

Appendix A
CLOSURE PLAN

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Closure Plan for the
Unserviceable Munitions
Treatment Unit

Yakima Training Center
Washington

May 2003



Prepared for:
Fort Lewis
Environmental and Natural Resources Division
Fort Lewis, Washington

CLOSURE PLAN FOR THE
UNSERVICEABLE MUNITIONS
TREATMENT UNIT

YAKIMA TRAINING CENTER
WASHINGTON

Prepared for
Fort Lewis
Environmental and Natural Resources Division
Fort Lewis, Washington

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ACRONYMS

ASP	Ammunition Supply Point
BLS	Below Land Surface
BGS	Below Ground Surface
CAR	Corrective Action Report
CCQC	Contractor Chemical Quality Control
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COC	Chain-of-Custody
COPC	Chemical of Potential Concern
COPEC	Contaminant of Potential Ecological Concern
COR	Contracting Officer's Representative
CQC	Chemical Quality Control
DCQCR	Daily Chemical Quality Control Report
DEFT	Decision Error Feasibility Trials
DoD	U.S. Department of Defense
DOT	Department of Transportation
DQA	Data Quality Assessment
DQI	Data Quality Indicator
DQO	Data Quality Objective
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
ESQ	Ecological Screening Quotient
FSP	Field Sampling Plan
HMX	Cyclotetramethylenetetranitramine
HTRW	Hazardous, Toxic, and Radioactive Waste
IDW	Investigation Derived Waste
LCS	Laboratory Control Sample
LDR	Land Disposal Restriction
MDL	Method Detection Limit
MQL	Method Quantitation Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSL	Mean Sea Level
MTCA	Model Toxics Control Act
NEW	Net Explosive Weight

ACRONYMS (CONTINUED)

NWS	National Weather Service
OB	Open Burning
OD	Open Detonation
OE	Ordnance and Explosives
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCB	Polychlorinated Biphenyl
PETN	Pentaerythritol Tetranitrate
POC	Point of Contact
PPE	Personnel Protective Equipment
PQL	Practical Quantitation Limit
QA	Quality Assurance
QAPP	Quality Assurance Program Plan
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund
RAS	Routine Analytical Services
RCRA	Resource Conservation and Recovery Act
RDX	Cyclotrimethylenetrinitramine
RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SQL	Soil Quantitation Limit
SSHP	Site Safety and Health Plan
STL	Severn Trent Laboratories
SVOC	Semivolatile Organic Compound
TNT	Trinitrotoluene
TPH	Total Petroleum Hydrocarbon
TRV	Threshold Reference Value
UCL	Upper Confidence Limit
UMTU	Unserviceable Munitions Treatment Unit
USACE	U.S. Army Corps of Engineers
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound
WAC	Washington Administrative Code
WDOE	Washington Department of Ecology
WMM	Waste Military Munitions
YTC	Yakima Training Center

Fort Lewis is one of the largest and most modern military reservations in the United States. Located on Puget Sound in the state of Washington, it is the premier military installation in the northwest. Fort Lewis is the owner of Yakima Training Center (YTC), which is located in the south-central part of Washington in Yakima and Kittitas Counties, approximately 100 miles east-southeast of Fort Lewis. The mission of YTC is to provide a central training area for Department of Defense (DoD) activities in the geographic area. The primary users of YTC are the various units stationed at Fort Lewis, together with other DoD installations and National Guard and Reserve units from Washington and Oregon.

The Unserviceable Munitions Treatment Unit (UMTU), located on Range 14 of YTC, has been used to thermally treat various propellant, explosive, and pyrotechnic items that have exceeded their shelf life or life cycle utilization, as well as off-specification versions of these same materials. The UMTU, which contains both open burning (OB) and open detonation (OD) areas, has been in operation since 1970 under the management of YTC. The U.S. Army has recently decided to discontinue treatment operations at YTC and is seeking closure of the UMTU.

A Resource Conservation and Recovery Act (RCRA) closure plan is needed for OB/OD units pursuing closure. This closure plan, which was developed following the requirements set forth in Washington Administrative Code (WAC) 173-303-610, provides a description of how final closure of the UMTU will be conducted in accordance with the closure performance standards. This may involve the removal of contaminated soils from the UMTU in order to demonstrate compliance with a risk-based clean closure standard.

The Washington Department of Ecology (WDOE) must approve the closure plan prior to closure of the UMTU. In addition, WDOE will notify the public of their opportunity to review and comment on closure activities once WDOE has approved the plan. As a courtesy, Fort Lewis will keep U.S. Environmental Protection Agency (EPA) Region 10 informed of progress on the closure of the unit.

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2.0

BACKGROUND

Fort Lewis has operated YTC as a U.S. Army training installation since its establishment in 1942 as an anti-aircraft firing range. The lands comprising YTC were initially leased by the federal government from numerous private landowners and various county, state, and federal agencies in 1941 and 1942 and were purchased in 1950 and 1951.

The terrain at YTC is well suited from a military standpoint for desert and hilly/sub-mountainous training. Training exercises at YTC include infantry, motorized, mechanized, and armored infantry maneuvers; airborne, tactical air support, air assault, and infantry special operations maneuvers; and live-fire gunnery training at the platoon, company, battalion, brigade, and Corps levels. Live-fire training includes larger caliber tank, infantry fighting vehicle, and anti-tank missile firing; air support bombing and gunnery; and indirect mortar and howitzer gunnery and the Multiple Launch Rocket System. The YTC Multipurpose Range Complex provides state-of-the-art live-fire training for infantry, tanks, and helicopters. Due to the Army's decision to consolidate thermal treatment throughout installations in the United States, Fort Lewis will close the UMTU.

Wastes treated at the UMTU are hazardous by virtue of their reactive properties and, to a lesser degree, by their toxicity. These wastes are treated by OB/OD, a technology recognized as a commonly accepted and proven treatment method whose specific practices and procedures are governed in accordance with various Army technical orders, policies, and guidance, as well as by hazardous waste regulations provided under RCRA.

On 10 December 1987, the EPA adopted new standards under Subpart X of 40 Code of Federal Regulations (CFR) Part 264. These became effective 11 January 1988 and are known as the "miscellaneous units" standards. According to these standards, under RCRA, facilities that were operating miscellaneous units as of 19 November 1980 and that wanted to continue operation had to submit an operating permit application by 8 November 1988.

Fort Lewis filed a RCRA Part B permit application with EPA Region 10 in November 1988 to obtain interim status for OB/OD operations for the Range 14 UMTU. In

December 1996 a revised permit application, developed in accordance with the post-1988 Subpart X permitting guidance, was submitted to WDOE. WDOE issued a request for additional information in July 1997; however, in March 2001 the Fort Lewis Commanding General decided that the UMTU would no longer be used. Therefore, Fort Lewis is now seeking closure of the unit.

3.0 FACILITY DESCRIPTION

This section describes the UMTU located on Range 14 of YTC in Washington. The UMTU is owned by Fort Lewis, Washington, and operated by YTC. A more complete description of the facility is located in other parts of this closure plan.

3.1 Facility Size and Location

YTC is a 323,537-acre U.S. Army training installation located in central Washington State on the east side of the Cascade Range (Figure 3-1). The installation is located approximately 7 miles northeast of the city of Yakima, straddling Yakima and Kittitas Counties. It is bounded on the north by Interstate 90 and Badger Pocket, and on the east by the Columbia River. The western boundary generally follows Interstate 82 and the southern boundary is along Yakima Ridge.

The original 261,451-acre portion of YTC—which includes the UMTU—has been used for military training exercises since its establishment in 1942. The federal government initially leased the lands comprising YTC in 1941 and 1942 from numerous landowners and various county, state, and federal agencies. These lands were then purchased in 1950 and 1951. Approximately 10% of the land was withdrawn from the public domain; the remainder was acquired by purchase or condemnation from private owners, counties, and the State of Washington.

In 1992, Congress authorized the purchase of approximately 63,000 additional acres, most of which lie directly north of the existing YTC, bringing the total to 323,537 acres. All of the lands comprising YTC were part of the property ceded to the United States in the treaty of 1855 by the confederated tribes and bands of the Yakama Indian Nation. None of the land was acquired directly from the Yakama Nation (U.S. Army, 1996).

The primary access to YTC is from Interstate 82. Commercial air service is available through Yakima Municipal Airport. There are two airfields on YTC: Yakima Army Airfield located near the cantonment area, and the Selah Airstrip and Drop Zone located

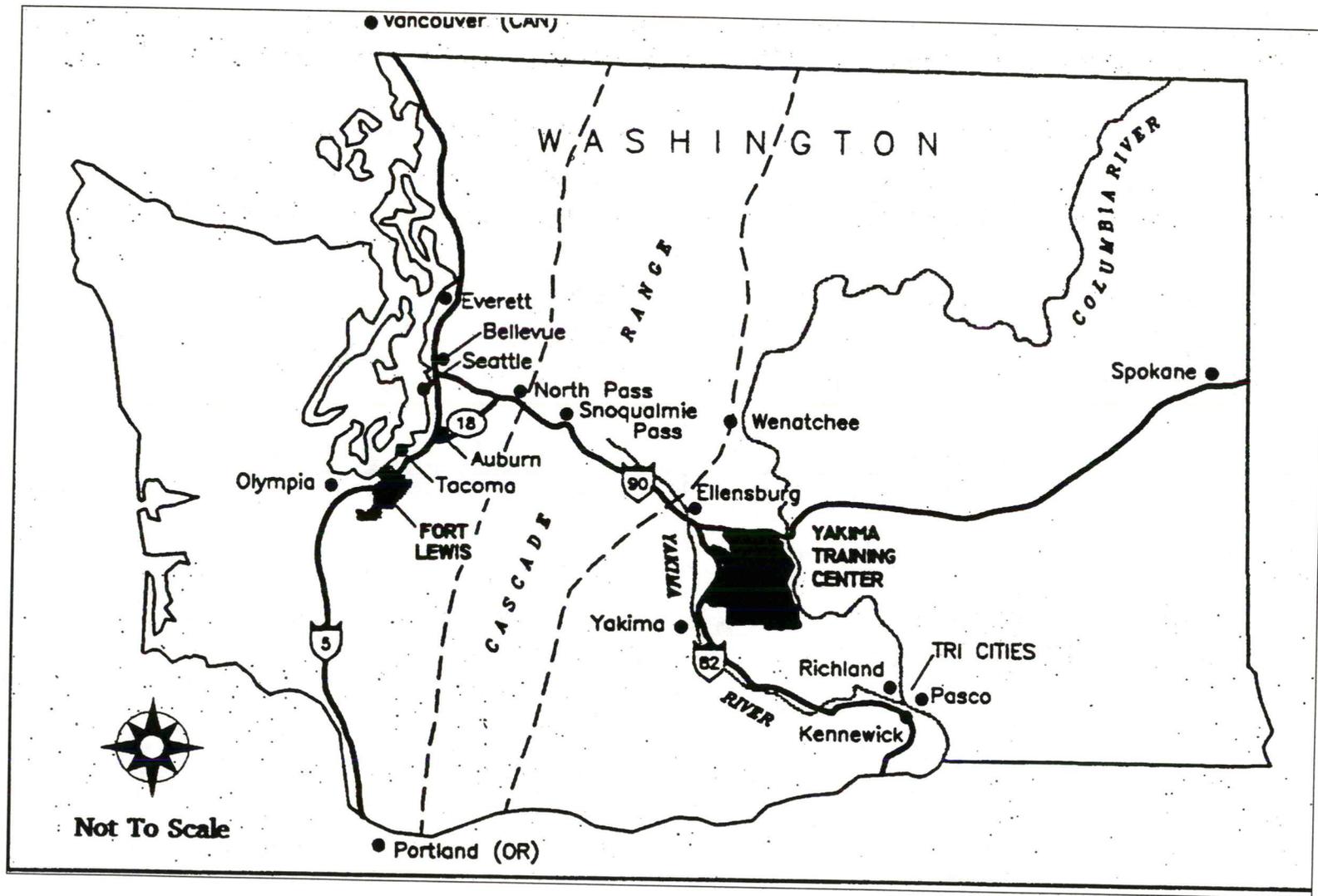


Figure 3-1. Yakima Training Center, Washington

northeast of the cantonment area. The Army, Navy, and Air Force use these airstrips for both helicopter and fixed wing training missions. The Pomona siding, a railroad freight and vehicle unloading point, is located about 6 miles by road from the cantonment area.

3.2 Description of Unit to Be Closed (UMTU)

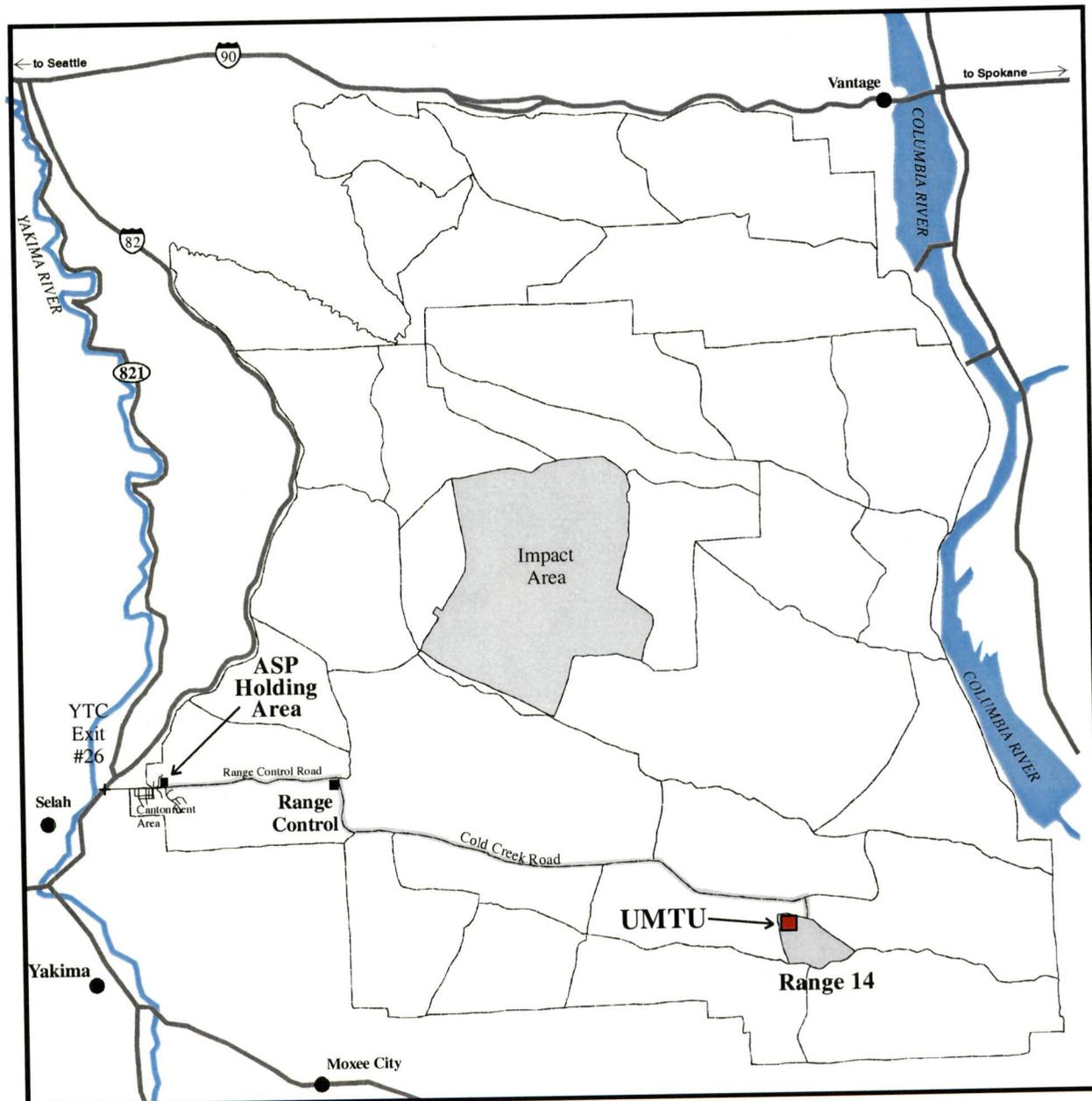
The UMTU is located on Range 14, which consists of approximately 2,000 acres in the southeastern portion of YTC (Figure 3-2). The UMTU consists of an approximately 8.3-acre OD area and a 0.86-acre OB area. The locations of the OB and OD areas are shown on Figure 3-3. The OD area is at UTM coordinates 723647E and 5165367N and the OB area is at UTM coordinates 723582E and 5165857N. OD and occasional OB have been conducted in this area since about 1970.

OD occurred at various points within the designated OD area, either on the ground surface, in craters created by previous treatment detonations, or in holes excavated by Explosive Ordnance Disposal (EOD) personnel. A single OB event occurred in a small metal burn pan known as a "popping kettle" in 2000, which has been removed from the site. Three monitoring wells, one upgradient and two downgradient, are located at the UMTU boundary. The UMTU is located within YTC, which is secured by a perimeter fence around the entire facility as well as 24-hour, 7-day/week surveillance by roving vehicle and helicopter patrols. The UMTU is also fenced on the north, east, and west sides; the southern boundary is within an active impact area and is not accessible.

3.3 Unit Operation

During the life cycle of conventional explosive ordnance, it becomes necessary to treat various propellants, explosives, and pyrotechnics that have been designated as unserviceable, unstable, or unusable. OB and OD is the primary method used by the U.S. Army and other military services for the treatment of these energetic waste materials. OB is typically used to treat propellants in engineered burn pans, whereas OD is used for explosives and is carried out on the ground surface or in craters.

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 Training Area Boundaries
 Access Road

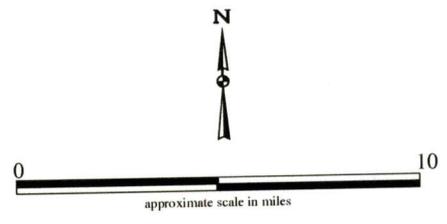
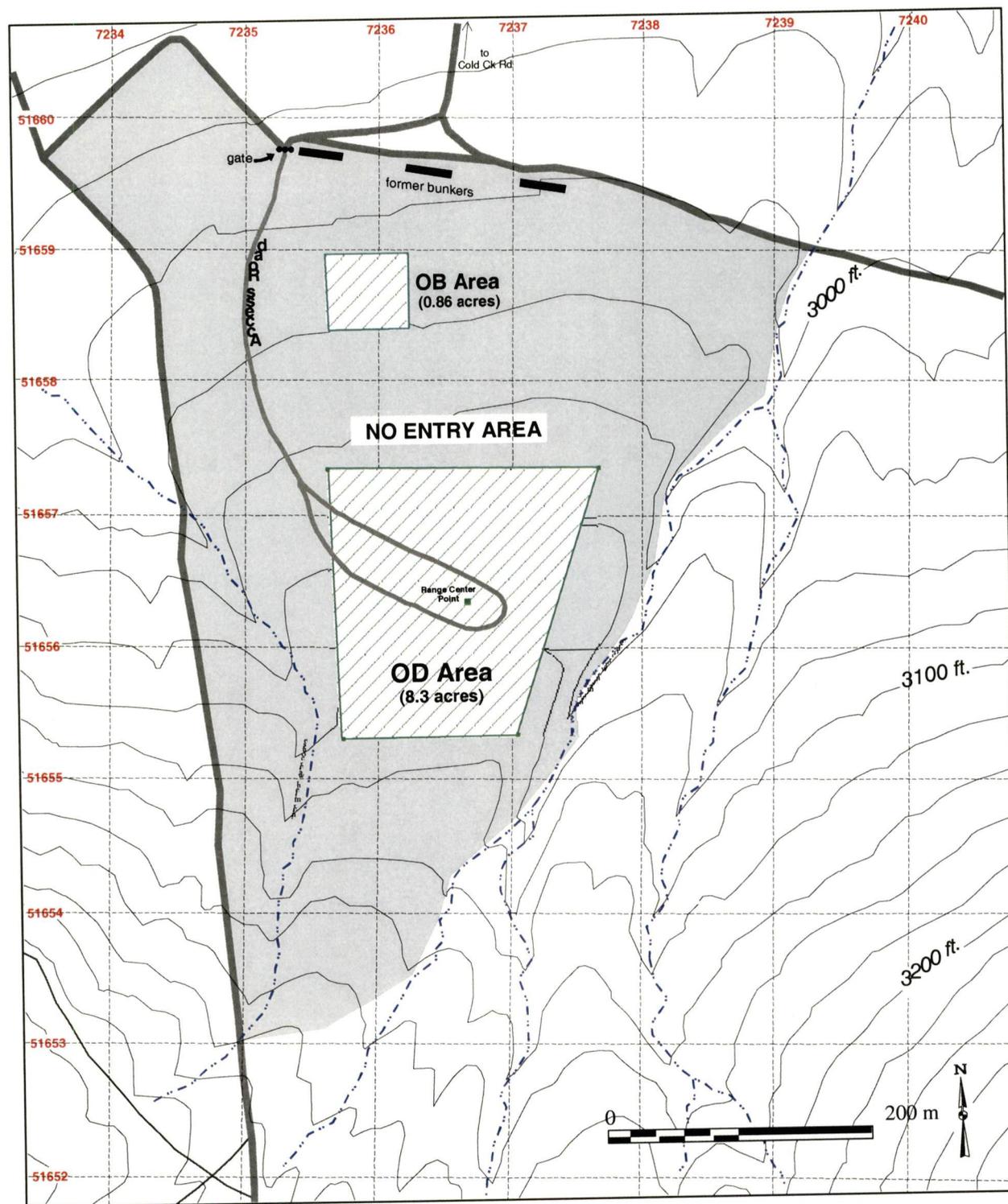


Figure 3-2. Map of YTC



Produced by: PW-ENRD-GIS Lab, Fort Lewis, Washington (Nov)

Figure 3-3. Location of OB and OD Units

3.4

Waste Characteristics

The wastes treated at the UMTU are hazardous by virtue of their characteristic reactivity and, to a lesser degree, their toxicity. They generally consist of an assortment of explosive or propellant fill materials wholly contained in metal or composite casings and can be thermally treated using elevated temperatures as the primary means to change their chemical and physical character.

A number of reactive compounds are present in military munitions. These compounds fall into four general categories:

- Primary explosives,
- Boosters and secondary explosives,
- Propellants, and
- Pyrotechnics.

Primary and secondary explosive compositions react violently by detonation, with velocities in the approximate range of 1,500 to 9,000 m/s (5,000 to 30,000 ft/s)¹. Propellants and pyrotechnics react by burning, generating large quantities of gas, together with intense light and heat. Table 3-1 provides a summary of compositions that have been treated at the UMTU and their chemical formulae. Also shown are their EPA hazardous waste numbers. The primary RCRA hazardous waste number for wastes treated at the UMTU is D003.² Since the RCRA-recommended treatment technology for D003 is DEACT,³ and ⁴ the OB/OD treatment methods used at the UMTU were appropriate.

Primary explosives are used to initiate larger, less sensitive energetic components. They are mixtures that are very sensitive to shock or friction and are a mixture of fuel, oxidizer, and explosive compounds.

¹ Slower explosive reactions, which are propagated by thermal conduction and radiation, are known as deflagration.

² D003 is RCRA reactivity characteristic [see 40 CFR 261.23(a)(6), (7), and (8)].

³ DEACT, or deactivation, is described in Table 1, 40 CFR 268.42 as the standard technology needed to remove the hazardous characteristics of a waste due to its ignitability, corrosivity, and/or reactivity.

⁴ The table in 40 CFR 268.40, "Applicability of Treatment Standards," identifies DEACT as the treatment standard for hazardous waste code D003 (in both wastewater and non-wastewater forms) for the explosives subcategory based on 40 CFR 261.23(a)(6), (7), and (8).

Table 3-1
Chemical Composition of Explosives

Explosive	Chemical Formula	Primary Hazardous Waste Number	Ancillary Hazardous Waste Number ^a
Primary and Secondary Explosives			
Primary Explosives:			
Diazodinitrophenol (DDNP)	C ₆ H ₂ N ₄ O ₅	D003	-
Lead azide	N ₆ Pb (71% Pb)	D003	D008
Lead mononitroresorcinate (LMNR)	C ₆ H ₃ O ₂ Pb (57.5% Pb)	D003	D008
Lead stephynate	C ₆ HN ₃ O ₈ Pb	D003	D008
Mercury fulminate ^b	C ₂ HgN ₂ O ₂	D003	P065, D009
Potassium dinitrofuoxane (KDNBF)	C ₆ H ₂ N ₄ O ₆ K	D003	-
Tetracene	C ₁₈ H ₁₂	D003	-
Fuels:			
Antimony sulfide	Sb ₂ S ₅	D003	-
Calcium silicide	CaSi ₂	D003	D001
Lead thiocyanate	Pb(SCN) ₂ (64% Pb)	D003	D008
Oxidizers:			
Ammonium perchlorate	NH ₄ ClO ₄	D003	-
Barium nitrate	BaN ₂ O ₆	D003	D005
Potassium chlorate	KClO ₃	D003	-
Aliphatic Nitrate Esters:			
1,1,1-Trimethylolethane trinitrate (TMETN)	C ₅ H ₉ O ₉ N ₃	D003	-
1,2,4-Butanetriol trinitrate (BTN)	C ₄ H ₇ N ₃ O ₉	D003	-
Diethyleneglycol dinitrate (DEGN)	C ₄ H ₈ N ₂ O ₇	D003	-
Nitrocellulose	C ₁₂ H ₁₆ (ONO ₂) ₄ O ₆	D003	-
Nitroglycerin	C ₃ H ₅ N ₃ O ₉	D003	P081
Nitrostarch	C ₆ H ₁ O ₅ NO ₂	D003	-
Pentaerythritol tetranitrate (PETN)	C ₅ H ₈ N ₄ O ₁₂	D003	-
Triethylene glycodinitrate (TEGN)	C ₆ H ₁₂ O ₄ N ₂ O ₄	D003	-
Nitramines:			
2,4,6-Trinitrophenylmethylnitramine (tetryl)	C ₇ H ₅ N ₅ O ₅	D003	-
Cyclotetramethylenetetranitramine (HMX)	C ₄ H ₈ N ₈ O ₂	D003	-
Cyclotrimethylenetrinitramine (RDX)	C ₃ H ₆ N ₆ O ₆	D003	-
Ethylenediamine dinitrate (EDDN Haleite)	C ₂ H ₆ N ₄ O ₄	D003	-
Nitroguanidine	CH ₄ N ₄ O ₂	D003	-
Nitroaromatics:			
1,3-Diamine-2,4,6-trinitrobenzene (DATB)	C ₆ H ₄ N ₆ O ₆	D003	-
1,3,5-Triamino-2,4,5-trinitrobenzene (TATB)	C ₆ H ₆ N ₆ O ₆	D003	-
2,2',4,4',6,6'-Hexanitrozobenzene (HNAB)	C ₁₂ N ₈ O ₁₂	D003	-
2,4,6-Trinitrotoluene (TNT)	C ₇ H ₅ N ₃ O ₆	D003	-
Hexanitrostilbenzene (HNS)	C ₁₂ H ₂ N ₆ O ₁₂	D003	-
Ammonium nitrate	NH ₄ NO ₃	D003	-
Black powder	K(Na)NO ₃	D003	-
Various compositions, including compositions A, B, and C; ednatols; octols; terylols; pentolite; tritonal; picratol; amatol; ammonal; plastic bonded explosives (PBX); minol; torpex; high blast explosive (HBX); and dynamite (military)	Mixtures of the above chemicals	D003	P081, if nitroglycerin is a component

**Table 3-1
(Continued)**

Explosive	Chemical Formula	Primary Hazardous Waste Number	Ancillary Hazardous Waste Number ^a
Propellants			
Mixtures of nitrocellulose, nitroglycerin, and nitroguanidine (designated as M-series propellants—single, double, and triple base)	Varies	D003	P081 if nitroglycerin is a component and D008 if lead is a component
Pyrotechnics			
Combinations of oxidizers, fuels, and binding agents. Typical components: <input type="checkbox"/> Oxidizers are peroxides and perchlorates; <input type="checkbox"/> Fuels are aluminum and magnesium; and <input type="checkbox"/> Binding agents are resins, waxes, plastics, oils, retardants, waterproofing agents, and color intensifiers.	Varies	Varies	-

^aAdditional EPA hazardous waste numbers may be applied if post-treatment laboratory analysis of ash indicates the treated item contains hazardous constituents not listed here.

^bMercury is no longer used to formulate military munitions.

Booster and secondary explosives create large volumes of hot gas in a short time after initiation. These non-initiating explosives are too insensitive to be initiated by means of impact, friction, or brief application of heat. These explosives are primarily nitrates, nitro compounds, and nitramines, the most common of which are RDX, TNT, tetryl, HMX, and various combinations of these compounds.

Propellants are low detonation rate explosives that generate large volumes of hot gas. The propellant mixtures are typically classified as single- or double-based. Single-based propellants are composed mainly of nitrocellulose, while double-based propellants are mixtures of nitrocellulose and nitroglycerin. All components of military propellants are in solid form and contain no free liquids.

Pyrotechnics generate large amounts of heat but much less gas than propellants or explosives. They use exothermic chemical reactions, which are generally non-explosive, self-sustaining, and self-contained. Pyrotechnic compositions are generally finely divided fuels such as metals, alloys, and hydrocarbons mixed with an oxidizer.

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4.0 ENVIRONMENTAL SETTING

YTC lies within the Columbia Basin Ecoregion, an arid region that occupies about two-thirds of eastern Washington and extends into north-central Oregon. The topography of the lower Columbia Basin ranges from sandy plains and plateaus to mountain slopes and rocky ridgelines. Elevations range from 500 ft along the Columbia River to more than 4,000 ft. The highest point on YTC is 4,184 ft and is located on Yakima Ridge.

The ecoregion was created beginning 17 million years ago by hundreds of lava flows. Floods of basalt occurred over millions of years, building the area into what is now one of the largest volcanic provinces in the world. These flood basalt lava flows cover an area of more than 63,000 square miles in Washington, Oregon, and Idaho. In some places, the flood basalt lavas—called Columbia River Basalt Group—can reach 2,000 to 5,000 ft deep.

Climatically, the region boasts hot dry summers with temperatures that can reach above 100°F during the day, then cool at night. Winters are wet and cold with strong winds and blowing snow. Temperatures in some areas are known to dip below 0°F. The lower Columbia Basin lies deep within the rain shadow of the Cascade Mountains, so it receives only 4 to 9 in. of precipitation per year, about half in the winter as snow. Along the margins of the ecoregion, closer to foothills, precipitation can range from 16 to 24 in.

The extremes of the ecoregion's heat and cold, little water, define the number of kinds of plants that grow in the lower Columbia Basin; vegetation is described broadly as shrub-steppe. It includes big sagebrush, spiny hopsage, bitterbrush, greasewood, and native grasses. Riparian vegetation consists of reeds and deciduous trees that grow along wetted shorelines of rivers and streams.

4.1 Site Physiography

YTC lies within the Walla Walla Subprovince of the Columbia Plateau Physiographic Province in southeastern Washington. The Yakima Fold Belt is a transition zone between the Cascade Mountains and the Columbia Plateau Basalts. The area is characterized by

long tightly folded anticlines and broad intervening synclines. The folds are asymmetrical, and most of the major faults associated with the anticlinal fold axes are thrust or reverse faults.

YTC is located on the north slope of Yakima Ridge in the upper portion of Selah Creek valley. Selah Creek flows to the west from an elevation of approximately 2,800 ft mean sea level (MSL) to an elevation of 1,160 ft MSL where it flows into the Yakima River. Selah Valley is bordered on the north by the Umtanum Ridge anticline and on the south by the Yakima Ridge anticline. The anticlines are separated by the Cold Creek syncline, which underlies Selah Creek.

