nonparametric Tests

Parametric or nonparametric statistical analysis methods were used to compare parameters of interest in the study sites with the reference site. The use of parametric or nonparametric tests was determined by assessing the sample distribution for each dataset (i.e., normal, lognormal, or unknown). The Shaprio-Wilk W Test for normality was used to determine if the dataset exhibited a normal or lognormal distribution. Datasets that followed a normal or lognormal distribution were assessed using parametric testing methods (i.e., Student t-Test). Nonparametric tests (i.e., Fisher's Exact Test, Mann-Whitney Test) were used to assess datasets containing greater than 15% nondetects, or datasets having an unknown distribution. Qualitative analysis was used to assess datasets having greater than 90% nondetects.

7.3.4 Test for Equal Variances

The F-Test for the equality of two variances was used to identify the type of statistical test used to assess data following a normal or lognormal distribution. The Student's two-sample t-Test was used to compare two population means (i.e., reference site vs. study site) where the two population variances were equal. The Satterthwaite's two-sample t-Test was used to compare two population means where the two population variances were unequal.

7.3.5 Test for Outliers

The Dixon's test for outliers was used for datasets where one or more sample points were unusually large compared to all other sample points in the same strata. Even if a sample point was determined to be an outlier, statistical analysis was performed with and without the outlier(s). However, statistical outliers were included in the final data evaluation.

7.3.6 Comparison to Reference Site Data/Human Health Risk Screening Criteria

For metals concentrations to be assessed as part of the risk assessment process, the mean concentrations of metals in the study site must be present above background levels. For datasets that were found to be significantly greater in the study site than in the reference site and that followed a normal or lognormal distribution, the 95% Upper Confidence Limit (UCL) of the dataset was compared to the human health risk screening criteria, established in Appendix L, JPG Data Quality Objectives (DQOs) documented in the JPG QAPP. For datasets that were significantly greater in the study site than the reference site and that followed an unknown distribution, the 99th percentile was compared to the human health risk screening value for the parameter of interest. Explosives and perchlorate datasets followed an unknown distribution. Therefore, the 99th percentile was used to compare explosives and perchlorate datasets to the human health risk screening criteria established in the JPG DQOs for these parameters. The 95% UCL was obtained by collecting samples from across the impact area (within each defined strata) and calculating the average concentration and standard deviation. Assuming that the impact area is heterogeneous, strata were defined in an attempt to group or isolate like areas.

7.4 REFERENCE SITE DATA EVALUATION

7.4.1 Reference Site Identification

The reference site (approximately 0.88 km^2) was located 11 km north of the firing line on West Perimeter Road adjacent to Gate 15 (See Figure 7-1). This area was selected as one having similar characteristics (i.e., soil type, vegetation, species habitat terrain) to the study sites identified for sampling within the JPG impact area. Soils within this area consist of a brown silt loam and are similar to soils located within each of the study areas. Although this area was identified as one having no signs of impact from military munitions, or any other activities that may have resulted in the presence of target analytes, uncertainty exists as to the exact activities that may have taken place within this area throughout the duration of JPG's existence. Though there was evidence of an old homestead in this area, there was no visual evidence of munitions-related activities. Twenty-one samples were collected within this area, consisting of, 16 five-point composite samples; 4 QA/QC samples (i.e., 2 split and 2 duplicate samples); and 1 bias sample collected for comparison to ecological sample results. Sample location coordinates are shown in Table H-1 of Appendix H.

7.4.2 Metals

Of the 13 metals analyzed for at the reference site, 100% of the samples tested for cadmium and silver were below detection limits or had estimated values below the detection limit. Three of the metals, antimony, mercury and molybdenum, were found to have a large number of nondetects. Based upon USEPA guidance (See Table 7-1), a Test for Proportions statistical analysis method was used to compare datasets having a large number of nondetects (> 50%). The 99th percentiles for each of these parameters (See Table 7-2) were below the human health risk screening criteria identified in Table 7-2, as outlined in the JPG DQOs. The remaining eight metals, arsenic, barium, chromium, copper, lead, manganese, nickel, and vanadium were found to be 100% above the laboratory detection limits for each of the parameters of interest. The 99th percentile for each these parameters, except manganese (See Table 7-2 and Section 7.13.1), were below the human health risk screening criteria for each of the parameters. Depending on the sample distribution of each parameter of interest at the study site and the reference site, a parametric or nonparametric test was used to determine if the parameter of interest was significantly greater in the study site than in the reference site. Table 7-2 lists the sample average, sample median, sample standard deviation, percentage of nondetects, sample distribution, 99th percentile, and human health risk criteria for each parameter of interest.

TABLE 7-2 REFERENCE SITE DATA SUMMARY

	Average (mg/kg)	Median (mg/kg)	STD@ (mg/kg)	%Non-Detects	Sample Distribution	High Value mg/kg (99th Percentile)	Health Risk Criteria (mg/kg)
Antimony	1.79	1.00	0.17	76%	Unknown	1.68	31
Arsenic	5.55	5.29	2.70	0%	Normal	16.10	--
Barium	96.20	91.90	31.35	0%	Normal	146.00	5,400
Cadmium	--	--	--	100	NA	NA	37
Chromium	10.62	10.30	2.77	0%	Unknown	13.90	210
Copper	7.02	6.54	2.16	0%	Normal	11.70	2900
Lead	24.02	20.00	15.30	0%	Unknown	72.30	400
Manganese*	878.86	855.00	418.52	0%	Normal	1970	1800
Mercury	0.054	0.051	0.017	48%	Unknown	0.094	23
Molybdenum	1.03	1.00	0.13	95%	Unknown	1.61	390
Nickel	6.11	5.94	1.81	0%	Normal	11.00	1600
Silver	1.00	1.00	0	100%	NA	NA	390
Vanadium	34.209	22.8	51.6078	0%	Unknown	51.30	550
RDX	0.013	.01	0.007	67%	Unknown	0.040	4
Perchlorate	0.021	0.02	0.015	90%	Unknown	0.071	100

* Value greater than the human health risk screening criteria.
# The metals summaries are inclusive of all quality assurance/quality control samples.
@ Standard Deviation.

7.4.3 Explosives

RDX and perchlorate were detected at the reference site. RDX was detected in the following seven samples collected within the reference site: REF-SL-01 (0.02 mg/kg), REF-SL-05 (0.019 mg/kg), REF-SL-11 (0.018 mg/kg), REF-SL-12 (0.011 mg/kg), REF-SL-18 (0.04 mg/kg), REF-SL-19 (0.016 mg/kg), and REF-SL-20 (0.011 mg/kg). Three of these samples were QA/QC samples (i.e., one duplicate and two split samples), however, RDX was not detected in the original field samples. Perchlorate was detected above the MDL in samples REF-SL-05 (0.071 mg/kg) and REF-SL-18 (0.052 mg/kg). The 99th percentiles, (0.04 mg/kg) and (0.071 mg/kg) for RDX and perchlorate respectively, were below the human health risk screening criteria (4 mg/kg, RDX and 100 mg/kg, perchlorate) listed in Table 7-3, as outlined in the JPG DQOs. Unlike within the study sites, there were no visual signs of munitions-related activities within the reference site. There was also no signal from the magnetometer handled by Explosive Ordnance Disposal (EOD) technicians signaling the presence of UXO in the area. As a result, it is uncertain whether the reference site chosen was an appropriate background/comparison site (e.g., clean) or whether detections of RDX and perchlorate within this area are suspect (e.g., possible cross contamination). The data was third party validated. There is no evidence of sampling or laboratory error. Reference surface water and sediment samples also were found to contain munitions constituents. For these reasons, we believe that the reference sample results are valid as reported. Because the low levels that were reported do not exceed the human health criteria, no additional sampling is recommended.

TABLE 7-3 STUDY SITE 1 DATA SUMMARY

	Average (mg/kg)	Median (mg/kg)	STD@ (mg/kg)	% Nondetect	Sample Distribution	High Value (mg/kg) (99th Percentile)	Human Health Risk Criteria (mg/kg)	Ho Not Rejected (NR) Rejected (R)
Antimony	--	--	--	100	NA	NA	31	NR
Arsenic	4.47	4.23	1.39	0	Normal	7.22	--	NR
Barium	116.85	89.35	85.08	0	Unknown	473.00	5,400	NR
Cadmium	1.02	1.00	0.11	95	Unknown	1.53	37	NR
Chromium	9.51	9.16	1.72	0	Normal	13.50	210	NR
Copper	34.12	19.45	42.00	0	Unknown	196.00	2900	R
Lead	17.58	16.55	3.67	0	Unknown	29.20	400	NR
Manganese	627.14	562.50	328.30	0	Normal	1440.00	1800	NR
Mercury	0.050	0.040	0.027	81	Unknown	0.139	23	NR
Molybdenum	1.16	1.00	0.34	76	Unknown	2.21	390	NR
Nickel	5.16	4.97	1.46	0	Normal	8.33	1600	NR
Silver	--	--	--	100	NA	NA	390	NR
Vanadium	21.3	20.2	4.67	0	Normal	28.50	550	NR
RDX	0.010	0.010	0.002	95	Unknown	0.018	4	NA
Perchlorate	0.033	0.020	0.033	76	Unknown	0.110	100	NA

NA – Not Analyzed
@STD – Standard Deviation
Ho – Null Hypothesis

7.5 STUDY SITE 1 DATA EVALUATION (COMBINED IMPACT AREAS 3 WEST (W), 3.3 W, 4.2 W, AND 4.5 W)

7.5.1 Site Identification

Study Site 1 (approximately 1.5 km^2) combined impact areas 3 West (W), 3.3 W, 4.2 W, and 4.5 W, as designated on the installation topographic map (See Figure 7-1). This study site, a substrata of the nondepleted uranium strata, was located 3.5 km north of the firing line, west of the depleted uranium impact area. This area was observed to be a heavily impacted area. JPG archive records indicate that testing activities in this area included: propellant, fuse, high explosive (HE) shell, small canister and illuminating munitions tests. Types of ordnance fired into this area include 105 and 155mm howitzers, 81mm mortars, 57, 75, 105 and 106 mm recoilless. This area consisted of both wooded and nonwooded areas containing a high amount of shrubbery. Soils in this area were poorly drained to somewhat poorly drained with a seasonally high water table. These soils typically have a grayish brown silt loam surface layer about 6 inches thick. The subsoil was a light brownish gray, mottled silt loam in the upper part and a yellowish brown, mottled silt loam and strong brown clay in the lower part (Jefferson County Soil Survey Map, 1985). The soils in this area were similar to soils in the reference site. Twenty-two samples were collected within this area, consisting of, 16 five-point composite samples; 4 QA/QC samples (i.e., 2 split and 2 duplicate samples); and 2 bias samples collected for comparison to ecological sample results. Sample location coordinates are shown in Table H-2

7.5.2 Metals

Of the 13 metals analyzed for at Study Site 1, 100% of the samples tested for antimony and silver were below MDLs or had estimated values below the detection limit. Cadmium was detected above the MDL in only one sample, ST1-SL-13 (1.53 mg/kg). However, this value (99th percentile) was below the human health risk criteria of 37 mg/kg defined in the JPG DQOs. Mercury and molybdenum had a high percentage (> 50%) of nondetects. The Fisher's Exact Test for Proportions statistical analysis method was used to compare the proportions of these parameters in Study Site 1 with the proportions of detects in the reference site. Using this statistical method, it was determined that the proportions of detects for mercury and molybdenum were not significantly greater in the study site than the reference site. The remaining eight metals, arsenic, barium, chromium, copper, lead, manganese, nickel, and vanadium were detected above the laboratory MDLs in all samples collected within this area. Depending on the sample distribution of each parameter of interest at both the study site and the reference site, a parametric or nonparametric test was used to determine if the mean concentration, median concentration, or proportions of detects for each parameter of interest was significantly greater in the study site than the referenced site. Of these remaining metals, only copper was found to be significantly greater in Study Site 1 than in the reference site. Using the Dixon's test for outliers, the high value for copper (196 mg/kg) at this site was determined to be an outlier. Statistical analysis was performed with and without the outlier. The nonparametric, Mann-Whitney test (for unknown sample distribution) was used to compare the datasets with the outlier included while the Student Two Sample t-Test (for normal or lognormal sample distributions) was used to compare the datasets without the outlier. In each case, the median for this dataset was significantly greater in Study Site 1 than in the reference site. Though the study site was significantly greater than the reference site, the 99th percentile (196 mg/kg) was less than the human health risk screening criteria (2,900 mg/kg) identified in Table 7-3, as outlined in the JPG DQOs.

7.5.3 Explosives

RDX and perchlorate were detected above the laboratory MDLs at Study Site 1. RDX was detected in samples ST1-SL-12 and ST1-SL-22 (0.011 mg/kg and 0.018 mg/kg, respectively). Perchlorate was detected in the following five samples collected at this site: ST1-SL-11 (0.056 mg/kg), ST1-SL-14 (0.025 mg/kg), ST1-SL-15 (0.036 mg/kg), ST1-SL-16 (0.11 mg/kg), and ST1-SL-20 (0.04 mg/kg). The 99th percentile for each of these parameters, 0.018 (RDX) and 0.11 (perchlorate), were below the human health risk screening criteria, 4 mg/kg (RDX) and 100 mg/kg (perchlorate), identified in Table 7-3, as outlined in the document, JPG DQOs. No other explosives were detected at this site.

7.6 STUDY SITE 2 DATA EVALUATION (IMPACT AREA 10 W)

7.6.1 Site Identification

Study Site 2 (approximately 0.30 km^2), designated as Impact Area 10 W on the installation topographic map, was a substrata of the nondepleted uranium sample strata. This area, located 9.5 km north of the firing line and 2.5 km east of West Perimeter Road, was observed to contain a high number of impact craters (See Figure 7-1). Types of ordnance fired into this area included 105mm, 155mm, and 90 mm HE rounds. The majority of the sample area consisted of grassland and shrubbery. The terrain in this area was moderately to gently sloping, with strong slopes (12 to 18 percent) along the tributary traversing the southern portion of the study area. The soils in this area consisted of silt loams of various soil descriptions depending on the topography of the area. The soils in this area were similar to the soils in the reference site. The southern portion of the sample area was wooded, and traversed by a tributary of Marble Creek, which empties into Big Creek. Twenty-one samples were collected within this area, consisting of 16 five-point composite samples; 4 QA/QC samples (i.e., 2 split and 2 duplicate samples); and 1 bias sample. Sample location coordinates are shown in Table H-2.

7.6.2 Metals

One hundred percent of the samples analyzed for antimony, cadmium, and silver were below laboratory MDLs. Mercury and molybdenum had a high percentage of (> 50%) nondetects. Using the Fisher's Exact test, it was determined that the proportions of detects for mercury were significantly greater in the reference site than in Study Site 2. There was not a significant difference in the proportions of detects for molybdenum in Study Site 2 and the reference site. The remaining eight metals, arsenic, barium, chromium, copper, lead, manganese, nickel, and vanadium were detected above MDLs within this study site. Depending on the sample distribution of each parameter of interest at both the study site and the reference site, a parametric or nonparametric test was used to determine if the mean concentration, median concentration, or the proportions of detects were significantly greater in the study site than in the reference site. The nonparametric, Mann-Whitney statistical analysis method, was used to compare each of these parameters in Study Site 2 with the reference site. Of these remaining metals, only copper was significantly greater in the study site than in the reference site ($p < 0.2$). Though copper was significantly greater in the study site than the reference site, the 99th percentile (65.3 mg/kg) was below the human health screening criteria (2,900 mg/kg) for this parameter. Sample data is shown in Table 7-4.

TABLE 7-4 STUDY SITE 2 DATA SUMMARY

	Average (mg/kg)	Median (mg/kg)	STD@ (mg/kg)	% Nondetect	Sample Distribution	High Value (mg/kg) (99th Percentile)	Human Health Risk Criteria (mg/kg)	Ho Not Rejected (NR) Rejected (R)
Antimony	1.00	1.00	0	100	NA	NA	31	NR
Arsenic	4.87	4.06	3.43	0	Unknown	10.90		NR
Barium	157.70	104.00	114.40	0	Unknown	415.00	5,400	NR
Cadmium	1.00	1.00	0	100	NA	NA	37	NR
Chromium	10.05	9.58	2.18	0	Unknown	15.50	210	NR
Copper	11.60	8.17	12.80	0	Unknown	65.30	2900	R
Lead	19.90	16.70	8.75	0	Unknown	34.60	400	NR
Manganese	460.20	361.00	372.10	0	Unknown	1250.00	1800	NR
Mercury	0.043	0.040	0.006	76	Unknown	0.059	23	NR
Molybdenum	1.10	1.00	0.32	90	Unknown	2.35	390	NR
Nickel	5.62	4.97	3.10	0	Unknown	16.40	1600	NR
Silver	1.00	1.00	0	100	NA	NA	390	NR
Vanadium	23.90	19.70	8.20	0	Unknown	49.80	550	NR
RDX	--	--	--	100	NA	NA	4	NA
Perchlorate	--	--	--	100	NA	NA	100	NA

NA – Not Analyzed ?
@STD – Standard Deviation
Ho – Null Hypothesis

7.6.3 Explosives

One hundred percent of the samples analyzed for explosives and perchlorate at this site were below the laboratory MDLs. Sample data is shown in Table 7-4.

7.7 STUDY SITE 3 DATA EVALUATION (IMPACT AREA 18 W)

7.7.1 Site Identification

Study Site 3 (approximately 2.25 km^2), designated as Impact Area 18W on the installation topographic map, was a substrata of the nondepleted uranium sample strata. This area, located 16 km north of the firing line and 2 km east of West Perimeter Road, was observed to be a heavily impacted area (See Figure 7-1). Archive reports indicated that 60 mm rounds and 81 mm illuminating rounds were fired into this area. Interviews with long-term JPG personnel indicated the potential for White Phosphorus to be present in the soils at this sample area. This area consisted of both wooded and nonwooded areas. Tributaries in this study site flowed to the southwest into Graham Creek. Soils in this area were predominately Cobbsfork soils. These soils are poorly drained, nearly level soils with a dark grayish brown silt loam surface layer. The upper part of the subsoil is light gray, mottled silt loam and silty clay loam. The lower part is a gray, dark yellowish brown, and yellowish brown, mottled silt loam and silty clay loam. The soils in this area were similar to the soils in the reference site. Twenty samples were collected within this area. These samples consisted of 16 five-point composite samples and 4 QA/QC samples (i.e., 2 split and 2 duplicate samples). No bias samples were collected in this area. Sample location coordinates are shown in Table H-4.

7.7.2 Metals

One hundred percent of the samples analyzed for mercury and silver at this site were below laboratory MDLs. Antimony, cadmium, and molybdenum had a high percentage of nondetects (> 50%). The study site had one more detect than the reference site for both cadmium and molybdenum. Therefore, upon qualitative analysis, it was determined that there was not a significant difference in the proportions of detects in Study Site 3 and the proportions of detects in the reference for each of these parameters. The nonparametric, Fisher's Exact Test for Proportions, was used to determined that the proportions of detects of antimony in Study Site 3 were significantly greater than in the reference site. Though the proportions of detects for antimony at Study Site 3 was significantly greater than the reference site, the 99th percentile for antimony (2.49 mg/kg) at Study Site 3 were below the human health risk criteria (31 mg/kg) identified in Table 7-5. The remaining eight metals, arsenic, barium, chromium, copper, lead, manganese, nickel, and vanadium, were detected in 100 % of the samples collected at Study Site 3 and followed an unknown distribution. Using the nonparametric, Mann-Whitney test, it was determined each of the parameters was not significantly greater in Study Site 3 than in the reference site.

7.7.3 Explosives

RDX was detected in samples ST3-SL-01 (0.04 mg/kg), ST3-SL-03 (0.04 mg/kg), and ST-SL-05 (0.06 mg/kg). The 99th percentile (0.06 mg/kg) was below the human health risk criteria (4 mg/kg) identified in Table 7-5, as outlined in the JPG DQOs. There were no other explosives detected at this site. Perchlorate was not detected at this site.

TABLE 7-5 STUDY SITE 3 DATA SUMMARY

	Average (mg/kg)	Median (mg/kg)	STD@ (mg/kg)	% Nondetect	Sample Distribution	High Value (mg/kg) (99th Percentile)	Human Health Risk Criteria (mg/kg)	Ho Not Rejected (NR) Rejected (R)
Antimony	1.36	1.00	0.53	55	Unknown	2.49	31	R
Arsenic	4.08	3.44	2.35	0	Unknown	8.3		NR
Barium	110.60	58.85	206.00	0	Unknown	979	5,400	NR
Cadmium	1.04	1.00	0.19	95	Unknown	1.84	37	NR
Chromium	9.05	8.88	2.17	0	Unknown	13.10	210	NR
Copper	4.40	4.16	1.32	0	Unknown	7.94	2900	NR
Lead	13.80	12.75	3.95	0	Unknown	27.70	400	NR
Manganese	196.10	125.00	191.10	0	Unknown	683.00	1800	NR
Mercury	--	--	--	100	NA	NA	23	NR
Molybdenum	1.08	1.00	0.27	90	Unknown	2.17	390	NR
Nickel	3.31	3.01	1.04	0	Unknown	5.74	1600	NR
Silver	--	--	--	100	NA	NA	390	NR
Vanadium	22.74	18.75	9.56	0	Unknown	45.30	550	NR
RDX	0.016	0.010	0.014	85	Unknown	0.060	4	NA
Perchlorate	--	--	--	100	NA	NA	100	NA

NA – Not Analyzed ?
@STD – Standard Deviation
Ho – Null Hypothesis

7.8 STUDY SITE 4 DATA EVALUATION (IMPACT AREAS 4.5 EAST (E) AND 5.3 E)

7.8.1 Site Identification

Study Site 4 (approximately 1.6 km^2), designated as Impact Areas 4.5 East (E) and 5.3 E on the installation topographic map, was a substrata of the nondepleted uranium sample strata. This study site, located 4.7 km north of the firing line and 0.75 km to the east of the depleted uranium sample area, was observed to have a high amount of impact craters (See Figure 7-1). Archive reports indicated that 81 mm mortar, 4.2-inch mortar inert and HE, and 105 howitzer rounds were fired into this area. Past land maintenance activities have involved the use of both chemical and mechanical methods to control vegetation growth for the purpose of observing munitions testing at this location. Chemical applications (i.e., bromocil) were used prior to the mechanical maintenance activities that had occurred over the past 20 years. Past maintenance practices have most likely resulted in this becoming a nonwooded, grassy area. This area consisted of gently sloping to nearly level terrain, with some moderately sloping areas. Soils in areas of nearly level terrain typically consisted of a deep, poorly drained grayish brown silt loam surface layer. Areas of gently sloping to moderately sloping terrain consisted of well-drained soils on the uplands, with a dark yellowish brown silt loam and brown silty clay loam surface layer. The soils in this area were similar to the soils in the reference site. Twenty samples were collected within this area. These samples consisted of 16 five-point composite samples and 4 QA/QC samples (i.e., 2 split and 2 duplicate samples). No bias samples were collected in this area. Sample location coordinates are shown in Table H-5.

7.8.2 Metals

One hundred percent of the samples analyzed for cadmium, mercury, and silver were below the MDLs. There was a high percentage of nondetects (> 50%) for antimony and molybdenum at the study site. Upon qualitative analysis, it was determined that there was no significant difference between the proportion of detects for antimony and molybdenum at Study Site 4 and the proportions of these parameters at the reference site. Using the nonparametric, Mann-Whitney test, only copper and vanadium were determined to be significantly greater in Study Site 4 than in the reference site. Though the medians for these parameters were significantly greater in the study site than in the reference site, the 99th percentiles, (44.6 mg/kg) and (46.9 mg/kg) for copper and vanadium respectively, were less than the human health risk screening criteria (2,900 mg/kg, copper) and (550 mg/kg, vanadium) identified in Table 7-6, as outlined in the JPG DQOs.

TABLE 7-6 STUDY SITE 4 DATA SUMMARY

	Average (mg/kg)	Median (mg/kg)	STD@ (mg/kg)	% Nondetect	Sample Distribution	High Value (mg/kg) (99th Percentile)	Human Health Risk Criteria (mg/kg)	Ho Not Rejected (NR) Rejected (R)
Antimony	1.23	1.00	0.73	90	Unknown	3.91	31	A
Arsenic	6.34	4.31	7.01	0	Unknown	34.00	--	A
Barium	81.00	55.30	100.50	0	Unknown	97.80	5,400	A
Cadmium	--	--	--	100	NA	NA	37	A
Chromium	11.06	10.45	3.33	0	Unknown	18.8	210	A
Copper	10.78	7.75	9.08	0	Unknown	44.6	2900	R
Lead	18.28	14.00	8.37	0	Unknown	43	400	A
Manganese	216.50	120.00	153.50	0	Unknown	553	1800	A
Mercury	--	--	--	100	NA	NA	23	A
Molybdenum	1.04	1.00	0.19	95	Unknown	1.87	390	A
Nickel	4.34	3.96	1.56	0	Unknown	7.61	1600	A
Silver	--	--	--	100	NA	NA	390	A
Vanadium	26.40	24.90	9.16	0	Unknown	46.90	550	R
RDX	0.015	0.010	0.014	85	Unknown	0.069	4	NA
Perchlorate	0.017	0.020	0.007	90	Unknown	0.029	100	NA

A -
NA – Not Analyzed
@STD – Standard Deviation
Ho – Null Hypothesis

7.8.3 Explosives

Perchlorate was detected in samples ST4-SL-16 (0.029 mg/kg) and ST4-SL-20 (0.028mg/kg). The 99th percentile (0.029 mg/kg) was below the human health risk criteria (100 mg/kg) for soil, as established by USACHPPM. RDX was detected in samples ST4-SL-13 (0.039 mg/kg), ST4-SL-14 (0.069 mg/kg), and ST4-SL-16 (0.019 mg/kg). The 99th percentile (0.069 mg/kg) was below the human health risk criteria (4 mg/kg) for RDX identified in Table 7-6, as outlined in the JPG DQOs. There were no other explosives detected at this site.

7.9 STUDY SITE 5 DATA EVALUATION (IMPACT AREA 9.8 E)

7.9.1 Site Identification

Study Site 5 (approximately 4.8 km^2), designated as Impact Area 9.8 E on the installation topographical map, was a substrata of the nondepleted uranium sample strata. This area, located 9.5 km north of the firing line and 2 km west of East Perimeter Road, was observed to be a very heavily impacted area (See Figure 7-1). Archive reports indicated that 105 and 155 mm HE and inert rounds were fired into this area. This area consisted of dense, low lying vegetation, as well as wooded areas. The terrain in this area ranges from nearly level to moderately sloping. The soils in this area consist of silt loams of various soil descriptions, depending on the topography of the area. The majority of the soils in this sample area were poorly drained, nearly level soils with a dark grayish brown silt loam surface layer. The upper part of the subsoil of this soil type is a light gray, mottled silt loam and silty clay loam. The lower part is a gray, dark yellowish brown, and yellowish brown, mottled silt loam and silty clay loam. The soils in this area were similar to the soils in the reference site. Twenty-one samples were collected within this area, consisting of 16 five-point composite samples; 4 QA/QC samples (i.e., 2 split and 2 duplicate samples); and 1 bias sample. Sample location coordinates are shown in Table H-6.

7.9.2 Metals

Samples analyzed for antimony, cadmium, mercury, molybdenum, and silver at Study Site 5 had a high percentage (> 50%) of nondetects. Due to cadmium and silver having greater than 90% nondetects, qualitative analysis was used to determine that there was no significant difference between the proportions of detects for these parameters at Study Site 5 and the proportions of these parameters at the reference site. The Fisher's Exact test was used to determine that the proportions of detects for antimony and molybdenum were not significantly greater in Study Site 5 than the reference site. The proportions of detects for mercury in Study Site 5 were not significantly greater than in the reference site. Of the remaining eight metals, only copper was found to be significantly greater in Study Site 5 than in the reference site. Even though copper was significantly greater in the study site than the reference site, the 99th percentile (71 mg/kg) for this dataset was below the human health risk screening criteria (2,900 mg/kg) identified in Table 7-7, as outlined in the JPG DQOs.

TABLE 7-7 STUDY SITE 5 DATA SUMMARY

	Average (mg/kg)	Median (mg/kg)	STD@ (mg/kg)	% Nondetect	Sample Distribution	High Value (mg/kg) (99% Percentile)	Human Health Risk Criteria (mg/kg)	Ho Not Rejected (NR) Rejected (R)
Antimony	1.14	1.00	0.42	76	Unknown	2.90	31	NR
Arsenic	4.32	3.38	2.47	0	Unknown	9.87	--	NR
Barium	52.70	46.60	17.10	0	Normal	103.00	5,400	NR
Cadmium	1.05	1.00	0.22	95	NA	2.03	37	NR
Chromium	9.77	9.35	2.56	0	Unknown	16.60	210	NR
Copper	17.80	11.00	18.64	0	Unknown	71.00	2900	R
Lead	16.10	14.00	5.59	0	Unknown	32.50	400	NR
Manganese	296.00	94.20	378.50	0	Unknown	1230.00	1800	NR
Mercury	0.0431	0.040	0.011	90	Unknown	0.088	23	NR
Molybdenum	1.04	1.00	0.13	85	Unknown	1.58	390	NR
Nickel	3.99	3.71	1.52	0	Normal	6.97	1600	NR
Silver	1.08	1.00	0.37	95	Unknown	2.70	390	NR
Vanadium	21.80	20.60	6.80	0	Unknown	36.90	550	NR
RDX	0.018	0.010	0.021	81	Unknown	0.098	4	NA
Perchlorate	0.030	0.020	0.025	66	Unknown	0.093	100	NA
2,4 Dinitrotoluene	0.047		0.122	95	Unknown	0.58	120	NA
2,6 Dinitrotoluene	0.012		0.008	95	Unknown	0.046	61	NA

NA – Not Analyzed
@STD – Standard Deviation
Ho – Null Hypothesis

7.9.3 Explosives

RDX, 2,4 dinitrotoluene, 2,6 dinitrotoluene, and perchlorate were detected at this study site. RDX was detected in the following five samples: ST5-SL-04 (0.024 mg/kg), ST5-SL-05 (0.011mg/kg), ST5-SL-07 (0.04 mg/kg), ST5-SL-17 (0.098 mg/kg), and ST5-SL-19 (0.049 mg/kg). The 99th percentile (0.098 mg/kg) was below the human health risk criteria (4 mg/kg) identified in Table 7-7. The explosives 2,4 dinitrotoluene and 2,6 dinitrotoluene were both detected in sample ST5-SL-09 (0.58 mg/kg and 0.046 mg/kg respectively). Each of these concentrations was below the human health risk screening criteria identified in the JPG DQOs. Perchlorate was detected in the following seven of the samples collected within Study Site 5: ST5-SL-04 (0.076 mg/kg), ST5-SL-11 (0.076 mg/kg), ST5-SL-13 (0.042 mg/kg), ST5-SL-14 (0.027 mg/kg), ST5-SL-15 (0.033 mg/kg), ST5-SL-16 (0.063 mg/kg), and ST5-SL-18

(0.093 mg/kg). The 99th percentile (0.093 mg/kg) was below the human health risk screening criteria (100 mg/kg), as established by USACHPPM. There were no other explosives detected at this site.

7.10 STUDY SITE 6 DATA EVALUATION (SUBSTRATA OF THE DU IMPACT STRATA LOCATED IN THE SOUTHERN PORTION OF THE DU IMPACT AREA)

7.10.1 Site Identification

Study Site 6 (approximately 2.0 km^2) was located in the southern portion of the DU impact area as designated on the installation topographic map (See Figure 7-1). Test rounds were scattered throughout the sample area due to the nature of the various types of munitions testing which have occurred in this area. However, in order to minimize dispersal of DU particles, test items were fired into two cloth targets located 3000 meters from the firing line and one in the northern portion of this area located 4000 meters from the firing line. According to JPG personnel, this sample area was used for munitions testing prior to being designated as the DU impact area. Study personnel surveyed HE ordnance (i.e., 155 mm rounds) in the sample area during the site visit. Multiple craters and UXO were surveyed in this area. This area consisted of wooded and nonwooded areas. The majority of the terrain in this area was nearly level. The soil in this area had a grayish brown silt loam surface layer. The subsurface layer, extending about 80 inches in depth, consisted of a light brownish gray silt loam in the upper part and a brown, firm clay loam in the lower part. The soils in this area were similar to the soils in the reference site. Twenty-three samples were collected within this area, consisting of 16 five-point composite samples; 4 QA/QC samples (i.e., 2 split and 2 duplicate samples); and 3 bias samples. Sample location coordinates are shown in Table H-7.

7.10.2 Metals

One hundred percent of the samples analyzed for antimony, cadmium, and silver were below MDLs. Mercury and molybdenum had a high percentage of nondetects (> 50%). Using the Fisher's Exact test, it was determined that Study Site 6 had a significantly greater proportion of detects for mercury than the reference site. However, the 99th percentile (0,085 mg/kg) for mercury at Study Site 6 was below the human health risk screening criteria (23 mg/kg). Using the Fisher's Exact statistical analysis method, it was determined that the proportions of detects for molybdenum were not significantly greater in Study Site 6 than in the reference site. Of the remaining eight metals, only copper was significantly greater in Study Site 6 than in the reference site. The Mann-Whitney statistical analysis method was used to determine whether copper was significantly greater in the study site than in the reference site. The Dixon's test for outliers determined that there were no outliers present in this dataset. Though copper was significantly greater in the study site than in the reference site, the 99th percentile (17.1 mg/kg) for copper was below the human health risk criteria (2,900 mg/kg) identified in Table 7-8.

TABLE 7-8 STUDY SITE 6 DATA SUMMARY

	Average (mg/kg)	Median (mg/kg)	STD@ (mg/kg)	% Nondetect	Sample Distribution	High Value (mg/kg) (99th Percentile)	Human Health Risk Criteria (mg/kg)	Ho Not Rejected (NR) Rejected (R)
Antimony	--	--	--	100	NA	NA	31	NR
Arsenic	3.90	2.32	3.79	0	Unknown	15.20	--	NR
Barium	85.40	76.60	37.80	0	Normal	182.00	5,400	NR
Cadmium	--	--	--	100	NA	NA	37	NR
Chromium	9.16	8.12	3.38	0	Unknown	19.10	210	NR
Copper	8.34	8.23	3.20	0	Normal	17.10	2900	R
Lead	16.00	15.30	4.70	0	Unknown	28.20	400	NR
Manganese	280.50	83.30	390.50	0	Unknown	1010.00	1800	NR
Mercury	0.043	0.040	0.009	87	Unknown	0.085	23	NR
Molybdenum	1.02	1.00	0.11	96	Unknown	1.54	390	NR
Nickel	4.14	2.94	2.63	0	Unknown	10.40	1600	NR
Silver	--	--	--	100	NA	NA	390	NR
Uranium	6.47	2.78	11.2	0	NA	45.8	200	NA
Vanadium	20.20	16.30	10.80	0	Unknown	55.10	550	NR
RDX	0.015	.010	0.016	83	Unknown	0.083	4	NA
Perchlorate	0.029	0.020	0.023	70	Unknown	0.097	100	NA
2,4,6 Trinitrotolune	0.012		0.010	91	Unknown	0.06	12	NA

NA – Not Analyzed
@ – Standard Deviation
Ho – Null Hypothesis

7.10.3 Explosives

Of the explosives analyzed for at this site, 2,4,6 Trinitrotoluene, and RDX and perchlorate were detected. 2,4,6 Trinitrotoluene was detected in samples ST6-SL-05 (0.012 mg/kg) and ST6-SL-22 (0.06 mg/kg). Each of these concentrations was below the human health risk screening criteria (12 mg/kg) identified in Table 7-8, as outlined in the JPG DQOs. RDX was detected in samples ST6-SL-02 (0.014 mg/kg), ST6-SL-21 (0.022 mg/kg), ST6-SL-22 (0.037 mg/kg), and ST6-SL-23 (0.083 mg/kg). The 99th percentile (0.083 mg/kg) was below the human health risk screening criteria (4 mg/kg) identified in Table 7-8. Perchlorate was detected in the following six samples collected at this study site: ST6-SL-01 (0.062 mg/kg), ST6-SL-04 (0.033 mg/kg), ST6-SL-07 (0.093 mg/kg), ST6-SL-10 (0.097 mg/kg), ST6-SL-14 (0.056 mg/kg), and ST6-SL-23 (0.048 mg/kg). The 99th percentile (0,097mg/kg) for perchlorate was below the human health risk screening criteria (100 mg/kg) identified in Table 7-8.

7.11 STUDY SITE 7 DATA EVALUATION (SUBSTRATA OF THE DU IMPACT STRATA LOCATED IN THE NORTHERN PORTION OF THE DU AREA)

7.11.1 Site Identification

Study Site 7 was a substrata of the DU impact strata. This area (approximately 2.25 km^2) consisted of the northern portion of the DU impact area (See Figure 7-1). According to long-term installation personnel, impacts in this sample area occurred as a result of test items fired into the southern portion of the impact area that ricocheted into the northern portion of the impact area. The majority of this sample area consisted of nearly level terrain. The majority of the soil consisted of a poorly drained grayish brown silt loam surface layer. The subsurface layer, extending about 80 inches in depth, consisted of a light brownish gray silt loam in the upper part and a brown, firm clay loam in the lower part. This sample area was traversed northeast to southwest by a tributary of Big Creek. The terrain along this tributary was moderate to steep sloping. The soils in this area were silt loams of various soil descriptions depending on the terrain. The soils in this area were similar to the soils in the reference site. The area consisted of both wooded and nonwooded terrain. Twenty-two samples were collected within this area, consisting of 16 five-point composite samples; 4 QA/QC samples (i.e., 2 split and 2 duplicate samples); and 2 bias samples (collected for comparison with ecological samples). Sample location coordinates are shown in Table H-8.

7.11.2 Metals

One hundred percent of the samples collected and analyzed for antimony, cadmium, and silver were below the MDLs. Mercury and molybdenum had a high percentage of nondetects (> 50%). Upon qualitative analysis, it was determined that the proportions of detects for molybdenum in Study Site 7 were not significantly greater than the proportions of detects in the reference site. The Fisher's Exact test determined that the proportions of detects in Study Site 7 were significantly greater than the proportions of detects for mercury in the reference site. However, the 99th percentile (0.094 mg/kg) for mercury in the Study Site 7 was below the human health risk criteria (23 mg/kg). Using the Mann-Whitney test, it was determined that the median for each of the remaining eight metals was significantly greater in the reference site than in the study site. The 99th percentiles for each of these parameters (except manganese, See Table 7-9 and Section 7.13.2) were below the human health risk-screening criteria's identified in Table 7-9, as outlined in the JPG DQOs. Though the 99th percentile (2470 mg/kg) for manganese was above the human health risk screening criteria (1970 mg/kg), this was not determined to be significant due to the mean concentration of manganese in Study Site 7 (415.2 mg/kg) being less than the reference site (878.6 mg/kg).

7.11.3 Explosives

RDX and perchlorate were detected at this site. RDX was detected in sample ST7-SL-22 (0.04 mg/kg). This concentration (99th percentile) was below the human health risk criteria (4mg/kg) identified in Table 7-9. Perchlorate was detected in 68 % of the samples collected at this study site (See Table 7-9 for samples with concentrations above the detection limit). The 99th percentile (0.18 mg/kg) for perchlorate was below the human health risk screening criteria (100 mg/kg) identified in Table 7-9.

TABLE 7-9 STUDY SITE 7 DATA SUMMARY

	Average (mg/kg)	Median (mg/kg)	STD@ (mg/kg)	% Nondetect	Sample Distribution	High Value (mg/kg) (99th Percentile)	Human Health Risk Criteria (mg/kg)	Ho Not Rejected (NR) Rejected (R)
Antimony	--	--	--	100	NA	NA	31	NR
Arsenic	4.06	3.95	1.77	0	Unknown	7.98	--	NR
Barium	64.70	55.50	30.20	0	Unknown	143.00	5,400	NR
Cadmium	--	--	--	100	NA	NA	37	NR
Chromium	8.04	7.62	2.11	0	Unknown	14.80	210	NR
Copper	6.39	5.73	2.79	0	Unknown	14.80	2900	NR
Lead	17.50	16.40	6.20	0	Unknown	30.40	400	NR
Manganese*	415.20	187.50	577.30	0	Unknown	2470.00	1800	NR
Mercury	0.0456	0.040	0.0128	73	Unknown	0.094	23	NR
Molybdenum	1.02	1.00	0.07	95	Unknown	1.35	390	NR
Nickel	3.45	2.84	1.78	0	Unknown	7.25	1600	NR
Silver	--	--	--	100	NA	NA	390	NR
Uranium	2.35	2.36	0.107	0	NA	2.52	200	NA
Vanadium	20.90	18.40	10.70	0	Unknown	59.1	550	NR
RDX	0.011	0.010	0.010	95	Unknown	0.018	4	NA
Perchlorate	0.07	0.038	0.072	32	Unknown	0.18	100	NA

* Value greater than the human health risk criteria.
NA – Not Analyzed ?
@STD – Standard Deviation
Ho – Null Hypothesis

7.12 SUMMARY OF PROBLEMS

Three issues were encountered during this site investigation. First, the detection of RDX and perchlorate in samples collected from the reference site has led to some uncertainty as to the use of this area as a valid background site. Second, background levels of arsenic and several manganese samples exceeded the human health risk criteria established in the JPG DQOs. Third, antimony sample values were rejected during third party data validation due to their low Laboratory Control Sample (LCS) recoveries.

Although the reference site had no visible signs of impact from military munitions, or any other activities that may have resulted in the presence of target analytes, uncertainty exists as to the exact activities that may have taken place within this area throughout the duration of JPG's existence. Unlike within the study sites, there were no visual signs of munitions-related activities within the reference site. There was also no signal from the magnetometer handled by EOD technicians signaling the presence of UXO in the area. As a result, detections of RDX and perchlorate within this area would be questionable. The data was third party validated. There is no evidence of sampling or laboratory error. Reference surface water and sediment samples also were found to contain munitions constituents. For these reasons, we believe that the reference sample results are valid as reported. Because the low levels that were reported do not exceed the human health criteria, no additional sampling is recommended.

7.12.1 Arsenic and Manganese

Reference site/background levels of arsenic exceeded the human health risk criteria of 0.039mg/kg identified in the JPG DQOs. An alternate health risk criteria for arsenic may need to be established to take naturally occurring arsenic into account on a regional basis. Though mean concentrations of manganese were not found to be above the human health risk criteria, several individual samples were found to have concentrations higher than the criteria.

7.12.2 Rejected Antimony Values

Fifty-nine of the nondetected values for antimony in sample group WO#6360 were rejected due to their low LCS recoveries (SAIC, 2003).

7.13 DATA QUALITY INDICATORS (DQI)

The DQI refer specifically to five areas that measure to some degree both quantitative and qualitative performance criteria of the project data. The performance criteria are precision, accuracy, representativeness, comparability, and completeness, also known as PARCCs.

7.13.1 Precision

Precision measures the reproducibility of the data. QA/QC samples were used to measure this parameter. The analytical result of one sample was compared to the associated split and/or duplicate sample result using the following equation:

Equation 1

$$RPD = (S - D)/((S+D)/2)\bullet 100$$

Where:

RPD = relative percent difference
S = sample result
D = duplicate/split sample result

The RPD goal for this project was defined at 50% for both organic (explosives) and inorganic (metals) data. A total of 16 split and 16 duplicate samples were collected.

7.13.2 Accuracy

Accuracy/bias is a measure of the bias that exists in a measurement system and is also the degree of agreement between a sample's theoretical and observed concentrations. When the measurement is applied to a particular set of observed values, it will be a combination of two components: a random component and common systematic error (or bias) component. Field sampling accuracy is usually assessed with equipment rinse blanks. As only dedicated sample equipment was used, no rinse blank samples were collected. All analytical data was validated by an independent review. The review included an evaluation of QC sample data for all of the samples collected. Based on this review, all of the analytical results reported were considered valid and subsequently accurate.

7.13.3 Representativeness

Representativeness is the degree to which data accurately characterize a population, parameter variations at a sampling point, a process condition, or an environmental condition. The degree of representativeness is dependant on the thoroughness and proper design of the QAPP and Sampling Plans (SP) and adherence to its prescribed procedures, especially regarding the assumptions made during the development and the statistical soundness of the sampling design. For this investigation, the study area was divided into a number of stratum based upon available information and observations that were made. Within these given strata, each stratum was assumed to be more or less homogenous within its given areas with respect to usage, topography and vegetation. The variability of the data, the number of samples collected, screening criteria/action levels, and the DQOs all contribute to determining whether or not a sufficient number of samples were collected to fully characterize each of the strata sampled. The following equation was used to assess the representativeness of the data:

Equation 2

$$n = ([t_{1-\alpha} + t_{1-\beta}]^2 s^2/\Delta^2) + t_{1-\alpha}^2/2$$

where:

n = number of required samples
s = variance (analyte specific)
Δ = Human health screening value – observed average concentration (analyte specific)
t = Student t-value for 1-alpha (confidence – 80%); and for 1-beta (power – 95%)

Using the above equation, the number of samples collected was determined to be sufficient for characterizing the majority of the metals that were analyzed. The number of samples collected and analyzed for this study was sufficient to assess the representativeness of the data for the following reasons:

- concentrations of the each of the parameters being investigated as part of this study were below the human health risk criteria, and
- there are significant cost constraints associated with collecting and analyzing the number of samples required to meet the 95% Power.

7.13.4 Comparability

Comparability is an expression of the confidence with which one data set can be compared with another. Comparability is also dependent on similar QA objectives. There are no numerical values that can be placed on this concept. This involves a subjective review and evaluation process.

- Comparability of Field Data. The confidence with which one data set can be compared with another was dependent upon the proper design of the sampling program and testing protocols, and ensuring that the field procedures were followed as outlined in the soil sampling plan section of the JPG QAPP.
- Comparability of Analytical Laboratory Data. The confidence with which one data set can be compared with another in the laboratory is dependent upon the use of identical or nearly identical analytical methods and procedures.

7.13.5 Completeness

Completeness is a comparison of the amount of valid data received versus the amount that is specified in the DQOs. It may be calculated as follows; where, *RPC* is the relative percent completeness, *V* is the number of valid measurements completed (or samples collected), and *n* is the number of measurements specified in the DQOs that are required to achieve a specified level of confidence.

Equation 3

$$\mathrm{RPC} = \frac{\mathrm{V}}{\mathrm{n}} \bullet 100$$

where:
RPC = Completeness
V = number of completed measurements
n = number of planned measurements

- Field Completeness Objectives. Field completeness was based on the number of samples collected versus the number of samples planned. Field completeness objectives were set at 90 % for all analytical chemistry samples, and 100 % for all field measurements (e.g., pH, conductivity, and temperature). Field completeness objectives were met for this study.
- Analytical Chemistry Completeness Objectives. Laboratory completeness was based on the numbers of samples that were shipped from the field for analyses compared to the number of valid results obtained. Laboratory completeness for this project was set at greater than 95 %. Analytical chemistry completeness objectives for antimony were not met due to low LCS recoveries in samples analyzed for this parameter as part of sample group WO# 6360. Fifty-nine of the samples analyzed for antimony were rejected upon third party validation (See section 7.13.3), resulting in 65.3% completeness for antimony.
- Completeness values are shown in Table 7-10.

TABLE 7-10 COMPLETENESS

	Completeness – Total Number of Samples Collected vs. Planned							
	Planned			Collected				
	Samples	Duplicates	Splits	Samples	Duplicates	Splits	Bias for Ecological	Completeness
Reference:	16	2	2	16	2	2	1	105
Stratum 1	16	2	2	16	2	2	2	110
Stratum 2	16	2	2	16	2	2	1	105
Stratum 3	16	2	2	16	2	2	0	100
Stratum 4	16	2	2	16	2	2	0	100
Stratum 5	16	2	2	19	2	2	1	105
Stratum 6	16	2	2	16	2	2	3	115
Stratum 7	16	2	2	16	2	2	2	110
Samples	128			128				
Duplicates	16			16				
Splits	16			16				
Bias				10				
Total	160			170				

7.14 SUMMARY

7.14.1 Metals

The only metal with a normal distribution that was significantly greater in the study site than the reference site was copper in Study Site 6. The Student t-Test was the statistical analysis method used to compare these two sites. However, the 95% UCL for the mean concentration of copper in Study Site 6 (9.48 mg/kg) was below the human health risk screening criteria for copper (2,900 mg/kg) identified in the JPG DQOs. The following datasets followed an unknown distribution and were found to be significantly greater in the study sites than in the reference site: antimony (Study Site 3), barium (Study Site 2), copper (Study Sites 1, 2, 4, and 5), and vanadium (Study Site 4). The nonparametric, Mann-Whitney (Wilcoxon) statistical method was used to compare barium, copper, and vanadium between the study sites and the reference site. Due to the large number of nondetects (> 50%), the nonparametric, Fisher's Exact test was used to compare the proportions of detects of barium at Study Site 2 with those at the reference site. Though each of these datasets was found to be significantly greater in the study site than in the reference site, the 99th percentile for each dataset was below the human health risk screening criteria for the parameter of interest.

7.14.2 Explosives

Of the explosives analyzed, only 2,4,6 trinitrotoluene, 2,4 dinitrotoluene, 2,6 dinitrotoluene, RDX, and perchlorate were found in samples collected at JPG. Upon qualitative analysis, it was determined that the explosives 2,4 dinitrotoluene and 2,6 dinitrotolune (each found in only one sample collected) and 2,4,6 trinitrotoluene (found in only two samples collected) would not be assessed due to the large number of nondetects (> 90%). RDX was found in the reference site and each of the study sites (except Study Site 2). The 99th percentile for RDX, found in Study Site 5 (0.098 mg/kg) was the highest concentration of RDX found in any of the samples analyzed as part of this investigation. This value was below the human health risk screening criteria (4 mg/kg) defined in the JPG DQOs. Perchlorate was found in the reference site and Study Sites 1, 2, 5, 6, and 7. The 99th percentile for perchlorate, found in Study Site 7 (0.0695 mg/kg) was the highest concentration of perchlorate found in any of the samples collected. This value was below the human health risk screening criteria (100 mg/kg) identified by USACHPPM for this study.

7.15 CONCLUSIONS

7.15.1 Metals

For the majority of the metals collected and analyzed as part of this soil investigation, proportions and concentrations of metals in the study sites were not significantly greater than in the reference site. The Null Hypotheses (Ho) defined for comparing the study sites to the reference sites were as follows:

For normal/lognormal distributions:

- Ho: mean metal concentration of study site <= mean metal concentration at the reference site (Ho: Study site mean<Reference site mean)

For unknown distributions:

- Ho: metal concentrations at the study site <= metal concentrations at the reference site (Ho: Study site median<Reference site median)

For proportions of detects:

- Ho: proportions of detects at the study site $\leq$ proportion of detects at the reference site (Ho: P study site<P reference site)

Soil investigators failed to reject the Null Hypothesis (Ho) for the majority of metals analyzed. Due to the human and ecological health risks associated with the false acceptance of Ho, the following decision errors were set: probability of making a Type I error (false rejection, rejecting the Null Hypothesis when it is true) set at 20% ($\alpha = 0.2$) giving a Confidence Level of 80%, and probability of making a Type II error (false acceptance, failing to reject the Null Hypothesis when it is false) set at 5% ($\beta = 0.05$), giving a 95% Power. Of the 13 metals analyzed, only for antimony (Study Site 3), barium (Study Site 2), copper (Study Sites 1, 2, 4, 5 and 6), and vanadium (Study Site 4) was it determined that the study site was significantly greater than the reference site. For these parameters, at these study sites, soil investigators rejected Ho. Though the parameters of interest for each of the datasets were significantly greater in the study site than in the reference site, the 99th percentile for each of the datasets was below the human health risk screening criteria referenced in Appendix L, *Data Quality Objectives* in the JPG QAPP. Of the 13 metals analyzed, only copper residues appeared to be distributed throughout the impact area.

7.15.2 Explosives

Of the explosives analyzed, only RDX and perchlorate were distributed throughout the impact area. The 99th percentile for these parameters were below the human health risk screening criteria, as referenced in Appendix L, *Data Quality Objectives* in the JPG QAPP.

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8 SURFACE WATER, SEDIMENT, AND BENTHIC MACROINVERTEBRATE INVESTIGATION

8.1 INTRODUCTION AND OBJECTIVES

Surface water, sediment, and benthic macroinvertebrate samples were collected from all the significant creeks at JPG from 7-11 October 2002. Creeks were sampled near the entrance and exit points to the installation, and near the midpoint to be closer to the source of possible contamination. Upstream locations were used as a reference. The objective of the sampling was to collect data needed to determine if munitions constituents were impacting the aquatic ecological health of JPG or migrating through the surface water pathway.

8.2 TECHNICAL APPROACH

8.2.1 Sampling Protocol

Prior to field activities and sample collection, a QAPP (USACHPPM, 2002) was developed for JPG, which outlined the surface water, sediment, and macroinvertebrate sampling strategy and rationale. The strategy involved the collection of physical, chemical, and biological data in order to assess the overall ecological health of JPG surface waters. Sampling locations were selected based on U.S. Geological Survey topographic maps, observations of creeks during the site visit 6-10 May 2002, and knowledge of the environmental setting and munitions usage at JPG. The sampling locations are shown in Figure 8-1. A detailed description of the sampling locations is in Appendix E. The drainage basins identified for sampling are briefly described in each watershed section.

8.2.2 Number and Type of Samples, Target Analytes, Analytical Methods, and Detection Limits

At each sampling location, one surface water, one sediment, and three benthic macroinvertebrate samples were collected. Both filtered and unfiltered water samples were collected for total and dissolved metals analysis, respectively. Two duplicate and two split samples were collected for QA/QC purposes. Sample 19 was a duplicate for sample 16, sample 20 was a duplicate for sample 04, sample 21 was a split for sample 05, and sample 22 was a split for sample 06. Table 8-1 shows the laboratory methods and detection limits for the surface water samples. Table 8-2 shows the laboratory methods and detection limits for the sediment samples. The analyte list was based on the munitions-related constituents.

FIGURE 8-1. SAMPLING LOCATIONS, SURFACE WATER, AND SEDIMENT

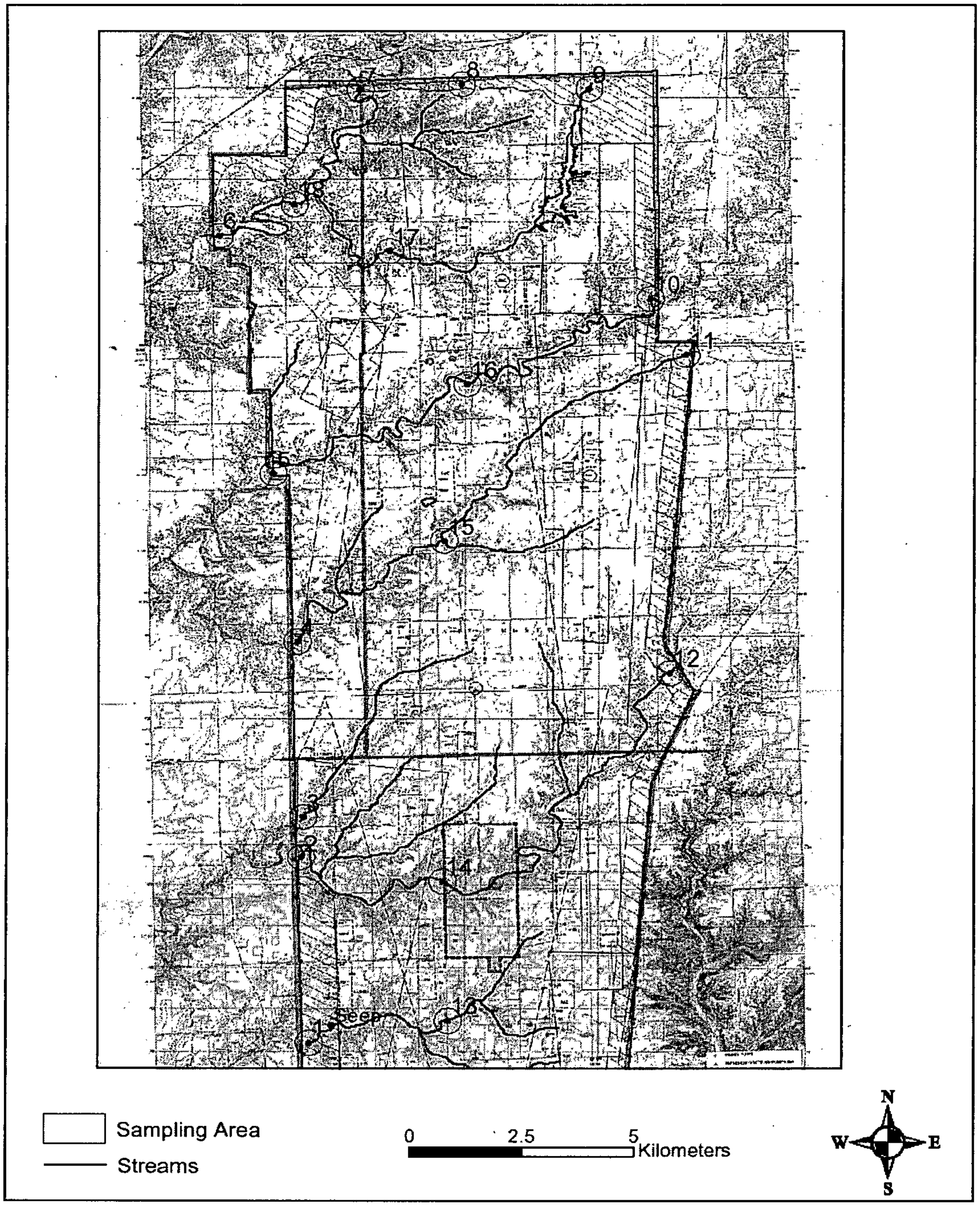


TABLE 8-1 PARAMETER LIST, ANALYTICAL METHOD, REPORTING LIMIT, AND PERFORMING LABORATORY FOR CHEMICAL DATA IN SURFACE WATER

Parameter	Analytical Method	Reporting Limit (µg/l)	Laboratory Performing Analyses
EXPLOSIVES AND DEGRADATES			
HMX	USEPA 8095M / CAD 13.2	3	U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, Maryland or Contractor
RDX	USEPA 8095M / CAD 13.2	0.3	
2,4,6-TNT	USEPA 8095M / CAD 13.2	0.03	
1,3,5-TNB	USEPA 8095M / CAD 13.2	0.03	
1,3-DNB	USEPA 8095M / CAD 13.2	0.09	
TETRYL	USEPA 8095M / CAD 13.2	0.5	
NB	USEPA 8095M / CAD 13.2	0.03	
2A-4,6-DNT	USEPA 8095M / CAD 13.2	0.1	
4A-2,6-DNT	USEPA 8095M / CAD 13.2	0.1	
2,6-DNT	USEPA 8095M / CAD 13.2	0.01	
2,4-DNT	USEPA 8095M / CAD 13.2	0.02	
2-NT	USEPA 8095M / CAD 13.2	0.09	
3-NT	USEPA 8095M / CAD 13.2	0.09	
4-NT	USEPA 8095M / CAD 13.2	0.09	
Nitroglycerin	USEPA 8095M / CAD 13.2	0.09	
White phosphorous	CHPPM /CAD MUS 5	0.005	
Perchlorate	USEPA 314	1	DATACHEM
METALS			
Antimony	USEPA 1638-ICP/MS	0.00891	Battelle, 760 6th Street, Richland, Washington 99352 Clean Laboratory – Trace Metals Method
Arsenic	USEPA 1638-ICP/MS	0.0436	
Barium	USEPA 1638-ICP/MS	0.00564	
Cadmium	USEPA 1638-ICP/MS	0.015	
Calcium	USEPA 1638-ICP/MS	1.75	
Chromium	USEPA 1638-ICP/MS	0.042	
Copper	USEPA 1638-ICP/MS	0.0135	
Lead	USEPA 1638-ICP/MS	0.0049	
Magnesium	USEPA 1638-ICP/MS	0.05	
Manganese	USEPA 1638-ICP/MS	0.01	
Mercury	USEPA 1631-CVAF	0.0002	
Molybdenum	USEPA 1638-ICP/MS	0.00826	
Nickel	USEPA 1638-ICP/MS	0.0323	
Silver	USEPA 1638-ICP/MS	0.00429	
Uranium	USEPA 1638-ICP/MS	0.01	
Vanadium	USEPA 1638-ICP/MS	0.0173	
Zinc	USEPA 1638-ICP/MS	0.0352	

NOTES: ICP/MS = inductively coupled plasma/mass spectrometry.
CVAF= cold vapor atomic furnace.

TABLE 8-2 PARAMETER LIST, ANALYTICAL METHOD, REPORTING LIMIT, AND PERFORMING LABORATORY FOR CHEMICAL DATA IN SEDIMENT

Parameter	Analytical Method	Reporting Limit (µg/g)	Laboratory Performing Analyses
EXPLOSIVES AND DEGRADATES			
HMX	USEPA 8095M / CAD 55.2	0.05	U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, Maryland
RDX	USEPA 8095M / CAD 55.2	0.01	
2,4,6-TNT	USEPA 8095M / CAD 55.2	0.01	
1,3,5-TNB	USEPA 8095M / CAD 55.2	0.02	
1,3-DNB	USEPA 8095M / CAD 55.2	0.02	
TETRYL	USEPA 8095M / CAD 55.2	0.02	
NB	USEPA 8095M / CAD 55.2	0.02	
2A-4,6-DNT	USEPA 8095M / CAD 55.2	0.02	
4A-2,6-DNT	USEPA 8095M / CAD 55.2	0.05	
2,6-DNT	USEPA 8095M / CAD 55.2	0.02	
2,4-DNT	USEPA 8095M / CAD 55.2	0.02	
2-NT	USEPA 8095M / CAD 55.2	0.02	
3-NT	USEPA 8095M / CAD 55.2	0.02	
4-NT	USEPA 8095M / CAD 55.2	0.02	
Nitroglycerin	USEPA 8095M / CAD 55.2	0.05	
White phosphorous	CHPPM / CAD MUS 5	0.00088	
Perchlorate	USEPA 300	0.04	DATACHEM
METALS			
Antimony	USEPA 200.8 / 6020 *	0.00891	Battelle Memorial Institute, 790 6th Street, Richland, Washington, 99352
Arsenic	USEPA 200.8 / 6020 *	0.0436	
Barium	USEPA 200.8 / 6020 *	0.170	
Cadmium	USEPA 200.8 / 6020 *	0.022	
Chromium	USEPA 200.8 / 6020 *	0.149	
Copper	USEPA 200.8 / 6020 *	0.175	
Lead	USEPA 200.8 / 6020 *	0.00049	
Manganese	USEPA 200.8 / 6020 *	0.010	
Mercury	USEPA 245.5 *	0.01	
Molybdenum	USEPA 200.8 / 6020 *	0.00826	
Nickel	USEPA 200.8 / 6020 *	0.220	
Silver	USEPA 200.8 / 6020 *	0.031	
Uranium	USEPA 200.8 / 6020 *	0.05	
Vanadium	USEPA 200.8 / 6020 *	0.126	
Zinc	USEPA 200.8 / 6020 *	0.706	
MISCELLANEOUS			
TOM	MSA 29-352 **	0.01 %	USACHPPM

NOTES:
CHPPM CAD = U. S. Army Center for Health Promotion and Preventive Medicine, Directorate of Laboratory Sciences, Chromatographic Analysis Division.
TOM= total organic matter.
* - These methods use clean techniques for digestion and analysis as described in USEPA, 1996b, Sampling Ambient Water for Trace Metals at USEPA Water Quality Criteria Levels, Office of Water, Engineering and Analysis Division, Washington, D.C.
** - Methods of Soil Analysis (MSA) 29-352 is the Walkley-Black method.

8.2.3 Water Quality Criteria, Sediment Benchmarks, and Biological Indices

Table 8-3 presents the Federal Water Quality Criteria (WQC), Indiana State Water Quality Standards (WQSs), and Sediment Quality Benchmarks (SQBs) for the protection of freshwater aquatic life. This table was used for qualitative comparison to the surface water and sediment chemical results to determine if there were any of the munitions-related constituents at a concentration that could be considered a risk to the aquatic ecosystem. Additionally, benthic macroinvertebrate data were used to calculate indices to compare reference locations and downstream locations to determine if there were any adverse effects on the ecological health of the aquatic biota. The details about water quality criteria, benchmarks, and biological indices can be found in Section 4.1.7 of the QAPP (USACHPPM, 2002).

8.3 SUMMARY OF FIELD ACTIVITIES

The sampling was originally scheduled for 16-25 September 2002. However, an extended drought left the creeks with very little flow and no flow at a majority of the sampling locations. The creeks were a series of stagnant pools. It was decided to delay sampling until there was flow. Table 8-4 shows the stream flow in Harberts Creek, a creek south of the firing line at JPG that has a gauging station about 3 miles downstream of the installation. There was 6-7 inches of rain on 27 September and the stream flow had returned to base flow within 3 days. The stream flow was stable for over a week at the time of sampling (7-11 October 2002) and stayed stable throughout the sampling period.

8.3.1 Unexploded Ordnance Safety Support

Prior to field activities, contracted unexploded ordnance (UXO) personnel briefed all sampling personnel on safety procedures while working in areas that may contain UXO. Additionally, contracted UXO personnel escorted the stream sampling team to all sampling locations in and around the impact areas. No samples were collected at impact area locations until a visual sweep of the sampling area was made and the location had been cleared for sampling. All field activities and sampling procedures were performed in accordance with the Site-Specific Safety and Health Plan developed in the QAPP (USACHPPM, 2002).

8.3.2 Surface Water Sampling

At each sampling location, surface water samples were collected by pumping the sample into the sample container using a continuous flow pump using Teflon tubing. The water samples were taken half way across the width of the stream and at a depth half way between the water surface and the streambed. Stagnant or ponded water was not collected. Both total (unfiltered) and dissolved (filtered) samples were collected for trace metals analysis. A 0.45-micron precleaned filter was added to the sample tubing line for dissolved metals sample collection. Water samples for trace metals analysis were collected per USEPA Method 1669 - *Sampling Ambient Water for Trace Metals at USEPA Water Quality Criteria Levels*. The "clean-hands - dirty-hands" technique was used to collect the trace metals samples, as described in the QAPP. All sampling equipment and containers were precleaned by either Battelle Laboratories (clean metals) or USACHPPM Laboratories (explosives and miscellaneous parameters) as outlined in the QAPP.

TABLE 8-3 FEDERAL AND STATE OF INDIANA AMBIENT WATER QUALITY CRITERIA FOR PROTECTION OF AQUATIC LIFE IN FRESH WATER AND SEDIMENT QUALITY BENCHMARKS

PARAMETER	FEDERAL AMBIENT WATER QUALITY CRITERIA (µg/L)		INDIANA AMBIENT WATER QUALITY CRITERIA (µg/L) [12]		SEDIMENT QUALITY BENCHMARK (µg/g)
	CMC	CCC	ACUTE	CHRONIC	
EXPLOSIVES AND DEGRADATES					
HMX	NA	330 [6,8]	NA No numeric criteria have been established for these compounds. However, the concentration of these compounds will not result in chronic or acute toxicity to aquatic life, or impairment of the designated uses.		0.330 [1]
RDX	4000 [6,7]	190 [6,8]			0.190 [1]
2,4,6-TNT	560 [6,7]	<40 [6,7]			0.13 [1]
1,3,5-TNB	30 [6,8]	14 [6,8]			0.02 [1]
1,3-DNB	110 [6,8]	30 [6,8]			0.04 [1]
TETRYL	NA				NA
NB	27,000 [6,7, 9]				27.0 [1]
2A-4,6-DNT	NA	NA			NA
4A-2,6-DNT	NA	NA			NA
2,6-DNT	18,500 [6,7]	NA			18.5 [1]
2,4-DNT	330 [9]	230 [9]			0.230 [1]
2-NT	NA	NA			NA
3-NT	NA	NA			NA
4-NT	NA	NA			NA
Nitroglycerin	1700 [6,7]	200 [6,7]			NA
White Phosphorous	0.5 [6]	0.1 [6]			0.26 [6]
Perchlorate	5,000 [6]	600 [6]			NA
METALS					
Antimony	180 [6]	30 [6]	NA	NA	NA
Arsenic	340 [11]	150 [11]	360	190	5.9 [2]
Barium	1000 [13]		1000		500 [3]
Cadmium	4.3 [5,11]	2.2 [5,11]	4.0 [5]	1.1 [5]	0.596 [2]
Calcium	NA				
Chromium	570 [11]	74 [11]	1737	207	26 [3]
Copper	13 [5,11]	9 [5,11]	18 [5]	9 [5]	16 [3]
Lead	65 [5,11]	2.5 [5,11]	82 [5]	3 [5]	31 [3]
Magnesium	NA				
Manganese	50 [13]		NA	NA	460 [3]
Mercury	2.4 [11]	0.012 [11]	2.4	0.012	0.174 [2]
Molybdenum	16,000 [6]	370 [6]	NA	NA	NA
Nickel	470 [5,11]	52 [5,11]	1418 [5]	158 [5]	21 [10]
Silver	3.4 [5,11]	NA	2.0 [5]	NA	1 [4]
Uranium	46 [6]	2.6 [6]	NA	NA	NA
Vanadium	280 [6]	20 [6]	NA	NA	NA
Zinc	120 [5,11]	120 [5,11]	117 [5]	106 [5]	124 [4]

Notes for Table 8-3 – Federal and State of Indiana Ambient Water Quality Criteria for the Protection of Aquatic Life in Freshwater, and Sediment Quality Benchmarks, Jefferson Proving Ground, Indiana Criteria are elements of water quality standards, expressed as concentrations, levels, or narrative statements representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use.

CMC – criteria maximum concentration. This concentration will protect against acute effects in aquatic life and is the highest in stream concentration of a priority toxic pollutant consisting of a 1-hour average not to be exceeded more than once every 3 years on average.
CCC – criteria continuous concentration. This concentration will protect against chronic effects in aquatic life and is the highest in stream concentration of a priority toxic pollutant consisting of a 4-day average not to be exceeded more than once every 3 years on average.
NA – nothing available.
1 - Calculated from water toxicity data based on 1% organic matter according to Talmage. S.S., and D.M. Opresko, 1995, Draft Ecological Criteria Documents for Explosives, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
2 - Smith, S.L., D.D. MacDonald, K.A. Keenleyside, C.G. Ingersoll, and L.J.Field, 1996, "a preliminary evaluation of sediment quality assessment values for freshwater ecosystems," J. Great Lakes Res. 22(3): 624-638.
3 - Ontario Ministry of the Environment and Energy, 1993, Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, Water Resources Branch, Ontario Ministry of the Environment and Energy.
4 - Long, E.R., and L.G. Morgan, The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National Status and Trends Program, NOAA, National Ocean Service, Seattle, Washington.
5 - Hardness dependent parameter. The criteria are as indicated at hardness of 100 mg/L as $CaCO_3$ but will be recalculated using site-specific hardness from each sampling location. The hardness dependent Federal water quality criteria are based on dissolved metals. The State hardness dependent water quality criteria are based on total recoverable metals.
6 - Lowest Observed Adverse Effect Level (LOAEL). Not enough data to develop criteria.
7 - Burrows, E.P., D.H. Rosenblatt, W.R. Mitchell, and D.L. Parmer, 1989, Organic Explosives and Related Compounds: Environmental and Health Considerations, U.S. Army Biomedical Research and Development Laboratory.
8 - Talmage, S.S., and D.M. Opresko. 1995. Draft Ecological Criteria Documents for Explosives, Prepared by Oak Ridge National Laboratory, Oak Ridge, Tennessee.
9 - U.S. Environmental Protection Agency, 1994, Water Quality Standards Handbook, Office of Water, Washington, D.C.
10 - Jones, D.S., G.W. Suter II, and R.N. Hull, 1997, Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision, report number ES/ER/TM-95/R4, prepared for the U.S. Department of Energy, Office of Environmental Management, prepared by Oak Ridge National Laboratory.
11 - U.S. Environmental Protection Agency, 1999, National Recommended Water Quality Criteria-Correction, USEPA 822-Z-99-001, Office of Water, Washington D.C.
12 - State of Indiana Title 327-Water Pollution Control Board, Article 2-Water Quality Standards Amended 4 February 2002.
13 – Based on National Secondary Drinking Water Regulations.

TABLE 8-4 FLOW FROM HARBERTS CREEK, CUBIC FEET PER SECOND, APRIL 01 2002 TO JANUARY 31 2003, MEAN DAILY VALUES

DATE	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
1	3.9	6.1	1.4	0.97	0.01	0	0.66	2.5	1.8	243
2	3.3	29	1.3	0.72	0	0	0.45	2.2	1.6	41
3	3	9.6	1.1	0.58	0	0	0.38	2	1.5	20
4	2.7	4.9	0.94	0.45	0	0	0.86	1.7	1.3	12
5	2.3	3.5	1.1	0.33	0	0	1.3	4.9	1.6	9.2
6	2.1	**290**	18	0.24	0	0	0.79	9.1	1.4	7.5
7	1.9	**82**	5.7	0.26	0	0	**0.59**	3.5	1.4	5.9
8	1.9	**524**	2.8	0.2	0	0	**0.53**	2.6	1.5	5.3
9	2.6	**73**	1.9	2.6	0	0	**0.48**	2.6	1.5	4.7
10	2.5	22	1.5	2.6	0	0	**0.54**	162	1.5	3.7
11	2.1	12	1.2	0.64	0	0	**0.87**	71	24	2.7
12	2	10	2.5	0.33	0	0	0.81	15	26	2.4
13	82	423	6.2	0.26	0	0	0.59	8.4	39	2.1
14	111	46	6.1	0.25	0	0	0.48	5.9	34	2
15	27	16	2.5	0.15	0	5.6	0.46	4.9	14	1.9
16	9.8	9.7	2.2	0.07	0	**0.67**	0.45	4.5	8.9	1.7
17	6.1	35	1.5	0.21	0	**0.18**	0.39	3.6	8.2	1.5
18	4.7	40	1.2	2.2	0	**0.04**	0.31	2.9	12	1.4
19	3.8	11	0.88	3.2	0.05	**0.03**	0.66	2.6	226	1.4
20	8.6	7.4	0.71	0.96	0.08	0.17	1.1	2.4	107	1.4
21	335	5.6	0.58	0.44	0.03	1.1	0.77	2.5	23	1.2
22	145	4.5	0.5	0.5	0	0.39	0.58	5.7	12	1
23	14	3.7	0.44	0.28	0	0.12	0.45	3.9	7.8	0.9
24	25	3.1	0.39	0.23	0	0.04	0.37	2.9	6.8	0.59
25	64	2.7	5.9	0.11	0	0.01	42	2.4	12	1.1
26	9.5	2.5	9.8	0.1	0	0.19	13	2.2	7.8	0.94
27	43	3.1	6.8	0.09	0	573	3.9	2	5.7	0.89
28	153	2.3	6.6	0.08	0	13	2.4	1.9	5.4	1
29	15	2.4	2.3	0.07	0	2.5	21	1.9	6	1.4
30	7.4	2.1	1.4	0.05	0	1.2	9.4	2	55	1.3
31		1.7		0.04	0		4.1		131	1.2
COUNT	**30**	**31**	**30**	**31**	**31**	**30**	**31**	**30**	**31**	**31**
MAX	**335**	**524**	**18**	**3.2**	**0.08**	**573**	**42**	**162**	**226**	**243**
MIN	**1.9**	**1.7**	**0.39**	**0.04**	**0**	**0**	**0.31**	**1.7**	**1.3**	**0.59**

Bolded flows represent days when study team was at JPG. The first was the scoping visit (flooded conditions), the second was when sampling was postponed due to lack of flow, and the third was when sampling occurred.

Sample tubing was precleaned by the laboratory with acid wash prior to use in the field. A new pair of talc-free gloves was worn by sampling personnel at each sampling location. An in-situ multi-parameter data logger was used at each sampling location to record the ambient surface water dissolved oxygen, pH, conductivity, and temperature. The readings were transcribed into the field log sheet while onsite. The data logger was calibrated each day and checked at the end of each day against known standards.

8.3.3 Sediment Sampling

Sediment samples were collected from areas in the stream where an obstruction allowed a small amount to settle behind it. There was very little sediment to be found. The current scours the streambed to limestone bedrock. Approximately 10 composite sediment (mostly sand and grit) samples were collected with a precleaned disposable plastic scoop, placed in an aluminum foil-lined stainless steel bowl, homogenized, and scooped into the precleaned sample containers for each analytical grouping. A new pair of talc-free nitrile gloves was used for each sampling location. Sediment sampling occurred after surface water sample collection.

8.3.4 Benthic Macroinvertebrate Sampling

It is widely recognized that biota accurately reflect the quality of the environment they are subjected to. Therefore, biological indices/indicator organisms were collected at JPG as supporting data in evaluating if munitions-related constituents were adversely affecting the ecological health of the aquatic biota. The macroinvertebrate sampling rationale and its usefulness as an indicator of environmental quality is detailed in the QAPP. Benthic macroinvertebrates were collected at each sampling location by cleaning the attached organisms from rocks and cobble into a net or bucket. The normal consolidation of rocks forming a riffle was nearly nonexistent in the JPG streams. Individual rocks from large areas of the stream needed to be collected and cleaned of organisms. Three samples were collected from each sampling location (except for sampling locations 3, 8, and 9 where there were so few organisms and poor substrate, that sampling was suspended with one subsample). Samples were preserved onsite with 10% formalin and Rose Bengal dye to aid in later sorting. The samples were then sent to the contractor for identification to species or the lowest practicable taxonomic level.

8.3.5 Sample Labels and Identification

8.3.5.1 Sample Labels

Labels detailing the following information were affixed to each sample container prior to field activities: sample identification number, sampling location, date, sample parameter, preservation requirements, and sampling personnel. The same information, along with pertinent field observations, was recorded in the field logbook.

8.3.5.2 Sample Identification

8.3.5.2.1 Field Samples

The surface water and sediment samples collected at each sampling location were assigned specific four-digit identification numbers. The first two letters corresponded to the type of sample ("SW" denoted surface water while "SE" denoted sediment and SG denoted seep). The last two digits were sequential numbers of the samples starting with 01 and ending with 22, yielding 22 total surface water samples and 22 total sediment samples. A waterproof marker was used to label the sample bottles.

8.3.5.2.2 Blank Samples

Blank samples collected for QA/QC purposes were assigned unique sample identifications based on the type of blank collected. The blank identification numbers are listed below. A discussion of QA/QC sample collection and data is found in section 8.2.2.

- Equipment blank (surface water) – Equip. Blk-1 [(U)unfiltered and (F)filtered]
- Sediment equipment blank – Sed. Equip. Blk-1
- Container blank – Container Blk-1

8.3.5.2.3 Macroinvertebrate Samples

The benthic macroinvertebrate samples were labeled with the installation, preservative, type of sample, date collected, stream name, and sampling location number.

8.3.6 Field Notes and Photographic Documentation

Field data and observations at each sampling location were recorded in a field notebook. Stream data included: the date and time of sample collection, weather conditions, general site descriptions, in-situ data logger physical parameters (pH, temperature, conductivity and dissolved oxygen), identification of duplicate samples collected (where applicable), and any notes on surface water and sediment sample collection. Photographs of the sampling locations were also taken. Sampling location photographs and field notes are included in Appendix E.

8.3.7 Sample Management and Laboratory Analysis

8.3.7.1 Sample Collection and Preservation

All environmental samples were collected in accordance with USEPA and USACHPPM approved field procedures (QAPP). Samples that required preservatives were preserved onsite. Prior to shipment, samples were stored in ice chests with sufficient ice to maintain a temperature of 4° Celsius. Macroinvertebrate samples were preserved onsite with formalin and Rose Bengal dye before shipment to the contractor.

8.3.7.2 Sample Handling and Shipment

All collected samples were stored in a secured building while awaiting shipment. Ice chests were used to ship the samples to the appropriate laboratory for analysis. Surface water and sediment samples for trace metals analysis were shipped to Battelle Laboratories in Sequim, Washington. Surface water and sediment samples for explosives and general parameters were shipped to USACHPPM Laboratories in Aberdeen Proving Ground, Maryland. Surface water and sediment for perchlorate were shipped to DATACHEM, Salt Lake City, Utah and total organic carbon and total organic matter were shipped to TriMatrix Laboratories, Inc., Grand Rapids Michigan. All ice chests were secured with strapping tape and custody seal, then shipped via Federal Express. Standardized field packing lists were included in each cooler, specifying the number and type of samples included in each cooler. The chain of custody and packing lists detailed the sample identification numbers, sample dates, and parameters to be analyzed.

A temperature control bottle was included in each cooler so that the temperature of the samples could be logged upon arrival at the laboratory. Macroinvertebrate samples were packed in separate coolers and shipped to Dr. James Matta, Milton, Pennsylvania (contractor) for picking, sorting and identification.

8.3.7.3 Laboratory Sample Receipt

All samples were received by the laboratories in satisfactory timeliness and condition except for the following:

- The explosives sediment samples shipped 10 October 2002 were delivered to the wrong building and sat over the weekend before discovery. The sample temperature was >4°C when received. The sampling locations were SE-(01, 02, 03, 04, 05, 10, 11, 12, 13, 14, 15, 16, 19, and 20).

8.4 FIELD INVESTIGATION RESULTS AND DISCUSSION

See Figure 8-1 for JPG sampling locations and Tables 8-5, 8-6, and 8-7 for complete chemical, physical and a summary of biological results. For the complete benthic macroinvertebrate results see Appendix F. The first and most important evaluation of the results was comparing the results to Federal WQC, State WQSs, and SQBs. The exceedances are highlighted in the tables and are discussed below.

- There were exceedances of the National Secondary Drinking Water Standard of 50 µg/L dissolved manganese in the water at sampling locations 03 (69.6 µg/L), 06 (50.7 µg/L), 10 (55.5 µg/L), 11 (72.7 µg/L), and 15 (410 µg/L). Sampling locations 10 and 11 were upstream reference locations. The drinking water standard for dissolved manganese is based on taste, staining, and deposition in drinking water systems. Since the surface water at JPG is not used for drinking it is of little concern. The lowest observed effect concentration of manganese to freshwater organisms was 1,500 µg/L (USEPA-440/9-76-023, Quality Criteria for Water).

TABLE 8-5. COMPLETE SURFACE WATER RESULTS, JPG FIRING RANGE STUDY, 7-11 OCTOBER 2002

PARAMETER	UNIT	SW-01	SW-02	SW-03	SW-04**,***	SW-05**	SW-06**,***	Reference SW-07	Reference SW-08	Reference SW-09	Reference SW-10	Reference SW-11	Reference SW-12	REGULATORY CRITERIA*			
														FEDERAL AMBIENT WATER QUALITY CRITERIA		INDIANA AMBIENT WATER QUALITY STANDARDS	
														CMC	CCC	CMC	CCC
Explosives and Degradates																	
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	**0.190**	**0.140**	**0.027 J**	0.100 U	**0.039 J**	0.100 U	0.100 U	0.100 U	**0.023 J**	**0.072 J**	**0.036 J**	**0.040 J**	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.5	0.1		
Metals																	
Hardness	mg/L	141	125	120	128	160	149	172	208	156	160	116	148	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	**0.0877** ***0.0992***	**0.0860** ***0.0895***	**0.0599** ***0.0644***	**0.0792** ***0.0836***	**0.0964** ***0.0993***	**0.0814** ***0.0856***	**0.0924** ***0.0913***	**0.0734** ***0.0651***	**0.0957** ***0.0886***	**0.1230** ***0.1110***	**0.1510** ***0.1580***	**0.0861** ***0.0844***	- 180	- 30	-	-
Arsenic	µg/L	**0.420** ***0.436***	**0.917** ***0.873***	**0.688** ***0.678***	**0.758** ***0.771***	**1.220** ***1.160***	**0.914** ***0.989***	**1.160** ***1.290***	**0.808** ***0.896***	**0.917** ***1.150***	**1.180** ***1.090***	**1.050** ***0.997***	**0.785** ***0.738***	- 340	- 150	360 -	190 -
Barium	µg/L	**66.6** ***66.4***	**52.5** ***47.8***	**78.5** ***75.5***	**44.6** ***44.1***	**52.3** ***52.8***	**45.0** ***45.0***	**52.9** ***51.2***	**58.2** ***57.3***	**65.3** ***62.6***	**58.4** ***58.1***	**56.5** ***54.9***	**55.2** ***53.7***	- 1000	1000	- -	- -
Cadmium	µg/L	**0.06610** ***0.34400***	**0.03220** ***0.01190***	**0.01480** ***0.00885***	**0.00959** ***0.00989***	**0.01380** ***0.01220***	**0.01140** ***0.00670***	**0.00963** ***0.01040***	**0.06130** ***0.02530***	**0.13600** ***0.01880***	**0.01700** ***0.08690***	**0.01980** ***0.02210***	**0.01740** ***0.01610***	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**35500** ***35800***	**34600** ***34500***	**32300** ***32600***	**36300** ***36400***	**46600** ***46700***	**46400** ***46300***	**51900** ***51800***	**57100** ***57100***	**44800** ***44300***	**53400** ***45600***	**33300** ***33300***	**43900** ***43600***	- -	- -	- -	- -
Chromium	µg/L	**0.3580** ***0.3020***	**0.4620** *0.0240 U*	0.0240 U *0.0240 U*	0.0240 U *0.0240 U*	**0.3110** ***0.2370***	**0.3110** ***0.2100***	**0.4080** ***0.3940***	**0.5220** ***0.8110***	**0.2920** ***0.4030***	**0.2980** ***0.3160***	**0.7540** ***0.1250***	**0.3390** ***0.2900***	- 570	- 74	1737 -	207 -
Copper	µg/L	**1.240** ***1.260***	**1.460** ***1.190***	**0.698** ***0.592***	**1.110** ***1.050***	**1.050** ***0.965***	**0.864** ***0.871***	**0.989** ***0.968***	**0.614** ***0.600***	**1.180** ***1.180***	**1.120** ***1.030***	**1.370** ***1.260***	**1.120** ***1.140***	- 13	- 9	18 -	9 -
Lead	µg/L	**0.03100** *0.00500 U*	**1.46000** ***0.00795***	**0.15400** *0.00500 U*	**0.05550** *0.00500 U*	**0.10300** ***0.01920***	**0.07200** ***0.00935***	**0.05780** ***0.01890***	**0.07110** ***0.00830***	**0.04080** *0.00500 U*	**0.07490** ***0.01300***	**2.01000** ***0.03410***	**0.23500** ***0.22500***	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**12600** ***12600***	**9400** ***9370***	**9250** ***9380***	**8910** ***8910***	**10200** ***10400***	**8000** ***8170***	**10300** ***10300***	**16400** ***15800***	**11200** ***11000***	**13500** ***11400***	**8050** ***8100***	**9560** ***9550***	- -	- -	- -	- -
Manganese	µg/L	**5.28** ***2.84***	**113.00** ***17.00***	**120.00** ***69.60***	**31.70** ***23.70***	**42.30** ***8.47***	**50.60** ***50.70***	**27.70** ***11.40***	**50.10** ***39.70***	**78.80** ***22.70***	**56.60** ***55.50***	**89.20** ***72.70***	**37.10** ***34.90***	- 50	- -	- -	- -
Mercury	µg/L	**0.001050** ***0.000958***	**0.003640** ***0.002270***	**0.002340** ***0.001640***	**0.001970** ***0.001830***	**0.002010** ***0.001310***	**0.001600** ***0.001200***	**0.001700** ***0.001330***	**0.000890** ***0.000860***	**0.002280** ***0.002020***	**0.001820** ***0.001350***	**0.001870** ***0.001330***	**0.002140** ***0.002160***	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.673** ***0.695***	**0.397** ***0.473***	**0.403** ***0.413***	**0.479** ***0.502***	**0.994** ***0.980***	**0.745** ***0.683***	**0.928** ***0.861***	**1.070** ***1.020***	**1.650** ***1.380***	**1.330** ***1.310***	**0.858** ***0.845***	**0.493** ***0.565***	- 16000	- 370	- -	- -
Nickel	µg/L	**1.48** ***1.45***	**2.07** ***1.70***	**1.65** ***1.55***	**1.72** ***1.54***	**2.04** ***1.98***	**2.04** ***2.19***	**2.23** ***2.48***	**2.43** ***2.44***	**2.33** ***2.35***	**2.42** ***2.52***	**1.75** ***1.67***	**2.01** ***2.28***	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.02710 B** ***0.04800 B***	**0.02640 B** ***0.02310 B***	**0.01400 B** ***0.01250 B***	**0.18200** ***0.20900***	**0.07600** ***0.09900***	**0.01280 B** ***0.01410 B***	**0.01220 B** *0.00400 U*	**0.04300 B** ***0.00401 B***	**0.01860 B** *0.00400 U*	**0.01010 B** ***0.00685 B***	**0.22000** ***0.25800***	**0.00858 B** ***0.00841B***	- 3.4	- -	2 -	- -
Uranium	µg/L	**0.636** ***0.654***	**1.140** ***1.060***	**0.236** ***0.231***	**0.312** ***0.319***	**0.434** ***0.420***	**0.379** ***0.374***	**0.510** ***0.483***	**0.796** ***0.779***	**1.110** ***1.040***	**0.580** ***0.575***	**0.665** ***0.650***	**0.640** ***0.653***	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.263** ***0.233***	**1.340** ***0.537***	**0.303** ***0.107***	**0.441** ***0.371***	**0.822** ***0.672***	**0.629** ***0.526***	**0.707** ***0.632***	**0.562** ***0.485***	**0.629** ***0.567***	**0.739** ***0.622***	**1.430** ***0.983***	**0.784** ***0.688***	- 280	- 20	- -	- -
Zinc	µg/L	**0.487** ***0.480***	**3.680** ***0.423***	**1.260** ***0.370***	**0.628** ***0.293***	**0.802** ***0.596***	**1.250** ***0.216***	**1.180** ***0.702***	**2.180** ***1.210***	**1.870** ***1.020***	**1.010** ***4.410***	**1.740** ***0.484***	**1.460** ***1.660***	- 120	- 120	117 -	106 -
Other Parameters																	
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	5000	600	-	-
TOC	mg/L	3.7	6.4	6.8	6.0	8.2	5.9	6.5	3.2	8.3	7.0	6.1	5.6	-	-	-	-
pH (Field, Lab)	s.u.	7.5	7.28	6.98	7.57	7.91	8.12	8.17	7.55	7.15	7.69	7.69	8.22	6.5 - 9.0		-	
D.O. (Field)	mg/L	6.5	2.91	2.7	9.5	10.39	2.17	11.24	10.51	7.37	8.14	8.4	13.21	-	-	-	-
Conductivity (Field)	µ-ohm	238	208	205	231	355	262	319	369	271	407	407	290	-	-	-	-
Temperature (Field)	Deg.Cel.	11.02	14.61	16.29	13.66	13.75	16.9	16.55	15.68	15.38	14.2	14.2	14.39	-	-	-	-

*-For complete citations see Table 8-3. **-19 was a duplicate for 16, 20 was a duplicate for 04, 21 was a split for 05, and 22 was a split for 06. ***-No parameter was higher than average reference value. Underlining-represents results substantially above reference (above all reference values). Bold-represents results above detection limit. B-represents parameter was also detected in laboratory blank for that run. J-estimate value below reporting limit. NA-not available. U-under detection limit.

Highlighted represents exceedance of WQC

TABLE 8-5. COMPLETE SURFACE WATER RESULTS, JPG FIRING RANGE STUDY, 7-11 OCTOBER 2002 (CONTINUED)

PARAMETER	UNIT	SW-13	SW-14	SW-15	SW-16	SW-17**	SW-18**	Duplicate for SW-16 SW-19	Duplicate for SW-04 SW-20	Split for SW-05 SW-21	Split for SW-06 SW-22	Seep (spring) SG-01	REGULATORY CRITERIA* FEDERAL AMBIENT WATER QUALITY CRITERIA CMC	REGULATORY CRITERIA* FEDERAL AMBIENT WATER QUALITY CRITERIA CCC	REGULATORY CRITERIA* INDIANA AMBIENT WATER QUALITY CRITERIA CMC	REGULATORY CRITERIA* INDIANA AMBIENT WATER QUALITY CRITERIA CCC
Explosives and Degradates																
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	0.025 J	0.100 U	0.037 J	0.13	0.100 U	0.100 U	0.051 J	0.100 U	0.031 J	0.021 J	0.100 U	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.026 U	0.5	0.1		
Metals																
Hardness	mg/L	116	120	128	175	98	144	175	128	156	148	198	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	0.0937 *0.0644*	0.0830 *0.0820*	0.0703 *0.0864*	0.1300 *0.1010*	0.0611 *0.0616*	0.0733 *0.0711*	0.1090 *0.1150*	0.0947 *0.1080*	0.0946 *0.0967*	0.0781 *0.0793*	0.0207 B *0.0143 B*	- 180	- 30	-	-
Arsenic	µg/L	0.572 *0.329*	0.747 *0.777*	2.000 *1.340*	1.530 *1.360*	0.773 *0.791*	0.839 *0.906*	1.450 *1.370*	0.740 *0.713*	1.150 *1.190*	0.900 *1.040*	0.385 *0.210*	- 340	- 150	360 -	190 -
Barium	µg/L	122.0 *49.0*	43.8 *45.0*	111.0 *72.9*	57.0 *53.4*	37.4 *34.9*	44.9 *42.7*	54.7 *53.7*	44.8 *44.1*	52.2 *51.4*	45.9 *44.2*	46.2 *43.7*	- 1000	1000	- -	- -
Cadmium	µg/L	0.10100 *0.01080*	0.00991 *0.00922*	0.02100 *0.01870*	0.02310 *0.01520*	0.00790 *0.01070*	0.01190 *0.01020*	0.01460 *0.01030*	0.01280 *0.00671*	0.00875 *0.01030*	0.01020 *0.00709*	0.06020 *0.07270*	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	92900 *27300*	34700 *36100*	39600 *39000*	50900 *50000*	30000 *30300*	45300 *44500*	50500 *49900*	37000 *36400*	46000 *45800*	46200 *45800*	49800 *50400*	- -	- -	- -	- -
Chromium	µg/L	0.0309 *0.0240 U*	0.1770 *0.0384*	0.0240 U *0.0240 U*	0.5750 *0.3990*	0.3430 *0.2500*	0.2320 *0.2740*	0.4540 *0.3220*	0.0322 *0.0240 U*	0.3180 *0.2380*	0.3090 *0.2940*	0.4380 *0.1650*	- 570	- 74	1737 -	207 -
Copper	µg/L	5.520 *0.657*	1.310 *1.240*	0.758 *0.893*	1.270 *0.951*	0.549 *0.526*	0.811 *0.780*	1.100 *0.989*	1.090 *1.030*	1.030 *0.935*	0.846 *0.943*	0.477 *0.250*	- 13	- 9	18 -	9 -
Lead	µg/L	0.09770 *0.00500 U*	0.03660 *0.00569*	0.10000 *0.02270*	0.37300 *0.00500 U*	0.18800 *0.03220*	0.07320 *0.01730*	0.14600 *0.00500 U*	0.03320 *0.00500 U*	0.08630 *0.00936*	0.05620 *0.01530*	0.42500 *0.005 U*	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	13100 *11600*	7670 *7830*	7520 *7420*	12400 *12200*	5340 *5460*	7950 *7920*	12300 *12100*	9090 *9130*	10200 *10100*	7990 *8160*	17700 *17800*	- -	- -	- -	- -
Manganese	µg/L	251.00 *4.65*	38.40 *34.60*	939.00 *401.00*	99.40 *8.48*	37.10 *20.20*	57.70 *42.10*	42.80 *7.79*	29.00 *24.90*	40.20 *7.17*	54.00 *22.90*	51.50 *18.80*	- 50	- -	- -	- -
Mercury	µg/L	0.001740 *0.001100*	0.002070 *0.001950*	0.001640 *0.001560*	0.003130 *0.001630*	0.001810 *0.001510*	0.001570 *0.001320*	0.002340 *0.001480*	0.001890 *0.001660*	0.002100 *0.001380*	0.001590 *0.001270*	0.001980 *0.000523*	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	0.218 *0.260*	0.463 *0.472*	0.527 *0.529*	1.160 *1.200*	0.455 *0.454*	0.661 *0.621*	1.210 *1.230*	0.498 *0.479*	0.991 *0.963*	0.749 *0.714*	0.147 *0.182*	- 16000	- 370	- -	- -
Nickel	µg/L	3.70 *1.14*	1.85 *1.72*	1.58 *1.58*	2.46 *2.28*	1.51 *1.46*	2.02 *2.01*	2.40 *2.26*	1.60 *1.57*	2.04 *1.87*	2.04 *2.35*	2.31 *1.90*	- 470	- 52	1418 -	158 -
Silver	µg/L	0.04670 B *0.02390 B*	0.01050 B *0.01160 B*	0.24900 *0.24300*	0.01990 B *0.00816 B*	0.01670 B *0.02160 B*	0.01370 B *0.01810 B*	0.00928 B *0.00957 B*	0.15400 *0.17100*	0.10500 *0.12700*	0.01150 B *0.00526 B*	0.0316 B *0.0149 B*	- 3.4	- -	2 -	- -
Uranium	µg/L	0.353 *0.368*	4.080 *4.330*	0.253 *0.327*	0.547 *0.516*	0.174 *0.161*	0.344 *0.325*	0.528 *0.521*	0.320 *0.313*	0.436 *0.412*	0.388 *0.371*	1.030 *1.010*	- 46	- 2.6	- -	- -
Vanadium	µg/L	0.326 *0.132*	0.631 *0.582*	0.475 *0.450*	1.220 *0.801*	0.588 *0.328*	0.546 *0.446*	1.010 *0.813*	0.431 *0.370*	0.807 *0.661*	0.625 *0.523*	0.775 *0.241*	- 280	- 20	- -	- -
Zinc	µg/L	12.500 *0.393*	0.750 *0.458*	1.100 *0.450*	1.590 *2.400*	1.020 *0.455*	1.580 *0.287*	0.941 *0.605*	1.670 *0.335*	0.658 *0.517*	0.588 *0.475*	3.500 *1.410*	- 120	- 120	117 -	106 -
Other Parameters																
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	5000	600	-	-
TOC	mg/L	3.2	5.6	6.8	9.0	7.0	5.4	9.1	6.1	8.2	5.8	1.1	-	-	-	-
pH (Field, Lab)	s.u.	7.7	7.88	7.62	8.07	8.14	7.95	8.07	7.6	7.91	8.12	6.85	6.5 - 9.0		-	
D.O. (Field)	mg/L	8.9	11.2	8.4	11.12	7.1	2.41	11.12	9.17	10.76	2.17	0.61	-	-	-	-
Conductivity (Field)	µ-ohm	203	220	14.57	400	170	257	400	231	355	262	379	-	-	-	-
Temperature (Field)	Deg. Cel.	12.37	14.53	259	13.36	16.34	16.15	13.36	13.66	13.69	16.9	15.09	-	-	-	-

*-For complete citations see Table 8-3. ** No parameter was higher than the average reference value. Underlining-represents results substantially above reference (above all reference values). Bold-represents results above detection limit. B-represents parameter was also detected in laboratory blank for that run. J-estimate value below reporting limit. NA-not available. U-under detection limit.

▨ Highlighted represents exceedance of WQC

TABLE 8-6. COMPLETE SEDIMENT RESULTS FOR JPG FIRING RANGE STUDY, 7-11 OCTOBER 2002

PARAMETER	UNIT	SE-01	SE-02	SE-03	SE-04**	SE-05**	SE-06**	Reference SE-07	Reference SE-08	Reference SE-09	Reference SE-10	Reference SE-11	Reference SE-12	REGULATORY CRITERIA* SEDIMENT QUALITY BENCHMARK
Explosives and Degradates														
HMX	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	**0.080**	**0.091**	**0.260**	0.050 U	0.050 U	0.050 U	0.050 U	0.330[1]
RDX	µg/g	**0.031**	**0.280**	**0.009 J**	**0.190**	**0.120**	**0.260**	**0.420**	**1.900**	**0.098**	**0.220**	**0.350**	**0.280**	0.190[1]
2,4,6-TNT	µg/g	0.010 U	**0.047**	0.010 U	**0.040**	**0.020**	**0.046**	**0.086**	**0.280**	**0.200**	**0.034**	**0.054**	**0.047**	0.52[1]
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.04[1]
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.02[1]
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	27.0[1]
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	18.5[1]
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.230[1]
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
4-NT	µg/g	0.040 U	0.060 U	0.040 U	0.070 U	0.050 U	0.080 U	0.070 U	0.070 U	0.050 U	0.060 U	0.070 U	0.060 U	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	NA
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.26[5]
Moisture (WP only)	Percent	**20**	**20**	**20**	**20**	**15**	**19**	**21**	**11**	**18**	**22**	**20**	**22**	NA
Metals														
Antimony	µg/g	**0.407**	**0.259**	**0.185**	**0.365**	**0.186**	**0.253**	**0.271**	**0.348**	**0.195**	**0.141**	**0.196**	**0.31**	NA
Arsenic	µg/g	**13.10**	**7.71**	**6.68**	**8.02**	**4.71 B**	**20.20**	**3.79 B**	**6.45**	**3.70 B**	**7.68**	**3.40 B**	**9.64**	5.9[2]
Barium	µg/g	**189**	**200**	**165**	**183**	**212**	**318**	**246**	**180**	**243**	**261**	**159**	**149**	500[3]
Cadmium	µg/g	**0.219 B**	**0.0955 B**	**0.0927 B**	**0.133 B**	**0.0669 B**	0.0587 U	**0.103 B**	**0.0955 B**	**0.0964 B**	**0.0822 B**	**0.0823 B**	**0.108 B**	0.596[2]
Chromium	µg/g	**31.20**	**11.70**	**9.98**	**19.40**	**11.40**	**18.20**	**17.50**	**11.90**	**7.53**	**9.40**	**8.61**	**12.70**	26[3]
Copper	µg/g	**5.20**	**2.77**	**2.83**	**3.63**	**2.37**	**3.59**	**3.07**	**4.61**	**3.85**	**8.20**	**2.28**	**3.07**	16[3]
Lead	µg/g	**15.10**	**8.46**	**4.88**	**7.76**	**6.03**	**10.50**	**6.84**	**11.50**	**7.03**	**7.85**	**4.80**	**9.04**	31[3]
Manganese	µg/g	**500**	**239**	**143**	**391**	**183**	**326**	**154**	**496**	**237**	**235**	**143**	**327**	460[3]
Mercury	µg/g	**0.00630 J**	**0.01040**	**0.08700**	**0.01740**	**0.01450**	**0.00710 B,J**	**0.01350 B**	**0.01600 B**	**0.01910 B**	**0.01020**	**0.01380**	**0.01380**	0.174[2]
Molybdenum	µg/g	**1.330**	**0.782**	**0.550**	**1.150**	**0.516**	**0.868**	**0.837**	**1.150**	**0.452**	**0.486**	**0.642**	**0.881**	NA
Nickel	µg/g	**5.26**	**4.14**	**2.33**	**8.27**	**3.34**	**5.73**	**5.24**	**6.61**	**3.08**	**4.06**	**2.42**	**3.69**	16[3]
Silver	µg/g	**0.1350**	**0.0465**	**0.0416**	**0.1100**	**0.0593**	**0.0803**	**0.0729**	**0.1350**	**0.0485**	**0.1060**	**0.1460**	**0.1020**	1[4]
Uranium	µg/g	**0.599**	**0.517**	**0.354**	**0.516**	**0.286**	**0.719**	**0.357**	**0.948**	**0.682**	**0.436**	**0.416**	**0.531**	NA
Vanadium	µg/g	**37.0**	**23.4**	**15.2**	**35.4**	**15.8**	**25.8**	**21.7**	**25.5**	**16.1**	**13.9**	**27.3**	**27.6**	NA
Zinc	µg/g	**33.2**	**21.7**	**17.1**	**24.3**	**18.6**	**44.6**	**16.7**	**23.8**	**19.2**	**16.0**	**15.6**	**21.7**	120[3]
Moisture	Percent	19.9	21.5	21.2	18.7	18.2	20.1	20.7	12.0	20.8	20.7	17.1	20.2	NA
Other Parameters														
Total Organic Matter	Percent	**1.1**	**0.7**	**0.7**	**0.8**	**0.5**	**0.9**	**0.6**	**1.6**	**0.6**	**0.6**	**0.7**	**0.8**	NA
Perchlorate	µg/g	0.013 U	0.013 U	0.013 U	0.012 U	0.013 U	0.013 U	0.013 U	0.011 U	0.013 U	0.013 U	0.013 U	0.013 U	NA

*-For complete citations see Table 8-3. ****-19 was a duplicate for 16, 20 was a duplicate for 04, 21 was a split for 05, and 22 was a split for 06.** Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of SQB

TABLE 8-6. COMPLETE SEDIMENT RESULTS FOR JPG FIRING RANGE STUDY, 7-11 OCTOBER 2002

PARAMETER	UNIT	SE-13	SE-14	SE-15	SE-16	SE-17	SE-18	Duplicate for 16 SE-19	Duplicate for 04 SE-20	Duplicate for 05 SE-21	Duplicate for 06 SE-22	REGULATORY CRITERIA* SEDIMENT QUALITY BENCHMARK
Explosives and Degradates												
HMX	µg/g	**0.140**	0.050 U	0.050 U	**0.320**	**0.04 J**	0.050 U	0.050 U	0.050 U	0.050 U	**0.046 J**	0.330^{1}
RDX	µg/g	**0.300**	**0.220**	**0.110**	**1.100**	**0.260**	**0.120**	0.010 U	**0.140**	0.010 U	**0.250**	0.190^{1}
2,4,6-TNT	µg/g	**0.050**	**0.051**	**0.038**	**0.130**	**0.043**	**0.016**	**0.018**	**0.030**	**0.007 J**	**0.040**	0.52^{1}
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.04^{1}
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.02^{1}
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	27.0^{1}
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	18.5^{1}
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.230^{1}
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	NA
4-NT	µg/g	0.070 U	0.070 U	0.060 U	0.060 U	0.070 U	0.050 U	0.050 U	0.070 U	0.020 U	0.070 U	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	NA
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.26^{5}
Moisture (WP only)	Percent	20	15	18	20	21	22	20	20	17	18	NA
Metals												
Antimony	µg/g	**0.474**	**0.485**	**0.323**	**0.151**	**0.280**	**0.217**	**0.162**	**0.259**	**0.172**	**0.343**	NA
Arsenic	µg/g	**8.82**	**23.80**	**11.40**	**4.84 B**	**5.52 B**	**15.90**	**4.26 B**	**9.28**	**6.96**	**18.70**	5.9^{2}
Barium	µg/g	**210**	**263**	**242**	**229**	**249**	**219**	**230**	**196**	**210**	**287**	500^{3}
Cadmium	µg/g	**0.1780 B**	0.0587 U	**0.1770 B**	**0.1060 B**	**0.1580 B**	0.0587 U	**0.1010 B**	**0.0945 B**	0.0587 U	0.0587 U	0.596^{2}
Chromium	µg/g	**23.5**	**24.9**	**23.0**	**11.5**	**19.6**	**14.2**	**18.5**	**13.4**	**12.6**	**33.6**	26^{3}
Copper	µg/g	**9.65**	**5.72**	**4.50**	**3.86**	**5.95**	**2.11**	**3.43**	**3.79**	**3.14**	**3.59**	16^{3}
Lead	µg/g	**19.40**	**11.70**	**12.30**	**7.36**	**10.90**	**6.72**	**7.64**	**7.59**	**8.52**	**10.20**	31^{3}
Manganese	µg/g	**743**	**639**	**392**	**310**	**434**	**219**	**225**	**325**	**230**	**298**	460^{3}
Mercury	µg/g	**0.00990 J**	**0.02110 B**	**0.02390**	**0.00800 J**	**0.02030**	**0.02120 B**	**0.01030**	**0.01360**	**0.00840 J**	**0.01160 B**	0.174^{2}
Molybdenum	µg/g	**1.120**	**1.470**	**1.000**	**0.329**	**0.606**	**0.554**	**0.438**	**0.802**	**0.476**	**0.897**	NA
Nickel	µg/g	**6.19**	**6.72**	**6.71**	**3.04**	**5.86**	**4.53**	**3.32**	**4.42**	**3.38**	**5.72**	16^{3}
Silver	µg/g	**0.0660**	**0.0674**	**0.1120**	**0.0545**	**0.0985**	**0.0592**	**0.0846**	**0.0606**	**0.0899**	**0.0625**	1^{4}
Uranium	µg/g	**0.629**	**3.050**	**0.666**	**0.646**	**0.964**	**0.462**	**0.618**	**0.504**	**0.338**	**0.755**	NA
Vanadium	µg/g	**25.2**	**49.4**	**35.1**	**17.5**	**26.8**	**23.0**	**15.1**	**20.8**	**17.7**	**26.4**	NA
Zinc	µg/g	**51.6**	**45.8**	**28.4**	**22.8**	**35.2**	**31.6**	**20.1**	**23.4**	**19.7**	**42.5**	120^{3}
Moisture	Percent	22.8	20.7	17.2	21.9	26.8	20.6	18.3	18.4	17.9	20.7	NA
Other Parameters												
Total Volatile Solids	Percent	0.9	0.9	1.2	0.8	1.7	0.4	0.5	0.9	0.5	0.9	NA
Perchlorate	µg/g	0.013 U	0.013 U	0.012 U	0.013 U	0.012 U	0.013 U	0.013 U	0.012 U	0.013 U	0.012 U	NA

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of SQB

TABLE 8-7 BENTHIC MACROINVERTEBRATE RESULTS, JPG FIRING RANGE STUDY, 7-11 OCTOBER 2002

Genus species	1A	1B	1C	1ABC	2A	2B	2C	2ABC	3	4A	4B	4C	4ABC
Otomesostoma												1	1
Sphaerium striatinum	1			1	1		1	2		5	3		8
Stagnicola exilis		2	2	4	5	1	1	7	2	64	8	1	73
Physella gyrina													
Heliosoma anceps										1			1
Ferrissia rivularis													
Bdellodrillus illuminatus			1	1									
Pristina sp.					4	3		7	3			1	1
Limnodrilus hoffmeisteri													
Morreobdella fervida													
Oronectes sloanii													
Cambarus robustus	16	4	14	34	3	1	1	5	1	1	6	8	15
Ascellus sp.	1	1	3	5	1			1	1				
Gammarus pseudolimnaeus		1		1									
Ephemerella crenula						1		1					
Caenis sp.	4	7	4	15	4	5	1	10		1	2	1	4
Stenonema terminatum	24	20	4	48	44	26	45	115	6	14	20	7	41
Ephemera sp.		1	2	3									
Leptophlebia sp.		1		1	12	6	1	19	4	17	36	27	80
Calopteryx maculata													
Argia moesta													
Basiaeschna janata	1			1									
Arigomphus submedianus													
Pachydiplax longipennis													
Macromia illinoiensis													
Acroneuria carolinensis					3	1	2	6					
Ranatraa buenoi													
Nigronia serricornis	4	2	1	7	3	2	3	8		3	8	2	13
Corydalus cornutus													
Sialis sp.		1		1		1		1					
Helicopsyche borealis						1	1	2		1	1		2
Chimasrra atterrima					2	1		3					
Cheumatopsyche spp.											1		1
Haliplus sp.													
Berosus sp.													
Psephenus hetricki	8	5	1	14		2	1	3	1	9	13	6	28
Stenemis sexlineata						1		1			1		1
Helichus lithophilus		2		2		1		1		1	1		2
Ablabesmyia mallochi							1	1	1				
Chironomus sp.													
Endochironomus sp.	1	1		2	2		1	3	2	1			1
Tanytarsus sp.													
Cnephia sp.										1			1
Tipula sp.													
Chrysops sp.													
Nematelus sp.												1	1
Antichaeta sp.											1	1	2
Number of Taxa	9	13	9	16	12	15	12	19	9	13	13	11	19
Number of Organisms	60	48	32	140	84	53	59	196	21	119	101	56	276
EPT/Total Individuals	47%	60%	31%	48%	77%	77%	85%	80%	48%	28%	59%	63%	46%
Diversity H	2.08	2.42	2.13	2.62	2.12	2.21	1.23	2.15	2.26	2.07	2.54	2.2	2.59

Genus species	**5A**	**5B**	**5C**	**5ABC**	**6A**	**6B**	**6C**	**6ABC**	**7A**	**7B**	**7C**	**7ABC**	**8**
Otomesostoma													1
Sphaerium striatinum	1	5	1	7	1			1	1			1	
Stagnicola exilis	82	28	37	147	1			1					1
Physella gyrina	8	12	10	30					1			1	6
Heliosoma anceps													1
Ferrissia rivularis											1	1	1
Bdellodrillus illuminatus													
Pristina sp.	3	1	2	6		4	1	5	1	3		4	3
Limnodrilus hoffmeisteri													
Morreobdella fervida													
Oronectes sloanii													
Cambarus robustus	1	6	3	10	1		1	2			1	1	1
Ascellus sp.													
Gammarus pseudolimnaeus													
Ephemerella crenula													
Caenis sp.	7	9	6	22	1	2	2	5	5	4	3	12	2
Stenonema terminatum	20	35	25	80	3	4	5	12	11	7	2	20	47
Ephemera sp.		2	1	3									
Leptophlebia sp.	6	3	1	10	1	3		4			2	2	
Calopteryx maculata											1	1	2
Argia moesta		4		4									
Basiaeschna janata													
Arigomphus submedianus													1
Pachydiplax longipennis													
Macromia illinoiensis													
Acroneuria carolinensis													
Ranatraa buenoi													
Nigronia serricornis	1			1									
Corydalus cornutus			1	1	6	2	1	9					
Sialis sp.		1		1									3
Helicopsyche borealis		4		4	11	20		31	1			1	9
Chimasrra atterrima		1		1						3	2	5	6
Cheumatopsyche spp.		1		1	1			1	1	2	2	5	
Haliplus sp.													
Berosus sp.										1		1	
Psephenus hetricki	12	16	42	70			1	1	2	4	2	8	2
Stenemis sexlineata	2	2		4	3		1	4	1		1	2	
Helichus lithophilus					3			3	1			1	
Ablabesmyia mallochi													
Chironomus sp.													
Endochironomus sp.	1			1		10		10	3	7	7	17	2
Tanytarsus sp.		1	3	4	4	1	1	6	1			1	
Cnephia sp.													
Tipula sp.													
Chrysops sp.									4	1	1	6	
Nematelus sp.													
Antichaeta sp.										1		1	
Number of Taxa	12	17	12	20	12	8	8	15	13	10	12	20	16
Number of Organisms	144	131	132	407	36	46	13	95	33	33	25	91	88
EPT/Total Individuals	23%	42%	25%	30%	75%	63%	54%	65%	55%	48%	44%	49%	73%
Diversity H	2.2	3.07	2.57	2.9	2.55	2.02	1.95	2.86	2.53	2.53	2.59	3.12	2.84

Genus Species	**09**	**10A**	**10B**	**10C**	**10ABC**	**11A**	**11B**	**11C**	**11ABC**	**12A**	**12B**	**12C**	**12ABC**
Otomesostoma													
Sphaerium striatinum	1		2	3	5					1			1
Stagnicola exilis	1	17	13	34	64	4	10	11	25				
Physella gyrina	2		4	1	5	1		1	2		1	1	2
Heliosoma anceps			1		1	2	5	2	9			1	1
Ferrissia rivularis													
Bdellodrillus illuminatus													
Pristina sp.	5	4		1	5	17	14	7	38		5	3	8
Limnodrilus hoffmeisteri													
Morreobdella fervida		1	1		2								
Oronectes sloanii			3	2	5	13	9	14	36	12	10	6	28
Cambarus robustus		1		1	2								
Ascellus sp.													
Gammarus pseudolimnaeus							1		1	1			1
Ephemerella crenula													
Caenis sp.	1	7	1	3	11	13	21	20	54	4	11	5	20
Stenonema terminatum	1	17	29	17	63	29	54	92	175	16	14	16	46
Ephemera sp.													
Leptophlebia sp.		8		1	9							6	6
Calopteryx maculata													
Argia moesta			2	1	3								
Basiaeschna janata							1		1				
Arigomphus submedianus													
Pachydiplax longipennis	1					1			1				
Macromia illinoiensis													
Acroneuria carolinensis													
Ranatraa buenoi			1		1								
Nigronia serricornis			5	1	6							1	1
Corydalus cornutus													
Sialis sp.		1		1	2								
Helicopsyche borealis			1	2	3								
Chimasrra atterrima													
Cheumatopsyche spp.													
Haliplus sp.						1			1	1			1
Berosus sp.													
Psephenus hetricki		4	2	6	12	1	1	1	3	3	2	7	12
Stenemis sexlineata			1	1	2		1		1	1			1
Helichus lithophilus			1		1		1		1	1			1
Ablabesmyia mallochi												2	2
Chironomus sp.	4					1			1			1	1
Endochironomus sp.	1					1		1	2	1	1	3	5
Tanytarsus sp.	1	1		1	2								
Cnephia sp.													
Tipula sp.													
Chrysops sp.													
Nematelus sp.													
Antichaeta sp.			1		1								
Number of Taxa	10	10	16	16	21	12	11	9	16	10	7	12	17
Number of Organisms	18	61	68	76	205	84	118	149	351	41	44	52	137
ETT/Total Individuals	11%	52%	46%	30%	42%	50%	64%	75%	65%	49%	57%	52%	53%
Diversity H	2.28	2.58	2.49	2.57	3	2.37	2.21	1.73	2.23	1.91	1.67	2.35	2.1

Genus species	**13A**	**13B**	**13C**	**13ABC**	**14A**	**14B**	**14C**	**14ABC**	**15A**	**15B**	**15C**	**15ABC**
Otomesostoma											1	1
Sphaerium striatinum		2	3	5						1		1
Stagnicola exilis	5	12	48	65	30	33	48	111	34	23	23	80
Physella gyrina		1	2	3	4	1	5	10				
Heliosoma anceps			2	2	1			1				
Ferrissia rivularis												
Bdellodrillus illuminatus												
Pristina sp.			1	1					5	2	4	11
Limnodrilus hoffmeisteri												
Morreobdella fervida												
Oronectes sloanii	15	8	5	28					1	5	2	8
Cambarus robustus			1	1								
Ascellus sp.		1	1	2								
Gammarus pseudolimnaeus	1	2	1	4								
Ephemerella crenula											2	2
Caenis sp.	1	6	2	9	4			4	1	2	1	4
Stenonema terminatum	2	2	10	14	6	9	3	18	13	4	13	30
Ephemera sp.												
Leptophlebia sp.									31	7	8	46
Calopteryx maculata												
Argia moesta												
Basiaeschna janata												
Arigomphus submedianus												
Pachydiplax longipennis												
Macromia illinoiensis												
Acroneuria carolinensis							1	1				
Ranatraa buenoi												
Nigronia serricornis		1	2	3	1		3	4				
Corydalus cornutus							1	1				
Sialis sp.		2		2								
Helicopsyche borealis		1	1	2	1		12	13				
Chimasrra atterrima					8	9	16	33				
Cheumatopsyche spp.												
Haliplus sp.												
Berosus sp.												
Psephenus hetricki			5	5	1			1	18	10	19	47
Stenemis sexlineata										1		1
Helichus lithophilus												
Ablabesmyia mallochi												
Chironomus sp.			1	1								
Endochironomus sp.		1		1							2	2
Tanytarsus sp.					1			1				
Cnephia sp.					1			1				
Tipula sp.							1	1				
Chrysops sp.							1	1				
Nematelus sp.												
Antichaeta sp.					3	1	5	9				
Number of Taxa	5	12	15	17	12	5	11	16	7	9	10	12
Number of Organisms	24	39	85	148	61	53	96	210	103	55	75	233
EPT/Total Individuals	13%	23%	15%	16%	30%	34%	33%	33%	44%	24%	32%	31%
Diversity H	1.3	2.49	2.15	2.55	2.21	1.49	2.08	2.26	2.06	2.2	2.36	2.42

Genus species	16A	16B	16C	16ABC	17A	17B	17C	17ABC	18A	18B	18C	18ABC
Otomesostoma												
Sphaerium striatinum	1	1		2	1	2	1	4	2	2		4
Stagnicola exilis	2	3	5	10	4	5		9				
Physella gyrina		1	1	2								
Heliosoma anceps												
Ferrissia rivularis						1		1				
Bdellodrillus illuminatus												
Pristina sp.	1			1								
Limnodrilus hoffmeisteri		2	1	3	1	2	1	4		4		4
Morreobdella fervida												
Oronectes sloanii	2	4	2	8	5		1	6	1	2	1	4
Cambarus robustus					2			2				
Ascellus sp.												
Gammarus pseudolimnaeus												
Ephemerella crenula					2			2				
Caenis sp.	2	3	7	12	4	7	1	12	8	3	2	13
Stenonema terminatum	13	12	23	48	4	26	19	49	21	10	15	46
Ephemera sp.									1	5	1	7
Leptophlebia sp.		4	3	7		2		2	3			3
Calopteryx maculata												
Argia moesta					1			1				
Basiaeschna janata												
Arigomphus submedianus		1		1								
Pachydiplax longipennis												
Macromia illinoiensis							1	1	1			1
Acroneuria carolinensis					1	1		2				
Ranatraa buenoi												
Nigronia serricornis		3	2	5								
Corydalus cornutus					2			2	1		4	5
Sialis sp.		2	1	3	1			1				
Helicopsyche borealis												
Chimasrra atterrima									12	20	11	43
Cheumatopsyche spp.									4	2		6
Haliplus sp.												
Berosus sp.												
Psephenus hetricki	27	14	9	50	5			5			2	2
Stenemis sexlineata			1	1	4			4				
Helichus lithophilus										1		1
Ablabesmyia mallochi									2			2
Chironomus sp.						1		1	1			1
Endochironomus sp.	1	3	2	6	1	2	2	5	7	5	3	15
Tanytarsus sp.												
Cnephia sp.												
Tipula sp.						1		1		3		3
Chrysops sp.		1		1								
Nematelus sp.												
Antichaeta sp.												
Number of Taxa	8	14	12	16	15	11	7	20	13	11	8	17
Number of Organisms	49	54	57	160	38	50	26	114	64	57	39	160
EPT/Total Individuals	31%	39%	60%	44%	29%	72%	77%	56%	77%	53%	74%	74%
Diversity H	1.64	2.8	2.41	2.67	3.01	2.07	1.06	2.79	2.53	2.55	2.04	3.72

- There were exceedances of the sediment benchmark of 0.190 μg/g for RDX at sampling locations 02 (0.280 μg/g), 04 (0.190 μg/g), 06 (0.260 μg/g), 07 (0.420 μg/g), 08 (1.90 μg/g), 10 (0.220 μg/g), 11 (0.350 μg/g), 12 (0.280 μg/g), 13 (0.300 μg/g), 14 (0.220 μg/g), 16 (1.100 μg/g), and 17 (0.260 μg/g). Sampling locations 07, 08, 09, 10, 11, and 12 were all upstream reference locations and should not be contaminated with explosives. Also, the RDX sediment benchmark was calculated from a series of freshwater toxicity tests and was very conservative. The lowest acute toxicity value for RDX in water was 3.6 mg/L and the maximum chronic to acute ratio was 0.52 making a chronic value 1.8 mg/L without being conservative (Bentley, 1977). Therefore, if all of the RDX in the sediment was available to the benthic organisms as if it were in the water with none tied up by carbon, only sampling location 08 with 1.9 mg/kg RDX would be close to possibly causing an adverse effect on the biota. Since there was no discernible adverse impact on any of the sampling location macroinvertebrates, none of the exceedances had an impact.
- Next, the data were evaluated by comparing the results from downstream locations to reference locations. This would determine if the firing and impact area activities were contributing munitions-related compounds to the watershed. Last, the ecological health of the benthic macroinvertebrate populations were evaluated to determine if firing and impact area activities were adversely impacting the aquatic biota. There were two watersheds (Middle Fork Creek and Marble Creek) that originated on JPG. To have a reference for comparison the reference results from the other watersheds were averaged. The results are presented below.

8.4.1 Collective Upstream Reference Sampling Locations

Sampling locations 07-12 were all upstream locations on the north and east boundary of JPG. Explosives are not naturally occurring compounds. Therefore, there should be no detectable levels of explosives in any of the reference sampling locations. Metals on the other hand are naturally occurring elements. The metals concentrations found at the reference locations should not be influenced by JPG activities and should represent background (environmental) levels for the JPG area. The reference locations were used for comparison to downstream locations that may have been influenced by upstream firing and impact area activities. Because Middle Fork Creek and Marble Creek originated on JPG, the reference surface water and sediment data were averaged for use in comparing to downstream locations. The benthic macroinvertebrate populations at the reference locations were used for comparison to downstream locations where explosive-related compounds could have adversely impacted the health of the aquatic biota. The reference locations were used within the same watershed when possible but an average of the six reference locations was also used, and where there were no or poor reference data for the watershed only the reference average was used (e.g., Middle Fork Creek and Marble Creek).

8.4.1.1 Surface Water Results

Surface water results and the average for the six reference locations are presented in Table 8-8.

TABLE 8-8 SURFACE WATER RESULTS AND AVERAGE FOR REFERENCE LOCATIONS

PARAMETER	UNIT	SW-07	SW-08	SW-09	SW-10	SW-11	SW-12	Reference Average (SW7-SW12)
Explosives and Degradates								
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0
RDX	µg/L	0.100 U	0.100 U	**0.023 J**	**0.072 J**	**0.036 J**	**0.040 J**	0.062
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.03
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.03
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.5
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.03
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.1
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.1
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.01
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.02
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024
Metals								
Hardness	mg/L	172	208	156	160	116	148	160
Antimony (Total/*Dissolved*)	µg/L	**0.0924** ***0.0913***	**0.0734** ***0.0651***	**0.0957** ***0.0886***	**0.1230** ***0.1110***	**0.1510** ***0.1580***	**0.0861** ***0.0844***	0.1036 0.0997
Arsenic	µg/L	**1.160** ***1.290***	**0.808** ***0.896***	**0.917** ***1.150***	**1.180** ***1.090***	**1.050** ***0.997***	**0.785** ***0.738***	0.983 1.027
Barium	µg/L	**52.9** ***51.2***	**58.2** ***57.3***	**65.3** ***62.6***	**58.4** ***58.1***	**56.5** ***54.9***	**55.2** ***53.7***	57.8 56.3
Cadmium	µg/L	**0.00963** ***0.01040***	**0.06130** ***0.02530***	**0.13600** ***0.01880***	**0.01700** ***0.08690***	**0.01980** ***0.02210***	**0.01740** ***0.01610***	0.04352 0.02993
Calcium	µg/L	**51900** ***51800***	**57100** ***57100***	**44800** ***44300***	**53400** ***45600***	**33300** ***33300***	**43900** ***43600***	47400 45950
Chromium	µg/L	**0.4080** ***0.3940***	**0.5220** ***0.8110***	**0.2920** ***0.4030***	**0.2980** ***0.3160***	**0.7540** ***0.1250***	**0.3390** ***0.2900***	0.4355 0.3898
Copper	µg/L	**0.989** ***0.968***	**0.614** ***0.600***	**1.180** ***1.180***	**1.120** ***1.030***	**1.370** ***1.260***	**1.120** ***1.140***	1.066 1.030
Lead	µg/L	**0.05780** ***0.01890***	**0.07110** ***0.00830***	**0.04080** *0.00500 U*	**0.07490** ***0.01300***	**2.01000** ***0.03410***	**0.23500** ***0.22500***	0.41493 0.05072
Magnesium	µg/L	**10300** ***10300***	**16400** ***15800***	**11200** ***11000***	**13500** ***11400***	**8050** ***8100***	**9560** ***9550***	11502 11025
Manganese	µg/L	**27.70** ***11.40***	**50.10** ***39.70***	**78.80** ***22.70***	**56.60** ***55.50***	**89.20** ***72.70***	**37.10** ***34.90***	56.58 39.48
Mercury	µg/L	**0.001700** ***0.001330***	**0.000890** ***0.000860***	**0.002280** ***0.002020***	**0.001820** ***0.001350***	**0.001870** ***0.001330***	**0.002140** ***0.002160***	0.001783 0.001508
Molybdenum	µg/L	**0.928** ***0.861***	**1.070** ***1.020***	**1.650** ***1.380***	**1.330** ***1.310***	**0.858** ***0.845***	**0.493** ***0.565***	1.055 0.997
Nickel	µg/L	**2.23** ***2.48***	**2.43** ***2.44***	**2.33** ***2.35***	**2.42** ***2.52***	**1.75** ***1.67***	**2.01** ***2.28***	2.20 2.29
Silver	µg/L	**0.01220 B** *0.00400 U*	**0.04300 B** ***0.00401 B***	**0.01860 B** *0.00400 U*	**0.01010 B** ***0.00685 B***	**0.22000** ***0.25800***	**0.00858 B** ***0.00841B***	0.05208 0.04755
Uranium	µg/L	**0.510** ***0.483***	**0.796** ***0.779***	**1.110** ***1.040***	**0.580** ***0.575***	**0.665** ***0.650***	**0.640** ***0.653***	0.717 0.697
Vanadium	µg/L	**0.707** ***0.632***	**0.562** ***0.485***	**0.629** ***0.567***	**0.739** ***0.622***	**1.430** ***0.983***	**0.784** ***0.688***	0.809 0.663
Zinc	µg/L	**1.180** ***0.702***	**2.180** ***1.210***	**1.870** ***1.020***	**1.010** ***4.410***	**1.740** ***0.484***	**1.460** ***1.660***	1.573 1.581
Other Parameters								
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0
TOC	mg/L	6.5	3.2	8.3	7.0	6.1	5.6	6.1
pH (Field, Lab)	s.u.	8.17	7.55	7.15	7.69	7.69	8.22	NA
D.O. (Field)	mg/L	11.24	10.51	7.37	8.14	8.4	13.21	NA
Conductivity (Field)	µ-ohm	319	369	271	407	407	290	NA
Temperature (Field)	Deg.Cel.	16.55	15.68	15.38	14.2	14.2	14.39	NA

Bold-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available.
U-under detection limit.

8.4.1.1.1 Metals and Hardness

Table 8-8 presents the hardness and metals reference data and the average. Since no military activity was known to have occured above the reference locations, the concentrations were initially assumed to represent reference metals levels for surface water in the area around JPG. The presence of some munitions constituents in the sediment samples suggests the possibility that military activity may in fact have occurred upstream of these locations. Metals that were not detected above the detection limit (flagged by a "U") were assumed to contain the detection limit concentration for that metal in the average. The hardness averaged 160 mg/L. This value is fairly high because of the limestone in the area. The harder the water the less toxic metals are to aquatic life.

8.4.1.1.2 Explosives and Degradates

No explosives were detected above the reporting limit in any of the reference surface water samples.

8.4.1.1.3 Perchlorate, Total Organic Carbon (TOC), and Field Parameters

Table 8-8 presents the perchlorate, TOC, and field parameters. Perchlorate was not detected, TOC averaged 6.1, and the field parameters were well within the range to support a healthy aquatic ecosystem.

8.4.1.1.4 Water Quality Criteria Screening

The Federal WQC and State WQS for metals are presented in Table 8-3 and 8-5. They are based on hardness of the water. The Federal WQC are based on dissolved metals and the State WQS are based on total metals. The harder the water the less toxic metals are to aquatic organisms. Even though the average hardness of the reference locations was 160 mg/L, 100 mg/L hardness was used in calculating WQC to be conservative because one of the sampling locations (17) had 98 mg/L hardness. All metals were within WQC and WQSs. However, manganese exceeded a secondary drinking water standard of 50 µg/L at sampling locations 10 (55.5 µg/L) and 11 (72.7 µg/L) indicating that the natural background in this limestone area can be above the standard. The lowest observed affect concentration for aquatic toxicity for manganese was 1,775 µg/L Kimball (nd). The tier II secondary chronic value was calculated to be 120 µg/L manganese (Jones, et. al 1997).

8.4.1.2 Sediment Results

Sediment results for all samples, along with the applicable SQBs, are presented in Table 8-6. The results of the reference locations and the reference averages are presented in Table 8-9. The analytical reference results are discussed below.

TABLE 8-9. SEDIMENT RESULTS FOR REFERENCE LOCATIONS, JPG FIRING RANGE STUDY, 7-11 OCTOBER 2002

PARAMETER	UNIT	SE-07	SE-08	SE-09	SE-10	SE-11	SE-12	Reference Average (SE-07-12)
Explosives and Degradates								
HMX	µg/g	**0.091**	**0.260**	0.050 U	0.050 U	0.050 U	0.050 U	0.092
RDX	µg/g	**0.420**	**1.900**	**0.098**	**0.220**	**0.350**	**0.280**	0.545
2,4,6-TNT	µg/g	**0.086**	**0.280**	**0.200**	**0.034**	**0.054**	**0.047**	0.117
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020
4-NT	µg/g	0.070 U	0.070 U	0.050 U	0.060 U	0.070 U	0.060 U	0.063
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.001
Moisture (WP only)	Percent	**21**	**11**	**18**	**22**	**20**	**22**	19
Metals								
Antimony	µg/g	**0.271**	**0.348**	**0.195**	**0.141**	**0.196**	**0.31**	0.244
Arsenic	µg/g	**3.79 B**	**6.45**	**3.70 B**	**7.68**	**3.40 B**	**9.64**	5.78
Barium	µg/g	**246**	**180**	**243**	**261**	**159**	**149**	206
Cadmium	µg/g	**0.103 B**	**0.0955 B**	**0.0964 B**	**0.0822 B**	**0.0823 B**	**0.108 B**	0.0946
Chromium	µg/g	**17.50**	**11.90**	**7.53**	**9.40**	**8.61**	**12.70**	11.27
Copper	µg/g	**3.07**	**4.61**	**3.85**	**8.20**	**2.28**	**3.07**	4.18
Lead	µg/g	**6.84**	**11.50**	**7.03**	**7.85**	**4.80**	**9.04**	7.84
Manganese	µg/g	**154**	**496**	**237**	**235**	**143**	**327**	265
Mercury	µg/g	**0.01350 B**	**0.01600 B**	**0.01910 B**	**0.01020**	**0.01380**	**0.01380**	0.01440
Molybdenum	µg/g	**0.837**	**1.150**	**0.452**	**0.486**	**0.642**	**0.881**	0.741
Nickel	µg/g	**5.24**	**6.61**	**3.08**	**4.06**	**2.42**	**3.69**	4.18
Silver	µg/g	**0.0729**	**0.1350**	**0.0485**	**0.1060**	**0.1460**	**0.1020**	0.1017
Uranium	µg/g	**0.357**	**0.948**	**0.682**	**0.436**	**0.416**	**0.531**	0.562
Vanadium	µg/g	**21.7**	**25.5**	**16.1**	**13.9**	**27.3**	**27.6**	22.0
Zinc	µg/g	**16.7**	**23.8**	**19.2**	**16.0**	**15.6**	**21.7**	18.8
Moisture	Percent	**20.7**	**12.0**	**20.8**	**20.7**	**17.1**	**20.2**	18.6
Other Parameters								
Total Organic Matter	Percent	**0.6**	**1.6**	**0.6**	**0.6**	**0.7**	**0.8**	0.8
Perchlorate	µg/g	0.013 U	0.011 U	0.013 U	0.013 U	0.013 U	0.013 U	0.013
Benthic Macroinvertebrate Summa								
Number of Taxa		20	16	10	21	16	17	17
Number of Individuals		91	88	18	205	351	134	148
EPT/Total Individuals		49%	73%	11%	41%	65%	53%	49%
Diversity H		3.12	2.84	2.28	3.00	2.23	2.31	2.63

Bold-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of SQB

8.4.1.2.1 Metals

Table 8-9 presents sediment results and average metals concentrations of the reference locations. These results represent the background sediment concentrations for the JPG area. As with the surface water data, metals that were not detected above the reporting limit were assumed to contain the reporting limit concentration for calculating the average. These average sediment metals concentrations represent the background level for the JPG drainage basins without their own reference site.

8.4.1.2.2 Explosives and Degradates

The explosive HMX was detected at sampling locations 07 (0.091 µg/g) and 08 (0.260 µg/g), RDX was detected at all six reference locations, and 2, 4, 6-TNT was detected at all six reference locations. The remainder of the explosives were not detected at any of the reference locations. The explosive HMX, RDX, and 2,4,6-TNT averaged 0.92, 0.545, and 0.117 µg/g, respectively. Since explosives would not be expected at the reference locations, the data has a degree of uncertainty attached to it. Possible reasons for the explosives being found in the reference locations include false positive detections, cross contamination, interference in the analytical method, or contamination offpost caused by stray shots or aerial deposition (smoke or unburned residue blowing in the wind). The data has been third party validated and explosives laboratory data passed the evaluation with the qualifiers. The detected explosives at reference locations are most likely due to undocumented military activity in the area.

8.4.1.2.3 Perchlorate and Total Organic Matter

There was no perchlorate detected at any of the reference locations and the total organic matter averaged 0.8 percent.

8.4.1.2.4 Sediment Quality Benchmarks

The results for the reference locations are presented in Table 8-9. The SQBs are presented and the exceedances are highlighted in Table 8-6. The RDX SQB of 0.19 µg/g was exceeded at sampling locations 07 (0.42 µg/g), 08 (1.90 µg/g), 10 (0.22 µg/g), 11 (0.35 µg/g), 12 (0.28 µg/g), and the reference average (0.545 µg/g). The arsenic SQB of 5.9 µg/g was exceeded at sampling locations 08 (6.45 µg/g), 10 (7.68 µg/g), and 12 (9.64 µg/g). The manganese SQB of 460 µg/g was exceeded at sampling location 08 (496 µg/g). The reference average was 265 µg/g manganese. These results indicate that reference locations exceeded SQBs for some constituents.

8.4.1.3 Benthic Macroinvertebrate Results

Benthic macroinvertebrate results for all sampling locations are presented in Table 8-7 and summarized for reference locations in Table 8-9. All of the JPG sampling locations to include the reference locations had a limited benthic macroinvertebrate population. The drought, the moderately high water caused by 6-7 inches of rain during the 27 September storm event, and the limited substrate made for a rather sparse benthic macroinvertebrate population. However, the reference locations had a good mix of pollution intolerant species with an average diversity of 2.63, 17 taxa, and 148 individuals per sample location. Diversity (H) values represent stream ecology as follows: above 3.0 – high quality, between 1.0 and 3.0 – intermediate quality, and below 1.0 – poor quality.

8.4.1.4 Collective Upstream Reference Sampling Locations Summary

Average reference conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results did not exceed WQC but some varied considerable from each other. Some of the sediment results for the reference locations exceeded SQBs for RDX, arsenic, and manganese. These exceedances indicate that reference locations can be high for some metals. The explosives detected at the reference locations suggest a potential problem at JPG that needs to be investigated further. However, these exceedances were not significant enough to adversely impact human health or the aquatic biota.

8.4.2 Middle Fork Creek Sampling Locations

See Figure 8-1 for sampling locations and watershed location in relation to firing line and impact fields. Middle Fork Creek drains the area of the firing line out to about 3000 meters near the western boundary and to 5500 meters near the eastern boundary. The stream starts close to the eastern boundary and drains southwest, draining several impact fields and the southeast corner of the Depleted Uranium Impact Area. There were two sampling locations (01 and 13) on Middle Fork Creek. Sampling location 01 was near the western perimeter road and sampling location 13 was near Morgan Road slightly more than midway through the installation. Since Middle Fork Creek originates on the installation, the average of the six reference locations from the other watersheds was used for background comparisons. When discussing the comparison between sampling locations and JPG reference locations, the term substantial was used if the sampling location value exceeded all of the six reference values.

8.4.2.1 Surface Water Results

Analytical results for all JPG surface water samples are presented in Table 8-5. The Federal WQC and State WQSs applicable to JPG surface waters are included in Table 8-5 for easy comparison. Middle Fork Creek surface water analytical results are presented in Table 8-10 and discussed below.

8.4.2.1.1 Metals and Hardness

There were more metals results lower than the average reference values than were higher at SW-01 and SW-13. The only metal at SW-01 that was substantially higher than the reference locations was dissolved cadmium (0.344 μg/L compared to 0.0299 μg/L). However, total cadmium was only 0.0661 μg/L at SW-01 and dissolved cadmium would not exceed total cadmium. Therefore, the increase is questionable. Sampling location SW-13, upstream of SW-01, had several total metals substantially higher than reference locations (barium, calcium,

TABLE 8-10 MIDDLE FORK CREEK SURFACE WATER RESULTS

PARAMETER	UNIT	SW-1	SW-13	Reference Average (SW7-SW12)	REGULATORY CRITERIA*			
					FEDERAL AMBIENT WATER QUALITY CRITERIA		INDIANA AMBIENT WATER QUALITY CRITERIA	
					CMC	CCC	CMC	CCC
Explosives and Degradates								
HMX	µg/L	3.0 U	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	**0.190**	**0.025 J**	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.09	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024	0.5	0.1		
Metals								
Hardness	mg/L	141	116	160	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	**0.0877** ***0.0992***	**0.0937** ***0.0644***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**0.420** ***0.436***	**0.572** ***0.329***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**66.6** ***66.4***	**122.0** ***49.0***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.06610** ***0.34400***	**0.10100** ***0.01080***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**35500** ***35800***	**92900** ***27300***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	**0.3580** ***0.3020***	**0.0309** *0.0240 U*	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**1.240** ***1.260***	**5.520** ***0.657***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**0.03100** *0.00500 U*	**0.09770** *0.00500 U*	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**12600** ***12600***	**13100** ***11600***	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**5.28** ***2.84***	**251.00** ***4.65***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.001050** ***0.000958***	**0.00174** ***0.00110***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.673** ***0.695***	**0.218** ***0.260***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**1.48** ***1.45***	**3.70** ***1.14***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.02710 B** ***0.04800 B***	**0.04670 B** ***0.02390 B***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**0.636** ***0.654***	**0.353** ***0.368***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.263** ***0.233***	**0.326** ***0.132***	0.809 0.663	- 280	- 20	- -	- -
Zinc	µg/L	**0.487** ***0.480***	**12.500** ***0.393***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters								
Perchlorate	µg/L	1.0 U	1.0 U	1.0	5000	600	-	-
TOC	mg/L	3.7	**3.2**	6.1	-	-	-	-
pH (Field, Lab)	s.u.	7.5	7.7		6.5 - 9.0		-	
D.O. (Field)	mg/L	6.5	8.9		-	-	-	-
Conductivity (Field)	µohm	238	203		-	-	-	-
Temperature (Field)	Deg.Cel.	11.02	12.37		-	-	-	-

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

copper, manganese, nickel, and zinc). Since none of the dissolved metals were any higher at SW-13 than the reference locations, there is a strong possibility that extra suspended solids somehow got into the total metals sample. Whether the solids were stirred up by the sampling effort or something happening upstream cannot be determined. Also, SW-01 that was downstream of SW-13 did not show similar results even though the SW-01 sample was collected about 2 hours earlier.

8.4.2.1.2 Explosives and Degradates

The explosive RDX was detected at SW-01 (0.19μg/L) and detected below the reporting limit at SW-13. However, RDX was also detected below the reporting limit at four of the six reference locations. No other explosives were detected in the surface water of Middle Fork Creek. The concentration detected at SW-01 is only 1/100 the level that is considered safe for aquatic life.