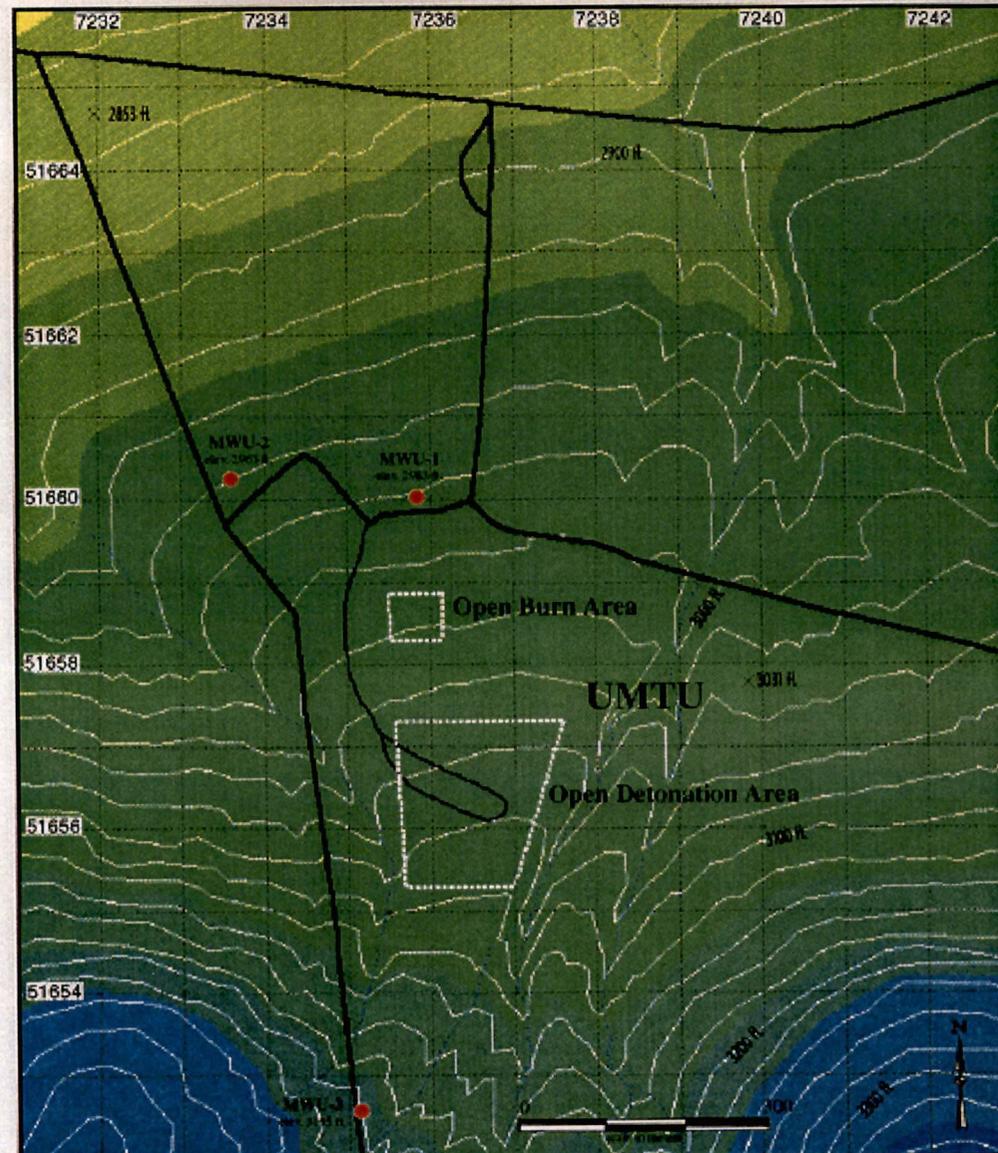
Topography of the UMTU is gently sloping toward the north from an elevation of approximately 3,080 ft above MSL at the southern boundary to 3,060 ft above MSL at the northern boundary. The UMTU is bounded by intermittent streams on the east and west sides. The area is sparsely vegetated with grasses. The topography of the area surrounding the UMTU is shown in Figure 4-1. There are no topographic characteristics that will affect the feasibility of cleanup operations.

4.2 Soil Characteristics

The U.S. Soil Conservation Service has mapped in excess of 160 soil series on YTC. These soils tend to be of the silt-loam class with occasionally high clay contents. These soils were primarily formed through colluvial, alluvial, and eolian processes. These soils typically are thin at the ridge crests and thicken downslope toward the creek valleys. Soils containing high percentages of cobbles and gravel are typically found in or near channels or creek beds. The cobbles and gravel tend to be derived from up-slope basaly outcroppings. In general, these soils tend to be well drained.

The boring logs from the three groundwater monitoring wells installed around the UMTU in 1994 indicate that the soils vary in thickness from 48 ft in MW-3 (upslope and upgradient well) to 35 ft in MW-2 (downslope and downgradient) with 42 ft of overburden soil present at MW-1, also downslope and downgradient. Soils in MW-3 were classified as medium

Elevation Map Range 14



Produced by: PW-EVRD-GIS Lab, Fort Lewis, Washington (Nov 05)

Elevation (in feet)
contour interval: 20 ft.

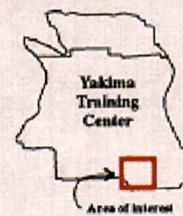


Figure 4-1. Topography of UMTU

brown, fine clayey soil at the surface grading to dark brown, clayey, sandy soil with increasing gravel and cobbles content at depth. Soils from MW-1 and MW-2 were classified as medium brown clayey, silty, sandy loam with 25 to 30% basalt fragments grading downward to a medium brown to orange-brown silty, clayey sandy soil with 50 to 75% basalt fragments. Groundwater was not observed in the soils during drilling operations. Data furnished by the Environmental and Natural Resource Division, Fort Lewis indicate that the soils at the UMTU are the Colockum Silt Loam. The general soils at the UMTU are depicted in Figure 4-2.

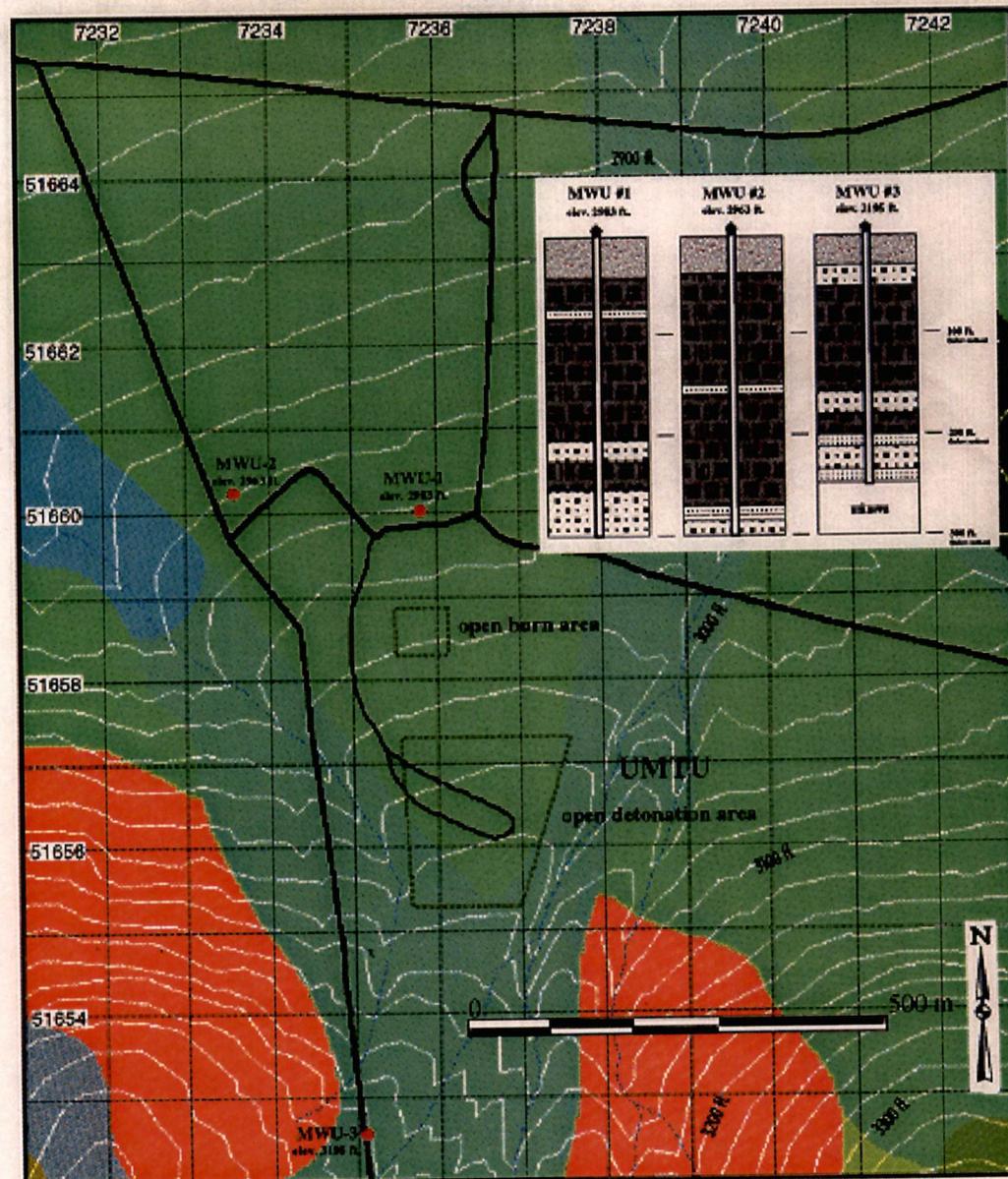
4.3 Site Geology

The UMTU site is covered by 35 to 48 ft of eolian and colluvial soils comprised of sand, silt, clay, gravel, and cobbles. The soils were classified as medium to dark brown, silt loams with varying amounts of sand and clay. The finer soil fractions were deposited by eolian processes and overly sandy gravels with cobbles and minor amounts of clay that are colluvial in origin. Underlying the soils are the basalts and sedimentary interbeds of the Ellensburg Formation of the Yakima Group. The three groundwater monitoring wells encountered groundwater in an interbed that varied from 205 ft below land surface (BLS) to 305 ft BLS. In MW-1 the elevation of the top of the interbed was 2,678.1 ft MSL and the water elevation was 2,702.1 ft MSL. In MW-2 the top of the interbed was 2,688.4 ft MSL and the water elevation was 2,703.5 ft MSL. In MW-3 the top of the interbed was 2,889.7 ft MSL and the water elevation was 3,057.7 ft MSL. The significant depth to groundwater and geologic characteristics underlying the UMTU minimize the potential of soil contamination to migrate to groundwater.

4.4 Hydrogeology

As stated above, the three groundwater monitoring wells encountered groundwater in an interbed that varied from 205 to 305 ft BLS. The calculated groundwater flow direction is N10°E toward the axis of Cold Creek syncline and the calculated gradient is 0.15 ft/ft. Immediately downslope from the UMTU is a surface water divide with Selah Creek flowing west to the Yakima River and Cold Creek flowing east to the Columbia River. The valley floor varies in elevation from 2,950 ft MSL at the divide to an elevation of 2,800 ft MSL at the

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Produced by: PW-EMED-GIS Lab, Fort Lewis, Washington (Nov 03)

Surface - Soils data

- Coloockum Silt Loam, 5-10% slope
- Coloockum Silt Loam, 10-15% slope
- Coloockum Silt Loam, 15-30% slope
- Woekum Silt Loam, 15-30 % slope
- Camaspach Very Cobbly Loam, 3-15% slope
- Horseflat Very Cobbly Loam, 15-30 % slope
- Argabak-Windery Complex, 3-15 % slope
- Blint Very Cobbly Loam, 15-30 % slope

Sub-Surface - geology (from drill log)

- Soil
- Sand
- Sand & Gravel
- Gravel
- Basalt flows

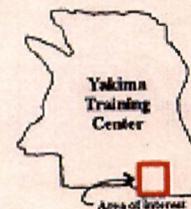


Figure 4-2. UMTU Soils Maps

approximate east and west edges of the UMTU. It appears that the groundwater in the interbed does not contribute to the flow of either Selah Creek or Cold Creek, immediately downgradient of the site, but continues downgradient to the axis of the Cold Creek syncline and flows east to the Columbia River or west to the Yakima River.

Aquifer systems in the Yakima region comprise many independent water-bearing strata within the gross geologic unit. There are three principal aquifers at YTC: the unconfined alluvial aquifer system, the Ellensburg sediment aquifer system, and the basalt aquifer system. The unconfined alluvial aquifer system lies nearest to the land surface. Materials included in this shallow aquifer are alluvial fan sediments, colluvial deposits, stream channel deposits, and glacial outwash deposits. Unconfined water is primarily found in unconsolidated sand and gravel associated with major and tributary streams. The second principal aquifer system is located in the post-basalt sediment. This aquifer system consists of many confined water-producing zones in weakly cemented permeable layers of gravel and well-sorted sand interbedded with less permeable clay. Confining strata usually consist of impermeable clay and/or relatively impermeable basalt. The basalt aquifer system contains both confined and unconfined aquifers. Most wells that are drilled into basalt penetrate and withdraw water from confined aquifers (COE, 1978).

Shallow groundwater within the Saddle Mountains Basalt and its sedimentary members is recharged from precipitation on basalt outcrops within the boundaries of YTC. Deeper groundwater within the Wanapum and Grande Ronde Basalts is primarily recharged from groundwater inflow from outside the region where these basalts and their associated interbeds lie at or near ground surface (DA, 1993b). The occurrence and movement of groundwater at a given location within the installation depend upon rock type, geologic structure, and topography. Extensive folding of the sedimentary and basalt strata created a complex groundwater system with highly variable hydraulic properties, depth to water, and flow direction. Reported depths to groundwater at YTC range from approximately 100 to 300 ft in higher elevations to less than 20 ft near the Yakima River. Groundwater-fed springs occur where stream valleys are incised to depths that intercept the aquifer table. Wells completed in the basalt aquifer at YTC are capable of yields on the order of 200 to 600 gal/min (DA, 1993a).

Subsurface drill logs from monitoring wells installed in the uppermost aquifer at the UMTU reveal that groundwater yielding sedimentary materials such as sand and gravel are interbedded with basalt flows. Depth to groundwater is approximately 250 to 300 ft on the northern edge of the UMTU. The depth decreases toward the south as the terrain elevation increases. Groundwater is almost always under confined conditions within these basalt flows (YTC, 1993b). It is likely that the water table or phreatic surface in the uppermost aquifer is generally graded to Selah Creek and interfaces directly with the stream (COE, 1978).

The drinking water supply for YTC is provided entirely by groundwater drawn from 12 wells located within the boundaries of the installation. Several of these wells, along with additional nonpotable water wells and 148 developed springs located outside of the cantonment area, also provide water for fire protection and for livestock and wildlife watering. Water withdrawn from all the drinking water wells is treated at the wellhead by chlorination prior to distribution and use. The nearest operational water well to the UMTU, D.W. No. 9, is approximately 3.6 miles northwest of the UMTU. This well is reported to be 135 ft in total depth with a static water level of approximately 43 ft. This well is used for drinking water for military units (YTC, 1988).

Three of the 12 YTC drinking water wells serve the cantonment area. Currently, only two of those wells are in operation; the third well cannot be pumped because the well casing has shifted. The combined water supply capacity of the two operable cantonment area wells is approximately 1 million gallons per day. Although current capacity is adequate, YTC is planning to develop 6 to 10 additional wells downrange to provide a better distribution of water for fire protection purposes. If the water yield and quality are acceptable, one or more of these wells may be developed for drinking water use (DA, 1993a).

Only two production wells are known to exist within 4 miles of the UMTU. The Range 13 well, a water supply well for livestock, is located approximately 2 miles north of the site. It was installed in 1992 to a depth of 350 ft. The Range 55 well, a drinking water well, is located approximately 3.5 miles northwest of the UMTU. The Range 55 well was installed in 1980 to a depth of 142 ft. Water elevation in the Range 13 well is 2,755 ft MSL, and water

elevation in the Range 55 well is 2,495 ft MSL. These wells are located across Selah Creek and on the opposite bank of the Cold Creek syncline from the UMTU.

4.5 Meteorology

Precipitation follows the pattern of a West Coast maritime climate with the typical late fall and early winter highs; however, since YTC lies in the rain shadow of the Cascade Mountains, total amounts of annual precipitation are small. Annual precipitation ranges from 6 to 16 in., with nearly half the rainfall occurring between November and January. The average annual precipitation for 1910 to 1990 was 7.58 in. (YTC, 1993a).

There is a readily available 5-year representative meteorological data set from the nearby National Weather Service (NWS) reporting station in Yakima (1986–1988 and 1990–1991). A wind rose from the Yakima NWS station is shown in Figure 4-3. As shown, the predominant flow is westerly as recorded at the Yakima Air Terminal Airport.

4.6 Demography and Population

The current demographics on-post are 120 base operations works (civilian and military), 40 additional base operations support (military special duty from Fort Lewis), and 200 tenant personnel (both civilian and military). Approximately 40 of the above individuals actually live on-post; however, a single resident is actually on-post no more than 3 weeks at a time.

The total population within 50 miles of the UMTU boundary, including the base, which represents an area of approximately 324,000 acres, is 301,539. The population within a 10-mile radius of the UMTU is very sparse and generally increases to the south and west. The distribution of this population is presented on Figure 4-4.

4.7 Land Use

The following sections provide an overview of land use patterns for areas in and around YTC. This information is summarized on Figure 4-5.

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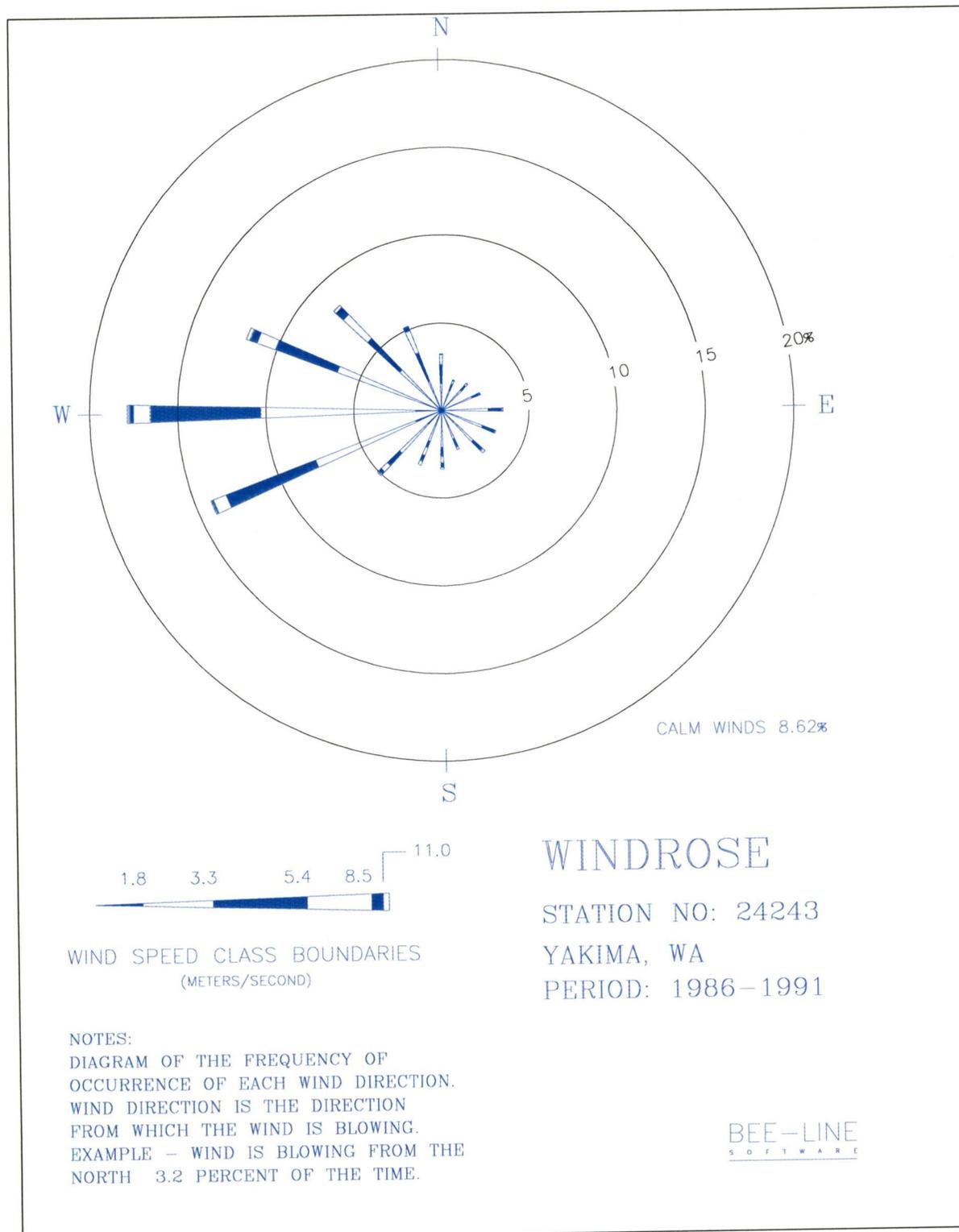
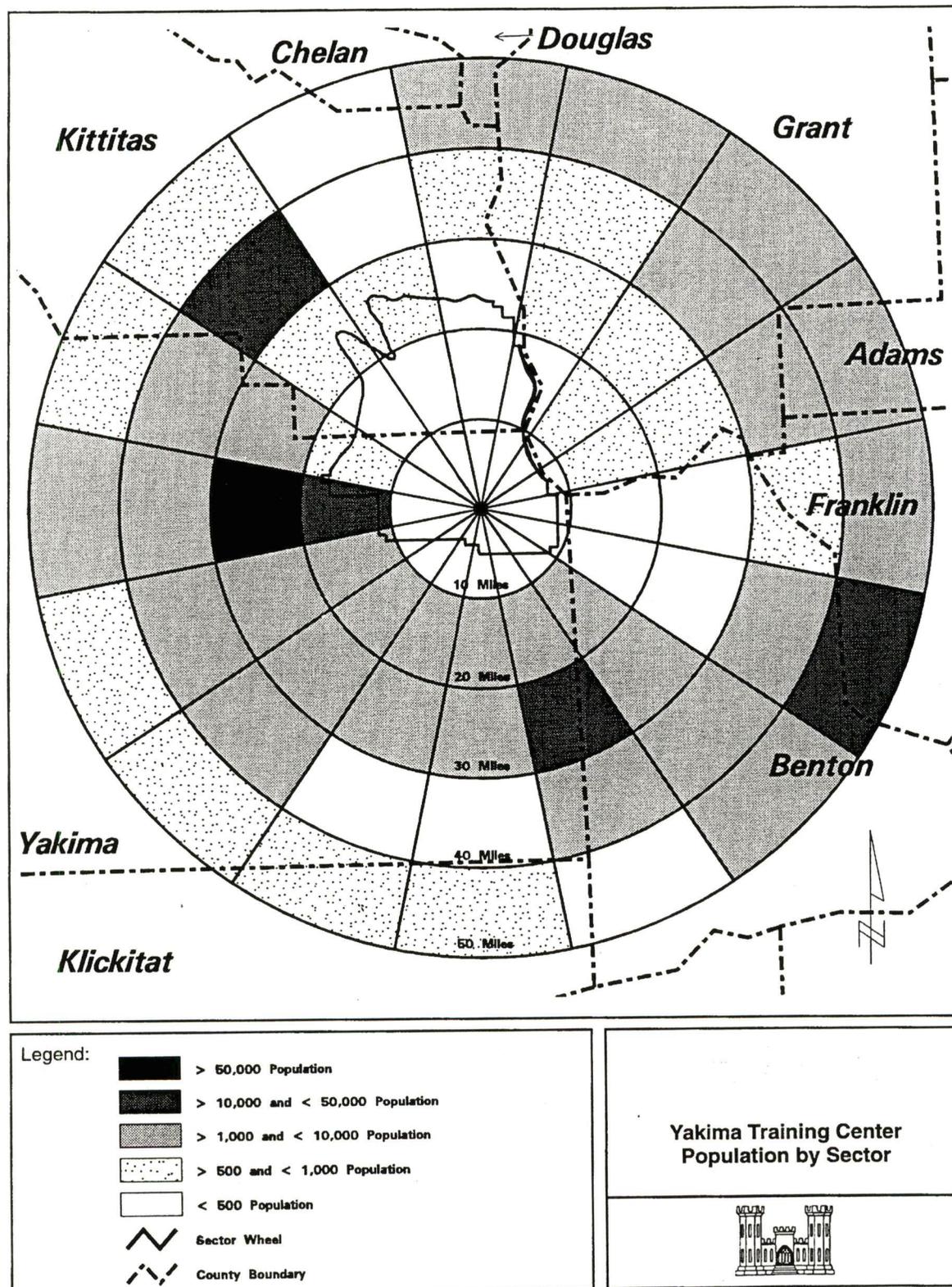


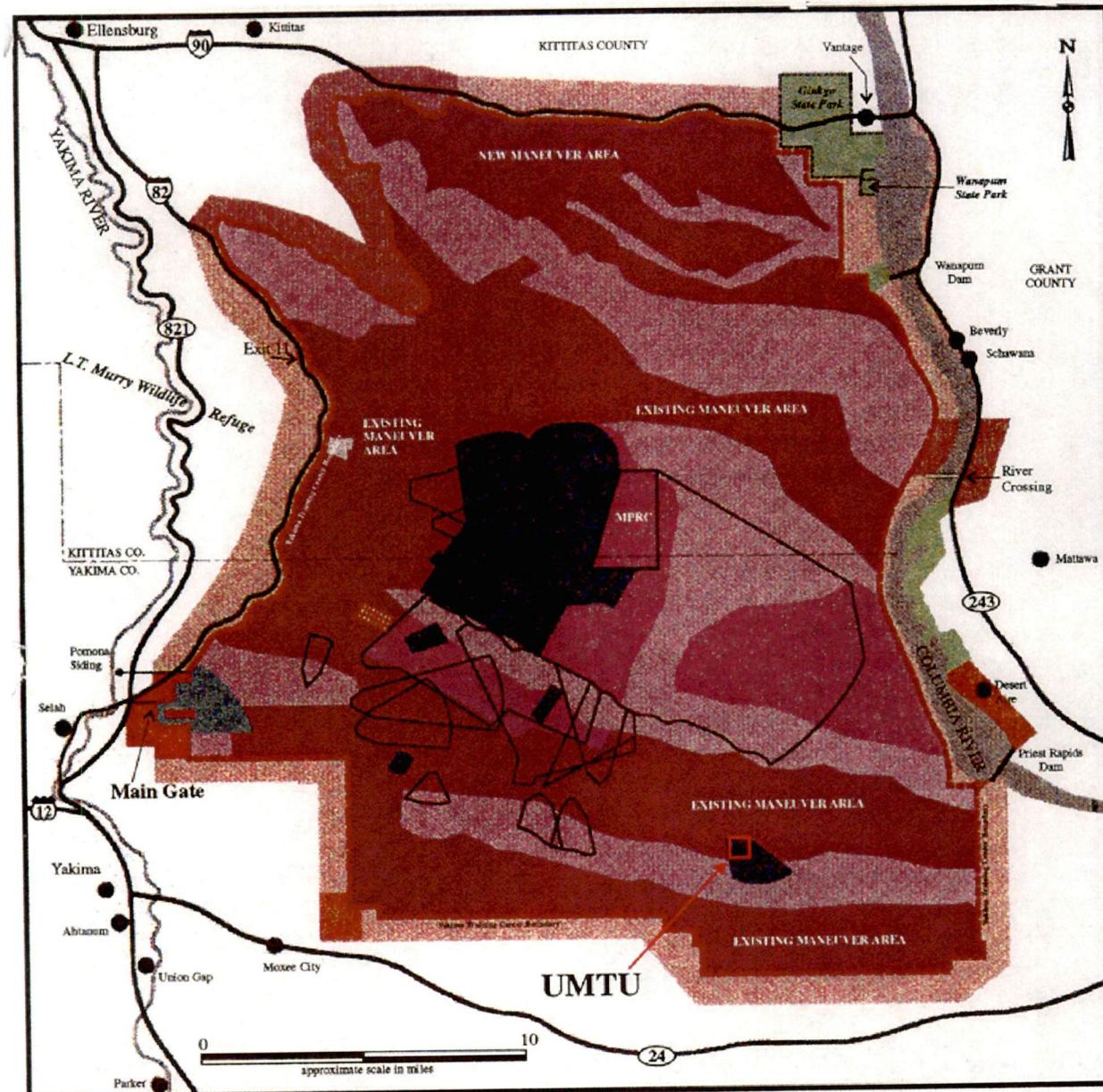
Figure 4-3. Wind Rose from the Yakima, Washington Airport (1986-1988, 1990-1991)



Source: U.S. Army Corps of Engineers (USACE)

Figure 4-4. YTC Population by Sector

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Produced by: PW-ENRD-GIS Lab, Fort Lewis, Washington (Nov 93)

YTC Land Use

- Cantonment
- Primary Maneuver Area
- 25-Percent Maneuver Area
- Light-Use Maneuver Area (Steep Terrain)
- Impact Area
- Firing Range Area
- Yakima Army Airfield
- Selah Airstrip and Drop Zone

Surrounding Communities

- Large-Lot, Rural Residential
- Agriculture, High-Intensity
- Agriculture, Low-Intensity
- Recreation



Figure 4-5. Land Use Patterns

4.7.1 Current Land Use

The current land use for both on-base and off-base areas is discussed below.

4.7.1.1 On-Base

YTC is a controlled access area, and no one is allowed on to the installation without permission. Areas where access is even more restricted include the Ammunition Supply Point (ASP), Yakima Research Station, and Impact Areas.

Before 1941, land use in the area that now constitutes YTC was characterized by ranching and limited mining. In 1941 and 1942, the U.S. Army leased 160,000 acres from private owners and various county, state, and federal agencies, and established the Yakima Anti-Aircraft Artillery Range. During World War II, YTC was used extensively for training artillery, infantry, and engineering units based in the Pacific Northwest. In 1946 and 1947, military use of YTC was reduced, and approximately 60,000 acres were cleared of unexploded ordnance (UXO) and returned to the original landowners. Use of YTC as an artillery training area again increased in 1949 and 1950. YTC expanded to 323,537 acres through additional land acquisitions in the early 1990s.

The primary users of YTC are the various units stationed at Fort Lewis and the National Guard and Army Reserve units from Oregon and Washington. Currently, training activities at YTC involve movement of troops, firing of artillery into "impact zones," range operations, drills for all branches of the military, and testing of military equipment. Although YTC is used year-round for military maneuvers and weapons training, the intensity of use is greatest between March and November (DA, 1993b).

The cantonment area (1,010 acres) is located in the western-most portion of the installation. It includes billets, administrative, commercial, light industrial, and open space uses and training areas (322,527 acres). The installation contains 100 permanent structures and 130 temporary structures. There are no educational or family housing facilities on the installation, although permanent and transient quarters are available. Transient troops training at YTC live in

the field or in the existing barracks and other quarters. Most permanent personnel reside in and around the City of Yakima.

The nearest structures to the UMTU are three abandoned and destroyed bunkers on the north side of the UMTU, approximately 820 ft north of the OD treatment area. The nearest occupied structure is the YTC Range Control Operations Center, located approximately 14 miles west of the UMTU.

Portions of the open range land of YTC have historically been used as grazing land for cattle and sheep. Grazing at YTC was phased out and finally terminated in 1995. Currently, there are two periods each year during which cattle/sheep are trailed through the installation from the south to the north in the spring, and back in the fall. Additionally, the public can hunt, fish, hike, or ride horseback on YTC in coordination with Range Control. Recreational activities take place anywhere throughout the nonrestricted areas of YTC, depending on scheduled training exercises. No fish habitat or agricultural land exists in the vicinity of the UMTU. Native American traditional way of life is practiced at YTC by the Yakama and Wanapum tribes.

The distance, direction, and terrain elevation of on-base environmental receptor points closest to the UMTU are presented in Table 4-1.