8.4.2.1.3 Perchlorate and Field Parameters

Perchlorate was not detected in the surface water of Middle Fork Creek. TOC and the field parameters were well within reference values and what would be required to support a healthy ecological community.

8.4.2.1.4 Water Quality Criteria Screening

There were no exceedances of Federal WQC or State WQSs in Middle Fork Creek.

8.4.2.2 Sediment Results

The Middle Fork Creek sediment sampling results along with the SQBs are presented in Table 8-11. The results are discussed below.

8.4.2.2.1 Metals

Metals were generally higher in the sediments of SE-01 and SE-13 than in the sediments of the reference locations. The metals that were substantially higher at both Middle Fork Creek sampling locations than at the reference locations were antimony, cadmium, chromium, lead, manganese, and zinc. Arsenic and vanadium were both substantially higher than the reference locations at SE-01 only. The significance of these metals being higher than the reference is not understood since only arsenic, barium, and manganese exceed SQBs. These three metals would not be considered major components of explosives. Also, of the metals substantially higher in the sediment, only cadmium, manganese, and zinc were correspondingly higher in the water samples, and cadmium was questionable because the dissolved far exceeded total in the water sample. The benthic macroinvertebrates showed no adverse impact.

TABLE 8-11 MIDDLE FORK CREEK SEDIMENT RESULTS

PARAMETER	UNIT	SE-01	SE-13	Reference Average (SE-7-SE-12)	REGULATORY CRITERIA*
					SEDIMENT QUALITY BENCHMARK
Explosives and Degradates					
HMX	µg/g	0.050 U	**0.140**	0.092	0.330^1
RDX	µg/g	**0.031**	**0.300**	0.545	0.190^1
2,4,6-TNT	µg/g	0.010 U	**0.050**	0.117	0.52^1
1,3-DNB	µg/g	0.020 U	0.020 U	0.020	0.04^1
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020	0.02^1
TETRYL	µg/g	0.020 U	0.020 U	0.020	NA
NB	µg/g	0.020 U	0.020 U	0.020	27.0^1
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010	18.5^1
2,4-DNT	µg/g	0.020 U	0.020 U	0.020	0.230^1
2-NT	µg/g	0.020 U	0.020 U	0.020	NA
3-NT	µg/g	0.020 U	0.020 U	0.020	NA
4-NT	µg/g	0.040 U	0.070 U	0.063	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050	NA
WP	µg/g	0.0010 U	0.0010 U	0.001	0.26^5
Moisture (WP only)	Percent	20	20	19	NA
Metals					
Antimony	µg/g	**0.407**	**0.474**	0.244	NA
Arsenic	µg/g	**13.10**	**8.82**	5.78	5.9^2
Barium	µg/g	**189**	**210**	206	500^3
Cadmium	µg/g	**0.219 B**	**0.1780 B**	0.0946	0.596^2
Chromium	µg/g	**31.20**	**23.5**	11.27	26^3
Copper	µg/g	**5.20**	**9.65**	4.18	16^3
Lead	µg/g	**15.10**	**19.40**	7.84	31^3
Manganese	µg/g	**500**	**743**	265	460^3
Mercury	µg/g	**0.00630 J**	**0.00990 J**	0.01440	0.174^2
Molybdenum	µg/g	**1.330**	**1.120**	0.741	NA
Nickel	µg/g	**5.26**	**6.19**	4.18	16^3
Silver	µg/g	**0.1350**	**0.0660**	0.1017	1^4
Uranium	µg/g	**0.599**	**0.629**	0.562	NA
Vanadium	µg/g	**37.0**	**25.2**	22.0	NA
Zinc	µg/g	**33.2**	**51.6**	18.8	120^3
Moisture	Percent	**19.9**	**22.8**	18.6	NA
Other Parameters					
Total Organic Matter	Percent	**1.1**	**0.9**	0.8	NA
Perchlorate	µg/g	0.013 U	0.013 U	0.013	NA
Benthic Macroinvertebrate Summary					
Number of Taxa		16	17	17	
Number of Individuals		140	148	148	
EPT/Total Individuals		48%	17%	49%	
Diversity H		2.62	2.55	2.63	

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of SQB

8.4.2.2.2 Explosives and Degradates

Three of the explosives were detected in the sediment samples of Middle Fork Creek and the reference locations. None of the explosives in the sediment were substantially higher in Middle Fork Creek than they were in the reference locations. The furthest downstream location (01) had only RDX detected at 0.031 µg/g in the sediment. However, sample SE-13 (mid-installation sample) had 0.14 µg/g HMX, 0.300 µg/g RDX and 0.050 µg/g 2,4,6-TNT. The average reference values were 0.092 µg/g HMX, 0.545 µg/g RDX, and 0.117 µg/g 2,4,6-TNT.

8.4.2.2.3 Perchlorate

Perchlorate was not detected in Middle Fork Creek Sediments.

8.4.2.2.4 Sediment Quality Benchmarks

The sediment results and SQBs for Middle Fork Creek are presented in Table 8-11. The explosive RDX in sediment sample SE-13 with 0.300 µg/g RDX exceeded the very conservative benchmark of 0.190 µg/g for RDX. However, the average reference location concentration of 0.545 µg/g RDX in the sediment exceeded the SQB even more. There were three metals that exceeded SQBs in Middle Fork Creek sediments: arsenic SQB of 5.9 µg/g at SE-01 with 13.1 µg/g arsenic and SE-13 with 8.82µg/g arsenic, chromium SQB of 26 µg/g at SE-1 with 31.2 µg/g chromium, and manganese SQB of 460 µg/g at SE-1 with 500 µg/g manganese and SE-13 with 743 µg/g manganese. The conservative SQBs were only slightly exceeded, and chemistry data alone can only indicate that there is a possibility of an adverse impact on the ecological health. Benthic macroinvertebrate data were used to make the final determination.

8.4.2.3 Benthic Macroinvertebrate Results

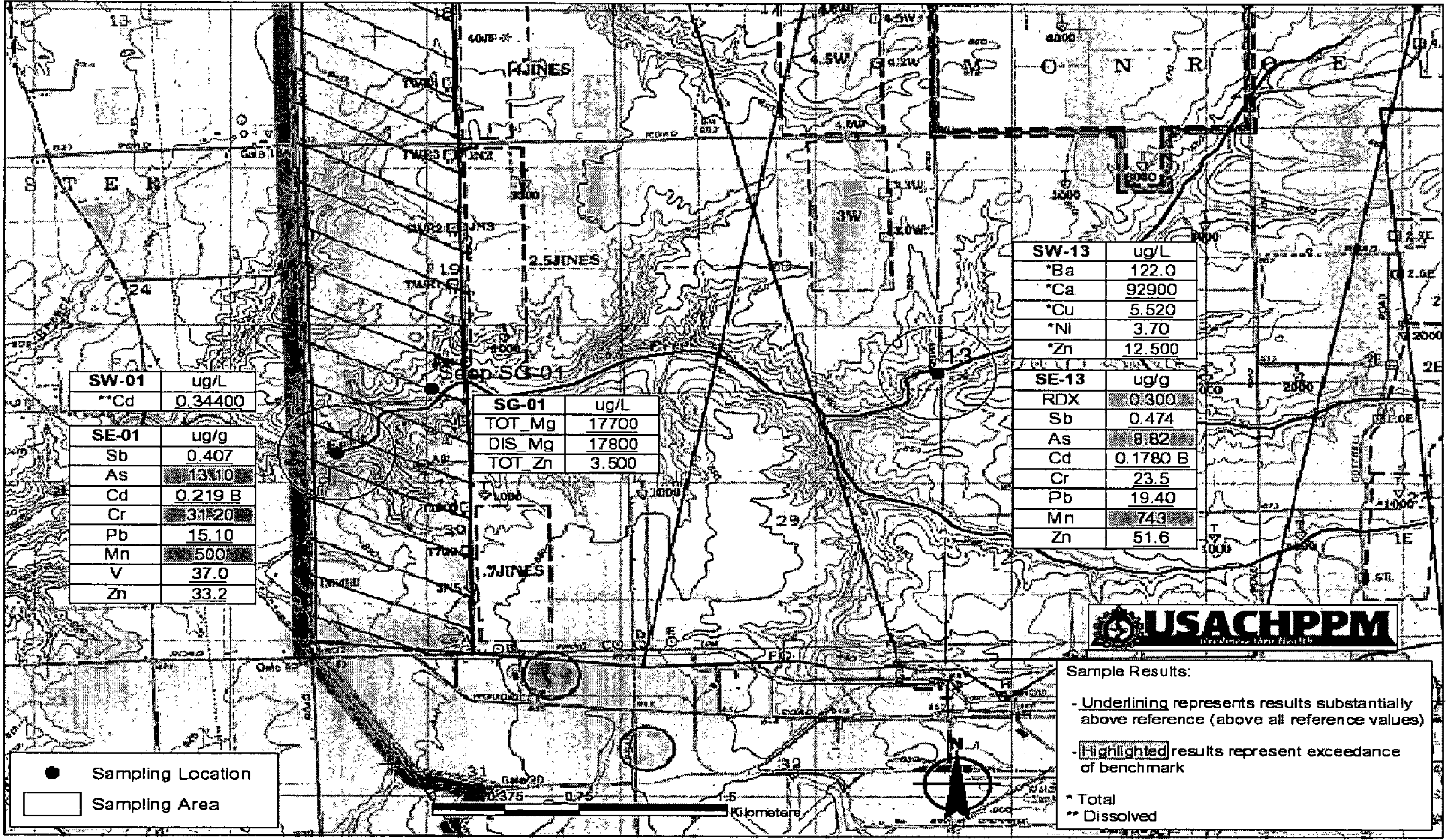
The benthic macroinvertebrate results for all samples are presented in Table 8-7 and results for Middle Fork Creek are summarized in Table 8-11. There were no discernable differences in the benthic macroinvertebrate population in Middle Fork Creek compared to the reference locations. There was no sign of adverse impact on the benthic macroinvertebrate population in Middle Fork Creek.

8.4.2.4 Middle Fork Creek Summary

Figure 8-2 shows the Middle Fork Creek results exceeding benchmark and reference values. Middle Fork Creek conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results did not exceed WQC but several of the total metals were higher at SE-13 than the reference locations, likely due to suspended solids picked up in the sample. The sediment results for Middle Fork Creek exceeded the SQBs for RDX, arsenic, chromium, and manganese and several metals were substantially higher than the reference locations. However, these exceedances were not significant enough to adversely impact human health or the aquatic biota.

FIGURE 8-2 MIDDLE FORK CREEK WATERSHED RESULTS EXCEEDING BENCHMARK OR BACKGROUND VALUES

FIGURE 8-2. Middle Fork Creek Watershed Results Exceeding Benchmark or Background Values, JPG Firing Range Study, 7-11 Oct. 2002



SW-01	ug/L
**Cd	0.34400

SE-01	ug/g
Sb	0.407
As	13.10
Cd	0.219 B
Cr	31.20
Pb	15.10
Mn	500
V	37.0
Zn	33.2

SG-01	ug/L
TOT_Mg	17700
DIS_Mg	17800
TOT_Zn	3.500

SW-13	ug/L
*Ba	122.0
*Ca	92900
*Cu	5.520
*Ni	3.70
*Zn	12.500

SE-13	ug/g
RDX	0.300
Sb	0.474
As	8.82
Cd	0.1780 B
Cr	23.5
Pb	19.40
Mn	743
Zn	51.6

● Sampling Location
▭ Sampling Area

Sample Results:

- Underlining represents results substantially above reference (above all reference values)
- Highlighted results represent exceedance of benchmark

* Total
** Dissolved

8.4.3 Big Creek Sampling Locations

The Big Creek drainage basin is just to the north of Middle Fork Creek drainage basin (See Figure 8-1). The drainage basin contains several impact fields and most of the Depleted Uranium Impact Area. There were three sampling locations on Big Creek; a reference sampling location (12), a sampling location a little over midway through JPG below the Depleted Uranium Impact Area near Morgan Road (14), and a downstream sampling location near the west perimeter road (02).

8.4.3.1 Surface Water Results

Surface water analytical results for all samples, along with the applicable Federal WQC and State WQSs are presented in Table 8-5. Big Creek surface water results are presented in Table 8-12.

8.4.3.1.1 Metals and Hardness

The only metal in the water samples to be substantially higher at SW-14 compared to both SW-12 (watershed reference) and the average reference locations was uranium. The concentration of uranium was 6-7 times higher. That would be expected immediately downstream of the Depleted Uranium Impact Area. Most of the metals results at SW-14 were lower than reference locations. The furthest downstream sampling location SW-02 near the installation boundary had several metals slightly higher than the watershed reference location SW-12. The only metals that were substantially higher than all reference locations at SW-02 were total lead, total manganese, total and dissolved uranium, total vanadium, and total zinc. For all of the metals just mentioned except for uranium, the dissolved fraction was well below the reference location concentrations.

8.4.3.1.2 Explosives and Degradates

The only explosive detected in Big Creek water samples was RDX at sampling location SW-02 (0.14 μg/L).

8.4.3.1.3 Perchlorate and Field Parameters

Perchlorate was not detected in Big Creek water samples. TOC and the field parameters were well within reference values and what would be required to support a healthy ecological community.

8.4.3.1.4 Water Quality Criteria Screening

There were no surface water results for Big Creek that exceeded Federal WQC or State WQSs.

TABLE 8-12 BIG CREEK SURFACE WATER RESULTS

PARAMETER	UNIT	SW-02	Watershed Reference SW-12	SW-14	Reference Average (SW-07-SW-12)	REGULATORY CRITERIA* FEDERAL AMBIENT WATER QUALITY CRITERIA CMC	CCC	INDIANA AMBIENT WATER QUALITY CRITERIA CMC	CCC
Explosives and Degradates									
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	**0.140**	**0.040 J**	0.100 U	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.09	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024	0.5	0.1		
Metals									
Hardness	mg/L	125	148	120	160	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	**0.0860** ***0.0895***	**0.0861** ***0.0844***	**0.0830** ***0.0820***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**0.917** ***0.873***	**0.785** ***0.738***	**0.747** ***0.777***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**52.5** ***47.8***	**55.2** ***53.7***	**43.8** ***45.0***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.03220** ***0.01190***	**0.01740** ***0.01610***	**0.00991** ***0.00922***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**34600** ***34500***	**43900** ***43600***	**34700** ***36100***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	**0.4620** *0.0240 U*	**0.3390** ***0.2900***	**0.1770** ***0.0384***	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**1.460** ***1.190***	**1.120** ***1.140***	**1.310** ***1.240***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**1.46000** ***0.00795***	**0.23500** ***0.22500***	**0.03660** ***0.00569***	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**9400** ***9370***	**9560** ***9550***	**7670** ***7830***	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**113.00** ***17.00***	**37.10** ***34.90***	**38.40** ***34.60***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.003640** ***0.002270***	**0.002140** ***0.002160***	**0.00207** ***0.00195***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.397** ***0.473***	**0.493** ***0.565***	**0.463** ***0.472***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**2.07** ***1.70***	**2.01** ***2.28***	**1.85** ***1.72***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.02640 B** ***0.02310 B***	**0.00858 B** ***0.00841B***	**0.01050 B** ***0.01160 B***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**1.140** ***1.060***	**0.640** ***0.653***	**4.080** ***4.330***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**1.340** ***0.537***	**0.784** ***0.688***	**0.631** ***0.582***	0.809 0.663	- 280	- 20	- -	- -
Zinc	µg/L	**3.680** ***0.423***	**1.460** ***1.660***	**0.750** ***0.458***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters									
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0	5000	600	-	-
TOC	mg/L	6.4	5.6	**5.6**	6.1	-	-	-	-
pH (Field, Lab)	s.u.	7.28	8.22	7.88		6.5 - 9.0		-	
D.O. (Field)	mg/L	2.91	13.21	11.2		-	-	-	-
Conductivity (Field)	µ-ohm	208	290	220		-	-	-	-
Temperature (Field)	Deg.Cel.	14.61	14.39	14.53		-	-	-	-

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

8.4.3.2 Sediment Results

Sediment analytical results for all samples, along with the applicable SQBs, are presented in Table 8-6 and Big Creek results are presented in Table 8-13. Big Creek sediment analytical results are discussed below.

8.4.3.2.1 Metals

The sediment metals results for the furthest downstream sampling location on Big Creek (SE-02) were lower than the watershed reference location (SE-12) except for barium and nickel being slightly but not substantially higher. The sampling location just downstream of the Depleted Uranium Impact Area (SE-14) had metals concentrations in the sediment substantially higher than the watershed reference location (SE-12) and the average reference locations for nearly all metals. Cadmium and silver were the only metals that were lower than those of the reference locations. Barium, copper, and lead were only higher than the watershed reference location (SE-12) but not higher than all reference location values. All other metals were substantially higher than all reference locations (antimony, arsenic, chromium, manganese, mercury, nickel, uranium, vanadium, and zinc). Why so many metals were substantially higher in the sediment and not in the water sample at sampling location (14) or the sediment in the further downstream sampling location (SE-2) was not at all clear. The benthic macroinvertebrates discussed later were not adversely affected by any of the elevated metals in the sediment.

8.4.3.2.2 Explosives and Degradates

There were only two of the explosives detected in the sediments from Big Creek (RDX and 2,4,6-TNT). They were nearly the same concentration at all three sampling locations to include the reference location (12) and lower than the average reference locations. The concentrations were 0.28 µg/g , 0.28 µg/g, and 0.22 µg/g and 0.047 µg/g, 0.047 µg/g, and 0.051 µg/g for RDX and 2,4,6-TNT respectively at sampling locations 02, 12, and 14 respectively. The average of the reference locations was 0.545 µg/g, and 0.117 µg/g for RDX and 2,4,6-TNT respectively.

8.4.3.2.3 Perchlorate

Perchlorate was not detected in the sediments of the Big Creek watershed. Total organic matter (TOM) was less than 1%.

8.4.3.2.4 Sediment Quality Benchmarks

The sediment results and SQBs for Big Creek are presented in Table 8-13. Big Creek sediment sample concentrations were compared to SQBs. The explosive RDX in sediment samples SE-02 (0.28 µg/g), SE-12 (0.28 µg/g), and SE-14 (0.22 µg/g) all exceeded the SQB of 0.190 µg/g for RDX. However, the average reference location concentration of 0.545 µg/g exceeded the SQB even more. There were two metals that exceeded SQBs in Big Creek sediments: arsenic SQB of 5.9 µg/g at SE-02 with 7.71 µg/g arsenic, SE-12 with 9.64 µg/g arsenic, and SE-14 with 23.8 µg/g arsenic, and manganese SQB of 460 µg/g at SE-14 with 639 µg/g manganese. The conservative SQBs were only slightly exceeded, and chemistry data alone can only indicate that there is a possibility of an adverse impact on the ecological health. Benthic macroinvertebrate data were used to make the final determination.

TABLE 8-13. BIG CREEK SEDIMENT RESULTS

PARAMETER	UNIT	SE-02	Watershed Reference SE-12	SE-14	Reference Average (SE-7-SE-12)	REGULATORY CRITERIA* SEDIMENT QUALITY BENCHMARK
Explosives and Degradates						
HMX	µg/g	0.050 U	0.050 U	0.050 U	0.092	0.330[1]
RDX	µg/g	**0.280**	**0.280**	**0.220**	0.545	0.190[1]
2,4,6-TNT	µg/g	**0.047**	**0.047**	**0.051**	0.117	0.52[1]
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020	0.04[1]
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020	0.02[1]
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020	NA
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020	27.0[1]
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010	18.5[1]
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020	0.230[1]
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020	NA
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020	NA
4-NT	µg/g	0.060 U	0.060 U	0.070 U	0.063	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050	NA
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.001	0.26[5]
Moisture (WP only)	Percent	**20**	**22**	**15**	19	NA
Metals						
Antimony	µg/g	**0.259**	**0.31**	**0.485**	0.244	NA
Arsenic	µg/g	**7.71**	**9.64**	**23.80**	5.78	5.9[2]
Barium	µg/g	**200**	**149**	**263**	206	500[3]
Cadmium	µg/g	**0.0955 B**	**0.108 B**	0.0587 U	0.0946	0.596[2]
Chromium	µg/g	**11.70**	**12.70**	**24.9**	11.27	26[3]
Copper	µg/g	**2.77**	**3.07**	**5.72**	4.18	16[3]
Lead	µg/g	**8.46**	**9.04**	**11.70**	7.84	31[3]
Manganese	µg/g	**239**	**327**	**639**	265	460[3]
Mercury	µg/g	**0.01040**	**0.01380**	**0.02110 B**	0.01440	0.174[2]
Molybdenum	µg/g	**0.782**	**0.881**	**1.470**	0.741	NA
Nickel	µg/g	**4.14**	**3.69**	**6.72**	4.18	16[3]
Silver	µg/g	**0.0465**	**0.1020**	**0.0674**	0.1017	1[4]
Uranium	µg/g	**0.517**	**0.531**	**3.050**	0.562	NA
Vanadium	µg/g	**23.4**	**27.6**	**49.4**	22.0	NA
Zinc	µg/g	**21.7**	**21.7**	**45.8**	18.8	120[3]
Moisture	Percent	21.5	20.2	20.7	18.6	NA
Other Parameters						
Total Organic Matter	Percent	**0.7**	**0.8**	**0.9**	0.8	NA
Perchlorate	µg/g	0.013 U	0.013 U	0.013 U	0.013	NA
Benthic Macroinvertebrates						
Number of species		19	16	17	NA	NA
Number of individuals		196	210	148	NA	NA
EPT/total individuals		76%	35%	49%	NA	NA
Diversity H		2.15	2.26	2.63	NA	NA

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **U**-under detection limit.

Highlighted represents exceedance of SQB

8.4.3.3 Benthic Macroinvertebrate Results

The benthic macroinvertebrate results for all samples are presented in Table 8-7 and results for Big Creek are summarized in Table 8-13. There were no discernable differences in the benthic macroinvertebrate population in Big Creek compared to the reference locations. In fact, the benthic macroinvertebrate results indicate there is a slight increase in diversity, number of taxa, number of individuals, and number of pollution intolerant organisms at the downstream locations compared to the reference locations. There was no sign of adverse impact on the benthic macroinvertebrate population in Big Creek.

8.4.3.4 Big Creek Summary

Figure 8-3 shows the Big Creek results exceeding benchmark or references values. Big Creek conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results did not exceed Federal WQC or State WQSs, but some of the total metals were higher at SW-02 than the reference locations even though dissolved metals were not higher. An excess of suspended solids may have been picked up in the sample. The sediment results for Big Creek exceeded SQBs for RDX, arsenic, and manganese. Several sediment metals were substantially higher than the reference locations at SE-14 but decreased again by the downstream sampling location SE-02. There were no adverse impacts on the human health or the benthic macroinvertebrate population.

8.4.4 Marble Creek Sampling Location

The Marble Creek drainage basin is just to the north of the Big Creek drainage basin (See Figure 8-1). The drainage basin contains several impact fields but is much smaller than other drainage basins, originating less than half way across JPG. Therefore, Marble Creek did not have its own reference location. There was only one downstream sampling location on Marble Creek near the west perimeter road (sampling location 03). The average results of the six reference locations on other watersheds were used for comparison with Marble Creek results.

8.4.4.1 Surface Water Results

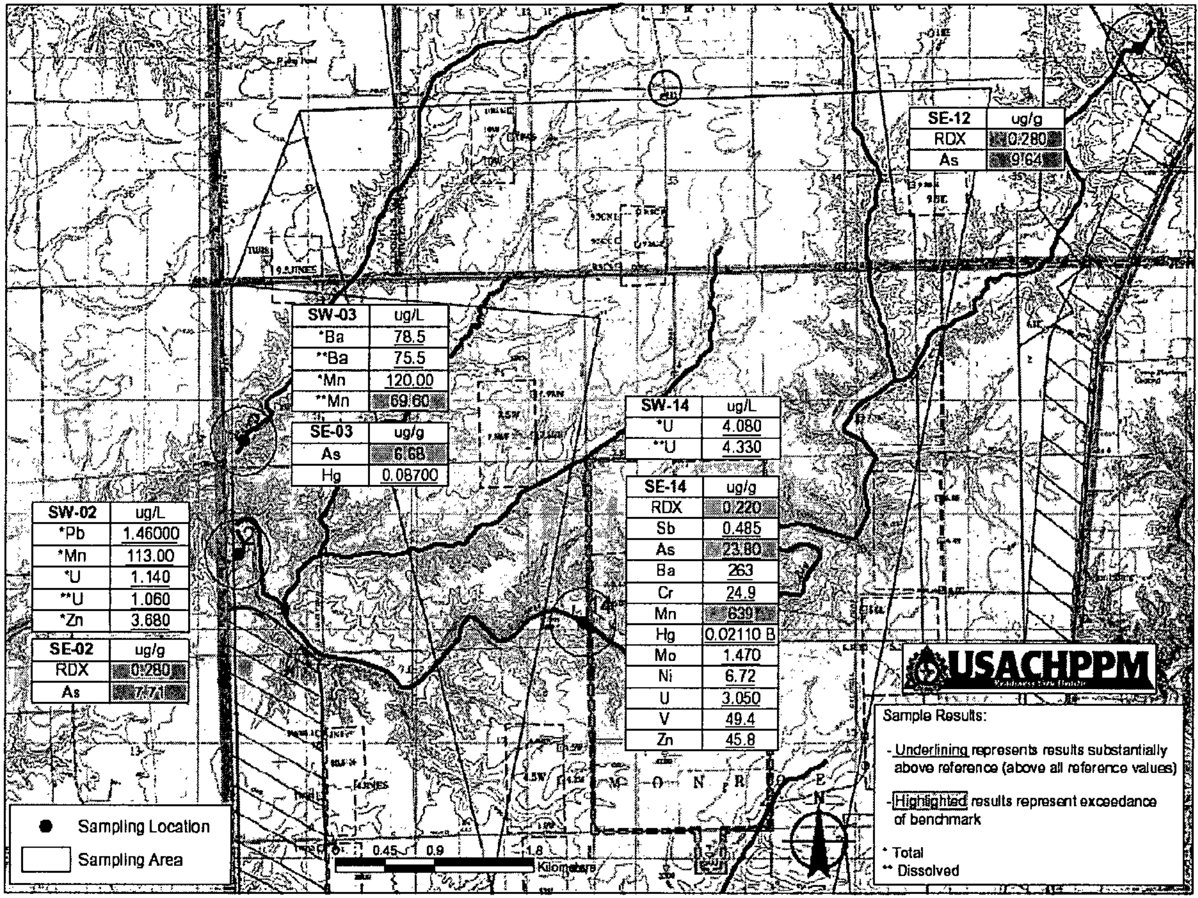
Surface water analytical results for all samples, along with applicable Federal WQC and State WQSs, are presented in Table 8-6 and the results for Marble Creek are presented in Table 8-14. The Marble Creek analytical results are discussed below.

8.4.4.1.1 Metals and Hardness

Both total and dissolved barium and manganese were the only surface water metals results that were substantially higher in the Marble Creek downstream sampling location (SW-03) than the reference locations. Total and dissolved mercury were only slightly higher than the reference average and the other 14 metals were all lower than the reference average.

FIGURE 8-3 MARBLE & BIG CREEK WATERSHED RESULTS EXCEEDING BENCHMARK OR BACKGROUND VALUES

FIGURE 8-3. Marble & Big Creek Watershed Results Exceeding Benchmark or Background Values, JPG Firing Range Study, 7-11 Oct. 2002



SE-12	ug/g
RDX	0.280
As	9.64

SW-03	ug/L
*Ba	78.5
**Ba	75.5
*Mn	120.00
**Mn	69.60

SE-03	ug/g
As	6.68
Hg	0.08700

SW-14	ug/L
*U	4.080
**U	4.330

SE-14	ug/g
RDX	0.220
Sb	0.485
As	23.80
Ba	263
Cr	24.9
Mn	639
Hg	0.02110 B
Mo	1.470
Ni	6.72
U	3.050
V	49.4
Zn	45.8

SW-02	ug/L
*Pb	1.46000
*Mn	113.00
*U	1.140
**U	1.060
*Zn	3.680

SE-02	ug/g
RDX	0.280
As	7.71

Sample Results:

- Underlining represents results substantially above reference (above all reference values)
- Highlighted results represent exceedance of benchmark

* Total
** Dissolved

TABLE 8-14. MARBLE CREEK SURFACE WATER RESULTS

PARAMETER	UNIT	SW-3	Reference Average (SW7-SW12)	REGULATORY CRITERIA*			
				FEDERAL AMBIENT WATER QUALITY CRITERIA		INDIANA AMBIENT WATER QUALITY CRITERIA	
				CMC	CCC	CMC	CCC
Explosives and Degradates							
HMX	µg/L	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	**0.027 J**	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.09	1700	200		
WP	µg/L	0.024 U	0.024	0.5	0.1		
Metals							
Hardness	mg/L	120	160	-	-	-	-
Antimony (Total/*Dissolved*) [1]	µg/L	**0.0599** ***0.0644***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**0.688** ***0.678***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**78.5** ***75.5***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.01480** ***0.00885***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**32300** ***32600***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	0.0240 U *0.0240 U*	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**0.698** ***0.592***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**0.15400** *0.00500 U*	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**9250** ***9380***	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**120.00** ***69.60***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.002340** ***0.001640***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.403** ***0.413***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**1.65** ***1.55***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.01400 B** ***0.01250 B***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**0.236** ***0.231***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.303** ***0.107***	0.809 0.663	- 280	- 20	- -	- -
Zinc	µg/L	**1.260** ***0.370***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters							
Perchlorate	µg/L	1.0 U	1.0	5000	600	-	-
TOC	mg/L	6.8	6.1	-	-	-	-
pH (Field, Lab)	s.u.	6.98		6.5 - 9.0		-	
D.O. (Field)	mg/L	2.7		-	-	-	-
Conductivity (Field)	µohm	205		-	-	-	-
Temperature (Field)	Deg.Cel.	16.29		-	-	-	-

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

8.4.4.1.2 Explosives and Degradates

There were no explosives above the reporting limit in the Marble Creek surface water sample (SW-03). RDX was estimated at 0.027 µg/L because the reporting limit was 0.10 µg/L. The reporting limit was 5 times the method detection limit.

8.4.4.1.3 Perchlorate and Field Parameters

There was no perchlorate detected in the Marble Creek water sample. TOC and the field parameters were well within reference values and what would be required to support a healthy ecological community.

8.4.4.1.4 Water Quality Criteria Screening

The only exceedance in the surface water results for Marble Creek was a dissolved manganese National Secondary Drinking Water Standard of 50 µg/L. The SW-3 result was 69.6 µg/L dissolved manganese.

8.4.4.2 Sediment Results

The sediment analytical results for all samples, along with the applicable SQBs, are presented in Table 8-6 and sediment results for Marble Creek are presented in Table 8-15. The Marble Creek sediment analytical results are discussed below.

8.4.4.2.1 Metals

The sediment mercury concentration for Marble Creek (SE-03) was the only sediment metal that was substantially higher than the average reference value. The mercury sediment concentration value was 6 times the reference value. The arsenic sediment concentration was only slightly higher than the reference average and all 13 other sediment metals were lower than the reference average.

8.4.4.2.2 Explosives and Degradates

There were no explosives detected above the reporting limit in the sediment of Marble Creek.

8.4.4.2.3 Perchlorate

Perchlorate was not detected in the sediments of the Marble Creek watershed. TOM was less than 1%.

TABLE 8-15 MARBLE CREEK SEDIMENT RESULTS

PARAMETER	UNIT	SE-3	Reference Average (SE7-SE12)	REGULATORY CRITERIA*
				SEDIMENT QUALITY BENCHMARK
Explosives and Degradates				
HMX	μg/g	0.050 U	0.092	0.330[1]
RDX	μg/g	**0.009 J**	0.545	0.190[1]
2,4,6-TNT	μg/g	0.010 U	0.117	0.52[1]
1,3-DNB	μg/g	0.020 U	0.020	0.04[1]
1,3,5-TNB	μg/g	0.020 U	0.020	0.02[1]
TETRYL	μg/g	0.020 U	0.020	NA
NB	μg/g	0.020 U	0.020	27.0[1]
2A-4,6-DNT	μg/g	0.020 U	0.020	NA
4A-2,6-DNT	μg/g	0.050 U	0.050	NA
2,6-DNT	μg/g	0.010 U	0.010	18.5[1]
2,4-DNT	μg/g	0.020 U	0.020	0.230[1]
2-NT	μg/g	0.020 U	0.020	NA
3-NT	μg/g	0.020 U	0.020	NA
4-NT	μg/g	0.040 U	0.063	NA
Nitroglycerin	μg/g	0.050 U	0.050	NA
WP	μg/g	0.0010 U	0.001	0.26[5]
Moisture (WP only)	Percent	20	19	NA
Metals				
Antimony	μg/g	**0.185**	0.244	NA
Arsenic	μg/g	**6.68**	5.78	5.9[2]
Barium	μg/g	**165**	206	500[3]
Cadmium	μg/g	**0.0927 B**	0.0946	0.596[2]
Chromium	μg/g	**9.98**	11.27	26[3]
Copper	μg/g	**2.83**	4.18	16[3]
Lead	μg/g	**4.88**	7.84	31[3]
Manganese	μg/g	**143**	265	460[3]
Mercury	μg/g	**0.08700**	0.01440	0.174[2]
Molybdenum	μg/g	**0.550**	0.741	NA
Nickel	μg/g	**2.33**	4.18	16[3]
Silver	μg/g	**0.0416**	0.1017	1[4]
Uranium	μg/g	**0.354**	0.562	NA
Vanadium	μg/g	**15.2**	22.0	NA
Zinc	μg/g	**17.1**	18.8	120[3]
Moisture	Percent	21.2	18.6	NA
Other Parameters				
Total Organic Matter	Percent	0.7	0.8	NA
Perchlorate	μg/g	0.013 U	0.013	NA
Benthic Macroinvertebrates				
Number of taxa		9	17	NA
Number of Individuals		21	148	NA
EPT/Total Individuals		48%	49%	NA
Diversity H		2.26	2.63	NA

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of SQB

8.4.4.2.4 Sediment Quality Benchmarks

The only SQB exceeded in the sediment results for Marble Creek was arsenic. The SQB for arsenic is 5.9 µg/g and the concentration in the sediment sample was 6.68 µg/g arsenic. The conservative SQB was only slightly exceeded, and chemistry data alone can only indicate that there is a possibility of an adverse impact on the ecological health. Benthic macroinvertebrate data were used to make the final determination.

8.4.4.3 Benthic Macroinvertebrate Results

The benthic macroinvertebrate population in Marble Creek was very sparse and only one of the three samples could be collected. A similar diversity, number of species, and mix of pollution intolerant species were present compared to reference locations especially sampling locations 8 and 9 where the lack of substrate, size of creek, and lack of organisms made it impossible to collect three similar subsamples.

8.4.4.4 Marble Creek Summary

Figure 8-3 shows the Marble Creek results exceeding benchmark or background values. Marble Creek conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results did not exceed Federal WQC or State WQSs and only two of the metals (total and dissolved barium and manganese) were substantially higher than the average reference values. The sediment results for Marble Creek exceeded the SQB for arsenic. The sediment mercury was substantially higher than the average reference value. All the other surface water and sediment metals concentrations were lower than the average reference value. The surface water and sediment explosives were below the reporting limit for explosives. There were no adverse impacts on human health or the benthic macroinvertebrate population.

8.4.5 Little Graham Creek Watershed and Sampling Locations

This watershed is in the north-central part of the installation. Several impact fields traverse the watershed from north to south. One tributary of Little Graham Creek originates off post to the east, flows southwest across the post, and then flows off post toward the southwest. The locations of the Little Graham Creek sampling locations appear in Figure 8-1. Little Graham Creek sampling location SW-11 is the upstream reference location. It is located along the eastern boundary of the post. Sampling location SW-15 is located in the middle of the basin, at the intersection of Horse and Poplar Branch and the main channel. Several impact fields and safety fans are between sampling locations SW-11 and SW-15. Sampling location SW-04 is located along the western boundary. It is the furthest downstream sampling location and it receives drainage from the entire Little Graham Creek watershed. One surface water grab sample was collected at each sampling location but sampling location 04 also had a duplicate sample collected (20).

8.4.5.1 Little Graham Creek Surface Water Results

Analytical results for all JPG surface water samples are presented in Table 8-5. The Federal WQC and State WQSs applicable to JPG surface waters are also included in this table for easy comparison. The Little Graham Creek surface water analytical sample results along with the reference for the Little Graham Creek watershed (SW-11), and reference average for all sampled watersheds on JPG are presented in Table 8-16. Little Graham Creek surface water results are discussed below.

8.4.5.1.1 Metals and Hardness

The Little Graham Creek surface water samples had moderate hardness values of 116 to 128 mg/L, but were lower than the average reference locations which was 160 mg/L.

In general, individual total metals concentrations exceeded their dissolved metals counterparts. However, a number of metals (antimony, arsenic, cadmium, calcium, copper, magnesium, molybdenum, silver, and uranium) had one or more total metal concentrations below their dissolved counterparts (see Table 8-16). Most metals were detected at low levels, some at or near the corresponding metal reporting limit.

The Little Graham Creek surface water metal results (SW-15 and SW-04) were similar to the reference watershed location (SW-11), and to the average reference concentrations for most metals (see Table 8-16). There were only three metals, both total and dissolved, that were substantially higher downstream than both the watershed reference location (SW-11) and the average reference locations. They were arsenic, barium, and manganese at sampling location SW-15, the mid-installation location. However, all three decreased to below reference values by the furthest downstream location (SW-04). Calcium, magnesium, and mercury were only slightly higher as the downstream location (SW-04) than SW-11 but not higher than average reference values. Generally, the metals showed a consistent decrease in concentration from upstream (SW-11) to downstream (SW-04) in both total and dissolved forms.

8.4.5.1.2 Explosives and Degradates

No explosives or explosive degradate compounds were found in Little Graham Creek surface water samples above reporting limits.

8.4.5.1.3 Perchlorate, TOC, and Field Parameters

Perchlorate and TOC concentrations, along with miscellaneous field parameter data, are shown in Table 8-16. Perchlorate was not detected in any Little Graham Creek samples. TOC ranged from 6.0 to 6.8 mg/L in Little Graham Creek surface water samples. The pH of the water was slightly alkaline, with values ranging from 7.57 to 7.69. Conductivity ranged from 231 to 407 µohm. The highest conductivity value (407 µohm) was found in the reference sample for Little Graham Creek (SW-11). Dissolved oxygen concentrations increased in the downstream samples. TOC and the field parameters were well within reference values and what would be required to support a healthy ecological community.

TABLE 8-16. LITTLE GRAHAM CREEK SURFACE WATER RESULTS

PARAMETER	UNIT	SW-04	Watershed Reference SW-11	SW-15	SW-20**	Reference Average (SW7-SW12)	REGULATORY CRITERIA*			
							FEDERAL AMBIENT WATER QUALITY CRITERIA		INDIANA AMBIENT WATER QUALITY CRITERIA	
							CMC	CCC	CMC	CCC
Explosives and Degradates										
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	0.100 U	**0.036 J**	**0.037 J**	0.100 U	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024	0.5	0.1		
Metals										
Hardness	mg/L	128	116	128	128	160	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	**0.0792** ***0.0836***	**0.1510** ***0.1580***	**0.0703** ***0.0864***	**0.0947** ***0.1080***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**0.758** ***0.771***	**1.050** ***0.997***	**2.000** ***1.340***	**0.740** ***0.713***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**44.6** ***44.1***	**56.5** ***54.9***	**111.0** ***72.9***	**44.8** ***44.1***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.00959** ***0.00989***	**0.01980** ***0.02210***	**0.02100** ***0.01870***	**0.01280** ***0.00671***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**36300** ***36400***	**33300** ***33300***	**39600** ***39000***	**37000** ***36400***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	0.0240 U *0.0240 U*	**0.7540** ***0.1250***	0.0240 U *0.0240 U*	**0.0322** *0.0240 U*	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**1.110** ***1.050***	**1.370** ***1.260***	**0.758** ***0.893***	**1.090** ***1.030***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**0.05550** *0.00500 U*	**2.01000** ***0.03410***	**0.10000** ***0.02270***	**0.03320** ***0.00500 U***	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**8910** ***8910***	**8050** ***8100***	**7520** ***7420***	**9090** ***9130***	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**31.70** ***23.70***	**89.20** ***72.70***	**939.00** ***401.00***	**29.00** ***24.90***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.001970** ***0.001830***	**0.001870** ***0.001330***	**0.00164** ***0.00156***	**0.00189** ***0.00166***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.479** ***0.502***	**0.858** ***0.845***	**0.527** ***0.529***	**0.498** ***0.479***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**1.72** ***1.54***	**1.75** ***1.67***	**1.58** ***1.58***	**1.60** ***1.57***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.18200** ***0.20900***	**0.22000** ***0.25800***	**0.24900** ***0.24300***	**0.15400** ***0.17100***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**0.312** ***0.319***	**0.665** ***0.650***	**0.253** ***0.327***	**0.320** ***0.313***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.441** ***0.371***	**1.430** ***0.983***	**0.475** ***0.450***	**0.431** ***0.370***	0.809 0.663	- 280	- 20	- -	- -
Zinc	µg/L	**0.628** ***0.293***	**1.740** ***0.484***	**1.100** ***0.450***	**1.670** ***0.335***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters										
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0	5000	600	-	-
TOC	mg/L	6.0	6.1	**6.8**	**6.1**	6.1	-	-	-	-
pH (Field, Lab)	s.u.	7.57	7.69	7.62	7.6		6.5 - 9.0		-	
D.O. (Field)	mg/L	9.5	8.4	8.4	9.17		-	-	-	-
Conductivity (Field)	µ-ohm	231	407	14.57	231		-	-	-	-
Temperature (Field)	Deg.Cel.	13.66	14.2	259	13.66		-	-	-	-

*-For complete citations see Table 8-3. **-SW-20 is a duplicate sample for SW-04. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of the secondary drinking water standard of 50 µg/L dissolved manganese.

8.4.5.1.4 Water Quality Criteria Screening

There were no parameters that exceeded the Federal WQC or State WQSs in Little Graham Creek.

8.4.5.2 Little Graham Creek Sediment Results

Little Graham Creek sediment analytical results, along with the SQBs, are presented in Table 8-17. The Little Graham Creek sediment analytical sample results are discussed below.

8.4.5.2.1 Metals

The Little Graham Creek sediment metals concentrations were detected at low levels in all Little Graham Creek sediment samples. Nearly all metals in Little Graham Creek were at least slightly higher in concentration at the downstream locations (SE-04 and SE-15) compared to the watershed reference (SE-11). Silver was the only exception. The metals that were substantially higher than the average reference locations at SE-04 (averaged with duplicate SE-20) were cadmium, chromium, vanadium, and zinc. The metals that were substantially higher than the average reference locations at SE-15 were arsenic, cadmium, chromium, lead, mercury, nickel, vanadium, and zinc. None of the metals increased by an order of magnitude from the upstream sampling location (SE-11) or average reference locations to the downstream sampling locations. Metals in the surrounding rocks and soil along with differential leaching rates may account for the existing variability in sediment metal concentrations. Since there was no substantial increase in the surface water metals in the furthest downstream sampling location (SW-04) and only arsenic, barium, and manganese had substantial increases at the mid-installation sampling location (SE-15), it is unlikely the increases in the sediment metals is significant. The benthic macroinvertebrate population was healthy at the downstream locations on Little Graham Creek.

8.4.5.2.2 Explosives and Degradates

Two of the explosives were detected in the sediment samples of Little Graham Creek and the reference locations. None of the explosives in the sediment were higher in Little Graham Creek than they were in the reference locations. The concentrations for sample SE-15 (mid-installation sample location) was 0.110 µg/g RDX and 0.038 µg/g 2,4,6-TNT, the average of SE-04 and it duplicate SE-20 was 0.165 µg/g RDX and 0.035 µg/g 2,4,6-TNT. The average of reference locations was 0.545 µg/g RDX, and 0.117 µg/g 2,4,6-TNT.

RDX and 2,4,6-TNT were found in the reference location (SE-11) at concentrations of 0.350 µg/g and 0.054 µg/g, respectively. Explosives detections at the reference location were clearly unexpected. The sample was collected very close to the eastern boundary where Little Graham Creek begins to flow onto the installation. Farm fields are upstream. See discussion in Section 8.4.1.2.2 for discussion on explosives found at reference locations.

TABLE 8-17. LITTLE GRAHAM CREEK SEDIMENT RESULTS

PARAMETER	UNIT	SE-04	Watershed Reference SE-11	SE-15	SE-20 **	Reference Average (SE-07-SE-12)	REGULATORY CRITERIA* SEDIMENT QUALITY BENCHMARK
Explosives and Degradates							
HMX	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.092	0.330[1]
RDX	µg/g	**0.190**	**0.350**	**0.110**	**0.140**	0.545	0.190[1]
2,4,6-TNT	µg/g	**0.040**	**0.054**	**0.038**	**0.030**	0.117	0.52[1]
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.04[1]
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.02[1]
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	27.0[1]
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010 U	0.010	18.5[1]
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.220[1]
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
4-NT	µg/g	0.070 U	0.070 U	0.060 U	0.070 U	0.063	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050	NA
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.001	
% Moisture (WP only)	Percent	20	20	18	20	19	
Metals							
Antimony	µg/g	**0.365**	**0.196**	**0.323**	**0.259**	0.244	NA
Arsenic	µg/g	**8.02**	**3.40 B**	**11.40**	**9.28**	5.78	5.9[2]
Barium	µg/g	**183**	**159**	**242**	**196**	206	NA
Cadmium	µg/g	**0.1330 B**	**0.0823 B**	**0.1770 B**	**0.0945 B**	0.0946	0.596[2]
Chromium	µg/g	**19.40**	**8.61**	**23.00**	**13.40**	11.27	26[3]
Copper	µg/g	**3.63**	**2.28**	**4.5**	**3.79**	4.18	16[3]
Lead	µg/g	**7.76**	**4.80**	**12.30**	**7.59**	7.84	31[3]
Manganese	µg/g	**391**	**143**	**392**	**325**	265	460[3]
Mercury	µg/g	**0.01740**	**0.01380**	**0.02390**	**0.01360**	0.01440	0.174[2]
Molybdenum	µg/g	**1.150**	**0.642**	**1.000**	**0.802**	0.741	NA
Nickel	µg/g	**8.27**	**2.42**	**6.71**	**4.42**	4.18	16[3]
Silver	µg/g	**0.1100**	**0.1460**	**0.1120**	**0.0606**	0.1017	1[4]
Uranium	µg/g	**0.516**	**0.416**	**0.666**	**0.504**	0.562	
Vanadium	µg/g	**35.4**	**27.3**	**35.1**	**20.8**	22.0	NA
Zinc	µg/g	**24.3**	**15.6**	**28.4**	**23.4**	18.8	120[3]
% Moisture	Percent	18.7	17.1	17.2	18.4	18.6	
Other Parameters							
Total Organic Matter	Percent	0.8	0.7	1.2	0.9	0.8	NA
Perchlorate	µg/g	0.012 U	0.013 U	0.012 U	0.012 U	0.013	NA
Benthic Macroinvertebrates							
Number of taxa		19	16	12	19	17	NA
Number of Individuals		276	351	233	276	148	NA
EPT/total individuals		46%	65%	35%	46%	49%	NA
Diversity H		2.84	2.23	2.42	2.84	2.63	NA

*-For complete citations see Table 8-3. **-SW-20 is a duplicate sample for SW-04. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of SQB

8.4.5.2.3 Perchlorate and TOM

Perchlorate was not detected in any Little Graham Creek sediment samples. The TOM is close to 1%, so the SQB does not need to be adjusted.

8.4.5.2.4 Sediment Quality Benchmarks

The Little Graham Creek sediment sample concentrations were compared to SQBs. The sediment sample results and the SQBs can be found in Table 8-17. Detected compounds exceeding their respective SQBs are highlighted in the table. One explosive compound (RDX) and one metal (arsenic) exceeded their respective benchmarks. The RDX benchmark of 0.190 µg/g was exceeded at the watershed reference sampling location (SE-11) with 0.350 µg/g RDX and the average reference value of 0.545 µg/g RDX. The downstream sampling location (SE-04) was right at the benchmark with 0.190 µg/g RDX. The arsenic benchmark of 5.9 µg/g was exceeded in the average of SE-04 and its duplicate (SE-20) with 8.65 µg/g and SE-15 with 11.40 µg/g arsenic. The conservative SQBs were only slightly exceeded, and chemistry data alone can only indicate that there is a possibility of an adverse impact on the ecological health. Benthic macroinvertebrate data were used to make the final determination.

8.4.5.3 Little Graham Creek Benthic Macroinvertebrate Results

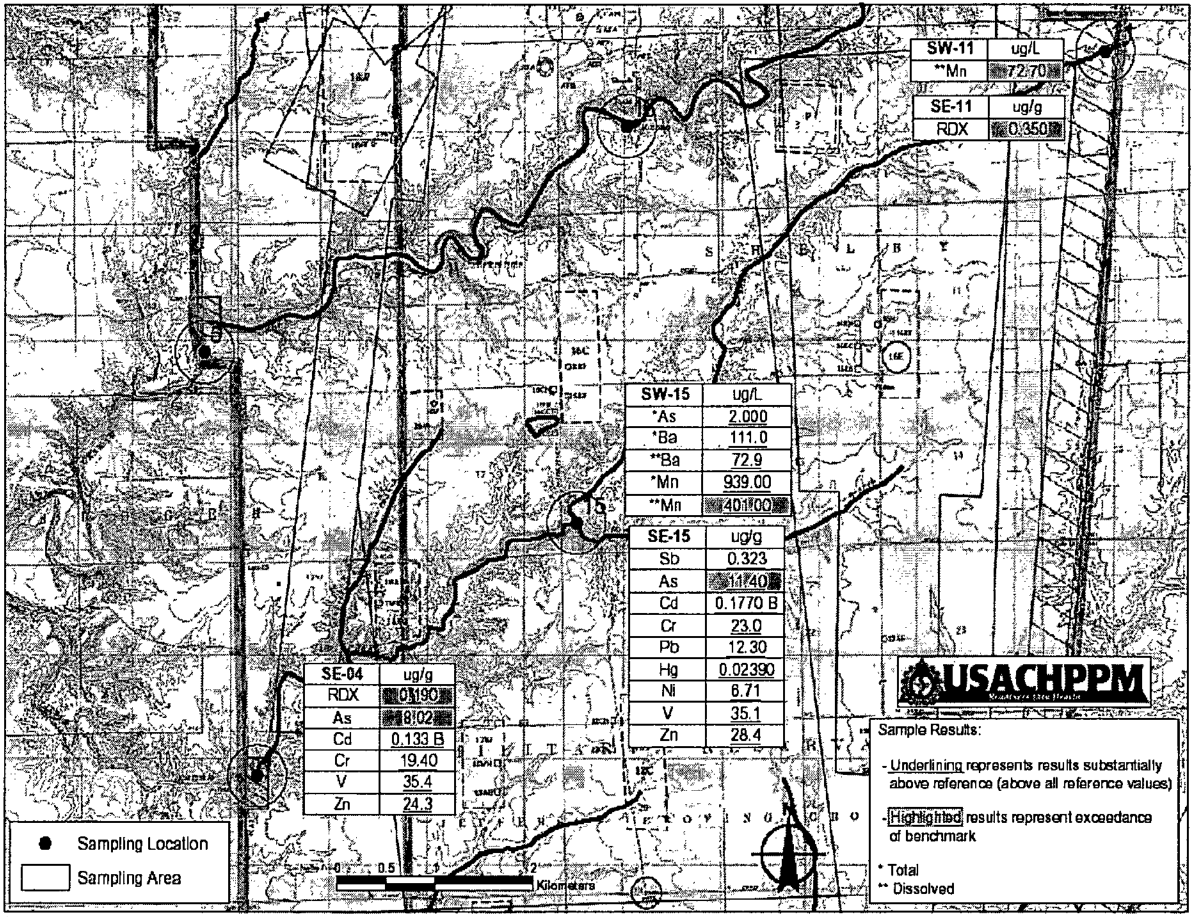
Little Graham Creek benthic macroinvertebrate results are presented in Table 8-17. There was some variability in the results but generally the benthic macroinvertebrate community was comparable and healthy at all sampling locations. The exceedance of RDX and arsenic benchmarks did not have an adverse impact on the biota.

8.4.5.4 Little Graham Creek Summary

Figure 8-4 shows the Little Graham Creek results exceeding benchmark or background values. Little Graham Creek conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results did not exceed Federal WQC or State WQSs at any of the sampling locations on Little Graham Creek and were not any higher than the average reference values at SW-04. Only total and dissolved arsenic, barium, and manganese were substantially higher than the average reference value at SW-15. The sediment results for Little Graham Creek exceeded the SQB for arsenic and RDX and was substantially higher than the average reference value for cadmium, chromium, vanadium, and zinc at SE-04 and antimony, arsenic, cadmium, chromium, lead, mercury, nickel, vanadium, and zinc at SE-15. There were no adverse impacts on the human health or the benthic macroinvertebrate ecology.

FIGURE 8-4 LITTLE GRAHAM CREEK WATERSHED RESULTS EXCEEDING BENCHMARK OR BACKGROUND VALUES

FIGURE 8-4. Little Graham Creek Watershed Results Exceeding Benchmark or Background Values, JPG Firing Range Study, 7-11 Oct. 2002



SW-11	ug/L
**Mn	72.70

SE-11	ug/g
RDX	0.350

SW-15	ug/L
*As	2.000
*Ba	111.0
**Ba	72.9
*Mn	939.00
**Mn	401.00

SE-15	ug/g
Sb	0.323
As	11.40
Cd	0.1770 B
Cr	23.0
Pb	12.30
Hg	0.02390
Ni	6.71
V	35.1
Zn	28.4

SE-04	ug/g
RDX	0.190
As	8.02
Cd	0.133 B
Cr	19.40
V	35.4
Zn	24.3

Sample Results:

- Underlining represents results substantially above reference (above all reference values)
- Highlighted results represent exceedance of benchmark

* Total
** Dissolved

8.4.6 Graham Creek Watershed and Sampling Locations

This watershed is the next watershed to the north of Little Graham Creek. Water in the main channel flows southwest across the installation. Numerous impact areas are found in this watershed, both north and south of the main channel. Small tributaries capture drainage from these impact areas and funnel it into the main channel. Graham Creek drainage eventually flows off post to the southwest. Graham Creek sampling locations are shown in Figure 8-1. Graham Creek sampling location SW-10 is the upstream reference location. This sampling location is located on the eastern boundary of the post, in the main channel. Sampling location SW-16 is located in the middle of the installation around designated impact areas and just south of the Air National Guard active target area. Sample SW-19 is a duplicate of SW-16. SW-05 is the furthest downstream location sampled in Graham Creek. It captures drainage from all of the onpost part of Graham Creek. SW-21 is a split sample of SW-05.

8.4.6.1 Graham Creek Surface Water Results

Analytical results for all JPG surface water samples are presented in Table 8-5. The Federal WQC and State WQSs applicable to JPG surface waters are also included in this table for easy comparison. The Graham Creek surface water results, along with the reference for the Graham Creek watershed, and reference average for all sampled watersheds on JPG are presented in Table 8-18. The surface water results are discussed below.

8.4.6.1.1 Metals and Hardness

Both total and dissolved metal samples were collected. The Graham Creek surface water samples had moderate hardness values (156 to 175 mg/L), which are about the same as the reference average for all of JPG (160 mg/L).

In general, individual total metals concentrations exceeded their dissolved metals counterparts. Most metals were detected at low levels, some at or near the corresponding metal reporting limit.

There was no consistent pattern of metal concentrations in Graham Creek surface water samples. When taking into account the variability between the splits and duplicates (averaging splits and duplicates with their corresponding sample) and the average reference locations, the only substantial increase in the downstream locations was the total and dissolved arsenic and total mercury at sampling location SW-16 and its duplicate SW-19. There was a slight but insignificant increase in dissolved arsenic, total and dissolved silver, and total and dissolved vanadium in SW-05 and its split sample (SW-21) compared to the watershed reference (SW-10). Most metals decreased in concentration from upstream to downstream. The most decrease was at the furthest downstream location (SW-05). For arsenic, chromium, mercury, and vanadium, both total and dissolved concentrations increased slightly from the upstream reach (SW-10) to the middle of the installation (SW-16), and then decreased toward the downstream reach (SW-05). Other metals (barium, molybdenum, and uranium) showed a consistent slight decrease in concentration from the upstream reference location (SW-10) to the furthest downstream location (SW-05) in both total and dissolved form. Only one metal, silver, displayed a slight increase in both total and dissolved concentrations from the reference location (SW-10) through to the

TABLE 8-18. GRAHAM CREEK SURFACE WATER RESULTS

PARAMETER	UNIT	SW-5	Watershed Reference SW-10	SW-16	SW-19**	SW-21**	Reference Average (SW7-SW12)	REGULATORY CRITERIA*			
								FEDERAL AMBIENT WATER QUALITY CRITERIA		INDIANA AMBIENT WATER QUALITY CRITERIA	
								CMC	CCC	CMC	CCC
Explosives and Degradates											
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	**0.039 J**	**0.072 J**	**0.13**	**0.051 J**	**0.031 J**	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.09	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024	0.5	0.1		
Metals											
Hardness	mg/L	160	160	175	175	156	160	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	**0.0964** ***0.0993***	**0.1230** ***0.1110***	**0.1300** ***0.1010***	**0.1090** ***0.1150***	**0.0946** ***0.0967***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**1.220** ***1.160***	**1.180** ***1.090***	**1.530** ***1.360***	**1.450** ***1.370***	**1.150** ***1.190***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**52.3** ***52.8***	**58.4** ***58.1***	**57.0** ***53.4***	**54.7** ***53.7***	**52.2** ***51.4***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.01380** ***0.01220***	**0.01700** ***0.08690***	**0.02310** ***0.01520***	**0.01460** ***0.01030***	**0.00875** ***0.01030***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**46600** ***46700***	**53400** ***45600***	**50900** ***50000***	**50500** ***49900***	**46000** ***45800***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	**0.3110** ***0.2370***	**0.2980** ***0.3160***	**0.5750** ***0.3990***	**0.4540** ***0.3220***	**0.3180** ***0.2380***	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**1.050** ***0.965***	**1.120** ***1.030***	**1.270** ***0.951***	**1.100** ***0.989***	**1.030** ***0.935***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**0.10300** ***0.01920***	**0.07490** ***0.01300***	**0.37300** ***0.00500 U***	**0.14600** ***0.00500 U***	**0.08630** ***0.00936***	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**10200** ***10400***	**13500** ***11400***	**12400** ***12200***	**12300** ***12100***	**10200** ***10100***	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**42.30** ***8.87***	**56.60** ***55.50***	**99.40** ***8.48***	**42.80** ***7.79***	**40.20** ***7.17***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.002010** ***0.001310***	**0.001820** ***0.001350***	**0.00313** ***0.00163***	**0.00234** ***0.00148***	**0.00210** ***0.00138***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.994** ***0.980***	**1.330** ***1.310***	**1.160** ***1.200***	**1.210** ***1.230***	**0.991** ***0.963***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**2.04** ***1.98***	**2.42** ***2.52***	**2.46** ***2.28***	**2.40** ***2.26***	**2.04** ***1.87***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.07600** ***0.09900***	**0.01010 B** ***0.00685 B***	**0.01990 B** ***0.00816 B***	**0.00928 B** ***0.00957 B***	**0.10500** ***0.12700***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**0.434** ***0.420***	**0.580** ***0.575***	**0.547** ***0.516***	**0.528** ***0.521***	**0.436** ***0.412***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.822** ***0.672***	**0.739** ***0.622***	**1.220** ***0.801***	**1.010** ***0.813***	**0.807** ***0.661***	0.809 0.663	- 280	- 20	- -	- -
Zinc	µg/L	**0.802** ***0.596***	**1.010** ***4.410***	**1.590** ***2.400***	**0.941** ***0.605***	**0.658** ***0.517***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters											
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0	5000	600	-	-
TOC	mg/L	8.2	7.0	**9.0**	**9.1**	**8.2**	6.1	-	-	-	-
pH (Field, Lab)	s.u.	7.91	7.69	8.07	8.07	7.91		6.5 - 9.0		-	
D.O. (Field)	mg/L	10.39	8.14	11.12	11.12	10.76		-	-	-	-
Conductivity (Field)	µ-ohm	355	407	400	400	355		-	-	-	-
Temperature (Field)	Deg. Cel.	13.75	14.2	13.36	13.36	13.69		-	-	-	-

*-For complete citations see Table 8-3. **-SW-19 is a duplicate sample for SW-16 and SW-21 is a split sample for SW-05. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

furthest downstream location (SW-05). However, this trend for silver has uncertainty because two of the samples for silver (at SW-10 and 16) have a "B" qualifier, indicating that silver was detected in the laboratory blank sample. Therefore, the trend for silver may not be accurate.

Overall, the metals data as a whole do not display any kind of a discernable pattern. There does not appear to be an association of increased metal concentrations with distance downstream. Therefore, it appears unlikely that firing range activities are contributing metals to the surface water of Graham Creek.

The Graham Creek surface water metal results (SW-05 and 16) were similar to the reference sampling location (SW-10) for the watershed and to the average reference locations for most metals (see Table 8-18).

8.4.6.1.2 Explosives and Degradates

RDX was detected in Graham Creek in the middle of the installation (sampling location SW-16) at a concentration of 0.13 µg/L. RDX was tenatively identified in all of the Graham Creek water samples to include the reference location. The values were presented with a J qualifier indicating that the value was an estimated concentration below the reporting limit. These values were not reportable but there was a good possibility that RDX was present. The estimated values for RDX were 0.039 µg/L, 0.072 µg/L, 0.051 µg/L, and 0.031µg/L for samples SW-05, SW-10, SW-16, and SW-21 respectively.

8.4.6.1.3 Perchlorate, TOC, and Field Parameters

Perchlorate was not detected in any Graham Creek samples. TOC ranged from 7.0 to 9.1 mg/L in Graham Creek surface water samples. The pH of the water was slightly alkaline, with values ranging from 7.69 to 8.07. Conductivity ranged from 355 to 407 µohm. The highest conductivity value (407 µohm) was found in the reference sample for Graham Creek (SW-10). Dissolved oxygen ranged from 8.14 to 11.12. TOC and the field parameters were well within reference values and what would be required to support a healthy ecological community.

8.4.6.1.4 Water Quality Criteria Screening

There were no parameters that exceeded the Federal WQC or State WQS in Graham Creek.

8.4.6.2 Graham Creek Sediment Results

Complete sediment analytical results, along with the SQBs, are presented in Table 8-6. Graham Creek sediment sample results along with the SQBs are included in Table 8-19 for easy comparison. Graham Creek sediment analytical sample results are discussed below.

8.4.6.2.1 Metals

There is no consistent pattern of metal concentrations in Graham Creek sediment. Because both downstream locations had either a duplicate or split sample there was variation within each sampling location. Therefore, the average of the sample and duplicate or split was used for

TABLE 8-19. GRAHAM CREEK SEDIMENT RESULTS

PARAMETER	UNIT	SE-5	SE-10	SE-16	SE-19**	SE-21**	Reference Average (SE7-SE12)	REGULATORY CRITERIA SEDIMENT QUALITY BENCHMARK*
Explosives and Degradates								
HMX	µg/g	0.050 U	0.050 U	**0.320**	0.050 U	0.050 U	0.092	0.330^1
RDX	µg/g	**0.120**	**0.220**	**1.100**	0.010 U	0.010 U	0.545	0.190^1
2,4,6-TNT	µg/g	**0.020**	**0.034**	**0.130**	**0.018**	**0.007 J**	0.117	0.52^1
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.04^1
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.02^1
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	27.0^1
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010	18.5^1
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.230^1
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020	NA
4-NT	µg/g	0.050 U	0.060 U	0.060 U	0.050 U	0.020 U	0.063	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050	NA
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.001	0.26^5
Moisture (WP only)	Percent	15	22	20	20	17	19	NA
Metals								
Antimony	µg/g	**0.186**	**0.141**	**0.151**	**0.162**	**0.172**	0.244	NA
Arsenic	µg/g	**4.71 B**	**7.68**	**4.84 B**	**4.26 B**	**6.96**	5.78	5.9^2
Barium	µg/g	**212**	**261**	**229**	**230**	**210**	206	500^3
Cadmium	µg/g	**0.0669 B**	**0.0822 B**	**0.1060 B**	**0.1010 B**	0.0587 U	0.0946	0.596^2
Chromium	µg/g	**11.40**	**9.40**	**11.5**	**18.5**	**12.6**	11.27	26^3
Copper	µg/g	**2.37**	**8.20**	**3.86**	**3.43**	**3.14**	4.18	16^3
Lead	µg/g	**6.03**	**7.85**	**7.36**	**7.64**	**8.52**	7.84	31^3
Manganese	µg/g	**183**	**235**	**310**	**225**	**230**	265	460^3
Mercury	µg/g	**0.01450**	**0.01020**	**0.00800 J**	**0.01030**	**0.00840 J**	0.01440	0.174^2
Molybdenum	µg/g	**0.516**	**0.486**	**0.329**	**0.438**	**0.476**	0.741	NA
Nickel	µg/g	**3.34**	**4.06**	**3.04**	**3.32**	**3.38**	4.18	16^3
Silver	µg/g	**0.0593**	**0.1060**	**0.0545**	**0.0846**	**0.0899**	0.1017	1^4
Uranium	µg/g	**0.286**	**0.436**	**0.646**	**0.618**	**0.338**	0.562	NA
Vanadium	µg/g	**15.8**	**13.9**	**17.5**	**15.1**	**17.7**	22.0	NA
Zinc	µg/g	**18.6**	**16.0**	**22.8**	**20.1**	**19.7**	18.8	120^3
Moisture	Percent	18.2	20.7	21.9	18.3	17.9	18.6	NA
Other Parameters								
Total Organic Matter	Percent	0.5	0.6	0.8	0.5	0.5	0.8	NA
Perchlorate	µg/g	0.013 U	0.013 U	0.013 U	0.013 U	0.013 U	0.013	NA
Benthic Macroinvertebrates								
Number of Taxa		20	21	16	NA	NA	17	NA
Number of individuals		407	205	160	NA	NA	148	NA
EPT/Total Individuals		30%	38%	23%	NA	NA	49%	NA
Diversity H		2.9	3.0	2.67	NA	NA	2.63	NA

*-For complete citations see Table 8-3. **-SE-19 is a duplicate sample for SE-16 and SE-21 is a split sample for SE-05. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available. **U**-under detection limit.

Highlighted represents exceedance of SQB

comparison to reference locations. None of the metals were substantially higher in the downstream locations compared to the average reference value. Six metals (arsenic, barium, copper, lead, nickel, and silver) all decreased in concentration from upstream (SE-10) to downstream locations (SE-05 and SE-16 and their respective duplicate SE-19 and split SE-21). Manganese and mercury were about equal in concentration from upstream to downstream. Cadmium, chromium, uranium, vanadium, and zinc all increased slightly at SE-16 and decreased from SE-16 to SE-05. Antimony and molybdenum were the only metals that continued to increase downstream. None of the metals increased by an order of magnitude or more from the upstream sampling location (SE-10) to the downstream sampling locations. Therefore, the metal levels present in Graham Creek sediment samples are likely due to naturally-occurring background metal concentrations with no more than a slight increase.

8.4.6.2.2 Explosives and Degradates

Of the 16 explosives and explosive degradates analyzed, only 3 (HMX, RDX, and 2,4,6-TNT) were detected in Graham Creek sediment samples (see Table 8-19). RDX and 2,4,6-TNT were detected in low concentrations in the reference sample (SE-10) and at the furthest downstream sample (SE-05). All three explosives were detected in the sample from the middle of the installation (SE-16).

Sample SE-19 was a duplicate for sample SE-16 and sample SE-21 was a split for sample SE-05. The results of the split and duplicate samples did not compare very well with the sample results. At sampling location SE-05, RDX and 2,4,6-TNT was detected at a concentration of 0.120 µg/g and 0.020 µg/g, respectively. Sample SE-21 was a split of sample SE-05. Sample SE-21 did not have detectable RDX in it, and the 2,4,6-TNT was reported at a concentration of 0.007 µg/g with a 'J' qualifier, indicating the concentration was an estimated value reported below the reporting limit. At sampling location SE-16, HMX, RDX, and 2,4,6-TNT were detected at concentrations of 0.320 µg/g, 1.100 µg/g, and 0.130 µg/g, respectively. Sample SE-19 was a duplicate of sample SE-16. Sample SE-19 did not have detectable HMX and RDX in it, and the detectable 2,4,6-TNT in it was at a concentration of 0.018 µg/g, which is just above the instrument detection limit of 0.010 µg/g. Because of the difference between duplicates, the RDX value at SE-05 and HMX, RDX, and 2,4,6-TNT values at SE-16 would be considered estimated values (see paragraph 8.5.2.1). RDX and 2,4,6-TNT were found in the reference location (SE-10) at concentrations of 0.220 µg/g and 0.034 µg/g, respectively.

8.4.6.2.3 Perchlorate and TOM

Perchlorate was not detected in any Graham Creek sediment samples. Total organic matter was slightly less than 1%, so the SQBs did not have to be adjusted.

8.4.6.2.4 Sediment Quality Benchmarks

The Graham Creek sediment sample concentrations were compared to SQBs. The sediment sample results and the SQBs can be found in Table 8-19. Detected compounds exceeding their respective SQBs are highlighted in Table 8-19. One explosive compound (RDX) and one metal (arsenic) exceeded their respective benchmarks. This situation is similar to the one in Little Graham Creek. Both RDX and arsenic exceeded their respective SQBs in Little Graham Creek.

TOM values for Graham Creek sediment samples are shown in Tables 8-6 and 8-19. Note that the TOM values (which range from 0.5 to 0.8%) are close to 1%. Therefore, the SQB values in Tables 8-6 and 8-19 (which assume 1% organic carbon) will be used for comparison.

Sample SE-10 had an RDX concentration of 0.220 μg/g. This concentration exceeded the RDX SQB of 0.190 μg/g. Sampling location SE-10 is the reference location for Graham Creek. As discussed previously, the detection of a military explosive compound (RDX) at this location is unexplained. The RDX value at SE-10 is less than two times the RDX SQB. There is a potential for RDX to adversely affect the stream ecology in the area around sampling location SE-10, but this potential is somewhat attenuated by the slight degree of exceedance. In the middle of the installation at sampling location SE-16, RDX sediment concentrations increase to 1.100 μg/g, which is substantially above the SQB of 0.190 μg/g. The duplicate for SE-16 (i.e., SE-19) showed no detectable RDX. Therefore, there is considerable uncertainty about the RDX detection in sample SE-16. Because of this uncertainty, the degree of SQB exceedance and/or detection of RDX in SE-16 is not known.

Sample SE-10 had an arsenic concentration of 7.68 μg/g. This concentration slightly exceeded the arsenic SQB of 5.9 μg/g. There is a potential for arsenic to adversely affect the stream ecology in the area around sampling location SE-10, but this potential is somewhat attenuated by the slight degree of exceedance. The detection of arsenic in SE-10 was considered reference because arsenic is a naturally occurring compound. However, chemistry data alone is insufficient to conclude adverse ecological health effects. Additional data (i.e., benthic macroinvertebrate results) was used to make this determination.

Split sample SE-21 had an arsenic concentration of 6.96 μg/g. This concentration slightly exceeded the arsenic SQB of 5.9 μg/g. The site sample for this split is SE-05. Sample SE-05 had an arsenic concentration of 4.71 μg/g, with a 'B' qualifier, indicating that arsenic was also detected in the laboratory blank sample. Therefore, there is uncertainty about the arsenic detection in sample SE-05. The detection may be the result of laboratory contamination. Because of this uncertainty, the degree of the SQB exceedance was not known. To determine whether arsenic was having an adverse effect on Graham Creek ecology, additional data (i.e., benthic macroinvertebrate results) was used.

8.4.6.3 Graham Creek Benthic Macroinvertebrate Results

The benthic macroinvertebrate results are presented in Table 8-7 and Graham Creek results are summarized in Table 8-19. The samples in Graham Creek were well within the variability seen between subsamples and between reference samples and all depict a healthy population. However, there is a subtle decrease in number of taxa, individuals, pollution intolerant individuals, and diversity at sampling location 16 compared to the watershed reference (10) but was the same as the average reference locations. The exceedance of the SQBs for RDX and arsenic at the watershed reference (10) had no adverse impact on the biota.

8.4.6.4 Graham Creek Summary

Figure 8-5 shows Graham Creek results exceeding benchmark or background values. Graham Creek conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results did not exceed Federal WQC or State WQSs and there were no substantially higher than the average reference values at the furthest downstream location SW-05. However, the midstream sampling location SW-16 was substantially higher in total and dissolved arsenic and total mercury than the average reference value. The sediment results for Graham Creek exceeded the SQB for arsenic and RDX at the watershed reference (SE-10) but the downstream locations were within SQBs when averaged with respective split and duplicate samples. HMX at sampling location SE-16 was the only sediment result substantially higher than average reference value. There were no adverse impacts on the human health or the benthic macroinvertebrate ecology.

8.4.7 Otter Creek Watershed and Sampling Locations

Some military activity occurs in this drainage basin, which is located in the extreme northern part of the post. Several impact areas can be found in the south-central part of this basin. The northeastern part of the basin contains Little Otter Dam; behind the dam is Old Timbers Lake. Three tributaries of Otter Creek originate off post to the north, flow to the south onto the post across the northern boundary, and then flow off post toward the west. The Otter Creek sampling locations appear in Figure 8-1. Otter Creek sampling locations SW-07, SW-08, and SW-09 served as upstream reference locations. Sampling locations SW-17 and SW-18 are located in the middle of the installation around designated impact areas. SW-17 is downstream of Little Otter Dam. It captures drainage from the dam and from Little Otter Fork tributary. SW-18 is downstream of the junction of the main channel and Little Otter Fork tributary. It captures drainage from the northern part of the post. Sampling location SW-06 is the furthest downstream location. This sampling location has water flowing through it from the entire watershed on post. Sample SW-22 is a split of SW-06.

8.4.7.1 Otter Creek Surface Water Results

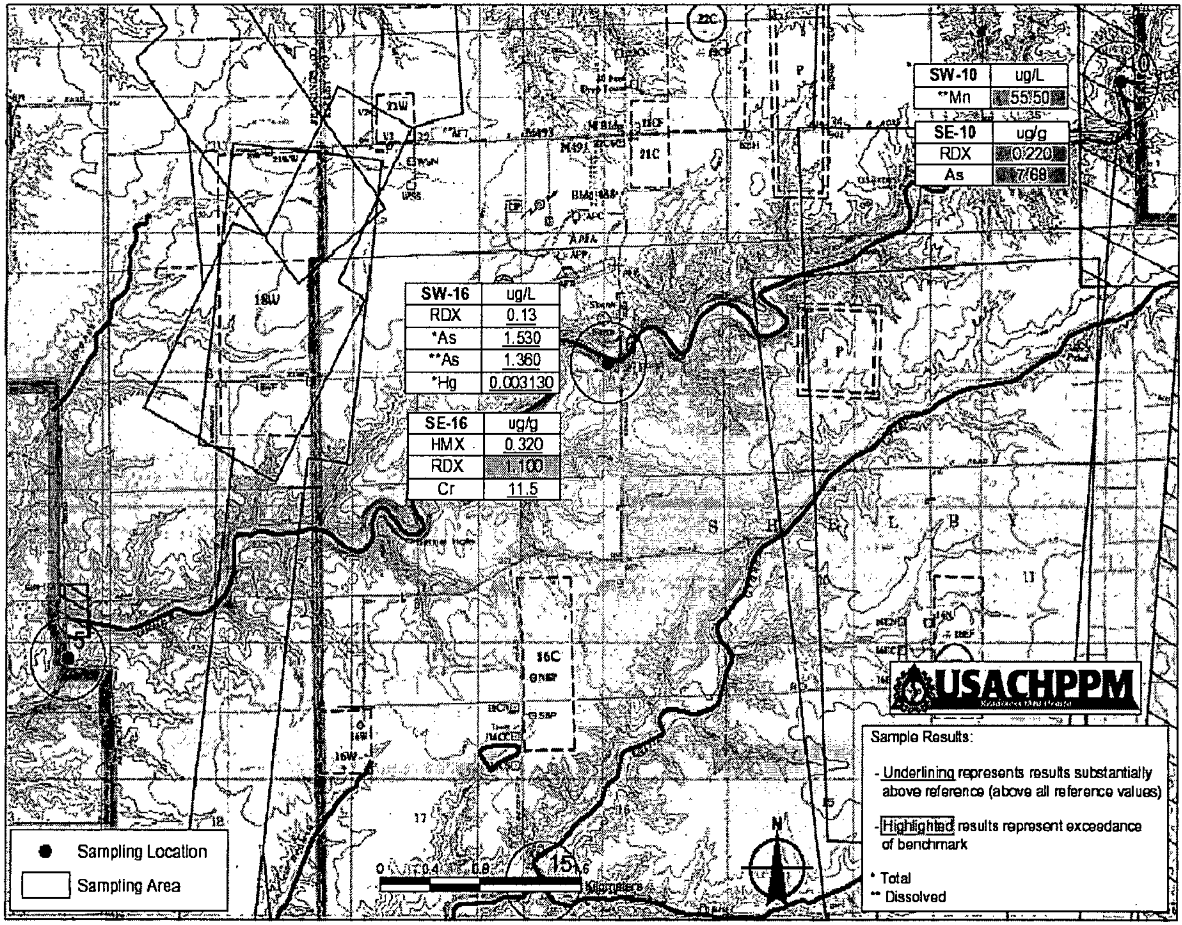
Analytical results for all JPG surface water samples are summarized in Table 8-5. The Otter Creek surface water results, along with the average reference locations for JPG (SW-07-SW-12) and watershed average reference locations (SW-07-SW-09) are presented in Table 8-20. The Federal WQC and State WQSs applicable to JPG surface waters are also included in these tables for easy comparison. The Otter Creek surface water analytical sample results are discussed below.

8.4.7.1.1 Metals and Hardness

Both total and dissolved metal samples were collected. The Otter Creek surface water samples had moderate hardness values (range: 98 to 208 mg/L, mean: 153 mg/L), which is about the same as the reference average for all of JPG (160 mg/L).

FIGURE 8-5 GRAHAM CREEK WATERSHED RESULTS EXCEEDING BENCHMARK OR BACKGROUND VALUES

FIGURE 8-5. Graham Creek Watershed Results Exceeding Benchmark or Background Values, JPG Firing Range Study, 7-11 Oct. 2002



SW-10	ug/L
**Mn	55.50

SE-10	ug/g
RDX	0.220
As	7.68

SW-16	ug/L
RDX	0.13
*As	1.530
**As	1.360
*Hg	0.003130

SE-16	ug/g
HMX	0.320
RDX	1.100
Cr	11.5

Sample Results:

- Underlining represents results substantially above reference (above all reference values)
- Highlighted results represent exceedance of benchmark

* Total
** Dissolved

TABLE 8-20. OTTER CREEK SURFACE WATER RESULTS

PARAMETER	UNIT	SW-06	SW-07	SW-08	SW-09	Reference Average (SW-07-SW-09)	SW-17	SW-18	SW-22**	Reference Average (SW-7-SW-12)	REGULATORY CRITERIA* FEDERAL AMBIENT WATER QUALITY CRITERIA CMC	CCC	INDIANA AMBIENT WATER QUALITY CRITERIA CMC	CCC
Explosives and Degradates														
HMX	µg/L	3..0U	3.0 U	3.0 U	3.0 U	3.0	3.0 U	3.0 U	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	0.100 U	0.100 U	0.100 U	**0.023 J**	0.062	0.100 U	0.100 U	**0.021 J**	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.03	0.030 U	0.030 U	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	0.090 U	0.090 U	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.03	0.030 U	0.030 U	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.5	0.50 U	0.50 U	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.03	0.030 U	0.030 U	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.1	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.1	0.10 U	0.10 U	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.01	0.010 U	0.010 U	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.02	0.020 U	0.020 U	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	0.090 U	0.090 U	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.09	0.090 U	0.090 U	0.090 U	0.09	1700	200		
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024	0.024 U	0.024 U	0.024 U	0.024	0.5	0.1		
Metals														
Hardness	mg/L	149	172	208	156	178	98	144	148	160	-	-	-	-
Antimony (Total/*Dissolved*)	µg/L	**0.0814** ***0.0856***	**0.0924** ***0.0913***	**0.0734** ***0.0651***	**0.0957** ***0.0886***	**0.0871** ***0.0816***	**0.0611** ***0.0616***	**0.0733** ***0.0711***	**0.0781** ***0.0793***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**0.914** ***0.989***	**1.160** ***1.290***	**0.808** ***0.896***	**0.917** ***1.150***	**0.961** ***1.112***	**0.773** ***0.791***	**0.839** ***0.906***	**0.900** ***1.040***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**45.0** ***45.0***	**52.9** ***51.2***	**58.2** ***57.3***	**65.3** ***62.6***	**58.8** ***57.0***	**37.4** ***34.9***	**44.9** ***42.7***	**45.9** ***44.2***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.01140** ***0.00670***	**0.00963** ***0.01040***	**0.06130** ***0.02530***	**0.13600** ***0.01880***	**0.0689** ***0.0181***	**0.00790** ***0.01070***	**0.01190** ***0.01020***	**0.01020** ***0.00709***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**46400** ***46300***	**51900** ***51800***	**57100** ***57100***	**44800** ***44300***	**51266** ***51066***	**30000** ***30300***	**45300** ***44500***	**46200** ***45800***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	**0.3110** ***0.2100***	**0.4080** ***0.3940***	**0.5220** ***0.8110***	**0.2920** ***0.4030***	**0.407** ***0.536***	**0.3430** ***0.2500***	**0.2320** ***0.2740***	**0.3090** ***0.2940***	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**0.864** ***0.871***	**0.989** ***0.968***	**0.614** ***0.600***	**1.180** ***1.180***	**0.927** ***0.916***	**0.549** ***0.526***	**0.811** ***0.780***	**0.846** ***0.943***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**0.07200** ***0.00935***	**0.05780** ***0.01890***	**0.07110** ***0.00830***	**0.04080** *0.00500 U*	**0.0565** ***0.0107***	**0.18800** ***0.03220***	**0.07320** ***0.01730***	**0.05620** ***0.01530***	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**8000** ***8170***	**10300** ***10300***	**16400** ***15800***	**11200** ***11000***	**12633** ***12366***	**5340** ***5460***	**7950** ***7920***	**7990** ***8160***	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**50.60** ***50.70***	**27.70** ***11.40***	**50.10** ***39.70***	**78.80** ***22.70***	**52.2** ***24.6***	**37.10** ***20.20***	**57.70** ***42.10***	**54.00** ***22.90***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.001600** ***0.001200***	**0.001700** ***0.001330***	**0.000890** ***0.000860***	**0.002280** ***0.002020***	**0.00162** ***0.00140***	**0.00181** ***0.00151***	**0.00157** ***0.00132***	**0.00159** ***0.00127***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.745** ***0.683***	**0.928** ***0.861***	**1.070** ***1.020***	**1.650** ***1.380***	**1.21** ***1.087***	**0.455** ***0.454***	**0.661** ***0.621***	**0.749** ***0.714***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**2.04** ***2.19***	**2.23** ***2.48***	**2.43** ***2.44***	**2.33** ***2.35***	**2.33** ***2.42***	**1.51** ***1.46***	**2.02** ***2.01***	**2.04** ***2.35***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.01280 B** ***0.01410 B***	**0.01220 B** *0.00400 U*	**0.04300 B** ***0.00401 B***	**0.01860 B** *0.00400 U*	**0.0246** ***0.0040***	**0.01670 B** ***0.02160 B***	**0.01370 B** ***0.01810 B***	**0.01150 B** ***0.00526 B***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**0.379** ***0.374***	**0.510** ***0.483***	**0.796** ***0.779***	**1.110** ***1.040***	**0.805** ***0.767***	**0.174** ***0.161***	**0.344** ***0.325***	**0.388** ***0.371***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.629** ***0.526***	**0.707** ***0.632***	**0.562** ***0.485***	**0.629** ***0.567***	**0.632** ***0.561***	**0.588** ***0.328***	**0.546** ***0.446***	**0.625** ***0.523***	0.809 0.663	- .280	- 20	- -	- -
Zinc	µg/L	**1.250** ***0.216***	**1.180** ***0.702***	**2.180** ***1.210***	**1.870** ***1.020***	**1.743** ***0.977***	**1.020** ***0.455***	**1.580** ***0.287***	**0.588** ***0.475***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters														
Perchlorate	µg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0	1.0 U	1.0 U	1.0 U	1.0	5000	600	-	-
TOC	mg/L	5.9	6.5	3.2	8.3	**60**	**7.0**	**5.4**	**5.8**	6.1	-	-	-	-
pH (Field)	s.u.	8.12	8.17	7.55	7.15	NA	8.14	7.95	8.12	NA	6.5 - 9.0		-	
D.O. (Field)	mg/L	2.17	11.24	10.51	7.37	NA	7.1	2.41	2.17	NA	-	-	-	-
Conductivity (Field)	µ-ohm	262	319	369	271	NA	170	257	262	NA	-	-	-	-
Temperature (Field)	Deg.Cel	16.9	16.55	15.68	15.38	NA	16.34	16.15	16.9	NA	-	-	-	-

*-For complete citations see Table 8-3. **-SW-22 is a split sample for SW-06. Underlining-represents results substantially above reference (above all reference values).
Bold-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available.
U-under detection limit.

In general, individual total metals concentrations exceeded their dissolved metals counterparts. However, a number of metals (antimony, arsenic, cadmium, calcium, chromium, copper, magnesium, manganese, nickel, and silver) had one or more total metal concentrations below their dissolved counterparts (see Table 8-20). Most metals were detected at low levels, some at or near the corresponding metal reporting limit.

The Otter Creek watershed had three reference sampling locations along the northern boundary of the installation. They were (from west to east) sampling locations SW-07, SW-08, and SW-09. In order to evaluate upstream-downstream trends in metal concentrations, the values from individual metals at these three sampling locations were averaged to provide one Otter Creek watershed reference value for comparison purposes. Where nondetect values were encountered, the detection limit was used. In addition to the Otter Creek watershed reference values, sample results were also compared to the reference average for all of JPG.

There was no consistent pattern of metal concentrations in Otter Creek surface water samples. If SW-06 and its split SW-22 are averaged before comparing downstream samples to references, all the following metals were lower in the downstream sampling sites (total: calcium, nickel, and silver) (total and dissolved: antimony, arsenic, barium, cadmium, chromium, copper, magnesium, molybdenum, uranium, vanadium, and zinc). There were no metals substantially higher than reference values. Dissolved silver, dissolved lead, and dissolved manganese were slightly higher at the downstream sampling locations.

- Dissolved silver increased at SW-06, SW-17, and SW-18 with values of 0.0141 µg/L, 0.0216 µg/L, and 0.0181 µg/L respectively compared to 0.0040 µg/L for the watershed average reference. However, the field and laboratory blanks averaged 0.0153 µg/L and 0.0141 µg/L respectively. Therefore, the detection of silver near these concentrations has uncertainty attached to it.
- Dissolved lead values at SW-17, SW-18, SW-06, and SW-22 were 0.0322 µg/L, 0.0173 µg/L, 0.00935µg/L, and 0.0153 µg/L (0.0123 µg/L for SW- 06 and SW-22 average) respectively compared to 0.0107 µg/L and 0.0507µg/L for the Otter Creek reference average and the JPG reference average respectively.
- Dissolved manganese at SW-06 was 50.7 µg/L and its split sample SW-22 was 22.9 µg/L compared to a watershed average of 24.6µg/L and JPG average reference of 39.48 µg/L. The variability between the sample and the split make the downstream increase questionable.

Overall, the metals data as a whole do not display any kind of a consistent pattern. There does not appear to be an association of increased metal concentrations with distance downstream. Therefore, it appears unlikely that firing range activities are contributing metals to the surface water of Otter Creek.

In general, the Otter Creek surface water metal results were similar to the Otter Creek reference average and to the JPG reference average concentrations for most metals (see Table 8-20).

8.4.7.1.2 Explosives and Degradates

No explosives were detected at the reporting limit in Otter Creek surface water samples. RDX was detected below the reporting limit at the reference location (SW-09) at an estimated concentration of 0.023 µg/L (see Table 8-20). As noted previously, explosives detections at reference locations are unexpected. At this time, no known explanation exists for this detection. RDX was also detected below the reporting limit at the furthest downstream location in a split sample (SW-22) at an estimated concentration of 0.021 µg/L (see Table 8-18). The reporting limit for both samples were 0.100 µg/L RDX.

8.4.7.1.3 Perchlorate, TOC, and Field Parameters

Perchlorate was not detected above the reporting limit in any Otter Creek sample. Sample SW-07 had an estimated perchlorate concentration of 0.87 µg/L with a reporting limit of 1.0 µg/L. This is the only detection of perchlorate in JPG surface water sampled during this study. It is an outlier detection. TOC ranged from 3.2 to 8.3 mg/L in Otter Creek surface water samples. The pH of the water was slightly alkaline, with values ranging from 7.15 to 8.17. The alkalinity is most likely due to the surface water flowing over limestone terrain. Conductivity ranged from 170 to 369 µohm. The highest conductivity value (369 µohm) was found in one of the reference samples for Otter Creek (SW-08). Dissolved oxygen ranged from 2.17 to 11.24. The TOC and field values were all within the range that could support a healthy ecological community.

8.4.7.1.4 Water Quality Criteria Screening

No parameters exceeded water quality criteria in Otter Creek surface water samples.

8.4.7.2 Otter Creek Sediment Results

Sediment analytical results for all sediment sampling at JPG are presented in Table 8-6 and results for Otter Creek are presented in Table 8-21. The SQBs are also presented for easy comparison. Otter Creek sediment analytical sample results are discussed below.

8.4.7.2.1 Metals

Metals were detected at low levels in almost all Otter Creek sediment samples. The metals that substantially increased in the downstream locations compared to the reference locations were arsenic in samples SE-06 and SE-18, barium in SE-06 and SE-17, chromium in SE-17, copper in SE-17, mercury at SE-17 and SE-18, and zinc in SE-06, SE-17 and SE-18 (see Table 8-21). Most of the metals (antimony, barium, chromium, copper, lead, manganese, nickel, silver, uranium, vanadium, and zinc) concentrations increased from the upstream sampling locations, Otter Creek average reference, and JPG average reference values to the middle of the installation (SE-17), and then decreased toward the downstream reach (SE-18), and then increased again toward the furthest downstream sampling location at the installation western boundary (SE-06) (see Table 8-21). One metal (arsenic) showed a pattern of increasing metal concentrations in downstream Otter Creek samples from upstream reference locations to downstream sampling locations, indicating possible onpost accumulation of this metal. The remaining metals showed

TABLE 8-21. OTTER CREEK SEDIMENT RESULTS

PARAMETER	UNIT	SE-06	SE-07	SE-08	SE-09	Watershed Reference Average (SE-07-SE-09)	SE-17	SE-18	SE-22**	JPG Reference Average (SE-07 -SE-12)	REGULATORY CRITERIA SEDIMENT QUALITY BENCHMARK*
Explosives and Degradates											
HMX	µg/g	**0.080**	**0.091**	**0.260**	0.050 U	0.134	**0.04 J**	0.050 U	**0.046 J**	0.092	0.330[1]
RDX	µg/g	**0.260**	**0.420**	**1.900**	**0.098**	0.806	**0.260**	**0.120**	**0.250**	0.545	0.190[1]
2,4,6-TNT	µg/g	**0.046**	**0.086**	**0.280**	**0.200**	0.189	**0.043**	**0.016**	**0.040**	0.117	0.52[1]
1,3-DNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	0.04[1]
1,3,5-TNB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	0.02[1]
TETRYL	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	NA
NB	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	27.0[1]
2A-4,6-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	NA
4A-2,6-DNT	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050	0.050 U	0.050 U	0.050 U	0.050	NA
2,6-DNT	µg/g	0.010 U	0.010 U	0.010 U	0.010 U	0.010	0.010 U	0.010 U	0.010 U	0.010	18.5[1]
2,4-DNT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	0.230[1]
2-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	NA
3-NT	µg/g	0.020 U	0.020 U	0.020 U	0.020 U	0.020	0.020 U	0.020 U	0.020 U	0.020	NA
4-NT	µg/g	0.080 U	0.070 U	0.070 U	0.050 U	0.063	0.070 U	0.050 U	0.070 U	0.063	NA
Nitroglycerin	µg/g	0.050 U	0.050 U	0.050 U	0.050 U	0.050	0.050 U	0.050 U	0.050 U	0.050	NA
WP	µg/g	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.001	0.0010 U	0.0010 U	0.0010 U	0.001	0.26[5]
Moisture (WP only)	µg/g	19	21	11	18		21	22	18	19	NA
Metals											
Antimony	µg/g	**0.253**	**0.271**	**0.348**	**0.195**	**.0271**	**0.280**	**0.217**	**0.343**	0.244	NA
Arsenic	µg/g	**20.20**	**3.79 B**	**6.45**	**3.70 B**	4.64	**5.52 B**	**15.90**	**18.70**	5.78	5.9[2]
Barium	µg/g	**318**	**246**	**180**	**243**	223	**249**	**219**	**287**	206	500[3]
Cadmium	µg/g	0.0587 U	**0.103 B**	**0.0955 B**	**0.0964 B**	**0.0983**	**0.1580 B**	0.0587 U	0.0587 U	0.0946	0.596[2]
Chromium	µg/g	**18.20**	**17.50**	**11.90**	**7.53**	12.31	**19.6**	**14.2**	**33.6**	11.27	26[3]
Copper	µg/g	**3.59**	**3.07**	**4.61**	**3.85**	3.84	**5.95**	**2.11**	**3.59**	4.18	16[3]
Lead	µg/g	**10.50**	**6.84**	**11.50**	**7.03**	8.45	**10.90**	**6.72**	**10.20**	7.84	31[3]
Manganese	µg/g	**326**	**154**	**496**	**237**	295.6	**434**	**219**	**298**	265	460[3]
Mercury	µg/g	**0.00710 B,J**	**0.01350 B**	**0.01600 B**	**0.01910 B**	**0.0162**	**0.02030**	**0.02120 B**	**0.01160 B**	0.01440	0.174[2]
Molybdenum	µg/g	**0.868**	**0.837**	**1.150**	**0.452**	**0.813**	**0.606**	**0.554**	**0.897**	0.741	NA
Nickel	µg/g	**5.73**	**5.24**	**6.61**	**3.08**	4.97	**5.86**	**4.53**	**5.72**	4.18	16[3]
Silver	µg/g	**0.0803**	**0.0729**	**0.1350**	**0.0485**	**0.0854**	**0.0985**	**0.0592**	**0.0625**	0.1017	1[4]
Uranium	µg/g	**0.719**	**0.357**	**0.948**	**0.682**	**0.662**	**0.964**	**0.462**	**0.755**	0.562	NA
Vanadium	µg/g	**25.8**	**21.7**	**25.5**	**16.1**	21.1	**26.8**	**23.0**	**26.4**	22.0	NA
Zinc	µg/g	**44.6**	**16.7**	**23.8**	**19.2**	19.9	**35.2**	**31.6**	**42.5**	18.8	120[3]
Moisture	Percent	20.1	20.7	12.0	20.8	17.8	26.8	20.6	20.7	18.6	NA
Other Parameters											
Total Organic Matter	Percent	0.9	0.6	1.6	0.6	0.9	1.7	0.4	0.9	0.8	NA
Perchlorate	µg/g	0.013 U	0.013 U	0.011 U	0.013 U	0.013	0.012 U	0.013 U	0.012 U	0.013	NA
Benthic Macroinvertebrates											
Number of Taxa		15	20	16	10	15	20	17	NA	17	NA
Number of Individuals		97	91	88	18	67	114	160	NA	148	NA
EPT/total individuals		55%	49%	73%	11%	44%	57%	90%	NA	49%	NA
Diversity H		2.86	3.12	2.84	2.28	2.75	2.79	3.72	NA	2.63	NA

*-For complete citations see Table 8-3. **-SE-22 is a split sample for SE-06. Underlining-represents results substantially above reference (above all reference values).
Bold-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **NA**-not available.
U-under detection limit.

Highlighted represents exceedance of SQB

no definite trend whatsoever. The metals levels present in Otter Creek sediment samples showed a more pronounced trend toward increasing metals in downstream locations than in the other watersheds.

8.4.7.2.2 Explosives and Degradates

Of the 16 explosives and explosive degradates analyzed, only three (HMX, RDX, and 2,4,6-TNT) were detected in Otter Creek sediment samples (see Table 8-21). All three of these explosive compounds were detected in low concentrations in the reference samples (SE-07 and SE-08), and two explosives (RDX and 2,4,6-TNT) were detected in the third reference sample (SE-09). All three of these explosive compounds were detected in the middle of the installation at sampling location SE-17, and two explosives were detected at SE-18. In addition, all three explosives were detected at the furthest downstream sample (SE-06).

In order to evaluate upstream-downstream trends in explosive concentrations, the detected values from individual samples at the three reference sampling locations along the northern boundary (SE-07, SE-08, and SE-09) were averaged. This provided one Otter Creek watershed reference value for comparison purposes (see Table 8-21). Where nondetect values were encountered, the detection limit was used.

RDX and 2,4,6-TNT were found in all three reference locations for Otter Creek (SE-07, SE-08, and SE-09) (see Table 8-21). RDX values in samples SE-07, SE-08, and SE-09 are 0.420, 1.900, and 0.098 µg/g, with an average of 0.806 µg/g; 2,4,6-TNT values are 0.086, 0.280, and 0.200 µg/g, with an average of 0.188 µg/g. These compounds and concentrations are surprizingly similar to what was found at sampling locations SE-10 and SE-11, the reference locations for Graham Creek and Little Graham Creek, respectively. In addition, HMX was detected in samples SE-07 and SE-08 in concentrations of 0.091 µg/g and 0.260 µg/g, respectively. HMX was not detected in sample SE-09, and also was not detected in the reference locations for Graham Creek and Little Graham Creek. Explosives detections at reference locations are clearly unexpected.

In the sample average of SE-06 and its split (SE-22) HMX, RDX, and 2,4,6-TNT were detected at concentrations of 0.062 µg/g, 0.255 µg/g, and 0.043 µg/g, respectively. The sample and split results compared fairly well so the detected concentrations were considered reliable. The sediment results for HMX, RDX, and 2,4,6-TNT in sample SE-06 were lower than the reference averages.

RDX and 2,4,6-TNT were found in the middle of the installation (in samples SE-17 and SE-18) at concentrations of 0.260 µg/g, and 0.043 µg/g, and 0.120 µg/g, and 0.016 µg/g respectively. The sediment results for RDX and 2,4,6-TNT in samples SE-17 and SE-18 were lower than the reference averages.

8.4.7.2.3 Perchlorate and TOM

Perchlorate was not detected in any Otter Creek sediment samples. Total organic matter was less than 1% on an average. Therefore, the calculation of the SQBs does not need to be adjusted.

8.4.7.2.4 Sediment Quality Benchmarks

The Otter Creek sediment sample concentrations were compared to SQBs. Detected compounds that exceeded their respective SQBs are highlighted in Table 8-21. One explosive compound (RDX) and two metals (arsenic and manganese) exceeded their respective benchmarks.

TOM values for Otter Creek sediment samples are shown in Tables 8-21. TOM values (range: 0.4 -1.7%, average: 0.95%) are close to 1%. Therefore, the SQB values in Tables 8-21 (which assume 1% organic carbon) will be used for comparison.

Samples SE-07 and SE-08 had RDX concentrations of 0.420 μg/g and 1.900 μg/g, respectively. These concentrations exceeded the RDX SQB of 0.190 μg/g. Sampling location SE-08 had an arsenic concentration of 6.45 μg/g, which exceeded the arsenic SQB of 5.9 μg/g. This sampling location also had a manganese concentration of 496 μg/g which exceeded the manganese SQB of 460 μg/g. Both arsenic and manganese exceed their respective SQBs by less than a factor of two. Sampling locations SE-07 and SE-08 are reference locations for Otter Creek. As discussed previously, the detection of a military explosive compound (RDX) at a reference location is unexplained. The RDX value in SE-07 is about two times the RDX SQB. However, the RDX value at SE-08 was ten times the RDX SQB. There was a potential for RDX, arsenic, and manganese to adversely affect stream ecology in the area around sampling locations 07 and 08, but the potential at sampling location SE-07 was somewhat attenuated by the slight degree of exceedance of the SQB. The potential for adverse affects at sampling location SE-08 was higher than at sampling location SE-07, due mainly to the higher RDX concentration. Nevertheless, sediment chemistry alone was insufficient to conclude adverse ecological effects. Chemistry data indicated a *potential* for ecological health effects. To determine if an actual ecological health effect had occurred biological data from the benthic macroinvertebrates was evaluated and no adverse impact was found (See paragraph 8.4.7.3).

In the middle of the installation in samples SE-17 and SE-18, arsenic and RDX exceeded the SQB. The RDX sediment concentration in SE-17 was 0.260 μg/g, which was slightly above the RDX SQB of 0.190 μg/g. The arsenic sediment concentration in sample SE-18 was 15.90 μg/g, which was above the arsenic SQB of 5.9 μg/g. Again, there was a *potential* for ecological health effects but benthic macroinvertebrate data was evaluated and no adverse impact was found (See paragraph 8.4.7.3).

Finally, as Otter Creek exits JPG and flows west (sampling location 06), RDX and arsenic were found in the sediment above their respective SQBs (see Table 8-21). Split sample SE-22 had remarkably similar values to SE-06. The RDX values in samples SE-06 and split SE-22 were 0.260 μg/g and 0.250 μg/g, respectively. Arsenic was 20.20 μg/g and 18.70 μg/g in samples SE-06 and split SE-22, respectively. This similarity lends credence to the presence and concentration values of the detected RDX and arsenic at sampling location SE-06. There was a *potential* for RDX and arsenic to adversely affect the stream ecology in the area around sampling location SE-06. To determine if an actual ecological health effect had occurred biological data from the benthic macroinvertebrates was evaluated and no adverse impact was found (See paragraph 8.4.7.3).

8.4.7.3 Otter Creek Benthic Macroinvertebrate Results

The complete benthic macroinvertebrate results are presented Table 8-7 and Otter Creek summary of results is presented in Table 8-21. The samples in Otter Creek were well within the variability seen between subsamples and between reference samples. All depict a healthy population. However, there is a subtle increase in the health of the benthic macroinvertebrate population seen in some of the metrics as compared to the watershed reference average. The difference indicates that water quality and the corresponding ecological community was not being adversely affected by the explosives compounds or firing range activity. The slightly better benthic macroinvertebrate metrics could be due to forested and protected watersheds, and the increase in stream size (order).

8.4.7.4 Otter Creek Summary

Figure 8-6 shows Otter Creek results exceeding benchmark or background values. Otter Creek conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The surface water results for Otter Creek did not exceed Federal WQC or State WQSs, and there were no results that were substantially higher than the average reference values. The sediment results for Otter Creek exceeded the SQB for arsenic at sampling locations SE-06, SE-08, and SE-18, and RDX at sampling locations SE-06, SE-07, SE-08, and SE-17. The only sediment results that were substantially higher than both average reference values were arsenic at SE-06 and SE-18, barium at SE-17, cadmium at SE-17, chromium at SE-06 and SE-17, copper at SE-17, mercury at SE-17 and SE-18, and zinc at SE-06, SE-17, and SE-18. HMX, RDX, and 2,4,6-TNT were detected in the sediments at several sampling locations (both reference and downstream). However, there were no adverse impacts on the benthic macroinvertebrate ecology.

8.4.8 Seep (Spring) Sampling Locations

There were three seeps (springs) identified as possible sampling locations during the scoping visit. The drought conditions caused two of the seeps to totally dry up. The third location had a very low flow (about 1/10th of a gallon per minute). The water from this seep was sampled to determine if undiluted ground water would meet Federal WQC and State WQSs. The seep was originating close to the northwest bank of Middle Fork Creek about 200 yards downstream of Jimestown Road near the western boundary of JPG. There were few activities upslope from the seep. There was an impact field across Jimestown Road but the majority of the watershed for the seep was in the buffer zone near the west boundary. There was a stone springhouse built around the seep. The sampling location was identified as GS-01 for ground-water seep.

8.4.8.1 Seep Sample Water Quality Results

The water quality results are presented in Table 8-5. The seep sample GS-01 water quality results, along with the average reference locations for JPG (SW-07-SW-12) are presented in Table 8-22. The Federal WQC and State WQSs applicable to JPG surface waters are also included in these tables for easy comparison. The seep sample water quality analytical sample results are discussed below.

FIGURE 8-6 OTTER CREEK WATERSHED RESULTS EXCEEDING BENCHMARK OR BACKGROUND VALUES

FIGURE 8-6. Otter Creek Watershed Results Exceeding Benchmark or Background Values, JPG Firing Range Study, 7-11 Oct. 2002

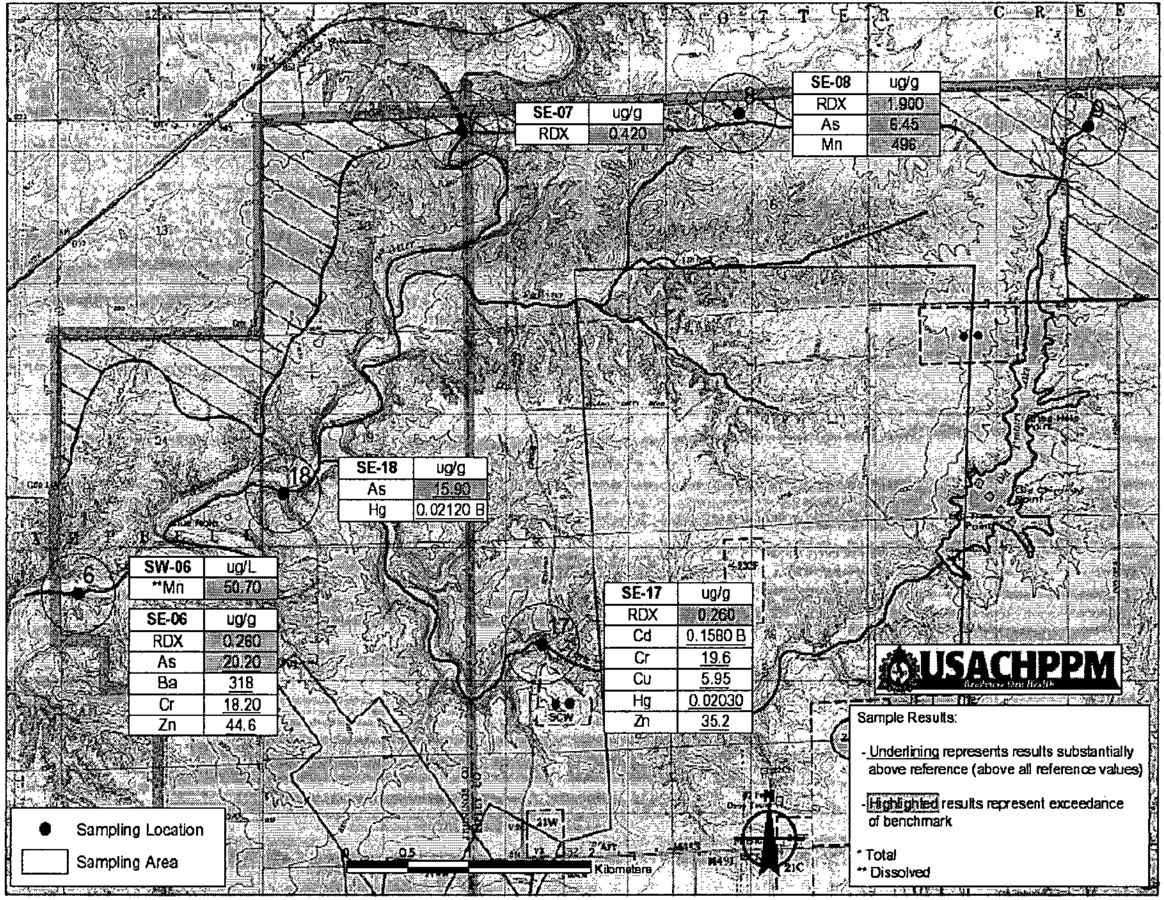


TABLE 8-22. SEEP SAMPLE RESULTS

PARAMETER	UNIT	SG-01	Reference Average (SW7-SW12)	REGULATORY CRITERIA*			
				FEDERAL AMBIENT WATER QUALITY CRITERIA		INDIANA AMBIENT WATER QUALITY CRITERIA	
				CMC	CCC	CMC	CCC
Explosives and Degradates							
HMX	µg/L	3.0 U	3.0	NA	330	No numeric criteria have been established for these compounds.	
RDX	µg/L	0.100 U	0.062	4000	190		
2,4,6-TNT	µg/L	0.030 U	0.03	570	130		
1,3-DNB	µg/L	0.090 U	0.09	110	30		
1,3,5-TNB	µg/L	0.030 U	0.03	30	14		
TETRYL	µg/L	0.50 U	0.5	NA	NA		
NB	µg/L	0.030 U	0.03	27,000			
2A-4,6-DNT	µg/L	0.10 U	0.1	NA	NA		
4A-2,6-DNT	µg/L	0.10 U	0.1	NA	NA		
2,6-DNT	µg/L	0.010 U	0.01	18,500	NA		
2,4-DNT	µg/L	0.020 U	0.02	330	230		
2-NT	µg/L	0.090 U	0.09	NA	NA		
3-NT	µg/L	0.090 U	0.09	NA	NA		
4-NT	µg/L	0.090 U	0.09	NA	NA		
Nitroglycerin	µg/L	0.090 U	0.09	1700	200		
WP	µg/L	0.026 U	0.024	0.5	0.1		
Metals							
Hardness	mg/L	**198**	160	-	-	-	-
Antimony (Total/*Dissolved*)[1]	µg/L	**0.0207 B** ***0.0143 B***	0.1036 0.0997	- 180	- 30	-	-
Arsenic	µg/L	**0.385** ***0.210***	0.983 1.027	- 340	- 150	360 -	190 -
Barium	µg/L	**46.2** ***43.7***	57.8 56.3	- 1000	1000	- -	- -
Cadmium	µg/L	**0.06020** ***0.07270***	0.04352 0.02993	- 4.3	- 2.2	4 -	1.1 -
Calcium	µg/L	**49800** ***50400***	47400 45950	- -	- -	- -	- -
Chromium	µg/L	**0.4380** ***0.1650***	0.4355 0.3898	- 570	- 74	1737 -	207 -
Copper	µg/L	**0.477** ***0.250***	1.066 1.030	- 13	- 9	18 -	9 -
Lead	µg/L	**0.42500** *0.005 U*	0.41493 0.05072	- 65	- 2.5	82 -	3 -
Magnesium	µg/L	**17700** ***17800***	11502 11025	- -	- -	- -	- -
Manganese	µg/L	**51.50** ***18.80***	56.58 39.48	- 50	- -	- -	- -
Mercury	µg/L	**0.001980** ***0.000523***	0.001783 0.001508	- 1.4	- 0.77	2.4 -	0.012 -
Molybdenum	µg/L	**0.147** ***0.182***	1.055 0.997	- 16000	- 370	- -	- -
Nickel	µg/L	**2.31** ***1.90***	2.20 2.29	- 470	- 52	1418 -	158 -
Silver	µg/L	**0.0316 B** ***0.0149 B***	0.05208 0.04755	- 3.4	- -	2 -	- -
Uranium	µg/L	**1.030** ***1.010***	0.717 0.697	- 46	- 2.6	- -	- -
Vanadium	µg/L	**0.775** ***0.241***	0.809 0.663	- 280	- 20	- -	- -
Zinc	µg/L	**3.500** ***1.410***	1.573 1.581	- 120	- 120	117 -	106 -
Other Parameters							
Perchlorate	µg/L	1.0 U	1.0	5000	600	-	-
TOC	mg/L	**1.1**	6.1	-	-	-	-
pH (Field, Lab)	s.u.	6.85		6.5 - 9.0		-	
D.O. (Field)	mg/L	0.61		-	-	-	-
Conductivity (Field)	µohm	379		-	-	-	-
Temperature (Field)	Deg.Cel.	15.09		-	-	-	-

*-For complete citations see Table 8-3. Underlining-represents results substantially above reference (above all reference values). **Bold**-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **NA**-not available. **U**-under detection limit.

8.4.8.1.1 Metals and Hardness

Both total and dissolved metals samples were collected. The seep water sample had a moderate hardness value of 198 mg/L, which is about the same as the reference average for all of JPG (160 mg/L).

In general, individual total metals concentrations exceeded their dissolved metals counterparts. However, a number of metals (cadmium, calcium, magnesium, and molybdenum) had total metal concentrations below their dissolved counterparts (see Table 8-22). Most metals were detected at low levels, some at or near the corresponding metals reporting limit.

There were no metals except total and dissolved magnesium and total zinc that were substantially higher than the average reference value for the stream locations.

Overall, the metals data do not display any kind of a consistent pattern. The metals were similar to the JPG reference average concentrations for most metals (see Table 8-22). No metals exceeded reference concentrations by more than an order of magnitude.

8.4.8.1.2 Explosives and Degradates

There were no explosives detected in the seep water sample.

8.4.8.1.3 Perchlorate, TOC, and Field Parameters

Perchlorate was not detected in the seep sample. TOC, pH, dissolved oxygen, conductivity, and temperature were all in the range expected from a ground-water seep. The pH and dissolved oxygen was lower than stream samples. This would be expected but the ground water would soon equilibrate as it oxygenates and loses excess carbon dioxide.

8.4.8.1.4 Water Quality Criteria Screening

No parameters exceeded water quality criteria in the seep sample.

8.4.8.1.5 Ground-Water Seep Summary

Figure 8-2 shows the ground-water seep results exceeding benchmark or background values. The ground-water seep conclusions are based on the one sampling event data collected during the field investigation. The data collected do not account for temporal variations and represent point estimates of exposure. The seep ground-water results do not exceed Federal WQC or State WQSs and the only results that were substantially higher than the average reference values were total and dissolved magnesium and total zinc.

8.5 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

8.5.1 Overview

Field and laboratory QA/QC procedures were followed during the JPG field investigation through strict adherence to approved procedures outlined in the QAPP. Proper sampling, handling, and shipment procedures prevented sample cross-contamination. The indicators used to assess both field and laboratory data quality include precision, accuracy, representativeness, and completeness (PARC). These parameters are discussed below.

8.5.2 Precision

Sampling precision is assessed through the evaluation of field duplicate samples. Duplicate samples are defined as samples collected simultaneously from the same source under identical conditions. Precision is stated in terms of the relative percent difference (RPD). The RPD is defined as follows:

$$\frac{(C_1 - C_2)}{\left[\frac{C_1 + C_2}{2}\right]} \times 100$$

where: C_1 = concentration of constituent in actual sample
C_2 = concentration of constituent in duplicate sample

8.5.2.1 Precision Data

Tables 8-23 and 8-24 show the calculated RPD values for the JPG surface water and sediment samples. Four pairs of field duplicates were collected for both surface water and sediment samples at Graham Creek (SW/SE-5/21 and SW/SE-16/19), Little Graham Creek (SW/SE-4/20), and Otter Creek (SW/SE-6/22) downstream sample locations. The RPD values were only calculated for constituents found above the detection limit in both duplicate/split pairs. Because HMX, RDX, and 2,4,6-TNT were found in reference samples, the detection limit was conservatively used to calculate RPD values for the explosives. When the RPD approaches 0, complete agreement is achieved between the original/duplicate pair, indicating a high degree of precision.

8.5.2.2 Surface Water RPD Results

The RPD values for surface water samples ranged from 0 to 119, with a median of 4. The majority of the duplicate metal results met the 30% RPD data quality objective specified in the QAPP. Lead, manganese, silver, and zinc concentrations were the only metals to exceed the RPD in various duplicate surface water samples.

TABLE 8-23. RPD VALUES FOR SURFACE WATER SPLIT AND DUPLICATE SAMPLE

Parameters		SW-16	SW-19	RPD (%)	SW-4	SW-20	RPD (%)	SW-5	SW-21	RPD (%)	SW-6	SW-22	RPD (%)
Explosives and Degradates													
HMX	µg/L	3.0 U	3.0 U	-	3.0 U	3.0 U	-	3.0 U	3.0 U	-	3.0 U	3.0 U	-
RDX	µg/L	0.13	0.051 J	-	0.100 U	0.100 U	-	0.039 J	0.031 J	-	0.100 U	0.021 J	-
2,4,6-TNT	µg/L	0.030 U	0.030 U	-	0.030 U	0.030 U	-	0.030 U	0.030 U	-	0.030 U	0.030 U	-
1,3-DNB	µg/L	*0.090 U*	*0.090 U*	-	*0.090 U*	*0.090 U*	-	*0.090 U*	*0.090 U*	-	*0.090 U*	*0.090 U*	-
1,3,5-TNB	µg/L	0.030 U	0.030 U	-	0.030 U	0.030 U	-	0.030 U	0.030 U	-	0.030 U	0.030 U	-
TETRYL	µg/L	0.50 U	0.50 U	-	0.50 U	0.50 U	-	0.50 U	0.50 U	-	0.50 U	0.50 U	-
NB	µg/L	0.030 U	0.030 U	-	0.030 U	0.030 U	-	0.030 U	0.030 U	-	0.030 U	0.030 U	-
2A-4,6-DNT	µg/L	0.10 U	0.10 U	-	0.10 U	0.10 U	-	0.10 U	0.10 U	-	0.10 U	0.10 U	-
4A-2,6-DNT	µg/L	0.10 U	0.10 U	-	0.10 U	0.10 U	-	0.10 U	0.10 U	-	0.10 U	0.10 U	-
2,6-DNT	µg/L	0.010 U	0.010 U	-	0.010 U	0.010 U	-	0.010 U	0.010 U	-	0.010 U	0.010 U	-
2,4-DNT	µg/L	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
2-NT	µg/L	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-
3-NT	µg/L	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-
4-NT	µg/L	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-
Nitroglycerin	µg/L	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-	0.090 U	0.090 U	-
WP	µg/L	0.024 U	0.024 U	-	0.024 U	0.024 U	-	0.024 U	0.024 U	-	0.024 U	0.024 U	-
Metals													
Hardness	mg/L	175	175	-	128	128	-	160	156	-	149	148	-
Antimony (Total/*Dissolved*)	µg/L	0.1300 *0.1010*	0.1090 *0.1150*	18% 13%	0.0792 *0.0836*	0.0947 *0.1080*	18% 25%	0.0964 *0.0993*	0.0946 *0.0967*	2% 3%	0.0814 *0.0856*	0.0781 *0.0793*	4% 8%
Arsenic	µg/L	1.530 *1.360*	1.450 *1.370*	5% 1%	0.758 *0.771*	0.740 *0.713*	2% 8%	1.220 *1.160*	1.150 *1.190*	6% 3%	0.914 *0.989*	0.900 *1.040*	2% 5%
Barium	µg/L	57.0 *53.4*	54.7 *53.7*	4% 1%	44.6 *44.1*	44.8 *44.1*	0% 0%	52.3 *52.8*	52.2 *51.4*	0% 3%	45.0 *45.0*	45.9 *44.2*	2% 2%
Cadmium	µg/L	0.02310 *0.01520*	0.01460 *0.01030*	**45%** **38%**	0.00959 *0.00989*	0.01280 *0.00671*	29% **38%**	0.01380 *0.01220*	0.00875 *0.01030*	**45%** 17%	0.01140 *0.00670*	0.01020 *0.00709*	11% 6%
Calcium	µg/L	50900 *50000*	50500 *49900*	1% 0%	36300 *36400*	37000 *36400*	2% 0%	46600 *46700*	46000 *45800*	1% 2%	46400 *46300*	46200 *45800*	0% 1%
Chromium	µg/L	0.5750 *0.3990*	0.4540 *0.3220*	24% 21%	0.0240 U *0.0240 U*	0.0322 *0.0240 U*	29% -	0.3110 *0.237*	0.3180 *0.2380*	2% 0%	0.3110 *0.210*	0.3090 *0.2940*	1% **33%**
Copper	µg/L	1.270 *0.951*	1.100 *0.989*	14% 4%	1.110 *1.050*	1.090 *1.030*	2% 2%	1.050 *0.965*	1.030 *0.935*	2% 3%	0.864 *0.871*	0.846 *0.943*	2% 8%
Lead	µg/L	0.37300 *0.00500 U*	0.14600 *0.00500 U*	**87%** -	0.05550 *0.00500 U*	0.03320 *0.00500 U*	**50%** -	0.10300 *0.01920*	0.08630 *0.00936*	18% **69%**	0.07200 *0.00935*	0.05620 *0.01530*	25% **48%**
Magnesium	µg/L	12400 *12200*	12300 *12100*	1% 1%	8910 *8910*	9090 *9130*	2% 2%	10200 *10400*	10200 *10100*	0% 3%	8000 *8170*	7990 *8160*	0% 0%
Manganese	µg/L	99.40 *8.48*	42.80 *7.79*	**80%** 8%	31.70 *23.70*	29.00 *24.90*	9% 5%	42.30 *8.87*	40.20 *7.17*	5% 21%	50.60 *50.70*	54.00 *22.90*	7% **76%**
Mercury	µg/L	0.00313 *0.00163*	0.00234 *0.00148*	29% 10%	0.001970 *0.001830*	0.00189 *0.00166*	4% 10%	0.002010 *0.001310*	0.00210 *0.00138*	4% 5%	0.001600 *0.001200*	0.00159 *0.00127*	1% 6%
Molybdenum	µg/L	1.160 *1.200*	1.210 *1.230*	4% 2%	0.479 *0.502*	0.498 *0.479*	4% 5%	0.994 *0.980*	0.991 *0.963*	0% 2%	0.745 *0.683*	0.749 *0.714*	1% 4%
Nickel	µg/L	2.46 *2.28*	2.40 *2.26*	2% 1%	1.72 *1.54*	1.60 *1.57*	7% 2%	2.04 *1.98*	2.04 *1.87*	0% 6%	2.04 *2.19*	2.04 *2.35*	0% 7%
Silver	µg/L	0.0199 B *0.00816 B*	0.00928 B *0.00957 B*	**73%** 16%	0.18200 *0.20900*	0.15400 *0.17100*	17% 20%	0.07600 *0.09900*	0.10500 *0.12700*	**32%** 25%	0.01280 B *0.01410 B*	0.01150 B *0.00526 B*	11% **91%**
Uranium	µg/L	0.547 *0.516*	0.528 *0.521*	4% 1%	0.312 *0.319*	0.320 *0.313*	3% 2%	0.434 *0.420*	0.436 *0.412*	0% 2%	0.379 *0.374*	0.388 *0.371*	2% 1%
Vanadium	µg/L	1.220 *0.801*	1.010 *0.813*	19% 1%	0.441 *0.371*	0.431 *0.370*	2% 0%	0.822 *0.672*	0.807 *0.661*	2% 2%	0.629 *0.526*	0.625 *0.523*	1% 1%
Zinc	µg/L	1.590 *2.400*	0.941 *0.605*	**51%** **119%**	0.628 *0.293*	1.670 *0.335*	**91%** 13%	0.802 *0.596*	0.658 *0.517*	20% 14%	1.250 *0.216*	0.588 *0.475*	**72%** **75%**
Other Parameters													
Perchlorate	µg/L	1.0 U	1.0 U	-	1.0 U	1.0 U	-	1.0 U	1.0 U	-	1.0 U	1.0 U	-
TOC	mg/L	9.0	9.1	1%	6.0	6.1	2%	8.2	8.2	0%	5.9	5.8	2%
pH (Field, Lab)	s.u.	8.07	8.07		7.57	7.60		7.91	7.91		8.12	8.12	
D.O. (Field)	mg/L	11.12	11.12		9.50	9.17		10.39	10.76		2.17	2.17	
Conductivity (Field)	µ ohm	400	400		231	231		355	355		262	262	
Temperature (Field)	Deg. Cel.	13.36	13.36		13.66	13.66		13.75	13.69		16.90	16.90	

Bold-represents RPD values that exceeded the 30% allowed **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **U**-under detection limit.

TABLE 8-24. RPD VALUES FOR SEDIMENT SPLIT AND DUPLICATE SAMPLE

PARAMETER	UNIT	SE-16	SE-19	RPD (%)	SE-4	SE-20	RPD (%)	SE-5	SE-21	RPD (%)	SE-6	SE-22	RPD (%)
Explosives and Degradates													
HMX	µg/g	**0.320**	0.050 U	146%	0.050 U	0.050 U	0%	0.050 U	0.050 U	-	**0.080**	**0.046 J**	54%
RDX	µg/g	**1.100**	0.010 U	196%	**0.190**	**0.140**	30%	**0.120**	0.010 U	119%	**0.260**	**0.250**	4%
2,4,6-TNT	µg/g	**0.130**	**0.018**	**151%**	**0.040**	**0.030**	29%	**0.020**	**0.007 J**	52%	**0.046**	**0.040**	14%
1,3-DNB	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
1,3,5-TNB	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
TETRYL	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
NB	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
2A-4,6-DNT	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
4A-2,6-DNT	µg/g	0.050 U	0.050 U	-	0.050 U	0.050 U	-	0.050 U	0.050 U	-	0.050 U	0.050 U	-
2,6-DNT	µg/g	0.010 U	0.010 U	-	0.010 U	0.010 U	-	0.010 U	0.010 U	-	0.010 U	0.010 U	-
2,4-DNT	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
2-NT	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
3-NT	µg/g	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-	0.020 U	0.020 U	-
4-NT	µg/g	0.060 U	0.050 U	-	0.070 U	0.070 U	-	0.050 U	0.020 U	-	0.080 U	0.070 U	-
Nitroglycerin	µg/g	0.050 U	0.050 U	-	0.050 U	0.050 U	-	0.050 U	0.050 U	-	0.050 U	0.050 U	-
WP	µg/g	0.0010 U	0.0010 U	-	0.0010 U	0.0010 U	-	0.0010 U	0.0010 U	-	0.0010 U	0.0010 U	-
Moisture (WP only)	Percent	20	20	0%	20	20	0%	15	17	13%	19	18	5%
Metals													
Antimony	µg/g	**0.151**	**0.162**	7%	**0.365**	**0.259**	34%	**0.186**	**0.172**	8%	**0.253**	**0.343**	30%
Arsenic	µg/g	**4.84 B**	**4.26 B**	13%	**8.02**	**9.28**	15%	**4.71 B**	**6.96**	39%	**20.20**	**18.70**	8%
Barium	µg/g	**229**	**230**	0%	**183**	**196**	7%	**212**	**210**	1%	**318**	**287**	10%
Cadmium	µg/g	**0.1060 B**	**0.1010B**	5%	**0.1330 B**	**0.0945 B**	34%	**0.0669 B**	0.0587 U	-	0.0587 U	0.0587 U	-
Chromium	µg/g	**11.5**	**18.5**	47%	**19.40**	**13.4**	37%	**11.40**	**12.6**	10%	**18.20**	**33.6**	**59%**
Copper	µg/g	**3.86**	**3.43**	12%	**3.63**	**3.79**	4%	**2.37**	**3.14**	28%	**3.59**	**3.59**	0%
Lead	µg/g	**7.36**	**7.64**	4%	**7.76**	**7.59**	2%	**6.03**	**8.52**	34%	**10.50**	**10.20**	3%
Manganese	µg/g	**310**	**225**	32%	**391**	**325**	18%	**183**	**230**	23%	**326**	**298**	9%
Mercury	µg/g	**0.0080 J**	**0.01030**	-	**0.01740**	**0.01360**	25%	**0.01450**	**0.00840 J**	-	**0.00710 B,J**	**0.01160 B**	-
Molybdenum	µg/g	**0.329**	**0.438**	28%	**1.150**	**0.802**	36%	**0.516**	**0.476**	8%	**0.868**	**0.897**	3%
Nickel	µg/g	**3.04**	**3.32**	9%	**8.27**	**4.42**	**61%**	**3.34**	**3.38**	1%	**5.73**	**5.72**	0%
Silver	µg/g	**0.0545**	**0.0846**	43%	**0.1100**	**0.0606**	**58%**	**0.0593**	**0.0899**	41%	**0.0803**	**0.0625**	25%
Uranium	µg/g	**0.646**	**0.618**	4%	**0.516**	**0.504**	2%	**0.286**	**0.338**	17%	**0.719**	**0.755**	5%
Vanadium	µg/g	**17.5**	**15.1**	15%	**35.4**	**20.8**	**52%**	**15.8**	**17.7**	11%	**25.8**	**26.4**	2%
Zinc	µg/g	**22.8**	**20.1**	13%	**24.3**	**23.4**	4%	**18.6**	**19.7**	6%	**44.6**	**42.5**	5%
Moisture	Percent	21.9	18.3	18%	18.7	18.4	2%	18.2	17.9	2%	20.1	20.7	3%
Other Parameters													
Total Organic Matter	Percent	0.8	0.5	46%	0.8	0.9	12%	0.5	0.5	0%	0.9	0.9	0%
Perchlorate	µg/g	0.013 U	0.013 U	-	0.012 U	0.012 U	-	0.013 U	0.013 U	-	0.013 U	0.012 U	-

Bold-represents RPD values that exceeded the 50% allowed **B**-represents parameter was also detected in laboratory blank for that run. **J**-estimate value below reporting limit. **U**-under detection limit.

8.5.2.3 Sediment RPD Results

The RPD values for sediment samples ranged from 0 to 196, with a median of 18. The majority of the duplicate sediment metal results met the 50% RPD data quality objective specified in the QAPP. The explosives, HMX, RDX, and 2,4,6-TNT exceeded the RPD data quality objective for various duplicate sediment samples. According to accepted EPA methods, the explosives values at the locations where duplicated samples exceed criteria would be estimated values (USEPA 1991). Chromium, nickel, silver, and vanadium were the only metals in some samples where the RPD values were in excess of 50. Overall, the sediment metal results were slightly more variable than the surface water metal results.

8.5.2.4 Precision Summary

Overall, the project precision for environmental analysis has been professionally judged to be adequate for an ecological health screening.

8.5.3 Accuracy

8.5.3.1 Field Accuracy

The field sampling accuracy was qualitatively assessed through the evaluation of equipment and container blanks to determine if contaminants were introduced during the sampling event. The criterion for evaluating blank contamination dictates that no contamination should be found in the blank. The field blank samples are described below:

- Field Equipment Blank. Two field equipment blanks were collected while onsite at JPG by flushing laboratory grade reagent water through the sampling equipment. The collection procedures used for the equipment blank mirrored the field sample collection procedures. For metals analyses, both unfiltered and filtered samples were collected. The filtered sample water was run through a 0.45-micron filter prior to collection into the sample bottle. The equipment blanks were analyzed for explosives, TOC, perchlorate, and metals (total and dissolved).
- Container Blank. Two container blanks were collected at JPG by pouring laboratory grade reagent water into the sample containers. The container blanks were analyzed for explosives, TOC, perchlorate, and metals (total and dissolved).
- Sediment Equipment Blank. Two sediment equipment blanks were collected by collecting the rinse water from the stainless steel bowl and plastic scoop used to homogenize sediment samples prior to transference into the sample bottles. These samples were used as an indicator that contamination was introduced through the stainless steel bowl.

8.5.3.1.1 Field Blank Results

The results of the rinse blank samples are shown in Table 8-25. The blank sample results, along with matrix spike duplicate (MSD) percent recoveries, are discussed below.

TABLE 8-25. BLANK RESULTS

Parameters	Units	Container Blank 1	Container Blank 2	Equipment Blank 1	Equipment Blank 2	Sediment Equipment Blank 1	Sediment Equipment Blank 2
Explosives and Degradates							
HMX	µg/L	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U
RDX	µg/L	0.100 U	0.100 U	**0.019 J**	0.100 U	0.100 U	0.100 U
2,4,6-TNT	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U
1,3-DNB	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U
1,3,5-TNB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U
TETRYL	µg/L	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U
NB	µg/L	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U
2A-4,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
4A-2,6-DNT	µg/L	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
2,6-DNT	µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
2,4-DNT	µg/L	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U
2-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U
3-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U
4-NT	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U
Nitroglycerin	µg/L	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U	0.090 U
WP	µg/L	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U	0.024 U
Metals							
Antimony (Total/*Dissolved*)	µg/L	0.00400 U *NA*	0.01360 B *NA*	**0.00884 B** *0.004 U*	**0.00430 B** *0.004 U*	**0.0787** *NA*	NA *NA*
Arsenic	µg/L	**0.0234 B** *NA*	**0.0193 B** *NA*	**0.0175 B** ***0.0231 B***	**0.0157 B** ***0.0128 B***	**0.0182** *NA*	NA *NA*
Barium	µg/L	**0.00837** *NA*	**0.00680** *NA*	**0.01230** ***0.03560***	**0.00481** *0.00400 U*	**0.03260** *NA*	NA *NA*
Cadmium	µg/L	0.00600 U *NA*	0.00600 U *NA*	0.00600 U ***0.0079***	0.00600 U *0.00600 U*	0.00600 U *NA*	NA *NA*
Calcium	µg/L	**35.10** *NA*	**30.70** *NA*	**39.40** **10.70**	**35.10** *7.73*	**43.70** *NA*	NA *NA*
Chromium	µg/L	0.3080 *NA*	0.0240 U *NA*	0.0240 U *0.0240 U*	**0.0343** *0.0240 U*	0.0240 U *NA*	NA *NA*
Copper	µg/L	0.023 U *NA*	0.023 U *NA*	0.023 U *0.023 U*	0.023 U *0.023 U*	0.120 *NA*	NA *NA*
Lead	µg/L	0.00500 U *NA*	0.00500 U *NA*	0.00500 U *0.00500 U*	0.00500 U *0.00500 U*	0.04590 *NA*	NA *NA*
Magnesium	µg/L	**39.20 B** *NA*	**39.70 B** *NA*	**36.70 B** ***12.30 B***	**40.90 B** *6.67 U*	**41.50 B** *NA*	NA *NA*
Manganese	µg/L	**0.0266** *NA*	0.0110 U *NA*	**0.0134** *0.0110 U*	0.0010 U *0.0110 U*	0.0129 *NA*	NA *NA*
Mercury	µg/L	**0.000336** *NA*	**0.003760** *NA*	**0.003620** ***0.003280***	**0.005150** ***0.000395***	**0.004040** *NA*	NA *NA*
Molybdenum	µg/L	**0.00663 B** *NA*	**0.03050 B** *NA*	**0.01230 B** ***0.01340 B***	**0.00626 B** ***0.00817 B***	**0.00762 B** *NA*	NA *NA*
Nickel	µg/L	**0.0906** *NA*	**0.0806** *NA*	**0.0289** *0.0110 U*	0.0110 U *0.0110 U*	**0.0318** *NA*	NA *NA*
Silver	µg/L	**0.0131 B** *NA*	**0.0255 B** *NA*	**0.0172 B** ***0.0149 B***	**0.0115 B** ***0.0120 B***	**0.0135 B** *NA*	NA *NA*
Uranium	µg/L	0.010 U *NA*	0.010 U *NA*	0.010 U *0.010 U*	0.010 U *0.010 U*	0.010 U *NA*	NA *NA*
Vanadium	µg/L	0.018 U *NA*	0.018 U *NA*	0.018 U *0.018 U*	0.018 U *0.018 U*	0.018 U *NA*	NA *NA*
Zinc	µg/L	0.062 U *NA*	**0.621** *NA*	**0.130** *0.062 U*	**0.751** *0.062 U*	**1.100** *NA*	NA *NA*
Other Parameters							
Perchlorate	µg/L	1.0 U	1.0 U	-	1.0 U	NA	NA
TOC	mg/L	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA

Bold-represents results above detection limit. **B**-represents parameter was also detected in laboratory blank for that run. **NA**-not analyzed. **U**-under detection limit. **J**-estimated value below reported limit.

8.5.3.1.2 Explosives

No explosives or degradates were detected above the instrument detection limit in any of the field blank samples. An estimated value for RDX (0.019 µg/L), below the reporting limit of 0.100 µg/L was identified in Equipment Blank 1.

8.5.3.1.3 Metals

No significant metal contamination was found in the blank samples. Metals levels were not found above 10% of the detection limit except for molybdenum in the SW-16 sample (0.32 µg/L) and zinc in all the blank samples. The low zinc levels may be explained as inherent in water chemistry and not due to sample contamination.

8.5.3.1.4 Perchlorate

Perchlorate was not detected in any of the blank samples above the detection limit of 1.0 µg/L.

8.5.3.2 Laboratory Accuracy

Laboratory accuracy is the closeness of agreement between an observed result and the true value of a sample analysis. Accuracy is expressed in terms of bias (high or low) and is assessed through the use of QC matrix spike and MSD samples. The percent accuracy (R) may be estimated by:

$$\%R = (Obs/Theor) \times 100$$

where: Obs = the measured value
Theor = the value of the spike added

8.5.3.2.1 Explosives

- Surface Water. Per USACHPPM DLS Report No. 02E1030-1, water matrix spikes were acceptable for all explosive analytes.
- Sediment. Per USACHPPM DLS Report No. 02E1119-1, soil matrix spikes were acceptable for all explosive analytes.

8.5.3.2.2 Metals

- Surface Water. The percent recovery for matrix spikes ranged from 60-1960%. The QAPP specified an accuracy data quality objective of 80-120%. All metals fell within the QA specifications except calcium, magnesium, and zinc. Two of the four matrix spikes/spike duplicates for calcium and magnesium were affected by native sample concentrations overwhelming spike concentrations. The remaining two matrix spikes/spike duplicates for those analytes were within QA specifications. One matrix spike/spike duplicate for zinc was just above the QA specifications at 124% and 125%, respectively. Laboratory replicate analyses for all metals, except calcium had RPD ranges from 0 to 10%, and were within precision limits of +/- 25%. There were two matrix spikes/spike duplicates for calcium with RPDs of 32% and 143%. Both samples were affected by high native sample concentrations. Based on all of the laboratory QC values, the surface water metals data are considered reliable.

- Sediment. The percent recovery for sediment matrix spikes ranged from 66-337%. The QAPP specified an accuracy data quality objective of 70-130%. All metals sediment results fell within the QA specifications except magnesium and chromium. One matrix spike duplicate for manganese recovered 66% of the spiked concentration, just below the QA specifications, and one matrix spike sample for chromium recovered 337% of the spiked concentration. Laboratory replicate analyses for sediment metals, except for one chromium (91%) and one manganese (43%) matrix spike/spike duplicate, had RPD ranges from 0 to 15%, and were within precision limits of +/- 30%. Based on all of the laboratory QC values, the sediment metals data are considered reliable.
- Perchlorate. Laboratory water matrix spike percent recoveries for perchlorate ranged from 104-114% and were within the acceptance limits of 80-120% specified in the QAPP. Likewise, laboratory sediment matrix spike percent recoveries for perchlorate ranged from 90.1-127% and were within the acceptance limits of 70-130% specified in the QAPP. Therefore, the surface water and sediment samples are considered acceptable for perchlorate.

8.5.4 Representativeness

Representativeness is defined as the degree to which the data accurately and precisely represent a characteristic of a population, parameter variations at a sample site, or an environmental condition. Representativeness is a qualitative parameter concerned most with the proper design of the sampling program.

The surface water and sediment sampling approach was a combination of purposive/judgmental sampling and a variation of the search sampling typically used in locating suspected "hot spots." Surface water and sediment data obtained from this sampling approach typically have the following limitations: (1) concentrations may not represent the average surface water or sediment concentrations at a sampling site; (2) the distribution of concentrations may not accurately represent the concentration distribution over JPG range areas; and (3) the concentration distribution is based on a predetermined conceptual model or understanding of constituent distributions. Therefore, the surface water and sediment sampling design and collection method provides reasonable yet conservative exposure concentrations for the surface water and sediment criteria screening assessment.

Representativeness was assessed by reviewing sample collection methods, equipment, and sample containers used during the field investigation, in addition to evaluating the RPD values calculated from the duplicate samples. Based on the evaluation of the factors above, the samples collected during the JPG field investigation are considered to be representative of the environmental conditions in the selected areas of the firing ranges and the impact area at JPG.

8.5.5 Completeness

Completeness is defined by the USEPA as a measure of the amount of valid data obtained from a sampling system and/or laboratory measurement system compared to the amount of data that was expected to be obtained under normal conditions. Data quality objectives were set at 90% for field and laboratory completeness. All surface water samples (100%) identified in the QAPP were collected during the field investigation. There was three seep (spring) water samples identified in the QAPP and only one sample could be collected (30%) due to the drought (springs were not flowing). All sediment samples (100%) identified in the QAPP were collected during the field investigation.

8.5.6 QA/QC Summary

The analytical results from the surface water and sediment samples are considered to be reliable and accurate according to field and laboratory QA/QC procedures. The majority of the samples were within acceptable limits for laboratory control sample spike recoveries. All data generated are considered reliable, and they can be used in the ecological screening.

Due to the volume of paper involved, the raw analytical data have not been reproduced in this report. The raw data will be kept on file at USACHPPM and can be provided upon request.

8.6 SUMMARY

8.6.1 Collective Upstream Reference Sampling Locations

Since there was no upstream reference location for two of the watersheds (Middle Fork Creek and Marble Creek), the results from the six reference locations in the other watersheds were averaged to develop a reference for the metals. This reference value was used to determine if munitions compounds and firing range activities may have impacted surface water quality. Three explosives constituents (HMX, RDX, 2,4,6-TNT) were detected in the reference sediment samples at higher concentrations then downstream locations.

8.6.2 Middle Fork Creek Sampling Locations

Based on the surface water, sediment and biological data collected from Middle Fork Creek, the munitions constituents and firing range activities in the Middle Fork Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. There was an increase in several surface water total metals concentrations at sampling location 13 (midstream), but were back to reference values by sampling location 01 (downstream). There were several increases in sediment metals concentrations over reference values at both sampling locations.

8.6.3 Big Creek Sampling Locations

Based on the surface water, sediment and biological data collected from Big Creek, the munitions constituents and firing range activities in the Big Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. There was an increase in total lead, manganese, and zinc at downstream sampling location and an increase in surface water total and dissolved uranium at both midstream and downstream sampling locations. At the midstream sampling location there was an increase in metals sediment concentrations over reference values but all returned to background values by the time Big Creek exited the installation.

8.6.4 Marble Creek Sampling Location

Based on the surface water, sediment and biological data collected from Marble Creek, the munitions constituents and firing range activities in the Marble Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. Marble Creek surface water and sediment results were almost entirely below reference values.

8.6.5 Little Graham Creek Sampling Locations

Based on the surface water, sediment and biological data collected from Little Graham Creek, the munitions constituents and firing range activities in the Little Graham Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. Most of the surface water metals results were below reference values. The sediment metals results indicated that the majority of the metals increased over the watershed reference values but only 4 of the 12 were higher than the average reference values at the furthest downstream sampling location.

8.6.6 Graham Creek Sampling Locations

Based on the surface water, sediment and biological data collected from Graham Creek, the munitions constituents and firing range activities in the Graham Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. The surface water results indicated an increase in a few of the metals at the midstream sampling location (16) but none were substantial when considering variability between duplicate and split samples and reference locations. There were no substantial increases in sediment metals concentrations compared to reference values.