4.7.1.2 Off-Base

Land adjacent to YTC is used for agricultural, livestock grazing, and recreation and includes rangelands and residential areas as well as various federal-and state-owned parcels. Most of the land is open and undeveloped.

Table 4-1
Nearest Receptor Locations On-Base

Description	Distance from UMTU (km)	Sector	Terrain Height (m MSL) ^a
Water spring	1	S	1024
Selah Creek	1.1	M	853
Cold Creek	3.1	NE	793
Nelson Springs	4	SE	3,260 ft
Potable water well	6	WNW	774
EOD bunker	1.6	N	918
Installation boundary	4.8	SSW	838
Range 55	7.5	NW	738
Range 12	8.6	WNW	750
Range Control	21.3	WNW	622
John Wayne Pioneer Trail	27.8	N	457
Cantonment area – Bachelor Officer's Quarters, On-site Workers	30	WNW	408
Badger Gap agricultural area	35.5	NNW	564

^a Terrain height at UMTU is 930 m MSL.

Sources: USGS 1:25,000,000 Yakima, Washington Quad, revised in 1971, and USGS 1:50,000 Yakima Firing Center Special Map, Revised, 1983.

The area north of I-90 contains a patchwork of private and government-owned land used primarily for grazing. Ginkgo State Park and Wanapum State Park border YTC at its northeast corner. Several small communities are located within the larger area beyond the Columbia River to the east, which is used for agricultural (hay fields, orchards, vineyards, etc.), open grazing, and retirement communities such as Desert Aire (located just inside of 10 miles from the UMTU). Toward the southern end of YTC's eastern border, land use is primarily for livestock grazing and agriculture. In this area, the Wanapum People live in a small village near Priest Rapids Dam, immediately adjacent to the YTC boundary. Several urban and smaller residential communities, including Yakima, Selah, Moxee City, and Terrace Heights are located at YTC's southwest corner. Scattered areas of irrigated land and orchards also exist to the southwest. Other communities located farther to the south include Toppenish, Wapato, Sunnyside, and Grandview. I-82 separates the western boundary of YTC from L.T. Murray Wildlife Recreation Area. The area extending into YTC boundaries at its northwest corner, referred to as Badger Pocket, consists of irrigated agricultural land with scattered residences and farm buildings (DA, 1993a).

The nearest off-base residence to the UMTU is a ranch approximately 3.3 miles to the southwest. Additionally, the village adjacent to Priest Rapids Dam is approximately 7.5 miles to the northeast of the UMTU. The City of Yakima is located 21.3 miles from the UMTU. Potential human receptors found at YTC and within an 49.7-mile radius of the UMTU are listed on Table 4-2.

The Yakima River supports approximately 33 fish species. Although the section of Yakima River adjacent to YTC provides little salmon habitat, this reach has a substantial recreation fishery for resident rainbow trout (DA, 1993a). The UMTU is located in the eastern portion of the Selah Creek Watershed on YTC. This watershed drains into the Yakima River, which is designated critical habitat for Mid-Columbia Steelhead Trout.

4.7.2 Future Land Use

Future land use is expected to remain equivalent to current land use (i.e., a federal facility dedicated to training troops).

4.8 Surface Waters and Water Quality

The UMTU is located within the Columbia Basin ecoregion of the United States. Specifically, it is within the western intermountain sagebrush steppe ecosystem (West, 1988). Topography at the site varies from low plains to steep slopes and ridges. The region is dry, receiving between 6 and 16 in. of rain per year. This limited amount of precipitation is a major determinant of the vegetative communities present near the UMTU. Two intermittent streams, Selah Creek and Cold Creek, are found to the west and east, respectively, of the UMTU. Selah Creek drains into the Yakima River west of the site, while Cold Creek drains off the installation to the east, then turns south and enters the Yakima River near Horns Rapids. These streams contain water intermittently in the vicinity of the UMTU. There are no permanent water bodies of any type within the boundaries of the UMTU. The closest perennial surface water bodies to the UMTU are the Columbia River, approximately 7.5 miles northeast of the UMTU, and Nelson Springs, approximately 2.5 miles southeast of the UMTU.

Table 4-2
Nearest Receptor Locations Off-Base

Description	Distance from UMTU (km)	Off-Site Distance from YTC Boundary (km)	Sector	Terrain Height (m MSL) ^a
Off-base residents	5.3	0.2	SSW	786
Off-base residents	8.5	1.5	S	579
Off-base residents	10.5	3.2	SSE	549
Public access road	10.9	4	SSE	533
Priest Rapids Wildlife Recreation Area	16.6	1.8	NNE	152
Columbia River	12.5	0.2	ENE	137
Community at Priest Rapids Camp	12.7	0.3	ENE	152
Village of Desert Aire Church	14.3	2.3	ENE	165
Nearest Irrigated Agricultural Land	15.2	6.7	SW	433
City of Mattawa	20.4	5.5	NNE	229
Moxee City schools (4)	24.3	4.8	WSW	335
East Valley High School – Moxee City	25	5.1	WSW	305
Yakima Sportsman State Park	26.5	6.5	W	305
City of Terrace Heights School	27.2	7.5	W	372
L.T. Murray Wildlife Refuge	30	0.1	WNW	762
City of Union Gap School – Child care facility	31	10.8	W	274
Toppenish City Hospital – Child care facilities (5)	31.3	26	SW	244
City of Sunnyside Hospital – Child care facilities (4)	32	25	S	213
City of Wapato – Child care facility	32	17	SW	259
Interstate 82	32.3	11.3	W	305
Yakama Indian Reservation	33.5	13.8	SWS	381
Ginko State Forest/Wanapum State Park	33.8	7.3	N	457
City of Yakima – Hospitals (2), Schools (21), Nursing Homes (10), Child care facilities (31)	34.3	14.3	W	305
City of Selah – Child care facilities (2)	35.3	5.3	ENE	335
Badger Gap community	35.5	3	NNW	564
Interstate 90	36.5	0.2	N	488
City of Kittitas	49	8.8	NNW	518
Naches schools (3)	49	8.8	W	548
City of Ellensburg	55.3	16	NNW	457
Snoqualmie National Forest	62	32.5	W	1006
Goat Rock Wilderness Area (Nearest PSD Class I Area)	96.3	76.8	W	1768

^a Terrain height at UMTU is 930 m MSL.

Sources: USGS 1:25,000,000 Yakima, Washington Quad, revised in 1971, and USGS 1:50,000 Yakima Firing Center Special Map, Revised, 1983.

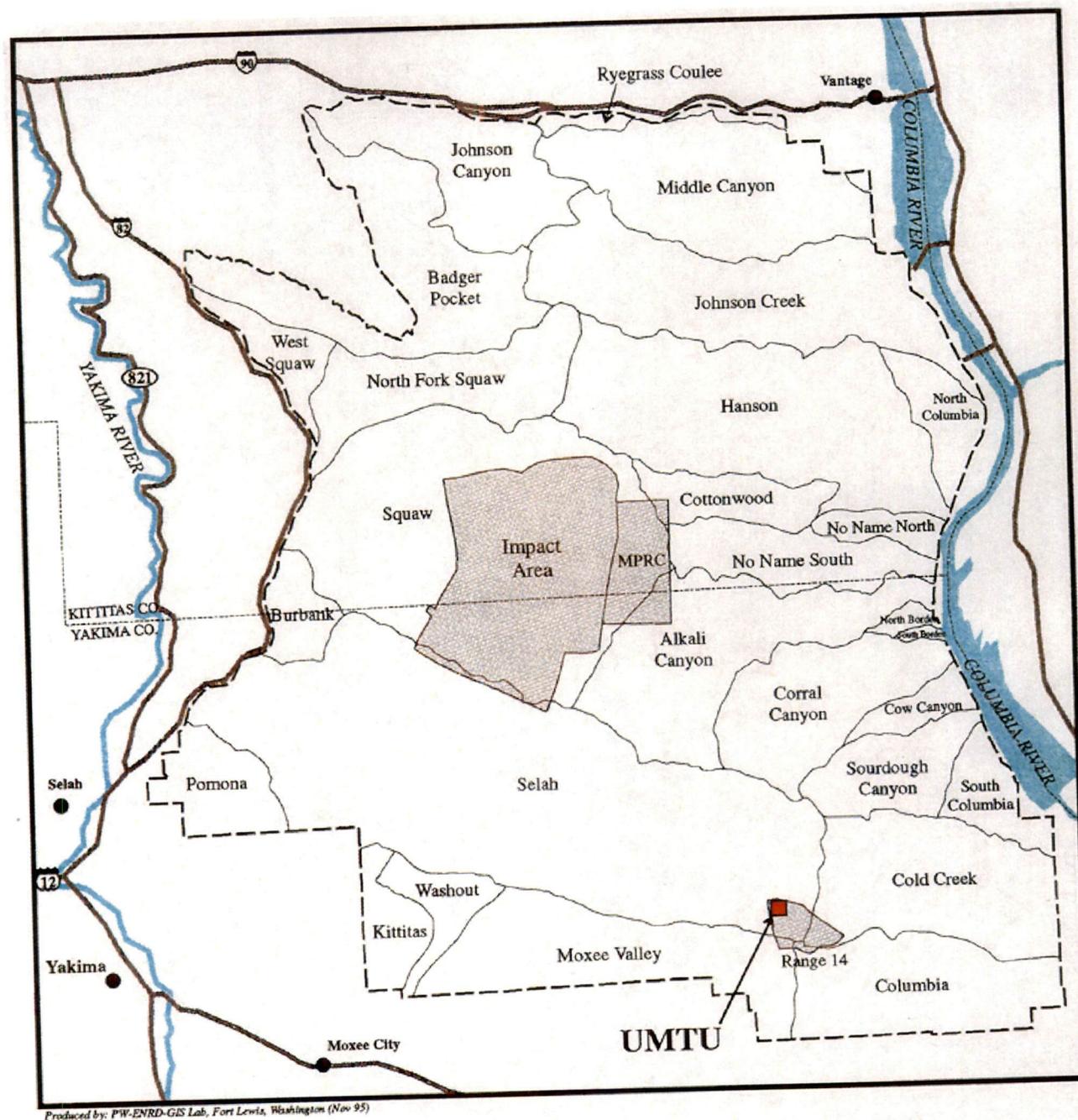
Two major watersheds are adjacent to YTC: the Columbia River system immediately to the east, and the Yakima River system immediately to the west. Eleven dominant drainage systems exist within the boundaries of YTC: four systems drain toward the Yakima River, and seven drain toward the Columbia River. Only two of the drainage systems flow year-round. Additionally, over 200 springs with flow rates ranging from 1 to 15 gal/min are located throughout the installation. Wetlands at YTC are limited to the immediate vicinity of perennial streams and springs found emanating from hill slopes. No substantial surface water bodies exist within the boundaries of YTC (DA, 1993b). The surface water drainage areas at YTC are shown in Figure 4-6. The UMTU lies in the Selah Creek Watershed in the southeast portion of YTC. The UMTU is located on a gently sloping hillside approximately 0.9 miles south of the Selah Creek streambed, the nearest surface water (YTC, 1995). Except for its upper reaches near the UMTU, Selah Creek flows year-round into the Yakima River, with a large portion of the watershed consisting of gently sloping lands lying between the creek channels and the steeper sloping hilly lands (DA, 1993a). No perennial surface waters are on or adjacent to the UMTU. Two intermittent streams and six springs are located in the general vicinity (DA, 1993b). The closest perennial surface water bodies are the Columbia River, located approximately 7.5 miles northeast of the UMTU, and Nelson Springs, located approximately 2.5 miles southeast of the UMTU on the south side of Yakima Ridge. Surface water sampling in the vicinity of the UMTU from Selah Creek, nearby wetlands, and springs has not been completed.

4.9 Floodplains

None of the 100-year floodplain encroaches within 15 ft of the nearest point on the UMTU and within 85 ft of the center of the UMTU. The unit is located on high ground, several miles from the 100-year floodplain zone.

4.10 Sensitive Species

A total of 246 wildlife species occur or are expected to occur on the basis of known ranges and habitat preferences (DA, 1996). Of the 246 species, 50 are mammals, 174 are birds (of which about half are year-round residents), 14 are reptiles, and 8 are amphibians.



Watershed Boundary

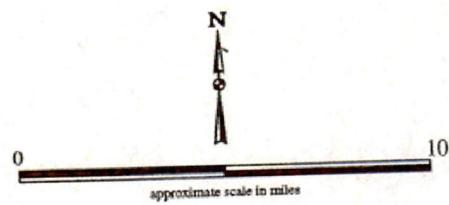


Figure 4-6. Surface Water Drainage

Terrestrial vegetation at YTC and UMTU is mostly range land containing shrub and grass species, with occasional trees. Sagebrush is abundant throughout the area. Common grasses in the area include bluebunch wheatgrass and bluebunch fescue. In addition to the activities at YTC, land uses in the vicinity of the site include military training activities, livestock grazing, agriculture, and outdoor recreation.

Wildlife habitat in the vicinity of the UMTU is characteristic of the shrub-steppe region of the Columbia Basin. Shrub communities are present throughout the region, with occasional riparian areas (floodplains and other transition zones between upland terrestrial and aquatic habitats). Riparian areas can be important habitats for many species, even though the total amount of riparian habitat in the vicinity of the UMTU is small.

Several small wetland areas are associated with Selah Creek and various springs within 0.8 miles of the UMTU boundary. YTC and the UMTU are within the Columbia River watershed. The UMTU is predominantly within the Selah Creek drainage, which discharges into the Yakima River west of the UMTU. The Yakima River is a tributary of the Columbia River. Both the Columbia and Yakima Rivers support both anadromous and resident salmonids, as well as at least 33 other cold water and warm water fishes (DA, 1996). The portion of the Columbia River closest to the UMTU is the part of the river impounded behind Priest Rapids Dam. YTC borders the Columbia River from a point approximately 1.9 miles downstream from Wanapum Dam to approximately 4.0 miles downstream from Priest Rapids Dam. The Yakima River supports a substantial recreational fishery for resident rainbow trout.

YTC lies in rugged topography within the Columbia River Basin and receives only 6 to 16 in. of precipitation annually. However, wetlands are located near perennial streams and the numerous springs found emanating from hill slopes. The nearest wetlands to the UMTU are in the Selah Creek channel, 9 miles north, and nearby springs 0.6 miles to the south. The Selah Creek wetlands are composed of cattails, rushes, and sedges with occasional patches of scrub-shrub vegetation, such as willows and cottonwoods.

One federal Candidate plant species (basalt daisy) and six state threatened species including Columbia milkvetch, dwarf desert primrose, white eatonella, basalt daisy, Hoovers

desert-parsely, and Hoovers tauschia occur on YTC. However, none of these plant species are known to be present within the boundaries of the UMTU.

Several state and federal sensitive wildlife species occur on or around YTC. Bald eagles, a federally threatened species are present on YTC but have not been documented on or adjacent to the UMTU. Ferruginous hawks, a state threatened species have historically been found on YTC however; recent surveys have not detected this species on or adjacent to the UMTU. Three state candidate mammal species (black and white tailed jackrabbit and Merriam's shrew) are known to occupy shrub-steppe upland habitats on YTC. Three state candidate raptor species (Golden eagle, Merlin and Burrowing owl) and four passerine species (Loggerhead shrike, sage thrasher, vesper sparrow, and sage sparrow) use shrub-steppe uplands on the installation. This habitat exists around the UMTU and it is therefore likely these species inhabit areas adjacent to the UMTU. YTC supports one of two populations of sage grouse remaining in the state of Washington. This species is a state threatened species and a federal candidate for listing as a threatened. The UMTU is within and adjacent to habitat known to be used by sage grouse. Soil sampling and excavation within the UMTU is not likely to affect these species.

5.0 PRE-CLOSURE SITE INVESTIGATION

Past site investigation activities at the UMTU were completed in order to characterize the extent of contamination as a result of thermal treatment operations being carried out at the UMTU. The data from these past investigations were used to complete the risk assessment (March 2002), which evaluated the risk to human health and ecological receptors. Based on the results of the risk assessment, all chemicals of potential concern (COPCs) were within Model Toxics Control Act (MTCA) cleanup levels for industrial exposure.

5.1 Sampling and Analysis

The investigations have involved sampling both soil and groundwater media, as summarized below.

5.1.1 Surface and Subsurface Soils

The Army Environmental Hygiene Agency initiated a Phase I soils investigation at the UMTU in August 1993. The purpose of the study was to establish baseline conditions within the UMTU and to evaluate the extent of surface migration, if any, of potential contaminants onto and off of the unit. The investigation included surface soils and intermittent stream sediment. Areas sampled included transects across the most active portions of the UMTU, OD craters, the OB area, intermittent watercourses, and natural background. Grab and composite samples were collected from 0 to 6 in. below ground surface (BGS) and 6–24 in. BGS, as well as field blanks, trip blanks, and field duplicates. The samples were analyzed for explosives, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), total metals, pesticides, herbicides, nitrate/nitrite, polychlorinated biphenyls (PCBs), picric acid, and total petroleum hydrocarbons (TPHs).

A Phase II soils investigation was conducted in August–September 1995 to gather additional baseline data for delineating constituent concentrations in the surface (0–6 in. BGS) and subsurface (6 in. to 20 ft BGS) soils in the UMTU and natural background areas. Sample collection locations included UMTU, background, OB area, and OD craters. Samples were

analyzed for explosives, SVOCs, total metals, and picric acid. Phase II analyses did not include VOCs, TPH, pesticides, PCBs, or herbicides since these constituents were not detected in the Phase I study.

In September 2000, a third round of soil sampling was completed for the UMTU area. The purpose of this soil sampling event was to monitor levels of contaminants of concern in surface soils within, adjacent to, and outside the UMTU site and the potential migration of these contaminants from the unit. Twelve grab samples were collected from 0–6-in. BGS. Eight of the samples were collected from a transect line that passed through the OB and OD areas. The remaining four samples were collected from the streambed locations; two samples represented upgradient locations and two samples represented downgradient locations. The samples were analyzed for explosives and total metals.

The results of the Phase I investigation do not indicate pervasive contamination of the area from OB/OD operations. Low levels of explosive compounds and related SVOCs were identified in crater samples, the OB area, one transect site, and two watercourse samples. Some of the metal concentrations exceeded Region III carcinogenic risk-based concentrations or state screening levels; however, none exceeded noncarcinogenic screening levels. One explosive (RDX) exceeded a screening level in one sample only.

The results of the Phase II investigation indicate that no explosive or SVOCs were detected and that the metals present in the samples were considered to be anthropogenic in origin.

For the September 2000 sampling event, four explosives (HMX, RDX, 2,4,6-trinitrotoluene, and nitroglycerin) were detected in the samples. All of the concentrations were below the MCTA Method B cleanup level with the exception of one sample result for nitroglycerin. All the individual sample results are well below the Method B cleanup level of 71 mg/kg except for the sample collected from sampling location HS02, which had a concentration of 230 mg/kg. The average of all samples collected (30.3 mg/kg) is less than the cleanup standard. However, the maximum concentration has been used based on the WAC stipulation that individual soil samples may be compared directly to cleanup levels if there is reliable

information that the soil samples have been taken from locations where the worst soil contamination ("hot spots") is likely to be found.

A review of the data indicates that all the explosive and SVOC contaminants are contained within the top 24 in. BGS of soil and that the metals are the only compounds detected consistently throughout the subsurface (from 2 to 20 ft BGS). However, the presence of metals is to be expected. The results of a study completed by the U.S. Geological Survey, in cooperation with the WDOE, have been used to define a range of values that represent the natural concentration of metals in surficial soils throughout Washington (WDOE 1994). In many cases the natural background concentration of a metal determined by this study is comparable to the maximum concentration detected in the UMTU site samples. The largest deviations from this occur with cadmium (background concentration of 1 mg/kg, site concentration of 5.2 mg/kg) and lead (background concentration of 17 mg/kg, site concentration of 86 mg/kg). However, these concentrations are still well within the cadmium and lead cleanup levels of 40 mg/kg and 250 mg/kg, respectively. The soil data are summarized in Attachment A-1.

5.1.2 Groundwater

Groundwater data have been collected as part of an ongoing annual monitoring program initiated on a quarterly basis in 1994. Ten rounds of groundwater samples have been collected since 1994 in order to determine the existence, nature, and extent of possible groundwater contamination in the uppermost aquifer related to the use of the UMTU site as a treatment facility. The single upgradient monitoring well has been used to collect samples representative of background conditions. [The background well is actually located side gradient due to topographic characteristics of the site. However, based on the groundwater flow direction calculated during quarterly and annual groundwater monitoring since 1994, the well is appropriately located to fulfill the requirements for a background well location (Woodward-Clyde 1996)].

The most recent round of sampling was completed in June 2000. Samples collected from the three monitoring wells [including quality control (QC) samples] were analyzed for nitroaromatics and nitroamines (Method 8330), PETN and nitroglycerin (modified

Method 8330/8332), dissolved metals (Method 6010/6020/7470), cyanide (Method 335.3), ammonia (Method 350.1), nitrate/nitrite (Method 353.2), phosphorous (Method 365.1), total dissolved solids (Method 160.1), sulfate (Method 375.2), and alkalinity (Method 310.1). Previous sampling events included the collection and analysis of samples for VOCs, SVOCs, organochlorine pesticides, and chlorinated herbicides. However, these analytes were consistently undetected; therefore, the target analyte list was revised to include only explosives, dissolved metals, and select cations/anions beginning with sampling round 8 (completed in June 1998). The data quality objectives (DQOs) were met for each sampling round (USACE 2001a). The groundwater data are summarized in Attachment A-1.

5.2 Site Investigation Data Analysis

Quality Assurance (QA)/QC samples collected during (Phase I) soil sampling effort included field blanks, trip blanks, and field duplicates. Field duplicates were collected for approximately 5% of the samples in each medium. Trip blanks were included in each cooler that contained samples for VOC analysis. Field samples and QA samples were analyzed in accordance with EPA-approved methods. All field sampling data packages met the U.S. Army Corps of Engineers (USACE) hazardous, toxic, and radioactive waste (HTRW) minimum chemistry data reporting requirements as specified in the Chemical Data Quality Management Policy for HTRW projects.

5.3 Data Summary

A summary of the data collected during all sampling events is provided in Attachment A-1.

6.0 CLOSURE PERFORMANCE STANDARDS

As stated in WAC 173-340-740, WDOE has determined that residential land use is generally the site use requiring the most protective cleanup levels and that exposure to hazardous substances under residential land use conditions represents the reasonable maximum exposure scenario. This is not consistent with Fort Lewis' plans to continue to use the site as a munition impact area/training range after the UMTU is closed, however, evaluating this exposure pathway will provide a conservative estimate for risk to human receptors.

6.1 Risk-Based Approach

The goal of risk-based clean closure is to ensure protection of human health and the environment. Therefore, both human health and ecological effects were considered separately within the risk-based clean closure framework. Risk-based cleanup levels were either taken directly from tables found in the WAC or calculated using the risk equations provided in WAC 173-340-720 and 740. The risk calculations take into consideration site-specific factors and conditions to ensure the protection of the most conservative receptors (child resident and sensitive ecological species).

6.2 Human Health Risk Assessment

The regulations contained in WAC 173-340 prescribe specific activities that must occur to ensure that a hazardous waste unit is cleaned up in a manner that protects human health and the environment. Clean closure refers to activities that provide a degree of human health and environmental protection adequate for WDOE to remove a regulated unit from the hazardous waste regulatory system. The degree of human health and environmental protection necessary for clean closure (i.e., the "clean closure performance standard") is described in WAC 173-303-610(2). A site is considered in compliance with clean closure performance standards when the concentrations of contaminants in groundwater and soil are less than the numeric cleanup levels calculated using residential exposure assumptions according to the MTCA regulations (WAC 173-340). Therefore, a human health risk assessment was completed in accordance with the requirements of WAC 173-340-708 to establish the appropriate cleanup levels for the UMTU.

Groundwater cleanup levels shall be based on estimates of the highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions. The department has determined that at most sites use of groundwater as a source of drinking water is the beneficial use requiring the highest quality of groundwater and that exposure to hazardous substances through ingestion of drinking water and other domestic uses represents the reasonable maximum exposure.

The cleanup levels for groundwater are the concentrations listed in Table 720-1 (Method A) and/or those calculated using Equation 720-1 of WAC 173-340-720(4)(A) (Method B). The calculations assumed a risk of 1×10^6 and a hazard quotient of one.

The presumed exposure scenario soil cleanup levels for unrestricted land use (clean closure) shall be based on estimates of the reasonable maximum exposure expected to occur under both current and future site use conditions. The department has determined that residential land use is generally the site use requiring the most protective cleanup levels and that exposure to hazardous substances under residential land use conditions represents the reasonable maximum exposure scenario. Therefore, the soil cleanup levels are based on a residential exposure scenario.

The soil cleanup levels for unrestricted land use are the concentrations in Table 740-1 (Method A) and/or the soil cleanup levels calculated using Equation 740-1 of WAC 173-340-740(3)(b)(iii)(B)(I) and (II) (Method B). The calculations assume a risk of 1×10^6 and a hazard quotient of one.

After the soil cleanup levels have been established at a site, sampling of the soil is to be conducted to determine whether compliance with the soil cleanup levels has been achieved. The sampling and analytical procedures for the pre-closure sampling of the hot spot at the UMTU are defined in the Sampling and Analysis Plan (SAP) (Attachment A-2). The SAP also describes the data analysis and evaluation procedures that will be used to evaluate compliance with soil cleanup levels.

6.3 Ecological Risk Assessment

An ecological evaluation was completed in order to determine whether residual site contamination has substantial potential for posing a threat of significant adverse effects to terrestrial receptors. The screening level risk assessment used the results from the previous soil/sediment sampling events to define the chemical concentrations to which various ecological receptors are exposed.

Target ecological receptors evaluated in this assessment were selected based on the following: their presence/abundance at the site, their position on the food web, their status, and their home range size. The target receptors included terrestrial plants, soil invertebrates, herbivorous birds (sage grouse), herbivorous mammals (great basin pocket mouse), carnivorous birds (ferruginous hawk and the burrowing owl), and carnivorous mammals (coyote). Since there is no standing water within the UMTU, only terrestrial shrub-scrub habitat and its associated ecological receptors were considered. Therefore, no aquatic habitats were evaluated.

The exposure of ecological receptors to contaminants of potential ecological concern (COPECs) released from past OB/OD operations was evaluated through exposure pathways. The exposure pathways that were used for the assessment included direct uptake pathways of a COPEC from soil and sediment for the lower trophic level receptors (soil and sediment invertebrates and terrestrial plants) and ingestion of COPEC-contaminated organisms for higher trophic level receptors (birds and mammals). The lower trophic level receptors were considered community level receptors and the higher trophic level receptors were considered class-specific guild receptors.

The toxicity of a COPEC is assessed by identifying threshold reference values (TRVs) specific to a COPEC and the measurement (target) receptor being evaluated. The community TRVs are media-specific and used to screen ecological effects to receptors inhabiting the soil. Class-specific guild TRVs are used to screen ecological effects to wildlife. The TRVs used for the screening level ecological risk assessment included those available from published and peer reviewed sources. There are no readily available published TRVs for most of the energetic compounds that were detected in the soil and sediment samples. Therefore, those

compounds without screening standards were qualitatively evaluated with respect to the potential risk to measurement receptors.

The risk was quantified using the quotient method to calculate an ecological screening quotient (ESQ). ESQs were calculated for each target receptor/COPEC combination. Since ecological receptors are normally concurrently exposed to multiple COPECs, individual ESQ values were summed to estimate a total ESQ for each receptor. For any individual ESQ less than 1.0, ecological risk was considered within acceptable levels. Those ESQs greater than or equal to 1.0 were considered unacceptable and evaluated in greater detail.

Only 2 of the 20 compounds detected during soil/sediment sampling at the UMTU exceeded benchmarks developed for terrestrial wildlife species, aluminum, and di-n-butylphthalate. However, based on a review of the fate of these chemicals in the environment and the toxicological studies that have been completed for these compounds, no ecological impact from these residual concentrations is expected to occur.

In order to quantitatively assess the impact to the measurement receptors, community-level (plants and soil invertebrates) TRVs as well as class-specific (mammals and birds) TRVs were needed. Due to the paucity of available toxicity data for these species, an assessment of the fate and transport characteristics of these compounds and the habitat characteristics of the species were used to evaluate the potential impact to these ecological receptors. No impact to these receptors is expected due to the fact that the receptors do not eat exclusively from the site, the existing soil concentration will not increase when the treatment activities are ceased, and all the species are currently thriving on the site.

Based on published reports, the biggest threat to these species is habitat loss and habitat fragmentation. Habitat management programs are focusing on land protection, protection of nesting habitats, and avoiding the use of pesticides around the nesting sites, all of which coincide with discontinuing the treatment operations at the UMTU.

6.4

Risk-Based Closure Performance Standards

The risk-based clean closure performance standards for the UMTU COPCs are listed in Table 6-1 (groundwater) and Table 6-2 (soil). These standards were calculated assuming exposure to human receptors through two pathways: groundwater protection and soil direct contact. The soil cleanup levels also take into consideration environmental protection (i.e., concentrations that result in no significant impact to ecological receptors). However, the ecological assessment (see Section 6.3) did not indicate effects at those levels protective of human health (Method A or Method B); therefore, no downward (more stringent) adjustment of the Method A and Method B levels was necessary.

Table 6-1
Groundwater Concentrations and Cleanup Levels
for the Protection of Human Health (Detected Metals Only)

COPC	Maximum Background Concentration (µg/L)	Maximum Well Concentration (µg/L)	(Table 720-1) Method A Cleanup Level (µg/L)	(Calculated) Method B Cleanup Level (µg/L)
Arsenic	0.98	0.71	5	4.8
Barium	ND	6.0	---	1,120
Calcium ^a	24,000	15,000	Not considered per EPA Risk Assessment Guidance for Superfund (RAGS)	
Chromium (Total)	2.9	6.8	50	24,000
Lead	ND	0.056	15	--
Potassium ^a	2,600	3,600	Not considered per EPA RAGS	
Selenium	1.4	1.3	--	80
Silicon	21,200	27,200	Not regulated as a hazardous constituent under 40 CFR 261, Appendix VIII	
Sodium ^a	15,000	13,000	Not considered per EPA RAGS	
Vanadium	11	24	112	112
Zinc	12	15	--	4,800

^a Chemicals that are essential human nutrients, present at concentrations below or only slightly above background, and toxic at very high doses were not considered for the risk assessment (EPA 1989).

Table 6-2
Soil Concentrations and Unrestricted Land Use Cleanup Levels
for the Protection of Human Health (Detected COPCs Only)

COPC	Maximum Background Concentration (mg/kg)	Maximum Concentration (mg/kg)	Method A Cleanup Level (mg/kg)	Method B (Standard) Cleanup Level (mg/kg)
HMX	---	4.8	---	4,000
RDX	---	28	---	240
Nitroglycerin	---	230	---	71
2-amino dinitrotoluene	---	0.024	---	16,000 ^a
2,4-Dinitrotoluene	---	2.7	---	160
2,4,6-TNT	---	9.8	---	40
Aluminum	20,000	35,000	76,000 ^b	
Arsenic	4.4	8.0	20	24
Barium	240	300	---	5,600
Beryllium	0.9	2.1	---	160
Cadmium	---	5.2	2 ^c	40
Chromium (Total)	21	27	100	
Di-n-butyl phthalate	---	28	---	8,000
Diphenylamine	---	3.9	---	2,000
Lead	13	86	250	
Mercury		0.074	1	
Methylene Chloride	---	0.031	0.5	4,800
Nitrocellulose ^d	---	267	---	128,000
p-Isopropyltoluene	---	0.003	---	16,000 ^a
Selenium	1.4	2.8	---	400

^a The toxicity values for toluene (a surrogate compound) were used to calculate cleanup levels for these chemicals.

^b EPA Region IX residential soil preliminary remediation goal.

^c The cleanup level for cadmium is based on the protection of groundwater for drinking water use.

^d The cleanup level for nitrocellulose was calculated using the toxicity value for nitrate.