8.6.7 Otter Creek Watershed Sampling Locations

Based on the surface water, sediment and biological data collected from Otter Creek, the munitions compounds and firing range activities in the Otter Creek drainage basin did not appear to adversely affect the basin's surface water quality or benthic ecology. None of the surface water metals increased substantially in downstream locations compared to reference locations. Most of the metals sediment concentrations increased in midstream locations compared to reference values. However, only arsenic, barium, chromium, and zinc remained substantially higher at the furthest downstream location (06).

8.7 CONCLUSIONS

There were no exceedances of Federal WQC or State WQSs in the surface water. There were a few SQBs exceeded in the sediment results to include reference locations. HMX, RDX, and 2,4,6-TNT were detected at very low levels in the sediment samples to include the reference locations. The general conclusion was that the aquatic benthic macroinvertebrate community was not adversely impacted by any of the munitions related constituents.

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9 HUMAN HEALTH RISKS EVALUATION

9.1 CONCEPTUAL SITE MODEL

A conceptual site model was developed which attempted to link the human health and ecological risk assessments. This was accomplished by illustrating the environmental processes and potential receptors that were thought to represent complete exposure pathways for any substances present in the environment. The conceptual model is intended to provide context for the discussion of study results in Chapters 9 and 10. Figure 9-1 depicts the predicted environmental fate and exposure pathways of substances released by training activities. A brief description of the concepts shown in this figure are provided in the following sections.

9.1.1 Sources of Substances of Potential Concern (SOPCs)

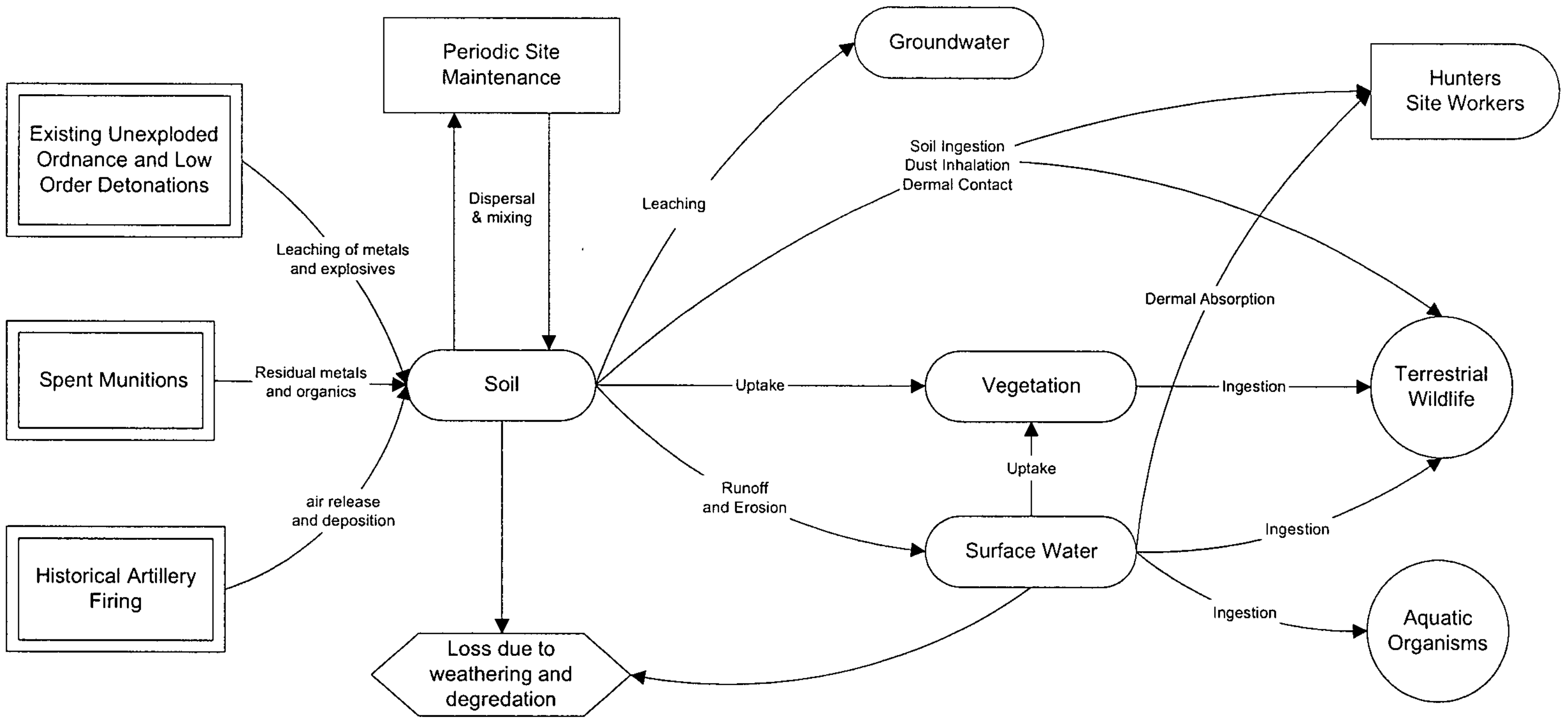
Since JPG is a closed range, there is not a continuing source of contamination in the range area. Historical artillery firing is the primary source for SOPCs found at the study sites. This would include spent munitions in the impact area, unexploded ordnance (UXO) remaining in the impact area, and aerial release and deposition of chemicals from the weapons historically fired at the firing points. SOPCs may have been distributed in the environment through direct contact with media or air release and subsequent deposition at the firing points or impact area. UXO, particularly those projectiles with compromised integrity, as well as ordnance that produced low-order detonations are thought to be sources of SOPC accumulation in the environment. Where the integrity of the projectile has not been compromised, it is expected that the explosives would be completely contained.

9.1.2 Fate and Transport of SOPCs

SOPCs at the firing points and impact area are thought to accumulate in surface soil where some loss due to weathering and degradation would occur. A portion of the compounds in soil would likely migrate downward in the subsurface soil horizons, and eventually to ground water. Another portion would accumulate in vegetation. Surface water could have been impacted directly by firing, or could receive contamination from soil runoff during rain events.

FIGURE 9-1 GENERAL CONCEPTUAL SITE MODEL

Conceptual Diagram for the Former Range Area



9.1.3 Hypothesized Human and Wildlife Exposure

The primary exposures of humans (i.e., wildlife refuge workers and recreational users) and wildlife to SOPCs are expected to be through soil ingestion, dust inhalation, and dermal contact with substances in soil. Human exposure to chemicals in surface water was evaluated since dermal contact could occur while wading in the various streams. Ingestion of wild game taken from the impact area by hunters is also a potentially complete pathway. However, previous studies addressing bioaccumulation of explosives in deer tissue conducted by USACHPPM (References 1, 2, and 3) concluded that range-related compounds did not tend to accumulate in tissue. Therefore, this pathway was not considered further. Terrestrial wildlife may also be exposed to SOPCs through ingestion of substances accumulated in vegetation. Based on previous artillery range studies, it was expected that there would be little, if any, direct terrestrial impact from the SOPCs evaluated (References 4 and 5).

9.2 DATA QUALITY SCREEN

Causes of variability can be both natural and anthropogenic. Natural variability in soil results from the inherently heterogeneous nature of the original geologic formation, local hydrology, weather, and biotic factors (Reference 6). Anthropogenic variability from uneven treatment or management of an area, and differing land uses, are then superimposed on natural variability (Reference 6). Variability in soil and vegetation samples is discussed in more detail in Chapters 7 and 10.

9.3 SCREENING OF SOPCS

Explosives and metals were the primary analytes for this study. Per USEPA guidance (Reference 7), substances that were detected in fewer than 5% of the samples were not considered further in the risk evaluation based on a low frequency of detection. After this initial evaluation of the data, the following substances were included as SOPCs: antimony, arsenic, barium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, vanadium, RDX, and perchlorate.

9.4 DISTRIBUTION EVALUATION

The distribution of the metals data in soils was evaluated prior to calculating a 95% upper confidence limit (UCL), by pooling data from all the study sites. Duplicate samples were averaged to determine the representative concentration for that area. This resulted in a pooled soil data set of 112 total samples. After consultation with the USACHPPM statistician, nondetect results in soil were included in the data set at the detection limit.

The total data set for soil ($n=112$) was tested for normality using the Kolmogorov-Smirnov test since the sample sizes were greater than 50. Low significance values, $p<0.05$, indicate that the distribution of the data differs significantly from a normal distribution. Data that did not initially test normal were assumed to be log-normally distributed. In this case, all of the soil analytes tested were found to be non-normally distributed and therefore log-normality was assumed.

9.5 DERIVATION OF EXPOSURE POINT CONCENTRATIONS

The 95% UCL of the arithmetic mean for each substance detected in soil, above background levels, was used as the exposure point concentration. As stated previously, lognormal distributions were assumed for all of the non-normal data which included all analytes in this case. This is a valid statistical approach due to the large sample size available in this case. The central limit theorem indicates that for sample sizes of 50 or greater, the mean of the population will tend to approximate a normal distribution regardless of the distribution of the population overall. In calculating the 95% UCL, nondetect results were treated on a chemical-specific basis. If a chemical only had a few nondetect results, they would have little effect on the resulting exposure point concentration and ½ the detection limit was used as a surrogate value. If the chemical had many nondetects, the value chosen for the nondetected results becomes more significant as it can introduce a bias into the calculated exposure point concentration. RDX was only detected in 23% of the samples collected. Therefore, it was assumed to be present at some level in the other samples. For these, a value equal to the detection limit was used in calculating the exposure point concentration. This may tend to overestimate the true mean but it will provide a degree of conservatism in the resulting value. This approach was developed in consultation with the USACHPPM statistician.

Exposure point concentrations for lognormal data were calculated by first log-transforming the data and then using the equation provided in the Supplemental *Guidance to RAGS: Calculating the Concentration Term* (Reference 8). The equation is shown below.

$$UCL = e^{(\bar{x}+0.5x^2+sH/\sqrt{n-1})}$$

where:

UCL = upper confidence limit
e = constant (base of the natural log)
x = mean of the transformed data
s = standard deviation of the transformed data
H = H-statistic
n = number of samples

The 95% UCLs used in the risk calculations are provided in Table 9-1.

When evaluating exposure, assumed usage patterns by the various receptors were considered. It was assumed that recreational users would be moving over large portions of the site and would therefore average their exposure over the entire study area. Therefore, the entire range area was treated as a single exposure unit when evaluating soil exposure. In contrast, the surface water bodies were evaluated individually for potential health risk. This was done since receptors could be inclined to return to the same area repeatedly (e.g., to a favorite fishing spot). Therefore, instead of averaging their exposure over a large area, as was done with soil, they may be repeatedly exposed to the same chemical concentrations in a specific water body. Since the sample sizes were limited, the maximum detected concentrations for each chemical in a given stream were used as the exposure point concentrations.

Ground water was sampled as a part of this study as well. However, no complete pathways were identified through which receptors would come in contact with ground water and so it was excluded from the risk screening.

TABLE 9-1 CALCULATED EXPOSURE POINT CONCENTRATIONS - SOIL

Compound	Exposure Point Concentration (mg/kg)
	Impact Area Values
Antimony	1.702
Arsenic	5.225
Barium	98.116
Chromium	10.118
Copper	13.438
Lead	18.183
Maganese	610.546
Mercury	0.031
Molybdenum	0.754
Nickel	4.777
Uranium	4.67
Vanadium	24.162
Perchlorate	0.030
RDX	0.013

9.6 HUMAN HEALTH RISK SCREENING

The previous sections discussing the various environmental media under investigation identified generic screening values that were used as a preliminary evaluation of the data collected during sampling. This comparison provided a context for the concentrations detected, but is not a substitute for a more comprehensive evaluation using site-specific exposure data. The purpose of the human health risk screening is to use site-specific screening values to evaluate the environmental condition of the range with respect to potential human health risk. It should be noted that this evaluation represents an assessment of potential health risk due to exposure to residual compounds in soil and is not intended as an occupational exposure study.

9.7 CHARACTERIZATION OF EXPOSURE SETTING

Section 5 identifies the exposure setting for the JPG.

Due to the nature of the range area, the chance for direct human contact with substances in the environment produced by firing is somewhat restricted. However, hunting and fishing are allowed at times throughout the year on the former range area. Therefore, the main receptors identified in this study are hunters and site workers.

9.8 EXPOSURE ASSESSMENT

An exposure pathway describes the process by which a chemical is transmitted from a source to an exposed population. In general, an exposure pathway must have four elements to be considered complete: a source and mechanism for release, a transport medium, a point for receptors to potentially come in contact with the contaminated medium (exposure point), and an exposure route (e.g., inhalation, ingestion, and dermal absorption) at the point of contact. An exposure pathway must be potentially complete to warrant evaluation in the risk evaluation. For evaluating the former range area at JPG, the complete exposure pathways would consist of the following: incidental ingestion of soil, dermal absorption of chemicals in soil, inhalation of chemicals in windblown dust, and dermal absorption of chemicals in surface water. Risk-based screening levels were developed for each compound detected incorporating each of the previously listed exposure pathways. The screening levels were developed using site-specific parameters that are intended to adequately represent the potentially exposed population. The exposure parameters used are listed in Table 9-2.

TABLE 9-2 EXPOSURE PATHWAY ASSESSMENT VALUES

Pathway	Parameter	Value	Source
Common Values	Exposure Duration	25 years	Reference 10
	Exposure Frequency	50 days/year	Prof. Judgment
	Averaging Time (noncarcinogenic)	Same as Exposure Duration	Reference 7
	Averaging Time (carcinogenic)	70 years	Reference 7
	Body Weight – adults	70 kg	Reference 7
Soil Ingestion	Ingestion Rate	100 mg/day	Reference 10
	Fraction Ingested	1.0	Prof. Judgment
Dermal Absorption (soil)	Surface Area (head, arms, & hands)	3300 cm^2	Reference 10
	Conversion Factor	1E-6 kg/mg	Reference 7
	Adherence Factor	0.2	Reference 10
	Absorption Factor	Chem. Specific	Reference 7
Dust Inhalation	Conversion Factor	1E+3 μg/mg	Reference 7
	Particulate Emission Factor	1.32E+9 m^3/kg	Reference 10
	Inhalation Rate	0.63m^3/hr	Reference 10
Surface Water Absorption	Dermal Permeability Constant	Chemical Specific	Reference 11
	Exposure Time	2 hours/event	Prof. Judgment
	Surface Area	7620 cm^2	Reference 12

9.9 TOXICITY ASSESSMENT

The screening levels were derived based on toxicity data published primarily by the USEPA for use in risk assessment. For the assessment of human health risks from exposure to chemicals, the following three basic toxicity values are of principal importance.

Reference doses (RfDs) for oral exposure – This represents the acceptable chronic daily intake for exposure to a specific chemical. RfDs are intended to be protective of sensitive subpopulations.

Reference concentrations (RfCs) for inhalation exposure – The RfC is analogous to the oral RfD and is likewise based on setting a daily intake that will be without any deleterious health effect. Reference concentrations are expressed in units of mg/m^3 and are converted to inhalation RfDs for use in the screening level equations by multiplying by 20 m^3/day and dividing by 70 kg to obtain units of mg/kg-day.

Cancer Slope Factors (CSFs) – For both oral and inhalation exposure routes. The slope factor is the cancer risk (proportion affected) per unit of dose. The slope factor is expressed on the basis of chemical weight [(mg/kg/day)$^{-1}$].

The primary source of toxicity information is the USEPA's Integrated Risk Information System (IRIS). If values are not available in IRIS, the Health Effects Assessment Summary Tables (HEAST), or the USEPA Region 9 Preliminary Remediation Goals (PRGs) Table were consulted.

USEPA recommends two different approaches for evaluating noncarcinogenic and carcinogenic health effects. The two approaches reflect the fundamental difference in the proposed mechanism of toxic action. In assessing the potential for noncancer health effects, USEPA assumes that there is a toxicologic threshold below which no adverse health effects occur. These toxicological thresholds are represented by RfDs for oral exposures and RfCs for inhalation exposures. No values have been developed for dermal exposures so the oral RfD is used to evaluate this route of exposure. The RfD represents an average daily intake expressed in units of (mg/kd*day).

For carcinogens, the threshold response level is believed to be inappropriate. CSFs are developed with the idea that cancer risk is linearly related to dose. Therefore, even though most of the cancer data obtained from laboratory animal studies are for relatively high doses, it is assumed that these doses can be extrapolated down to the extremely small doses that would be expected from environmental exposure. This nonthreshold theory assumes that even a single molecule of a carcinogen may cause changes in a single cell that could result in the cell dividing in an uncontrolled manner and eventually lead to cancer. It should be pointed out that this method leads to a plausible upper limit of cancer risk, but does not necessarily give a realistic prediction of the true risk.

The carcinogenic potency of a substance depends, in part, on its route of entry into the body. Therefore CSFs are classified, like RfDs, according to the route of administration (i.e., inhalation, ingestion). Ideally, route-specific CSFs should be used to evaluate the carcinogenic risk posed by each carcinogen through each exposure route of concern. However, only a limited number of CSFs have been developed and may exist for only one route of exposure. The oral slope factor is presented as the risk per mg/kg-day. For inhalation, a unit risk factor is provided that is a quantitative estimate in terms of risk per ug/m^3 of air breathed for adults. For use in the screening level equations, this is converted to an inhalation CSF by dividing by 20 m^3/day and multiplying by 70 kg in order to obtain units of (mg/kg*day)$^{-1}$. Dermal CSFs have not been derived for any chemicals so the oral value was used instead. The USEPA has developed a classification system which indicates the likelihood that a particular chemical is a human carcinogen based on a weight-of-evidence (WOE) judgment using human and animal evidence. This classification system is described below.

A – Human carcinogen.
B1 – Probable human carcinogen – limited evidence of human carcinogenicity.
B2 – Probable human carcinogen – sufficient animal evidence and inadequate human data.
C – Possible human carcinogen – limited evidence in animals and no human data.
D – Not classified as to carcinogenicity.
E –- No evidence for carcinogenicity.

Screening levels were calculated separately for non-cancer and cancer effects for each compound. Whichever value was more stringent was then chosen as the screening level for that particular compound. The toxicological reference values used are listed in Table 9-3.

9.10 Screening Level Derivation

To develop risk-based screening levels, values describing the extent, frequency, and duration of the exposure are combined with target risk values and toxicity information in order to back-calculate an environmental concentration that represents a safe level. The equations used in calculating screening levels were derived from standard USEPA intake equations. Table 9-3 presents the values used for the various intake parameters. These values are based on a combination of USEPA default values and site-specific information where appropriate.

9.10.1 Exposure Parameters

When available, exposure parameters were first chosen from site-specific information, then from the USEPA's Supplemental Guidance for Developing Soil Screening Levels (Reference 10), Dermal Exposure Assessment (Reference 11), Risk Assessment Guidance for Superfund (RAGS) (Reference 7), or finally the Exposure Factors Handbook (Reference 12). Many of the parameters used in RAGS vary according to the general default conditions. Variability in parameter selection is a source of uncertainty in this methodology.

The following discussion lists the criteria and justification for selecting the individual exposure parameters. The source of the value for each variable is described. Additionally, the exposure-specific values chosen are explained.

TABLE 9-3 TOXICITY REFERENCE VALUES

Compound	RfD(oral) (mg/kg*day)	Source	RfD(inh) (mg/kg*day)	Source	CSF(oral) $(mg/kg*day)^{-1}$	Source	CSF(inh) $(mg/kg*day)^{-1}$	Source	WOE
Antimony	4.00E-04	IRIS	na	na	na	na	na	na	na
Arsenic	3.00E-04	IRIS	na	na	1.50E+00	Iris	1.50E+01	REG9	A
Barium	7.00E-02	IRIS	1.40E-04	HEAST	na	na	na	na	D
Cadmium	5.00E-04	IRIS	na	na	na	na	6.30E+00	Iris	B1
Chromium	3.00E-03	IRIS	2.20E-06	REG9	na	na	2.90E+02	REG9	A
Copper	4.00E-02	HEAST	na	na	na	na	na	na	D
Lead	na	na	na	na	na	na	na	na	na
Manganese	2.40E-02	IRIS	1.45E-05	IRIS	na	na	na	na	D
Mercury	8.60E-05	IRIS	na	na	na	na	na	na	na
Molybdenum	5.00E-03	IRIS	na	na	na	na	na	na	na
Nickel	2.00E-02	IRIS	na	na	na	na	na	na	na
Silver	5.00E-03	IRIS	na	na	na	na	na	na	D
Uranium	2.00E-04	NCEA	na	na	na	na	na	na	na
Vanadium	9.00E-03	IRIS	na	na	na	na	na	na	na
Zinc	3.00E-01	IRIS	na	na	na	na	na	na	na
Perchlorate	1.00E-04	w - IRIS	na	na	na	na	na	na	na
RDX	3.00E-03	IRIS	3.00E-03	R.Ext.	1.10E-01	IRIS	1.10E-01	R.Ext.	C

Sources: IRIS – USEPA Integrated Risk Information System; HEAST – Health Effects Summary Tables; W-IRIS – withdrawn from IRIS; REG 9 – USEPA Region 9 Preliminary Remediation Goals Table; NCEA – USEPA National Center for Environmental Assessment Provisional Value.

9.10.1.1 Exposure Frequency and Duration (EF and ED)

Exposure frequency is site-specific and defined as a measure of the expected number of days per year that a person is exposed (Reference 7). Exposure duration is the expected number of years a person will most likely be exposed. The EF and ED can vary between 0 to 365 days per year and 0 to 70 years, respectively. For the receptors evaluated in this study, soil screening values were calculated based on an exposure frequency of 50 days per year and an exposure duration of 25 years. These were based on professional judgment and should provide a conservative evaluation of potential risk.

9.10.1.2 Non-carcinogenic Averaging Time (AT)

Averaging time is the value used to average exposures over a person's exposure duration (non-carcinogenic) or lifetime (carcinogenic). For the non-carcinogenic evaluation, averaging time is equal to the exposure duration. This value can vary from 0 to 70 years. For this risk screening, the averaging time was 25 years.

9.10.1.3 Carcinogenic Averaging Time (AT)

For the cancer evaluation, averaging time is equal to an average lifespan of 70 years. This value does not vary.

9.10.1.4 Body Weight (BW)

Body weight refers to a person's weight in kilograms. The recommended value is 70 kg for adults, ages 18-75 years (Reference 7).

9.10.1.5 Soil Ingestion Rate (IRS)

The soil ingestion rate recommended by the USEPA for adults in an industrial setting is 100 mg/day (Reference 10).

9.10.1.6 Dermal Surface Area Available for Absorption (SA)

Dermal surface area available for absorption is the amount of skin area that could come in contact with a contaminated surface. The range of possible values was obtained from USEPA guidance (Reference 10). It was assumed that a receptor's arms, hands, and head would be susceptible to soil exposure. The value for males was used since it is larger than that of females and, therefore, provides a conservative estimate. For surface water exposure, it was assumed that the lower extremities would be in contact with water while wading. Therefore, the value for surface area of adult male lower extremities was used as provided in the USEPA's Exposure Factors Handbook (Reference 12).

9.10.1.7 Soil Adherence Factor (AF)

The soil adherence factor refers to the ability of the soil to adhere to the skin surface therefore allowing chemicals in the soil to be dermally absorbed. The USEPA recommended value of 0.2 (mg/cm^2-event) for adults in a commercial/industrial scenario was used (Reference 10).

9.10.1.8 Dermal Absorption Factor (ABS)

The dermal absorption factor is a chemical-specific constant that indicates the relative efficiency of dermal absorption into the skin from a particular substance. The USEPA Region 9 PRG table (Reference 13) was the source for the dermal absorption factors used in this evaluation. Table B-1 in Appendix B lists the specific values used for each substance.

9.10.1.9 Particulate Emission Factor (PEF)

The particulate emission factor is a measure of the area of land necessary to emit a given mass of dust particulates. The supplemental soil screening guidance (Reference 10) presents an equation for calculating a site-specific value. However, due to the large number of variables involved, it is impractical to calculate a site-specific PEF for the entire range. Therefore, a default value presented in the guidance was used in calculating the soil screening levels.

9.10.1.10 Inhalation Rate (IR)

Inhalation rate is a measure of the amount of air a person inhales each day. The USEPA recommends several adult inhalation rates depending on activity level. The moderate activity adult inhalation rate of 20 m^3/day was used for this evaluation (Reference 7).

9.10.1.11 Exposure Time (ET)

The exposure time represents the average time a receptor would be expected to spend in contact with surface water during each event. The value of 2 hours was chosen based on professional judgment.

9.10.1.12 Dermal Permeability Constant (PC)

This value represents the ability of chemicals in water to move through the skin. Values are presented in the USEPA's dermal exposure assessment guidance

(Reference 11) on a chemical-specific basis. Since none of the metals were specifically listed in this reference, the surrogate value of $1X10^{-3}$ was used as recommended. For RDX, a value was calculated using the following equation (1).

$$\log K_p = -2.72 + 0.71 \log K_{o/w} - 0.0061 MW \qquad \textbf{(1)}$$

Where:

K_p= Dermal Permeability Constant (cm/hour)
log $K_{o/w}$= Octanol Water Partition Coefficient
MW = Molecular Weight

For RDX, a K_p value of $3.5X10^{-4}$ was calculated using an MW of 222.26 g/mol and a log $K_{o/w}$ of 0.87.

Equations (2) and (3) calculate screening levels for all three pathways associated with soil exposure (ingestion, dermal absorption, dust inhalation). If toxicological reference values were not available for certain pathways, the terms evaluating that pathway in the denominator were removed. Screening levels were derived based on a hazard index (HI) of 1.0 and an excess cancer risk level of 1.0E-5.

Non-Carcinogenic Level

$$ScreeningLevel(mg/kg) = \frac{THQ * BW * AT}{EF * ED[(\frac{1}{RfD_o} * \frac{IRS}{10^6}) + (\frac{1}{RfD_o} * \frac{SA * AF * ABS}{10^6}) + (\frac{1}{RfD_i} * \frac{IR}{PEF})]} \qquad \textbf{(2)}$$

Carcinogenic Level

(3)

$$ScreeningLevel(mg/kg) = \frac{TR * BW * AT}{EF * ED[(CSF_o * \frac{IRS}{10^6}) + (CSF_o * \frac{SA * AF * ABS}{10^6}) + (\frac{IR * CSF_i}{PEF})]}$$

Where:

THQ = Target Hazard Quotient
TR = Target Cancer Risk Level
BW = Body Weight (kg)
AT = Averaging Time (days)
EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
RfD_o = Oral Reference Dose (mg/kg*day)
IRS = Soil Ingestion Rate (mg/day)
SA = Skin Surface Area (cm^2/event)
AF = Soil Adherence Factor (mg/cm^2)
ABS = Absorption Factor (unitless)
CSF_o = Oral Cancer Slope Factor $(mg/kd*day)^{-1}$
IR = Inhalation Rate (m^3/hour)
RfD_i = Inhalation Reference Dose (mg/kd*day)
CSF_i = Inhalation Cancer Slope Factor $(mg/kd*day)^{-1}$
PEF = Particulate Emission Factor (m^3/kg)

Equations (4) and (5) were derived to calculate screening levels for dermal exposure to chemicals in surface water.

Non-Carcinogenic

(4)

$$ScreeningLevel(\mu g/L) = \frac{THQ * BW * AT}{EF * ED * ET[\frac{1}{RfD_o} * SA * PC * CF]}$$

Carcinogenic

(5)

$$ScreeningLevel(\mu g/L) = \frac{TR * BW * AT}{EF * ED * ET[CSF_o * SA * PC * CF]}$$

Where:

THQ = Hazard Quotient
BW = Body Weight (kg)
AT = Averaging Time (days)

EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
ET = Exposure Time (hours/event)
RfD_o = Oral Reference Dose (mg/kg*day)
SA = Skin Surface Area (cm^2)
PC = Permeability Constant (cm/hour)
CF = Conversion Factor (µg/mg)
TR = Target Risk
CSF_o = Oral Cancer Slope Factor $(mg/kd*day)^{-1}$

9.11 LEAD

An exception to this general process of risk screening is inorganic lead. Quantifying lead's potential health risk involves many uncertainties, some of which may be unique to lead. Age, health, nutritional state, body burden, and exposure duration influence the absorption, release, and excretion of lead. In addition, current knowledge of lead pharmacokinetics indicates that an estimate derived by standard procedures would not truly describe the potential risk (Reference 14). As a result, the existing Region 9 Preliminary Remediation Goal (Reference 13) for lead was used in this risk evaluation to approximate the recreational and site worker exposure.

9.12 EXPOSURE POINT CONCENTRATIONS

As discussed in Section 9.5, the 95%UCL of the mean was used as the exposure point concentration of each substance detected in soil. A single set of exposure point concentrations was calculated to represent the entire range area. In cases where a large degree of variability in the data caused the 95th UCL to be greater than the maximum detection, the maximum value was used instead of the 95th UCL. For the surface water evaluation, the maximum detected values were used for the screening due to the small size of the dataset.

9.13 DATA EVALUATION

Once the screening levels were developed and the exposure point concentrations were calculated, the risk screening simply consisted of directly comparing the two values. Tables 9-4 and 9-5 present the SOPCs along with their respective exposure point concentrations and site-specific screening values. This evaluation was conducted for the range area soils, and for surface water on an individual stream basis.

Table 9-4 Impact Area Soils Risk Screening

Compound	Exposure Point Concentration (mg/kg)	Site-Specific Screening Value (mg/kg)
Antimony	1.70	1706.18
Arsenic	5.23	79.62
Barium	98.12	297827.62
Chromium	10.12	12708.66
Copper	13.44	170617.70
Lead	18.18	750*
Maganese	610.55	101520.54
Mercury	0.03	366.83
Molybdenum	0.75	21327.21
Nickel	4.78	85308.85
Vanadium	24.16	38388.98
Perchlorate	0.03	307.83
Uranium	4.67	853.1
RDX	0.01	783.57

*Generic USEPA Region 9 Industrial PRG (Reference 13)

As this table indicates, none of the substances detected in soil in the impact area are present at levels that exceed the site-specific screening values. Therefore, exposure to impact area soils should not pose a health risk to humans under the conditions evaluated in this assessment.

Table 9-5 Surface Water Risk Screening

	Marble Creek	Middle Creek	Big Creek	Otter Creek	Graham Creek	Little Graham Creek	Screening Level
Compound	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Antimony	0.0599	0.0937	0.0861	0.0957	0.13	0.0957	13412.1
Arsenic	0.688	0.572	0.917	1.16	1.53	1.16	625.9
Barium	78.5	122	55.2	65.3	58.4	122	2347112.9
Cadmium	0.0148	0.101	0.0322	0.136	0.0231	0.136	16765.1
Chromium	Nd	0.358	0.462	0.522	0.575	0.522	100590.6
Copper	0.698	5.52	1.46	1.18	1.27	5.52	1341207.3
Lead	0.154	0.0977	1.46	0.188	0.373	1.46	na
Manganese	120	251	113	78.8	99.4	251	804724.4
Mercury	0.00234	0.00174	0.00364	0.00228	0.00313	0.00364	2883.6
Molybdenum	0.403	0.673	0.493	1.65	1.33	1.65	167650.9
Nickel	1.65	3.7	2.07	2.43	2.46	3.7	670603.7
Silver	0.014	0.0467	0.0264	0.043	0.105	0.0467	167650.9
Uranium	0.236	0.636	4.08	1.11	0.58	4.08	6706.0
Vanadium	0.303	0.326	1.34	0.707	1.22	1.34	301771.7
Zinc	1.26	12.5	3.68	2.18	1.59	12.5	10059055.1
RDX	0.027	0.19	0.14	0.023	0.13	0.19	287401.6

As this table indicates, all of the maximum detections of chemicals in surface water are well below the site-specific screening levels. This indicates that there would not be an unacceptable risk to recreational users wading in streams under the conditions described in the exposure assessment.

9.14 UNCERTAINTY

The process of evaluating risk uses principles drawn from many scientific disciplines, including chemistry, toxicology, physics, mathematics, and statistics. Because the data sets used in the calculations are incomplete, many assumptions are required. Therefore, calculated risk screening values contain inherent uncertainties. However, the majority of the estimates used are biased toward being conservative in an attempt to ensure that the resulting values are slightly overprotective of human health.

9.14.1 Exposure Assessment

While the use of the former range area is generally understood in terms of the types of activities that receptors would engage in, there is still uncertainty in the assumptions made regarding frequency of exposure, and the specific intake parameters. Values are chosen for variables such as body weight and skin surface area that are meant to be conservative. For most receptors, this will result in an overestimation of risk. However, an individual could exceed the values used and would therefore represent a higher potential risk than estimated in the assessment.

9.14.2 Toxicity Assessment

The derivation of toxicity values is also a source of uncertainty. Most of the data on health effects comes from animal studies. USEPA collects and evaluates all known studies for each chemical. The most sensitive animal and the adverse effect which occurs at the lowest dose is then used to derive, by the application of uncertainty and modifying factors, the RfD for noncarcinogens. Humans are assumed to be even more sensitive than the most sensitive animal. The health effect in humans may not be the same, but human data is sought to corroborate the animal data. The same data evaluation process takes place for carcinogens, but the data is extrapolated to humans by using the 95% UCL of the mean slope from the primary study used to derive the CSF. Since the screening values are based on the available toxicological reference values, this uncertainty is carried through into the risk evaluation.

9.15 SUMMARY

Environmental field sampling conducted within the former firing points and impact areas at JPG indicated several metals and explosives were present in site soils. The substances detected in a relatively high percentage of the samples were antimony, arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, silver, urantium, vanadium, perchlorate, and RDX. Using the sampling data collected, the 95% UCL of the arithmetic mean was calculated for each substance. These values were used as exposure point concentrations to represent average conditions that an individual may be exposed to over the entire site. Site-specific risk-based screening values were then derived and the risk evaluation was performed by comparing these with the exposure point concentrations for each substance. Screening levels were also derived evaluating dermal absorption of chemicals in surface water. A risk screening for surface water was conducted in a similar manner except the maximum detections of each compound were used as the exposure point concentrations. Each stream was evaluated separately since they could represent discrete areas of exposure.

9.16 CONCLUSIONS

Based on the data collected during sampling, the SOPC's detected in both soil and surface water within the former range area would not be expected to present a health risk to site workers or recreational users (hunters). All of the exposure point concentrations evaluated were well below the calculated site-specific screening levels.

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10 ECOLOGICAL HEALTH RISK EVALUATION

10.1 INTRODUCTION

10.1.1 Overview

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) was tasked to conduct a field investigation of the Firing Range at Jefferson Proving Ground (JPG) in order to evaluate the potential chemical impact of past live-fire range testing operations on ground water, surface water, soil, plants, and animals. A human health and ecological risk assessment (ERA) was conducted to evaluate data collected during the field investigation. This report focuses on the ecological risk assessment.

10.1.2 Objective

Since JPG has been inactive since 1995, the objective of this field investigation was to determine if live-fire artillery testing activities have caused adverse ecological impacts, specifically due to chemical contamination explosives residues.

10.2 RATIONALE AND METHODS

10.2.1 Rationale

A weight of evidence approach was used to determine if artillery testing activities have caused adverse ecological impacts. Rodents were selected as the receptors of concern since they have a high degree of contact with potentially contaminated site media, consume a large amount of vegetative matter, and are prey for many predatory species. Differences in sperm parameters were selected as the endpoints in this evaluation since they indicate potential reproductive effects which could impact the rodent population. Since the cause of differences in sperm parameters cannot be definitively determined, other measures were used to establish causality, and to determine if rodents are exposed to substances of potential concern (SOPCs). These included vegetation and soil sampling to determine potential exposures via ingestion, and organ to body weight ratio analysis and histopathological evaluation to generate evidence that rodents have been exposed to SOPCs. Finally, hazard quotients were calculated to determine if rodents are estimated to have adverse effects due to SOPC exposure. The information generated from each of these methods was evaluated in total to determine if the rodent population is at risk due to reduced reproductive success as determined by Rodent Sperm Analysis (sperm parameters), and to determine if the differences seen in sperm parameters are attributable to SOPC exposure.

10.2.2 Problem Formulation

Problem formulation begins during the planning processes for an investigation and is designed to focus the investigation to receptors of concern and potentially contaminated media. The result of the problem formulation stage was the development of a conceptual site model that details media that may be contaminated, transport route of potential contamination, and ecological receptors that are potentially exposed to contaminated media.

The conceptual site model considers both the potential physical and chemical stressors associated with firing range activities. The focus of this investigation was to identify potential ecological threats posed by chemical stressors caused by past firing range operations. However, physical stressors may have more of an effect on the ecosystem than chemical stressors. It is difficult to filter out the effects of physical vs. chemical stressors on the ecosystem. JPG offers a unique opportunity to more closely evaluate the chemical effects of artillery firing since this range was last used in 1995. Therefore, if impacts are seen, they cannot be caused by the physical disturbance characteristic of artrillery firing.

10.2.3 Assessment Endpoints

The structure of the wet meadow ecosystem was selected as the assessment endpoint. The wet meadow ecosystem was selected since this ecosystem is the dominant ecosystem on impact areas at JPG. Effects to the wet meadow ecosystem are discussed.

10.2.4 Measurement Endpoints

Due to the limited access to the range, a thorough assessment of the entire range ecosystem was not possible. Organisms were chosen based on their importance to the structure of the ecosystem and their potential for exposure to artillery-generated SOPCs. Evaluating only two components of a system cannot fully characterize a change in ecosystem structure. Nevertheless, rodents and plants were chosen for evaluation because they are important components of the ecosystem structure. It is assumed that if the rodent population is exhibiting deleterious effects attributable to SOPC exposure, then the structure of the system may also be impacted. The specific measurement endpoints for vegetation included analysis of two plant species for contaminant uptake and a qualitative assessment of the vegetative community. Rodents were evaluated for sperm effects (sperm count, motility and morphology), organ to body weight ratios, and histopathology.

10.3 FLORA AND FAUNA FOUND AT JPG

10.3.1 Vegetation

Upland forests comprise 27,000 acres (54%) of the 50,000-acre refuge. The upland forest classification includes both evergreen and deciduous species ranging in age from young(~15-30 years) to mature (>50 years). The primary evergreen species at the site is eastern red cedar (*Juniperus virginiana*). Dominant deciduous trees include sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*) and black gum (*Nyssa sylvatica*) on poorly drained upland depression sites. Tulip poplar (*Liriodendron tulipifera*) and white ash (*Fraxinus americana*) are the species making up the young upland forests on well drained sites. White oak (*Quercus alba*), red oak (*Quercus rubra*) and shagbark hickory (*Carya ovata*) are the dominant species on intermediate and within some mature upland forests. American beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*) dominate the remainder of the mature upland forests.

The second most abundant habitat at JPG is grasslands. This habitat type makes up 8,500 acres (17%) of the area. The dominant grassland species at the site appears to be broomsedge (*Andropogon sp.*). Other habitat types at JPG include 5,000 acres (10%) palustrian wetland, 3,000 acres (6%) woodland, 6,000 acres (12%) early successional shrubland, 250 acres (0.5%) of open water, and 250 acres (0.5%) of bare soil and paved areas. The palustrine wetland category includes all growth stages of palustrine vegetation including early successional and forested wetland. A total of 46 state-listed plant species are found on JPG (see Appendix A of QAPP ERA SAP).

10.3.2 Wildlife

The JPG provides habitats for, and subsequently attracts, an abundance of wildlife species. Eight freshwater mussels species, 41 fish species, 24 amphibian species, 17 reptile species, 46 mammal species, and 201 bird species have either been recorded or can reasonably be expected to be present for a portion of the year. The state-endangered river otter was reestablished on JPG in 1996 (USFWS, 2000).

The wide array of both resident and migratory species found at JPG is due to the grassland/forest/wetland complex found within the landscape of the installation. These large habitat blocks of forests, shrublands, grasslands, forested wetlands, and occasional emergent marsh contribute to the increased biodiversity of the natural communities found at the refuge.

Biodiversity is enhanced at the site by the presence of area-sensitive species; for example, species such as Henslows sparrow and cerulean warblers, which require large blocks of grassland and mature forest respectively, are relatively common on JPG.

Habitat management activities at the refuge emphasize numerous goals which include; enhancement of existing wetlands, active management of grassland and shrubland areas, and the protection of late second-growth forests and wooded wetlands. All of these habitat management activities are designed to benefit populations of native fish and wildlife species.

The value of the habitat within the proposed refuge has been recognized at both the state and national levels. The Big Oaks National Wildlife Refuge (NWR) was named a Globally Important Bird Area by the American Bird Conservancy due to large Henslows sparrow populations within the grassland areas. The Indiana Department of Natural Resources states that, "JPG is indeed a natural treasure that contains a full array of the regions natural communities and species assemblages." (USFWS, 2000).

10.4 STUDY SITES

Three study sites were selected representing a high explosive (HE) impact area, a depleted uranium (DU) impact area, and a comparison area (CA), (a site not used for artillery firing activities) to collect rodent and vegetation samples. The three locations were chosen based on similarity of vegetative communities, habitat for rodent species, topography, soil types, geology, hydrology, and historical use.

10.4.1 Study Site Descriptions

4.5W is an impact area that received HE round impacts based on historical documentation and personal communications with installation personnel. 4.5W is a heavily cratered shrub scrub successional wet meadow dominated by willow, sweet gum, oak, and forbs. This site will be designated as HE for the purposes of the ERA.

7.5 CF is located on the north central portion of the DU area and received both HE and DU round impacts (Figure 10-1). 7.5 CF is a shrubby successional wet meadow dominated by willow, sweet gum, oak, and forbs. This area will be designated as DU for the purposes of the ERA.

10.4.2 Comparison Area

The initial CA was selected during a site scoping visit in April and was located near gate 15 on the western boundary of the installation. The site appeared to contain similar vegetation, hydrology, and habitat as the impact area sites during the May, 2002 scoping visit. However, upon returning to the installation in September to conduct trapping, it was apparent that the comparison site vegetation and hydrology were different from the impact area sites. Traps were set on this site for 2 nights with no success most likely due to habitat and heavy rains. It was decided to conclude trapping on this site, select a different comparison site, and to return in 2 weeks to trap the new comparison location. The new comparison site (DA) was located near gate 5 on the eastern boundary of the installation. The site was used as an unexploded ordnance (UXO) detection technology demonstration site by the Army Environmental Center (AEC). In this demonstration, inert rounds were placed on the site and their locations were noted. Various UXO detection technologies were employed to determine the locations of the duds and remove them. After discussions with installation and AEC personnel, it was decided that the possibility that these inert rounds could have caused environmental contamination was low. This was due to their short duration in the field, 100% recovery of the rounds placed on the site, and the fact that they were inert (i.e., did not contain HE). No other sites on the installation were suitable for use as a comparison area. The vegetation of the comparison area is characterized by wet meadow vegetation. Two of the four grids are dominated by successional wet meadow, with the remaining two characterized by wet and upland meadow vegetation.

Soils were analyzed at the DA site, and qualitatively compared to soils collected from within trap grids on the HE and DU areas (Table 10-1). A qualitative comparison was conducted since the sample population was small (2 samples from DU and HE and 4 samples from DA). The only explosive detected in either DU or HE samples was RDX at 0.014 ppm. The explosives detected in DA soils included 2,4,6 TNT (max = 0.43 ppm, average = 0.16 ppm), RDX (max = 1.7 ppm, average = 0.99 ppm), and HMX (max = 0.82 ppm, average = 0.21 ppm). Thus, the DA soils are more contaminated by explosives than DU or HE soils. Metals concentrations were also generally greater in DA soils than in HE or DU soils.

FIGURE 10-1 RODENT TRAPPING AND VEGETATION SAMPLING GRIDS

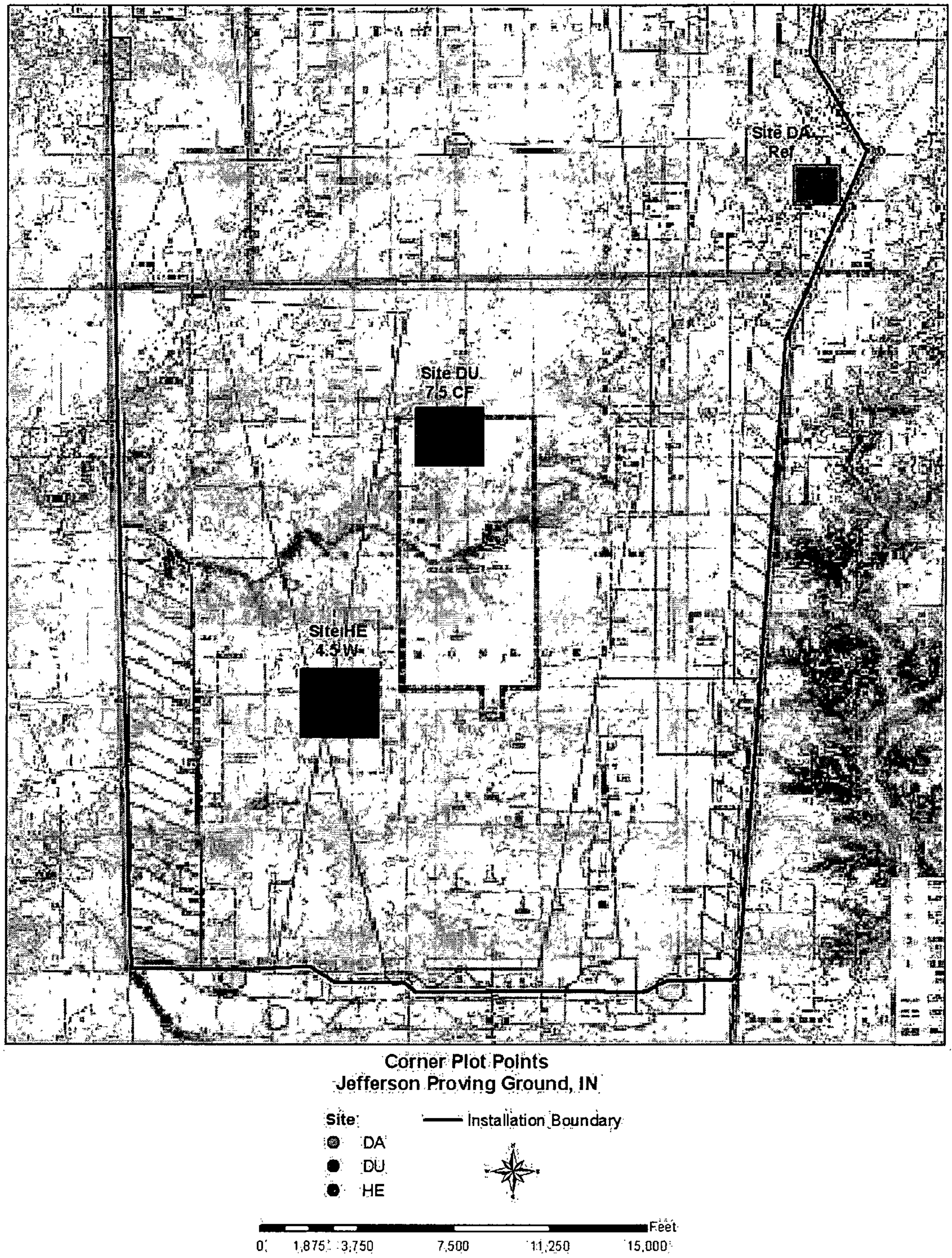

TABLE 10-1 SOIL SAMPLE RESULTS FROM 4 SOIL SAMPLES TAKEN FROM DA AREA. HE AND DU RESULTS ARE SHOWN SO QUALITATIVE COMPARISON CAN BE PERFORMED

Analyte	Sample area			
	HE	DU	DA	
	average (ppm)	average (ppm)	maximum (ppm)	average (ppm)
EXPLOSIVES				
2,4,6-Trinitrotoluene (TNT)	nd	nd	0.43	0.16
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	0.014	0.025	1.7	0.99
HMX	nd	nd	0.82	0.21
METALS				
arsenic	6.3	3.3	16.4	8.47
barium	78.5	43.4	134	80.5
chromium	8.62	8.24	52.8	25.7
copper	47.4	5.55	nd	nd
lead	17.1	11.1	37.5	22.9
manganese	690	35.3	2500	2161
mercury	nd	nd	0.0711	0.0358
nickel	6.48	2.74	nd	nd
vanadium	27.5	19.7	53.4	37.7

10.5 METHODS

10.5.1 Rodent Trapping

Meadow voles (*Microtus pennsylvanicus*) were used to assess the potential impact of artillery firing activities by comparing sperm parameters (i.e., sperm count, motility, and morphology) in rodents captured from the three study sites.

Each sampling site was divided into quadrants and numbers (1-4) uniquely identified the quadrants. The quadrants served as the template for biota sampling (i.e., placement of trap grids and vegetation sampling).

Traps were set in a grid format consisting of 100 traps. The grid consisted of 10 rows spaced approximately 10 m apart. Each row contained 10 traps with approximately 10 m between traps along the row. To maximize trap success, traps were strategically placed in preferable habitat and in areas where there was evidence of rodents (i.e., runs). The traps were left open for 3 consecutive nights on two diagonal quadrants (i.e., 1 and 4). On the fourth morning, the grids were relocated to the two remaining diagonal quadrants within the sampling site (i.e., 2 and 3). The traps remained open for 3 more nights. On the sixth morning trapping was concluded and all traps were removed from the trapping location. The grids on HE and DU areas were trapped concurrently for 6 nights. The traps were moved to the DA 2 weeks later for 6 nights of trapping.

The traps were discretely numbered (1-100) for each grid and placed in the grid formation, and were baited with a sweet feed horse mixture. Cotton balls were placed in each trap to provide nesting material for captured rodents. Traps were set during the late afternoon and were checked within the first 2 hours of sunrise each morning.

Captured animals were temporarily placed in zip-loc bags for field evaluation to determine species, sex, and age. All animals were weighed using a Pesola scale, which was calibrated daily and zeroed to account for bag weight. A Global Positioning System (GPS) with an accuracy of 3 meters was used to map each trap location where rodents were captured. Dominant vegetation surrounding each capturing trap was documented.

Females and juvenile males were marked by clipping fur from the rump and released. Adult males were transported to the field laboratory in the trap they were captured in. Sperm analysis was performed by a technician from Pathology Associates (PAI). The methods used by PAI are included in Appendix F. Wet weights were obtained for livers, spleens, and epididymis. These organs were also inspected for gross abnormalities, and tissues were harvested for histopathological analysis. Percent differences were calculated by dividing the mean of each parameter evaluated on the impact area by the mean of that parameter on the comparison area, subtracting the quotient from 1 and multiplying by 100.

10.5.2 Vegetation

The vegetative community dominating the impact area is successional wet meadow and is composed primarily of shrubs, young trees, grasses, and forbs. Woolgrass and broomsedge were found on each of the study and comparison sites. The plants and seeds are consumed by avian and mamallian species. Therefore, these two plants were selected to be sampled for heavy metals and explosives (Table 10-2) and perchlorate uptake. Only aboveground portions of plants were sampled.

Vegetation samples were picked by hand and placed in clean plastic bags. A minimum wet weight of 100 g was obtained for each sample. All vegetation samples were placed on ice immediately upon collection and were maintained at 4°C. Woolgrass samples were composed of approximately of 50% seed head and 50% basal leaf. Vegetation samples were not washed in the field, or in the laboratory to provide a worst-case estimate of potential contaminant exposure to rodents. Thus, any contaminants found in vegetation samples may not reflect true contaminant uptake since it is unclear what contaminant concentration is actually in the plant vs. what is on the surface of the plant.

Eighteen broom sedge and 18 woolgrass samples were collected from each study area. A duplicate sample was taken from the fifth sample on each area.

TABLE 10-2 HEAVY METAL AND EXPLOSIVE ANALYTES

HEAVY METALS
antimony
arsenic
barium
cadium
chromium
copper
lead
manganese
mercury
molybdenum
nickel
silver
uranium
vanadium

Explosives
1,3,5-Trinitrobenzene
1,3-Dinitrobenzene
2,4,6-Trinitrotoluene (TNT)
2,4-Dinitrotoluene
2,6-Dinitrotoluene
2-Amino-4,6-dinitrotoluene
2-Nitrotoluene
3-Nitrotoluene
4-Amino-2,6-dinitrotoluene
4-Nitrotoluene
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HMX
Nitrobenzene

10.6 DATA EVALUATION

All data were evaluated using SPSS software. Data were checked for normality using the Shapiro-Wilk test. Data found to be non-normally distributed were log transformed and were reevaluated for normality. The means of the data sets were compared using a one tailed t-test. If data were not normally or log normally distributed they were compared using the Mann Whitney u test.

Parameters were compared statistically between the comparison, HE, and DU rodent populations to determine if differences seen can be attributed to chance or if the differences are real. However, statistical significance does not necessarily indicate biological significance, and the lack of statistical significance does not indicate the lack of biological significance. P values from the t test results are reported. P values > .05 were considered significant.

10.7 RODENT RESULTS

Meadow voles (*Microtus pennsylvanicus*) were captured on all three study sites and adult males were used for Rodent Sperm Analysis. Other species caught on JPG included *Microtus ochrogaster* (Prairie Vole), *Cryptotis parva* (Least shrew), *Peromyscus leucopus* (White-footed mouse), and *P. maniculatus* (Deer Mouse). Table 10-3 summarizes the number of animals captured on each site.

TABLE 10-3 NUMBER OF ANIMALS CAUGHT BY SAMPLING LOCATION

Species	Impact Areas		Comparison Area
	HE	DU	DA
Microtus pennsylvanicus (Meadow Vole	21	10	41
Microtus ochrogaster (Prairie Vole)	1	3	0
Cryptotis parva (Least Shrew)	0	1	0
Peromyscus leucopus (White-footed Mouse)	1	0	0
Peromyscus maniculatus (Deer Mouse)	1	0	1

The results of the rodent data collected (sperm analysis and organ:body weight ratios) from adult male *M. pennsylvanicus* are found in Table 10-4.

TABLE 10-4 RODENT DATA RESULTS

Parameter	M. PENNSYLVANICUS		
	HE	DU	DA
Sperm Count (10^6 sperm/g epididymis)	1922.1^a	1866.9^b	2498.6^b
Sperm Morphology (% abnormal sperm)	0.3	1.4	0.9
Sperm Motility (% motile)	84	73	76
Liver: Body Weight Ratio	3.9282^a	3.9382^b	4.6008^b
Epididymis: Body Weight Ratio	0.1466^a	0.1601^a	0.1460^a
Spleen: Body Weight Ratio	0.1898^a	0.1080^b	0.2447^a
Kidney: Body Weight Ratio	1.2327^a	1.1093^b	1.0687^b
Male Body Weight (grams)	38.2070^a	35.1973^b	40.1532^a

[a,b] Means with uncommon subscripts between the appropriate comparisons (HE vs DA and DU vs DA) differ ($P < 0.05$).

10.7.1 Sperm Count

M. pennsylvanicus sperm count was significantly reduced by 23.07% on the HE area ($p = .045$) as compared to the DA area. Sperm count was reduced by 25.28% on the DU area but the difference between DU and DA was not significant ($p = .068$).

10.7.2 Sperm Morphology

Individuals taken from the HE area had 0.3% abnormal sperm. *M. pennsylvanicus* had 1.4 and 0.9% abnormal sperm on the DU and DA, respectively. These are straight percent abnormal sperm calculated by evaluating the number of abnormal sperm per 200 sperm sampled. There were no statistical differences observed in sperm morphology between the reference and impact sites.

10.7.3 Sperm Motility

The percent motile sperm for *M. pennsylvanicus* from the HE area was 84%. The DU area voles were reported to have 73% motile sperm. These percent motile sperm values for the impact areas were compared to the DA area value of 76%. Therefore, HE had 8% more motile sperm and the DU rodents had 3 % less motile sperm as compared to DA. The observed differences in sperm motility between the impact and reference areas were not statistically significant.

10.7.4 Liver:Body Weight Ratios

Male *M. pennsylvanicus* liver:body weight ratios were reported as significantly reduced by 14.63% on the HE area ($p = 0.028$). Liver:body weight ratios were reduced by 14.41% on the DU area; however, this difference was not significant ($p = 0.069$).

10.7.5 Epididymis:Body Weight Ratios

M. pennsylvanicus epididymis:body weight ratios were not different between HE and the comparison areas ($p = 0.47$). Epididymis:body weight ratios were 9.37% larger on the DU area; however, this difference was not significant ($p = 0.28$).

10.7.6 Spleen:Body Weight Ratios

M. pennsylvanicus spleen:body weight ratios were reduced by 18.93% on the HE area as compared to DA; however, this difference was not significant ($p = 0.38$). Spleen:body weight ratios were significantly reduced by 54.16% on the DU area ($p = 0.045$).

10.7.7 Kidney:Body Weight Ratios

M. pennsylvanicus kidney:body weight ratios were significantly increased by 13.38% on the HE area ($p = 0.053$) as compared to DA rodents. Kidney: body weight ratios on the DU area were increased by 3.70%; however, this difference was not significant ($p = 0.295$).

10.7.8 Male Body Weight

Male *M. pennsylvanicus* body weights were not significantly reduced on HE by 4.84% ($p = 0.175$) as compared to DA. They were significantly reduced on DU by 12.34% ($p = 0.039$).

10.7.9 Histopathology

The histopathological evaluation found no significant differences in the liver, spleen, kidneys, and testes between the HE, DU, and DA area animals. Incidental background and/or parasitic findings were noted in all tissues and in all areas.

10.8 VEGETATION RESULTS

Vegetation was analyzed for heavy metals and explosives. Table 10-5 shows the detection levels for heavy metals. If the metal is not listed, there was not a detection. For explosives, nitrobenzene was detected in two broomsedge and two woolgrass samples collected from the HE area, and one woolgrass sample collected from the DU area. The concentration in every sample was 0.2 ppm, which is below the method reporting limit. In addition, the same concentration was detected in a laboratory blank. Therefore, it was determined these concentrations were false positives, and it was concluded that no explosive compounds were found in vegetation.

10.8.1 Woolgrass

Barium concentrations in woolgrass were not different between the sites ($p = 0.666$ for DA vs. HE, $p = 0.387$ for DA vs. DU). Average concentration on the HE area was 25.18 ppm, 17.64 ppm on DU, and 23.92 ppm on DA.

Copper concentrations in woolgrass were not different between the sites ($p = 0.114$ for DA vs. HE, $p = 0.23$ for DA vs. DU). Average concentration on the HE area was 8.34 ppm, 8.82 ppm on DU, and 9.36 ppm on DA.

Manganese concentrations in woolgrass were not different between the sites ($p = 0.094$ for DA vs. HE, $p = 0.094$ for DA vs. DU). Average concentration on the HE area was 809.22 ppm, 803.67 ppm on DU, and 1046.11 ppm on DA.

Nickel concentrations in woolgrass were not different between the sites ($p = 0.387$ for DA vs. HE, $p = 0.190$ for DA vs. DU). Average concentration on the HE area was 2.112 ppm, 1.832 ppm on DU, and 2.57 ppm on DA.

10.8.2 Broomsedge

Barium concentrations in broomsedge were not different between the sites ($p = 0.317$ for DA vs. HE, $p = 0.084$ for DA vs. DU). Average concentration on the HE area was 11.20 ppm, 13.898 ppm on DU, and 9.63 ppm on DA. Copper concentrations in broomsedge were significantly elevated on the DA area compared to the HE area ($p = 0.017$ for DA vs. HE). Concentrations were not different between the DA and DU areas ($p= 0.138$ for DA vs. DU). Average concentration on the HE area was 3.02 ppm, 3.41 ppm on DU, and 3.80 ppm on DA.

Manganese concentrations in broomsedge were significantly elevated on the DA area compared to the HE area ($p = 0.001$ for DA vs. HE). Concentrations were also significantly elevated on the DA area compared to the DU area ($p= 0.006$ for DA vs. DU). Average concentration on the HE area was 182.67 ppm, 255.67 ppm on DU, and 297.78 ppm on DA.

TABLE 10-5 ANALYTICAL RESULTS FOR HEAVY METALS FROM VEGETATION SAMPLES COLLECTED ON IMPACT AREAS (HE = HIGH EXPLOSIVE; DU = DEPLETED URANIUM) AND THE COMPARISON AREA (DA). ANALYTE CONCENTRATIONS ARE IN PPM AND REPRESENT AVERAGE CONCENTRATIONS

Analyte (ppm)	Woolgrass			Broomsedge		
	HE	DU	DA	HE	DU	DA
Barium	25.18[a]	17.64[a]	23.92[a]	11.20[a]	13.898[a]	9.63[a]
Copper	8.34[a]	8.82[a]	9.36[a]	3.02[a]	3.41[c]	3.80[b,c]
Manganese	809.22[a]	803.67[a]	1046.11[a]	182.67[a]	255.67[a]	297.78[b]
Nickel	2.112[a]	1.832[a]	2.57[a]	nd[d]	nd	nd

[d] nd = non-detect

10.9 RODENT DISCUSSION

There are two primary concerns associated with potential chemical risks at Army firing ranges: 1) impacts to prey species and 2) impacts to predator species through either contaminant toxicity or reduced prey availability. Since explosives and the metals found on Army firing ranges are not expected to bioaccumulate (Whaley and Leach, 1994, USACHPPM, 2002; Torres and Johnson, 2001), prey species are not evaluated for body burden. Therefore, predatory species are not expected to be exposed to SOPCs via prey. However, some of the explosives and metals expected to occur on Army ranges are known to cause reproductive effects in mammals (Das and Dasgupta, 2000; Kempinas et al., 1988; Laskey et al., 1984). Thus, there is potential for reproductive effects in the small mammal population. If small mammal populations are impacted, predator populations may also be impacted due to reduced prey availability.

10.9.1 Sperm Count

The cause of the observed sperm count reductions in *M. pennsylvanicus* cannot be definitively established. It is possible that chemical contamination, specifically exposure to explosives, is the causative agent of the reductions. However, accepted measures of contaminant exposure (i.e., increased liver weight and reduced epididymis weight; Chapin et al., 1997; Dilley et al., 1982; Levine et al., 1984; histopathological changes) were not observed. In addition, the fact that the reference area was more contaminated than the impact area indicates that the observed sperm count reductions were not caused by exposure to contaminants. However, it may be possible to see a change in sperm parameters with no observed change in organ to body weight ratio. There are other factors that can potentially cause sperm count reduction. Certain mammalian species are known to change reproductive effort such as delay to sexual maturity as available resources change (Glass et al., 1984; Glass et al., 1987).

Thus, it is possible that reduced sperm count is an effect of, or response to reduced resource availability. It is known that rodent populations naturally cycle. It is not established whether these fluctuations are predator or density-dependent. There is increasing evidence indicating that rodent population fluctuations may be density driven (Agrell, et al., 1995). It is possible that the observed decrease in sperm count in *M. pennsylvanicus* is a density mediated response to reduce the population. However, we have not investigated this theory.

Several authors have reported that sperm output for rats or mice must decrease by 80-99% before a reduction in fertility is seen (Aafjes et al., 1980; Meistrich et al., 1982; Robaire et al., 1984 Grey et al., 1992). Therefore, it is concluded that rodents are robustly fertile (Meistrich, et al., 1994; Gray, et al., 1992). Dewsbury and Sawrey (1984) found that a 75% reduction in sperm count had no effect on reproductive success in *Peromyscus maniculatus*. There is some evidence indicating that a small reduction in sperm count may result in a reduction in reproductive success and thus population. Chapin et al. (1997), found an association between sperm count and fertility and reported that small reductions in sperm count (approximately greater than 20%) result in reduced fertility. However, the bulk of the scientific evidence available indicates that an 80% reduction in sperm count is necessary before a reduction in fertility is seen. Therefore we assumed that an 80% reduction in sperm count from the comparison site condition is needed to conclude that reproductive success is compromised. *M. pennsylvanicus* sperm count was reduced by 23.07% on the HE area and 25.28% on the DU area as compared to the comparison site. These reductions are well below the established 80% threshold, indicating that these reductions will have no effect on rodent population. In addition, the sperm count reductions cannot be linked to chemical exposure as discussed above.

10.9.2 Sperm Morphology

Abnormal sperm morphology can be caused by chemical stressors (Chapin et al., 1997) and may also occur normally in a population. The incidence of abnormal sperm has not been investigated in wild rodent populations. *M. pennsylvanicus* had a lesser incidence of abnormal sperm on the DU area than the DA area. However, *M. pennsylvanicus* had a greater incidence of abnormal sperm on the HE area as compared to DA. The lack of consistency in results (increased abnormal sperm on comparison site as compared to HE site) indicate that the observed abnormalities are due to factors other than chemical stressors.

In addition, the observed differences (1.4% abnormal on DU, .3% abnormal on HE and .85% abnormal on DA) were well below the 4% difference needed to cause a reproductive effect as established by Chapin, et al., 1997.

10.9.3 Sperm Motility

The observed differences in sperm motility between the impact and reference areas were not statistically significant. In addition, these differences (3.9 % less motile on DU and 9% more motile on HE as compared to reference) are both well below the 40% threshold needed before a reproductive effect is realized.

10.9.4 Organ:Body Weight Ratios

Changes in organ:body weight ratios can indicate exposure to chemical stressors (Chapin et al., 1997; Dilley et al., 1982; Levine et al., 1984). Increased liver weights typically indicate exposure to a chemical stressor since the organ must compensate to remove the toxic, resulting in an increased mass.

M. pennsylvanicus livers were not significantly smaller on the HE and DU areas as compared to the DA area. *M. pennsylvanicus* spleen masses were not significantly reduced on the DU area, but were not different between the DA and HE sites. Kidney to body weight ratios were not significantly greater on the HE site compared to DA and were not different on the DU area as compared to DA. Chapin et al. (1997), found reduced epididymis weights in rats exposed to chemical stressors. The epididymis to body weight ratios for *M. pennsylvanicus* were not different between the HE and DA sites. Epididymis to body weight ratios were not significantly greater on the DU area.

While a clear determination of exposure cannot be made based on differences in organ:body weight ratios, it appears that *M. pennsylvanicus* are not exposed to SOPCs at JPG, since no trends in organ:body weight ratios indicate exposures are apparent.

10.9.5 Histopathology

The histopathological investigation did not find any differences in spleen, liver, kidney or testes in animals harvested from the impact and reference areas that can be linked to potential SOPC exposure at the HE or DU areas. Therefore, it appears that rodents at JPG are not exposed to SOPCs at this site.

10.10 VEGETATION DISCUSSION

The vegetation data was used to calculate hazard quotients (HQs) for rodents, and does not indicate the health of the vegetative community. The plant species sampled were expected to provide a worst-case dietary exposure to rodents since vegetation was sampled near impact craters on the impact areas.

Barium, copper, manganese, and nickel were detected in woolgrass samples. Concentrations of these metals were not statistically different between the sites. Barium, copper, and manganese were detected in broomsedge samples. Copper was significantly elevated in DA broomsedge compared to HE broomsedge. There was no difference in copper concentrations between HE and DA broomsedge samples. Manganese concentrations in broomsedge were significantly elevated on the DU area compared to DA broomsedge. Manganese was also significantly elevated in broomsedge on DA as compared to HE broomsedge samples.

10.11 HAZARD QUOTIENTS

The traditional HQ approach compares estimated exposures (mg contaminant/kg body weight-day) to screening toxicity values (e.g., chronic NOAELs) to estimate potential risk. If the HQ exceeds the conventional "threshold" value of 1.0, it is interpreted that there is potential risk to the receptors. Generally, the HQ calculation is a screening level tool.

10.11.1 Receptors

Receptors were selected based on their presence at the study sites, the availability of exposure and toxicological information, and their potential for exposure to contaminants. The meadow vole (*Microtus pennsylvanicus*) was selected as the representative small mammal. The red-tailed hawk (*Buteo jamaicensis*) was selected as the avian species because red-tailed hawks were observed around the study sites. Reptiles and amphibians were not quantitatively evaluated due to the lack of toxicological data.

10.11.2 Exposure Assumptions

The ingestion pathway was the only pathway evaluated due to the lack of dermal and inhalation data in wildlife. The 95th UCL of the mean for each SOPC in soil and vegetation were used to estimate the exposure dose. If an SOPC was not detected in vegetation, the risk was calculated only using the soil concentration, and vice versa for vegetation. Potential exposure to water was not included in the ingestion pathway. It was assumed the small mammals were obtaining the majority of their water from the vegetation (Reich, 1981). Receptors are assumed to be exposed throughout their entire lifetime. For small mammals the non-soil portion of the diet (98%) was assumed to consist of 100% vegetation as represented by the two vegetation species collected (equal proportion of each). For the red-tailed hawk, the diet exposure dose was calculated based on the percentage of small mammals in their diet (12.6%, USEPA, 1993) assuming the bioavailability of contaminants from the small mammals to the hawk was equal to 1 for a worst-case scenario. Table 10-6 contains exposure parameters used in the risk estimation (USEPA, 1993).

TABLE 10-6 EXPOSURE ASSUMPTIONS

Parameter	Units	*M. pennsylvanicus*	*B. jamaicensis*
Normalized Ingestion Rate (total)	g wwt/g-day	0.33	.1
Calculated Diet Ingestion Rates			
Broomsedge	g bs wwt/g-day	0.1617	0
Woolgrass	g wg wwt/g-day	0.1617	0
Small mammals	g mam wwt/g-day	0	.013
Fraction of Soil in Diet	unitless	0.0066	0
Fraction of small mammal in diet	unitless	0	.126

10.11.3 Toxicological Benchmarks

The chronic lowest observed adverse effect level (LOAEL) for metal SOPCs (Table 10-7) were taken directly from Toxicological Benchmarks for Wildlife (Sample et al., 1996).

TABLE 10-7 CHRONIC LOWEST OBSERVED ADVERSE EFFECT LEVEL (LOAEL; MG/KG-DAY) FOR METALS AND EXPLOSIVES EVALUATED IN THIS STUDY

SOPC	Mammalian LOAEL	Avian LOAEL
METALS		
Antimony	1.25	data gap
Arsenic	1.26	7.38
Barium	19.8	41.7
Chromium	13.14	20
Copper	15.14	61.7
Lead	80	11.3
Manganese	284	977
Mercury	0.032	0.09
Molybdenum	0.26	data gap
Nickel	40	107
Uranium	11.2[a]	data gap
Vanadium	2.1	11.4
EXPLOSIVES		
Nitrobenzene	4.6	data gap
RDX	3.5[b]	data gap
Other		
Perchlorate	data gap	data gap

[a] Values obtained from ATSTR Uranium Toxicological Profile (ATSDR, 1999)

[b] Values obtained from USACHPPM Wildlife Toxicity Assessment (USACHPPM, 2001)

10.11.4 Risk Estimation

The following equations for risk estimation were adapted from the USEPAs Wildlife Exposure Factors Handbook (USEPA, 1993).

Equation 1-1

$$NIR_k = (P_k)(NIR_{total})$$

where:

NIR_k = Normalized ingestion rate of the k item in the diet (g/g-day)
P_k = percent of the k item in the diet (unitless)
NIR_{total} = Normalized ingestion rate of total diet (g/g-day)

Equation 1-2

$$E_{oral} = (C_{veg} \times NIR_{veg}) + (C_{soil} \times NIR_{soil})$$

where:

E_{oral} = average daily oral exposure (g/g-day)
C_{veg} = 95 UCL of the SOPC in vegetation (mg/kg)

NIR_{veg} = normalized ingestion rate of vegetation (g/g-day)
C_{soil} = 95 UCL of the SOPC in soil (mg/kg)
NIR_{soil} = normalized ingestion rate of soil (g/g-day)

Equation 1-3

$$HQ = \frac{E\ oral}{Tox\ Value}$$

where:

HQ = hazard quotient (unitless); above 1.0 indicated potential risk
E oral = average daily oral exposure (mg/kg-day)
Tox Value = lowest observed adverse effect level (LOAEL; mg/kg-day) or USACHPPM derived Wildlife Toxicity Assessment (WTA)

10.11.5 Results and Uncertainty

Table 10-8 presents the hazard quotients (HQ) for each receptor on each site. There were only two HQs that exceeded the standard "threshold" value of 1.0. The exceptions were the HQs for the *M. pennsylvanicus* for manganese and nickel on the comparison area. All other HQs were below 1.

The analytical data for soil and vegetation are total concentrations of metals and are not necessarily representative of the percentage of SOPC that is bioavailable. The chronic LOAELs and exposure assumptions used produce conservative risk estimates. The HQ results support the conclusion that risk of adverse effects to small mammals and birds from SOPC exposure is low. These results are comparable to conclusions from studies at other artillery ranges that indicated the primary SOPCs were metals and the ecological risk was low (USACHPPM, 1998, USACHPPM, 2003).

10.12 DATA QUALITY INDICATORS

10.12.1 Precision

10.12.1.1 Analysis of Data

There are two approaches to the evaluation of field duplicate results. The first approach utilizes the relative percent difference (RPD) between the two results. The second approach utilizes the difference between the two results. The appropriateness of the two approaches is dependent upon the concentration of the analyte relative to the quantitation of detection limit for the analyte in the sample (Reference 6, Appendix A). The duplicate result for a single analyte will fall into one of three categories:

- both results were non-detected,
- one result was non-detected and the other result was a positive result, or
- both results were positive.

TABLE 10-8 HAZARD QUOTIENTS FOR THE REPRESENTATIVE SMALL MAMMAL AND BIRD

Analyte	**Comparison (DA)**		**High Explosive (HE)**		**Depleted Uranium (DU)**	
	M. pennsylvanicus	*B. jamaicensis*	*M. pennsylvanicus*	*B. jamaicensis*	*M. pennsylvanicus*	*B. jamaicensis*
Metals						
Antimony	4.5×10^{-3}	data gap	9.0×10^{-3}	data gap	nd	data gap
Arsenic	3.7×10^{-2}	2.5×10^{-4}	2.7×10^{-2}	1.8×10^{-4}	nd	nd
Barium	0.5	8.7×10^{-3}	0.5	8.8×10^{-3}	0.4	7.8×10^{-3}
Chromium	6.3×10^{-3}	1.6×10^{-4}	5.1×10^{-3}	1.3×10^{-4}	nd	nd
Copper	0.2	1.6×10^{-3}	0.2	1.5×10^{-3}	0.2	1.5×10^{-3}
Lead	2.4×10^{-3}	6.8×10^{-4}	1.5×10^{-3}	4.2×10^{-4}	nd	nd
Manganese	671	1.0×10^{-2}	0.7	7.6×10^{-3}	0.9	1.1×10^{-2}
Mercury	1.4×10^{-2}	2.0×10^{-4}	6.3×10^{-3}	8.8×10^{-5}	nd	nd
Molybdenum	1.9×10^{-2}	data gap	1.9×10^{-2}	data gap	nd	data gap
Nickel	15	2.4×10^{-4}	1.6×10^{-2}	2.4×10^{-4}	1.4×10^{-2}	2.1×10^{-4}
Uranium	1.73×10^{-4}	data gap	3.02×10^{-3}	data gap	2.94×10^{-4}	data gap
Vanadium	0.2	1.2×10^{-3}	7.5×10^{-2}	5.5×10^{-4}	nd	nd
Explosives						
RDX	2.4×10^{-5}	data gap	2.5×10^{-5}	data gap	nd	data gap
Nitrobenzene	nd[a]	data gap	8.0×10^{-3}	data gap	2.7×10^{-3}	data gap
Other						
Perchlorate	data gap	data gap	data gap	data gap	data gap	data gap

[a] nd = non detect, therefore HQ is not calculated

B DATA GAP = TOXICITY VALUE NOT AVAILABLE, THEREFORE HQ IS NOT CALCULATED

10.12.1.2 Evaluation Criteria

If both of the field duplicate results are greater than or equal to five times the method detection limit (MDL), the RPD must be less than or equal to 40% for solid samples (Reference 6, Appendix A). If the results exceed 40% the positive analytical results should be considered estimated.

If both of the field duplicates results are less than five times the MDL, the difference between the results must be less than or equal to twice the MDL.

When one of the duplicates samples was a not-detected result and the other was a positive result, the difference between the positive result and one-half of the MDL should be less than two times the MDL.

10.12.1.3 Discussion

A majority of the duplicate samples had results that were not-detected in both samples. These results did not need further analysis (see Tables 10-9 and 10-10). Two duplicate analyses had positive results that were greater than or equal to five times the MDL, and these results were within the specified acceptance limits. Three of the duplicate analyses had a not-detected result and the other result detected. Upon calculation this was shown to be less than two times the MDL and therefore is not considered to be estimated. Twenty-five of the duplicate analyses had results less than or five times the MDL. Of these 25 analyses, only one of these samples (bolded in Table 10-9) resulted in a difference that was greater than two times the MDL, therefore being considered estimated.

TABLE 10-9 THE RELATIVE PERCENT DIFFERENCE OF DUPLICATES FOR BROOMSEDGE VEGETATION SAMPLES

	Broomsedge											
	Impact				**Comparison**				**Depleted Uranium**			
	sample	**duplicate**	**RPD**	**Difference**	**sample**	**duplicate**	**------ --- RPD**	**Difference**	**sample**	**duplicate**	**RPD**	**Difference**
EXPLOSIVES												
HMX	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
RDX	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
1, 3, 5 – Trinitrobenzene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
1, 3 – Dinitrobenzene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Tetryl	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Nitrobenzene	nd, 0.05	0.2	---	0.15	nd	nd	0	0	nd	nd	0	0
2, 4, 6 – Trinitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
4-Amino-2,6 – Dinitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
2-Amino-2,6 – Dinitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
2, 6 – Dinitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
2, 4 – Dinitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
2-Nitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
4-Nitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
3-Nitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
METALS												
Perchorate	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Antimony	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Arsenic	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Barium	10.2	8.34	---	1.86	8.18	6.62	---	1.56	5.7200	5.3600	---	0.36
Cadmium	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Chromium	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Copper	3.18	2.34	---	0.84	4.03	5.18	---	1.15	2.9300	3.2600	---	0.33
Lead	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Manganese	154	156	---	2.0	**234**	**375**	**---**	**141.0**	204	189	---	15.0
Mercury	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Molybdenum	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Nickel	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Silver	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Uranium	0.00181	0.0024	---	0.00059	0.00154	0.00524	---	0.0037	0.00378	0.00229	---	0.00149
Vanadium	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0

TABLE 10-10 THE RELATIVE PERCENT DIFFERENCE OF DUPLICATES FOR WOOLGRASS VEGETATION SAMPLES

	Woolgrass											
	Impact				Comparison				Depleted Uranium			
	sample	duplicate	RPD	Difference	sample	duplicate	RPD	Difference	sample	duplicate	RPD	Difference
EXPLOSIVES												
HMX	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
RDX	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
1, 3, 5 – Trinitrobenzene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
1, 3 – Dinitrobenzene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Tetryl	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Nitrobenzene	0.2	0.2	---	0	nd	nd	0	0	nd, 0.05	0.2	---	0.15
2, 4, 6 – Trinitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
4-Amino-2,6 – Dinitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
2-Amino-2,6 – Dinitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
2, 6 – Dinitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
2, 4 – Dinitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
2-Nitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
4-Nitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
3-Nitrotoluene	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
METALS												
Perchorate	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Antimony	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Arsenic	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Barium	24.8	21.3	---	3.5	28.1	32	---	3.9	21.5	10	---	11.5
Cadmium	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Chromium	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Copper	7.27	7.67	---	0.4	9.23	8.25	---	0.98	6.23	8.97	---	2.74
Lead	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Manganese	1340	1340	0	---	1060	1030	3.0	---	815	718	---	97.0
Mercury	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Molybdenum	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Nickel	nd, 1.0	2.06	---	1.06	2.21	2.37	---	0.16	nd	nd	0	0
Silver	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0
Uranium	0.00647	0.00646	---	0.00001	0.00523	0.00401	---	0.00122	0.00314	0.00351	---	0.00037
Vanadium	nd	nd	0	0	nd	nd	0	0	nd	nd	0	0

10.12.2 Accuracy

Accuracy/bias is a measure of the bias that exists in a measurement system and is also the degree of agreement between a samples theoretical and observed concentrations. When the measurement is applied to a particular set of observed values, it will be a combination of two components: a random component and common systematic error (or bias) component. Field sampling accuracy is usually assessed with equipment rinse blanks. As only dedicated sample equipment was used, no rinse blank samples were collected. All analytical data was validated by an independent review. The review included an evaluation of quality control sample data for all of the samples collected. Based on this review, all of the analytical results reported were considered valid and subsequently accurate.

10.12.3 Representativeness

Representativeness is the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. The degree of representativeness is dependant on the thoroughness and proper design of the QAPP and Sampling and Analysis Plans (SAPs).

Vegetation species to be analyzed were selected after careful evaluation of four parameters: species dominance in study area, use as a food source by small mammals, ability to accumulate contaminants, and proximity of plants to craters.

10.12.4 Comparability

Comparability is an expression of the confidence with which one data set can be compared with another. Comparability of field data will be dependent upon the proper design of the sampling program and testing protocols. Study sites were matched for habitat, hydrogeology, and topography for data comparability.

10.12.5 Completeness

Based on the SAP, from each grid, two species of vegetation were collected, broomsedge and woolgrass. Two samples of each species were collected. Duplicates were to be collected from the fifth plant sampled, which would correspond to third grid on each study site. Due to an oversight, nitroglycerin was not an analyte. Eighteen samples were planned and collected (including duplicates) on each sampling site. With the exception of nitroglycerin, 100% of samples were collected as planned.

10.13 SUMMARY OF PROBLEMS

The initial comparison area was selected during a site scoping visit in April and was located near gate 15 on the western boundary of the installation. The site appeared to contain similar vegetation, hydrology, and habitat as the impact area sites during the May, 2002 scoping visit. However, upon returning to the installation in September to conduct trapping, it was apparent that the comparison site vegetation and hydrology were different from the impact area sites. Traps were set on this site for 2 nights with no success most likely due to habitat and heavy rains. It was decided to conclude trapping on this site, select a different comparison site, and to return in 2 weeks to trap the new comparison location. The new comparison site (DA) was located near gate 5 on the eastern boundary of the installation. The site was used as a UXO detection technology demonstration site by the AEC. In this demonstration, inert rounds were placed on the site and their locations were noted. Various UXO detection technologies were employed to determine the locations of the duds and remove them. After discussions with installation and AEC personnel, it was decided that the possibility that these inert rounds could have caused environmental contamination was low. This was due to their short duration in the field, 100% recovery of the rounds placed on the site, and the fact that they were inert (i.e., did not contain HE). No other sites on the installation were suitable for use as a comparison area. However, the analytical results for soil samples collected at this site showed that it is more contaminated with explosive compounds than impact area soils. Metals concentrations were also generally greater in DA soils than in HE or DU soils.

The comparison site was trapped 2 weeks after the impact area trapping was completed due to the problems discussed above. This could have caused the differences observed in sperm parameters.

10.14 SUMMARY

The sperm count in *M. pennsylvanicus* was reduced on the impact area study sites. Since the comparison site was more contaminated than the impact area sites, the cause of these reductions are probably not chemically mediated. In addition, the observed reductions in count are below the assumed 80% reduction threshold required before reproductive effects are seen.

M. pennsylvanicus had a lesser incidence of abnormal sperm (morphology) on the DU area than the CA, and a greater incidence of abnormal sperm on the HE area than on the CA. The lack of consistency in results (increased abnormal sperm on comparison site as compared to HE site) and the fact that the comparison site is more contaminated than impact area sites indicate that the observed abnormalities are due to factors other than chemical stressors. In addition, the observed differences were well below the 4% difference needed to cause a reproductive effect.

The result trend for sperm motility was similar to sperm morphology (more motile sperm were observed from animals taken from the HE area than on the comparison site, and fewer motile sperm were observed in DU animals than on the comparison site). The lack of consistency in results and the fact that the comparison site is more contaminated than impact area sites indicate that the observed differences in motility are due to factors other than chemical stressors. In addition, the observed differences were well below the 40% difference needed to cause a reproductive effect.

The fact that the CA was more contaminated than the impact area, sperm counts were reduced on the less contaminated impact areas, the lack of consistency in morphology and motility results, and that any differences seen in sperm parameters did not exceed established thresholds, indicate that rodent populations at JPG are not being negatively impacted by SOPC contamination.

Organ to body weight ratios did not indicate that rodents are exposed to SOPCs.

Histpopathological evaluation did not indicate any chemically mediated changes in the histopathology of the organs collected from *M. pennsylvanicus*.
Hazard quotients for rodents and raptors did not exceed 1 on the impact area, indicating these receptors are not at risk due to SOPC exposure.

10.15 CONCLUSIONS

Based on the above weight of evidence, it appears that the small mammal population at JPG are not being affected by SOPCs attributable to test artillery range operations.

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11 LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

Laboratory data quality is determined through the assessment of the laboratory Data Quality Indicators (DQI), internal assessments, and the validation of laboratory data. Precision, accuracy, completeness, representativeness and comparability for the laboratory analyses were reviewed, calculated (where applicable) and compared to the JPG QAPP target values. A 100 % external (Third Party) laboratory data validation was performed by the Science Applications International Corporation (SAIC). The project produced acceptable results for 98.5 % of the sample analyses (see SAIC Analytical Data Validation Report in Appendix D). The report identifies 82 of 684 results or values for metals in vegetation and 59 of 2088 results or values for metals in soil as rejected data (see SAIC Analytical Data Validation Report in Appendix D).

Method audits are a subset of Fixed Laboratory Technical Systems Audits (TSAs) and consist of the auditor observing the analyst while he/she performs the analytical method on actual real world samples to ensure the analytical laboratory standing operating procedures (SOPs) are followed as required by the JPG QAPP. These types of audits are also covered under the laboratory's Quality System requirements and are required to be performed annually. Method audits are not required for this project if the laboratory can demonstrate that a method audit for the specific analytical procedure used in support of this QAPP has been performed within the last year. The following method audits were conducted to meet the above requirements:

- USACHPPM DLS SOP CAD 82, *"The Analysis of White Phosphorus in Water and Sediment,"* audit conducted 26 September 2002.
- USACHPPM DLS SOP U_004.001, *"Uranium in Soil Preparation,"* conducted 15 October 2002.
- USACHPPM SOP U_006.000, *"Determination of Uranium – 238 and Isotopic Uranium Ratios by ICP/MS,"* conducted 10 December 2002.
- USCOE ECB Method 8330M, *"Explosives in Vegetation,"* conducted 9 September 2002.

The results of the method audits and corrective actions implemented are provided in Appendix C.

All sample holding times were met except for samples SE-1, SE-2, SE-3, SE-13, and SE-17 for total volatile solids in sediment (see SAIC Analytical Data Validation Report in Appendix D for a detailed explanation of holding times).

11.1 LABORATORY DQIs

11.1.1 Laboratory Precision

Laboratory precision is assessed through the use of matrix spikes (MS) and matrix spike duplicates (MSD) and calculated as the relative percent difference (RPD) between the two samples (See JPG QAPP Section 1.8.5). The average RPD for each set of MS and MSD samples in all sample delivery groups were calculated, and the values are provided in Tables 11-1 through 11-3. The average RPD for the MS/MSD for each analyte was below the JPG QAPP target RPD except for chromium in sediment. A detailed discussion of metals acceptability for precision is provided in the SAIC third party data validation report provided in Appendix D.

TABLE 11-1. RESULTS OF LABORATORY PRECISION, ACCURACY AND COMPLETENESS REVIEW FOR GROUND WATER AND SOIL

PARAMETER	Ground Water						Soil					
	Precision (RPD)		Accuracy (%R)		Completeness (%)		Precision (RPD)		Accuracy (%R)		Completeness (%)	
	Average	Target	Average	Target	Actual	Target	Average	Target	Average	Target	Actual	Target
Antimony - Sb	1.5	<30	103	70-130	100	95.0	3.9	<50	58.9	50-150	97.2	95.0
Arsenic - As	.91	<30	95	70-130	100	95.0	1.5	<50	106	50-150	100	95.0
Barium - Ba	1.3	<30	121	70-130	100	95.0	3.0	<50	118	50-150	100	95.0
Cadmium - Cd	.76	<30	70	70-130	100	95.0	1.0	<50	107	50-150	100	95.0
Calcium - Ca	2.3	<30	91	70-130	100	95.0	N/A	N/A	N/A	N/A	N/A	N/A
Chromium - Cr	1.3	<30	101	70-130	100	95.0	1.2	<50	107	50-150	100	95.0
Copper - Cu	3.4	<30	87	70-130	100	95.0	2.2	<50	105	50-150	100	95.0
Lead - Pb	4.5	<30	92	70-130	100	95.0	1.6	<50	108	50-150	100	95.0
Molybdenum - Mo	1.3	<30	100	70-130	100	95.0	1.3	<50	109	50-150	100	95.0
Manganese - Mn	1.8	<30	112	70-130	100	95.0	11	<50	129	50-150	100	95.0
Mercury - Hg	.32	<30	101	70-130	100	95.0	1.0	<50	101	50-150	100	95.0
Nickel - Ni	2.6	<30	98	70-130	100	95.0	1.3	<50	106	50-150	100	95.0
Silver - Ag	1.4	<30	94	70-130	100	95.0	1.1	<50	113	50-150	100	95.0
Uranium - U	3.1	<30	101	70-130	100	95.0	5.2	<50	109	50-150	100	95.0
Vanadium - V	2.1	<30	110	70-130	100	95.0	1.8	<50	115	50-150	100	95.0
Zinc - Zn	4.0	<30	106	70-130	100	95.0	N/A	N/A	N/A	N/A	N/A	N/A
Perchlorate	5.4	<30	114	70-130	100	95.0	1.9	<50	96.5	50-150	100	95.0
HMX	4.3	<30	98	70-130	100	95.0	4.9	<50	90.8	50-150	100	95.0
RDX	0	<30	100	70-130	100	95.0	2.8	<50	80.5	50-150	100	95.0
1,3,5-TNB	0	<30	96	70-130	100	95.0	2.0	<50	76.5	50-150	100	95.0
1,3-DNB	52.9	<30	99	70-130	100	95.0	1.6	<50	86.2	50-150	100	95.0
Tetryl	5.3	<30	101	70-130	100	95.0	13	<50	104	50-150	100	95.0
NB	4.3	<30	96	70-130	100	95.0	1.4	<50	94.0	50-150	100	95.0
2,4,6-TNT	0	<30	100	70-130	100	95.0	6.0	<50	89.7	50-150	100	95.0
4AM26DNT	8.7	<30	92	70-130	100	95.0	11	<50	58.1	50-150	100	95.0
2AM46DNT	0	<30	100	70-130	100	95.0	4.2	<50	80.6	50-150	100	95.0
2,4-DNT	0	<30	100	70-130	100	95.0	2.2	<50	89.9	50-150	100	95.0
2,6-DNT	3.9	<30	99	70-130	100	95.0	1.7	<50	91.9	50-150	100	95.0

PARAMETER	Ground Water						Soil					
	Precision (RPD)		Accuracy (%R)		Completeness (%)		Precision (RPD)		Accuracy (%R)		Completeness (%)	
	Average	Target	Average	Target	Actual	Target	Average	Target	Average	Target	Actual	Target
2-NT	1.4	<30	101	70-130	100	95.0	2.4	<50	105	50-150	100	95.0
3-NT	1.4	<30	99	70-130	100	95.0	2.3	<50	98.9	50-150	100	95.0
4-NT	0	<30	99	70-130	100	95.0	1.7	<50	96.8	50-150	100	95.0
Nitroglycerin	12	<30	96	70-130	100	95.0	4.7	<50	99.4	50-150	100	95.0
Total Organic Carbon – TOC	2.0	<30	101	70-130	100	95.0	N/A	N/A	N/A	N/A	N/A	N/A
Total Dissolved Solids - TDS	1.9	<30	100	70-130	100	95.0	N/A	N/A	N/A	N/A	N/A	N/A

N/A – Not Applicable in this matrix.

TABLE 11-2. RESULTS OF LABORATORY PRECISION, ACCURACY AND COMPLETENESS REVIEW FOR SURFACE WATER AND SEDIMENT

PARAMETER	Surface Water						Sediment					
	Precision (RPD)		Accuracy (%R)		Completeness (%)		Precision (RPD)		Accuracy (%R)		Completeness (%)	
	Average	Target	Average	Target	Actual	Target	Average	Target	Average	Target	Actual	Target
Antimony - Sb	13	<30	106	70-130	100	95.0	14	<50	105	50-150	100	95.0
Arsenic - As	4.1	<30	106	70-130	100	95.0	3.0	<50	106	50-150	100	95.0
Barium - Ba	1.0	<30	101	70-130	100	95.0	6.8	<50	102	50-150	100	95.0
Calcium - Ca	22.8	<30	**154**	70-130	100	95.0	N/A	N/A	N/A	N/A	N/A	N/A
Cadmium - Cd	4.2	<30	103	70-130	100	95.0	11	<50	99	50-150	100	95.0
Chromium - Cr	8.0	<30	98.8	70-130	100	95.0	**62**	<50	**162**	50-150	100	95.0
Copper - Cu	4.4	<30	96.8	70-130	100	95.0	6.5	<50	102	50-150	100	95.0
Lead - Pb	5.7	<30	106	70-130	100	95.0	3.5	<50	103	50-150	100	95.0
Magnesium - Mg	3.9	<30	**878**	70-130	100	95.0	N/A	N/A	N/A	N/A	N/A	N/A
Molybdenum - Mo	3.5	<30	102	70-130	100	95.0	14	<50	108	50-150	100	95.0
Manganese - Mn	1.8	<30	101	70-130	100	95.0	18	<50	79	50-150	100	95.0
Mercury - Hg	2.7	<30	105	70-130	100	95.0	19	<50	99	50-150	100	95.0
Nickel - Ni	3.0	<30	93.6	70-130	100	95.0	16	<50	105	50-150	100	95.0
Silver - Ag	20	<30	93.1	70-130	100	95.0	5.8	<50	100	50-150	100	95.0
Uranium - U	1.5	<30	111	70-130	100	95.0	29	<50	107	50-150	100	95.0
Vanadium - V	2.1	<30	103	70-130	100	95.0	19	<50	103	50-150	100	95.0
Zinc - Zn	14	<30	101	70-130	100	95.0	2.5	<50	105	50-150	100	95.0
Perchlorate	3.6	<30	106	70-130	100	95.0	4.0	<50	101	50-150	100	95.0
HMX	1.0	<30	98.8	70-130	100	95.0	7.3	<50	127	50-150	100	95.0
RDX	8.4	<30	100	70-130	100	95.0	3.8	<50	107	50-150	100	95.0
1,3,5-TNB	12	<30	102	70-130	100	95.0	0	<50	97	50-150	100	95.0
1,3-DNB	2.1	<30	98.6	70-130	100	95.0	1.1	<50	94	50-150	100	95.0
Tetryl	6.8	<30	103	70-130	100	95.0	11	<50	84	50-150	100	95.0
NB	6.1	<30	104	70-130	100	95.0	0	<50	122	50-150	100	95.0
2,4,6-TNT	12	<30	102	70-130	100	95.0	1.0	<50	99	50-150	100	95.0
4AM26DNT	4.4	<30	98.4	70-130	100	95.0	3.3	<50	89	50-150	100	95.0

PARAMETER	Surface Water						Sediment					
	Precision (RPD)		Accuracy (%R)		Completeness (%)		Precision (RPD)		Accuracy (%R)		Completeness (%)	
	Average	Target	Average	Target	Actual	Target	Average	Target	Average	Target	Actual	Target
2AM46DNT	4.0	<30	102	70-130	100	95.0	1.0	<50	97	50-150	100	95.0
2,4-DNT	3.1	<30	101	70-130	100	95.0	1.0	<50	97	50-150	100	95.0
2,6-DNT	2.5	<30	101	70-130	100	95.0	2.0	<50	98	50-150	100	95.0
2-NT	4.8	<30	101	70-130	100	95.0	2.0	<50	97	50-150	100	95.0
3-NT	3.3	<30	104	70-130	100	95.0	1.0	<50	98	50-150	100	95.0
4-NT	4.2	<30	100	70-130	100	95.0	2.1	<50	98	50-150	100	95.0
Nitroglycerin	9.0	<30	96	70-130	100	95.0	1.7	<50	122	50-150	100	95.0
White Phosphorus	12	<30	101	70-130	100	95	3.8	<50	108	50-150	100	95.0
Total Volatile Solids - TVS	N/A	N/A	N/A	N/A	N/A	N/A	5.0	<50	101	50-150	100	100

N/A – Not Applicable in this matrix.
*Bolded/shaded values are outside of the target acceptance criteria.

TABLE 11-3 RESULTS OF LABORATORY PRECISION, ACCURACY AND COMPLETENESS REVIEW FOR VEGETATION

PARAMETER	Vegetation					
	Precision (RPD)		Accuracy (%R)		Completeness (%)	
	Average	Target	Average	Target	Actual	Target
Antimony - Sb	3.5	<50	85.6	50-150	100	95.0
Arsenic - As	.93	<50	86.8	50-150	100	95.0
Barium - Ba	1.5	<50	97.9	50-150	100	95.0
Cadmium - Cd	.57	<50	87.2	50-150	100	95.0
Chromium - Cr	.59	<50	101	50-150	100	95.0
Copper - Cu	.91	<50	95.7	50-150	100	95.0
Lead - Pb	.25	<50	96.3	50-150	100	95.0
Molybdenum - Mo	.49	<50	98.9	50-150	100	95.0
Manganese - Mn	4.2	<50	100	50-150	100	95.0
Mercury - Hg	2.1	<50	72.4	50-150	100	95.0
Nickel - Ni	.63	<50	97.3	50-150	100	95.0
Silver - Ag	16	<50	78.4	50-150	**91.8**	95.0
Vanadium - V	.80	<50	101	50-150	100	95.0
HMX	9.5	<50	64.5	50-150	100	95.0
RDX	12	<50	**37.8**	50-150	100	95.0
1,3,5-TNB	33	<50	58.6	50-150	100	95.0
1,3-DNB	9.5	<50	54.4	50-150	100	95.0
Tetryl	11	<50	80.7	50-150	100	95.0
NB	9.0	<50	62.8	50-150	100	95.0
2,4,6-TNT	8.0	<50	75.2	50-150	100	95.0
4AM26DNT	6.0	<50	78.8	50-150	100	95.0
2AM46DNT	9.0	<50	58.9	50-150	100	95.0
2,4-DNT	2.5	<50	71.9	50-150	100	95.0
2,6-DNT	24	<50	97.2	50-150	100	95.0
2-NT	7.5	<50	81.4	50-150	100	95.0
3-NT	19	<50	65.7	50-150	100	95.0
4-NT	30	<50	67.5	50-150	100	95.0
Nitroglycerin	NA	<50	NA	50-150	NA	95.0

N/A – Not Applicable in this matrix.

*Bolded/shaded values are outside of the target acceptance criteria.

11.1.2 Laboratory Accuracy

Laboratory accuracy is assessed through the use of matrix spikes, laboratory control spikes, and/or surrogates and calculated as the percent recovery (See JPG QAPP Section 1.8.5). The average percent recovery for each set of QC samples in all sample delivery groups was calculated and the values are provided in Tables 11-1 through 11.3. The average percent recovery for all analytes were within the JPG QAPP target range except RDX in vegetation, magnesium and calcium in surface water, and chromium in sediment. A detailed discussion of metals acceptability for accuracy is provided in the Battelle QA/QC Summary for metals in sediment (see Appendix B) and in the SAIC third party data validation report provided in Appendix D. The limits for accuracy for RDX in vegetation (50-150) identified in the JPG QAPP were estimated due to the lack of completed method detection limit (MDL) studies at the time the document was developed (See Table 11-3). The values for percent recovery for RDX were within the method acceptance limits of 17-48% recovery. The method acceptance limits of 17-48% recovery were used for the third party data validation (See Appendix D). All other explosives compounds were within the method QC acceptance limits and the JPG QAPP target limits.

11.1.3 Laboratory Completeness

Laboratory completeness is a comparison of the amount of valid data measured versus the total amount of samples collected. All QAPP target values for laboratory completeness were exceeded except silver in vegetation (see Table 11-3). A detailed discussion of metals acceptability for completeness is provided in the SAIC third party data validation report provided in Appendix D. Completeness values are provided in Tables 11-1 through 11-3. Nitroglycerin (NG) was not analyzed for in vegetation samples due to the detection of NG in the soil samples being very limited. Therefore, we believe the lack of NG analysis in vegetation did not affect the overall results presented in the report.

11.1.4 Laboratory Representativeness and Comparability

Laboratory representativeness and comparability are assessed by ensuring that the proper analytical methods were used, by meeting the sample holding times, and analyzing and assessing field duplicate samples. The appropriate DLS personnel reviewed all data packages from contract and in-house laboratories and the methodology used was found to be identical or nearly identical to analytical methodology required by the JPG QAPP. The SAIC analytical data validation report discusses any missed sample holding times and their effect on the validity of the data (See Appendix D).

Laboratory representativeness is calculated as the RPD between the field duplicate samples (See JPG QAPP Section 1.8.5). The RPD between the field duplicate samples is also a measure of sampling precision. The sampling precision tables showing the RPD values between duplicate samples are provided in Sections 6 for ground waters, 7 for soils, and 10 for vegetation.

11.2 INTERNAL AUDIT AND ASSESSMENT REPORTS

All internal audit and assessment reports are provided in Appendix C.

11.3 THIRD PARTY DATA VALIDATION

The SAIC performed a data validation on 100% of the analytical data. The results of the data validation are provided in Appendix D.

APPENDIX A

GENERAL REFERENCES

1. U. S. Environmental Protection Agency Guidance for the Planning for Data Collection in Support of Environmental Decision-Making Using the Data Quality Objective Process, September 1994, EPA/600/R-96/055 (EPA QA/G-4).
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8. U.S. Army Corps of Engineers, Chemical Quality Assurance for HTRW Projects, EM-200-1-6. October 10, 1997. Web site: http://www.usace.army.mil/inet/usace-docs/eng-manuals/em.htm
9. U.S. EPA, National Enforcement Investigations Center (NEIC) Policies and Procedures, EPA-330/9-78-001-R, May 1978, Rev. December 1981. NTIS: 1-800-553-6847.
10. U.S. EPA, Guidance for the Data Quality Objectives Process, EPA/600/R-96/055, September 1994, (EPA QA/G-4). Web site: http://www.epa.gov/quality1/qa_docs.html
11. U.S. EPA, Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations, (EPA QA/G-6) EPA/600/R-96/027, November 1995.Web site: http://www.epa.gov/quality1/qa_docs.html
12. U.S. EPA, Guidance for the Data Quality Assessment Process: Practical Methods for Data Analysis, (EPA QA/G-9) EPA/600/R-96/084, January 1998. Web site: http://www.epa.gov/quality1/qa_docs.html
13. U.S. EPA, EPA Guidance for Quality Assurance Project Plans, (EPA QA/G-5) EPA/600/R-98/018, February 1998. Web site: http://www.epa.gov/quality1/qa_docs.html

14. U.S. EPA, EPA Requirements for Quality Assurance Project Plans, (EPA QA/R-5), November 1999. Web site: http://www.epa.gov/quality1/qa_docs.html

15. U.S. EPA, Region 9, Draft Laboratory Documentation Requirements for Data Validation, (9QA-07- 97) July 1997. Web site: http://www.epa.gov/region09/qa/rq_qadocs.html

16. Intergovernmental Data Quality Task Force, Uniform Federal Policy for Implementing Environmental Quality Systems: Evaluating, Assessing and Documenting Environmental Data Collection/Use and Technology Programs, Interim Final, Version 1, November 2000.

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18. Federal Register, Definition and Procedure for the Determination of Method Detection Limit. Code of Federal Regulations, Part 136, Appendix B, Oct. 26 (1984).

19. U.S. Army Corps of Engineers, Louisville District, Closure of Jefferson Proving Ground, Indiana and Realignment to Yuma Proving Ground, Arizona, Final Environmental Impact Statement, Volume 1 of 2, September 1991.

20. Greeman, Theodore K., Lineaments and Fracture Traces, Jennings County and Jefferson Proving Ground, Indiana, U. S. Geological Survey, Open-File

    Report 81-1120, Prepared in cooperation with the Indiana Department of Natural Resources and the U.S. Army, Jefferson Proving Ground, December 1981.

21. Tetra Tech NUS, Subpart X Permitting Support for Jefferson Proving Ground, Indiana, Preliminary Soil and Groundwater Analysis Report for the Open Burning (OB) Unit at Jefferson Proving Ground, Indiana, Volume I-Technical Evaluations, January 2000.

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JEFFERSON PROVING GROUND

URANIUM ANALYSIS
(Total & Isotopic)

GROUNDWATER SAMPLES (3)

WO 6363

JEFFERSON PROVING GROUND

URANIUM ANALYSIS
(Total & Isotopic)

FINAL REPORT

WO 6363

U.S. Army Center for Health Promotion and Preventive Medicine

04 NOV 2002

DIRECTORATE OF LABORATORY SCIENCES (DLS)
FINAL ANALYTICAL REPORT
PROGRAM 38 - SUBJONO: 8220
REPORT SERIAL NO. 128983
DLS PROFILE #: 27475 - WORK ORDER #: 6363
JEFFERSON PG

04-Nov-02

Tom
WRITER: SEB 11/4/02
CHIEF: 11/4/02
TEAM LEADER: 4 Nov 02
LOG OUT: SEB 11/4/02

Readiness Thru Health

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MARYLAND 21010-5422

REPLY TO
ATTENTION OF

MCHB- TS-LRD (40-5F)

DIRECTORATE OF LABORATORY SCIENCES (DLS)
RADIOLOGIC, CLASSIC & CLINICAL CHEMISTRY DIVISION
FINAL ANALYTICAL REPORT

04-Nov-02

CLIENT: Bridgett Lyons
Ground Water and Solid Waste

PROJECT SITE: JEFFERSON PG
PROGRAM 38 **SUBJONO:** 8220
DLS PROFILE #: 27475 **DLS WORK ORDER #:** 6363
REPORT SERIAL NUMBER: 128983

This report shall not be reproduced except in full without the written approval of DLS. The results relate only to the specific samples identified within the report. This report must not be used by the client to claim product endorsement by NVLAP or any agency of the US Government.

REPORT RELEASE AUTHORIZATION:

Signature: ______________________ **Date:** 4 Nov 02

AIHA
Industrial Hygiene
ACCREDITED
LABORATORY

A2LA
Certificate# 28.02

DLS HOLDS ACCREDITATION FROM AIHA, A2LA, NLLAP, AND COLA

Readiness thru Health

DLS Final Analytical Report, JEFFERSON PG
Program 38, SUBJONO 8220, DLS WO# 6363, Report Serial No. 128983, 11/4/2002

CASE NARRATIVE

1. Analytical Results.

a. The results of analyzing three water samples for total and isotopic uranium analysis, DLS Id numbers 6363001 through 6363003, are provided. The results for total Uranium are reported in ug/liter. The results of the ratios are reported with one sigma uncertainty; which is the uncertainty of repeated measurements at the instrument only.

b. The samples were prepared using EPA method 3020A, (Acid Digestion of Aqueous Samples for Determination of Total Metals By GFAA and ICP-MS). Sample 6363003 was prepared and analyzed in duplicate. A Pre-digestion spike and a pre-digestion spike duplicate was prepared and analyzed on sample 6363003.

c. The samples were analyzed by Determination of Uranium-238 and Isotopic Uranium Ratios by Inductively Coupled Plasma-Mass Spectrometry, method number U_006, on a Perkin-Elmer Elan 6000 Inductively Coupled Plasma Mass Spectrometer. A reporting limit of 0.1 microgram per liter was successfully analyzed at the instrument for all samples. The method detection limit for this method is 0.01 ug/liter but due to sample dilutions during analysis it was raised to 0.02 ug/liter.

d. The laboratory quality control report contains laboratory control sample, instrument spike, pre-digestion spike, pre-digestion spike duplicate and sample duplicate recovery values. All QC data were within the acceptance limits.

e. The isotopic uranium analysis was performed by correcting for mass discrimination with an isotopically certified standard (U005-A). This standard was periodically analyzed as a sample in order to verify accuracy and instrument stability. This data can be found in Table 3. The isotopic ratio data of the pre-digestion and post-digestion duplicates are in Table 1 and 2.

2. The reference for the theoretical value for the uranium-235/uranium-238 ratio, listed in table 3, is from National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY 11973.

3. Point of Contact. For additional information on profile number 27475-8220, work order 6363, is Mr. Ronald J. Swatski (410)436-8247.

List of the report contents:

Section	Number of Pages
Cover Sheet	1
Cover Letter	1
Case Narrative	2
Sample Summary	1
Analytical Data Report	1
Quality Control Data Report	6
Raw Data	0
Terminology/Abbreviations	1

Report Point-of-Contact: Thomas Beegle

Reviewer: ADC/RJS

List of all tests used:

DLS Final Analytical Report, JEFFERSON PG

Program 38, SUBJONO 8220, DLS WO# 6363, Report Serial No. 128983, 11/4/2002

DLS Procedure	Count
MET 44	9

Number of samples included in the report, by matrix:

Matrix	Quantity
Water (Ground water)	3

Analyst(s):

Analyst Code	Analyst Name	Signature
0007	BEEGLETE	

DLS Final Analytical Report, JEFFERSON PG

Program 38, SUBJONO 8220, DLS WO# 6363, Report Serial No. 128983, 11/4/2002

SAMPLE SUMMARY

Sorted by Field ID

Field ID	DLS ID	Date Collected	Matrix
MW-10	6363001	19-Sep-02	Water (Ground water)
MW-RS1	6363003	19-Sep-02	Water (Ground water)
MW-RS1 DISS	6363002	19-Sep-02	Water (Ground water)

DLS Final Analytical Report, JEFFERSON PG

Program 38, SUBJONO 8220, DLS WO# 6363, Report Serial No. 128983, 11/4/2002

ANALYTICAL DATA REPORT

(FORMAT OPTION 1)

Sorted by Field ID

Field ID: MW-10 **DLS ID:** 6363001

ANALYTE	RESULT/UNITS	METHOD REPORTING LIMIT	ANALYTICAL METHOD	ANALYST	DATE ANALYZED
Uranium, Total	2.42 ug/L	0.0200	MET 44	0007	28-Oct-02
Uranium, U235/U238 ratio	0.00720		MET 44	0007	28-Oct-02
Uranium Ratio Uncertainty	0.000100		MET 44	0007	28-Oct-02

Field ID: MW-RS1 **DLS ID:** 6363003

ANALYTE	RESULT/UNITS	METHOD REPORTING LIMIT	ANALYTICAL METHOD	ANALYST	DATE ANALYZED
Uranium, Total	3.28 ug/L	0.0200	MET 44	0007	28-Oct-02
Uranium, U235/U238 ratio	0.00724		MET 44	0007	28-Oct-02
Uranium Ratio Uncertainty	0.0000900		MET 44	0007	28-Oct-02

Field ID: MW-RS1 DISS **DLS ID:** 6363002

ANALYTE	RESULT/UNITS	METHOD REPORTING LIMIT	ANALYTICAL METHOD	ANALYST	DATE ANALYZED
Uranium, Total	3.30 ug/L	0.0200	MET 44	0007	28-Oct-02
Uranium, U235/U238 ratio	0.00720		MET 44	0007	28-Oct-02
Uranium Ratio Uncertainty	0.0000500		MET 44	0007	28-Oct-02

U.S. Army Center for Health Promotion and Preventive Medicine
Directorate of Laboratory Sciences
Aberdeen Proving Ground, MD 21010-5422

Quality Control Report

DLS Workorder:	6363
Installation:	Jefferson PG
Project Officer:	B.Lyons
Profile:	27475-8220

Laboratory Control Sample Report

DLS Workorder: 6363 **Installation:** Jefferson PG

Target	Date	Sample #	Matrix	Observed	Theoretical	Units	% Recovery	Analyst	Method
U	28-Oct-02	02URA4-3	GW	10.7	9.99	ug/L	107.1	TEB	In - House

Instrument Spike Sample Report

DLS Workorder: 6363 **Installation:** Jefferson PG

Target	Date	Sample #	Matrix	Initial Result	Sample Volume	Spike Solution Conc	Spike Volume	Spiked Result	Units	% Recovery	Analyst	Method
U	10/28/02	6363001	GW	1.21	10	1000	0.1	11.3	ug/L	102.0	TEB	In - House

Pre-digested Spike Sample Report

DLS Workorder: 6363 **Installation:** Jefferson PG

Target	Date	Sample #	Matrix	Initial Result	Spiked Result	Theoretical Spike Amount	Units	% Recovery	Analyst	Method
U	10/28/02	6363003	GW	3.28	13.58	9.99	ug/L	103.1	TEB	In - House
U	10/28/02	6363003	GW	3.28	13.58	9.99	ug/L	103.1	TEB	In - House

Duplicate Report

DLS Workorder: 6363 **Installation:** Jefferson PG

Target	Date	Sample #	Matrix	Initial Result	Duplicate Result	Units	RPD	Analyst	Method	Type *
U	10/28/02	6363001	GW	1.21	1.25	ug/L	3.25	TEB	In - House	I
U	10/28/02	6363003	GW	6.79	6.79	ug/L	0.00	TEB	In - House	S
U	10/28/02	6363003	GW	1.64	1.63	ug/L	0.61	TEB	In - House	P

*** Type of Duplicate**

I = Instrument

S = Predigested Spike

November 1, 2002

Isotopic Uranium
Quality Control Data

Table 1 Pre-digestion duplicate

Sample ID	Initial result	Duplicate
6363003	$(7.24+/-0.09) \times 10^{-3}$	$(7.13+/-0.07) \times 10^{-3}$
6363003MS/MSD	$(7.19+/-0.03) \times 10^{-3}$	$(7.24+/-0.04) \times 10^{-3}$

Table 2 Post-digestion duplicate

Sample ID	Initial result	Duplicate
6363001	$(7.20+/-0.10) \times 10^{-3}$	$(7.15+/-0.10) \times 10^{-3}$

Table 3

Quality Control Sample	Theoretical	Actual
U005-A	5.09×10^{-3}	$(5.10+/-0.03) \times 10^{-3}$
U005-A	5.09×10^{-3}	$(5.11+/-0.03) \times 10^{-3}$
U005-A	5.09×10^{-3}	$(5.10+/-0.03) \times 10^{-3}$
U005-A	5.09×10^{-3}	$(5.10+/-0.05) \times 10^{-3}$
02URA4-3	7.257×10^{-3}	$(7.24+/-0.02) \times 10^{-3}$
10 ppb Nat U	7.257×10^{-3}	$(7.27+/-0.04) \times 10^{-3}$

TERMINOLOGY/ABBREVIATIONS

Term	Description
A2LA	American Association for Laboratory Accreditation

CHAIN OF CUSTODY FORMS

CHAIN-OF-CUSTODY RECORD

The proponent of this form is the Directorate of Laboratory Sciences

INSTALLATION JPG PROJECT NO. 38-8220-02

PROJECT OFFICER Bridgett Lyons

PACKED BY See original Chain of Custody for packers

NOTE: For use of this form, see AEHA TG 155, or DLS SOP No. 5

SAMPLE PARAMETER

DATE SAMPLED	FIELD IDENTIFICATION NUMBER	LAB NUMBER	SAMPLE TYPE	COMP	GRAB	TOTAL NUMBER OF CONTAINERS	METALS	Hg	DISSOLVED METHALS	DISSOLVED Hg	NOTHING FOLLOWS
19 Sep 02	MW-RSI		GW			2	1	1			
19 Sep 02	MW-RSI (DISS)		GW			2			1	1	
18 Sep 02	MW10		GW			2	1	1			
	NOTHING FOLLOWS										
					TOTAL	6	2	2	1	1	

DATE SHIPPED 19 SEP 02 CARRIER USED FEDEX SEAL INTACT YES ☐ NO ☐

LAB NUMBER	RELINQUISHED BY	DATE/TIME	RECEIVED BY	DATE/TIME	COMMENTS
ALL		9-20-02 1035	See SML's COMMENTS		To SML's holding refrigerator in room#0202 for temporary stotage. BS 9-20-02
ALL	From SML's holding refrigerator.	9-23-02 1015	Zachary Chadwick	9-23-02 1015	
	Zachary Chadwick	9/23/02 1030	Room 2404	9/23/02 1030	

REMARKS *THIS CHAIN OF CUSTODY IS AN ADDENDUM TO THE CHAIN OF CUSTODY ORIGINALLY SUBMITTED TO SML ON 20 SEP 02*
This is SML's Internal COC

CHPPM FORM 235-R-E, 1 Jun 96 (MCHB-DC-LLI) Replaces AEHA Form 235-R, 1 JUN 93, which is obsolete.

SAMPLE INFORMATION

ANALYST NOTEBOOK PAGES

EXTRACTION LOGS

Report ID: HRA0021ACODE
Report Seq#: 127375

Page: 1 of 1
Run Date: 17-Oct-02 8:22

U.S. Army Center for Health Promotion and Preventive Medicine
Directorate of Laboratory Sciences
Aberdeen Proving Ground, MD 21010-5403

Buckslip (Sample Receipt) with Acodes

Uranium analysis
added per Tom
Beegle. HW 10/17/02

Reviewed by: Judy Taylor (Signature of Sample Clerk) **Date Reviewed:** 10/17/02

Received by: (Signature) **Date Received:** 10/17/02

Profile: 27475 - 8220
Workorder #: 6363
Queue: RAD
Location: JEFFERSON PG
Jono: 27HR6E **Subjono:** 8220

Description: JPG (range study) -Lyons
Workorder ID: 8220263
Date Received: 20-Sep-2002
Customer: Program 38
POC: Bridgett Lyons

HSN	Container ID	Customer Sample ID	Matrix - Description	Date Collected	Sample Due Date
6363001	6363001-1	MW-10	GW Water (Ground water)	19-Sep-2002 10:20	04-Nov-200
	Acodes:				
	RAD1456	- Uranium, Total			
	RAD1479W	- Uranium,235/238Ratio			
6363002	6363002-1	MW-RS1 DISS	GW Water (Ground water)	19-Sep-2002 10:40	04-Nov-200
	Acodes:				
	RAD1456	- Uranium, Total			
	RAD1479W	- Uranium,235/238Ratio			
6363003	6363003-1	MW-RS1	GW Water (Ground water)	19-Sep-2002 10:15	04-Nov-200
	Acodes:				
	RAD1456	- Uranium, Total			
	RAD1479W	- Uranium,235/238Ratio			

Total Samples Received: 3

Total Containers Received: 3

Beegle, Thomas E Mr USACHPPM

From: CHPPM AME Automailer [chppm-sampnews@apg.amedd.army.mil]
Sent: Tuesday, August 06, 2002 5:13 PM
To: fred.belkin@apg.amedd.army.mil; geraldine.miles@apg.amedd.army.mil; chppm-sampnews@apg.amedd.army.mil; eric.rustine@apg.amedd.army.mil
Cc: bridgett.lyons@apg.amedd.army.mil
Subject: 330RE - Jefferson Proving Ground (#1033.001)

Order Confirmation #1033.001

REQUEST FOR LABORATORY SERVICES

See CHPPM TG214 for instructions on completing this form

PART I: PROJECT INFORMATION

PLEASE PRINT OR TYPE ALL REQUESTED INFORMATION

*DATA FIELD = required input

1. DATE OF REQUEST: 8/6/2002 5:12:59 P

2. *PROGRAM NUMBER: 38

3. *JONO: 27HR6E

4. *SUBJONO: 38MA8220

5. *PROJECT OFFICER (s): B. Lyons

6. *TELEPHONE: 410 436-7846

7. *Was this project coordinated with DLS? ● YES ○ NO

8. DLS TECHNICAL CONSULTANT: Valis

9. *FUND SOURCE: ○ P84 ○ CONTINGENCY ● OTHER REIMBURSABLE *(specify)*: AEC Range Studies

10. *DATE SAMPLES TO ARRIVE AT DLS: 19-27 September 2002

Note: Prior arrangements must be made with SML for samples that will arrive outside of routine duty hours which are M-F 0730-1700)

11. PROJECT INSTALLATION: Jefferson Proving Ground

12. INSTALLATION LOCATION (STATE): IN

13. PROJECT NAME: JPG Range Study

PART II: ANALYSIS REQUESTED

1. PROJECT DESCRIPTION/OBJECTIVE:

Determine if munitions have contaminated ground water.

2. SAMPLE OR SITE HISTORY (High toxicity, etc.):

`JPG was used to test weapon systems from WWII until 1994.`

****Project officer is not required to use the following table; customized spreadsheet/table may be attached.****

ACODE/DLS TEST CODE	ANALYTICAL METHOD DESCRIPTION	STD METHOD	MATRIX	SAMPLE COUNT	COMMENTS/SPECIAL REQUES (.g. Blanks, Extra Containers, Forms, etc.)
671	Arsenic (As)	EPA 200.8	Water (Ground water)	21	
1632	Explosives in Water (GC-ECD)	CAD 13	Water (Ground water)	21	
656	Hardness-Calc, Ca, Mg	SM 2340B	Water (Ground water)	21	
397	Magnesium (Mg)	EPA 200.7 Analysis	Water (Ground water)	21	
401W	Mercury (Hg)	EPA 245.1 Analysis	Water (Ground water)	21	
1543	Met-Ultra Trace Level	EPA 200.8	Water (Ground water)	21	

*List additional analyses on last page - Are there additional analysis pages ● YES ○ NO

PART III: TURNAROUND REQUEST TIME

1. *INDICATE SAMPLE OR PROJECT TAT PRIORITY:

● *Standard (29 Days)*
○ *High-Priority (14 days)*
○ *Top-Priority (7 days)*

2. *DATE RESULTS REQUIRED: 4 November 2002

****Note****

TAT is calculated with calendar days from the date of sample receipt. All samples are routinely processed as STANDARD analysis. High-Priority and Top Priority requests should be coordinated with DLS and are subject to cost surcharges.

PART IV: PROJECT COORDINATION INFORMATION

1. *ARE SAMPLNG KITS/SUPPLIES NEEDED? ● YES (Complete Item 2) ○ NO (Skip to Item 3)

2. *DATE SAMPLING KIT/SUPPLIES REQUIRED: 10 September 2002

3. *EXPECTED # OF SHIPMENTS: 6
(For preparation of blanks)

a. KIT HANDLING PREFERENCE:

● PICK-UP at DLS by project officer

○ SHIP TO: (Please provide address in box below)

Shipping Address: (include Bldg# and Phone#)

b. Number of coolers requested: 0

4. SPECIAL HANDLING REQUIREMENTS:

☑ CHAIN-OF-CUSTODY (COC)

☐ SAFETY CONSIDERATION/HAZARDOUS MAT (Specify):

☐ ANALYSES WITH SHORT HOLDING TIMES (Li Specific Analyses):

☐ OTHER (Specify):

PART V: REPORT DELIVERY OPTIONS

1. *<u>DELIVERY RESULTS BY</u>: *(Indicate preference **A hard copy will be furnished in all cases**)*

● ELECTRONIC DATA DELIVERABLE (EDD):

○ FAX TO:

○ MAIL TO:

2. EDD DATA TYPE:

● Excel

○ Access

○ Other:

2. *REQUEST SUBMITTED BY:
B. Lyons

3. PRINT NAME:

4. SIGNATUR

(Note: Signature Required if Submitted by Hard Copy)

FOR DLS USE ONLY

Date Rec'd:

Expiration:

Profile #:

Processor Initials & Date:

Work Order #:

Processor Initials & Date:

DLS Laboratory Team Responses:

RAD		MET		EXP	
ASB		GCMS		IH	
CLS		PES		CDT	

Date Sample Kit Completed:

Date Sample Kit Shipped/Picked Up:

Quote Completed:		Sent:		Quote Report #:	
Invoice Completed:		Sent:		Invoice Report #:	

Notes:

ANALYSIS REQUESTED Continued					
ACODE/DLS TEST CODE	**ANALYTICAL METHOD DESCRIPTION**	**STD METHOD**	**MATRIX**	**SAMPLE COUNT**	**COMMENTS/SPECIAL RI** **(.g. Blanks, Extra Containers, Forms, e**
683	Molybdenum (Mo)	EPA 200.8	Water (Ground water)	21	
2103	Perchlorate	EPA 314.0	Water (Ground water)	21	
1583	Total Dissolved Solids (TDS)	EPA 160.1	Water (Ground water)	21	
1479W	Uranium,235/238Ratio	MET 44	Water (Ground water)	21	
714	Vanadium (V)	EPA 200.8	Water (Ground water)	21	

6363 dn.mdb

Laboratory Control Sample Report

Workorder: 6363

Element	Date	Sample #	Matrix	Observed	Theoretical	Units	% Recovery	Analyst	Method
U	10/28/02	02URA4-3	GW	10.7	9.99	ug/L	107.1	TEB	In - House

Duplicate Report

Workorder: 6363

Element	Date	Sample #	Matrix	Initial Result	Duplicate Result	Units	RPD	Analyst	Method	Type *
U	10/28/02	6363001	GW	1.21	1.25	ug/L	3.25	TEB	In - House	I
U	↓	6363003	↓	6.79	6.79	ug/L	0.00	↓	↓	S
U	10/28/02	6363003	GW	1.64	1.63	ug/L	0.61	TEB	In - House	P

*** Type of Duplicate**

I = Instrument

P = Predigested/Matrix

S = Spiked

Instrument Spike Sample Report

Workorder: 6363

Element	Date	Sample #	Matrix	Initial Result	Sample Volume	Spike Solution Conc	Spike Volume	Spiked Result	Units	% Recovery	Analyst	Method
U	10/28/02	6363001	GW	1.21	10	1000	0.1	11.3	ug/L	102.0	TEB	In - House
~~U~~	~~10/28/02~~	~~6363003~~	~~GW~~	~~1.64~~	~~10~~	~~1000~~	~~0.1~~		~~ug/L~~		~~TEB~~	~~In - House~~

Matrix Spike Sample Report

Workorder:

Element	Date	Sample #	Matrix	Initial Result	Spiked Result	Theoretical Amount	Units	% Recovery	Analyst	Method
U	↑	6363003	↑	3.28	13.58	9.99	ug/L	103.1	↑	↑
U	10/28/02	6363001	GW	1.21		9.99	ug/L		TEB	In - House
U	10/28/02	6363003	GW	3.28	13.58	9.99	ug/L	103.1	TEB	In - House

TABLE 1-13. METALS AND INORGANICS ANALYTE LIST, ANALYTICAL METHOD, REPORTING LIMITS, AND EPA HEALTH ADVISORIES FOR GROUND WATER

ANALTYE	ANALYTICAL METHOD	LABORATORY SOP	PERFORMING LABORATORY	MRI (ug/L)	CURRENT DRINKING WATER STANDARDS[1]	
					MCL (ug/L)	SECONDARY STANDARDS
Antimony	EPA 200.8	MET 21.X	USACHPPM-ASD	5	6	N/A
Arsenic	EPA 200.8	MET 21.X	USACHPPM-ASD	4	10	N/A
Barium	EPA 200.8	MET 21.X	USACHPPM-ASD	5	2000	N/A
Cadmium	EPA 200.8	MET 21.X	USACHPPM-ASD	2	5	N/A
Calcium	EPA 200.7	MET 41.X	USACHPPM-ASD	100	N/A	N/A
Chromium	EPA 200.8	MET 21.X	USACHPPM-ASD	4	100	N/A
Copper	EPA 200.8	MET 21.X	USACHPPM-ASD	5	N/A	1000
Lead	EPA 200.8	MET 21.X	USACHPPM-ASD	4	15	N/A
Manganese	EPA 200.8	MET 21.X	USACHPPM-ASD	4	N/A	50
Magnesium	EPA 200.7	MET 41.X	USACHPPM-ASD	N/A	N/A	N/A
Mercury	EPA 245.1	MET 17.X	USACHPPM-ASD	0.2	2	N/A
Molybdenum	EPA 200.8	MET 21.X	USACHPPM-ASD	4	N/A	N/A
Nickel	EPA 200.8	MET 21.X	USACHPPM-ASD	10	N/A	N/A
Silver	EPA 200.8	MET 21.X	USACHPPM-ASD	2	N/A	100
Vanadium	EPA 200.8	MET 21.X	USACHPPM-ASD	5	N/A	N/A
Uranium	EPA 6020	RAD U_006.0	USACHPPM-RCCCD	20*	N/A	N/A
OTHER INORGANICS						
Perchlorate	EPA 314.0	IC-EP314.0	DATACHEM	2	N/A	N/A
Hardness	SM2340B	656	USACHPPM ASD	N/A	N/A	N/A
TDS.	EPA 160.1	GR-07-101	TriMatrix	25,000	N/A	N/A
Conductivity	Field	N/A	USACHPPM DEHE	None	N/A	N/A
DO	Field	N/A	USACHPPM DEHE	None	N/A	N/A
PH	Field	N/A	USACHPPM DEHE	None	N/A	N/A
Temperature	Field	N/A	USACHPPM DEHE	None	N/A	N/A
Turbidity	Field	N/A	USACHPPM DEHE	None	N/A	N/A

DO – Dissolved oxygen
MRL - Method Reporting Limit
N/A – Not Available
TDS – Total Dissolved Solids
MCL is for uranium and will be changed to 30 µg/L effective 8 December 2003.

Metals samples preparation - EPA 200.2

[1] Internet Web Page http://www.epa/safewater/mcl.html

and analysis of a daily low-level (at the MRL) concentration standard or by analysis of Laboratory Fortified Blanks (LFBs). An LFB is a blank matrix that is spiked at the MRL with all of the contaminants of concern. Sensitivity will be evaluated by calculating the percent recovery of the analytes at the MRL.

Analyte-specific and method-specific measurement performance criteria, where applicable, can be found in Appendix E. QA/QC activities and/or QC checks or samples that will be performed or analyzed to measure sensitivity are also identified in the appropriate tables in Section 1.

9.11.7 Quantitation Limits

MRLs for the potential energetic and metal contaminants of concern are provided for the various sample matrices in appropriate tables of section 1. These MRLs are based on performance of a yearly Method Detection Level (MDL) study in the USACHPPM DLS for each analytical procedure. MRLs are set at a level approximately 3-10 times the experimentally determined yearly MDL values. In addition the MRL must be at or above the level of the lowest calibration standard. Any results below the lowest calibration standard must be reported as estimated values. MRLs are also compared for adequacy to applicable human health screening values, advisories, and/or standards.

9.12 LABORATORY QUALITY ASSURANCE OBJECTIVES TABLE

TABLE 9-1. ANALYTICAL LABORATORY PERFORMANCE CRITERIA

PARAMETER	QA/QC CRITERIA		
	PRECISION (RPD)	ACCURACY (%R)	COMPLETENESS
SOIL			
Explosives	<50%	50-150	95%
Metals	<50%	50-150	95%
Perchlorate	<50%	50-150	95%
SURFACE WATER			
Explosives	<30%	70-130	95%
White Phosphorus	<30%	70-130	95%
Metals	<30%	70-130	95%
Perchlorate	<30%	70-130	95%
TOC	<30%	70-130	95%
SEDIMENT			
Explosives	<50%	50-150	95%
White Phosphorus	<50%	50-150	95%
Metals	<50%	50-150	95%
Perchlorate	<50%	50-150	95%
TOM	<50%	50-150	95%

GROUND WATER			
Explosives	<30%	70-130	95%
Metals	<30%	70-130	95%
Perchlorate	<30%	70-130	95%
TDS	<30%	70-130	95%
VEGETAION #1			
Explosives	<50%*	50-150*	95%
Metals	<50%	50-150	95%
VEGETATION #2			
Explosives	<50%*	50-150*	95%
Metals	<50%	50-150	95%

* - In a recent similar site investigation, several target explosives were incompletely recovered, as follows: tetryl= 0-47%, RDX = 12-84%, 1,3,5-TNB = 5-96%, and NB = 40-74%. It is likely that recoveries in JPG vegetation will fall outside the 50-150% criteria in some instances.

REVIEWER CHECKLIST   EFFECTIVE 09-JUL-99

JOB# 6363   INSTALLATION Jefferson P.G.

SECONDARY REVIEWER

C. Report:

- ✓ Were all requirements on the customer's analytical request form met?
- ✓ Are the requested reporting limits met?
- ✓ Are all the samples included in the report?
- ✓ Correct units reported?
- ✓ Spot check calculations, when needed.
- ✓ Is the report narrative clear and correct, (detailing pertinent QC, any difficulties encountered in performing the analysis, and a brief summation of the results) ?
- ✓ All sections of final report complete including QC report and Change of Custody(if applicable)?
- ✓ If any corrections are needed, complete now and inform the initial reviewer.
- ✓ Take to Division chief for signature and review. If any changes are needed, complete now and inform initial reviewer.
- ✓ Get analyst's signatures for the report.
- ____ Take report downstairs to LISM for date stamp.
- ____ Complete DLS Project folder checklist and return file folder to Admin office.

4 Nov 02

FINAL REVIEWER/TITLE

ASD FORM 33.3 (3/22/01)

ANALYSIS REVIEWER CHECKLIST EFFECTIVE 24-JUNE-99

JOB# 6363

INSTALLATION JPG

INSTRUMENT ICP-MS

METHOD U-006.

INITIAL REVIEWER

A. Procedure:

✓ Were there any deviations from the customer's request and/or from requested methods ?
N/A Did samples meet holding times criteria? (180 days for metals/ 28 days for Hg)
✓ Samples preserved accordingly? Soils (4^{O} C) / Waters (pH < 2)

B. Data:

✓ Reviewed analysts' checklists?
See Comment Are the analysts' narratives clear and correct, (detailing pertinent QC, ICV/CCV, ICB/CCB, ICSA/AB, acceptable corr. coeff., or any other difficulties encountered in performing the analysis) ? — Terse correction needed in text
✓ Was a standard corresponding to the reporting limits run?
✓ All samples within calibration range or was the LDR checked at the appropriate level? Is the RPD between values of undiluted and diluted aliquots acceptable?
✓ Frequency of quality control, duplicates, spikes, and blanks was met?
✓ QC samples recovered within acceptable limits?
✓ Calculations correct? (ensure that correct final volumes, dilution/correction factors are used).
✓ Review raw data. Document any discrepancies.
✓ View data in the LIMS.
No Release batch in LIMS.
✓ Produce QC report from Access Table. (See "SOP# MET 25.2")
N/A Prepare Case Narrative which includes information provided by the analysts on the individual narratives. The Case Narrative must also include the reporting units, number of samples received, date when samples were received, every procedure performed on the samples, the analytes measured, and any information or documentation essential to the quality and satisfactory completion of the project.
N/A Generate LIMS Report, assemble and include a copy of the chain of custody.
N/A Copy Case Narrative on LIMS Report.
N/A Make copy of narrative for QCC if outliers were reported.
N/A Complete DLS Project folder checklist and return file folder to Admin office.
✓ Pass to 2ry reviewer.

REVIEWER/TITLE/DATE

- Chemist
01 Nov 2002

ASD FORM 16.7(10/10/02)

ANALYST CHECKLIST

EFFECTIVE 21-MAY-99

Job# 6363 *Installation* JBG

✓ QC assigned if analyzing samples that were not digested. See SOP# MET 25.2

✓ Method of choice has been followed correctly (ICV, CCV, ICSA/ICSAB, ICB, CCB, appropriate spikes, and dilution tests, ICS and CCB every 10 samples, proper # of calibration standards, etc.). Follow run-log, any deviations, please list. Record % recovery of ICV/CCV, ICSAB, and all other QC on raw data. Also, record dilution factors and how post spike is prepared on raw data.

✓ Most appropriate wavelength / mass used?

✓ Quality controls (CCV, CCB, SICSAB, duplicates, pre/post spikes, LCS/LFB) are within acceptable ranges. Respond to out of control situations. Document in raw data and case narrative what corrective action was taken. .

✓ Examine blank for contamination. Notify team leader if high.

✓ Run reporting limits every analysis.

✓ If samples are out of calibration range, dilute to bring in range or run high standard to determine linear dynamic range. Check %RPD between values of undiluted sample and diluted sample (RPD must be within 10% for values under LDR).

✓ High-lite reported results on raw data (**only results being reported**). If needed to rerun samples, give explanation on raw data for reason why.

✓ Printouts: initial, job number, installation, method (s) used, samples included, and instrument on first page and sign and date last page.

✓ Enter data and quality control into access software.

✓ Print "LIMS entry data and Quality Control data" from access input.

N/A Save Quality Control data on p:\acp\qcaccess drive (See "SOP # MET 25.2")

✓ Spot check calculations.

N/A Update standard preparation logbook, instrument maintenance logbook, and other appropriate logbooks as needed (pipet, balance). Whenever standards (i.e. internal standard, and calibration solutions or reagents (i.e. standard dilution) are prepared be sure to include in logbook the manufacturer, lot number, and how prepared.

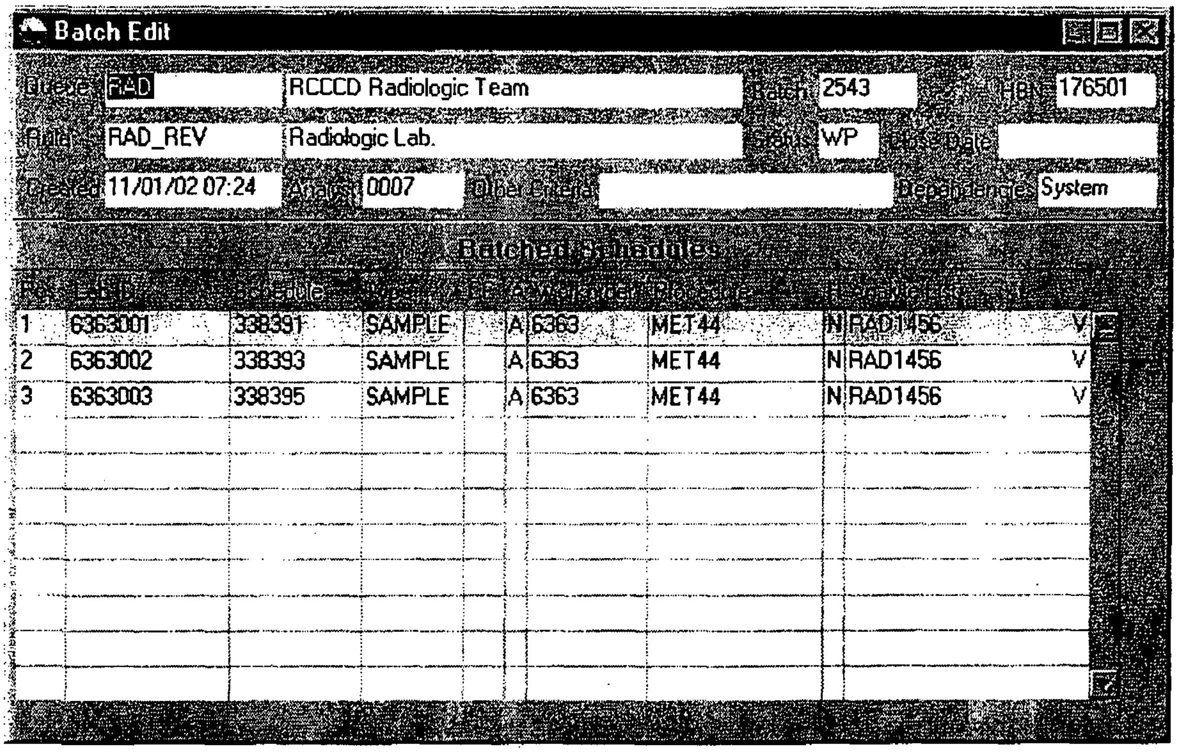
✓ Case narrative has been completed. (See p:\ drive of "word",acp\narrativ\form17.doc). Narrative is to include: 1) installation and job #, 2) sample numbers, 3) matrix, 4)deviations, if any, 5) if **drinking water**, indicate if MCL has been exceeded and if reporting limits are below MCL. If dilutions are needed, notify team leader first 6) list any QC failures and corrective action done, 7) sign narrative and include title.

✓ Turn in to team leader: 1) raw data (photocopies of all pertinent data if more than one job is analyzed on the same run), 2) Photocopies of all pertinent standard/reagent log-book(s) entries in the rep 2) acess LIMS data, 3) access QC data, 4) case narrative.

Chemist
Analyst/Title

11/1/02
Date

ASD FORM 15.4



Queue: RAD — RCCCD Radiologic Team
Batch: 2543
HBN: 176501
Role: RAD_REV — Radiologic Lab.
Status: WP
Close Date:
Created: 11/01/02 07:24
Analyst: 0007
Other Criteria:
Dependencies: System

Batched Schedules

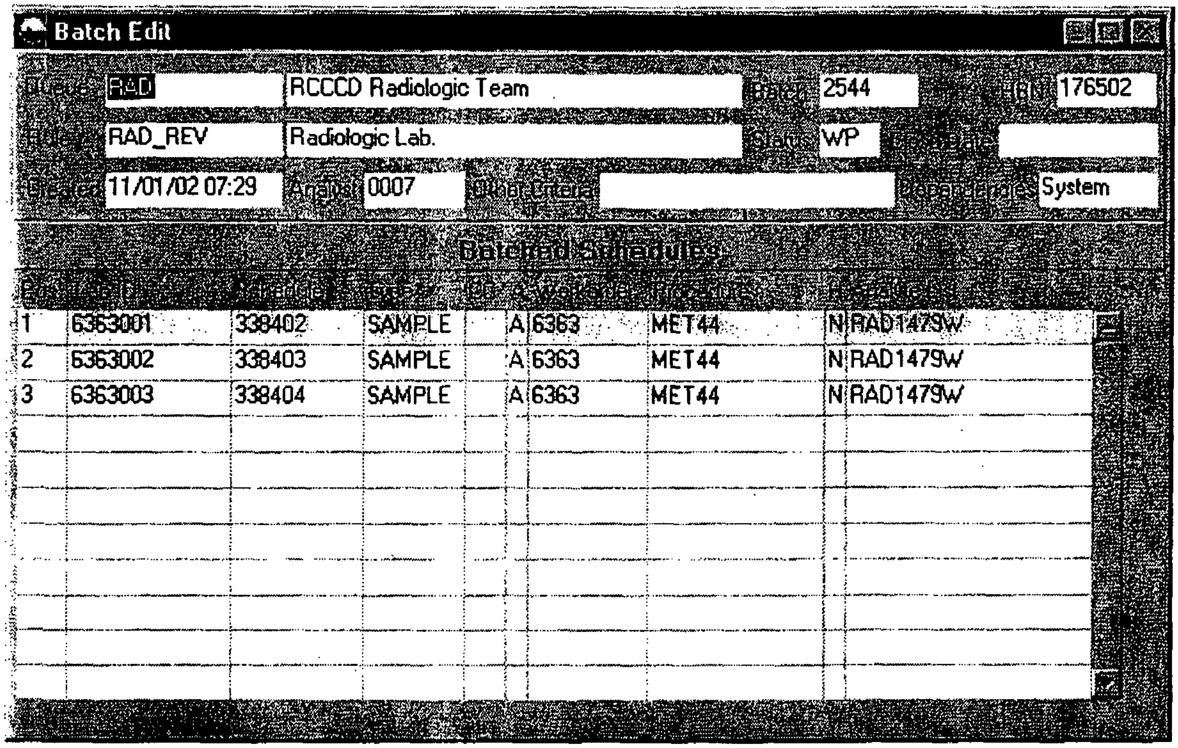
Pos	Lab ID	Schedule	Type	[illegible]	A	Workorder	Procedure	H	[illegible]	
1	6363001	338391	SAMPLE		A	6363	MET44	N	RAD1456	V
2	6363002	338393	SAMPLE		A	6363	MET44	N	RAD1456	V
3	6363003	338395	SAMPLE		A	6363	MET44	N	RAD1456	V

11/1/02

D.