The costs associated with soil excavation and disposal can become substantial, therefore, it is critical that reasonable cleanup levels be established for the site. The cleanup standards guiding the closure decisions for the UMTU are based on residential exposure, an extremely conservative assumption given the fact that the UMTU is located within a secure, fenced, federal facility. In the event that the surface soil sampling results exceed the cleanup standard, the most appropriate cleanup action for the UMTU would be excavation and removal. The critical issue then is to decide to what depth the soil should be removed. Since the cleanup levels are based on human exposure via direct contact, it is important to remove any contaminated soil, thereby ensuring no human contact with the soil. Post-closure land use will be limited to a munition impact area and training range, therefore, a reasonable estimate of the excavation depth is the depth of the soil that could be disturbed during emergency treatment and training conditions. Crater depths up to 5 ft BGS were typical for the OD treatment events at the

UMTU. Therefore, the direct contact pathway could be eliminated by excavating the soil down to a depth of 6 ft BGS and back-filling the excavated area with clean fill material. Excavation beyond this depth becomes cost-prohibitive for the following reasons:

- The direct contact pathway is already eliminated;
- Deeper soil excavation requires larger, more expensive equipment;
- Additional costs for subsurface UXO investigation and clearance; and
- Increased risk to workers from potential subsurface UXO.

6.5 **Demonstrating Compliance with the Risk-Based Closure Performance Standard**

Statistical methods will be used to determine whether the site has been clean closed (i.e., if the concentration of nitroglycerin is less than the MTCA Method B cleanup level of 71 mg/kg). WDOE's *Statistical Guidance for Ecology Site Managers* discusses the statistical approach used to demonstrate compliance with the cleanup levels. Specifically, the decision rule for demonstrating compliance with a cleanup level has three parts:

- Upper 95% confidence limit on the true population mean (average) must be less than the cleanup level;
- No sample concentration can be more than twice the cleanup level; and
- Less than 10% of the samples can exceed the cleanup level.

WAC 173-340-740(7) requires that, for cleanup levels based on chronic or carcinogenic threats, the true mean soil concentration be used to evaluate compliance with soil cleanup levels. Specifically, the data analysis will involve calculating the upper one-sided 95% confidence limit on the true mean soil concentration using Land's Method (for lognormally distributed data). If the data are neither lognormally or normally distributed (as determined using the D'Agostino's test), the largest value in the data set will be compared to the cleanup level.

In order to use the statistical methods to demonstrate compliance with soil cleanup levels, the data review [see Section 10 of the Quality Assurance Program Plan (QAPP)] must address any analytical results that are reported below the practical quantitation limit (PQL). In accordance with WAC 173-340-740, if less than 15% of the measurements are below the

PQL, measurements below the method detection limit (MDL) will be assigned a value equal to one-half the MDL and measurements above the MDL but below the PQL will be assigned a value equal to the MDL. If the data show that between 15% and 50% of the measurements are below the PQL, Cohen's method will be used to calculate a corrected mean and standard deviation for use in calculating the upper confidence limit (UCL) on the true mean soil concentration. If more than 50% of the measurements are below the PQL, the largest value in the data set will be used in place of the UCL on the true mean soil concentration.

The procedures for analyzing the data have been incorporated into *MTCASat*, an Excel-based program that performs statistical calculations required in WDOE's *Statistical Guidance for Ecology Site Managers*. The analytical results will be input as data into the *MTCASat* program in order to determine the correct data distribution (lognormal, normal, or neither) and the resulting 95% UCL, if applicable. Should the results of *MTCASat* indicate that both normal and lognormal distribution assumptions be rejected, the largest value in the data set will be compared to the cleanup level (71 mg/kg) to demonstrate compliance with the clean closure performance standard.

7.0 CLOSURE OF THE UMTU

Closure must fulfill the regulatory requirements of WAC 173-303-610. This closure represents final closure of the facility in accordance with the closure performance standard, as discussed above.

7.1 Closure in Accordance with the Closure Performance Standard

When a facility operator is no longer going to use a dangerous waste management unit for waste management, the dangerous waste regulations (WAC 173-303) prescribe specific activities that must occur to ensure the unit is cleaned up in a manner that protects human health and the environment. These specific activities are referred to as "closure." "Clean closure" refers to activities that provide a degree of human health and environmental protection adequate for WDOE to remove the unit from the dangerous waste regulatory system. The degree of human health and environmental protection necessary for clean closure is described in WAC 173-303-610(2) and is referred to as the "clean closure performance standard." In order for the site to be considered clean closed, COPCs must not exist in concentrations that pose a risk to human health or the environment.

7.2 Maximum Extent of Operations Unclosed During Active Life of Facility

The maximum extent of operations that will be unclosed during the active life of the facility is the largest area that would need to be closed if the facility were forced to close unexpectedly during the period from the initial receipt of hazardous waste until the WDOE receives certification of final closure. In the case of the UMTU, this is equivalent to the maximum design capacity of the OB and OD units. Therefore, the maximum extent of operations unclosed during the active life of the facility is the entire UMTU, which includes the approximately 8.3-acre OD area and the 0.86-acre OB area.

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8.0 **MAXIMUM HAZARDOUS WASTE INVENTORY AND WASTE MANAGEMENT METHODS**

The maximum hazardous waste inventory and waste management procedures to be used for closure of the UMTU are discussed below.

8.1 **Maximum Hazardous Waste Inventory**

The maximum waste inventory ever on-site includes the energetic waste treatment quantity, the quantities of UXO, and the quantities of ash and debris generated during treatment events, as described below.

8.1.1 **Energetic Waste Treatment Quantity**

Storage facilities are not required at the UMTU because the manifested wastes arrive the day of the treatment event. Should treatment of the waste military munitions (WMM) be delayed (e.g., due to a weather hold), the UMTU operators would direct the vehicle transporting the WMM to be held adjacent to the ASP in the ASP explosive vehicle holding area. This area meets both the DoD Explosive Safety Board safety and explosive quantity-distance criteria and, so long as the waste is held for a period of 10 days or less, it meets the requirements of a RCRA transfer facility [WAC 173-303-240(5)].

No energetic waste materials are stored at the UMTU. The maximum waste quantity, expressed as Net Explosive Weight (NEW), that was treated during a single OB event was 1,000 lb. The maximum waste quantity treated during a single OD event was 2,000 lb. Energetic wastes are transported to the treatment units just prior to the treatment event and are treated as they are received. Therefore, the maximum waste inventory in treatment at any time was 1,000 lb NEW for OB and 2,000 lb NEW for OD.

8.1.2 UXO Quantities

OB and OD treatment operations are conducted in accordance with Standard Operating Procedures (SOPs) that indicate the correct type and amount of donor charge/fuel that must be used to initiate and sustain the burn or detonation. The quantities of donor materials are calculated to ensure complete destruction of the items. The destructive force of an OD treatment event seldom leaves any recoverable residue. Likewise, the only materials that are ejected during burning are typically consumed before they reach the ground surface. However, if any items were discovered during the post-treatment inspection, they were collected and retreated as soon as practicably, generally that same day, but never longer than the next day.

8.1.3 Debris Quantities Generated

OD is a very efficient method of treatment; therefore, very little shrapnel remains in the OD unit. After each OD event the area was inspected for ejected debris. Visual inspection of the shrapnel was used to determine whether it was reactive (in which case it was retreated) or non-reactive (in which case it was collected and removed off-site for proper disposal or recycle).

8.2 Waste Management Methods

The methods of removing, transporting, treating, storing, and disposing of all wastes at the unit that may remain at closure and that may be generated during closure are discussed below.

8.2.1 UXO

Any UXO discovered during closure will be detonated in place.

8.2.2 OB/OD Debris

Shrapnel from fragmentation and other waste munition components can be energetic-contaminated or have other hazardous characteristics or constituents. Therefore,

trained EOD specialists will evaluate OB and OD debris for appropriate waste characterization and management.

8.2.3 Investigation-Derived Waste (IDW)

Materials that may become IDW are personnel protective equipment (PPE) (disposable coveralls, gloves, booties, etc.), disposable equipment (plastic ground and equipment covers, aluminum foil, Teflon tubing, broken or unused sample containers, sample container boxes, tape, etc.), soil cuttings from hand augering, cleaning fluids such as spent solvents and washwater, and packing and shipping materials. However, just because these wastes come from a site undergoing remediation (soil removal) does not automatically render them as hazardous wastes under RCRA. Therefore, it must be determined whether the waste itself meets the RCRA definition of a hazardous waste, and if so, the RCRA standards for storing, treatment, and disposal will be applicable to the management of these wastes.

8.2.3.1 Characterizing IDW

The most important characterization decision is whether IDW contains “hazardous waste” under RCRA. IDW generated during closure may either exhibit a RCRA characteristic or contain RCRA listed waste. In order to properly handle the IDW, a reasonable effort to ascertain whether the IDW is hazardous will be made. In order to determine whether a solid waste is designated as a dangerous waste, Fort Lewis will:

- Determine whether the waste is a listed discarded chemical product, WAC 173-303-081;
- Determine whether the waste is a listed dangerous waste source, WAC 173-303-082;
- If the waste is not listed in WAC 173-303-081 or 173-303-082, or for the purposes of compliance with the federal land disposal restrictions (LDRs) as adopted by reference in WAC 173-303-140, determine whether the waste exhibits any dangerous waste characteristics, WAC 173-303-090; and
- If the waste is not listed in WAC 173-303-081 or 173-303-082, and does not exhibit a characteristic in WAC 173-303-090, determine whether the waste meets any dangerous waste criteria, WAC 173-303-100.

Fort Lewis will make these determinations, in the order listed above, until the determination is made as to whether the waste is designated as a dangerous waste. For the purpose of determining whether a solid waste is a dangerous waste as identified in WAC 173-303-080 through 173-303-100, Fort Lewis will rely on knowledge of the properties of the substances from the characterization of waste munitions and sample results from previous site investigations.

8.2.3.2 Management of Non-Hazardous IDW

Nonhazardous PPE, disposable equipment, and paper and cardboard wastes will be bagged and placed into a closure contractor-provided garbage receptacle for off-site disposal. Nonhazardous decontamination fluids will be distributed on the ground to allow infiltration.

8.2.3.3 Management of Hazardous IDW

Hazardous IDW will be containerized and disposed of off-site at a permitted facility that can demonstrate compliance with all RCRA Subtitle C design, operation, and closure requirements. All hazardous waste is managed through the YTC Hazardous Waste Tracking System and the YTC less than 90-day storage yard.

8.2.4 Non-IDW Decontamination Fluids

It may be necessary to decontaminate heavy equipment that is used for removing the soil during closure. These non-IDW decontamination fluids will be containerized and analyzed for toxicity characteristic metals.

8.2.5 Soil That Contains OB/OD Residues

If the results of the pre-closure site investigation indicate the presence of nitroglycerin in surface soils above the cleanup level of 71 mg/kg, soil will be removed in order to eliminate an exposure pathway that might pose a risk to a residential receptor. However, even though the surface soil was contaminated above the acceptable cleanup level, the soils that are

excavated may not meet the criteria for a hazardous waste. Therefore, excavated soils will be containerized and managed as a hazardous waste in a staging area located at the UMTU. A sample of the soil material will be analyzed in order to determine the appropriate method of disposal. If the analytical results indicate that the soil material is a hazardous waste, it will be sent to a RCRA-permitted or interim status hazardous waste management facility for treatment (if necessary) and disposal (WAC 173-303). All hazardous waste is managed through the YTC Hazardous Waste Tracking System and the YTC less than 90-day storage yard. If the analytical results indicate that the soil is not a hazardous waste, it will be disposed of at the YTC Demolition/Inert Waste Landfill.

8.2.6 Waste Containerization

All drums used for waste containerization will be Department of Transportation (DOT)-approved, 55-gal steel drums (drum specification DOT 17-E or DOT 17-H). Before any waste is placed into the drum, a unique identification number should be assigned. Each drum will be labeled with the following information using indelible ink:

- Drum identification number,
- Type of waste, and
- Date of generation of waste.

8.2.7 Use of Off-Site Hazardous Waste Management Units

In accordance with WAC 173-303-140, Fort Lewis will ensure that the proper LDR notification accompanies shipments of hazardous waste from the installation. If the waste exhibits a toxicity characteristic and requires treatment in accordance with the LDR, it will be sent off-site for treatment with the proper manifest and in accordance with LDR requirements. Specifically, with each shipment of waste, Fort Lewis will notify the treatment or storage facility in writing of the appropriate treatment standards and prohibition levels. The notification will include the EPA hazardous waste number, the waste constituents that the treatment facility will monitor, and the manifest number associated with the shipment of waste. Compliance with the LDR numeric treatment standards will be determined using "grab" samples rather than composite samples.

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9.0 CLOSURE PROCESS

Closure of the UMTU will involve the evaluation of the existing site conditions (soil concentration levels of nitroglycerin) and, if necessary, the removal of soil to eliminate exposure via a direct contact pathway. Based on the results of the human health and ecological risk assessment and discussions during meetings with representatives from WDOE, the soil investigation/removal will be limited to the area where the nitroglycerin concentration exceeded (in September 2000) these standards.

9.1 UXO Sweep and Disposal

The presence of UXO at the site presents a safety hazard for the site investigation and removal (earth-moving) operations. Therefore, it will be necessary to conduct a UXO survey and subsequent UXO response at the OD area. Fort Lewis policy included the visual inspection of the OD area after each treatment event; however, in order to ensure that no UXO is present due to range training activities occurring on the congruent Range 14 site, qualified EOD subcontractor personnel will conduct a visual inspection of the UMTU prior to any site activities. If any UXO is discovered, YTC EOD personnel will treat the UXO by blowing it in place.

As described in Section 9.2, closure of the facility may require soil removal. Therefore, in addition to the visual inspection of the UMTU, a geophysical survey will be used as a non-intrusive method to identify subsurface UXO near the contaminated area. Qualified EOD subcontractor personnel will be responsible for identifying any subsurface UXO at the hot spot. Following the closure of the UMTU, the area will be revert back to a range training area. Therefore, subsurface UXO removal is necessary only in support of the closure activities (i.e., the soil removal efforts).

9.2 Soil Removal

Based on the surface soil sampling results from September 2000 (the most recent data set available for the site), one sample (out of 13 samples collected during the sampling event) had a nitroglycerin concentration exceeding the MTCA Method B Cleanup level of 71

mg/kg. This cleanup level was calculated assuming residential exposure (child) at a cancer risk of 1×10^{-6} . This sampling location represents the single "hot spot" that must be addressed during the closure of the UMTU.

During closure, the current soil concentration at the suspected hot spot will be determined using grab surface soil samples collected in accordance with the procedures described in Section 4.0 of the SAP. The samples will be collected using a random start systematic sampling strategy. The analytical results will be compared (using statistical analyses, as applicable) to the calculated risk-based closure standard (71 mg/kg) to determine whether the existing nitroglycerin concentration represents a potential exposure hazard to human receptors (assuming a conservative residential exposure scenario). Since the results of the risk assessment indicate that a nitroglycerin concentration of 71 mg/kg is also protective to ecological receptors, this level will be used as the risk-based clean closure standard for the site. If the statistical analysis (described in Section 3.3 of the QAPP) indicates that the current concentration of nitroglycerin in surface soils is less than 71 mg/kg, compliance with clean closure standards will be documented and the UMTU can be clean closed. If the statistical analysis indicates that the current concentration is greater than 71 mg/kg, the analytical results of each sample collected will be reviewed and the location(s) of the sample(s) exceeding the cleanup standard will be flagged. The flagged sampling location(s) will then be excavated, as described below.

Field team personnel will mark a 2.5 ft radius around each sampling location to be excavated. EOD personnel will conduct a subsurface investigation/clearance to remove any UXO that could be encountered during the excavation. A standard backhoe will then be used to excavate the soil within the marked area, down to a depth of 6 ft. The excavated soil will be moved to a nearby temporary storage area for waste analysis and disposal. Due to geologic conditions at the site, it is possible that backhoe refusal will occur before the depth of 6 ft has been reached. If this happens, the level at which backhoe refusal occurs will become the point of compliance for the site. The excavated area will be back-filled with clean fill material from on-site and re-graded to the current topography of the site.

In the event that soils are excavated from the site, they will be stockpiled nearby in a bermed staging area for sampling and analysis to determine the final disposition of the

material. The soil will be placed in plastic-lined, tarped, roll-off boxes in the bermed staging area. Excavated soil will be sampled to determine whether it should be disposed of as a hazardous waste or a solid waste (see Section 8.2.3.1). If the soils exhibit a characteristic of a hazardous waste, they will be managed in accordance with RCRA Subtitle C regulations and sent to a RCRA-permitted or interim status facility for treatment (if necessary) and disposal. If the analytical results indicate that the soil is not a hazardous waste, it will be disposed of at the YTC Demolition/Inert Waste Landfill.

9.3 Equipment Decontamination

All sampling equipment and hand tools will be decontaminated at a location convenient to the sampling locations. In the event that soil removal is necessary, a staging area will be constructed near the unit and used to decontaminate heavy equipment. The staging area will consist of a compacted earthen foundation surrounded by 1-ft high earthen berms. The foundation and berms will be overlain with a 30-mil thick high density polyethylene liner of sufficient durability to withstand decontamination activities. Sand or similar material may be spread on top of the liner to prevent tearing. The staging area will be sloped toward one corner of the area so that decontamination fluids will collect in a lined catch basin (a plastic-lined 55-gal drum recessed into the earth). The liner will overlap the drum in such a way that the decontamination fluids from the area will feed into the drum through gravity and not to the surrounding soil underneath the liner.

The staging area will be covered with plastic sheeting at the end of each day, when no decontamination activities are in progress, and during precipitation events to prevent accumulation of rainwater in the bermed staging area.

Heavy equipment used for soil removal will be decontaminated by using high-pressure water. The decontamination solutions collected in the catch basin will be removed from the drum via pump and transferred to leakproof DOT-approved shipping containers and placed in the staging area. Decontamination solutions from sampling equipment and heavy equipment will be consolidated on-site. Decontamination solutions and fluids are considered IDW and will be managed according to the procedures described in Section 8.2.3.1.

9.4 **Equipment Decontamination Verification Sampling**

Rinsate (equipment) blank samples are samples of analyte-free (deionized) water that are rinsed over sampling/excavation equipment that are decontaminated in the field for use. These samples will be collected and submitted for nitroglycerin analysis to assess cross-contamination from the sampling equipment. An equipment blank will be performed on sampling and excavation equipment after decontamination at a frequency of one per day.

9.5 **Follow-up Activities**

If soil removal is necessary, the wastes will be removed from the staging area and the sand (if used) and the liner will be placed in a drum and sampled to determine whether they are hazardous waste. If hazardous, the materials will be collected and transported to an off-site permitted Subtitle C facility. If the materials are not hazardous, the sand will be left on-site and the liner will be double-bagged and disposed of in the closure contractor-provided dumpster.

A bound, weatherproof site logbook will be maintained throughout the closure process. This book will contain a summary of each day's activities and will reference the field notebook when applicable. All information related to sampling or field activities, including sampling time, weather conditions, unusual events, field measurements, etc., will be recorded in the field notebook.

10.0 SCHEDULE FOR CLOSURE AND CERTIFICATION

Significant closure milestones include the notification of closure, time allowed for closure activities, and certification of closure.

10.1 Timetable for Closure Activities

This closure plan provides notification of Fort Lewis' intent to begin closure of the UMTU, which is no longer required for treatment of waste energetic materials. However, no closure activities will occur until this closure plan has been approved by WDOE. A schedule of the closure activities is presented in Table 10-1.

Table 10-1
Timetable of Closure Activities

Closure Activity	Cumulative Time (Days) from WDOE Approval of Closure Plan
Secure Subcontract for Soil Sampling	30 – 45
Removal of Surface UXO	45 – 75
Closure Sampling/Post-Closure Sampling	75 – 105
Backfill Area	75 – 105
Submit Closure Certification Report	135 – 180

10.2 Total Time Required to Close the Unit

Final closure of the UMTU is expected to be completed within 180 days of the start date. Should an extension become necessary, Fort Lewis will notify WDOE of the reason for the extension and the revised closure completion date.

10.3 Extension of Closure Time

An extension of the closure period is not anticipated; therefore, a request to extend the closure time is not included in this closure plan.

10.4 **Closure Certification**

Within 60 days following completion of closure of the UMTU, Fort Lewis will submit to WDOE, by registered mail, a certification that the unit has been closed in accordance with the approved closure plan. The certification will be signed by the installation commander or his designee and by an independent professional engineer who is registered in Washington.

11.0 CONTINGENT CLOSURE PLAN

The goal of this closure plan is to demonstrate clean closure of the UMTU. However, if the site is not currently in compliance with the clean up standards, and if excavation to the point of compliance is not feasible, the UMTU will be closed with waste in place and become subject to the post-closure requirements in WAC 173-303-610(7) (Post-closure care and use of property).

11.1 Closure with Waste in Place – Delay of Closure

Under the contingent closure plan the UMTU will be closed with waste in place. “Waste in place” means that waste constituents and/or residues occur at concentrations greater than the risk-based clean closure criteria. Delay of closure, also referred to as an administrative closure, is considered to be a temporary deferral of closure activities. Precedence for administrative closure is being established in Region 9 (Makua Military Reservation) and Region 2 (Fort Dix, New Jersey). In these situations, the cleanup and corrective action activities at the OB/OD units are deferred until the range is closed. At that time, the UMTU closure would be consistent with the cleanup requirements established under the Military Munitions Rule.

11.2 Maintenance and Inspection Requirements During Delay of Closure

As part of the administrative closure of the UMTU, Fort Lewis will request an extension to begin closure of the UMTU based on the facility’s intention to cease activities requiring a permit (i.e., OB/OD of waste munitions) and to continue to use Range 14 for OD activities involving training and emergency response operations. In accordance with WAC 173-303-610(3)(c)(ii), Fort Lewis will demonstrate that steps are being taken to prevent threats to human health and the environment, including compliance with all interim status requirements. Demonstration of compliance will include the following:

- If the concentration of nitroglycerin in all of the samples exceeds the cleanup standard of 71 mg/kg, Fort Lewis may opt to delay closure of the UMTU.
- Only conduct OD of military munitions that do not meet the definition of solid waste set forth in WAC 173-303-578(2)(a) for the purposes of research,

testing, or training, or those carried out during an explosives or munitions emergency response as defined in 40 CFR 260.10;

- Maintain compliance with all applicable interim status requirements of 40 CFR 265 and 270 until the closure and contingent post-closure (if applicable) periods for Range 14 are complete;
- Maintain at the facility, until closure is completed and certified by an independent registered professional engineer registered in the State of Washington, an operating record as required by 40 CFR 265.73(a) and (b)(1) through (6) as well as the following:
 - A description of the types and quantities of materials received for training and emergency responses and the methods and dates of their treatment;
 - Waste Analysis Plan, as required by 40 CFR 265.13;
 - Personnel training documents and records as required by 40 CFR 265.16
 - Contingency Plan as required by 40 CFR 265.53;
 - Closure Plan and Contingent Closure Plan as required by 40 CFR 265.110 and 265.118, respectively; and
 - Inspection schedules and record of facility inspections as required by 40 CFR 265.15; and
- Maintain security at Range 14 during the extension of closure.

11.2.1 Maintenance and Inspection Requirements

The use of the property during the delay of closure will be limited to activities that will not result in endangerment of personnel entering the area or disturbance/damage to the facility's monitoring wells. Fort Lewis must inspect all security devices and monitoring equipment and repair these items as needed. Fort Lewis must also maintain all fences, gates, and monitoring devices as listed in Table 11-1.

**Table 11-1
Inspection and Maintenance Plan for the UMTU**

Area/Equipment	Specific Items	Potential Problems	Corrective Action	Inspection Frequency
Inspections				
Security devices	Facility fence	Broken	Repair immediately if damaged	Quarterly
	Access gate	Locking mechanism jammed	Repair/replace	Quarterly
	Signs	Illegible	Replace	Quarterly
Detection/monitoring equipment	Monitoring wells	Unlocked well caps, damaged casings, protective posts or well pads	Secure well caps; if damage precludes the use of the wall, seal damaged well and install a replacement well	Quarterly

**Table 11-1
(Continued)**

Area/Equipment	Specific Items	Potential Problems	Corrective Action	Inspection Frequency
Inspections				
Benchmarks	N/A	Damage	Replace if damaged	Quarterly
Soil	Re-seeded vegetation	Erosion	Re-seed; implement soil retention measures	Quarterly
Monitoring				
Groundwater Monitoring	MW-1, MW-2, MW-3	Energetic compounds	Evaluate sampling results to determine whether contamination is being released to groundwater	Annually

11.2.2 Monitoring Requirements

The UMTU must be monitored in accordance with the requirements of 40 CFR Part 265, Subpart F (Groundwater Monitoring). The existing monitoring well network, which consists of three (one upgradient and two downgradient) wells, will be used to collect samples on an annual basis and analyze them for energetic compounds using Method 8330 and modified Method 8330 (nitroglycerin and PETN). Elevation of the groundwater surface at each monitoring well must be determined each time a sample is obtained. Fort Lewis must also prepare an outline for a groundwater quality assessment program that describes the methodology that will be used to determine whether the energetics have entered into the groundwater, the rate and extent of migration of the energetics into the groundwater, and the concentrations of the energetics in the groundwater. If any energetics are detected prior to closure of the UMTU, Fort Lewis must, after notifying WDOE that the UMTU may be affecting groundwater quality, implement the groundwater quality assessment plan. Fort Lewis must then continue to make the determinations listed above on a quarterly basis until final closure of the facility. The monitoring requirements are listed in Table 11-1.

11.2.3 Annual Costs for Delay of Closure

The tasks Fort Lewis must continue throughout the delay of closure period are comparable to those required during interim status, including inspection, maintenance, and monitoring costs discussed above. In addition, costs for soil excavation will have already been

incurred when the decision to delay closure is made. Deferral of cleanup would also involve conducting a risk assessment to demonstrate that OB/OD residues will not endanger human health or the environment and implementing long-term security measures to control unit access. Because these costs would continue until final closure of the unit, the total cost for delaying closure of the UMTU is much higher than the costs for clean closure. As such, it is critical that reasonable cleanup levels and disposal options be established for the site. The tasks and estimated costs associated with the delayed closure are listed in Table 11-2.

Table 11-2

Annual Costs Associated with the Delay of Closure

Task	Assumptions	Cost
Conduct groundwater sampling	Use existing monitoring well network; collect 1 sample during each round of sampling; analyze samples for energetics only	\$ 5,350
Complete annual reporting requirements	Groundwater monitoring and quality assessment reports prepared annually by contractor personnel; copies provided to WDOE annually.	\$ 2,400
Conduct and document routine inspections; update plans as necessary	Quarterly inspections performed by Fort Lewis/YTC personnel reports and plans updated quarterly	\$ 1,000
Miscellaneous repairs		\$ 1,200
	TOTAL	\$ 9,950

11.3 Closure of Range 14

In accordance with 40 CFR 265.112(d), Fort Lewis will notify WDOE at least 60 days prior to the date on which closure is expected to begin. At that time, Fort Lewis will submit a revised closure plan describing the closure procedures for Range 14, including the UMTU. The closure plan will include site characterization and investigative techniques, data analysis, a human health and ecological risk assessment, a description of how the range will be closed in accordance with the closure performance standard, a detailed description of the steps needed to remove or decontaminate hazardous waste residues and contaminated soils, a closure schedule, and a contingent closure plan/post-closure plan if clean closure is the goal. Fort Lewis will begin closure of Range 14 once WDOE approves the closure plan.

11.4 **Certification of Closure**

Within 60 days after the completion of closure of Range 14, Fort Lewis will provide WDOE, by registered mail, a certification by an independent professional engineer who is registered in Washington that the unit has been closed in accordance with the contingent closure plan. The certification will be signed by both the registered professional engineer and the Installation Commander or his designee.

11.5 **Contingent Closure Schedule**

When circumstances dictate that Range 14 must close, Fort Lewis will provide a formal intent to begin final closure to WDOE through written notification submitted by certified mail. The contingent closure plan involves the delay of closure of the UMTU until Range 14 is closed. Fort Lewis currently has no plans to close Range 14; therefore, the contingent closure schedule (estimated year of closure for Range 14) cannot be provided at this time.

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12.0

CLOSURE COST ESTIMATE

The UMTU is located at a federal government facility, operated by Fort Lewis for the U.S. Army and DoD. As such, it is exempt from the requirements for closure cost estimates.

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13.0**FINANCIAL ASSURANCE MECHANISM**

In accordance with 40 CFR 264.143, "Financial Assurance for Closure," federal facilities are exempt from the requirements for financial assurance. Therefore, this section is not applicable.