11/01/02

all [illegible]



Batch Edit

Queue: RAD — RCCCD Radiologic Team
Batch: 2544
176502

Holder: RAD_REV — Radiologic Lab.
Status: WP

Created: 11/01/02 07:29
Analyst: 0007
Other Criteria:
Dependencies: System

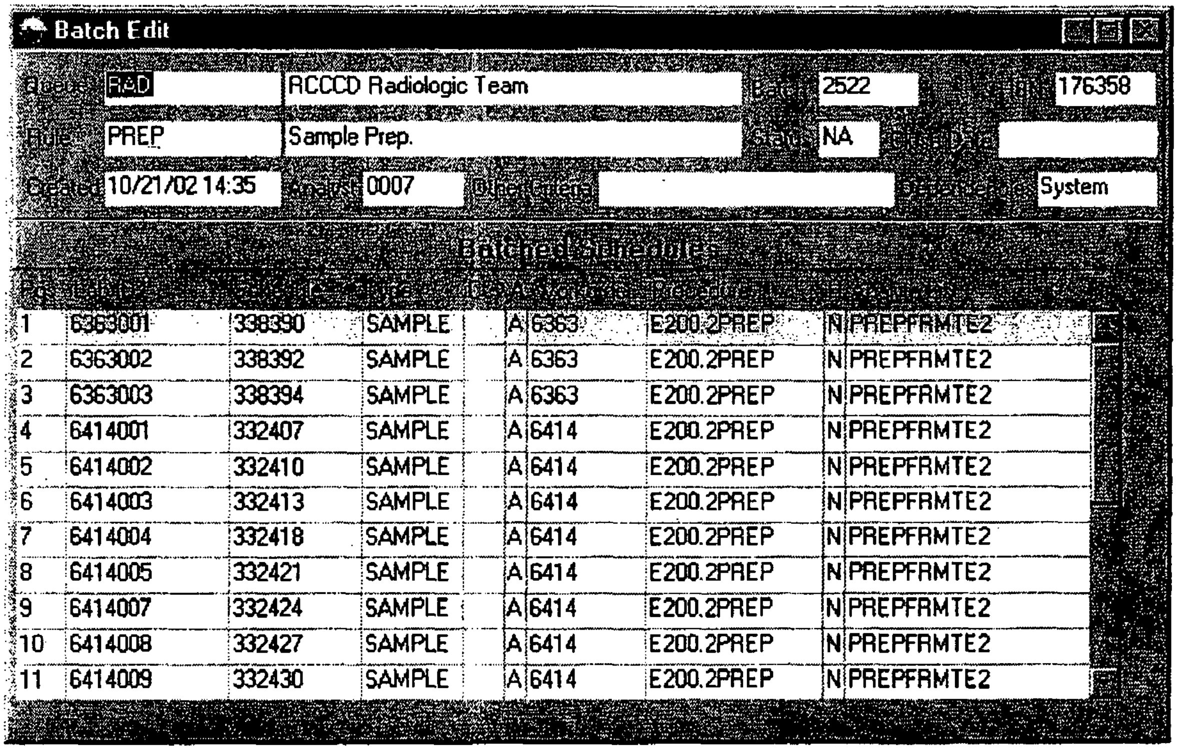
Batched Schedules

1	6363001	338402	SAMPLE		A	6363	MET44	N	RAD1479W
2	6363002	338403	SAMPLE		A	6363	MET44	N	RAD1479W
3	6363003	338404	SAMPLE		A	6363	MET44	N	RAD1479W

0

11/1/02

11/01/02



Batch Edit

Queue RAD RCCCD Radiologic Team Batch 2522 176358

Rule PREP Sample Prep. Status NA

Created 10/21/02 14:35 Analyst 0007 Other Criteria System

Batched Schedules

1	6363001	338390	SAMPLE		A	6363	E200.2PREP	N	PREPFRMTE2
2	6363002	338392	SAMPLE		A	6363	E200.2PREP	N	PREPFRMTE2
3	6363003	338394	SAMPLE		A	6363	E200.2PREP	N	PREPFRMTE2
4	6414001	332407	SAMPLE		A	6414	E200.2PREP	N	PREPFRMTE2
5	6414002	332410	SAMPLE		A	6414	E200.2PREP	N	PREPFRMTE2
6	6414003	332413	SAMPLE		A	6414	E200.2PREP	N	PREPFRMTE2
7	6414004	332418	SAMPLE		A	6414	E200.2PREP	N	PREPFRMTE2
8	6414005	332421	SAMPLE		A	6414	E200.2PREP	N	PREPFRMTE2
9	6414007	332424	SAMPLE		A	6414	E200.2PREP	N	PREPFRMTE2
10	6414008	332427	SAMPLE		A	6414	E200.2PREP	N	PREPFRMTE2
11	6414009	332430	SAMPLE		A	6414	E200.2PREP	N	PREPFRMTE2

EB
11/1/02

All
4 [illegible]

Project No.
Book No. TITLE

From Page No.

28 Oct 02

Title: ICP-MS U in Water JPG

Profile #: 27475-8220 WO #: 6363

Method #: U_006.000

Changed pump tubing. Ignited plasma and allowed the instrument to warm-up for one hour. Performed instrument tune, optimization and auto lens calibration. Ran the daily performance check. All values were above specifications such that the instrument was approved for use.

Prepared calibration curve of 0, 0.1, 1, 10, and 20 ppb uranium from High Purity Uranium solution (Lot # 127813, Exp Jan 04) in 2% nitric acid. Prepared independent calibration verification from ~~NIST 3164~~ (RE 10/28/02) NIST 3164 (Lot # 791402) at a concentration of 9.99 ppb in 2% nitric acid. Will use the 0.1 ppb standard as the PQL. Prepared 40 ppb LDR calibration verification. Samples will be analyzed at a two (2) fold dilution. Prepared 6363001 as an instrument duplicate and instrument spike. The instrument spike contained 100 µl of 1 ppm uranium solution. All samples/standards were internally spiked with 100 ppb solution of Ho, Rh and Ir (SEB 10/22/02) added by peristaltic pump. There were no incidents or deviation from the expected norm. Replicate was worked without modifications required.

Samples were also analyzed for isotopic ratios. Prepared calibration standard U-005A at a concentration of 10 ppb from 100 ppm stock solution (7Apr98). This standard has a true ratio of 5.09×10^{-3} and will be used for calibration and re-analyzed every fifth sample to ensure instrument stability. The sample dilutions from the concentration analysis will be re-analyzed for this analysis. A 10 ppb Nat Uranium solution will also analyzed as part of the QA package. There were no incidents or deviations from the expected norm. The results from both analyses are calculated here.

$ICV = \frac{9.12\,ppb}{9.99\,ppb} \times 100 = 91.3\%$ $CCV_1 = \frac{9.06\,ppb}{9.99\,ppb} \times 100 = 90.7\%$ $CCV_2 = \frac{10.1\,ppb}{9.99\,ppb} \times 100 = 101.1\%$

$0.1\,ppb\ PQL = \frac{0.0983}{0.1} \times 100 = 98.3\%$ $40\,ppb\ LDR = \frac{40.7\,ppb}{40\,ppb} \times 100 = 101.8\%$

LCS3 = $\frac{10.7\,ppb}{9.99\,ppb} \times 100 = 107.1\%$
02URA4-3

Instrument Spike:

$6363001\ IS = \frac{11.3\,ppb(10.1) - 1.21\,ppb(10)}{1000\,ppb(0.1)} \times 100 = 102\%$

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by	10/28/02

From Page No.___

Matrix Spike

6363003MS = $\frac{6.79\,ppb\left(\frac{10\,mls}{5\,mls}\right) - 1.64\,ppb\left(\frac{10\,mls}{5\,mls}\right)}{9.99\,ppb} \times 100 = \frac{10.3\,ppb}{9.99\,ppb} \times 100 = 103.1\%$

6363003MSD = $\frac{6.79\,ppb\left(\frac{10\,mls}{5\,mls}\right) - 1.64\,ppb\left(\frac{10\,mls}{5\,mls}\right)}{9.99\,ppb} \times 100 = \frac{10.3\,ppb}{9.99\,ppb} \times 100 = 103.1\%$

Duplicates

6363003Dup = $\frac{|1.64 - 1.63|}{1.635} \times 100 = 0.6\%$ 6363001ID = $\frac{|1.21 - 1.25|}{1.23} \times 100 = 3.3\%$

6363003MS/MSD = $\frac{|6.79 - 6.79|}{6.79} \times 100 = 0\%$

6363001 = $1.21\,\mu g/L \times \frac{10\,mls}{5\,mls} \times \frac{0.1L}{0.1L} = 2.42\,\mu g/L$ Batch #: 2543

6363002 = $1.65\,\mu g/L \times \frac{10\,mls}{5\,mls} \times \frac{0.1L}{0.1L} = 3.3\,\mu g/L$

6363003 = $1.64\,\mu g/L \times \frac{10\,ml}{5\,mls} \times \frac{0.1L}{0.1L} = 3.28\,\mu g/L$

Reagent Blk = 10.829%	$(6.68 \pm 0.72) \times 10^{-3}$	U005A Std
LCS3 = 0.208%	$(7.24 \pm 0.02) \times 10^{-3}$	$(5.10 \pm 0.03) \times 10^{-3}$
6363001 = 1.326%	$(7.20 \pm 0.10) \times 10^{-3}$	$(5.11 \pm 0.03) \times 10^{-3}$
6363001ID = 1.337%	$(7.15 \pm 0.10) \times 10^{-3}$	$(5.10 \pm 0.03) \times 10^{-3}$
6363001IS = 0.586%	$(7.26 \pm 0.04) \times 10^{-3}$	$(5.10 \pm 0.05) \times 10^{-3}$
6363002 = 0.703%	$(7.20 \pm 0.05) \times 10^{-3}$	
6363003 = 1.238%	$(7.24 \pm 0.09) \times 10^{-3}$	Batch #: 2544
6363003Dup = 0.953%	$(7.13 \pm 0.07) \times 10^{-3}$	
6363003MS = 0.421%	$(7.14 \pm 0.03) \times 10^{-3}$	Results were entered into the LIMS
6363003MSD = 0.553%	$(7.24 \pm 0.04) \times 10^{-3}$	and submitted for review.
10 ppb Nat U = 0.536%	$(7.27 \pm 0.04) \times 10^{-3}$	

EBengl 10/29/02

29 Oct 02

Title ICP+MS U in Water JPG

Profile #: 27475-8220 WO #: 6414

Method #: U-006.000

Changed pump tubing. Ignited the plasma and allowed the instrument to warm up for one hour. Performed instrument tune, optimization and auto lens calibration. Ran the daily performance check. All values were above specifications such that that the instrument was approved for use.

Prepared calibration curve of 0, 0.1, 1, 10 and 20 ppb uranium from High Purity Uranium Solution (Lot # 127813, Exp Jan 04) in 2% nitric acid. Prepared independent calibration verification from NIST 3164 (Lot # 791402) at a concentration of 9.99 ppb in

To Page No.___

Witnessed & Understood by me,	Date	Invented by EBengl	Date
		Recorded by	10/28/02

JEFFERSON PROVING GROUND

URANIUM BY ICP/MS ANALYSIS
(Total & Isotopic)
Uranium 235
Uranium 238

GROUNDWATER SAMPLES (3)

WO 6363

Jefferson PG
Profile # 27475-8220
WO#: 6363
Batch #: 2544
11/1/02

Sample Information

Sample Date/Time: Monday, October 28, 2002 13:11:58
Sample ID: Blank

Replicates

Repeat 1

	MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
>	238U	66.007		
	235U	7.600		

Repeat 2

	MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
>	238U	64.607		
	235U	8.533		

Repeat 3

	MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
>	238U	72.207		
	235U	8.200		

Repeat 4

	MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
>	238U	68.607		
	235U	8.200		

Repeat 5

	MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
>	238U	67.807		
	235U	8.667		

Repeat 6

	MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
>	238U	73.007		
	235U	6.933		

Repeat 7

	MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
>	238U	64.407		
	235U	7.733		

Summary

Net Intens. Mean	Net Intens. RSD	Ratio (Norm Mean)	Ratio (Norm RSD)

```
    Sample Information
    Sample Date/Time: Monday, October 28, 2002 13:16:41
    Sample ID: Standard
    Replicates
    Repeat 1
   MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>   238U               402925.940       402857.847
    235U                 2078.751         2070.770
    Repeat 2
   MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>   238U               400963.888       400895.795
    235U                 2078.418         2070.437
    Repeat 3
   MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>   238U               403269.053       403200.961
    235U                 2124.825         2116.844
    Repeat 4
   MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>   238U               403073.222       403005.130
    235U                 2075.951         2067.970
    Repeat 5
   MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>   238U               408946.422       408878.329
    235U                 2102.888         2094.907
    Repeat 6
   MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
[>  238U               408166.099       408098.007
L   235U                 2129.292         2121.311
    Repeat 7
   MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
[>  238U               405973.313       405905.221
L   235U                 2145.561         2137.580
    Summary
    Net Intens. Mean    Net Intens. RSD    Ratio (Norm Mean)    Ratio (Norm RSD)
       404691.613             0.737
         2097.117             1.359
```

```
   Sample Information
   Sample Date/Time: Monday, October 28, 2002 13:21:25
   Sample ID: U005-A
   Replicates
   Repeat 1
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>   238U                401603.752       401535.659     1.000e+000
    235U                  2107.422         2099.441     5.136e-003
   Repeat 2
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>   238U                404269.848       404201.756     1.000e+000
    235U                  2095.620         2087.639     5.073e-003
   Repeat 3
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>   238U                405180.190       405112.097     1.000e+000
    235U                  2106.155         2098.174     5.087e-003
   Repeat 4
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>   238U                401969.460       401901.367     1.000e+000
    235U                  2111.023         2103.042     5.140e-003
   Repeat 5
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>   238U                406347.362       406279.269     1.000e+000
    235U                  2108.822         2100.841     5.079e-003
   Repeat 6
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>   238U                413351.135       413283.042     1.000e+000
    235U                  2156.363         2148.382     5.106e-003
   Repeat 7
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>   238U                415302.924       415234.831     1.000e+000
    235U                  2150.695         2142.714     5.069e-003
   Summary
   Net Intens. Mean   Net Intens. RSD   Ratio (Norm Mean)   Ratio (Norm RSD)
      406792.575            1.327         1.0000e+000              0.000
        2111.462            1.129         5.0985e-003              0.577
```

```
    Sample Information
    Sample Date/Time: Monday, October 28, 2002 13:26:23
    Sample ID: Reag Blk
    Replicates
    Repeat 1
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                  932.524          864.431      1.000e+000
   235U                   13.267            5.286      6.006e-003
    Repeat 2
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                  910.720          842.627      1.000e+000
   235U                   13.200            5.219      6.084e-003
    Repeat 3
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                  872.114          804.021      1.000e+000
   235U                   12.933            4.952      6.050e-003
    Repeat 4
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                  874.514          806.422      1.000e+000
   235U                   14.200            6.219      7.575e-003
    Repeat 5
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                  835.508          767.415      1.000e+000
   235U                   13.267            5.286      6.765e-003
    Repeat 6
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                  849.510          781.418      1.000e+000
   235U                   13.200            5.219      6.560e-003
    Repeat 7
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                  815.505          747.412      1.000e+000
   235U                   13.867            5.886      7.735e-003
   Summary
   Net Intens. Mean    Net Intens. RSD    Ratio (Norm Mean)    Ratio (Norm RSD)
            801.964              5.134         1.0000e+000                0.000
              5.438              8.184         6.6823e-003               10.829
```

```
Sample Information
Sample Date/Time: Monday, October 28, 2002 13:31:10
Sample ID: LCS 3
Replicates
 Repeat 1
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
>  238U                 467932.581         467864.488      1.000e+000
   235U                   3459.285           3451.304      7.246e-003
 Repeat 2
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
>  238U                 467193.294         467125.202      1.000e+000
   235U                   3452.617           3444.636      7.243e-003
 Repeat 3
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
>  238U                 468489.654         468421.561      1.000e+000
   235U                   3449.750           3441.769      7.217e-003
 Repeat 4
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
>  238U                 468804.153         468736.060      1.000e+000
   235U                   3463.153           3455.172      7.240e-003
 Repeat 5
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
>  238U                 471101.320         471033.227      1.000e+000
   235U                   3491.493           3483.512      7.264e-003
 Repeat 6
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
>  238U                 469980.796         469912.703      1.000e+000
   235U                   3480.091           3472.110      7.258e-003
 Repeat 7
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
>  238U                 470737.998         470669.905      1.000e+000
   235U                   3476.223           3468.242      7.238e-003
 Summary
 Net Intens. Mean    Net Intens. RSD    Ratio (Norm Mean)    Ratio (Norm RSD)
      469109.021               0.312         1.0000e+000               0.000
        3459.535               0.447         7.2437e-003               0.208
```

```
Sample Information
Sample Date/Time: Monday, October 28, 2002 13:35:58
Sample ID: 6363001x2
Replicates
 Repeat 1
MassAnalyte          Meas. Intensity     Net Intensity   Ratio (Norm)
  238U                     52975.932         52907.839    1.000e+000
  235U                       398.406           390.425    7.248e-003
 Repeat 2
MassAnalyte          Meas. Intensity     Net Intensity   Ratio (Norm)
  238U                     53173.885         53105.792    1.000e+000
  235U                       388.939           380.958    7.046e-003
 Repeat 3
MassAnalyte          Meas. Intensity     Net Intensity   Ratio (Norm)
  238U                     53564.579         53496.487    1.000e+000
  235U                       403.406           395.425    7.260e-003
 Repeat 4
MassAnalyte          Meas. Intensity     Net Intensity   Ratio (Norm)
  238U                     53794.664         53726.572    1.000e+000
  235U                       409.406           401.425    7.339e-003
 Repeat 5
MassAnalyte          Meas. Intensity     Net Intensity   Ratio (Norm)
  238U                     54306.245         54238.153    1.000e+000
  235U                       403.606           395.625    7.165e-003
 Repeat 6
MassAnalyte          Meas. Intensity     Net Intensity   Ratio (Norm)
  238U                     53903.886         53835.793    1.000e+000
  235U                       401.339           393.358    7.177e-003
 Repeat 7
MassAnalyte          Meas. Intensity     Net Intensity   Ratio (Norm)
  238U                     54290.384         54222.291    1.000e+000
  235U                       401.939           393.958    7.137e-003
 Summary
  Net Intens. Mean     Net Intens. RSD    Ratio (Norm Mean)    Ratio (Norm RSD)
         53647.561               0.958         1.0000e+000               0.000
           393.025               1.597         7.1960e-003               1.326
```

```
Sample Information
Sample Date/Time: Monday, October 28, 2002 13:40:46
Sample ID: 6363001IDx2
Replicates
 Repeat 1
MassAnalyte          Meas. Intensity     Net Intensity     Ratio (Norm)
 238U                      53136.944         53068.851      1.000e+000
 235U                        387.805           379.824      7.030e-003
 Repeat 2
MassAnalyte          Meas. Intensity     Net Intensity     Ratio (Norm)
 238U                      53448.534         53380.442      1.000e+000
 235U                        394.539           386.558      7.113e-003
 Repeat 3
MassAnalyte          Meas. Intensity     Net Intensity     Ratio (Norm)
 238U                      53756.919         53688.826      1.000e+000
 235U                        400.939           392.958      7.189e-003
 Repeat 4
MassAnalyte          Meas. Intensity     Net Intensity     Ratio (Norm)
 238U                      54384.349         54316.257      1.000e+000
 235U                        410.406           402.425      7.277e-003
 Repeat 5
MassAnalyte          Meas. Intensity     Net Intensity     Ratio (Norm)
 238U                      54503.815         54435.723      1.000e+000
 235U                        399.006           391.025      7.056e-003
 Repeat 6
MassAnalyte          Meas. Intensity     Net Intensity     Ratio (Norm)
 238U                      54991.528         54923.435      1.000e+000
 235U                        408.139           400.158      7.156e-003
 Repeat 7
MassAnalyte          Meas. Intensity     Net Intensity     Ratio (Norm)
 238U                      54603.605         54535.513      1.000e+000
 235U                        411.206           403.225      7.263e-003
 Summary
 Net Intens. Mean    Net Intens. RSD    Ratio (Norm Mean)    Ratio (Norm RSD)
       54049.864               1.255         1.0000e+000               0.000
         393.739               2.223         7.1549e-003               1.337
```

```
    Sample Information
    Sample Date/Time: Monday, October 28, 2002 13:45:34
    Sample ID: 6363001ISx2
    Replicates
    Repeat 1
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
>   238U                 481159.527        481091.434     1.000e+000
    235U                   3527.769          3519.788     7.186e-003
    Repeat 2
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
>   238U                 481095.208        481027.115     1.000e+000
    235U                   3564.711          3556.730     7.263e-003
    Repeat 3
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
>   238U                 487579.820        487511.727     1.000e+000
    235U                   3617.258          3609.277     7.272e-003
    Repeat 4
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
>   238U                 486791.120        486723.027     1.000e+000
    235U                   3628.994          3621.013     7.307e-003
    Repeat 5
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
>   238U                 491749.141        491681.049     1.000e+000
    235U                   3620.592          3612.611     7.217e-003
    Repeat 6
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
[>  238U                 485960.051        485891.958     1.000e+000
[   235U                   3616.524          3608.543     7.295e-003
    Repeat 7
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
[>  238U                 485979.498        485911.405     1.000e+000
[   235U                   3594.986          3587.005     7.251e-003
    Summary
   Net Intens. Mean    Net Intens. RSD   Ratio (Norm Mean)   Ratio (Norm RSD)
      485691.102                0.767        1.0000e+000              0.000
        3587.853                1.030        7.2559e-003              0.586
```

```
    Sample Information
    Sample Date/Time: Monday, October 28, 2002 13:50:23
    Sample ID: U005 A ccv
    Replicates
    Repeat 1
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U                411349.388       411281.295       1.000e+000
-  235U                  2136.360         2128.379       5.083e-003
    Repeat 2
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U                414323.806       414255.713       1.000e+000
-  235U                  2166.564         2158.583       5.118e-003
    Repeat 3
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U                416198.311       416130.218       1.000e+000
-  235U                  2168.231         2160.250       5.099e-003
    Repeat 4
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U                421701.349       421633.256       1.000e+000
-  235U                  2187.968         2179.987       5.079e-003
    Repeat 5
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U                421450.894       421382.801       1.000e+000
-  235U                  2195.502         2187.521       5.099e-003
    Repeat 6
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U                419951.138       419883.046       1.000e+000
-  235U                  2200.703         2192.722       5.130e-003
    Repeat 7
  MassAnalyte        Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U                418790.489       418722.397       1.000e+000
-  235U                  2205.504         2197.523       5.155e-003
    Summary
   Net Intens. Mean    Net Intens. RSD    Ratio (Norm Mean)    Ratio (Norm RSD)
        417612.675              0.929          1.0000e+000               0.000
          2172.138              1.129          5.1090e-003               0.531
```

Sample Information

Sample Date/Time: Monday, October 28, 2002 13:55:12
Sample ID: 6363002x2

Replicates

Repeat 1

MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
238U	70237.851	70169.758	1.000e+000
235U	517.876	509.895	7.138e-003

Repeat 2

MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
238U	69861.776	69793.683	1.000e+000
235U	524.010	516.029	7.262e-003

Repeat 3

MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
238U	71061.390	70993.298	1.000e+000
235U	532.210	524.229	7.253e-003

Repeat 4

MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
238U	70810.323	70742.231	1.000e+000
235U	524.743	516.762	7.175e-003

Repeat 5

MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
238U	71306.029	71237.936	1.000e+000
235U	526.010	518.029	7.143e-003

Repeat 6

MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
238U	71622.840	71554.747	1.000e+000
235U	534.477	526.496	7.227e-003

Repeat 7

MassAnalyte	Meas. Intensity	Net Intensity	Ratio (Norm)
238U	71512.880	71444.787	1.000e+000
235U	530.877	522.896	7.189e-003

Summary

Net Intens. Mean	Net Intens. RSD	Ratio (Norm Mean)	Ratio (Norm RSD)
70848.063	0.931	1.0000e+000	0.000
519.191	1.101	7.1982e-003	0.703

```
Sample Information
Sample Date/Time: Monday, October 28, 2002 14:00:02
Sample ID: 6363003x2
Replicates
  Repeat 1
MassAnalyte          Meas. Intensity    Net Intensity    Ratio (Norm)
  238U                  68082.238          68014.145      1.000e+000
  235U                    515.943            507.962      7.336e-003
  Repeat 2
MassAnalyte          Meas. Intensity    Net Intensity    Ratio (Norm)
  238U                  69165.933          69097.840      1.000e+000
  235U                    515.276            507.295      7.211e-003
  Repeat 3
MassAnalyte          Meas. Intensity    Net Intensity    Ratio (Norm)
  238U                  69166.938          69098.845      1.000e+000
  235U                    518.076            510.095      7.251e-003
  Repeat 4
MassAnalyte          Meas. Intensity    Net Intensity    Ratio (Norm)
  238U                  69255.575          69187.482      1.000e+000
  235U                    507.742            499.761      7.095e-003
  Repeat 5
MassAnalyte          Meas. Intensity    Net Intensity    Ratio (Norm)
  238U                  69372.753          69304.660      1.000e+000
  235U                    515.143            507.162      7.188e-003
  Repeat 6
MassAnalyte          Meas. Intensity    Net Intensity    Ratio (Norm)
  238U                  69362.502          69294.409      1.000e+000
  235U                    517.809            509.828      7.227e-003
  Repeat 7
MassAnalyte          Meas. Intensity    Net Intensity    Ratio (Norm)
  238U                  69085.939          69017.847      1.000e+000
  235U                    525.076            517.095      7.359e-003
  Summary
  Net Intens. Mean    Net Intens. RSD    Ratio (Norm Mean)    Ratio (Norm RSD)
         69002.176              0.650         1.0000e+000                0.000
           508.457              1.009         7.2382e-003                1.238
```

```
    Sample Information
    Sample Date/Time: Monday, October 28, 2002 14:04:52
    Sample ID: 6363003dupx2
    Replicates
    Repeat 1
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                    68093.493        68025.400     1.000e+000
-  235U                      510.542          502.562     7.257e-003
    Repeat 2
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                    68994.691        68926.598     1.000e+000
-  235U                      510.542          502.562     7.162e-003
    Repeat 3
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                    69391.445        69323.352     1.000e+000
-  235U                      512.343          504.362     7.146e-003
    Repeat 4
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                    69553.044        69484.951     1.000e+000
-  235U                      507.076          499.095     7.055e-003
    Repeat 5
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                    70487.098        70419.006     1.000e+000
-  235U                      517.343          509.362     7.105e-003
    Repeat 6
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                    69847.907        69779.814     1.000e+000
-  235U                      510.876          502.895     7.079e-003
    Repeat 7
  MassAnalyte          Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                    70120.464        70052.372     1.000e+000
-  235U                      513.676          505.695     7.091e-003
    Summary
    Net Intens. Mean    Net Intens. RSD   Ratio (Norm Mean)   Ratio (Norm RSD)
          69430.213               1.135        1.0000e+000               0.000
            503.790               0.632        7.1278e-003               0.953
```

```
    Sample Information
    Sample Date/Time: Monday, October 28, 2002 14:09:42
    Sample ID: 6363003MSx2
    Replicates
     Repeat 1
   MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
->  238U                   292222.864        292154.771      1.000e+000
-   235U                     2155.896          2147.915      7.221e-003
     Repeat 2
   MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
->  238U                   291504.132        291436.039      1.000e+000
-   235U                     2143.561          2135.580      7.198e-003
     Repeat 3
   MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
->  238U                   294107.946        294039.854      1.000e+000
-   235U                     2152.162          2144.181      7.163e-003
     Repeat 4
   MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
->  238U                   296269.541        296201.448      1.000e+000
-   235U                     2162.164          2154.183      7.144e-003
     Repeat 5
   MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
->  238U                   293761.697        293693.604      1.000e+000
-   235U                     2159.763          2151.782      7.197e-003
     Repeat 6
   MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
->  238U                   298071.219        298003.126      1.000e+000
-   `235U                    2187.034          2179.053      7.182e-003
     Repeat 7
   MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
->  238U                   297943.177        297875.084      1.000e+000
-   235U                     2199.969          2191.988      7.228e-003
     Summary
    Net Intens. Mean     Net Intens. RSD     Ratio (Norm Mean)     Ratio (Norm RSD)
        294771.990                 0.895         1.0000e+000                0.000
          2157.812                 0.936         7.1903e-003                0.421
```

```
   Sample Information
   Sample Date/Time: Monday, October 28, 2002 14:14:33
   Sample ID: 6363003MSDx2
   Replicates
   Repeat 1
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                 291853.185       291785.092     1.000e+000
   235U                   2177.966         2169.985     7.305e-003
   Repeat 2
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                 297066.311       296998.218     1.000e+000
   235U                   2197.369         2189.388     7.241e-003
   Repeat 3
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                 294621.212       294553.119     1.000e+000
   235U                   2160.163         2152.182     7.177e-003
   Repeat 4
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                 295183.088       295114.996     1.000e+000
   235U                   2189.434         2181.453     7.261e-003
   Repeat 5
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                 298862.983       298794.890     1.000e+000
   235U                   2205.770         2197.789     7.225e-003
   Repeat 6
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                 296204.200       296136.108     1.000e+000
   235U                   2197.502         2189.521     7.262e-003
   Repeat 7
  MassAnalyte        Meas. Intensity    Net Intensity   Ratio (Norm)
>  238U                 296345.704       296277.611     1.000e+000
   235U                   2186.701         2178.720     7.223e-003
   Summary
   Net Intens. Mean    Net Intens. RSD    Ratio (Norm Mean)    Ratio (Norm RSD)
      295665.719                0.741          1.0000e+000               0.000
        2179.863                0.694          7.2420e-003               0.553
```

```
   Sample Information
   Sample Date/Time: Monday, October 28, 2002 14:19:23
   Sample ID: U005 A ccv
   Replicates
    Repeat 1
  MassAnalyte      Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U               409569.146       409501.053      1.000e+000
-  235U                 2126.492         2118.511      5.082e-003
    Repeat 2
  MassAnalyte      Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U               415228.397       415160.304      1.000e+000
-  235U                 2157.096         2149.115      5.085e-003
    Repeat 3
  MassAnalyte      Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U               416804.669       416736.576      1.000e+000
-  235U                 2182.433         2174.452      5.125e-003
    Repeat 4
  MassAnalyte      Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U               413496.259       413428.166      1.000e+000
-  235U                 2129.625         2121.644      5.041e-003
    Repeat 5
  MassAnalyte      Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U               416784.697       416716.604      1.000e+000
-  235U                 2162.764         2154.783      5.079e-003
    Repeat 6
  MassAnalyte      Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U               412587.042       412518.949      1.000e+000
-  235U                 2163.364         2155.383      5.132e-003
    Repeat 7
  MassAnalyte      Meas. Intensity    Net Intensity    Ratio (Norm)
>  238U               413226.802       413158.709      1.000e+000
-  235U                 2166.431         2158.450      5.132e-003
   Summary
  Net Intens. Mean    Net Intens. RSD    Ratio (Norm Mean)    Ratio (Norm RSD)
     413888.623             0.621           1.0000e+000                 0.000
       2147.477             0.945           5.0964e-003                 0.675
```

```
    Sample Information
    Sample Date/Time: Monday, October 28, 2002 14:24:13
    Sample ID: 10ppb Nat U
    Replicates
    Repeat 1
  MassAnalyte           Meas. Intensity     Net Intensity    Ratio (Norm)
>   238U                   427729.225        427661.132      1.000e+000
-   235U                     3176.553          3168.572      7.278e-003
    Repeat 2
  MassAnalyte           Meas. Intensity     Net Intensity    Ratio (Norm)
>   238U                   432306.399        432238.306      1.000e+000
-   235U                     3185.822          3177.841      7.222e-003
    Repeat 3
  MassAnalyte           Meas. Intensity     Net Intensity    Ratio (Norm)
>   238U                   432134.909        432066.816      1.000e+000
-   235U                     3225.898          3217.917      7.316e-003
    Repeat 4
  MassAnalyte           Meas. Intensity     Net Intensity    Ratio (Norm)
>   238U                   431645.391        431577.298      1.000e+000
-   235U                     3215.695          3207.714      7.301e-003
    Repeat 5
  MassAnalyte           Meas. Intensity     Net Intensity    Ratio (Norm)
>   238U                   433843.301        433775.208      1.000e+000
-   235U                     3234.566          3226.585      7.306e-003
    Repeat 6
  MassAnalyte           Meas. Intensity     Net Intensity    Ratio (Norm)
[>  238U                   431649.719        431581.627      1.000e+000
L   235U                     3189.889          3181.908      7.242e-003
    Repeat 7
  MassAnalyte           Meas. Intensity     Net Intensity    Ratio (Norm)
[>  238U                   432244.563        432176.470      1.000e+000
L   235U                     3189.089          3181.108      7.230e-003
    Summary
  Net Intens. Mean     Net Intens. RSD    Ratio (Norm Mean)    Ratio (Norm RSD)
     431582.408                  0.436         1.0000e+000               0.000
       3194.521                  0.705         7.2705e-003               0.536
```

```
Sample Information
Sample Date/Time: Monday, October 28, 2002 14:29:02
Sample ID: U005 A ccv
Replicates
 Repeat 1
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
  238U                   401337.190         401269.097      1.000e+000
  235U                     2109.689           2101.708      5.145e-003
 Repeat 2
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
  238U                   404113.090         404044.998      1.000e+000
  235U                     2092.353           2084.372      5.067e-003
 Repeat 3
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
  238U                   404915.825         404847.732      1.000e+000
  235U                     2121.824           2113.843      5.129e-003
 Repeat 4
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
  238U                   406342.218         406274.126      1.000e+000
  235U                     2096.420           2088.440      5.049e-003
 Repeat 5
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
  238U                   404462.198         404394.106      1.000e+000
  235U                     2095.154           2087.173      5.070e-003
 Repeat 6
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
  238U                   409058.782         408990.689      1.000e+000
  235U                     2113.090           2105.109      5.056e-003
 Repeat 7
MassAnalyte          Meas. Intensity     Net Intensity    Ratio (Norm)
  238U                   404290.832         404222.739      1.000e+000
  235U                     2134.293           2126.312      5.167e-003
 Summary
 Net Intens. Mean    Net Intens. RSD    Ratio (Norm Mean)    Ratio (Norm RSD)
    404863.355                 0.581         1.0000e+000                0.000
      2100.994                 0.740         5.0974e-003                0.940
```

Isotope Ratio Method Report

File Name: uratio1.mth
File Path: c:\elandata\Method\uratio1.mth

Timing Parameters

Sweeps/Reading:	500
Readings/Replicate:	1
Number of Replicates:	7
Tuning File:	default.tun
Optimization File:	uranium.dac
Settling Time:	Normal

	Analyte	Mass	Scan Mode	MCA Channels	Dwell Time	Integration Time
⌈>	U	238.050	Peak Hopping	1	10.0 ms	5000 ms
⌊	U	235.044	Peak Hopping	1	30.0 ms	15000 ms

Signal Processing

Detector Mode:	Pulse
Measurement Units:	Cps
AutoLens:	On
Spectral Peak Processing:	Average
Signal Profile Processing:	Average
Blank Subtraction:	After Internal Standard
Baseline Readings:	0
Smoothing:	Yes, Factor 5

Equations

Analyte	Mass	Corrections

Calibration Information

Ref. Mass	Analyte	Mass	Standard Ratio	Ratio Correction Factor
⌈>	U	238.050	1.000	1.000
⌊	U	235.044	0.005	1.018

	AS Pos	Sample Flush	Sample Flush	Read Delay	Read Delay	Wash	Wash
Blank	1	35 s	-48 rpm	30 s	-20 rpm	45	-48 rpm
Standard	2	35 s	-48 rpm	30 s	-20 rpm	45	-48 rpm

Report Options

Report Template for Printing:	sum.rop
Send to Printer:	Yes
Report Template for File:	
Send to File:	No
Report Filename:	

Create NetCDF File: No
Send to Serial Port: No
Port: COM1

Sampling Devices

Peristaltic Pump Control: Yes
Autosampler: AS-90/91
Autosampler Tray File: c:\elandata\Autosampler\as-90\as90b.try
Sampling Device Type: None
Dil. Factor: 10
Dil. to Vol. (mL): 10
1st Dil. Pos.: 1
Probe Purge Pos.: 10

FIAS Program

Step	Read	Time	Pump 1	Pump 2	Valve	A/S Loc.	Sw 2	Sw 3	Sw 4

Repeat Statement

HGA Program

Description:
Sample Volume:
Injection Temperature:
Injection Speed:
Read delay:
Closure delay:
Modifier #1:
Modifier #2:

Step	Cell Temp	Ramp	Hold	Int. Flow	Gas Norm.	Gas Alt.	To Vent	To ICP	Read

Pipet Seq	Mod#1	Mod#2	Sample	Start Step	End Step	Wash	Rep From	Rep To	# Rep

Jefferson PG
Proj #: 27475-8220
WO #: 6363
Batch #: 2543

SEBerg 11/1/02

Summary By Analyte

Dataset Name: C:\elandata\Dataset\102802

	Net Intensity				Concentration			
	Value	SD	%RSD	Units	Value	SD	%RSD	Units
Analyte U238								
Standard 1	2.74e-004	1.9e-005	6.95	cps				
Standard 2	1.03e-002	4.7e-004	4.56	cps	0.102	4.64e-003	4.56	ug/L
Standard 3	0.101	6.03e-003	5.95	cps	1.	5.95e-002	5.95	ug/L
Standard 4	0.998	6.49e-002	6.5	cps	9.86	0.641	6.5	ug/L
Standard 5	2.03	0.119	5.85	cps	20.1	1.17	5.85	ug/L
ICV 9.99 ppb	0.924	1.96e-002	2.12	cps	91.3% 9.12	0.194	2.12	ug/L
ICB	1.76e-003	5.78e-005	3.28	cps	1.74e-002	5.71e-004	3.28	ug/L
0.1 ppb	9.96e-003	2.63e-004	2.64	cps	98.3% 9.83e-002	2.6e-003	2.64	ug/L
Reagent Blk	1.72e-003	9.35e-005	5.43	cps	1.7e-002	9.23e-004	5.43	ug/L
LCS 3	1.08	5.92e-002	5.47	cps	107.1% 10.7	0.585	5.47	ug/L
40ppb LDR	4.12	0.263	6.38	cps	101.8% 40.7	2.6	6.38	ug/L
Rinse	1.44e-003	1.78e-004	12.4	cps	1.42e-002	1.75e-003	12.4	ug/L
CCV	0.917	8.61e-003	0.939	cps	90.7% 9.06	8.5e-002	0.939	ug/L
CCB	1.66e-003	5.66e-005	3.41	cps	1.64e-002	5.59e-004	3.41	ug/L
6363001x2	0.123	1.12e-003	0.914	cps	1.21	1.11e-002	0.914	ug/L
6363001IDx2	0.126	5.15e-003	4.08	cps	1.25 3.3% RPD	5.09e-002	4.08	ug/L
6363001ISx2	1.15	3.85e-002	3.35	cps	102% 11.3	0.38	3.35	ug/L
6363002x2	0.167	4.99e-003	2.98	cps	1.65	4.93e-002	2.98	ug/L
6363003x2	0.166	7.57e-003	4.56	cps	1.64	7.47e-002	4.56	ug/L
6363003dupx2	0.165	5.54e-003	3.36	cps	1.63 0.6% RPD	5.47e-002	3.36	ug/L
6363003MSx2	0.688	1.7e-002	2.47	cps	103.1% 6.79	0.168	2.47	ug/L
6363003MSDx2	0.688	1.22e-002	1.77	cps	103.1% 6.79 0% RPD	0.12	1.77	ug/L
Rinse	3.6e-004	1.e-005	2.78	cps	3.55e-003	9.88e-005	2.78	ug/L
CCV	1.03	3.51e-002	3.41	cps	101.1% 10.1	0.346	3.41	ug/L
CCB	1.58e-003	5.07e-005	3.2	cps	1.56e-002	5.01e-004	3.2	ug/L
Analyte Ir193								
Standard 1	0.734	4.82e-003	0.657	cps				
Standard 2	0.732	2.79e-003	0.381	cps				ug/L
Standard 3	0.73	2.98e-003	0.408	cps				ug/L
Standard 4	0.728	6.9e-003	0.948	cps				ug/L
Standard 5	0.735	4.71e-003	0.641	cps				ug/L
ICV 9.99 ppb	0.727	1.74e-003	0.239	cps				ug/L
ICB	0.728	3.31e-003	0.454	cps				ug/L
0.1 ppb	0.724	4.24e-003	0.585	cps				ug/L
Reagent Blk	0.723	6.45e-003	0.892	cps				ug/L
LCS 3	0.729	2.77e-003	0.38	cps				ug/L
40ppb LDR	0.736	4.9e-003	0.666	cps				ug/L
Rinse	0.702	2.04e-003	0.291	cps				ug/L
CCV	0.726	5.44e-003	0.748	cps				ug/L
CCB	0.724	4.1e-003	0.566	cps				ug/L
6363001x2	0.754	4.56e-003	0.605	cps				ug/L
6363001IDx2	0.757	6.64e-003	0.878	cps				ug/L
6363001ISx2	0.759	6.07e-003	0.799	cps				ug/L
6363002x2	0.762	6.68e-003	0.878	cps				ug/L
6363003x2	0.763	4.08e-003	0.535	cps				ug/L
6363003dupx2	0.768	5.41e-003	0.704	cps				ug/L
6363003MSx2	0.77	5.07e-003	0.658	cps				ug/L
6363003MSDx2	0.773	5.41e-003	0.701	cps				ug/L
Rinse	0.716	2.71e-003	0.379	cps				ug/L
CCV	S	S	S	cps				ug/L
CCB	0.735	1.2e-003	0.163	cps				ug/L

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Dataset Name: C:\elandata\Dataset\102802

	Net Intensity				Concentration			
	Value	SD	%RSD	Units	Value	SD	%RSD	Units
Analyte U235								
Standard 1	1.69e-005	6.89e-006	40.7	cps				
Standard 2	9.84e-005	2.12e-005	21.6	cps				ug/L
Standard 3	7.91e-004	6.96e-005	8.8	cps				ug/L
Standard 4	7.42e-003	4.83e-004	6.51	cps				ug/L
Standard 5	1.52e-002	8.48e-004	5.56	cps				ug/L
ICV 9.99 ppb	6.87e-003	2.18e-004	3.18	cps				ug/L
ICB	3.32e-005	4.23e-006	12.7	cps				ug/L
0.1 ppb	8.94e-005	1.17e-005	13.1	cps				ug/L
Reagent Blk	2.62e-005	5.46e-006	20.8	cps				ug/L
LCS 3	8.03e-003	4.75e-004	5.91	cps				ug/L
40ppb LDR	3.15e-002	2.04e-003	6.48	cps				ug/L
Rinse	2.66e-005	6.43e-006	24.2	cps				ug/L
CCV	6.89e-003	1.e-004	1.46	cps				ug/L
CCB	3.4e-005	8.37e-006	24.7	cps				ug/L
6363001x2	9.55e-004	2.94e-005	3.08	cps				ug/L
6363001IDx2	9.51e-004	3.49e-005	3.67	cps				ug/L
6363001ISx2	8.57e-003	2.17e-004	2.53	cps				ug/L
6363002x2	1.28e-003	8.07e-005	6.31	cps				ug/L
6363003x2	1.25e-003	3.83e-005	3.07	cps				ug/L
6363003dupx2	1.2e-003	6.92e-005	5.76	cps				ug/L
6363003MSx2	5.12e-003	9.68e-005	1.89	cps				ug/L
6363003MSDx2	5.07e-003	8.91e-005	1.76	cps				ug/L
Rinse	1.89e-005	7.33e-006	38.8	cps				ug/L
CCV	7.6e-003	1.96e-004	2.59	cps				ug/L
CCB	2.71e-005	4.57e-006	16.9	cps				ug/L
Analyte Ho165								
Standard 1	1.69	6.42e-003	0.38	cps				
Standard 2	1.68	1.61e-002	0.962	cps				ug/L
Standard 3	1.68	6.56e-003	0.391	cps				ug/L
Standard 4	1.67	1.75e-002	1.05	cps				ug/L
Standard 5	1.67	1.03e-002	0.618	cps				ug/L
ICV 9.99 ppb	1.67	9.47e-003	0.567	cps				ug/L
ICB	1.67	1.9e-002	1.14	cps				ug/L
0.1 ppb	1.68	1.28e-002	0.763	cps				ug/L
Reagent Blk	1.74	4.87e-003	0.28	cps				ug/L
LCS 3	1.75	1.24e-002	0.71	cps				ug/L
40ppb LDR	1.67	1.26e-002	0.756	cps				ug/L
Rinse	1.73	7.94e-003	0.46	cps				ug/L
CCV	1.68	8.47e-003	0.505	cps				ug/L
CCB	1.67	1.32e-002	0.79	cps				ug/L
6363001x2	1.8	8.21e-003	0.456	cps				ug/L
6363001IDx2	1.8	5.15e-003	0.285	cps				ug/L
6363001ISx2	1.8	9.91e-003	0.55	cps				ug/L
6363002x2	1.8	1.47e-002	0.814	cps				ug/L
6363003x2	1.8	9.15e-003	0.508	cps				ug/L
6363003dupx2	1.81	1.25e-002	0.691	cps				ug/L
6363003MSx2	1.82	6.14e-003	0.337	cps				ug/L
6363003MSDx2	1.83	9.35e-003	0.511	cps				ug/L
Rinse	1.73	1.34e-002	0.772	cps				ug/L
CCV	1.7	1.89e-002	1.11	cps				ug/L
CCB	1.7	1.22e-002	0.713	cps				ug/L

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Dataset Name:  C:\elandata\Dataset\102802

                    Net Intensity                              Concentration

             Value        SD          %RSD      Units    Value       SD          %RSD       Units



Analyte  Rh103
 Standard 1   4.34e+005  2.17e+004  5.01     cps
 Standard 2   4.27e+005  1.7e+004   3.99     cps
 Standard 3   4.28e+005  2.29e+004  5.34     cps
 Standard 4   4.33e+005  2.32e+004  5.35     cps
 Standard 5   4.22e+005  2.24e+004  5.31     cps
 ICV 9.99 ppb 4.56e+005  7.98e+003  1.75     cps
 ICB          4.34e+005  1.54e+004  3.56     cps
 0.1 ppb      4.36e+005  1.24e+004  2.85     cps
 Reagent Blk  4.66e+005  2.01e+004  4.31     cps
 LCS 3        4.55e+005  2.08e+004  4.56     cps
 40ppb LDR    4.3e+005   2.63e+004  6.11     cps
 Rinse        4.31e+005  1.09e+004  2.53     cps
 CCV          4.83e+005  2.84e+003  0.588    cps
 CCB          4.48e+005  1.13e+004  2.52     cps
 6363001x2    4.29e+005  3.89e+003  0.907    cps
 6363001IDx2  4.2e+005   1.68e+004  4.01     cps
 6363001ISx2  4.18e+005  1.16e+004  2.77     cps
 6363002x2    4.12e+005  1.01e+004  2.46     cps
 6363003x2    4.09e+005  1.76e+004  4.3      cps
 6363003dupx2 4.14e+005  1.46e+004  3.53     cps
 6363003MSx2  4.29e+005  8.21e+003  1.91     cps
 6363003MSDx2 4.28e+005  6.44e+003  1.51     cps
 Rinse        4.45e+005  5.43e+003  1.22     cps
 CCV          4.29e+005  1.23e+004  2.86     cps
 CCB          4.82e+005  2.06e+003  0.427    cps


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Quantitative Method Report

File Name: totalu.mth
File Path: c:\elandata\Method\totalu.mth

Timing Parameters

Sweeps/Reading:	150
Readings/Replicate:	1
Number of Replicates:	5
Tuning File:	default.tun
Optimization File:	uranium.dac
QC Enabled:	No
Settling Time:	Normal

Analyte	Mass	Scan Mode	MCA Channels	Dwell Time	Integration Time
U	238.050	Peak Hopping	1	10.0 ms	1500 ms
Ir	192.963	Peak Hopping	1	10.0 ms	1500 ms
U	235.044	Peak Hopping	1	10.0 ms	1500 ms
Ho	164.930	Peak Hopping	1	10.0 ms	1500 ms
Rh	102.905	Peak Hopping	1	10.0 ms	1500 ms

Signal Processing

Detector Mode:	Pulse
Measurement Units:	Cps
AutoLens:	On
Spectral Peak Processing:	Average
Signal Profile Processing:	Average
Blank Subtraction:	Before Internal Standard
Baseline Readings:	0
Smoothing:	Yes, Factor 5

Equations

Analyte	Mass	Corrections

Calibration Information

Analyte	Mass	Curve Type	Sample Units	Std Units	Std 1	Std 2	Std 3	Std 4
U	238.050	Linear Thru Zero	ug/L	ug/L	0	0.1	1	10
Ir	192.963	Linear Thru Zero	ug/L	ug/L				
U	235.044	Linear Thru Zero	ug/L	ug/L				
Ho	164.930	Linear Thru Zero	ug/L	ug/L				
Rh	102.905	Linear Thru Zero	ug/L	ug/L				

Analyte	Mass	Std 5	Std 6	Std 7	Std 8	Std 9	Std 10	Std 11	Std 12
U	238.050	20							
Ir	192.963								

U	235.044
Ho	164.930
Rh	102.905

	AS Pos	Sample Flush	Sample Flush	Read Delay	Read Delay	Wash	Wash
Blank		45 s	-48 rpm	45 s	-24 rpm	45 s	-48 rpm
Standard 1	1	35 s	-48 rpm	30 s	-20 rpm	45 s	-48 rpm
Standard 2	2	35 s	-48 rpm	30 s	-20 rpm	45 s	-48 rpm
Standard 3	3	35 s	-48 rpm	30 s	-20 rpm	45 s	-48 rpm
Standard 4	4	35 s	-48 rpm	30 s	-20 rpm	45 s	-48 rpm
Standard 5	5	35 s	-48 rpm	30 s	-20 rpm	90 s	-48 rpm
Standard 6		40 s	-48 rpm	50 s	-24 rpm	45 s	-48 rpm
Standard 7		40 s	-48 rpm	50 s	-24 rpm	45 s	-48 rpm
Standard 8		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 9		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 10		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 11		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 12		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 13		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 14		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 15		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 16		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 17		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 18		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 19		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 20		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 21		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 22		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 23		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 24		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 25		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 26		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 27		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 28		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 29		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm
Standard 30		35 s	-48 rpm	15 s	-24 rpm	45 s	-48 rpm

Reporting Options

Report Template for Printing:	c:\elandata\ReportOptions\quant comprehensive.rop
Send to Printer:	Yes
Report Template for File:	c:\elandata\ReportOptions\quant summary.rop
Send to File:	Yes
Report Filename:	c:\elandata\ReportOutput\test2.rep
Create NetCDF File:	No
Send to Serial Port:	No
Port:	COM1

Sampling Devices

Peristaltic Pump Control: Yes
Autosampler: AS-90/91
Autosampler Tray File: c:\elandata\Autosampler\as-90\as90b.try
Sampling Device Type: None
Dil. Factor: 10
Dil. to Vol. (mL): 10
1st Dil. Pos.: 1
Probe Purge Pos.: 10

FIAS Program

Step	Read	Time	Pump 1	Pump 2	Valve	A/S Loc.	Sw 2	Sw 3	Sw 4

Repeat Statement

HGA Program

Description:
Sample Volume: uL
Injection Temperature: C
Injection Speed:
Read delay: s
Closure delay: s
Modifier #1:
Modifier #2:

Step	Cell Temp	Ramp	Hold	Int. Flow	Gas Norm.	Gas Alt.	To Vent	To ICP	Read

Pipet Seq.	Mod#1	Mod#2	Sample	Start Step	Wash	Rep. From	End S Wash	Rep. To	# Re

Quantitative Analysis Calibration Report

File Name:
File Path:
Calibration Type: External Calibration

Analyte	Mass	Curve Type	Slope	Intercept	Corr. Coeff.
U238	238.050	Linear Thru Zero	0.10	0.00	0.999974
Ir193	192.963	Linear Thru Zero	0.00	0.00	0.000000
U235	235.044	Linear Thru Zero	0.00	0.00	0.000000
Ho165	164.930	Linear Thru Zero	0.00	0.00	0.000000
Rh103	102.905	Linear Thru Zero	0.00	0.00	0.000000

Report Date/Time: Monday, October 28, 2002 12:34:10

Quantitative Analysis - Comprehensive Report

Sample ID: Standard 1
Sample Date/Time: Monday, October 28, 2002 10:33:41
Sample Description:
Solution Type: Standard
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\Standard 1.001
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	99.34	0.000		ug/L
Ir	193	294100.26	0.741		ug/L
U	235	6.00	0.000		ug/L
Ho	165	667314.64	1.681		ug/L
Rh	103	397021.12	397021.116		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	128.68	0.000		ug/L
Ir	193	318132.75	0.736		ug/L
U	235	12.00	0.000		ug/L
Ho	165	732021.12	1.693		ug/L
Rh	103	432474.52	432474.524		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	126.68	0.000		ug/L
Ir	193	324603.87	0.728		ug/L
U	235	8.00	0.000		ug/L
Ho	165	752290.40	1.687		ug/L
Rh	103	445925.35	445925.350		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	124.68	0.000		ug/L
Ir	193	329181.29	0.732		ug/L

|	U	235	4.00	0.000		ug/L
|	Ho	165	764103.02	1.698		ug/L
L>	Rh	103	449997.84	449997.838		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
[	U	238	115.35	0.000		ug/L
|	Ir	193	325963.78	0.733		ug/L
|	U	235	6.67	0.000		ug/L
|	Ho	165	752338.86	1.691		ug/L
L>	Rh	103	444961.90	444961.903		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
[	U	238	118.95	0.000		ug/L
|	Ir	193	318396.39	0.734		ug/L
|	U	235	7.33	0.000		ug/L
|	Ho	165	733613.61	1.690		ug/L
L>	Rh	103	434076.15	434076.146		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
[	U	238	12.090	0.000	
|	Ir	193	14164.073	0.005	
|	U	235	2.982	0.000	
|	Ho	165	38817.365	0.006	
L>	Rh	103	21725.815	21725.815	

Quantitative Analysis - Comprehensive Report

Sample ID: Standard 2
Sample Date/Time: Monday, October 28, 2002 10:36:31
Sample Description:
Solution Type: Standard
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\Standard 2.002
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	4405.12	0.011	0.107422	ug/L
Ir	193	291056.57	0.731		ug/L
U	235	52.67	0.000		ug/L
Ho	165	656391.24	1.649		ug/L
Rh	103	398068.43	398068.432		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	4433.13	0.010	0.101351	ug/L
Ir	193	311289.79	0.733		ug/L
U	235	40.67	0.000		ug/L
Ho	165	711056.38	1.675		ug/L
Rh	103	424593.91	424593.908		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	4401.12	0.010	0.097570	ug/L
Ir	193	319065.98	0.729		ug/L
U	235	33.34	0.000		ug/L
Ho	165	740435.35	1.691		ug/L
Rh	103	437862.16	437862.155		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	4317.75	0.010	0.096445	ug/L
Ir	193	319643.40	0.736		ug/L

|	U	235	44.00	0.000		ug/L
|	Ho	165	732279.91	1.685		ug/L
└>	Rh	103	434581.92	434581.921		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	4396.45	0.010	0.097212	ug/L
|	Ir	193	320229.02	0.729		ug/L
|	U	235	38.00	0.000		ug/L
|	Ho	165	735987.71	1.676		ug/L
└>	Rh	103	439007.28	439007.285		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
┌	U	238	4390.71	0.010	0.100000	ug/L
|	Ir	193	312256.95	0.732		ug/L
|	U	235	41.74	0.000		ug/L
|	Ho	165	715230.12	1.675		ug/L
└>	Rh	103	426822.74	426822.740		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
┌	U	238	43.219	0.000	0.005
|	Ir	193	12398.266	0.003	
|	U	235	7.252	0.000	
|	Ho	165	34771.793	0.016	
└>	Rh	103	17046.368	17046.368	

Quantitative Analysis - Comprehensive Report

Sample ID: Standard 3
Sample Date/Time: Monday, October 28, 2002 10:39:23
Sample Description:
Solution Type: Standard
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\Standard 3.003
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	43400.83	0.112	1.101282	ug/L
│	Ir	193	284445.40	0.731		ug/L
│	U	235	349.37	0.001		ug/L
│	Ho	165	649627.71	1.670		ug/L
⌊>	Rh	103	389048.78	389048.779		ug/L

Repeat 2

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	43307.20	0.102	1.005756	ug/L
│	Ir	193	311837.60	0.734		ug/L
│	U	235	345.37	0.001		ug/L
│	Ho	165	708944.33	1.668		ug/L
⌊>	Rh	103	425081.47	425081.471		ug/L

Repeat 3

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	43138.01	0.098	0.966281	ug/L
│	Ir	193	321374.43	0.729		ug/L
│	U	235	342.71	0.001		ug/L
│	Ho	165	739339.98	1.678		ug/L
⌊>	Rh	103	440718.27	440718.274		ug/L

Repeat 4

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	42852.45	0.098	0.962999	ug/L
│	Ir	193	321240.79	0.731		ug/L

```
|   U       235        330.04        0.001                   ug/L
|   Ho      165     738578.67        1.681                   ug/L
L>  Rh      103     439293.24   439293.237                   ug/L
    Repeat 5
    Analyte Mass   Meas. Intensity  Net Intensity  Concentration  Sample Unit
[   U       238      43360.70        0.098       0.962833    ug/L
|   Ir      193     322596.29        0.726                   ug/L
|   U       235        318.04        0.001                   ug/L
|   Ho      165     747780.88        1.682                   ug/L
L>  Rh      103     444580.26   444580.256                   ug/L
```

Mean Values

```
    Analyte Mass   Meas. Intens. Mean   Net Intens. Mean   Conc. Mean   Sample Unit
[   U       238          43211.84             0.101        0.999830     ug/L
|   Ir      193         312298.90             0.730                     ug/L
|   U       235            337.10             0.001                     ug/L
|   Ho      165         716854.31             1.676                     ug/L
L>  Rh      103         427744.40        427744.404                     ug/L
```

Standard Deviations

```
    Analyte Mass   Meas. Intens. SD   Net Intens. SD   Conc. SD
[   U       238           224.488           0.006        0.060
|   Ir      193         16158.503           0.003
|   U       235            12.882           0.000
|   Ho      165         40360.838           0.007
L>  Rh      103         22855.991       22855.991
```

Quantitative Analysis - Comprehensive Report

Sample ID: Standard 4
Sample Date/Time: Monday, October 28, 2002 10:42:16
Sample Description:
Solution Type: Standard
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\Standard 4.004
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

```
   Repeat 1
   Analyte   Mass   Meas. Intensity   Net Intensity   Concentration   Sample Unit
[  U         238         435647.76            1.109       11.107218   ug/L
|  Ir        193         285587.30            0.727                   ug/L
|  U         235           3234.02            0.008                   ug/L
|  Ho        165         647975.67            1.649                   ug/L
L> Rh        103         392849.74       392849.738                   ug/L
   Repeat 2
   Analyte   Mass   Meas. Intensity   Net Intensity   Concentration   Sample Unit
[  U         238         432919.06            1.001       10.026676   ug/L
|  Ir        193         312250.51            0.722                   ug/L
|  U         235           3232.02            0.007                   ug/L
|  Ho        165         712456.41            1.647                   ug/L
L> Rh        103         432460.10       432460.095                   ug/L
   Repeat 3
   Analyte   Mass   Meas. Intensity   Net Intensity   Concentration   Sample Unit
[  U         238         430330.34            0.973        9.750364   ug/L
|  Ir        193         326052.44            0.738                   ug/L
|  U         235           3184.01            0.007                   ug/L
|  Ho        165         745247.96            1.686                   ug/L
L> Rh        103         442056.13       442056.134                   ug/L
   Repeat 4
   Analyte   Mass   Meas. Intensity   Net Intensity   Concentration   Sample Unit
[  U         238         427383.54            0.958        9.597427   ug/L
|  Ir        193         326430.30            0.732                   ug/L
```

U	235	3206.68	0.007		ug/L
Ho	165	748919.01	1.679		ug/L
Rh	103	446025.07	446025.068		ug/L

Repeat 5

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	427150.71	0.950	9.510946	ug/L
Ir	193	324389.73	0.721		ug/L
U	235	3152.00	0.007		ug/L
Ho	165	752649.28	1.673		ug/L
Rh	103	449835.49	449835.495		ug/L

Mean Values

Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
U	238	430686.28	0.998	9.998526	ug/L
Ir	193	314942.06	0.728		ug/L
U	235	3201.75	0.007		ug/L
Ho	165	721449.67	1.667		ug/L
Rh	103	432645.31	432645.306		ug/L

Standard Deviations

Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
U	238	3644.746	0.065	0.650
Ir	193	17418.564	0.007	
U	235	34.542	0.000	
Ho	165	44084.141	0.018	
Rh	103	23166.818	23166.818	

Quantitative Analysis - Comprehensive Report

Sample ID: Standard 5
Sample Date/Time: Monday, October 28, 2002 10:45:10
Sample Description:
Solution Type: Standard
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\Standard 5.005
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	858299.77	2.229	22.006536	ug/L
Ir	193	282670.52	0.734		ug/L
U	235	6410.08	0.017		ug/L
Ho	165	637969.10	1.657		ug/L
Rh	103	385044.74	385044.739		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	862594.28	2.062	20.360073	ug/L
Ir	193	311101.74	0.744		ug/L
U	235	6440.76	0.015		ug/L
Ho	165	700352.91	1.674		ug/L
Rh	103	418264.63	418264.631		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	850048.23	1.976	19.512694	ug/L
Ir	193	315586.28	0.734		ug/L
U	235	6423.42	0.015		ug/L
Ho	165	725047.30	1.686		ug/L
Rh	103	430080.97	430080.968		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	855120.39	1.947	19.219233	ug/L
Ir	193	322005.12	0.733		ug/L

U	235	6398.07	0.015		ug/L
Ho	165	734230.49	1.672		ug/L
Rh	103	439253.37	439253.369		ug/L

Repeat 5

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	855196.06	1.951	19.263558	ug/L
Ir	193	321008.29	0.732		ug/L
U	235	6431.42	0.015		ug/L
Ho	165	732438.42	1.671		ug/L
Rh	103	438281.43	438281.430		ug/L

Mean Values

Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
U	238	856251.74	2.033	20.072419	ug/L
Ir	193	310474.39	0.735		ug/L
U	235	6420.75	0.015		ug/L
Ho	165	706007.64	1.672		ug/L
Rh	103	422185.03	422185.027		ug/L

Standard Deviations

Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
U	238	4617.906	0.119	1.175
Ir	193	16151.634	0.005	
U	235	16.954	0.001	
Ho	165	40369.676	0.010	
Rh	103	22402.784	22402.784	

Quantitative Analysis - Comprehensive Report

Sample ID: ICV 9.99 ppb
Sample Date/Time: Monday, October 28, 2002 10:48:51
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\ICV 9.99 ppb.006
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	423703.29	0.958	9.457845	ug/L
Ir	193	322174.90	0.728		ug/L
U	235	3184.01	0.007		ug/L
Ho	165	735972.97	1.664		ug/L
Rh	103	442276.14	442276.144		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	418053.91	0.911	8.998406	ug/L
Ir	193	332504.60	0.725		ug/L
U	235	3045.96	0.007		ug/L
Ho	165	766338.33	1.671		ug/L
Rh	103	458659.72	458659.717		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	421171.81	0.914	9.022861	ug/L
Ir	193	335220.57	0.727		ug/L
U	235	3114.65	0.007		ug/L
Ho	165	775463.02	1.683		ug/L
Rh	103	460828.06	460828.060		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	422124.76	0.921	9.090026	ug/L
Ir	193	332411.80	0.725		ug/L

|	U	235	3190.01	0.007		ug/L
|	Ho	165	770045.60	1.680		ug/L
⌊>	Rh	103	458458.04	458458.043		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	421570.70	0.913	9.017262	ug/L
|	Ir	193	336188.35	0.728		ug/L
|	U	235	3125.32	0.007		ug/L
|	Ho	165	766642.02	1.661		ug/L
⌊>	Rh	103	461550.91	461550.913		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
⌈	U	238	421324.89	0.924	9.117280	ug/L
|	Ir	193	331700.04	0.727		ug/L
|	U	235	3131.99	0.007		ug/L
|	Ho	165	762892.39	1.672		ug/L
⌊>	Rh	103	456354.58	456354.575		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
⌈	U	238	2066.382	0.020	0.194
|	Ir	193	5577.214	0.002	
|	U	235	58.774	0.000	
|	Ho	165	15490.144	0.009	
⌊>	Rh	103	7983.647	7983.647	

Quantitative Analysis - Comprehensive Report

```
Sample ID: ICB
Sample Date/Time: Monday, October 28, 2002 10:51:47
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\ICB.007
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration
```

Replicates

```
   Repeat 1
   Analyte  Mass   Meas. Intensity   Net Intensity   Concentration   Sample Unit
[  U         238            724.76           0.002        0.017545   ug/L
|  Ir        193         296741.64           0.728                   ug/L
|  U         235             14.00           0.000                   ug/L
|  Ho        165         669312.44           1.641                   ug/L
L> Rh        103         407823.49      407823.487                   ug/L
   Repeat 2
   Analyte  Mass   Meas. Intensity   Net Intensity   Concentration   Sample Unit
[  U         238            806.77           0.002        0.018346   ug/L
|  Ir        193         314580.36           0.725                   ug/L
|  U         235             12.67           0.000                   ug/L
|  Ho        165         723467.32           1.666                   ug/L
L> Rh        103         434141.45      434141.452                   ug/L
   Repeat 3
   Analyte  Mass   Meas. Intensity   Net Intensity   Concentration   Sample Unit
[  U         238            770.76           0.002        0.017114   ug/L
|  Ir        193         325533.42           0.732                   ug/L
|  U         235             15.33           0.000                   ug/L
|  Ho        165         746088.94           1.678                   ug/L
L> Rh        103         444626.33      444626.328                   ug/L
   Repeat 4
   Analyte  Mass   Meas. Intensity   Net Intensity   Concentration   Sample Unit
[  U         238            762.10           0.002        0.016904   ug/L
|  Ir        193         322716.98           0.725                   ug/L
```

U	235	17.34	0.000		ug/L
Ho	165	749823.40	1.685		ug/L
Rh	103	445093.93	445093.935		ug/L

Repeat 5

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	764.10	0.002	0.017153	ug/L
Ir	193	321237.38	0.730		ug/L
U	235	12.67	0.000		ug/L
Ho	165	742561.07	1.689		ug/L
Rh	103	439766.86	439766.859		ug/L

Mean Values

Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
U	238	765.70	0.002	0.017412	ug/L
Ir	193	316161.96	0.728		ug/L
U	235	14.40	0.000		ug/L
Ho	165	726250.64	1.672		ug/L
Rh	103	434290.41	434290.412		ug/L

Standard Deviations

Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
U	238	29.173	0.000	0.001
Ir	193	11578.029	0.003	
U	235	1.978	0.000	
Ho	165	33410.211	0.019	
Rh	103	15443.923	15443.923	

Quantitative Analysis - Comprehensive Report

Sample ID: 0.1 ppb
Sample Date/Time: Monday, October 28, 2002 10:54:41
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\0.1 ppb.008
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	4317.75	0.010	0.102827	ug/L
│	Ir	193	300743.08	0.725		ug/L
│	U	235	30.67	0.000		ug/L
│	Ho	165	691371.38	1.668		ug/L
└>	Rh	103	414545.52	414545.522		ug/L

Repeat 2

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	4308.41	0.010	0.097530	ug/L
│	Ir	193	314625.34	0.721		ug/L
│	U	235	41.34	0.000		ug/L
│	Ho	165	728129.92	1.670		ug/L
└>	Rh	103	436115.08	436115.079		ug/L

Repeat 3

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	4347.76	0.010	0.096765	ug/L
│	Ir	193	320389.92	0.722		ug/L
│	U	235	39.34	0.000		ug/L
│	Ho	165	740704.12	1.670		ug/L
└>	Rh	103	443579.77	443579.768		ug/L

Repeat 4

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	4324.42	0.010	0.096415	ug/L
│	Ir	193	323893.28	0.731		ug/L

```
│  U         235           37.34          0.000                      ug/L
│  Ho        165       749638.03          1.693                      ug/L
└> Rh        103       442797.99     442797.992                      ug/L
   Repeat 5
   Analyte   Mass   Meas. Intensity  Net Intensity  Concentration  Sample Unit
┌  U         238         4405.79          0.010       0.098117     ug/L
│  Ir        193       319927.00          0.722                      ug/L
│  U         235           46.67          0.000                      ug/L
│  Ho        165       749996.84          1.692                      ug/L
└> Rh        103       443306.80     443306.795                      ug/L
```

Mean Values

```
   Analyte   Mass   Meas. Intens. Mean   Net Intens. Mean   Conc. Mean   Sample Unit
┌  U         238               4340.83              0.010     0.098331   ug/L
│  Ir        193             315915.72              0.724                ug/L
│  U         235                 39.07              0.000                ug/L
│  Ho        165             731968.06              1.678                ug/L
└> Rh        103             436069.03         436069.031                ug/L
```

Standard Deviations

```
   Analyte   Mass   Meas. Intens. SD   Net Intens. SD   Conc. SD
┌  U         238             39.116            0.000      0.003
│  Ir        193           9105.278            0.004
│  U         235              5.843            0.000
│  Ho        165          24374.194            0.013
└> Rh        103          12423.153        12423.153
```

Quantitative Analysis - Comprehensive Report

Sample ID: Reagent Blk
Sample Date/Time: Monday, October 28, 2002 10:57:32
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\Reagent Blk.009
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	809.44	0.002	0.018567	ug/L
Ir	193	307525.87	0.715		ug/L
U	235	14.67	0.000		ug/L
Ho	165	753386.74	1.750		ug/L
Rh	103	430401.78	430401.781		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	799.44	0.002	0.016774	ug/L
Ir	193	338859.96	0.720		ug/L
U	235	10.00	0.000		ug/L
Ho	165	819371.86	1.741		ug/L
Rh	103	470525.55	470525.548		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	773.43	0.002	0.016166	ug/L
Ir	193	345082.90	0.731		ug/L
U	235	11.33	0.000		ug/L
Ho	165	823410.82	1.743		ug/L
Rh	103	472337.40	472337.400		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	808.10	0.002	0.016862	ug/L
Ir	193	344557.73	0.728		ug/L

│	U	235	14.00	0.000		ug/L
│	Ho	165	824636.00	1.743		ug/L
└>	Rh	103	473118.01	473118.013		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	807.44	0.002	0.016566	ug/L
│	Ir	193	347441.96	0.722		ug/L
│	U	235	10.67	0.000		ug/L
│	Ho	165	835783.72	1.737		ug/L
└>	Rh	103	481192.55	481192.548		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
┌	U	238	799.57	0.002	0.016987	ug/L
│	Ir	193	336693.68	0.723		ug/L
│	U	235	12.13	0.000		ug/L
│	Ho	165	811317.83	1.743		ug/L
└>	Rh	103	465515.06	465515.058		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
┌	U	238	15.127	0.000	0.001
│	Ir	193	16607.241	0.006	
│	U	235	2.077	0.000	
│	Ho	165	32950.997	0.005	
└>	Rh	103	20051.061	20051.061	