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Attachment A-1
SITE CHARACTERIZATION RESULTS

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Groundwater Data

Results in ug/L

Method	Average			MONITORING WELL 2								
	Maximum Bkgd Conc	Maximum POC Conc	POC Conc	Oct-94	Jan-95	Apr-95	Jul-95	Mar-96	Sep-96	Jun-97	Jun-98	Sep-00
Explosives (8330)												
HMX	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-trinitrobenzene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-dinitrobenzene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
nitrobenzene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
tetryl	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
amino-DNTs	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4,6-trinitrotoluene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,6 dinitrotoluene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4-dinitrotoluene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
nitroglycerine	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
PETN	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
Inorganic Compounds												
Alkalinity	110	84	79.60	78	76	78	78	78	80	78	76	77
Ammonia	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloride	9.8	4	3.42	3.8	3.8	3.6	3.5	4	3.4	3.8	NA	NA
Cyanide, Total	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nitrate/Nitrite, as N	3.6	0.9	0.77	0.8	0.9	0.8	0.8	0.8	0.82	0.85	0.84	0.77
Phosphorous, Total	0.19	0.2	0.09	0.09	0.09	0.08	0.14	ND	0.1	0.069	0.065	0.2
Solids, Total Dissolved	200	160	144.00	137	151	128	136	140	160	140	140	160
Sulfate	13	6.9	6.07	6.9	6.2	6.3	6.3	6.1	5.3	6.6	6.6	6.5
Sulfide	0	2	2.00	ND	ND	ND	ND	ND	ND	ND	NA	NA
Total Organic Carbon	4.3	3.1	1.80	ND	ND	ND	ND	ND	3.1	ND	NA	NA
Dissolved Metals (6000/7000)												
Antimony	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	NA	NA
Arsenic	0.98	0.71	0.58	ND	ND	ND	ND	ND	ND	ND	ND	0.44
Barium	0	6	4.40	6	6	5	ND	ND	5	ND	ND	2.7
Beryllium	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	NA	NA
Cadmium	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	24000	19000	14680.00	15000	14600	14300	14500	15000	15000	14000	NA	NA
Chromium	2.9	6.8	5.48	ND	ND	ND	ND	ND	ND	ND	ND	6.2
Cobalt	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	NA	NA
Copper	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	NA	NA
Lead	0	0.056	0.04	ND	ND	ND	ND	ND	ND	ND	ND	0.018
Mercury	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	NA	NA
Potassium	2600	3600	2753.33	3000	2200	2500	3200	2500	2600	2400	NA	NA
Selenium	1.4	1.3	1.13	ND	ND	ND	ND	ND	ND	ND	ND	0.96
Silicon	21200	27200	25653.33	26100	26000	25900	25300	26700	27200	26900	NA	NA
Silver	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	15000	13000	9434.00	9870	9310	9320	9440	8800	9200	8600	NA	NA
Thallium	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	NA	NA
Tin	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	NA	NA
Vanadium	11	24	21.53	21	20	24	22	21	23	19	NA	NA
Zinc	12	15	12.00	10	12	11	ND	ND	15	ND	NA	NA

Results in ug/L

Method	MONITORING WELL 3											
	Maximum Bkgd Conc	Maximum POC Conc	Average POC Conc	Oct-94	Jan-95	Apr-95	Jul-95	Mar-96	Sep-96	Jun-97	Jun-98	Sep-00
Explosives (8330)												
HMX	0	0	0.00	ND								
RDX	0	0	0.00	ND								
1,3,5-trinitrobenzene	0	0	0.00	ND								
1,3-dinitrobenzene	0	0	0.00	ND								
nitrobenzene	0	0	0.00	ND								
tetryl	0	0	0.00	ND								
amino-DNTs	0	0	0.00	ND								
2,4,6-trinitrotoluene	0	0	0.00	ND								
2,6 dinitrotoluene	0	0	0.00	ND								
2,4-dinitrotoluene	0	0	0.00	ND								
nitroglycerine	0	0	0.00	ND								
PETN	0	0	0.00	ND								
Inorganic Compounds												
Alkalinity	110	84	79.60	98	98	104	104	100	100	100	98	91
Ammonia	0	0	0.00	ND								
Chloride	9.8	4	3.42	7.1	7.7	8.4	8.7	9.8	7.8	8.6	NA	NA
Cyanide, Total	0	0	0.00	ND								
Nitrate/Nitrite, as N	3.6	0.9	0.77	1.7	1.8	0.9	1.3	2.4	3.6	2.3	1.3	1.3
Phosphorous, Total	0.19	0.2	0.09	0.07	0.08	0.04	0.07	ND	ND	0.058	0.065	0.18
Solids, Total Dissolved	200	160	144.00	160	175	144	179	180	190	170	170	200
Sulfate	13	6.9	6.07	11	12	12	13	12.3	11.8	13	11	12
Sulfide	0	2	2.00	ND	NA	NA						
Total Organic Carbon	4.3	3.1	1.80	0.7	1	1	1.1	ND	2.3	ND	NA	NA
Dissolved Metals (6000/7000)												
Antimony	0	0	0.00	ND	NA	NA						
Arsenic	0.98	0.71	0.58	ND	0.98							
Barium	0	6	4.40	ND								
Beryllium	0	0	0.00	ND	NA	NA						
Cadmium	0	0	0.00	ND								
Calcium	24000	19000	14680.00	18100	19300	19500	20600	21000	22000	19000	NA	NA
Chromium	2.9	6.8	5.48	ND	2.9							
Cobalt	0	0	0.00	ND	NA	NA						
Copper	0	0	0.00	ND	NA	NA						
Lead	0	0.056	0.04	ND								
Mercury	0	0	0.00	ND								
Nickel	0	0	0.00	ND	NA	NA						
Potassium	2600	3600	2753.33	ND	ND	ND	2600	ND	ND	ND	NA	NA
Selenium	1.4	1.3	1.13	ND	1.4							
Silicon	21200	27200	25653.33	16700	18800	18500	18500	20300	21100	19500	NA	NA
Silver	0	0	0.00	ND								
Sodium	15000	13000	9434.00	15000	14000	14200	14500	14000	14000	13000	NA	NA
Thallium	0	0	0.00	ND	NA	NA						
Tin	0	0	0.00	ND	NA	NA						
Vanadium	11	24	21.53	ND	ND	ND	ND	ND	11	ND	NA	NA
Zinc	12	15	12.00	ND	ND	ND	ND	12	ND	ND	NA	NA

Results in ug/L

Method	Maximum Bkgd Conc	Maximum POC Conc	Average POC Conc	MONITORING WELL - DUP										
				Oct-94 MW-3	Jan-95 MW-3	Apr-95 MW-3	Jul-95 MW-3	Mar-96 MW-3	Sep-96 MW-3	Jun-97 MW-1	Jun-98 MW-1	Sep-00 MW-3		
Pest/PCBs/Herbicides														
Gamma-BHC	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Endrin	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Methoxychlor	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Toxaphene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
2,4-D	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
2,4,5-TP	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Volatile Organics (8260)				MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-3	MW-1	MW-1	MW-3	
Ethylbenzene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Total xylenes	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Styrene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Bromoform	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
1,1,2,2-tetrachloroethane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
1,2,3-trichloropropane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
1,3-dichlorobenzene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
1,4-dichlorobenzene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
1,2-dichlorobenzene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
DBCP	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Naphthalene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Hexachlorobutadiene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Acetonitrile	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Acrolein	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Acrylonitrile	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Chloroprene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
Allyl chloride	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
1,4-dichloro-2-butene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
1,4-dioxane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
ethyl methacrylate	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
iodomethane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
isobutyl alcohol	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
methacrylonitrile	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
methyl methacrylate	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
propionitrile	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
vinyl acetate	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
dichlorodifluoromethane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
chloromethane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
vinyl chloride	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
bromomethane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
chloroethane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
trichlorofluoromethane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
acetone	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
1,1-dichloroethene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
carbon disulfide	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
methylene chloride	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
trans-1,2-dichloroethene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
1,1-dichloroethane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
2-butanone	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
chloroform	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
1,1,1-trichloroethane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
carbon tetrachloride	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
1,2-dichloroethane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
benzene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
trichloroethene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
1,2-dichloropropane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
bromodichloromethane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
dibromomethane	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
2-hexanone	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
cis-1,3-dichloropropene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
toluene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
trans-1,3-dichloropropene	0	0	0.00	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA

Soil Data

mg/kg										
	Sample Number	Sample Depth	HMX	RDX	1,3,5-trinitrobenzene	1,3-dinitrobenzene	Tetryl	Nitrobenzene	2,4,6-trinitrotoluene	2,6-dinitrotoluene
PHASE II INVESTIGATION										
# 2	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND	ND
	B	2' - 4'	ND	ND	ND	ND	ND	ND	ND	ND
	C	7' - 8.2'	ND	ND	ND	ND	ND	ND	ND	ND
	D	12.2' - 14.8'	ND	ND	ND	ND	ND	ND	ND	ND
	E	19' - 20'	ND	ND	ND	ND	ND	ND	ND	ND
# 3	A	6.6' - 7.1'	ND	ND	ND	ND	ND	ND	ND	ND
	B	7.1' - 8.6'	ND	ND	ND	ND	ND	ND	ND	ND
	C	8.6' - 10'	ND	ND	ND	ND	ND	ND	ND	ND
	D	11' - 13.4'	ND	ND	ND	ND	ND	ND	ND	ND
	E	13.4' - 16.6'	ND	ND	ND	ND	ND	ND	ND	ND
# 4	A	0' - .5'	ND	ND	ND	ND	ND	ND	ND	ND
	B	2' - 4'	ND	ND	ND	ND	ND	ND	ND	ND
	C	6' - 9'	ND	ND	ND	ND	ND	ND	ND	ND
	D	12' - 15'	ND	ND	ND	ND	ND	ND	ND	ND
	E	17' - 20'	ND	ND	ND	ND	ND	ND	ND	ND
# 5	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND	ND
	B	.5' - 2'	ND	ND	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND	ND	ND
	D	4' - 6.4'	ND	ND	ND	ND	ND	ND	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA	NA
# 6	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND	ND
	B	.5' - 2'	ND	ND	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND	ND	ND
	D	4' - 7.3'	ND	ND	ND	ND	ND	ND	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA	NA
# 7	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND	ND
	B	.5' - 2'	ND	ND	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND	ND	ND
	D	4' - 7.5'	ND	ND	ND	ND	ND	ND	ND	ND
	E	7.5' - 9'	ND	ND	ND	ND	ND	ND	ND	ND
# 8	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND	ND
	B	2' - 4'	ND	ND	ND	ND	ND	ND	ND	ND
	C	6' - 9'	ND	ND	ND	ND	ND	ND	ND	ND
	D	12' - 15'	ND	ND	ND	ND	ND	ND	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA	NA
# 9	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND	ND
	B	.5' - 2'	ND	ND	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND	ND	ND
	D	4' - 7.1'	ND	ND	ND	ND	ND	ND	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA	NA
OD Craters										
	C3A	0 - .5'	ND	ND	ND	ND	ND	ND	ND	ND
	C3B	0 - .5'	ND	ND	ND	ND	ND	ND	ND	ND
	C3C	0 - .5'	ND	ND	ND	ND	ND	ND	ND	ND
	C4A	0 - .5'	ND	ND	ND	ND	ND	ND	ND	ND
	C4B	0 - .5'	ND	ND	ND	ND	ND	ND	ND	ND
	C4C	0 - .5'	ND	ND	ND	ND	ND	ND	ND	ND
Beneath the OD craters										
	3-A	6.6' - 7.1'	ND	ND	ND	ND	ND	ND	ND	ND
	3-B	7.1' - 8.6'	ND	ND	ND	ND	ND	ND	ND	ND
	3-C	8.6' - 10'	ND	ND	ND	ND	ND	ND	ND	ND
	3-D	11' - 13.4'	ND	ND	ND	ND	ND	ND	ND	ND
	3-E	13.4' - 16.6'	ND	ND	ND	ND	ND	ND	ND	ND
Maximum Phase II Site Sample Concentration										
Average Phase II Site Sample Concentration										

mg/kg									
	Sample Number	Sample Depth	o-nitrotoluene	m-nitrotoluene	p-nitrotoluene	2-amino-dinitrotoluene	4-amino-dinitrotoluene	nitroglycerin	PETN
<i>PHASE I INVESTIGATION</i>									
Transects									
#1	1A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	1B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	2A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	2B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	3A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	3B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	4A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	4B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
#2	1A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	1B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	2A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	2B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	3A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	3B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	4A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	4B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
#3	1A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	1B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	2A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	2B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	3A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	3B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	4A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	4B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
#4	1A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	1B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	2A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	2B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	3A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	3B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	4A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	4B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
OD Crater									
	C1A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	C1B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	C2A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	C2B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
OB Area									
	B1	0 - 6"	ND	ND	ND	ND	ND	ND	ND

mg/kg									
	Sample Number	Sample Depth	o-nitrotoluene	m-nitrotoluene	p-nitrotoluene	2-amino-dinitrotoluene	4-amino-dinitrotoluene	nitroglycerin	PETN
Watercourse									
	W-1	1 - 4"	ND	ND	ND	ND	ND	ND	ND
	W-1 DUP	1 - 4"	ND	ND	ND	ND	ND	ND	ND
	W-2	1 - 4"	ND	ND	ND	ND	ND	ND	ND
	W-2 DUP	1 - 4"	ND	ND	ND	ND	ND	ND	ND
	W-3	1 - 4"	ND	ND	ND	ND	ND	ND	ND
	W-4	1 - 4"	ND	ND	ND	ND	ND	ND	ND
	W-5	1 - 4"	ND	ND	ND	ND	ND	ND	ND
	W-6	1 - 4"	ND	ND	ND	ND	ND	ND	ND
	W-7	1 - 4"	ND	ND	ND	ND	ND	ND	ND
	W-8	1 - 4"	ND	ND	ND	ND	ND	ND	ND
	W-9	1 - 4"	ND	ND	ND	ND	ND	ND	ND
	W-10	1 - 4"	ND	ND	ND	ND	ND	ND	ND
Maximum Phase I Site Sample Concentration									
			0	0	0	0	0	0	0
Average Phase I Site Sample Concentration									
Background									
	G1A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	G1B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	G2A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	G2B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
	G3A	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	G3B	6 - 24"	ND	ND	ND	ND	ND	ND	ND
Maximum Phase I Background Concentration									
			0	0	0	0	0	0	0

mg/kg									
	Sample Number	Sample Depth	o-nitrotoluene	m-nitrotoluene	p-nitrotoluene	2-amino-dinitrotoluene	4-amino-dinitrotoluene	nitroglycerin	PETN
PHASE II INVESTIGATION									
# 2	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND
	B	2' - 4'	ND	ND	ND	ND	ND	ND	ND
	C	7' - 8.2'	ND	ND	ND	ND	ND	ND	ND
	D	12.2' - 14.8'	ND	ND	ND	ND	ND	ND	ND
	E	19' - 20'	ND	ND	ND	ND	ND	ND	ND
# 3	A	6.6' - 7.1'	ND	ND	ND	ND	ND	ND	ND
	B	7.1' - 8.6'	ND	ND	ND	ND	ND	ND	ND
	C	8.6' - 10'	ND	ND	ND	ND	ND	ND	ND
	D	11' - 13.4'	ND	ND	ND	ND	ND	ND	ND
	E	13.4' - 16.6'	ND	ND	ND	ND	ND	ND	ND
# 4	A	0' - .5'	ND	ND	ND	ND	ND	ND	ND
	B	2' - 4'	ND	ND	ND	ND	ND	ND	ND
	C	6' - 9'	ND	ND	ND	ND	ND	ND	ND
	D	12' - 15'	ND	ND	ND	ND	ND	ND	ND
	E	17' - 20'	ND	ND	ND	ND	ND	ND	ND
# 5	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND
	B	.5' - 2'	ND	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND	ND
	D	4' - 6.4'	ND	ND	ND	ND	ND	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA
# 6	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND
	B	.5' - 2'	ND	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND	ND
	D	4' - 7.3'	ND	ND	ND	ND	ND	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA
# 7	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND
	B	.5' - 2'	ND	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND	ND
	D	4' - 7.5'	ND	ND	ND	ND	ND	ND	ND
	E	7.5' - 9'	ND	ND	ND	ND	ND	ND	ND
# 8	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND
	B	2' - 4'	ND	ND	ND	ND	ND	ND	ND
	C	6' - 9'	ND	ND	ND	ND	ND	ND	ND
	D	12' - 15'	ND	ND	ND	ND	ND	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA
# 9	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND
	B	.5' - 2'	ND	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND	ND
	D	4' - 7.1'	ND	ND	ND	ND	ND	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA
OD Craters									
	C3A	0 - .5'	ND	ND	ND	ND	ND	ND	ND
	C3B	0 - .5'	ND	ND	ND	ND	ND	ND	ND
	C3C	0 - .5'	ND	ND	ND	ND	ND	ND	ND
	C4A	0 - .5'	ND	ND	ND	ND	ND	ND	ND
	C4B	0 - .5'	ND	ND	ND	ND	ND	ND	ND
	C4C	0 - .5'	ND	ND	ND	ND	ND	ND	ND
Beneath the OD craters									
	3-A	6.6' - 7.1'	ND	ND	ND	ND	ND	ND	ND
	3-B	7.1' - 8.6'	ND	ND	ND	ND	ND	ND	ND
	3-C	8.6' - 10'	ND	ND	ND	ND	ND	ND	ND
	3-D	11' - 13.4'	ND	ND	ND	ND	ND	ND	ND
	3-E	13.4' - 16.6'	ND	ND	ND	ND	ND	ND	ND
Maximum Phase II Site Sample Concentration									
Average Phase II Site Sample Concentration									

mg/kg									
	Sample Number	Sample Depth	o-nitrotoluene	m-nitrotoluene	p-nitrotoluene	2-amino-dinitrotoluene	4-amino-dinitrotoluene	nitroglycerin	PETN
# 11	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND
(Background)	B	.5' - 2'	ND	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND	ND
	D	4' - 6.1'	ND	ND	ND	ND	ND	ND	ND
	E	NO SAMPLE	NA	NA	NA	NA	NA	NA	NA
# 12	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND
(Background)	B	.5' - 2'	ND	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND	ND
	D	NO SAMPLE	NA	NA	NA	NA	NA	NA	NA
	E	NO SAMPLE	NA	NA	NA	NA	NA	NA	NA
# 13	A	0 - .5'	ND	ND	ND	ND	ND	ND	ND
(Background)	B	.5' - 2'	ND	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND	ND
	D	4' - 6'	ND	ND	ND	ND	ND	ND	ND
	E	NO SAMPLE	NA	NA	NA	NA	NA	NA	NA
Maximum Phase II Background Concentration			0	0	0	0	0	0	0
September 2000 Sampling									
	HS01	0 - 6"	ND	ND	ND	ND	ND	0.4	ND
	HS02	0 - 6"	ND	ND	ND	ND	ND	230	ND
	HS03	0 - 6"	ND	ND	ND	ND	ND	0.25	ND
	HS04	0 - 6"	ND	ND	ND	ND	ND	9	ND
	HS05	0 - 6"	ND	ND	ND	ND	ND	0.21	ND
	HS06	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	HS07	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	HS08	0 - 6"	ND	ND	ND	ND	ND	1.6	ND
	HS09	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	HS10	0 - 6"	ND	ND	ND	0.024	ND	0.33	ND
	HS11	0 - 6"	ND	ND	ND	ND	ND	0.64	ND
	HS12	0 - 6"	ND	ND	ND	ND	ND	ND	ND
	HS13	0 - 6"	ND	ND	ND	ND	ND	ND	ND
Maximum September 2000 Site Sample Concentration			0	0	0	0.024	0	230	0
Average September 2000 Site Sample Concentration						0.024		30.30375	
MAXIMUM SITE SOIL CONCENTRATION - ALL PHASES			0	0	0	0.024	0	230	0
AVERAGE SITE SOIL CONCENTRATION - ALL PHASES						0.024		30.30375	
natural background study									
MAXIMUM BACKGROUND CONCENTRATION - PHASE I and II ONLY			0	0	0	0	0	0	0

mg/kg												
	Sample Number	Sample Depth	NO2/NO3	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium
<i>PHASE I INVESTIGATION</i>												
Transects												
#1	1A	0 - 6"	1	ND	1.7	150	0.59	ND		17	5.8	ND
	1B	6 - 24"	ND	ND	2.3	150	0.66	ND		19	6.9	ND
	2A	0 - 6"	2	ND	1.5	140	ND	ND		14	7.4	ND
	2B	6 - 24"	5.7	ND	2	150	0.58	ND		16	6.9	ND
	3A	0 - 6"	3.5	ND	1.7	140	0.53	ND		15	5.6	ND
	3B	6 - 24"	1.5	ND	3.1	150	0.63	ND		18	7.8	ND
	4A	0 - 6"	8.8	ND	2	140	0.55		0.4	18	6.6	ND
	4B	6 - 24"	2	ND	2.3	140	0.61	ND		19	7.9	ND
#2	1A	0 - 6"	6.2	ND	1.7	146	0.554	ND		14.1	7.7	ND
	1B	6 - 24"	2.7	ND	2.3	150	0.58		0.54	13	9.2	ND
	2A	0 - 6"	3.8	ND	3	150	0.67	ND		18	7.6	ND
	2B	6 - 24"	2.5	ND	2.7	160	0.69	ND		16	8.7	ND
	3A	0 - 6"	1.6	ND	2.2	160	0.62	ND		14	7.5	ND
	3B	6 - 24"	ND	ND	3.1	160	0.67	ND		17	9.4	ND
	4A	0 - 6"	1.3	ND	2	140	0.54		0.61	14	10	ND
	4B	6 - 24"	1	ND	2.2	160	0.66	ND		17	6.9	ND
	4A-DUP	0 - 6"	1.3	ND	2.3	150	0.57		0.61	16	10	ND
	4B-DUP	6 - 24"	4.5	ND	2.2	160	0.64	ND		17	7.4	ND
#3	1A	0 - 6"	1.6	ND	1.9	149	0.557	ND		12.4	9.07	ND
	1B	6 - 24"	0.55	ND	2.2	150	0.67	ND		15	9.7	ND
	2A	0 - 6"	6.6	ND	ND	150	0.51		0.25	14	10	ND
	2B	6 - 24"	0.59	ND	5	170	0.6	ND		16	8.5	ND
	3A	0 - 6"	4.9	ND	3.9	170	0.57	ND		16	9.2	ND
	3B	6 - 24"	0.85	ND	5.7	160	0.62	ND		17	9.6	ND
	4A	0 - 6"	2.9	ND	3.9	160	0.53		0.62	15	15	ND
	4B	6 - 24"	1.4	ND	4.3	170	0.65	ND		18	9.6	ND
	4A-DUP	0 - 6"	1.4	ND	4	160	0.53		0.64	15	14	ND
	4B-DUP	6 - 24"	1.4	ND	5.5	160	0.61	ND		18	10	ND
#4	1A	0 - 6"	1.6	ND	3.9	149	0.554	ND		13.1	8.72	ND
	1B	6 - 24"	ND	ND	6.3	140	0.58	ND		16	9.7	ND
	2A	0 - 6"	2	ND	5.1	170	0.57		0.26	16	10	ND
	2B	6 - 24"	0.8	ND	6.6	160	0.6	ND		17	9.1	ND
	3A	0 - 6"	1.1	ND	5.5	160	0.55		0.31	15	9.4	ND
	3B	6 - 24"	ND	ND	4.5	170	0.65	ND		18	9.9	ND
	4A	0 - 6"	3.5	ND	5.7	160	0.54	ND		16	13	ND
	4B	6 - 24"	1.2	ND	6.6	170	0.63	ND		20	11	ND
OD Crater												
	C1A	0 - 6"	1.1	ND	8	170	0.59		0.4	15	7.3	ND
	C1B	6 - 24"	5.1	ND	3.2	143	0.519		0.42	13.9	9.29	ND
	C2A	0 - 6"	4.6	ND	6.7	180	0.67		0.27	18	19	ND
	C2B	6 - 24"	0.62	ND	3.3	180	0.57		0.3	15	34	ND
OB Area												
	B1	0 - 6"	8.3	ND	ND	140	ND		1	14	86	ND

mg/kg												
	Sample Number	Sample Depth	NO2/NO3	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium
Watercourse												
	W-1	1 - 4"	2.1	ND	1.5	180	0.56	ND	14	9.8	ND	1.2
	W-1 DUP	1 - 4"	1.4	ND	ND	220	0.57	ND	12	9	ND	ND
	W-2	1 - 4"	46	ND	2.5	155	0.561	0.52	12.6	9.67	ND	1.1
	W-2 DUP	1 - 4"	45	ND	3.6	140	0.55	0.37	14	11	ND	0.79
	W-3	1 - 4"	3.2	ND	1.4	150	0.53	0.57	13	9.5	ND	0.94
	W-4	1 - 4"	5.8	ND	1.4	160	0.54	0.85	16	11	ND	1.1
	W-5	1 - 4"	6.4	ND	1.5	170	0.5	0.43	14	10	ND	0.54
	W-6	1 - 4"	1	ND	1.2	130	ND	ND	12	9.2	ND	0.9
	W-7	1 - 4"	6.3	ND	1.3	170	ND	0.31	12	9.2	ND	0.84
	W-8	1 - 4"	0.95	ND	0.74	180	0.58	ND	13	8.2	ND	1.1
	W-9	1 - 4"	4.4	ND	3.6	143	0.543	ND	14.1	8.31	ND	0.89
	W-10	1 - 4"	2.3	ND	2.3	120	ND	0.91	7.8	9.7	ND	1.2
Maximum Phase I Site Sample Concentration												
			46	0	8	220	0.69	1	20	86	0	2.8
Average Phase I Site Sample Concentration												
			4.6195918		3.2628	156.698	0.586417	0.504286	15.283019	11.23		1.373939
Background												
	G1A	0 - 6"	0.62	ND	2.1	110	ND	ND	21	8.1	ND	1.3
	G1B	6 - 24"	ND	ND	3.1	160	0.55	ND	15	8.8	ND	1.4
	G2A	0 - 6"	0.82	ND	1.6	110	ND	ND	14	8.9	ND	1.1
	G2B	6 - 24"	ND	ND	2	140	0.6	ND	17	9.9	ND	0.79
	G3A	0 - 6"	0.47	ND	1.7	130	ND	ND	13	10	ND	1.2
	G3B	6 - 24"	ND	ND	1.5	140	0.59	ND	15	8.9	ND	0.78
Maximum Phase I Background Concentration												
			0.82	0	3.1	160	0.6	0	21	10	0	1.4

mg/kg												
	Sample Number	Sample Depth	NO2/NO3	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium
PHASE II INVESTIGATION												
# 2	A	0 - 5'	ND	16000	1	140	0.5	ND		14	10	ND
	B	2' - 4'	ND	20000	2	180	0.8	ND		19	ND	ND
	C	7' - 8.2'	ND	24000	2	210	1.4	ND		23	ND	ND
	D	12.2' - 14.8	ND	25000	4	160	1.5	ND		19	ND	ND
	E	19' - 20'	ND	24000	2	170	1.2	ND		17	ND	ND
# 3	A	6.6' - 7.1'	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	B	7.1' - 8.6'	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	C	8.6' - 10'	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	D	11' - 13.4'	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	E	13.4' - 16.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
# 4	A	0' - .5'	ND	20000	3	160	0.6	0.8		19	20	ND
	B	2' - 4'	ND	19000	4	180	0.8	ND		24	11	ND
	C	6' - 9'	ND	17000	1.6	150	1.1	ND		21	ND	ND
	D	12' - 15'	ND	13000	ND	110	1.1	ND		10	ND	ND
	E	17' - 20'	ND	19000	3.3	88	1.1	ND		15	ND	ND
# 5	A	0 - 5'	ND	18000	2	180	0.7	ND		17	12	ND
	B	.5' - 2'	ND	20000	3.6	180	0.8	ND		20	11	ND
	C	2' - 4'	ND	18000	3.8	300	0.9	ND		20	ND	ND
	D	4' - 6.4'	ND	16000	1.1	160	0.7	ND		17	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
# 6	A	0 - 5'	ND	17000	2.3	170	0.6	0.41		15	17	ND
	B	.5' - 2'	ND	19000	2.1	180	0.7	ND		18	ND	ND
	C	2' - 4'	ND	22000	3.6	170	0.8	ND		27	ND	ND
	D	4' - 7.3'	ND	18000	ND	190	0.9	ND		20	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
# 7	A	0 - 5'	ND	15000	2.1	160	0.6	ND		15	ND	ND
	B	.5' - 2'	ND	19000	4.2	170	0.7	ND		18	ND	ND
	C	2' - 4'	ND	18000	4.4	170	0.7	ND		24	ND	ND
	D	4' - 7.5'	ND	17000	1.8	260	0.9	ND		22	ND	ND
	E	7.5' - 9'	ND	11000	1.4	160	0.7	ND		17	ND	ND
# 8	A	0 - 5'	ND	17000	2.9	170	0.6	0.45		16	ND	ND
	B	2' - 4'	ND	18000	4.9	170	0.8	ND		27	ND	ND
	C	6' - 9'	ND	23000	ND	160	1.4	ND		25	ND	ND
	D	12' - 15'	ND	14000	1.5	150	1.2	ND		16	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
# 9	A	0 - 5'	ND	16000	2.6	160	0.6	ND		16	ND	ND
	B	.5' - 2'	ND	20000	4.1	160	0.8	ND		23	10	ND
	C	2' - 4'	ND	20000	2.3	150	0.8	ND		25	ND	ND
	D	4' - 7.1'	ND	13000	2.2	160	0.7	ND		16	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OD Craters												
	C3A	0 - 5'	ND	20000	2	180	0.8	ND		18	ND	ND
	C3B	0 - 5'	ND	19000	4	210	0.8	ND		17	ND	ND
	C3C	0 - 5'	ND	19000	2	170	0.7	ND		16	11	ND
	C4A	0 - 5'	ND	23000	4	180	0.8	ND		27	11	ND
	C4B	0 - 5'	ND	21000	3	190	0.8	ND		26	13	ND
	C4C	0 - 5'	ND	20000	2	170	0.7	2		21	56	ND
Beneath the OD craters												
	3-A	6.6' - 7.1'	ND	17000	4	220	1.2	ND		15	ND	ND
	3-B	7.1' - 8.6'	ND	35000	4	160	2.1	ND		26	ND	ND
	3-C	8.6' - 10'	ND	20000	7	190	1.4	ND		15	ND	ND
	3-D	11' - 13.4'	ND	24000	3	150	1.5	ND		24	ND	ND
	3-E	13.4' - 16.6	ND	24000	4	140	1.5	ND		23	ND	ND
Maximum Phase II Site Sample Concentration												
				35000	7	300	2.1	2	27	56		
Average Phase II Site Sample Concentration												
				19238.095	2.94359	172.333	0.928571	0.915	19.595238	16.55		

mg/kg												
	Sample Number	Sample Depth	NO2/NO3	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Selenium
# 11	A	0 - .5'	ND	15000	ND	140	0.6	ND	15	ND	ND	ND
(Background)	B	.5' - 2'	ND	20000	3.7	220	0.8	ND	20	ND	ND	ND
	C	2' - 4'	ND	17000	3.2	190	0.9	ND	17	ND	ND	ND
	D	4' - 6.1'	ND	12000	2.3	150	0.8	ND	15	ND	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
# 12	A	0 - .5'	ND	13000	2.8	170	0.6	ND	11	ND	ND	ND
(Background)	B	.5' - 2'	ND	17000	2.1	240	0.8	ND	15	ND	ND	ND
	C	2' - 4'	ND	11000	2.2	170	0.7	ND	15	ND	ND	ND
	D	NO SAMPL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
# 13	A	0 - .5'	ND	19000	2	160	0.6	ND	18	ND	ND	ND
(Background)	B	.5' - 2'	ND	18000	2.6	170	0.8	ND	18	ND	ND	ND
	C	2' - 4'	ND	19000	4.4	220	0.8	ND	19	13	ND	ND
	D	4' - 6'	ND	10000	1.4	160	ND	ND	7	ND	ND	ND
	E	NO SAMPL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Maximum Phase II Background Concentration			0	20000	4.4	240	0.9	0	20	13	0	0
September 2000 Sampling												
	HS01	0 - 6"	ND	ND	4.1	120	ND	3.3	20	9	ND	ND
	HS02	0 - 6"	ND	ND	3.8	150	ND	3.8	23	14	0.048	ND
	HS03	0 - 6"	ND	ND	3.5	160	ND	4.3	17	16	ND	ND
	HS04	0 - 6"	ND	ND	3.2	140	ND	3.1	19	9.3	ND	ND
	HS05	0 - 6"	ND	ND	3.9	140	ND	3.4	20	9	ND	ND
	HS06	0 - 6"	ND	ND	4.1	140	ND	3.2	18	8.5	ND	ND
	HS07	0 - 6"	ND	ND	4.2	150	ND	4	19	8	ND	ND
	HS08	0 - 6"	ND	ND	4.3	160	ND	3.2	21	8.9	ND	ND
	HS09	0 - 6"	ND	ND	2.8	150	ND	5.2	13	6.2	ND	ND
	HS10	0 - 6"	ND	ND	3	140	ND	4.7	14	40	0.074	ND
	HS11	0 - 6"	ND	ND	3.6	160	ND	5.2	20	12	0.044	ND
	HS12	0 - 6"	ND	ND	3.9	140	ND	3.1	20	8.4	ND	ND
	HS13	0 - 6"	ND	ND	4.2	150	ND	3.1	20	8.9	ND	ND
Maximum September 2000 Site Sample Concentration			0	0	4.3	160	0	5.2	23	40	0.074	0
Average September 2000 Site Sample Concentration					3.73846	146.154		3.815385	18.769231	12.17	0.055333	
MAXIMUM SITE SOIL CONCENTRATION - ALL PHASES			46	35000	8	300	2.1	5.2	27	86	0.074	2.8
AVERAGE SITE SOIL CONCENTRATION - ALL PHASES			4.6195918	19238.095	3.20137	161.509	0.746089	1.680263	17.37963	12.14	0.055333	1.373939
natural background study				37200	7		2	1	42	17	0.07	
MAXIMUM BACKGROUND CONCENTRATION - PHASE I and II ONLY			0.82	20000	4.4	240	0.9	0	21	13	0	1.4

mg/kg								
	Sample Number	Sample Depth	2,4-DNT	n-nitrosodiphenylamine	di-n-butylphthalate	Nitro cellulose	methylene chloride	p-isopropyltoluene
<i>PHASE I INVESTIGATION</i>								
Transects								
#1	1A	0 - 6"	ND	ND	ND	ND	ND	ND
	1B	6 - 24"	ND	ND	ND	ND	ND	ND
	2A	0 - 6"	ND	ND	ND	ND	ND	ND
	2B	6 - 24"	ND	ND	ND	ND	ND	ND
	3A	0 - 6"	ND	ND	ND	ND	ND	ND
	3B	6 - 24"	ND	ND	ND	ND	ND	ND
	4A	0 - 6"	ND	ND	ND	ND	ND	ND
	4B	6 - 24"	ND	ND	ND	ND	ND	ND
#2	1A	0 - 6"	ND	ND	ND	ND	ND	ND
	1B	6 - 24"	ND	ND	ND	ND	ND	ND
	2A	0 - 6"	ND	ND	ND	ND	ND	ND
	2B	6 - 24"	ND	ND	ND	ND	ND	ND
	3A	0 - 6"	ND	ND	ND	ND	ND	ND
	3B	6 - 24"	ND	ND	ND	ND	ND	ND
	4A	0 - 6"	ND	ND	ND	ND	ND	ND
	4B	6 - 24"	ND	ND	ND	ND	ND	ND
	4A-DUP	0 - 6"	ND	ND	ND	ND	ND	ND
	4B-DUP	6 - 24"	ND	ND	ND	ND	ND	ND
#3	1A	0 - 6"	ND	ND	ND	ND	ND	ND
	1B	6 - 24"	ND	ND	ND	ND	ND	ND
	2A	0 - 6"	ND	ND	ND	ND	0.017	0.003
	2B	6 - 24"	ND	ND	ND	ND	0.009	ND
	3A	0 - 6"	ND	ND	ND	ND	0.012	ND
	3B	6 - 24"	ND	ND	ND	ND	0.011	ND
	4A	0 - 6"	ND	ND	ND	ND	ND	ND
	4B	6 - 24"	ND	ND	ND	ND	ND	ND
	4A-DUP	0 - 6"	ND	ND	ND	ND	ND	ND
	4B-DUP	6 - 24"	ND	ND	ND	ND	ND	ND
#4	1A	0 - 6"	ND	ND	ND	ND	ND	ND
	1B	6 - 24"	ND	ND	ND	ND	ND	ND
	2A	0 - 6"	ND	ND	ND	ND	0.012	ND
	2B	6 - 24"	ND	ND	ND	ND	0.01	ND
	3A	0 - 6"	ND	ND	ND	ND	0.014	ND
	3B	6 - 24"	ND	ND	ND	ND	0.01	ND
	4A	0 - 6"	ND	ND	ND	ND	ND	ND
	4B	6 - 24"	ND	ND	ND	ND	ND	ND
OD Crater								
	C1A	0 - 6"	ND	ND	ND	ND	ND	ND
	C1B	6 - 24"	ND	ND	ND	ND	ND	ND
	C2A	0 - 6"	ND	ND	ND	ND	ND	ND
	C2B	6 - 24"	ND	ND	ND	ND	ND	ND
OB Area								
	B1	0 - 6"	3.3	3.9	28	267	0.031	ND

mg/kg								
	Sample Number	Sample Depth	2,4-DNT	n-nitrosodiphenylamine	di-n-butylphthalate	Nitro cellulose	methylene chloride	p-isopropyltoluene
Watercourse								
	W-1	1 - 4"	ND	ND	ND	ND	ND	ND
	W-1 DUP	1 - 4"	ND	ND	ND	ND	ND	ND
	W-2	1 - 4"	ND	ND	ND	ND	ND	ND
	W-2 DUP	1 - 4"	2	ND	ND	ND	ND	ND
	W-3	1 - 4"	ND	ND	ND	ND	ND	ND
	W-4	1 - 4"	ND	ND	ND	ND	ND	ND
	W-5	1 - 4"	ND	ND	ND	ND	ND	ND
	W-6	1 - 4"	2.1	ND	ND	ND	ND	ND
	W-7	1 - 4"	ND	ND	ND	ND	ND	ND
	W-8	1 - 4"	ND	ND	ND	ND	ND	ND
	W-9	1 - 4"	ND	ND	ND	ND	ND	ND
	W-10	1 - 4"	ND	ND	ND	ND	ND	ND
Maximum Phase I Site Sample Concentration			3.3	3.9	28	267	0.031	0.003
Average Phase I Site Sample Concentration			2.467	3.9	28	267		
Background								
	G1A	0 - 6"	ND	ND	ND	ND	ND	ND
	G1B	6 - 24"	ND	ND	ND	ND	ND	ND
	G2A	0 - 6"	ND	ND	ND	ND	ND	ND
	G2B	6 - 24"	ND	ND	ND	ND	ND	ND
	G3A	0 - 6"	ND	ND	ND	ND	ND	ND
	G3B	6 - 24"	ND	ND	ND	ND	ND	ND
Maximum Phase I Background Concentration			0	0	0	0	0	0

mg/kg								
	Sample Number	Sample Depth	2,4-DNT	n-nitrosodiphenylamine	di-n-butylphthalate	Nitro cellulose	methylene chloride	p-isopropyltoluene
PHASE II INVESTIGATION								
# 2	A	0 - 5'	ND	ND	ND	ND	ND	ND
	B	2' - 4'	ND	ND	ND	ND	ND	ND
	C	7' - 8.2'	ND	ND	ND	ND	ND	ND
	D	12.2' - 14.8'	ND	ND	ND	ND	ND	ND
	E	19' - 20'	ND	ND	ND	ND	ND	ND
# 3	A	6.6' - 7.1'	ND	ND	ND	ND	ND	ND
	B	7.1' - 8.6'	ND	ND	ND	ND	ND	ND
	C	8.6' - 10'	ND	ND	ND	ND	ND	ND
	D	11' - 13.4'	ND	ND	ND	ND	ND	ND
	E	13.4' - 16.6'	ND	ND	ND	ND	ND	ND
# 4	A	0' - 5'	ND	ND	ND	ND	ND	ND
	B	2' - 4'	ND	ND	ND	ND	ND	ND
	C	6' - 9'	ND	ND	ND	ND	ND	ND
	D	12' - 15'	ND	ND	ND	ND	ND	ND
	E	17' - 20'	ND	ND	ND	ND	ND	ND
# 5	A	0 - 5'	ND	ND	ND	ND	ND	ND
	B	.5' - 2'	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND
	D	4' - 6.4'	ND	ND	ND	ND	ND	ND
	E	NO SAMPLE	NA	NA	NA	NA	NA	NA
# 6	A	0 - 5'	ND	ND	ND	ND	ND	ND
	B	.5' - 2'	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND
	D	4' - 7.3'	ND	ND	ND	ND	ND	ND
	E	NO SAMPLE	NA	NA	NA	NA	NA	NA
# 7	A	0 - 5'	ND	ND	ND	ND	ND	ND
	B	.5' - 2'	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND
	D	4' - 7.5'	ND	ND	ND	ND	ND	ND
	E	7.5' - 9'	ND	ND	ND	ND	ND	ND
# 8	A	0 - 5'	ND	ND	ND	ND	ND	ND
	B	2' - 4'	ND	ND	ND	ND	ND	ND
	C	6' - 9'	ND	ND	ND	ND	ND	ND
	D	12' - 15'	ND	ND	ND	ND	ND	ND
	E	NO SAMPLE	NA	NA	NA	NA	NA	NA
# 9	A	0 - 5'	ND	ND	ND	ND	ND	ND
	B	.5' - 2'	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND
	D	4' - 7.1'	ND	ND	ND	ND	ND	ND
	E	NO SAMPLE	NA	NA	NA	NA	NA	NA
OD Craters								
	C3A	0 - 5'	ND	ND	ND	ND	ND	ND
	C3B	0 - 5'	ND	ND	ND	ND	ND	ND
	C3C	0 - 5'	ND	ND	ND	ND	ND	ND
	C4A	0 - 5'	ND	ND	ND	ND	ND	ND
	C4B	0 - 5'	ND	ND	ND	ND	ND	ND
	C4C	0 - 5'	ND	ND	ND	ND	ND	ND
Beneath the OD craters								
	3-A	6.6' - 7.1'	ND	ND	ND	ND	ND	ND
	3-B	7.1' - 8.6'	ND	ND	ND	ND	ND	ND
	3-C	8.6' - 10'	ND	ND	ND	ND	ND	ND
	3-D	11' - 13.4'	ND	ND	ND	ND	ND	ND
	3-E	13.4' - 16.6'	ND	ND	ND	ND	ND	ND
Maximum Phase II Site Sample Concentration								
Average Phase II Site Sample Concentration								

mg/kg								
	Sample Number	Sample Depth	2,4-DNT	n-nitrosodiphenylamine	di-n-butylphthalate	Nitro cellulose	methylene chloride	p-isopropyltoluene
# 11	A	0 - .5'	ND	ND	ND	ND	ND	ND
(Background)	B	.5' - 2'	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND
	D	4' - 6.1'	ND	ND	ND	ND	ND	ND
	E	NO SAMPLE	NA	NA	NA	NA	NA	NA
# 12	A	0 - .5'	ND	ND	ND	ND	ND	ND
(Background)	B	.5' - 2'	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND
	D	NO SAMPLE	NA	NA	NA	NA	NA	NA
	E	NO SAMPLE	NA	NA	NA	NA	NA	NA
# 13	A	0 - .5'	ND	ND	ND	ND	ND	ND
(Background)	B	.5' - 2'	ND	ND	ND	ND	ND	ND
	C	2' - 4'	ND	ND	ND	ND	ND	ND
	D	4' - 6'	ND	ND	ND	ND	ND	ND
	E	NO SAMPLE	NA	NA	NA	NA	NA	NA
Maximum Phase II Background Concentration			0	0	0	0	0	0
September 2000 Sampling								
	HS01	0 - 6"	ND	ND	ND	ND	ND	ND
	HS02	0 - 6"	ND	ND	ND	ND	ND	ND
	HS03	0 - 6"	ND	ND	ND	ND	ND	ND
	HS04	0 - 6"	ND	ND	ND	ND	ND	ND
	HS05	0 - 6"	ND	ND	ND	ND	ND	ND
	HS06	0 - 6"	ND	ND	ND	ND	ND	ND
	HS07	0 - 6"	ND	ND	ND	ND	ND	ND
	HS08	0 - 6"	ND	ND	ND	ND	ND	ND
	HS09	0 - 6"	ND	ND	ND	ND	ND	ND
	HS10	0 - 6"	ND	ND	ND	ND	ND	ND
	HS11	0 - 6"	ND	ND	ND	ND	ND	ND
	HS12	0 - 6"	ND	ND	ND	ND	ND	ND
	HS13	0 - 6"	ND	ND	ND	ND	ND	ND
Maximum September 2000 Site Sample Concentration			0	0	0	0	0	0
Average September 2000 Site Sample Concentration								
MAXIMUM SITE SOIL CONCENTRATION - ALL PHASES			3.3	3.9	28	267	0.031	0.003
AVERAGE SITE SOIL CONCENTRATION - ALL PHASES			2.467	3.9	28	267	0.014	0.003
natural background study								
MAXIMUM BACKGROUND CONCENTRATION - PHASE I and II ONLY			0	0	0	0	0	0

Attachment A-2
SAMPLING AND ANALYSIS PLAN

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SAMPLING AND ANALYSIS PLAN
FOR THE CLOSURE OF
THE UNSERVICEABLE MUNITIONS
TREATMENT UNIT AT RANGE 14
YAKIMA TRAINING CENTER
YAKIMA, WASHINGTON

Part 1: Field Sampling Plan

Prepared for:

U.S. Army Corps of Engineers
Mobile, Alabama

Prepared by:

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1.0 INTRODUCTION

A site investigation of the Range 14 OB and OD areas, known as the UMTU, located at YTC, will be conducted in order to determine whether the site currently meets clean closure standards. Based on the results of previous soil sampling, the WDOE has determined that the site will meet clean closure standards if the concentration of nitroglycerin (the only constituent exceeding the risk-based cleanup level assuming residential exposure as of September 2000) is below the MTCA¹ cleanup level. Therefore, soil samples will be collected and analyzed exclusively for nitroglycerin. All groundwater samples from past quarterly monitoring events have remained well below MCTA cleanup levels; therefore, this investigation will focus only on soil.

The SAP for this project is presented in two parts: the Field Sampling Plan (FSP) and the QAPP. This FSP defines the procedures and methods that will be used to collect field measurements and samples during field activities. This FSP discusses the following:

- Procedures for the collection of surface soil and subsurface soil samples, including field measurements and QA/QC samples;
- Requirements for sample chain-of-custody (COC), documentation, and shipping;
- Management of IDW; and
- The schedule of field activities.

Specifically, this FSP addresses issues associated with sampling tasks that will be conducted to determine compliance with clean closure standards. The FSP should be used in conjunction with the QAPP.

¹ The MTCA cleanup regulation is contained in WAC 173-340. The MTCA establishes the processes and standards used to identify, investigate, and clean up facilities where hazardous substances are located.

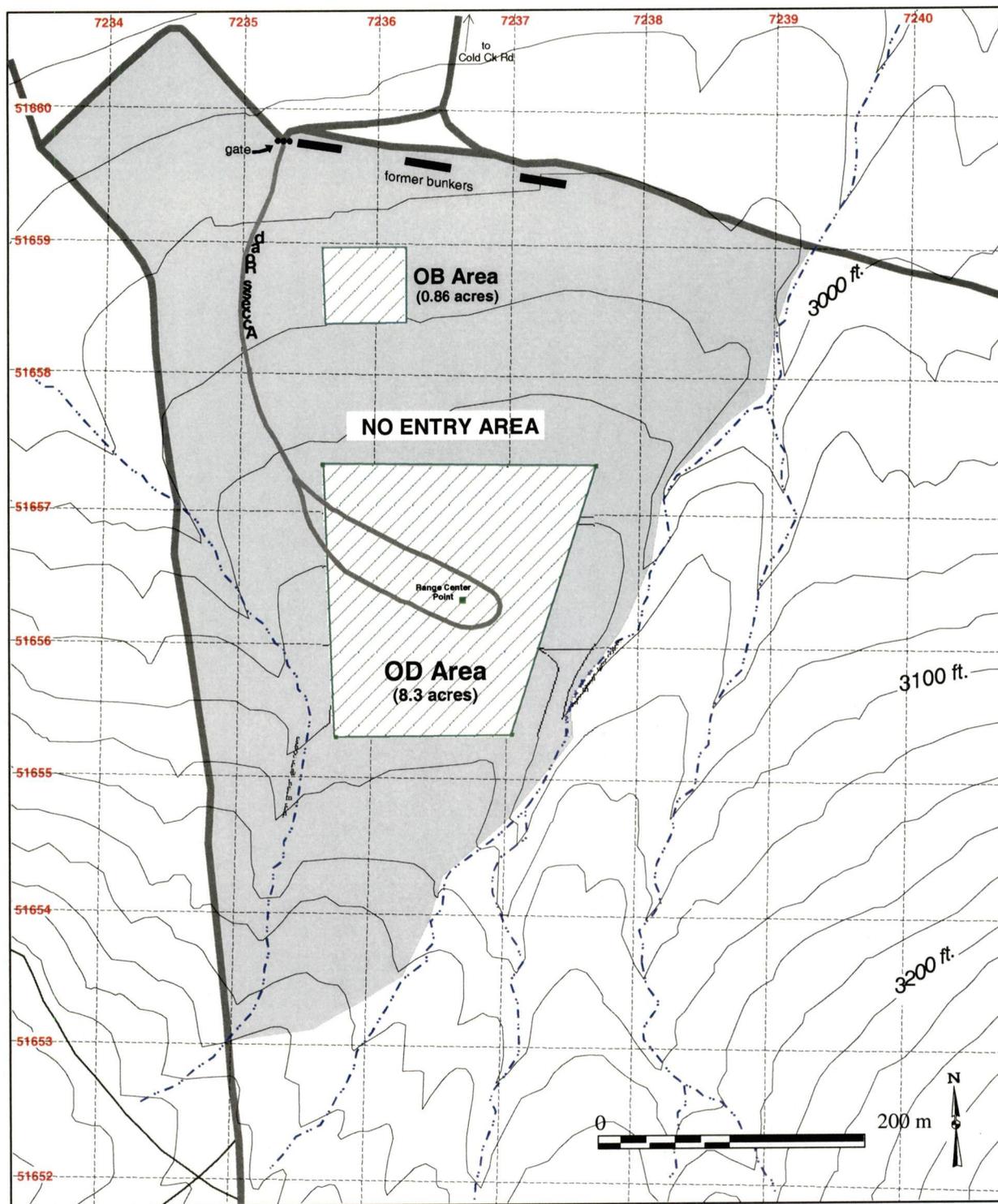
1.1 Site History and Contaminants

Thermal treatment operations at the UMTU were conducted by OD, either on the ground surface or in craters created by previous treatment detonations, or in holes excavated by EOD personnel. A single OB event occurred in a small metal burn pan known as a “popping kettle” in 2000. These treatment activities are necessary for the disposition of conventional munitions and explosives and response to emergency operations involving energetic materials. OB/OD treatment operations were conducted by military and civilian EOD specialists and ammunition handlers from the Army, Navy, Air Force, National Guard, and qualified civilian agency representatives. Thermal treatment activities were completed by personnel trained in disposal procedures and in accordance with DoD safety and operational procedures. Figure 1-1 is a diagram showing the location of the OB/OD areas.

Historically the UMTU was used infrequently for OB activities since about 1970. The OB events were conducted on the ground surface at varying locations within the UMTU until 1996 when a designated area (see Figure 1-1) was established to accomplish OB activities. Materials treated by OB included waste propellants and obsolete small explosive items such as squib switches generated by user services.

The 0.86-acre OB area is located on the north side of the UMTU. An OB device consisting of a 2-ft³ steel box was used to conduct a single burn event in 1996. The burn was initiated using a propane torch. The burn residue and metal box were removed after the treatment event.

OD occurred at various points within the designated OD area (see Figure 1-1), either on the ground surface or in craters created by previous treatment detonations. Explosive items were detonated using Composition 4 (C-4) Military Explosive as the initiating explosive. In addition to C-4, other explosive items treated by OD included fuses, primers, squib switches, pyrotechnics, high-explosive-loaded projectiles, bombs, torpedoes, depth charges, rocket motors, grenades, mines, etc. After detonation, the user demolition team would inspect the OD and



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Figure 1-1. Location of OB and OD Units

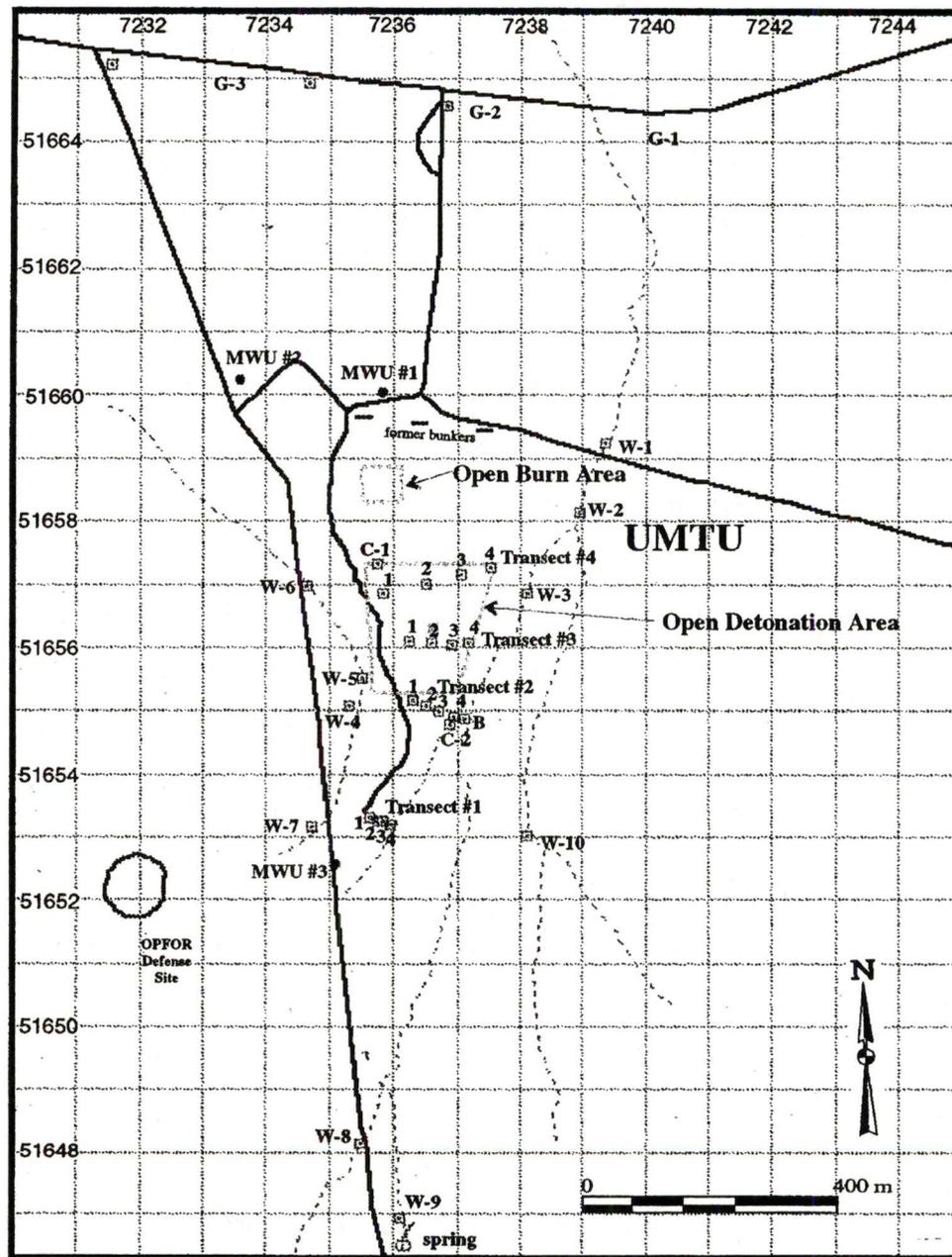
surrounding areas for UXO and ejected debris. UXO was retreated on-site; scrap metal, weapons debris, and other inert material were collected and removed off-site for disposal.

As discussed in Section 1.2, the single contaminant of concern for the pre-closure site investigation is nitroglycerin. Nitroglycerin is a component of single base propellant, an item that was commonly treated by burning at the OB area. No other compounds, including explosives or their derivatives, were found in excess of applicable cleanup levels; therefore, no other analyses are proposed.

1.2 Summary of Existing Site Data

The Army Environmental Hygiene Agency initiated a Phase I soils investigation at the UMTU in August 1993. The purpose of the study was to establish baseline conditions within the UMTU and to evaluate the extent of surface migration, if any, of potential contaminants onto and off of the unit. The investigation included surface soils and intermittent stream sediment. Areas sampled included transects across the most active portions of the UMTU, OD craters, the OB area, intermittent watercourses, and natural background. Grab and composite samples were collected from 0 to 6 in. and 6 to 24 in., as well as field blanks, trip blanks, and field duplicates. The samples were analyzed for explosives, VOCs, SVOCs, total metals, pesticides, herbicides, nitrate/nitrite, PCBs, picric acid, and TPH. The sampling locations are shown in Figure 1-2.

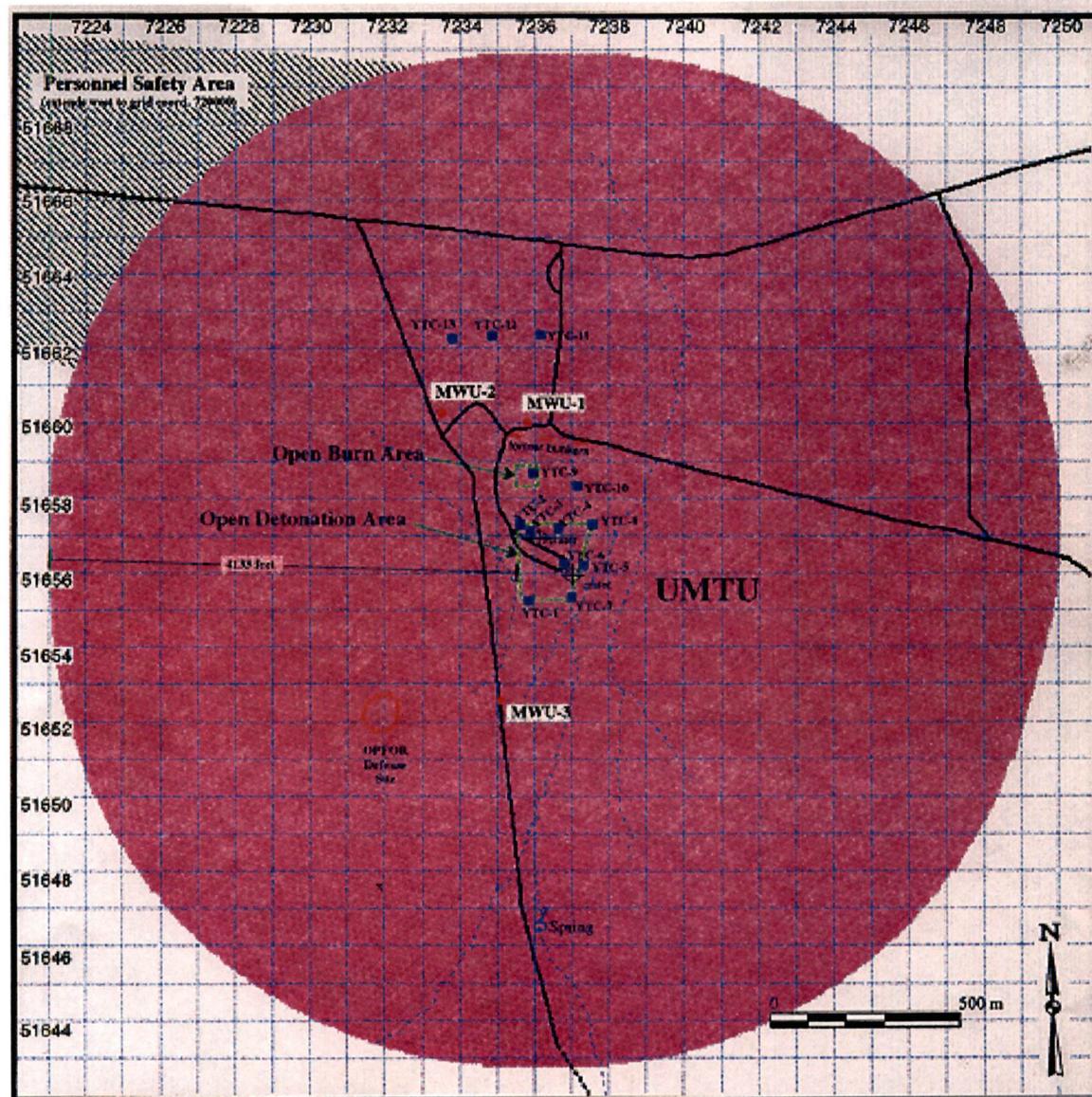
A Phase II soils investigation was conducted in August–September 1995 to gather additional baseline data for delineating constituent concentrations in the surface (0–6-in.) and subsurface (6 in. to 20 ft) soils in the UMTU and natural background areas. Sample collection locations included the UMTU, background, OB area, and OD craters. Samples were analyzed for explosives, SVOCs, total metals, and picric acid. Phase II analyses did not include VOCs, TPH, pesticides, PCBs, or herbicides since these constituents were not detected in the Phase I study. The sampling locations are shown in Figure 1-3.



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Figure 1-2. UMTU Phase I AEHA Soil Sampling Locations



Produced by: PIW-BHARD-GIS Lab, Fort Lewis, Washington (Nov 95)

-  Range 14 Safety Fan
-  Personnel Area
-  Monitoring Well
-  Sampling Point
-  Roads
-  Water Course
-  UTM Grid Lines

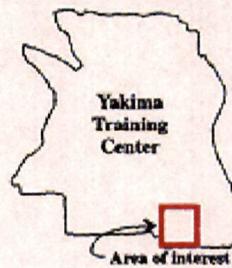


Figure 1-3. UMTU Phase II Soil Sampling Locations

In September 2000, a third round of soil sampling was completed for the UMTU area. The purpose of this soil sampling event was to monitor levels of contaminants of concern in surface soils within, adjacent to, and outside the UMTU site and the potential migration of these contaminants from the unit. Twelve grab samples were collected from 0 to 6-in. depth BGS. Eight of the samples were collected from a transect line that passed through the OB and OD areas. The remaining four samples were collected from the streambed locations; two samples represented upgradient locations and two samples represented downgradient locations. The samples were analyzed for explosives and total metals. The sampling locations are shown in Figure 1-4.

The results of the Phase I investigation do not indicate pervasive contamination of the area from OB/OD operations. Low levels of explosive compounds and related SVOCs were identified in crater samples, the OB area, one transect site, and two watercourse samples. Some of the metal concentrations exceeded Region III carcinogenic risk-based concentrations or state screening levels; however, none exceeded noncarcinogenic screening levels. One explosive (RDX) exceeded a screening level in one sample only.

The results of the Phase II investigation indicate that no explosive or SVOC compounds were detected and that the metals present in the samples were considered to be anthropogenic in origin.

For the September 2000 sampling event, four explosives (HMX, RDX, 2,4,6-trinitrotoluene, and nitroglycerin) were detected in the samples. All of the concentrations were below the MCTA Method B cleanup level with the exception of one sample result for nitroglycerin. All the individual sample results are well below the Method B cleanup level of 71 mg/kg except for the sample collected from sampling location HS02, which had a concentration of 230 mg/kg. The average of all samples collected (30.3 mg/kg) is less than the cleanup standard. However, the maximum concentration has been used based on the WAC stipulation that individual soil samples may be compared directly with cleanup levels if there is reliable information that the soil samples have been taken from locations where the worst soil contamination ("hot spots") is likely to be found.

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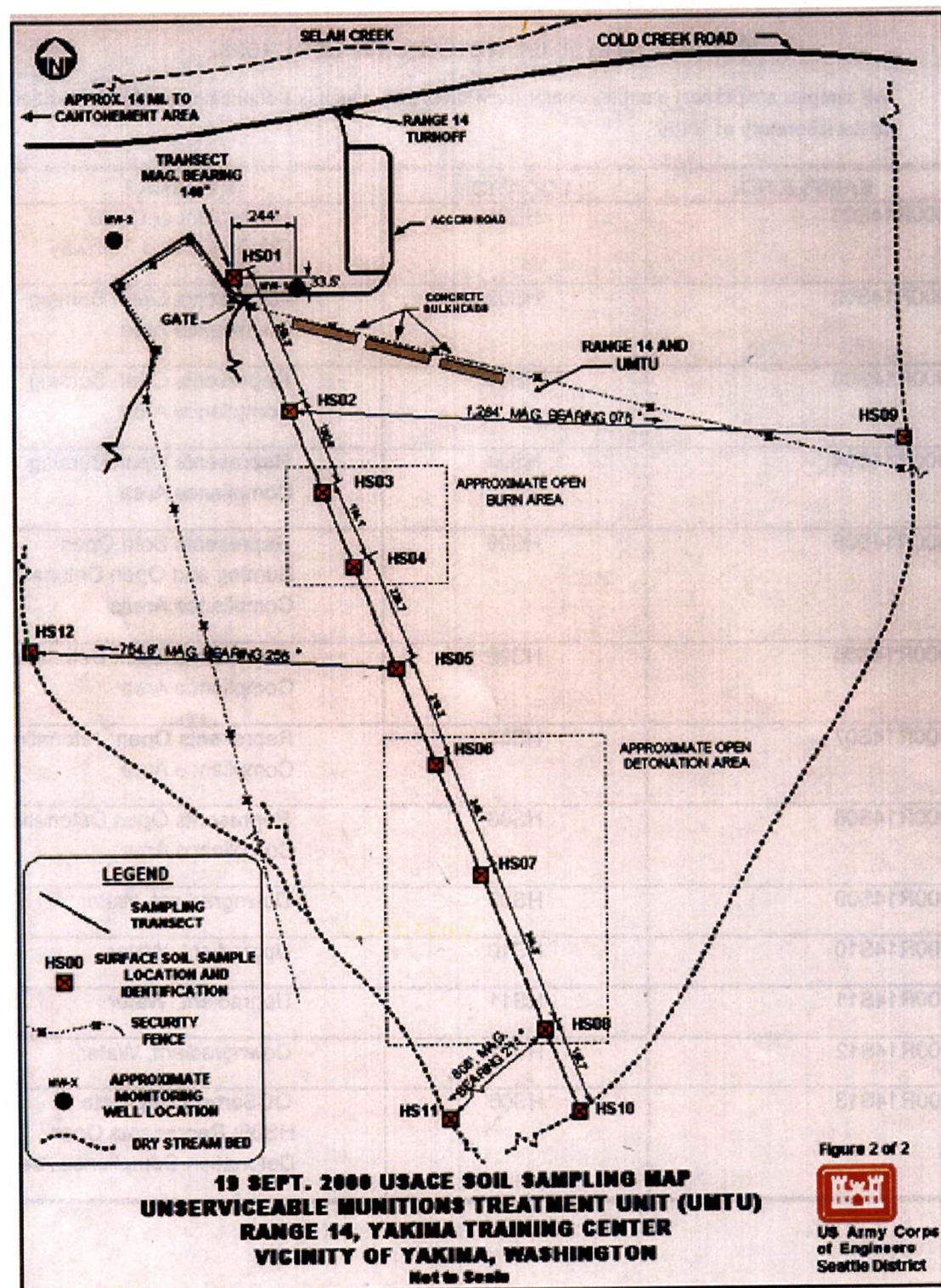


Figure 1-4. Site Map, June 2000 Conditions (not to scale)

A review of the data indicates that all the explosive and SVOC contaminants are contained within the top 24 in. of soil and that the metals are the only compounds detected consistently throughout the subsurface (from 2 to 20 ft). However, the presence of metals is to be expected. The results of a study completed by the U.S. Geological Survey, in cooperation with the WDOE, have been used to define a range of values that represent the natural concentration of metals in surficial soils throughout Washington (WDOE 1994). In many cases the natural background concentration of a metal determined by this study is comparable to the maximum concentration detected in the UMTU site samples. The largest deviations from this occur with cadmium (background concentration of 1 mg/kg, site concentration of 5.2 mg/kg) and lead (background concentration of 17 mg/kg, site concentration of 86 mg/kg). However, these concentrations are still well within the cadmium and lead cleanup levels of 40 mg/kg and 250 mg/kg, respectively.