Quantitative Analysis - Comprehensive Report

Sample ID: LCS 3
Sample Date/Time: Monday, October 28, 2002 11:00:22
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\LCS 3.010
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	498391.73	1.179	11.644204	ug/L
|	Ir	193	306049.18	0.724		ug/L
|	U	235	3727.53	0.009		ug/L
|	Ho	165	740895.70	1.753		ug/L
└>	Rh	103	422556.62	422556.622		ug/L

Repeat 2

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	490640.82	1.100	10.861235	ug/L
|	Ir	193	325985.61	0.731		ug/L
|	U	235	3610.82	0.008		ug/L
|	Ho	165	784653.92	1.759		ug/L
└>	Rh	103	445972.80	445972.802		ug/L

Repeat 3

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	490990.57	1.052	10.389510	ug/L
|	Ir	193	340177.52	0.729		ug/L
|	U	235	3683.51	0.008		ug/L
|	Ho	165	821245.14	1.760		ug/L
└>	Rh	103	466554.04	466554.042		ug/L

Repeat 4

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	486462.44	1.039	10.257006	ug/L
|	Ir	193	342309.08	0.731		ug/L

U	235	3610.15	0.008		ug/L
Ho	165	811879.00	1.734		ug/L
Rh	103	468222.82	468222.824		ug/L

Repeat 5

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	492433.11	1.044	10.303497	ug/L
Ir	193	344166.43	0.729		ug/L
U	235	3605.48	0.008		ug/L
Ho	165	819709.10	1.737		ug/L
Rh	103	471831.02	471831.023		ug/L

Mean Values

Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
U	238	491783.73	1.083	10.691090	ug/L
Ir	193	331737.56	0.729		ug/L
U	235	3647.50	0.008		ug/L
Ho	165	795676.57	1.749		ug/L
Rh	103	455027.46	455027.462		ug/L

Standard Deviations

Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
U	238	4311.001	0.059	0.585
Ir	193	16050.269	0.003	
U	235	55.242	0.000	
Ho	165	33971.590	0.012	
Rh	103	20770.662	20770.662	

Quantitative Analysis - Comprehensive Report

Sample ID: 40ppb LDR
Sample Date/Time: Monday, October 28, 2002 11:03:12
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\40ppb LDR.011
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	1778711.24	4.570	45.116926	ug/L
Ir	193	287861.14	0.740		ug/L
U	235	13516.41	0.035		ug/L
Ho	165	642147.26	1.650		ug/L
Rh	103	389215.24	389215.239		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	1749294.25	4.156	41.028460	ug/L
Ir	193	311931.62	0.741		ug/L
U	235	13574.47	0.032		ug/L
Ho	165	706350.90	1.678		ug/L
Rh	103	420921.92	420921.918		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	1752161.36	3.998	39.472006	ug/L
Ir	193	322427.87	0.736		ug/L
U	235	13342.90	0.030		ug/L
Ho	165	732924.47	1.672		ug/L
Rh	103	438236.75	438236.752		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	1765264.00	3.947	38.969366	ug/L
Ir	193	327282.21	0.732		ug/L

U	235	13484.38	0.030		ug/L
Ho	165	748928.14	1.675		ug/L
Rh	103	447208.67	447208.669		ug/L

Repeat 5

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	1799877.06	3.951	39.006737	ug/L
Ir	193	332363.35	0.730		ug/L
U	235	13594.49	0.030		ug/L
Ho	165	766343.95	1.682		ug/L
Rh	103	455540.62	455540.625		ug/L

Mean Values

Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
U	238	1769061.58	4.124	40.718699	ug/L
Ir	193	316373.24	0.736		ug/L
U	235	13502.53	0.031		ug/L
Ho	165	719338.94	1.671		ug/L
Rh	103	430224.64	430224.641		ug/L

Standard Deviations

Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
U	238	20817.637	0.263	2.597
Ir	193	17635.301	0.005	
U	235	99.546	0.002	
Ho	165	48468.555	0.013	
Rh	103	26276.710	26276.710	

Quantitative Analysis - Comprehensive Report

Sample ID: Rinse
Sample Date/Time: Monday, October 28, 2002 11:06:05
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\Rinse.012
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	679.42	0.002	0.016254	ug/L
Ir	193	290417.70	0.704		ug/L
U	235	10.67	0.000		ug/L
Ho	165	708573.21	1.717		ug/L
Rh	103	412663.34	412663.340		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	667.42	0.002	0.015329	ug/L
Ir	193	300903.08	0.700		ug/L
U	235	14.00	0.000		ug/L
Ho	165	742336.48	1.727		ug/L
Rh	103	429830.23	429830.231		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	646.08	0.001	0.014531	ug/L
Ir	193	308722.04	0.703		ug/L
U	235	11.33	0.000		ug/L
Ho	165	756018.71	1.722		ug/L
Rh	103	438944.05	438944.046		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	560.07	0.001	0.012605	ug/L
Ir	193	306677.17	0.699		ug/L

|	U	235	7.33	0.000		ug/L
|	Ho	165	759405.08	1.731		ug/L
└>	Rh	103	438638.85	438638.854		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	536.06	0.001	0.012161	ug/L
|	Ir	193	305712.73	0.702		ug/L
|	U	235	14.00	0.000		ug/L
|	Ho	165	756191.52	1.738		ug/L
└>	Rh	103	435178.40	435178.397		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
┌	U	238	617.81	0.001	0.014176	ug/L
|	Ir	193	302486.54	0.702		ug/L
|	U	235	11.47	0.000		ug/L
|	Ho	165	744505.00	1.727		ug/L
└>	Rh	103	431050.97	431050.974		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
┌	U	238	65.330	0.000	0.002
|	Ir	193	7331.702	0.002	
|	U	235	2.765	0.000	
|	Ho	165	21136.156	0.008	
└>	Rh	103	10914.525	10914.525	

Quantitative Analysis - Comprehensive Report

Sample ID: CCV
Sample Date/Time: Monday, October 28, 2002 11:09:02
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\CCV.013
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	445225.28	0.930	9.184153	ug/L
Ir	193	345678.43	0.722		ug/L
U	235	3306.05	0.007		ug/L
Ho	165	796562.38	1.664		ug/L
Rh	103	478591.06	478591.060		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	445632.39	0.917	9.053973	ug/L
Ir	193	349754.94	0.720		ug/L
U	235	3332.06	0.007		ug/L
Ho	165	816696.76	1.681		ug/L
Rh	103	485916.26	485916.261		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	437698.57	0.908	8.959412	ug/L
Ir	193	350531.71	0.727		ug/L
U	235	3249.36	0.007		ug/L
Ho	165	807404.71	1.674		ug/L
Rh	103	482302.49	482302.493		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	442150.33	0.912	9.003018	ug/L
Ir	193	354276.09	0.731		ug/L

U	235	3380.07	0.007		ug/L
Ho	165	815310.72	1.682		ug/L
Rh	103	484848.10	484848.103		ug/L

Repeat 5

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	444596.07	0.919	9.074732	ug/L
Ir	193	354360.83	0.733		ug/L
U	235	3378.07	0.007		ug/L
Ho	165	815592.86	1.686		ug/L
Rh	103	483677.29	483677.287		ug/L

Mean Values

Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
U	238	443060.53	0.917	9.055058	ug/L
Ir	193	350920.40	0.726		ug/L
U	235	3329.12	0.007		ug/L
Ho	165	810313.49	1.677		ug/L
Rh	103	483067.04	483067.041		ug/L

Standard Deviations

Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
U	238	3287.763	0.009	0.085
Ir	193	3608.492	0.005	
U	235	54.531	0.000	
Ho	165	8531.473	0.008	
Rh	103	2840.844	2840.844	

Quantitative Analysis - Comprehensive Report

Sample ID: CCB
Sample Date/Time: Monday, October 28, 2002 11:11:58
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\CCB.014
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	738.09	0.002	0.016996	ug/L
Ir	193	311710.86	0.727		ug/L
U	235	13.33	0.000		ug/L
Ho	165	711815.56	1.660		ug/L
Rh	103	428725.67	428725.666		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	753.43	0.002	0.016598	ug/L
Ir	193	322743.58	0.720		ug/L
U	235	20.67	0.000		ug/L
Ho	165	745617.90	1.664		ug/L
Rh	103	448139.25	448139.250		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	732.76	0.002	0.016012	ug/L
Ir	193	328991.64	0.728		ug/L
U	235	14.67	0.000		ug/L
Ho	165	758116.48	1.678		ug/L
Rh	103	451802.31	451802.314		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	762.10	0.002	0.016626	ug/L
Ir	193	327711.26	0.724		ug/L

```
|   U      235        16.67       0.000                    ug/L
|   Ho     165    766194.22       1.693                    ug/L
└>  Rh     103    452539.85  452539.854                    ug/L
    Repeat 5
    Analyte Mass  Meas. Intensity  Net Intensity  Concentration  Sample Unit
┌   U      238       723.42       0.002      0.015588      ug/L
|   Ir     193    329356.61       0.719                    ug/L
|   U      235        10.67       0.000                    ug/L
|   Ho     165    764218.29       1.668                    ug/L
└>  Rh     103    458156.57  458156.570                    ug/L
```

Mean Values

```
    Analyte  Mass  Meas. Intens. Mean  Net Intens. Mean  Conc. Mean  Sample Unit
┌   U        238              741.96             0.002    0.016364   ug/L
|   Ir       193           324102.79             0.724               ug/L
|   U        235               15.20             0.000               ug/L
|   Ho       165           749192.49             1.673               ug/L
└>  Rh       103           447872.73        447872.731               ug/L
```

Standard Deviations

```
    Analyte  Mass  Meas. Intens. SD  Net Intens. SD  Conc. SD
┌   U        238            15.654           0.000     0.001
|   Ir       193          7415.051           0.004
|   U        235             3.754           0.000
|   Ho       165         22384.613           0.013
└>  Rh       103         11287.849       11287.849
```

Quantitative Analysis - Comprehensive Report

Sample ID: 6363001x2
Sample Date/Time: Monday, October 28, 2002 11:14:52
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\6363001x2.015
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	53077.05	0.124	1.228858	ug/L
Ir	193	321438.52	0.754		ug/L
U	235	394.71	0.001		ug/L
Ho	165	764950.01	1.794		ug/L
Rh	103	426411.71	426411.709		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	52042.48	0.122	1.204118	ug/L
Ir	193	322607.20	0.756		ug/L
U	235	408.71	0.001		ug/L
Ho	165	766509.15	1.796		ug/L
Rh	103	426690.55	426690.546		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	52154.90	0.123	1.211261	ug/L
Ir	193	319553.41	0.752		ug/L
U	235	415.38	0.001		ug/L
Ho	165	766100.02	1.802		ug/L
Rh	103	425090.40	425090.399		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	52856.88	0.122	1.200195	ug/L
Ir	193	325234.71	0.748		ug/L

```
|   U        235          430.72         0.001                    ug/L
|   Ho       165       780258.99         1.795                    ug/L
L>  Rh       103       434783.95    434783.951                    ug/L
    Repeat 5
    Analyte  Mass   Meas. Intensity   Net Intensity  Concentration  Sample Unit
[   U        238        52864.91         0.123       1.214208       ug/L
|   Ir       193       326750.87         0.760                      ug/L
|   U        235          398.05         0.001                      ug/L
|   Ho       165       779559.58         1.814                      ug/L
L>  Rh       103       429831.61    429831.605                      ug/L
```

Mean Values

```
    Analyte  Mass  Meas. Intens. Mean  Net Intens. Mean  Conc. Mean  Sample Unit
[   U        238          52599.25            0.123       1.211728   ug/L
|   Ir       193         323116.94            0.754                  ug/L
|   U        235            409.51            0.001                  ug/L
|   Ho       165         771475.55            1.800                  ug/L
L>  Rh       103         428561.64       428561.642                  ug/L
```

Standard Deviations

```
    Analyte  Mass  Meas. Intens. SD   Net Intens. SD   Conc. SD
[   U        238          467.085           0.001        0.011
|   Ir       193         2892.493           0.005
|   U        235           14.450           0.000
|   Ho       165         7724.063           0.008
L>  Rh       103         3889.173        3889.173
```

Quantitative Analysis - Comprehensive Report

Sample ID: 6363001IDx2
Sample Date/Time: Monday, October 28, 2002 11:17:43
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\6363001IDx2.016
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	53065.00	0.135	1.333608	ug/L
|	Ir	193	295911.94	0.753		ug/L
|	U	235	392.71	0.001		ug/L
|	Ho	165	708045.26	1.802		ug/L
⌊>	Rh	103	392829.18	392829.182		ug/L

Repeat 2

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	52973.99	0.127	1.258691	ug/L
|	Ir	193	312531.24	0.752		ug/L
|	U	235	392.04	0.001		ug/L
|	Ho	165	750928.69	1.807		ug/L
⌊>	Rh	103	415496.66	415496.655		ug/L

Repeat 3

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	53010.80	0.123	1.218041	ug/L
|	Ir	193	322741.53	0.751		ug/L
|	U	235	413.38	0.001		ug/L
|	Ho	165	771923.85	1.797		ug/L
⌊>	Rh	103	429661.24	429661.244		ug/L

Repeat 4

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	53433.08	0.124	1.219436	ug/L
|	Ir	193	331285.98	0.766		ug/L

|	U	235	390.71	0.001		ug/L
|	Ho	165	782954.91	1.810		ug/L
└>	Rh	103	432588.58	432588.578		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	52986.71	0.123	1.213315	ug/L
|	Ir	193	328636.92	0.762		ug/L
|	U	235	407.38	0.001		ug/L
|	Ho	165	777026.80	1.802		ug/L
└>	Rh	103	431138.92	431138.921		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
┌	U	238	53093.91	0.126	1.248618	ug/L
|	Ir	193	318221.52	0.757		ug/L
|	U	235	399.25	0.001		ug/L
|	Ho	165	758175.90	1.804		ug/L
└>	Rh	103	420342.92	420342.916		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
┌	U	238	192.775	0.005	0.051
|	Ir	193	14402.151	0.007	
|	U	235	10.409	0.000	
|	Ho	165	30512.149	0.005	
└>	Rh	103	16836.218	16836.218	

Quantitative Analysis - Comprehensive Report

Sample ID: 6363001ISx2
Sample Date/Time: Monday, October 28, 2002 11:20:35
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\6363001ISx2.017
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	484739.15	1.217	12.012458	ug/L
Ir	193	304556.30	0.764		ug/L
U	235	3561.47	0.009		ug/L
Ho	165	716103.84	1.798		ug/L
Rh	103	398382.37	398382.367		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	476284.30	1.136	11.218316	ug/L
Ir	193	313887.97	0.749		ug/L
U	235	3517.45	0.008		ug/L
Ho	165	749556.57	1.788		ug/L
Rh	103	419143.25	419143.246		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	476356.66	1.127	11.128591	ug/L
Ir	193	320856.94	0.759		ug/L
U	235	3622.82	0.009		ug/L
Ho	165	766216.71	1.813		ug/L
Rh	103	422586.83	422586.832		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	487988.67	1.140	11.259357	ug/L
Ir	193	324918.94	0.759		ug/L

|	U	235	3644.83	0.009		ug/L
|	Ho	165	773760.15	1.808		ug/L
└>	Rh	103	427878.07	427878.065		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	476447.63	1.124	11.097484	ug/L
|	Ir	193	323319.78	0.763		ug/L
|	U	235	3577.47	0.008		ug/L
|	Ho	165	765873.66	1.807		ug/L
└>	Rh	103	423852.29	423852.295		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
┌	U	238	480363.28	1.149	11.343241	ug/L
|	Ir	193	317507.99	0.759		ug/L
|	U	235	3584.81	0.009		ug/L
|	Ho	165	754302.19	1.803		ug/L
└>	Rh	103	418368.56	418368.561		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
┌	U	238	5597.282	0.038	0.380
|	Ir	193	8378.026	0.006	
|	U	235	50.456	0.000	
|	Ho	165	23108.988	0.010	
└>	Rh	103	11601.119	11601.119	

Quantitative Analysis - Comprehensive Report

Sample ID: 6363002x2
Sample Date/Time: Monday, October 28, 2002 11:23:28
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\6363002x2.018
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	69661.05	0.176	1.734242	ug/L
Ir	193	300299.86	0.757		ug/L
U	235	542.06	0.001		ug/L
Ho	165	720229.40	1.816		ug/L
Rh	103	396555.74	396555.742		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	68369.37	0.168	1.654254	ug/L
Ir	193	309501.38	0.759		ug/L
U	235	556.73	0.001		ug/L
Ho	165	732529.59	1.795		ug/L
Rh	103	408021.71	408021.714		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	69026.58	0.163	1.611144	ug/L
Ir	193	319343.44	0.755		ug/L
U	235	526.06	0.001		ug/L
Ho	165	753692.97	1.782		ug/L
Rh	103	422966.53	422966.528		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	69275.14	0.166	1.640090	ug/L
Ir	193	320640.13	0.769		ug/L

|	U	235	498.73	0.001		ug/L
|	Ho	165	756279.33	1.814		ug/L
⌊>	Rh	103	416997.60	416997.597		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	68055.84	0.164	1.618196	ug/L
|	Ir	193	319256.86	0.769		ug/L
|	U	235	508.73	0.001		ug/L
|	Ho	165	752189.97	1.812		ug/L
⌊>	Rh	103	415200.88	415200.878		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
⌈	U	238	68877.59	0.167	1.651585	ug/L
|	Ir	193	313808.33	0.762		ug/L
|	U	235	526.46	0.001		ug/L
|	Ho	165	742984.25	1.804		ug/L
⌊>	Rh	103	411948.49	411948.492		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
⌈	U	238	657.192	0.005	0.049
|	Ir	193	8775.335	0.007	
|	U	235	23.684	0.000	
|	Ho	165	15837.171	0.015	
⌊>	Rh	103	10122.066	10122.066	

Quantitative Analysis - Comprehensive Report

Sample ID: 6363003x2
Sample Date/Time: Monday, October 28, 2002 11:26:21
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\6363003x2.019
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	67751.04	0.178	1.759315	ug/L
Ir	193	289816.28	0.762		ug/L
U	235	488.72	0.001		ug/L
Ho	165	680689.28	1.790		ug/L
Rh	103	380186.04	380186.036		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	67989.52	0.168	1.653873	ug/L
Ir	193	307707.06	0.758		ug/L
U	235	495.39	0.001		ug/L
Ho	165	728378.83	1.795		ug/L
Rh	103	405848.22	405848.221		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	67331.02	0.163	1.613362	ug/L
Ir	193	316417.11	0.768		ug/L
U	235	532.06	0.001		ug/L
Ho	165	747081.62	1.813		ug/L
Rh	103	412009.47	412009.471		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	67024.21	0.159	1.574458	ug/L
Ir	193	322170.13	0.767		ug/L

|	U	235	512.73	0.001		ug/L
|	Ho	165	754933.41	1.796		ug/L
└>	Rh	103	420266.30	420266.303		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	68274.24	0.161	1.585788	ug/L
|	Ir	193	323319.78	0.761		ug/L
|	U	235	516.73	0.001		ug/L
|	Ho	165	767224.11	1.805		ug/L
└>	Rh	103	425045.76	425045.762		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
┌	U	238	67674.00	0.166	1.637359	ug/L
|	Ir	193	311886.07	0.763		ug/L
|	U	235	509.13	0.001		ug/L
|	Ho	165	735661.45	1.800		ug/L
└>	Rh	103	408671.16	408671.159		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
┌	U	238	501.406	0.008	0.075
|	Ir	193	13798.204	0.004	
|	U	235	17.333	0.000	
|	Ho	165	33812.001	0.009	
└>	Rh	103	17557.694	17557.694	

Quantitative Analysis - Comprehensive Report

Sample ID: 6363003dupx2
Sample Date/Time: Monday, October 28, 2002 11:29:14
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\6363003dupx2.020
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	68057.85	0.174	1.716727	ug/L
Ir	193	297115.32	0.759		ug/L
U	235	512.06	0.001		ug/L
Ho	165	698788.90	1.785		ug/L
Rh	103	391382.13	391382.126		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	67950.00	0.167	1.646038	ug/L
Ir	193	313793.93	0.770		ug/L
U	235	466.72	0.001		ug/L
Ho	165	733475.76	1.800		ug/L
Rh	103	407542.96	407542.955		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	68583.07	0.163	1.612705	ug/L
Ir	193	324590.23	0.773		ug/L
U	235	513.39	0.001		ug/L
Ho	165	761731.02	1.814		ug/L
Rh	103	419842.06	419842.058		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	68506.70	0.161	1.587560	ug/L
Ir	193	327784.92	0.769		ug/L

│	U	235	484.72	0.001		ug/L
│	Ho	165	771830.32	1.812		ug/L
└>	Rh	103	426016.81	426016.814		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	68213.27	0.160	1.584408	ug/L
│	Ir	193	327619.85	0.771		ug/L
│	U	235	506.73	0.001		ug/L
│	Ho	165	770969.58	1.814		ug/L
└>	Rh	103	425036.15	425036.148		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
┌	U	238	68262.18	0.165	1.629488	ug/L
│	Ir	193	318180.85	0.768		ug/L
│	U	235	496.72	0.001		ug/L
│	Ho	165	747359.12	1.805		ug/L
└>	Rh	103	413964.02	413964.020		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
┌	U	238	275.846	0.006	0.055
│	Ir	193	13090.214	0.005	
│	U	235	20.355	0.000	
│	Ho	165	31283.619	0.012	
└>	Rh	103	14608.090	14608.090	

Quantitative Analysis - Comprehensive Report

Sample ID: 6363003MSx2
Sample Date/Time: Monday, October 28, 2002 11:32:08
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\6363003MSx2.021
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

```
    Repeat 1
    Analyte  Mass   Meas. Intensity  Net Intensity  Concentration  Sample Unit
[   U        238        298154.74          0.718       7.083605   ug/L
|   Ir       193        320505.82          0.771                  ug/L
|   U        235          2199.72          0.005                  ug/L
|   Ho       165        756036.97          1.819                  ug/L
L>  Rh       103        415538.52     415538.518                  ug/L
    Repeat 2
    Analyte  Mass   Meas. Intensity  Net Intensity  Concentration  Sample Unit
[   U        238        294111.14          0.686       6.768985   ug/L
|   Ir       193        328018.89          0.765                  ug/L
|   U        235          2187.05          0.005                  ug/L
|   Ho       165        783066.81          1.826                  ug/L
L>  Rh       103        428955.09     428955.090                  ug/L
    Repeat 3
    Analyte  Mass   Meas. Intensity  Net Intensity  Concentration  Sample Unit
[   U        238        292810.71          0.675       6.659624   ug/L
|   Ir       193        333527.46          0.768                  ug/L
|   U        235          2196.39          0.005                  ug/L
|   Ho       165        789592.31          1.819                  ug/L
L>  Rh       103        434071.36     434071.363                  ug/L
    Repeat 4
    Analyte  Mass   Meas. Intensity  Net Intensity  Concentration  Sample Unit
[   U        238        293686.50          0.678       6.697460   ug/L
|   Ir       193        332875.79          0.769                  ug/L
```

|	U	235	2199.72	0.005		ug/L
|	Ho	165	793975.95	1.834		ug/L
└>	Rh	103	432910.13	432910.133		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	298651.00	0.685	6.762510	ug/L
|	Ir	193	339350.79	0.778		ug/L
|	U	235	2213.73	0.005		ug/L
|	Ho	165	796347.53	1.827		ug/L
└>	Rh	103	435993.44	435993.437		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
┌	U	238	295482.82	0.688	6.794437	ug/L
|	Ir	193	330855.75	0.770		ug/L
|	U	235	2199.32	0.005		ug/L
|	Ho	165	783803.91	1.825		ug/L
└>	Rh	103	429493.71	429493.708		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
┌	U	238	2712.239	0.017	0.168
|	Ir	193	7045.445	0.005	
|	U	235	9.578	0.000	
|	Ho	165	16323.789	0.006	
└>	Rh	103	8214.481	8214.481	

Quantitative Analysis - Comprehensive Report

Sample ID: 6363003MSDx2
Sample Date/Time: Monday, October 28, 2002 11:35:02
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\6363003MSDx2.022
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	297688.46	0.706	6.966528	ug/L
Ir	193	322788.58	0.765		ug/L
U	235	2121.04	0.005		ug/L
Ho	165	765479.31	1.815		ug/L
Rh	103	421861.11	421861.112		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	290891.23	0.693	6.837167	ug/L
Ir	193	323990.11	0.771		ug/L
U	235	2178.38	0.005		ug/L
Ho	165	769679.97	1.832		ug/L
Rh	103	420028.09	420028.093		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	294589.57	0.684	6.751237	ug/L
Ir	193	331979.20	0.771		ug/L
U	235	2190.39	0.005		ug/L
Ho	165	786201.78	1.825		ug/L
Rh	103	430782.37	430782.368		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	292017.98	0.673	6.640207	ug/L
Ir	193	337544.57	0.777		ug/L

U	235	2213.73	0.005		ug/L
Ho	165	798763.18	1.840		ug/L
Rh	103	434162.07	434162.066		ug/L

Repeat 5

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	296534.04	0.686	6.770941	ug/L
Ir	193	336518.01	0.778		ug/L
U	235	2138.37	0.005		ug/L
Ho	165	790829.45	1.829		ug/L
Rh	103	432363.91	432363.906		ug/L

Mean Values

Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
U	238	294344.26	0.688	6.793216	ug/L
Ir	193	330564.09	0.773		ug/L
U	235	2168.38	0.005		ug/L
Ho	165	782190.74	1.828		ug/L
Rh	103	427839.51	427839.509		ug/L

Standard Deviations

Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
U	238	2888.507	0.012	0.120
Ir	193	6889.385	0.005	
U	235	38.021	0.000	
Ho	165	14152.322	0.009	
Rh	103	6439.425	6439.425	

Quantitative Analysis - Comprehensive Report

Sample ID: Rinse
Sample Date/Time: Monday, October 28, 2002 11:37:57
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\Rinse.023
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	162.02	0.000	0.003669	ug/L
|	Ir	193	312703.64	0.717		ug/L
|	U	235	10.67	0.000		ug/L
|	Ho	165	761838.54	1.748		ug/L
L>	Rh	103	435945.33	435945.331		ug/L

Repeat 2

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	163.35	0.000	0.003607	ug/L
|	Ir	193	318232.27	0.712		ug/L
|	U	235	7.33	0.000		ug/L
|	Ho	165	769146.29	1.721		ug/L
L>	Rh	103	447036.73	447036.728		ug/L

Repeat 3

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	160.02	0.000	0.003514	ug/L
|	Ir	193	321262.61	0.715		ug/L
|	U	235	3.33	0.000		ug/L
|	Ho	165	771942.14	1.717		ug/L
L>	Rh	103	449554.15	449554.149		ug/L

Repeat 4

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
⌈	U	238	161.35	0.000	0.003566	ug/L
|	Ir	193	320637.40	0.718		ug/L

|	U	235	11.33	0.000		ug/L
|	Ho	165	774713.20	1.734		ug/L
└>	Rh	103	446751.31	446751.310		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
┌	U	238	154.68	0.000	0.003408	ug/L
|	Ir	193	321887.84	0.718		ug/L
|	U	235	9.33	0.000		ug/L
|	Ho	165	780869.77	1.743		ug/L
└>	Rh	103	448049.83	448049.834		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
┌	U	238	160.28	0.000	0.003553	ug/L
|	Ir	193	318944.75	0.716		ug/L
|	U	235	8.40	0.000		ug/L
|	Ho	165	771701.99	1.732		ug/L
└>	Rh	103	445467.47	445467.470		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
┌	U	238	3.354	0.000	0.000
|	Ir	193	3753.612	0.003	
|	U	235	3.218	0.000	
|	Ho	165	7017.698	0.013	
└>	Rh	103	5434.876	5434.876	

Quantitative Analysis - Comprehensive Report

Sample ID: CCV
Sample Date/Time: Monday, October 28, 2002 11:40:53
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\CCV.024
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	442989.13	1.086	10.720366	ug/L
Ir	193	300995.67	0.738		ug/L
U	235	3168.00	0.008		ug/L
Ho	165	682932.16	1.674		ug/L
Rh	103	407950.38	407950.379		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	439663.06	1.029	10.158904	ug/L
Ir	193	317455.19	0.743		ug/L
U	235	3270.03	0.008		ug/L
Ho	165	723967.09	1.694		ug/L
Rh	103	427264.72	427264.719		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	440839.27	1.004	9.911684	ug/L
Ir	193	325407.93	0.741		ug/L
U	235	3298.04	0.008		ug/L
Ho	165	747547.79	1.702		ug/L
Rh	103	439093.21	439093.207		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	432805.01	0.998	9.854060	ug/L
Ir	193	S	S		ug/L

|	U	235	3163.33	0.007		ug/L
|	Ho	165	736624.70	1.699		ug/L
L>	Rh	103	433611.67	433611.670		ug/L

Repeat 5

	Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
[	U	238	442633.67	1.018	10.051079	ug/L
|	Ir	193	324747.08	0.747		ug/L
|	U	235	3370.73	0.008		ug/L
|	Ho	165	750757.34	1.727		ug/L
L>	Rh	103	434766.08	434766.084		ug/L

Mean Values

	Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
[	U	238	439786.03	1.027	10.139219	ug/L
|	Ir	193	S	S		ug/L
|	U	235	3254.03	0.008		ug/L
|	Ho	165	728365.82	1.699		ug/L
L>	Rh	103	428537.21	428537.212		ug/L

Standard Deviations

	Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
[	U	238	4130.012	0.035	0.346
|	Ir	193	S	S	
|	U	235	88.657	0.000	
|	Ho	165	27482.282	0.019	
L>	Rh	103	12261.881	12261.881	

Quantitative Analysis - Comprehensive Report

Sample ID: CCB
Sample Date/Time: Monday, October 28, 2002 11:43:50
Sample Description:
Solution Type: Sample
Blank File:
Number of Replicates: 5
Peak Processing Mode: Average
Signal Profile Processing Mode: Average
Dual Detector Mode: Pulse
Current Dead Time (ns): 35
Acq. Dead Time(ns): 35
Cumulative Autodilution Factor: 1

Sample File: c:\elandata\Sample\TotalU.sam
Method File: c:\elandata\Method\totalu.mth
Dataset File: C:\elandata\Dataset\102802\CCB.025
Tuning File: c:\elandata\Tuning\default.tun
Optimization File: c:\elandata\Optimize\uranium.dac
Calibration File:
Calibration Type: External Calibration

Replicates

Repeat 1

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	778.10	0.002	0.015897	ug/L
Ir	193	356003.76	0.737		ug/L
U	235	12.67	0.000		ug/L
Ho	165	819589.16	1.696		ug/L
Rh	103	483230.50	483230.499		ug/L

Repeat 2

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	744.09	0.002	0.015308	ug/L
Ir	193	352040.28	0.734		ug/L
U	235	13.33	0.000		ug/L
Ho	165	810655.59	1.689		ug/L
Rh	103	479877.96	479877.959		ug/L

Repeat 3

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	768.76	0.002	0.015787	ug/L
Ir	193	353117.83	0.735		ug/L
U	235	12.00	0.000		ug/L
Ho	165	821475.17	1.709		ug/L
Rh	103	480734.12	480734.117		ug/L

Repeat 4

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	792.10	0.002	0.016203	ug/L
Ir	193	355158.35	0.736		ug/L

U	235	10.67	0.000		ug/L
Ho	165	830063.00	1.720		ug/L
Rh	103	482620.33	482620.325		ug/L

Repeat 5

Analyte	Mass	Meas. Intensity	Net Intensity	Concentration	Sample Unit
U	238	734.09	0.002	0.014941	ug/L
Ir	193	356622.30	0.735		ug/L
U	235	16.67	0.000		ug/L
Ho	165	829650.68	1.710		ug/L
Rh	103	485074.97	485074.968		ug/L

Mean Values

Analyte	Mass	Meas. Intens. Mean	Net Intens. Mean	Conc. Mean	Sample Unit
U	238	763.43	0.002	0.015627	ug/L
Ir	193	354588.50	0.735		ug/L
U	235	13.07	0.000		ug/L
Ho	165	822286.72	1.705		ug/L
Rh	103	482307.57	482307.574		ug/L

Standard Deviations

Analyte	Mass	Meas. Intens. SD	Net Intens. SD	Conc. SD
U	238	23.981	0.000	0.001
Ir	193	1944.242	0.001	
U	235	2.241	0.000	
Ho	165	8029.900	0.012	
Rh	103	2060.756	2060.756	

MALE REPRODUCTIVE ASSESSMENT REPORT

FOR

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

PREPARED FOR

U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE

PREPARED BY

PATHOLOGY ASSOCIATES (PAI)
A DIVISION OF CHARLES RIVER LABORATORIES, INC.

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I. QUALITY ASSURANCE STATEMENT

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

II. MATERIALS AND METHODS

A. Sample Collection

Microtus pennsylvanicus (Meadow vole) were captured in Sherman live traps on uranium depleted (DU) and high explosive (HE) impact areas from September 19-24 and on reference (DA) areas from October 10-15, 2002. Adult male animals were identified and submitted for sperm analysis. All animals submitted for sperm analysis were euthanized with carbon dioxide inhalation and exsanguination. After euthanasia, a terminal body weight for each animal was measured and recorded. For all animals, the abdominal cavity was opened and the reproductive organs exposed. For motility assessment, the right epididymis was dissected away from the testis and immediately placed in a petri dish containing 3 mL of a solution consisting of 1% Bovine Serum Albumin dissolved in Phosphate Buffered Saline. The solution was prewarmed to a temperature of approximately 38°C. The epididymis was pierced and a minimum 3-minute period was allowed for the sperm to disperse from the epididymis.

The liver, spleen, kidneys and testes were removed from the body, weighed and preserved in 10% neutral buffered formalin (NBF). The left epididymis was removed and the caudal section was trimmed and weighed. The left cauda epididymis was then placed in a petri dish containing 3 mL of deionized water and used to determine total sperm count.

B. Sperm Motility Evaluation

Following the dispersal period, a 9 μL sperm sample was obtained from the petri dish and loaded into a 20 μM deep Cell-Vu chamber. The chamber was cover slipped and immediately loaded onto the prewarmed stage of the Hamilton Thorne IVOS automated sperm analyzer. Five fields were automatically selected by the analyzer and each motion image was recorded and stored digitally. The images were subsequently analyzed for percent motility. The percent progressive motility and the sperm motion parameters listed below were also obtained for each animal. The images were permanently stored to optical media.

Motility	The ratio (%) of moving sperm to total sperm present.
Progressive Motility	The ratio (%) of sperm that meet a minimum velocity (75 μM/sec) and a track straightness (45%) criteria to total number of sperm.
Path Velocity (VAP)	Velocity of the average cell path.
Straight-line Velocity (VSL)	Velocity from the beginning of the sperm track to the end of the track.
Curvilinear Velocity (VCL)	Velocity of the actual path (point-to-point).
Beat Cross Frequency (BCF)	The frequency with which the sperm track crosses the sperm path.

C. Total Sperm Count Determination

Each epididymis was homogenized and the suspension was transferred to a glass test tube and vortexed. A 100 μL sample was transferred to a reaction vial containing a Hoechst dye (H33342) which uniquely stains the DNA of the sperm. A sample of the stained sperm was placed into a 20 μM deep glass slide which was loaded into the analyzer. Twenty fields were automatically selected by the analyzer for each animal and total sperm counts determined. The counts reported were adjusted for epididymal weight.

D. Sperm Morphology Evaluation

Two eosin stained slides were prepared for each animal from the epididymis total count preparation. The slides were evaluated and a minimum of 200 sperm cells/animal were examined for morphological development.

E. Tissue Histopathological Evaluation

The preserved tissues (liver, spleen, kidneys and testes) were transferred to PAI, Frederick, MD for processing and evaluation. The tissues were embedded in paraffin, sectioned at approximately five microns, stained with hematoxiylin and eosin (H&E), and examined by a veterinary pathologist.

The technical qualities of tissue fixation, microtomy and staining for the majority of tissues were good. Autolysis and/or fixation artifacts were present in most sections of testes. In addition, staining of testes sections was not optimal for spermatogenic staging.

F. Statistical Analyses

The means and standard deviations for the animal body weight data, the organ-to-body weight ratios (as a percent of body weight), the sperm motility and motion data, the total count data and the sperm morphology data were calculated. Summary data for the impact areas (DU and HE) were reported combined (DU&HE) and separately. Data were grouped by parameter and tested for normality of distribution using the Shapiro-Wilk test. Normally distributed data analyzed by analysis of variance (ANOVA). If a significant effect was seen ($p<0.05$), the Dunnett's test was used for comparison of the impact groups (DU and HE) to the reference group (DA). Data failing the Shapiro-Wilk test were analyzed by the Kruskal-Wallis nonparametric test. If a significant effect was seen ($p<0.05$), the Mann-Whitney U test was used for comparison of the impact groups (DU and HE) to the reference group (DA). Histopathological findings were not statistically analyzed. Statistical analyses were performed using verified SAS computer programs.

III. RESULTS

A. Body and Organ Weights

Table 1 (Summary Data: Impact Areas Combined)
Table 2 (Summary Data: Impact Areas Separated)
Appendix A (Individual Body and Organ Weight Data)
Appendix B (Individual Organ Weight to Body Weight Ratio)

A statistically significant decrease in the liver-to-body weight ratio was observed in the combined impact area data (DU+HE) compared to the reference area data (DA). A similar and corresponding decrease in the liver-to-body weight ratio was not observed when the impact areas were separated. No other statistically significant differences or biologically meaningful differences were observed in the body weight or relative organ weight data, including spleen, kidney, left epididymis and testes, for the combined or separated impact areas.

B. Sperm Analysis Parameters

Table 3 (Summary Data: Impact Areas Combined)
Table 4 (Summary Data: Impact Areas Separated)
Appendix C (Individual Sperm Motility and Total Count Data)
Appendix D (Individual Sperm Morphology Data)

A statistically significant reduction of the curvilinear velocity (VCL) for the high explosive (HE) impact area was observed. A similar, although not statistically significant, reduction in the straight-line (VSL) and average path (VAP) velocities was also observed. No biologically meaningful differences were observed for the sperm analysis parameters examined, including sperm motility, progressive motility, VAP, VCL, VSL, BCF, epididymal sperm count or sperm morphology, either as combined or separated impact areas.

C. Microscopic Tissue Evaluation

Table 5 (Summary Data: Impact Areas Combined)
Table 6 (Summary Data: Impact Areas Separated)
Appendix E (Individual Organ Microscopic Evaluation Data)

No significant differences in the microscopic findings were noted in the liver, spleen, kidneys and testes between the impact and the reference area animals. Incidental, background and/or parasitic findings were noted in all tissues and in all areas. Minimal inflammation is a common liver finding in rodents and parasitic cysts were noted in livers of two reference voles. Extramedullary hematopoiesis (EMH) was absent or unidentifiable in the spleens of 6/14 impact animals and 2/10 reference animals. EMH is common in mouse spleens and its absence suggests a possible alteration in the ability to produce or the need for new blood cells. Additional diagnosis is unobtainable with the tissues provided. Inflammation and degenerative tubular changes of minimal or mild severity are common in rodent kidneys and were present in both reference and impact animals. Degenerative changes in the seminiferous tubules were present in both reference and impact animals. Generally, these changes were minimal in severity and located near the rete testes. Most likely these areas of the seminiferous tubules represent the tubuli recti in which germinal epithelial cell loss is normal. Degenerative tubular changes were more severe in three of the impact voles evaluated. There are no apparent microscopic changes in the tissues examined that can be directly linked to exposure to (HE) or (DU) environments.

IV. DISCUSSION AND CONCLUSIONS

There were no exposure-related changes to body weight, organ-to-body weight ratios, sperm analysis parameters or microscopic evaluation of selected tissues. Incidental changes occurred in all areas (weight, sperm analysis and histopathological evaluation), but none were consistent between the impact exposure areas (HE, DU or HE+DU). Incidental changes included a decrease in the liver-to-body weight ratio of the combined (HE+DU) impact areas; however, a corresponding decrease was not observed when the impact data was separated by contaminant (HE or DU). Incidental changes in the sperm analysis parameters included a reduction in the curvilinear velocity (VCL), straight-line velocity (VSL) and average path velocity (VAP) for the HE impact area. These reductions were not considered exposure-related because progressive motility, of which velocity and straightness are components, was not reduced. In fact, the percent progressive motility for the HE impact area was equivalent to the reference. There were incidental microscopic findings in all tissues of all exposure areas.

In conclusion, high explosives (HE) or depleted uranium (DU) at Jefferson Proving Ground did not have an adverse impact on the body weight, organ-to-body weight ratio, sperm analysis parameters or microscopic cellular structure for the Meadow voles examined.

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TABLE 1

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

SUMMARY OF BODY WEIGHT AND ORGAN WEIGHT TO BODY WEIGHT RATIO
IMPACT AREAS COMBINED

AREA GROUPING:		DA (REFERENCE)	DU+HE[a] (IMPACT)
ANIMAL BODY WEIGHT (BW) (grams)	MEAN	40.1532	37.1321
	SD	4.6977	4.4082
	N	10	14
LIVER/BW RATIO (% of Body Weight)	MEAN	4.6008	3.9318[y]
	SD	0.8165	0.5719
	N	10	14
SPLEEN/BW RATIO (% of Body Weight)	MEAN[x]	0.2447	0.1605
	SD	0.2457	0.0830
	N	10	14
KIDNEYS/BW RATIO (% of Body Weight)	MEAN	1.0687	1.1886
	SD	0.1355	0.2304
	N	10	14
LEFT EPIDIDYMIS/BW RATIO (% of Body Weight)	MEAN	0.1460	0.1514
	SD	0.0242	0.0454
	N	10	14
TESTES/BW RATIO (% of Body Weight)	MEAN	3.1790	3.3670
	SD	0.3525	0.5974
	N	14	14

[a] DATA FOR HE AND DU IMPACT AREAS COMBINED.

[x] DATA ARE NOT NORMALLY DISTRIBUTED (SHAPIRO-WILK TEST $p < 0.05$).

[y] ANALYSIS OF VARIANCE TEST (ANOVA) SIGNIFICANTLY DIFFERENT FROM DA (REFERENCE) GROUP ($p < 0.05$).

TABLE 2

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

SUMMARY OF BODY WEIGHT AND ORGAN WEIGHT TO BODY WEIGHT RATIO IMPACT AREAS SEPARATED

AREA GROUPING:		DA (REFERENCE)	DU (-------IMPACT	HE ------)
ANIMAL BODY WEIGHT (BW) (grams)				
	MEAN	40.1532	35.1973	38.2070
	SD	4.6977	4.8082	4.0470
	N	10	5	9
LIVER/BW RATIO (% of Body Weight)				
	MEAN	4.6008	3.9382	3.9282
	SD	0.8165	0.6243	0.5802
	N	10	5	9
SPLEEN/BW RATIO (% of Body Weight)				
	MEAN*	0.2447	0.1080	0.1898
	SD	0.2457	0.0339	0.0890
	N	10	5	9
KIDNEYS/BW RATIO (% of Body Weight)				
	MEAN	1.0687	1.1093	1.2327
	SD	0.1355	0.1309	0.2675
	N	10	5	9
LEFT EPIDIDYMIS/BW RATIO (% of Body Weight)				
	MEAN	0.1460	0.1601	0.1466
	SD	0.0242	0.0495	0.0453
	N	10	5	9
TESTES/BW RATIO (% of Body Weight)				
	MEAN	3.1790	3.7136	3.1745
	SD	0.3525	0.4436	0.6039
	N	14	5	9

*DATA ARE NOT NORMALLY DISTRIBUTED (SHAPIRO-WILK TEST $p < 0.05$).
NONE SIGNIFICANTLY DIFFERENT FROM DA (REFERENCE) GROUP.

TABLE 3

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

SUMMARY OF SPERM ANALYSIS PARAMETERS
IMPACT AREAS COMBINED

AREA GROUPING:		DA (REFERENCE)	DU+HE[a] (IMPACT)
MOTILITY (% MOTILE)			
	MEAN[x]	76	80
	SD	17	11
	N	10	14
PROGRESSIVE MOTILITY (% PROGRESSIVELY MOTILE)			
	MEAN[x]	67	71
	SD	16	12
	N	10	14
VAP (μm/sec)			
	MEAN[x]	230.1	194.7
	SD	18.3	54.5
	N	10	14
VCL (μm/sec)			
	MEAN[x]	478.0	408.8
	SD	36.8	108.6
	N	10	14
VSL (μm/sec)			
	MEAN	158.9	138.3
	SD	12.0	35.1
	N	10	14
BCF			
	MEAN[x]	26.5	29.6
	SD	3.2	10.1
	N	10	14
EPIDIDYMAL SPERM COUNT (10^6 SPERM/GRAM OF TISSUE)			
	MEAN[x]	2498.6	1902.4
	SD	499.1	799.3
	N	10	14
MORPHOLOGY[b] (% ABNORMAL SPERM)			
	MEAN[x]	0.9	0.8
	SD	0.7	1.0
	N	10	11

---

[a] DATA FOR HE AND DU IMPACT AREAS COMBINED.
[b] MEAN AND STANDARD DEVIATIONS WERE CALCULATED USING THE TOTAL NUMBER OF ABNORMAL SPERM AS A PERCENTAGE OF THE NUMBER OF SPERM EXAMINED.

[x] DATA ARE NOT NORMALLY DISTRIBUTED (SHAPIRO-WILK TEST $p < 0.05$).
NONE STATISTICALLY DIFFERENT FROM DA (REFERENCE) GROUP.

TABLE 4

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

SUMMARY OF SPERM ANALYSIS PARAMETERS
IMPACT AREAS SEPARATED

AREA GROUPING:		DA	DU	HE
		(REFERENCE)	(-------IMPACT	------)
MOTILITY (% MOTILE)				
	MEAN[x]	76	73	84
	SD	17	14	7
	N	10	5	9
PROGRESSIVE MOTILITY (% PROGRESSIVELY MOTILE)				
	MEAN[x]	67	63	76
	SD	16	9	10
	N	10	5	9
VAP (μm/sec)				
	MEAN[x]	230.1	227.2	176.6
	SD	18.3	28.8	58.3
	N	10	5	9
VCL (μm/sec)				
	MEAN[x]	478.0	478.3	370.2[z]
	SD	36.8	47.4	115.6
	N	10	5	9
VSL (μm/sec)				
	MEAN	158.9	149.2	132.2
	SD	12.0	29.4	38.1
	N	10	5	9
BCF				
	MEAN[x]	26.5	24.9	32.3
	SD	3.2	5.5	11.4
	N	10	5	9
EPIDIDYMAL SPERM COUNT (10^6 SPERM/GRAM OF TISSUE)				
	MEAN[x]	2498.6	1866.9	1922.1
	SD	499.1	737.6	874.6
	N	10	5	9
MORPHOLOGY[a] (% ABNORMAL SPERM)				
	MEAN[x]	0.9	1.4	0.3
	SD	0.7	1.1	0.6
	N	10	5	6

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[a] MEAN AND STANDARD DEVIATIONS WERE CALCULATED USING THE TOTAL NUMBER OF ABNORMAL SPERM AS A PERCENTAGE OF THE NUMBER OF SPERM EXAMINED.

[x] DATA ARE NOT NORMALLY DISTRIBUTED (SHAPIRO-WILK TEST $p < 0.05$).
[z] KRUSKAL-WALLIS/MANN-WHITNEY U TEST SIGNIFICANTLY DIFFERENT FROM DA (REFERENCE) GROUP ($p < 0.05$).

TABLE 5

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

SUMMARY OF MICROSCOPIC HISTOPATHOLOGICAL FINDINGS
IMPACT AREAS COMBINED

AREA GROUPING:	DA (REFERENCE)	DU+HE[a] (IMPACT)
NUMBER EXAMINED	10	14
LIVER		
NORMAL	4	5
NECROSIS, HEPATOCELLULAR	2	0
INFLAMMATION SUBACUTE	5	9
INFLAMMATION MONONUCLEAR, PORTAL	2	0
INFLAMMATION CHRONIC	1	0
HYPERPLASIA, BILE DUCT EPITHELIUM	0	1
PROTOZOAL CYST	1	0
CESTODE CYST	1	0
SPLEEN		
NORMAL	7	6
LYMPHOID DEPLETION	0	1
PLASMACYTOSIS	0	1
DECREASED EMH	2	6
INCREASED EMH	1	1
INCREASED EMM	0	1
KIDNEY		
NORMAL	2	3
INFLAMMATION MONONUCLEAR, INTERSTITIAL	3	4
DEGENERATION, TUBULAR	3	7
DEGENERATION VACUOLAR, DCT	0	3
ATROPHY/LOSS, TUBULES	0	1
INFLAMMATION SUBACUTE, INTERSTITIAL	2	6
INFLAMMATION CHRONIC	1	1
PROTOZOAL CYSTS	1	0
HYALIN CASTS	2	4
MINERALIZATION	2	1
TESTES		
NORMAL	2	2
DESQUAMATED GERMINAL CELLS	3	2
DEGENERATION, SEMINIFEROUS TUBULE(S)	8	11
POLYNUCLEATED SPERMATIDS	2	3
INFLAMMATION SUBACUTE	0	1
FOREIGN BODY	0	1

[a] DATA FOR HE AND DU IMPACT AREAS COMBINED.

EMH=EXTRAMEDULLARY HEMATOPOIESIS.
EMM=EXTRAMDULLARY MYELOPOIESIS
DCT=DISTAL CONVOLUTED TUBULE

INCIDENCE OF FINDINGS NOT STATISTICALLY ANALYZED.

TABLE 6

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

SUMMARY OF MICROSCOPIC HISTOPATHOLOGICAL FINDINGS IMPACT AREAS COMBINED

AREA GROUPING:	DA (REFERENCE)	DU (-------IMPACT	HE ------)
NUMBER EXAMINED	10	5	9
LIVER			
NORMAL	4	3	2
NECROSIS, HEPATOCELLULAR	2	0	0
INFLAMMATION SUBACUTE	5	2	7
INFLAMMATION MONONUCLEAR, PORTAL	2	0	0
INFLAMMATION CHRONIC	1	0	0
HYPERPLASIA, BILE DUCT EPITHELIUM	0	0	1
PROTOZOAL CYST	1	0	0
CESTODE CYST	1	0	0
SPLEEN			
NORMAL	7	1	5
LYMPHOID DEPLETION	0	1	0
PLASMACYTOSIS	0	1	0
DECREASED EMH	2	3	3
INCREASED EMH	1	0	1
INCREASED EMM	0	1	0
KIDNEY			
NORMAL	2	2	1
INFLAMMATION MONONUCLEAR, INTERSTITIAL	3	2	2
DEGENERATION, TUBULAR	3	1	6
DEGENERATION VACUOLAR, DCT	0	1	2
ATROPHY/LOSS, TUBULES	0	0	1
INFLAMMATION SUBACUTE, INTERSTITIAL	2	1	5
INFLAMMATION CHRONIC	1	0	1
PROTOZOAL CYSTS	1	0	0
HYALIN CASTS	2	0	4
MINERALIZATION	2	0	1
TESTES			
NORMAL	2	1	1
DESQUAMATED GERMINAL CELLS	3	0	2
DEGENERATION, SEMINIFEROUS TUBULE(S)	8	4	7
POLYNUCLEATED SPERMATIDS	2	1	2
INFLAMMATION SUBACUTE	0	0	1
FOREIGN BODY	0	0	1

EMH=EXTRAMEDULLARY HEMATOPOIESIS.
EMM=EXTRAMDULLARY MYELOPOIESIS
DCT=DISTAL CONVOLUTED TUBULE

INCIDENCE OF FINDINGS NOT STATISTICALLY ANALYZED.

APPENDIX A

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

INDIVIDUAL BODY AND ORGAN WEIGHT DATA

UNIQUE ANIMAL ID	ANIMAL ID	ANIMAL WEIGHT	LIVER WEIGHT	SPLEEN WEIGHT	KIDNEY WEIGHT	LEFT EPIDIDYMIS WEIGHT	TESTES WEIGHT
DA AREA	**(REFERENCE SITE)**						
16	MV-DA-3-34	36.5305	1.7508	0.0945	0.3937	0.0547	0.9196
18	MV-DA-2-30	34.5176	1.8365	0.0369	0.3719	0.0404	1.0642
20	MV-DA-3-84	40.0246	2.4793	0.3661	0.3912	0.0765	1.4277
21	MV-DA-3-34	40.6456	1.6997	0.0734	0.4852	0.0610	1.3056
22	MV-DA-3-78	49.6924	2.6148	0.0943	0.5805	0.0666	1.4702
23	MV-DA-2-81	40.7145	1.7459	0.0502	0.3293	0.0578	1.1460
24	MV-DA-3-58	44.1791	1.9709	0.0652	0.4003	0.0769	1.6386
25	MV-DA-1-45	41.4941	1.7971	0.1308	0.5079	0.0636	1.3936
26	MV-DA-1-66	40.2249	1.3784	0.0446	0.4760	0.0560	1.3363
27	MV-DA-1-88	33.5089	1.2566	0.0332	0.3586	0.0367	1.0883
DU AREA	**(IMPACT SITE)**						
1	MV-DU-3-75	30.6389	1.0816	0.0438	0.3851	0.0716	1.1842
5	MV-DU-1-57	32.7974	1.6312	0.0369	0.3416	0.0379	1.3365
8	MV-DU-4-71	31.9921	1.2617	0.0260	0.3962	0.0594	1.2308
12	MV-DU-4-51	41.6958	1.6124	0.0274	0.4011	0.0508	1.2256
15	MV-DU-1-43	38.8625	1.3122	0.0534	0.4072	0.0558	1.4929
HE AREA	**(IMPACT SITE)**						
2	MV-HE-3-82	36.8328	1.3895	0.0381	0.3819	0.0619	1.1036
3	MV-HE-2-44	31.9620	1.3300	0.0657	0.4647	0.0259	0.7348
4	MV-HE-3-22	40.5749	1.4154	0.0542	0.3304	0.0664	1.3673
7	MV-HE-4-24	40.2796	1.6815	0.0391	0.6452	0.0252	0.8953
9	MV-HE-1-87	41.0036	1.5237	0.0759	0.5449	0.0714	1.3155
10	MV-HE-1-95	38.8827	1.4296	0.0498	0.4805	0.0744	1.5395
11	MV-HE-4-4	32.3957	1.6000	0.1090	0.4784	0.0454	1.0235
13	MV-HE-1-52	44.3544	1.3123	0.0854	0.5487	0.0822	1.7025
14	MV-HE-1-43	37.5772	1.6787	0.1225	0.3415	0.0574	1.3217

APPENDIX B

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

INDIVIDUAL ORGAN WEIGHT TO BODY WEIGHT RATIO

UNIQUE ANIMAL ID	ANIMAL ID	LIVER TO BW RATIO	SPLEEN TO BW RATIO	KIDNEY TO BW RATIO	LEFT EPIDIDYMIS TO BW RATIO	TESTES TO BW RATIO
DA AREA	**(REFERENCE SITE)**					
16	MV-DA-3-34	4.7927	0.2587	1.0777	0.1497	2.5173
18	MV-DA-2-30	5.3205	0.1069	1.0774	0.1170	3.0831
20	MV-DA-3-84	6.1944	0.9147	0.9774	0.1911	3.5671
21	MV-DA-3-34	4.1818	0.1806	1.1937	0.1501	3.2122
22	MV-DA-3-78	5.2620	0.1898	1.1682	0.1340	2.9586
23	MV-DA-2-81	4.2882	0.1233	0.8088	0.1420	2.8147
24	MV-DA-3-58	4.4612	0.1476	0.9061	0.1741	3.7090
25	MV-DA-1-45	4.3310	0.3152	1.2240	0.1533	3.3585
26	MV-DA-1-66	3.4267	0.1109	1.1833	0.1392	3.3221
27	MV-DA-1-88	3.7500	0.0991	1.0702	0.1095	3.2478
DU AREA	**(IMPACT SITE)**					
1	MV-DU-3-75	3.5302	0.1430	1.2569	0.2337	3.8650
5	MV-DU-1-57	4.9736	0.1125	1.0415	0.1156	4.0750
8	MV-DU-4-71	3.9438	0.0813	1.2384	0.1857	3.8472
12	MV-DU-4-51	3.8671	0.0657	0.9620	0.1218	2.9394
15	MV-DU-1-43	3.3765	0.1374	1.0478	0.1436	3.8415
HE AREA	**(IMPACT SITE)**					
2	MV-HE-3-82	3.7725	0.1034	1.0368	0.1681	2.9962
3	MV-HE-2-44	4.1612	0.2056	1.4539	0.0810	2.2990
4	MV-HE-3-22	3.4884	0.1336	0.8143	0.1636	3.3698
7	MV-HE-4-24	4.1746	0.0971	1.6018	0.0626	2.2227
9	MV-HE-1-87	3.7160	0.1851	1.3289	0.1741	3.2083
10	MV-HE-1-95	3.6767	0.1281	1.2358	0.1913	3.9593
11	MV-HE-4-4	4.9389	0.3365	1.4767	0.1401	3.1594
13	MV-HE-1-52	2.9587	0.1925	1.2371	0.1853	3.8384
14	MV-HE-1-43	4.4673	0.3260	0.9088	0.1528	3.5173

APPENDIX C

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

INDIVIDUAL SPERM MOTILITY AND TOTAL COUNT DATA

UNIQUE ANIMAL ID	ANIMAL ID	------PERCENT------		------MOTION PARAMETERS------				TOTAL[a] SPERM COUNT
		MOTILITY	PROGRESSIVE MOTILITY	VAP	VCL	VSL	BCV	
DA AREA	**(REFERENCE SITE)**							
16	MV-DA-3-34	92	84	189.6	400.5	131.6	20.7	2671.4
18	MV-DA-2-30	75	65	242.5	495.4	174.4	30.2	1527.0
20	MV-DA-3-84	37	30	256.2	543.3	160.3	28.1	2282.6
21	MV-DA-3-34	78	71	225.1	476.4	162.7	22.6	2742.7
22	MV-DA-3-78	88	78	219.6	450.2	157.2	24.7	2390.4
23	MV-DA-2-81	85	71	243.3	494.9	156.4	26.9	3156.8
24	MV-DA-3-58	78	69	241.3	480.8	174.6	30.9	2355.7
25	MV-DA-1-45	83	74	220.2	462.6	162.2	25.9	2338.7
26	MV-DA-1-66	87	79	231.6	480.2	154.7	28.1	3276.9
27	MV-DA-1-88	58	51	231.6	495.4	154.8	27.0	2243.7
DU AREA	**(IMPACT SITE)**							
1	MV-DU-3-75	77	64	247.0	507.7	151.5	26.2	755.7
5	MV-DU-1-57	49	48	256.8	514.0	195.6	33.3	1462.2
8	MV-DU-4-71	82	70	182.5	396.4	115.1	19.6	2288.4
12	MV-DU-4-51	84	71	228.5	488.9	145.5	24.8	2439.1
15	MV-DU-1-43	73	60	221.0	484.6	138.5	20.4	2389.2
HE AREA	**(IMPACT SITE)**							
2	MV-HE-3-82	76	70	234.5	434.8	188.1	27.5	2267.8
3	MV-HE-2-44	85	54	83.0	173.7	71.5	46.3	958.8
4	MV-HE-3-22	93	80	222.4	444.2	155.3	30.1	1590.5
7	MV-HE-4-24	87	83	94.2	245.7	81.8	48.6	373.4
9	MV-HE-1-87	80	78	205.9	447.3	136.1	23.1	2262.6
10	MV-HE-1-95	80	80	188.2	407.9	144.3	24.2	2684.4
11	MV-HE-4-4	92	87	138.1	261.4	122.5	45.8	2452.9
13	MV-HE-1-52	91	83	186.9	393.9	121.2	19.6	3132.5
14	MV-HE-1-43	72	68	236.3	522.9	168.7	25.2	1575.7

[a] MILLION SPERM/GRAM TISSUE.

APPENDIX D

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

INDIVIDUAL SPERM MORPHOLOGY DATA

UNIQUE ANIMAL ID	ANIMAL ID	Normal	Head				Tail			
			Amorphous	Small	Enlarged	Double	Coiled	Bent	Double	Other
DA AREA (REFERENCE SITE)										
16	MV-DA-3-34	200	0	0	0	0	0	0	0	0
18	MV-DA-2-30	197	3	0	0	0	0	0	0	0
20	MV-DA-3-84	197	1	2	0	0	0	0	0	0
21	MV-DA-3-34	198	1	1	0	0	0	0	0	0
22	MV-DA-3-78	200	0	0	0	0	0	0	0	0
23	MV-DA-2-81	196	4	0	0	0	0	0	0	0
24	MV-DA-3-58	200	0	0	0	0	0	0	0	0
25	MV-DA-1-45	199	0	0	1	0	0	0	0	0
26	MV-DA-1-66	198	2	0	0	0	0	0	0	0
27	MV-DA-1-88	198	1	1	0	0	0	0	0	0
DU AREA (IMPACT SITE)										
1	MV-DU-3-75	196	1	1	0	0	2	0	0	0
5	MV-DU-1-57	199	1	0	0	0	0	0	0	0
8	MV-DU-4-71	198	2	0	0	0	0	0	0	0
12	MV-DU-4-51	199	1	0	0	0	0	0	0	0
15	MV-DU-1-43	194	6	0	0	0	0	0	0	0
HE AREA (IMPACT SITE)										
2	MV-HE-3-82	199	1	0	0	0	0	0	0	0
3	MV-HE-2-44									
4	MV-HE-3-22	200	0	0	0	0	0	0	0	0
7	MV-HE-4-24									
9	MV-HE-1-87	200	0	0	0	0	0	0	0	0
10	MV-HE-1-95	200	0	0	0	0	0	0	0	0
11	MV-HE-4-4									
13	MV-HE-1-52	197	2	0	1	0	0	0	0	0
14	MV-HE-1-43	200	0	0	0	0	0	0	0	0

APPENDIX E

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

INDIVIDUAL MICROSCOPIC EVALUATION DATA FOR LIVER, SPLEEN, KIDNEY AND TESTES

POSITIVE FINDINGS ONLY

DA AREA (REFERENCE SITE)

UNIQUE ANIMAL ID	ANIMAL ID	ORGAN	FINDING
16	MV-DA-3-34	LIVER	INFLAMMATION SUBACUTE, MINIMAL, MULTIFOCAL
		LIVER	PROTOZOAL CYST, PRESENT, MULTIFOCAL
		KIDNEY	INFLAMMATION SUBACUTE, INTERSTITIAL, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL
		TESTES	POLYNUCLEATED SPERMATIDS, MINIMAL, MULTIFOCAL
18	MV-DA-2-30	SPLEEN	DECREASED EMH, PRESENT
		KIDNEY	DEGENERATION, TUBULAR, MINIMAL, FOCAL
		TESTES	DESQUAMATED GERMINAL CELLS, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL
		TESTES	POLYNUCLEATED SPERMATIDS, MINIMAL, MULTIFOCAL
20	MV-DA-3-84	LIVER	INFLAMMATION SUBACUTE, MINIMAL, MULTIFOCAL
		SPLEEN	INCREASED EMH, MINIMAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL
21	MV-DA-3-34	KIDNEY	INFLAMMATION MONONUCLEAR, INTERSTITIAL, MODERATE, MULTIFOCAL
		KIDNEY	DEGENERATION, TUBULAR, MILD, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL
22	MV-DA-3-78	LIVER	INFLAMMATION SUBACUTE, MINIMAL, MULTIFOCAL
		LIVER	INFLAMMATION MONONUCLEAR, PORTAL, MILD, MULTIFOCAL
		KIDNEY	INFLAMMATION CHRONIC, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL
23	MV-DA-2-81	LIVER	INFLAMMATION SUBACUTE, MINIMAL, MULTIFOCAL
24	MV-DA-3-58	LIVER	NECROSIS, HEPATOCELLULAR, MINIMAL, FOCAL
		LIVER	INFLAMMATION SUBACUTE, MINIMAL, MULTIFOCAL
		SPLEEN	DECREASED EMH, PRESENT
		KIDNEY	MINERALIZATION, MINIMAL, MULTIFOCAL
25	MV-DA-1-45	LIVER	NECROSIS, HEPATOCELLULAR, MINIMAL, MULTIFOCAL
		LIVER	INFLAMMATION MONONUCLEAR, PORTAL, MINIMAL, MULTIFOCAL
		LIVER	INFLAMMATION CHRONIC, MINIMAL, FOCAL
		LIVER	CESTODE CYST, PRESENT, FOCAL
		KIDNEY	INFLAMMATION MONONUCLEAR, INTERSTITIAL, MINIMAL, MULTIFOCAL
		KIDNEY	INFLAMMATION SUBACUTE, INTERSTITIAL, MINIMAL, MULTIFOCAL
		KIDNEY	PROTOZOAL CYSTS, PRESENT, FOCAL
		KIDNEY	HYALIN CASTS, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL
26	MV-DA-1-66	KIDNEY	INFLAMMATION MONONUCLEAR, INTERSTITIAL, MINIMAL, MULTIFOCAL
		KIDNEY	DEGENERATION, TUBULAR, MINIMAL, MULTIFOCAL
		KIDNEY	HYALIN CASTS, MINIMAL, FOCAL
		TESTES	DESQUAMATED GERMINAL CELLS, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, FOCAL
27	MV-DA-1-88	KIDNEY	MINERALIZATION, MINIMAL, FOCAL
		TESTES	DESQUAMATED GERMINAL CELLS, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL

EMH=EXTRAMEDULLARY HEMATOPOIESIS.

APPENDIX E (CONTINUED)

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

INDIVIDUAL MICROSCOPIC EVALUATION DATA FOR LIVER, SPLEEN, KIDNEY AND TESTES

POSITIVE FINDINGS ONLY

DU AREA (IMPACT SITE)

UNIQUE ANIMAL ID	ANIMAL ID	ORGAN	FINDING
1	MV-DU-3-75	SPLEEN	PLASMACYTOSIS, MILD
		SPLEEN	DECREASED EMH, PRESENT
		KIDNEY	INFLAMMATION MONONUCLEAR, INTERSTITIAL, MINIMAL, MULTIFOCAL
		KIDNEY	DEGENERATION, TUBULAR, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL
5	MV-DU-1-57	LIVER	INFLAMMATION SUBACUTE, MINIMAL, MULTIFOCAL
		KIDNEY	DEGENERATION VACUOLAR, DCT, MINIMAL
		KIDNEY	INFLAMMATION SUBACUTE, INTERSTITIAL, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL
8	MV-DU-4-71	SPLEEN	DECREASED EMH, PRESENT
12	MV-DU-4-51	LIVER	INFLAMMATION SUBACUTE, MINIMAL, FOCAL
		SPLEEN	DECREASED EMH, PRESENT
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL
		TESTES	POLYNUCLEATED SPERMATIDS, MINIMAL, MULTIFOCAL
15	MV-DU-1-43	SPLEEN	LYMPHOID DEPLETION, MILD
		SPLEEN	INCREASED EMM, MINIMAL
		KIDNEY	INFLAMMATION MONONUCLEAR, INTERSTITIAL, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL

EMH=EXTRAMEDULLARY HEMATOPOIESIS.
EMM=EXTRAMDULLARY MYELOPOIESIS
DCT=DISTAL CONVOLUTED TUBULE

APPENDIX E (CONTINUED)

REPRODUCTIVE ASSESSMENT OF SMALL RODENTS EXPOSED TO MILITARY RELATED CONTAMINATION AT JEFFERSON PROVING GROUND, SEPTEMBER 2002

INDIVIDUAL MICROSCOPIC EVALUATION DATA FOR LIVER, SPLEEN, KIDNEY AND TESTES

POSITIVE FINDINGS ONLY

HE AREA (IMPACT SITE)

UNIQUE ANIMAL ID	ANIMAL ID	ORGAN	FINDING
2	MV-HE-3-82	SPLEEN	DECREASED EMH, PRESENT
		TESTES	DESQUAMATED GERMINAL CELLS, MINIMAL, FOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, FOCAL
3	MV-HE-2-44	SPLEEN	DECREASED EMH, PRESENT
		KIDNEY	DEGENERATION, TUBULAR, MINIMAL, FOCAL
		KIDNEY	INFLAMMATION SUBACUTE, INTERSTITIAL, MINIMAL, FOCAL
		KIDNEY	HYALIN CASTS, MINIMAL, MULTIFOCAL
		TESTES	POLYNUCLEATED SPERMATIDS, MINIMAL, FOCAL
4	MV-HE-3-22	LIVER	INFLAMMATION SUBACUTE, MINIMAL, MULTIFOCAL
		KIDNEY	HYALIN CASTS, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MILD, MULTIFOCAL
		TESTES	INFLAMMATION SUBACUTE, MINIMAL, FOCAL
		TESTES	FOREIGN BODY, PRESENT
7	MV-HE-4-24	LIVER	INFLAMMATION SUBACUTE, MINIMAL, MULTIFOCAL
		SPLEEN	DECREASED EMH, PRESENT
		KIDNEY	DEGENERATION VACUOLAR, DCT, MINIMAL
		KIDNEY	INFLAMMATION SUBACUTE, INTERSTITIAL, MINIMAL, MULTIFOCAL
		KIDNEY	HYALIN CASTS, MINIMAL, MULTIFOCAL
		KIDNEY	MINERALIZATION, MINIMAL, FOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MILD, MULTIFOCAL
		TESTES	POLYNUCLEATED SPERMATIDS, MINIMAL, MULTIFOCAL
9	MV-HE-1-87	LIVER	INFLAMMATION SUBACUTE, MINIMAL, FOCAL
		LIVER	HYPERPLASIA, BILE DUCT EPITHELIUM, MINIMAL
		KIDNEY	DEGENERATION, TUBULAR, MINIMAL, FOCAL
		KIDNEY	DEGENERATION VACUOLAR, DCT, MINIMAL, MULTIFOCAL
		KIDNEY	INFLAMMATION SUBACUTE, INTERSTITIAL, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL
10	MV-HE-1-95	LIVER	INFLAMMATION SUBACUTE, MINIMAL, MULTIFOCAL
		KIDNEY	INFLAMMATION MONONUCLEAR, INTERSTITIAL, MILD, MULTIFOCAL
		KIDNEY	DEGENERATION, TUBULAR, MINIMAL, FOCAL
		KIDNEY	ATROPHY/LOSS, TUBULES, MILD, MULTIFOCAL
		KIDNEY	INFLAMMATION SUBACUTE, INTERSTITIAL, MINIMAL, MULTIFOCAL
		KIDNEY	INFLAMMATION CHRONIC, MODERATE, MULTIFOCAL
		KIDNEY	HYALIN CASTS, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, FOCAL
11	MV-HE-4-4	LIVER	INFLAMMATION SUBACUTE, MINIMAL, MULTIFOCAL
		KIDNEY	DEGENERATION, TUBULAR, MINIMAL, FOCAL
		KIDNEY	INFLAMMATION SUBACUTE, INTERSTITIAL, MINIMAL, MULTIFOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MILD, MULTIFOCAL
13	MV-HE-1-52	LIVER	INFLAMMATION SUBACUTE, MINIMAL, MULTIFOCAL
		KIDNEY	INFLAMMATION MONONUCLEAR, INTERSTITIAL, MINIMAL, MULTIFOCAL
		KIDNEY	DEGENERATION, TUBULAR, MINIMAL, MULTIFOCAL
14	MV-HE-1-43	LIVER	INFLAMMATION SUBACUTE, MINIMAL, FOCAL
		SPLEEN	INCREASED EMH, MILD
		KIDNEY	DEGENERATION, TUBULAR, MINIMAL, FOCAL
		TESTES	DESQUAMATED GERMINAL CELLS, MINIMAL, FOCAL
		TESTES	DEGENERATION, SEMINIFEROUS TUBULE(S), MINIMAL, MULTIFOCAL

EMH=EXTRAMEDULLARY HEMATOPOIESIS.
DCT=DISTAL CONVOLUTED TUBULE