1.3 Site-Specific Sampling and Analysis Problems

The OB and OD areas are cleared, well maintained areas with minimal vegetation and without any physical structures or overhead obstructions; therefore, problems associated with the collection of soil and groundwater samples are expected to be minimal. Possible safety concerns related to sampling and analysis are annotated in the Site Safety and Health Plan (SSHP) prepared for this project. Possible sampling and analysis problems and proposed solutions are identified below.

1.3.1 Presence of UXO

Due to the nature of past and current operations at the site, there is a possibility of the presence of UXO. Sites potentially contaminated with UXO will be screened by qualified subcontractor EOD technicians prior to sampling. The EOD personnel will locate an access route to the sampling area that is free of anomalies using appropriate geophysical detection instruments. They will flag, identify, and record the appropriate location of all discovered ordnance and explosives (OE) for subsequent destruction.

Based on site-specific considerations, the 0 to 6-in. soil layer is considered to be directly contactable surface soil; therefore, the initial sampling activities (closure sampling) will focus on the collection of soils in this stratum. However, if statistical evaluation of these surface soil samples indicates that the site does not meet cleanup levels, soil excavation will be necessary, and post-excavation sampling (collecting samples from the bottom and sides of the excavated area) will be used to evaluate compliance with clean closure standards. No soil sampling and/or excavation will occur until the on-site EOD technician has removed/disposed of the UXO hazard. Site-specific UXO avoidance procedures are further discussed in the SSHP. UXO-qualified personnel will conduct a subsurface clearance of the excavation area (footprint) and remove all discovered UXO. Excavation will occur in 2-ft increments, and at the end of each 2-ft increment, EOD personnel will screen for anomalies. EOD personnel will also visually survey the surface of the sampling area (each proposed surface soil sampling location) for any indication of UXO or UXO-related contamination. EOD personnel will also conduct a survey of the proposed sample locations using geophysical instrumentation capable of detecting the smallest known or anticipated UXO to a depth of 1 ft.

1.3.2 Water Requirements

Potable water will be transported to the site for equipment decontamination. Potable water for personal consumption will be brought onto the site separately (i.e., in water bottles). Lab-grade (American Society for Testing and Materials Type II) de-ionized water will be brought to the site in 5-gal containers and used for field blanks.

1.3.3 Endangered Species

One federal Candidate plant species (basalt daisy) and six state threatened species including Columbia milkvetch, dwarf desert primrose, white eatonella, basalt daisy, Hoovers desert-parsely, and Hoovers tauschia occur on YTC. However, none of these plant species are known to be present within the boundaries of the UMTU.

Several state and federal sensitive wildlife species occur on or around YTC. Bald eagles, a federally threatened species are present on YTC but have not been documented on or adjacent to the UMTU. Ferruginous hawks, a state threatened species have historically been found on YTC however; recent surveys have not detected this species on or adjacent to the UMTU. Three state candidate mammal species (black and white tailed jackrabbit and Merriam's shrew) are known to occupy shrub-steppe upland habitats on YTC. Three state candidate raptor species (Golden eagle, Merlin and Burrowing owl) and four passerine species (Loggerhead shrike, sage thrasher, vesper sparrow, and sage sparrow) use shrub-steppe uplands on the installation. This habitat exists around the UMTU and it is therefore likely these species inhabit areas adjacent to the UMTU. YTC supports one of two populations of sage grouse remaining in the state of Washington. This species is a state threatened species and a federal candidate for listing as a threatened. The UMTU is within and adjacent to habitat known to be used by sage grouse.

Soil sampling and excavation within the UMTU not likely to affect these species.

1.3.4 Sampling Activity on an Active Range

The UMTU is located within Range 14, an active training range used by DoD personnel. All sampling activities will be scheduled and confirmed well in advance with YTC Range Control personnel. Should the UMTU area become unavailable for sampling once the field team has mobilized to the site, changes in the schedule will be communicated to the Contracting Officer's Representative (COR) immediately. In addition, a Change Control Approval Form (found in Section 10) discussing the schedule and cost impact of the downtime will be completed by contractor personnel and submitted to the COR and USACE Program Manager for review and approval.

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2.0

PROJECT ORGANIZATION AND RESPONSIBILITIES

The project team for the UMTU site investigation project and their roles and responsibilities are discussed in this section. Figure 2-1 presents the overall project organization, including subcontractors.

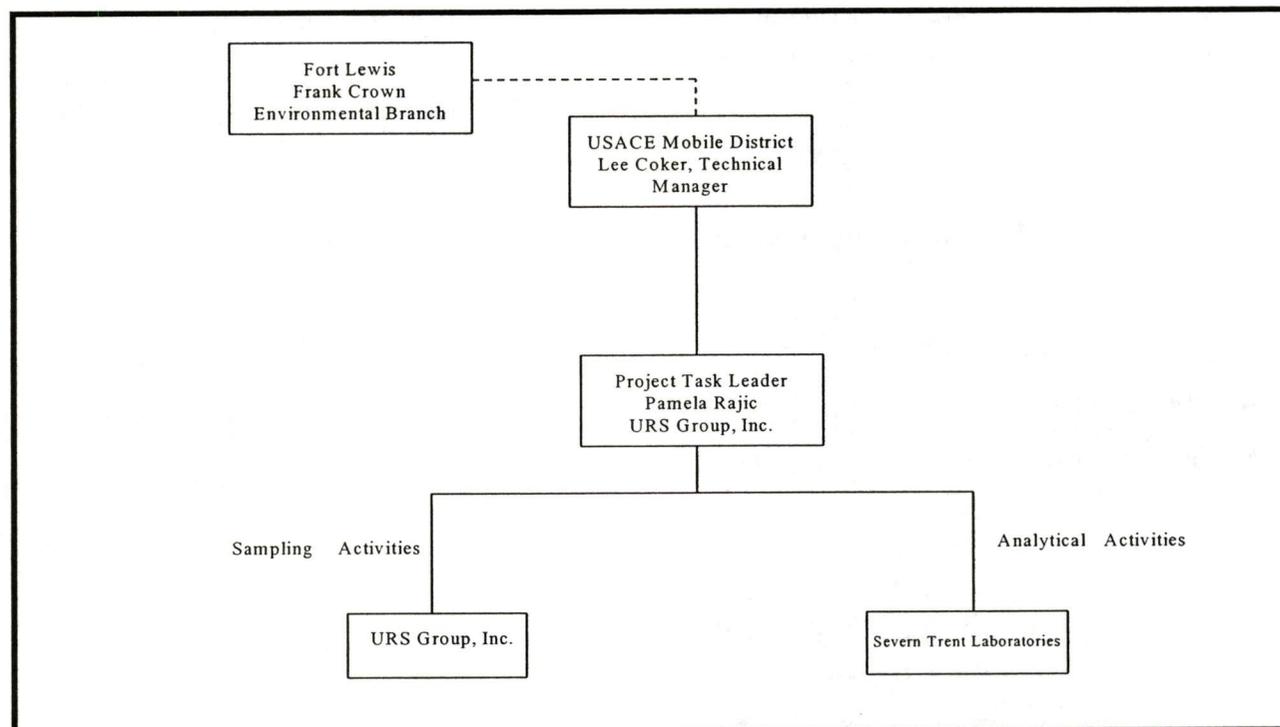


Figure 2-1. Project Organization

2.1

Roles and Responsibilities

The team members that will be supporting the UMTU closure effort are discussed below.

2.1.1

Task Leader

Ms. Pamela Rajic will serve as the task leader for this project. In this capacity, she will be responsible for organizing and directing the technical activities of the project and for

reporting the results of these activities. She will have day-to-day interaction with the technical staff. In the execution of these duties, Ms. Rajic will:

- Establish technical objectives and assist the field task leader in the preparation and review of work plans;
- Be responsible for responding to work plan revisions;
- Ensure technical quality of reports, memoranda, and other communications through review of results; and
- Maintain contact with the USACE Technical Manager in areas that require decisions on technical matters.

2.1.2 Field Task Leader/Chemical QC Representative

Mr. Chris Wesh will serve as field task leader, resolving any geological and scope-related issues that arise during field activities. The field task leader is responsible for managing the execution of a specific task. Specifically, the responsibilities of the field task leader are to:

- Ensure that planned activities are executed in accordance with this plan and other work plans;
- Ensure that technical personnel are qualified by experience or training to perform assigned work and comply with the technical and QA requirements applicable to the work being performed;
- Review, as appropriate, all project documentation; and
- Oversee activities performed by subcontractors.

The field task leader will be responsible for on-site coordination of field activities and initiation of field change notices of the project work plan. He will also be responsible for the coordination of activities for subcontractors involved in the investigation—the analytical laboratory, the drilling firm, and site surveyors. All field data collected will be reviewed by the field task leader. He will observe field activities to ensure all tasks are conducted according to the SAP.

Mr. Wesh will also serve as the Chemical Quality Control (CQC) representative. In this role he will be responsible for ensuring all QC procedures are followed during field activities and sample collection.

2.1.3 Safety Officer

Mr. Don Jenkins will serve as the site safety and health representative. In this role he will be responsible for:

- Implementing field surveillance activities necessary to ensure that worker health and safety concerns are fully addressed, including adherence to the SSHP requirements;
- Providing site-specific training to employees assigned to work at the site and enforcing the requirements stated in the URS Group, Inc. *Health and Safety Manual*; and
- Reviewing and coordinating with the Environmental Affairs Coordinator on any proposed changes to these safety plans and ceasing work when the health or safety of project personnel is jeopardized.

2.1.4 EOD Support

Qualified EOD personnel will be subcontracted for the UXO/EOD support required for the field work. This support will include conducting a preliminary investigation of the sampling area to identify any UXO, and remaining on-site during all field work to ensure the continued safety of personnel.

2.2 Subcontractor Qualifications

Severn Trent Laboratories (STL) will be the primary laboratory used during the site closure activities. STL will provide chemical analyses (nitroglycerin) for all samples. All soil samples will be collected in appropriate sample containers, sealed, and labeled. Each sample is identified by affixing a pressure-sensitive gummed label or standardized tag on the container. This label will contain the sample identification number, date and time of collection, source,

preservative used, analysis required, and the collector's initials. All samples will be recorded on a COC record. Sample COC and documentation are discussed in detail in Section 5.0.

The sample containers will then be placed in a transportation case, along with the COC record, pertinent field records, and analysis request form as needed. Samples will be packed so as not to break. The transportation case will be sealed or locked so that any tampering can be readily detected.

When transferring samples, the transferee must sign and record the date and time on the COC record. Every person who takes custody must fill in the appropriate section of the record. The number of custodians in the chain of possession will be kept to a minimum.

All packages sent to the laboratory will be accompanied by the COC record and other pertinent forms. URS will maintain copies of these forms. Mailed packages will be registered with return receipt requested. For packages sent by common carrier, receipts will be retained as part of the permanent COC documentation.

2.3 IDW Disposal

IDW from the investigation will include decontamination fluids, PPE, disposable equipment, and packaging and shipping materials. Disposal procedures will be based on whether the IDW is hazardous or non-hazardous. Additional discussion concerning IDW disposal procedures is provided in Section 8.2.3 of the Closure Plan.

3.0

SCOPE AND OBJECTIVES

The objective of the investigation is to conduct defensible soil sampling, analysis, and data validation in order to determine compliance with MTCA cleanup levels. Closure sampling will include surface soil (0 to 6 in.) sampling at the suspected hot spot using a systematic sampling approach.

Sampling and analyses will be conducted in accordance with EPA regulations and as described in this FSP and QAPP. The sampling locations described in this document have been selected based on historical data and the requirements specified in *Washington State Department of Ecology Toxics Cleanup Program, Guidance on Sampling and Data Analysis Methods*, January 1995. Final sampling locations may vary somewhat from what is presented due to site conditions at the time of sampling.

In order to meet QC requirements stated in the QAPP, the contractor will be collecting field replicates, equipment rinsate blanks, and temperature blanks. The contractor has designated a CQC representative to perform the QC responsibilities described in Sections 8 and 9. All analytical laboratories will follow method-specific QA/QC procedures discussed in the QAPP.

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4.0 FIELD ACTIVITIES

In order to evaluate compliance with the MTCA soil cleanup level established for residential exposure (clean closure standard), samples will be collected from the sampling location identified during the September 2000 sampling event as the single area where Method B (residential exposure) cleanup levels were exceeded. The samples will be analyzed for nitroglycerin and the results will be compared to the Method B cleanup level to determine whether the site currently meets the risk-based clean closure standards. If the current nitroglycerin concentration exceeds the clean closure standards, soil will be removed from the site down to the point of compliance. The sampling and analysis methodology will follow EPA Soil Screening Guidance Publication 9355.4-23, April 1996, Attachments 1 and 2, where applicable.

YTC will notify WDOE's site manager prior to the sampling activities in order to comply with WDOE's protocol, which allows WDOE to collect split samples if they choose to do so. All soil sample locations will be confirmed with a representative of the installation and/or USACE. The results of the site investigation will be used to support the closure of the UMTU.

As a result of current and past activities, UXO may be present in both the OB and OD areas. Contractors will coordinate mobilization to the site with the installation point of contact (POC). The installation POC is Mr. Larry Fain, a staff engineer at YTC (509-577-3545). Entry requests will be coordinated with the POC at least 10 days prior to mobilizing to the site. Contractors will be accompanied by installation personnel at all times and will take direction from the EOD technician while at the site. If known or suspected ordnance is discovered at any time during sample collection activities, operations will stop in the affected area. No activities will take place until an installation UXO-qualified specialist declares the area safe and clear to proceed with sampling activities.

4.1 **Closure Sampling**

Surface soil samples will be collected in order to determine the presence and concentration of nitroglycerin contamination at the site. Based on the limited depth of contamination expected for OB operations, only surface soil samples will be collected for this site investigation. Surface soils for this sampling effort will be considered from 0 to 6 in. BGS.

4.1.1 **Sampling Locations**

As stated in the WDOE Toxics Cleanup Program *Guidance on Sampling and Data Analysis Methods*, area-wide sampling is the preferred approach where the spatial distribution of potential or suspected contaminants over the study area is uncertain. Consequently, sampling locations will be distributed over the entire study area in an effort to locate any soil that may require cleanup. Since it is impractical to send the entire soil mass to a laboratory for analysis, inferences about the mean (average) concentration of nitroglycerin in the study area, from a statistical analysis of the sampling data, will be used to decide whether the area complies with a cleanup level.

The study area is defined as the 15 by 15 ft square area surrounding the September 2000 sampling location of interest. This area will be established using the sampling coordinates recorded and reported in Soil Monitoring Round 5 Sampling (USACE 2001). The sampling program proposed for this investigation is systematic sampling in which samples are taken at regularly spaced intervals. An initial sampling location is chosen at random and then the remaining sampling locations are defined so that all locations are in regular intervals over an area (grid). Systematic sampling provides a practical and easy method for designating sampling locations and ensures uniform coverage of the area. A square grid will be placed over the sampling area to define the systematic locations for soil sampling. The proposed study area is represented in Figure 4-1 with long dashed lines (around sampling location HS02).

The number of samples that will be collected during closure sampling was determined using the Decision Error Feasibility Trials (DEFT) software program (see Section 3.1

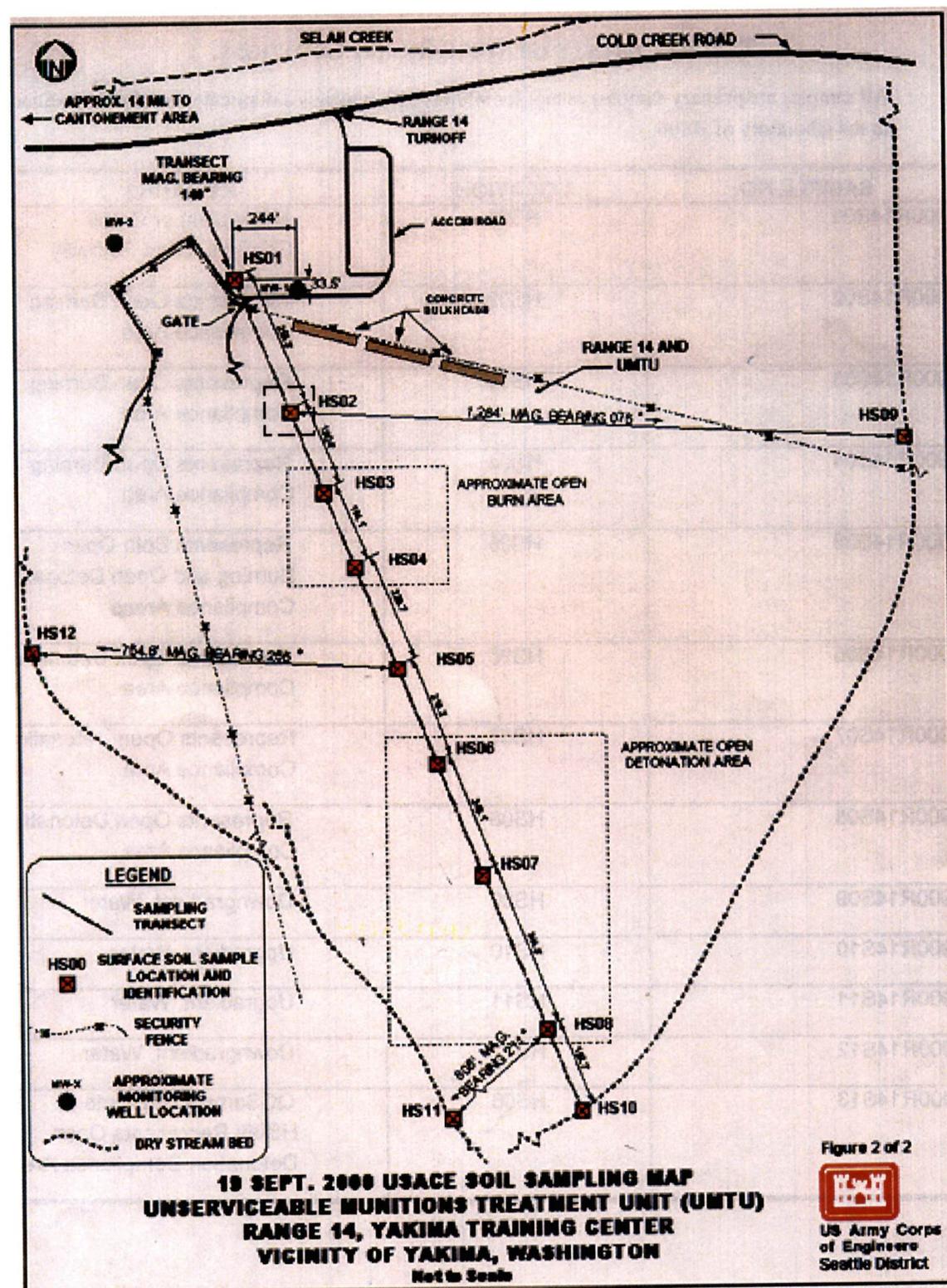


Figure 4-1. Proposed Closure Sampling Grid

of the QAPP). The program, which calculates the number of samples required to meet user-specified DQO criteria, determined that 10 primary samples would meet the decision criteria used for this investigation; therefore, YTC will collect 11 samples during closure. The distance between the sampling locations in the systematic grid is calculated using the size of the sample area and the number of samples, as shown below:

$$L = [(A/n_f)]^{1/2}$$

where L is the distance between the grids, A is the sample area, and n_f is the number of samples being collected. For the sample area of 225 ft² and 11 samples, the calculated grid distance is approximately 5 ft.

Randomization is necessary in order to make probability or confidence statements about the results of the sampling. Therefore, the actual location of the first sampling point in the grid will be chosen by a random procedure. One set of (X,Y) coordinates will be generated using the following equations:

$$X = X_{\min} + (X_{\max} - X_{\min}) \times \text{RND}$$

$$Y = Y_{\min} + (Y_{\max} - Y_{\min}) \times \text{RND}$$

Where (X_{\min}, Y_{\min}) represents the lower left-hand corner of the square circumscribing the sample area, (X_{\max}, Y_{\max}) represents the upper right-hand corner of the square, and RND is a random number between 0 and 1 obtained from a table of random numbers. Using this location as one intersection of two gridlines, gridlines will be run parallel to the coordinate axes and separated by the distance L. The sampling locations will be the points at the intersections of the gridlines that are within the sample area boundary.

4.1.2 Sampling Procedures

Grab surface soil samples will be collected using stainless hand augers, trowels, and bowls from a depth of 0–6 in. BGS. All surface soil samples will be submitted for nitroglycerin analyses. The procedure for collecting surface soil samples is provided below:

1. Using a precleaned or decontaminated stainless steel hand auger or trowel, collect the sample from the 0–6-in. interval, then homogenize soil in a stainless steel bowl for the sample containers.
2. Transfer sample into the appropriate laboratory supplied sample bottle with a stainless steel lab spoon or equivalent.
3. Secure the cap tightly.
4. Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
5. Place filled sample containers on ice immediately.
6. Complete all COC documents and record in the field logbook. Prepare samples for shipment.
7. Place excess soil back into borehole.
8. Decontaminate sampling equipment after use and between sample locations.

Homogenizing Techniques—Applying proper homogenization techniques will help ensure that conditions are being accurately represented. Homogenization will be accomplished by filling a properly decontaminated stainless steel tray or bowl with the sample and mixing it with a decontaminated stainless steel instrument. Round bowls will be used for sample mixing. Adequate mixing is achieved by stirring the material in a circular manner and occasionally turning the material over. The extent of the mixing required will depend on the nature of the sample and will be done to achieve a consistent physical appearance prior to filling sample containers. Once mixing is completed, the sample will be divided in half, and containers will be filled by scooping sample material alternately from each half.

4.1.3 QA/QC Sampling

Field QC duplicates and QA surface soil samples will be collected at a frequency of 10% of the number of surface soil samples collected. An equipment rinsate blank will be performed on soil sampling equipment after decontamination at a frequency of one per day per analysis. Temperature blanks will also be included in all sample coolers being submitted for laboratory analysis.

Field QC duplicates and QA split surface soil samples are grab field replicates and will be collected simultaneously with the scheduled surface soil samples. Equipment rinsate blanks will be performed by collecting deionized water that has been rinsed over decontaminated surface soil sampling equipment. Temperature blanks will be prepared by placing water in empty vials. Temperature blanks will be placed in all shipping containers. Field control samples are described in detail in Section 8.2.1. Table 4-1 presents a sample and analysis matrix for closure soil sampling.

Table 4-1
Sample Matrix for Method 8332

Sample Location	Primary Samples	MS/MSD	Field Duplicate	Field Split
Node 1	1			
Node 2	1			
Node 3	1	1		
Node 4	1			
Node 5	1			
Node 6	1		1	
Node 7	1			
Node 8	1			
Node 9	1			1
Node 10	1			
Node 11	1			

4.1.4 Sample Containers and Preservation Techniques

Surface soil samples will be placed into 8-oz. glass jars with a Teflon-lined cap. The samples will be stored at a maximum of 4°C using ice packs placed in the sample cooler.

4.1.5 Decontamination Procedures

The decontamination procedure for soil sampling field equipment is as follows:

1. Remove any solid particles from the equipment or material by brushing and then rinsing with available tap water. The purpose of the initial step is to remove gross contamination.
2. Wash equipment with a brush and a phosphate-free detergent solution.
3. Rinse with tap water.

4. For organic contaminants, an optional rinse with a solvent (isopropanol or methanol) may be necessary to dissolve and remove coatings of organic contaminants. For glass and Teflon sampling equipment, rinse equipment with at least a 10% nitric acid solution.
5. Rinse thoroughly with distilled water.
6. Rinse with pesticide-grade isopropanol. Allow equipment to air dry thoroughly.
7. If the equipment must be reused before the alcohol evaporates, it should be rinsed thoroughly with organic-free water.

Unless the equipment is going to be used immediately, it must be wrapped in new aluminum foil, shiny side out, to keep it clean until needed. For large bulky equipment, new Visqueen can be substituted for the aluminum foil.

4.2 Excavated Soil Sampling

Soil that is excavated from the site must be characterized to determine whether it is a hazardous waste subject to RCRA Subtitle C regulations. A solid waste is a RCRA hazardous waste if it contains a listed waste or exhibits any of the hazardous characteristics and is not excluded from regulation as a hazardous waste. In order to determine whether a solid waste is designated as a dangerous waste, Fort Lewis will:

- Determine whether the waste is a listed discarded chemical product, WAC 173-303-081;
- Determine whether the waste is a listed dangerous waste source, WAC 173-303-082;
- If the waste is not listed in WAC 173-303-081 or 173-303-082, or for the purposes of compliance with the federal LDRs as adopted by reference in WAC 173-303-140, determine whether the waste exhibits any dangerous waste characteristics, WAC 173-303-090; and
- If the waste is not listed in WAC 173-303-081 or 173-303-082, and does not exhibit a characteristic in WAC 173-303-090, determine whether the waste meets any dangerous waste criteria, WAC 173-303-100.

5.0

SAMPLE COC/DOCUMENTATION

This section describes procedures for maintaining sample control through proper sample documentation. When samples are collected for chemical or physical characteristics analysis, documentation such as the COC and sample analysis request forms, custody seals, and logbooks need to be completed. The information presented in this section enables maintenance of sample integrity from the time of collection through transportation and storage. It is this documentation that will verify that the samples were properly handled.

5.1

Field Logbook

Project field logbooks will be bound and will have numbered, water-resistant pages. All pertinent information regarding the site and sampling procedures will be documented in indelible ink. Notations will be made in a logbook, noting the time and date of entries. Logbooks will be kept in the field team member's possession or in a secure place during the field work. Information recorded in this logbook will include, but not be limited to, the following:

- Name and exact location of site of investigation or interest;
- Date and time of site arrival and departure;
- Affiliation of persons contacted;
- Name of person keeping log;
- Names and title/responsibility of all persons on-site;
- Purpose of visit;
- All available information on-site (processes or products, waste generation, nature of spilled material) and the composition and concentration of substance, if known;
- Field instrument equipment used and purpose of use (i.e., health and safety screening, sample selection for laboratory analysis), calibration methods used, field results, and QC information;
- Location of sampling points;
- Identification number, volume, sampling method, and containers (size/type) for each sample collected, including any sample manipulations such as filtration, compositing, and executed preservation techniques;

- Date and time of sample and data collection and any factor that may affect their quality;
- Name of sample collector;
- Sample identification numbers and a description of samples (especially any related QC samples);
- Weather conditions on the day of sampling and any additional pertinent field observations;
- Descriptions of the number of shipping coolers packaged (attach associated COC forms) and the shipping method employed (note applicable tracking numbers); and
- Name and address of all receiving laboratories.

Following the site activities, the logbook(s) will become part of the permanent project file.

5.2 Sample Numbering System

A sample numbering system will be used to identify each sample collected and submitted for analysis. The sample identification numbers for each sampling effort will be used on sample labels, sample tracking matrix forms, COC forms, field logbooks, and all other applicable documentation. Sample identification numbers will be recorded in the field logbook.

Each sample collected must be assigned a unique sample number. Sample numbers will change when the media or location changes. Sample numbers will not change because different analyses are requested.

A list of sample numbers will be prepared prior to the field visit. The list will be used by field personnel and receiving laboratories to ensure that all samples are collected as planned. Any sample numbers not used will be voided and noted in the field logbook.

5.3 Sample Documentation

Sample documentation procedures are used to ensure the collection of usable project data. The procedures that will be used during the closure activities are described below.

5.3.1 Sample Labels

Sample labels are required for properly identifying samples and evidence. Samples must be properly labeled with the label affixed to the container prior to transportation to the laboratory. Information on sample labels will include, but not be limited to, the following:

- Project Code: An assigned contractor project number and site name.
- Station Number: A unique identifier assigned to a sampling point by the sampling team.
- Sample Identification Number: Each sample, including field control samples, collected for a project should be assigned a unique number. This assignment number incorporates information on the sample type and date.
- Samplers: Each sampler's name and signature or initials.
- Preservatives: Whether a preservative is used and what type of preservative.
- Analysis: The type of analysis requested.
- Date/Time: The date and time the sample was taken.
- Type of Sample: The type of sample identified as discrete or composite.

5.3.2 Sample Field Logbook

In addition to the items listed above, the approximate locations of all sampling points will be documented. The exact locations will be surveyed for purposes of generating an accurate representation of the site conditions using the data generated to date, defining data gaps, and identifying potential future data needs.

5.3.3 COC Forms

COC procedures provide documentation of the handling of each sample collection until it is destroyed. COC procedures are implemented so that a record of sample collection, transfer of samples between personnel, sample shipping, and receipt by the laboratory that will analyze the sample is maintained. Records concerning the cleaning of empty containers at the site will also be maintained.

The COC form serves as a legal record of possession of the sample. The form is initiated with the acquisition of the sample and remains with the sample at all times. The COC form contains the name of the field investigator assuming responsibility for the samples. An example COC form is shown in Figure 5-1. A sample is considered to be under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession,
- The sample is in the sampler's view after being in possession,
- The sample was in the sampler's possession and then was locked up to prevent tampering, or
- The sample is in a designated secure area.

In addition to the COC form, there is also a COC seal. The COC seal ensures that no sample tampering occurred between the field and the laboratory analysis.

All sample sets will be accompanied by a COC form. When transferring possession of samples, the individual receiving the samples will sign, date, and note the time that he/she received the samples on the COC form. This COC form documents transfer of custody of samples from the field investigator to another person, other laboratories, or other organizational units. Shipping containers must be secured by using nylon strapping tape and custody seals. The custody seal must be placed on the container so that it cannot be opened without breaking the seal. The seal must be signed and dated by the field investigator. The original and one copy of the form will be placed in a plastic bag taped to the inside lid of the secured shipping container. A copy of the form will also be retained by the task leader. The original record will be transmitted to the task leader after samples are accepted by the laboratory. This copy will become part of the project file. If sent by common carrier, an airbill will be used. Receipts from airbills will be retained as part of the documentation of the COC. The airbill number or the registered mail serial number will be recorded in the remarks section of the COC form.

SAMPLE CHAIN OF CUSTODY												Laboratory NAME			
ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD												Address ADDRESS 1			
												ADDRESS 2			
												Phone (AC) Number			
												Page ___ of ___ Pages			
Project No.				Required Analysis								___ Standard Report Delivery			
Project Name and Location												___ Expedited Report Delivery Date due _____			
Client Name		Client Manager													
Client Address (City, State, Zip)															
Sample		Sample Identification		Matrix Type		Number of Containers Submitted								Remarks	
Date	Time														
Relinquished by: (signature)		Date	Time	Relinquished by: (signature)		Date	Time	Relinquished by: (signature)		Date	Time				
Received by: (signature)		Date	Time	Received by: (signature)		Date	Time	Received by: (signature)		Date	Time				
Laboratory Use Only															
Received by: (signature)		Date	Time	Custody Intact	YES	NO	Custody Seal No.	SL Log No.	Laboratory Remarks						

Figure 5-1. Example COC Form

The COC form may also include a sample analysis request. To ensure that proper analysis is performed on the samples, additional paperwork may need to be filled out, as required by the laboratory performing the analysis.

5.3.4 Documentation Procedures

The logbook and supporting paperwork will be completed with indelible ink. Maintaining sample integrity through proper documentation is essential.

5.3.5 Corrections to Documentation

Original data recorded in field logbooks, on sample labels, and on COC records will be written in waterproof ink. If an error is made on an accountable document, corrections will be made by crossing out the error and entering the correct information. Any error discovered on a document will be corrected by the person who made the entry. Corrections must be initialed and dated.

6.0

SAMPLE PACKAGING AND SHIPPING

This section describes procedures for properly packaging and shipping environmental samples. The procedures described in this section are performed after samples have been collected and placed in proper containers and correctly preserved. Environmental samples should be packaged for shipment as follows:

- Sample container is adequately identified with sample labels.
- Evidence tape or custody seals may be used for additional sample security.
- Each sample bottle is placed in a separate plastic bag, which is then sealed. As much air as possible is squeezed from the bag before sealing. Bags may be sealed with evidence tape or custody seals for additional security.
- A picnic cooler (such as a Coleman or other sturdy cooler) is typically used as a shipping container. In preparation for shipping samples, the drain plug is taped shut from the inside and outside, and a large plastic bag is used as a liner for the cooler. Approximately 3 in. of inert packing material, such as asbestos-free vermiculite, perlite, or Styrofoam beads, is placed in the bottom of the liner.
- The bottles are placed upright in the lined picnic cooler in such a way that they do not touch and will not touch during shipment. Cardboard separators, or packing material may be placed between the bottles at the discretion of the shipper.
- Samples will be shipped to the laboratory on ice and chilled to 4°C.
- Additional inert packing material is placed in the cooler to partially cover the sample bottles (more than halfway). Ice in double bags must be placed around, among, and on top of the sample bottles. If chemical ice is used, it will be placed in a double plastic bag. The cooler will then be filled with inert packing material and the liner taped shut.
- The paperwork going to the laboratory is placed inside a plastic bag. The bag is sealed and taped to the inside of the cooler lid. A copy of the COC form should be included in the paperwork sent to the laboratory. The last block on the COC form should indicate the overnight carrier and the airbill number. The airbill must be filled out before the samples are handed over to the carrier. The laboratory will be notified if the sample contains explosives or if the shipper suspects that the sample contains any other substance that would require laboratory personnel to take additional safety precautions.
- The cooler is closed and taped shut with strapping tape (filament-type).

- At least two signed custody seals are placed on the cooler, one on the front and one on the side. Additional seals may be used if the sampler or shipper determines that more seals are necessary.
- The cooler is handed over to the overnight carrier. A standard airbill is necessary for shipping environmental samples. The shipper should be aware of carrier weight or other policy limitations.

7.0 INVESTIGATIVE-DERIVED WASTE

Both solid and liquid wastes will be generated during field activities. Solid wastes will include disposables such as plastic sheeting and latex gloves. All material will be handled in separate containers by type. Liquid wastes will be limited to decontamination solutions and purge water from well development and pre-sampling activities. Because some quantities of contaminated material may be present, all wastes will be treated as contaminated until definitive data are available to confirm otherwise. Additionally, waste minimization and pollution prevention techniques will be implemented to the greatest extent practicable.

Materials that may become IDW are PPE (disposable coveralls, gloves, booties, etc.), disposable equipment (plastic ground and equipment covers, aluminum foil, broken or unused sample containers, sample container boxes, tape, etc.), cleaning fluids such as spent solvents and washwater, and packing and shipping materials. However, just because these wastes come from a site undergoing remediation (soil removal) does not automatically render them as hazardous wastes under RCRA. Therefore, it must be determined whether the waste itself meets the RCRA definition of a hazardous waste, and if so, the RCRA standards for storing, treatment, and disposal will be applicable to the management of these wastes.

7.1 Characterizing IDW

The most important characterization decision is whether IDW contains "hazardous waste" under RCRA. IDW generated during closure may either exhibit a RCRA characteristic or contain RCRA listed waste. In order to properly handle the IDW, a reasonable effort to determine whether the IDW is hazardous will be made. In order to determine whether a solid waste is designated as a dangerous waste, Fort Lewis will:

1. Determine whether the waste is a listed discarded chemical product, WAC 173-303-081;
2. Determine whether the waste is a listed dangerous waste source, WAC 173-303-082;

3. If the waste is not listed in WAC 173-303-081 or 173-303-082, or for the purposes of compliance with the federal land disposal restrictions as adopted by reference in WAC 173-303-140, determine whether the waste exhibits any dangerous waste characteristics, WAC 173-303-090; and
4. If the waste is not listed in WAC 173-303-081 or 173-303-082, and does not exhibit a characteristic in WAC 173-303-090, determine whether the waste meets any dangerous waste criteria, WAC 173-303-100.

Fort Lewis will make these determinations, in the order listed above, until the determination is made as to whether the waste is designated as a dangerous waste. For the purpose of determining whether a solid waste is a dangerous waste as identified in WAC 173-303-080 through 173-303-100, Fort Lewis will rely on knowledge of the properties of the substances from the characterization of waste munitions and sample results from previous site investigations.

7.2 Management of Non-Hazardous IDW

Nonhazardous PPE, disposable equipment, and/or paper and cardboard wastes will be bagged and placed into the on-site garbage receptacle for off-site disposal. Nonhazardous decontamination fluids will be distributed on the ground to allow infiltration.

7.3 Management of Hazardous IDW

Hazardous IDW will be containerized and disposed off-site at a permitted facility that can demonstrate compliance with RCRA Subtitle C design, operation, and closure requirements. Hazardous waste at YTC is managed through the YTC Hazardous Waste Tracking System and the YTC less than 90-day storage yard.

7.4 Waste Minimization

An effort will be made to minimize the amount of waste generated during sampling activities. Plastic sheeting will be reused as long as sample integrity is not compromised. Decontamination liquid wastes will be minimized by sparing usage. Other waste

minimization and reduction techniques will include segregation, decontamination, compaction, selection of PPE, material recycling, and selection of equipment. Every attempt will be made to keep waste types segregated. Waste minimization and pollution prevention techniques will be documented in project logs and records.

7.5 Long-Term Storage and Disposal

Hazardous waste at YTC is managed through the YTC Hazardous Waste Tracking System and the YTC less than 90-day storage yard.

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8.0 CONTRACTOR CHEMICAL QUALITY CONTROL

Contractor Chemical Quality Control (CCQC) is a three-phase control process consisting of a preparatory phase, initial phase, and the follow-up phase. The contractor CQC representative will implement and track the CCQC process. The CCQC phases are performed for each definable feature or work. A definable feature is a task that is separate and distinct from other tasks and has separate control requirements. Definable features of this field effort include surface soil sampling and excavation. The three-phase process and a description of the QA/QC samples are provided below.

8.1 Three-Phase CCQC

8.1.1 Preparatory Phase

The following project-specific checklist will be used upon mobilization to the OB/OD site and maintained by the CQC representative:

- Checklist of field equipment and other materials;
- Contract specifications;
- Contract plans;
- SAP;
- Example tables for recording all data;
- Base maps for documenting sampling locations;
- QA sample table;
- Field screening instruments;
- Calibration gas;
- Calibration standards;
- Instrument operating manual;
- Backup instrument for field screening;
- Sample collection equipment;
- Labels for sample containers;
- Examples of completed sample shipping documents (e.g., airbills);

- Sample containers of the types to be used for each analysis;
- COC forms;
- COC seals;
- Sample shipping coolers;
- Strapping tape;
- Sample packing materials, including plastic bags and vermiculite;
- Ice/cool packs for shipping containers; and
- Laboratory information: name, address, phone number, POC, turnaround time for analyses, and documentation that all laboratories have been notified that the samples will be shipped and confirmation that the laboratory will accept the samples.

The CQC representative, in conjunction with the sampling team, will conduct the preparatory phase prior to beginning any definable feature of the work. It includes a review of work requirements, a physical examination of required materials and equipment, an examination of the work area to ascertain completion of preliminary work, and a demonstration of field activities. If new sampling or technical personnel arrive on-site during the work effort, the CQC representative must repeat this phase before new personnel begin work. The CQC representative will also review pertinent sections of the plans and specifications during a preparatory meeting to ensure that field personnel are cognizant of the overall project DQOs as well as any specific sampling and analysis requirements. This should include reading the sections aloud, if necessary, to clarify the requirements. This review will include the following, at a minimum:

- The SAP will be reviewed in detail.
- All instruments will be calibrated using the certified calibration standards, gases, etc.
- Equipment decontamination procedures will be demonstrated in detail using the proper decontamination solutions in accordance with the SAP.
- A full set of sample custody forms will be completed and used as a guide during sampling. The sample numbering system will be discussed. The laboratory addresses and phone numbers will be recorded on the form. Analytical test methods will be discussed and recorded on the form. Caution should be exercised to ensure that the test method is clearly specified. Sample preservation will be recorded on the form. All required data will be documented on this sample form.

- The sampling team will demonstrate in detail how each type of sample will be collected, using the intended sample containers, sampling equipment, decontamination procedures, and data reporting requirements.
- Laboratory turnaround times will be established and documented in the minutes of the preparatory meeting. The CQC representative will present a tracking system to ensure that all data are received in a timely manner.

Activities that involve only contractor personnel may be reviewed/performed and documented prior to mobilizing to the site.

8.1.2 Initial Phase

The following checklist of activities will be utilized by the CQC representative during the field effort:

- The CQC representative will oversee the sampling activities and review the work for compliance with contract requirements.
- Individual sample labels and COC forms will be inspected for accuracy, completeness, and consistency.
- The packaging and shipping of the samples will also be inspected by the CQC representative.
- Initial instrument calibration and ongoing calibrations will be observed, verified, and documented.
- Field notes will be inspected to ensure that all pertinent data are recorded in accordance with the contract requirements.
- The sampling team leader will complete the table that matches up primary and QA samples, at the conclusion of each day of sampling and attach a copy of the Daily Chemical Quality Control Reports (DCQCRs).

8.1.3 Follow-Up Phase

The CQC representative is responsible for continued daily contract compliance until completion of the field work.

8.2 **Field and Laboratory Control Samples**

The samples described below include field control and/or laboratory QC samples used to assess the source of error at each stage of the sampling and analytical process.

8.2.1 **Field Control Samples**

The applicability and appropriateness of the field sampling protocol can be verified by the inclusion of a program of scheduled field control samples, such as field replicates [duplicates, splits, field spikes, field blanks (rinsate/equipment, bottle, and trip), and background (upgradient) samples]. All field control samples will be handled exactly as the environmental samples. The identity of field control samples collected must be held blind to the laboratory until the data are reported.

Field replicates are samples taken in quantity at a particular location or time in order to assess error associated with sample heterogeneity, sampling methodology applicability, and sample handling technique. The different types of replicates include field duplicates/triplicates, field splits, or field spikes. Field replicates matrices whose subsequent analysis allows prior homogenization of the media are obtained from one location in sufficient volume to fill all sample containers. The media is then homogenized, divided into two or more equal parts, and aliquots of each part are used to fill each sample container.

Blank samples associated with this field sampling effort include rinsate (equipment) blanks, temperature blanks, and field blanks. These blank samples are described below:

- **Rinsate (Equipment) Blanks.** Rinsate blanks are samples of analyte-free (deionized) water that are rinsed over decontaminated sampling equipment, collected, and submitted for analysis. These samples are used to assess cross-contamination from the sampling equipment, in addition to incidental contamination and/or the sample container.
- **Temperature Blanks.** A temperature blank is a container (e.g., 40 mL) of water packaged along with the field samples in the shipping cooler that will

represent the temperature of the incoming cooler upon receipt at the laboratory. Use of these samples within a shipping container enables the receiving laboratory to assess the temperature of the shipment without disturbing any project field samples.

- Field Blanks. A field blank is a container (e.g., 40 mL) of distilled water (a "clean" sample) that is otherwise treated the same as other samples taken from the field. These samples are used to detect any contaminants that may be introduced during sample collection, storage, analysis, and transport.

8.2.2 Laboratory QA/QC Procedures

Laboratory QA/QC procedures are implemented in order to prevent, detect, and correct errors in the analytical process. It should be emphasized that additional samples are required when matrix spike (MS)/matrix spike duplicate (MSD) analysis is required to assess the appropriateness and accuracy of the laboratory's analytical method with regard to the matrix under investigation. Laboratory QA/QC procedures are discussed in detail in the QAPP.

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9.0**DAILY CHEMICAL QUALITY CONTROL REPORTS**

During the field investigation, DCQCRs will be prepared, dated, and signed by the CQC representative. These reports will include weather information at the time of sampling, field instrument measurements, calibrations, departures from the approved SAP, problems, and instructions from government personnel. Any deviations that may affect DQOs must be conveyed to the USACE Technical Manager immediately. The following should be attached to the DCQCRs: QA sample tables that match up primary and QA samples (refer to Section 8.0), copies of COC forms, and any other project forms that are generated.

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10.0

CORRECTIVE ACTIONS AND CHANGE CONTROL

In the event a discrepancy is discovered by field personnel, or during an audit, and/or the laboratory discovers discrepancies or problems, the following actions will be taken:

1. The CQC representative will complete a Corrective Action Report (CAR) (Figure 10-1) with the assistance of the appropriate persons or parties involved and include a description of the discrepancy in the DCQCR (include attachments if required).
2. The CAR will be reviewed by the contractor task leader and approved or revised per the task leader's comments.
3. The CAR will be reviewed by the installation POC and approved or revised per the reviewers' comments.
4. If the corrective action has previously been implemented and meets the approval of the contractor task leader and the installation POC, the CQC representative will close out the CAR. If corrective action remains to be implemented, the appropriate actions will be taken as defined by the CAR that has been approved by the contractor task leader and the installation POC. The CQC representative will monitor the progress of the corrective action and close out the CAR upon completion.

Typical discrepancies or problems include, but are not limited to, improper sampling procedures, improper instrument calibration procedures, improper sample preservation, problems with samples upon receipt at the laboratory, etc.

Proposed deviations from this FSP or related documents (scope of work, QAPP, etc.) must be documented and approved on a Change Control Approval Form (Figure 10-2). Also, proposed corrective actions that may affect costs will be documented and approved on the Change Control Approval Form. The purpose of this form is to prevent field personnel from implementing a technical change without client approval and consideration of the impacts to schedule and budget. Proposed changes brought to the attention of the contractor field task leader by client representatives, sampling personnel, or others will be processed in the following manner:

<p>URS GROUP, INC.</p> <p>CHANGE ACTION REPORT</p> <p>PROJECT:</p>
<p>Initiator Name: _____ Observation Date: _____ Time: _____</p>
<p>PROBLEM DESCRIPTION:</p>
<p>CORRECTIVE ACTION:</p> <p style="text-align: center;">Date Completed: _____</p>
<p>APPROVAL SIGNATURES:</p> <p>Radian CQC Representative: _____ Date: _____</p> <p>Client Point of Contact: _____ Date: _____</p>

Distribution:

Figure 10-1. Example CAR

1. A Change Control Approval Form will be initiated by the contractor task leader with the assistance of the appropriate persons or parties involved (include attachments if required).
2. The Change Control Approval Form will be submitted to and reviewed by the contractor task leader for approval. If the change is out of the scope of the current scope of work and/or will affect costs, the task leader will obtain appropriate contractor management and client approval before approving the change.
3. The Change Control Approval Form will be submitted to and reviewed by the installation POC and USACE field POC for approval.
4. Completed Change Control Approval Forms will be copied to the CQC representative for inclusion in the DCQCR.

Proposed changes may include, but are not limited to, moving a sampling location, modifying sampling procedures, adding or reducing the number of samples collected, etc.

11.0 PROJECT SCHEDULE

Table 11-1 presents the schedule for the project. Updates or changes to the schedule will be reflected in monthly reports submitted to the client and distributed to the contractor field task leader and-CQC representative.

Table 11-1
Project Schedule

Task	Duration (Days)
Mobilize to site	1
Collect closure samples	1
Analytical results – turnaround time	2
Excavate soil	1
Backfill	1
Demobilize from site	1

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SAMPLING AND ANALYSIS PLAN
FOR THE CLOSURE OF THE
UNSERVICABLE MUNITIONS
TREATMENT UNIT AT RANGE 14
YAKIMA TRAINING CENTER
YAKIMA, WASHINGTON

Part 2: Quality Assurance Project Plan

Prepared for:

U.S. Army Corps of Engineers
Mobile, Alabama

Prepared by:

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1093 Commerce Park Drive, Suite 100
Oak Ridge, Tennessee 37830

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1.0 PROJECT DESCRIPTION

The USACE Mobile District contracted URS Group, Inc. to conduct an investigation of the UMTU at YTC, Washington. This work is being conducted to support the closure of the UMTU located within Range 14. Refer to Section 1.0 of the FSP for additional information.

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2.0

PROJECT ORGANIZATION AND RESPONSIBILITIES

The project team for the site characterization is presented in Section 2.0 of the FSP.

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3.0 PROJECT OBJECTIVES FOR DATA MEASUREMENT

In order to generate data that will meet project-specific requirements, it is necessary to define the types of decisions that will be made and to identify the purpose of the data. DQOs are an integrated set of specifications that define data quality requirements based on the intended use of the data. Project-specific DQOs are established to encompass both field and laboratory operations.

3.1 DQO Development Process

The DQO process is a seven-step iterative planning approach used to prepare plans for environmental data collection activities. It provides a systematic approach for defining the criteria that a data collection design should satisfy, including when, where, and how to collect samples, determining the tolerable decision error rates, the number of samples that should be collected, and measurement quality objectives (QC acceptance limits) for data quality indicators (DQIs) such as the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters.

The DQO process was used to develop a data collection design for evaluating the site against the risk-based cleanup levels required for clean closure of the UMTU. The seven-step process and outputs are discussed below.

(1) State the Problem

Based on September 2000 soil sampling data, the concentration of nitroglycerin at one of the sampling locations exceeded the risk-based clean closure standard developed using MCTA Method B procedures. The conceptual site model, presented in Figure 3-1, illustrates the contamination problem in terms of the potentially contaminated media and migration pathways and potential human and ecological receptors. The source of potential contamination is located within 6 in. of the surface of the soil. Based on clean closure requirements specified in WAC, a

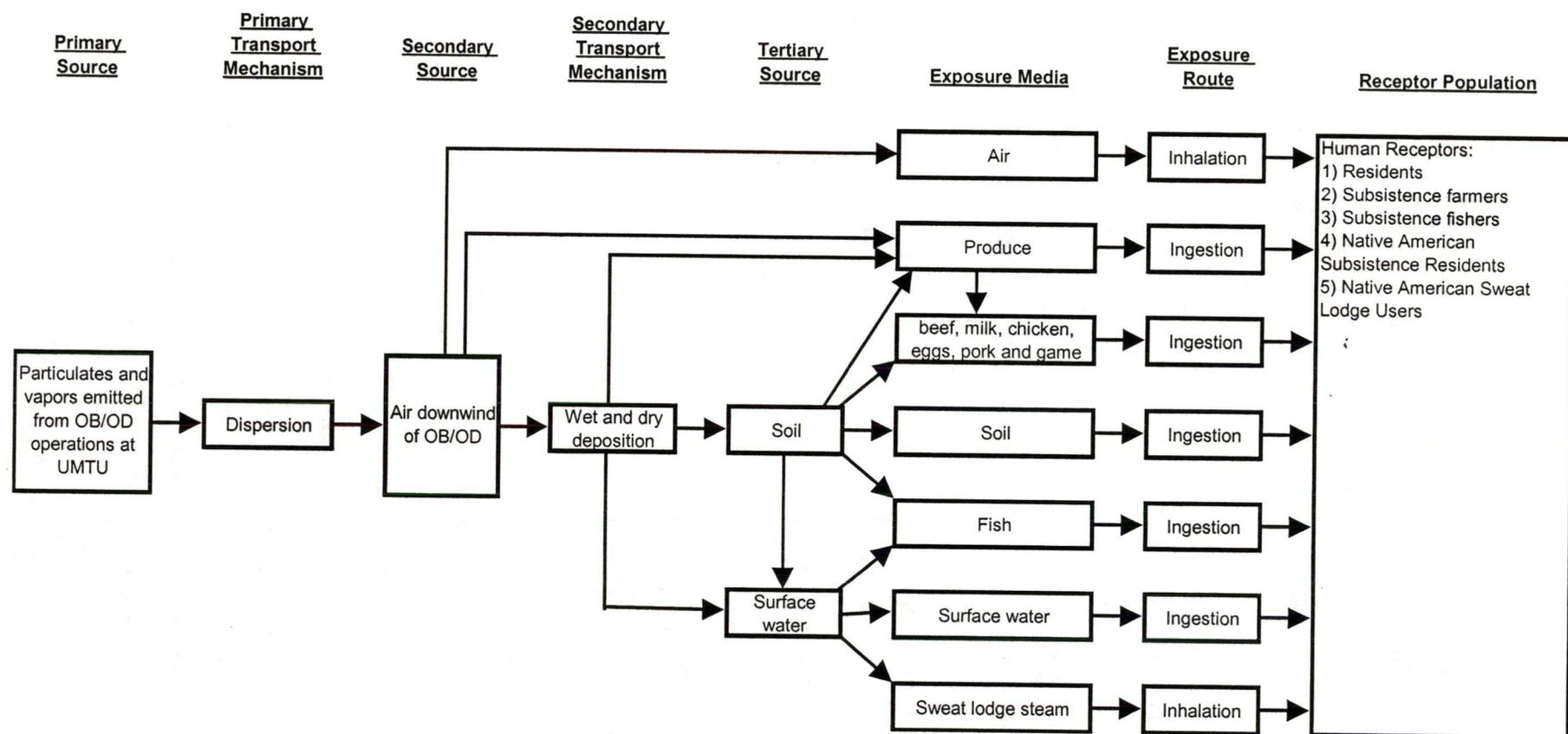


Figure 3-1. Conceptual Site Exposure Model

residential land use scenario is being evaluated; therefore, the primary exposure scenario at the site will be nitroglycerin contamination of the surface soils ingested by children.

(2) Identify the Decision

Based on the problem stated in Step 1, the investigation will proceed in two phases. The first phase will address the sampling to determine whether the site is currently in compliance with the clean closure standards. If the site is not currently in compliance, the second phase will involve the remediation (removal) of the contaminated soil and the subsequent soil investigation to ensure compliance with the standards. The principal study question for each of these phases can be stated as *“Does the concentration of nitroglycerin in the surface soil exceed risk-based concentration limits?”* The two alternative actions that can be taken based on the outcome of the investigation are:

- Recommend that the site is in compliance with the clean closure levels and proceed with clean closure of the site or
- Recommend that the contaminated soil be removed and replaced with clean backfill.

The alternative actions and the principal study question were combined into a decision statement that presents a choice among alternative actions: *“Determine whether nitroglycerin contamination of the surface soil poses a hazard to the health of a child resident by exceeding clean closure risk-based standards and warrants remediation or whether the contamination is less than clean closure levels and YTC may proceed with clean closure of the UMTU.”*

(3) Identify Inputs to the Decision

In order to determine whether the concentration of nitroglycerin in the surface soils exceed risk-based clean closure limits, the clean closure levels must be known. This value was calculated in accordance with Method B cleanup procedures [WAC 173-340-740(3)(b)(iii)(B)(II)], using a toxicity value of 1.40×10^{-2} mg/kg-day for nitroglycerin (per

Health Effects Assessment Summary Tables). SW-846 Method 8332 is the most appropriate analytical method for this investigation, providing the most accuracy and precision available for measuring nitroglycerin in soils. The standard MDL for Method 8332 is 1.0 mg/kg, well below the action level of 71 mg/kg required for clean closure of the site.

(4) Define the Boundaries of the Study

The population of interest is the nitroglycerin contained in the surface soils at the suspected hot spot (sampling location identified from past sampling data). The spatial boundary for this investigation was selected on the basis of the cleanup standard being defined in terms of the child resident being exposed to the contaminant via ingestion and dermal contact. One of the primary activities of children that exposes them to soil is playing in their backyards in play areas that are devoid of vegetation. The average area of a backyard play area is 14 × 14 ft; therefore, the spatial boundary has been defined as the 15 × 15-ft area surrounding the hot spot and the 0 to 6-in. deep soil layer. The scale of decision-making (the smallest unit to which the decision rule is applied) for this investigation was based on an efficient area/volume of soil that can be removed with the backhoe and is defined as the 5 × 5-ft area surrounding the suspected hot spot. Since the nitroglycerin is relatively stable over time, no temporal boundary has been placed on the study. Sampling and excavation constraints include the presence of UXO at the site.

(5) Develop a Decision Rule

The decision rule is defined in terms of an “if...then” statement that combines the qualitative information about the site with the measurable, health-based concentration criteria. The decision rule is developed by specifying the statistical parameter that characterizes the population of interest, specifying the action level for the decision, and confirming that the action level is above measurement detection limits so that reliable comparisons can be made.

The statistical parameter of interest is a descriptive measure such as mean, median, difference between two means, etc., that specifies the characteristic or attribute that the decision-maker would like to know about the statistical population. In measuring the long-term

effects of a contaminant in the surface soil, the amount of risk is based on the mean concentration of the contaminant because this parameter best represents the random integration of exposure over the long term. Likewise, in accordance with WAC 173-340-740(7)(c)(iv)(B), for cleanup levels based on carcinogenic threats (such as nitroglycerin), the true mean soil concentration shall be used to evaluate compliance with cleanup levels.

The action level is a contaminant concentration or numerical value that is used to decide whether the contamination levels are unacceptable. For this evaluation the action level is the Method B cleanup level calculated in accordance with WAC 173-340-740(3)(b)(iii)(B)(II) (71 mg/kg).

Using these inputs, the decision rule is as follows: *If the mean concentration of nitroglycerin in the surface soil is less than 71 mg/kg, the site will be in compliance with the risk-based clean closure standards and will be clean closed as is. Otherwise, if the mean concentration of nitroglycerin in the surface soil is greater than or equal to 71 mg/kg, the soil will be removed and backfilled with clean soil.*

(6) Specify Tolerable Limits on Decision Errors

The possible range of the parameter of interest, in this case the mean concentration, was estimated as 0 to 230 mg/kg. The lower limit of 0 mg/kg reflects the absence of nitroglycerin, whereas the upper limit of 230 mg/kg reflects the maximum concentration detected in the September 2000 data.

The two potential decision errors that could be made based on interpreting sampling and analytical data are:

- Decision Error A: Concluding that the mean nitroglycerin concentration was less than 71 mg/kg when it was truly greater than 71 mg/kg, or
- Decision Error B: Concluding that the mean nitroglycerin concentration was greater than 71 mg/kg when it was truly less than 71 mg/kg.

The consequences of Decision Error A, incorrectly deciding the site was “clean” (mean nitroglycerin concentration less than 71 mg/kg), would leave contaminated soil at the site. The consequences of Decision Error B, incorrectly deciding the site was “not clean” (mean nitroglycerin concentration greater than 71 mg/kg), would cause the needless expenditure of resources. Decision Error A has the more severe consequences since the true state of soil contamination (nitroglycerin present above clean closure standards) may impact human health and the environment. Therefore, the baseline condition (null hypothesis) chosen for the site was that the mean nitroglycerin concentration in the surface soils was truly greater than or equal to the action level of 71 mg/kg. The alternative condition (alternative hypothesis) is that the mean nitroglycerin concentration in the surface soils was truly less than the action level of 71 mg/kg.

The false rejection decision error will occur if the null hypothesis is falsely rejected (a decision that the mean is less than 71 mg/kg when it is actually greater than or equal to 71 mg/kg) and the false acceptance decision criteria will occur if the null hypothesis is falsely accepted (the data indicate that the mean concentration is greater than or equal to 71 mg/kg when, in fact, the true concentration is less than 71 mg/kg).

The gray region (where the consequences of a false acceptance decision error are relatively minor) occurs where the sample data tend toward rejecting the baseline condition but the evidence is not sufficient to be overwhelming. The width of the gray region can be wide during cleanup attainment evaluation since use of a wide gray region will usually yield conclusive evidence that the site is clean (successful remediation). The first boundary of the gray region is set equal to the action level (71 mg/kg). The other boundary is established by evaluating the consequences of a false acceptance decision error over the range of possible parameter values in which this error may occur. The boundary corresponds to the parameter value at which the consequences of a false acceptance decision error are significant enough to have to set a limit on the probability of this error occurring. For this evaluation, a concentration of 35 mg/kg was selected as the desired lower limit for the gray region.

The tolerable false rejection decision error rate was set equal to 0.05 and the false acceptance decision error rate was set equal to 0.20. These rates balance the high number and

costs of sampling to investigate a site that is actually clean (false acceptance decision) with the impact of failure to remove contaminated soil if the data indicate the site is clean when it actually exceeds clean closure standards (false rejection decision). False rejection decision errors are higher than the most stringent limits that are typically used for environmental data due to the future use of the area as a training range (residential exposure is not imminent) and the access restrictions (only military personnel can access the site) that are currently in place.

(7) Optimize the Design for Obtaining Data

The outputs from the previous steps of the DQO process provide a succinct collection of information that is used to develop the data collection design. Specifically, the inputs, boundaries, and decision rule are used to determine the type, location, and timing of samples and the limits on decision errors provide crucial information for selecting the number of samples to be collected.

Using the DQO information in coordination with the DQOs DEFT software program developed by EPA, 10 samples will be required to meet the DQOs. Grab samples from a depth of 0 to 6 in. will be collected and analyzed for nitroglycerin. The sample locations will be determined in accordance with the procedures established for systematic sampling (i.e, laying a two-dimensional square grid over the sampling area and sampling in a pattern of equally spaced points). See Section 4.1.1 of the FSP.

3.2 Data Quality Objectives

3.2.1 Data Uses and Needs

Analytical results from previous site sampling indicated that the concentrations of all site contaminants were less than the cleanup levels (when compared directly to the MTCA Method B standards) with the exception of nitroglycerin. In order to demonstrate clean closure of the UMTU, WAC 173-303-610(2) requires that all site contaminants comply with the Method B cleanup levels assuming residential exposure. Data from the initial round of sampling will be

evaluated against the nitroglycerin Method B soil cleanup level. If the data indicate that the current site concentration is not less than the cleanup level, the contaminated soil will be removed and post-excavation sampling will be completed. This sampling data will be used to confirm that all contaminated soil has been removed.

3.2.2 Data Types

Surface contamination is the prime focus for both phases of sampling. In addition, since the previous analyses indicated compliance with contaminants of potential concern, only nitroglycerin will be considered.

3.2.3 Data Quality Needs

In order to use the data to demonstrate compliance with the cleanup levels, Level III data will be required. The samples will be analyzed for nitroglycerin using Method 8332 (modified), and the level of concern is 71 mg/kg. This level is based on a residential exposure scenario (direct contact/ingestion of contaminated soil). Given the relatively high cleanup level, detection limits in the low mg/kg range will be acceptable.

3.2.4 Data Quantity Needs

To provide a representative and unbiased measure of nitroglycerin within the sampling area, soil samples will initially be taken from the 0–6-in. depth interval. The samples will be located on a two-dimensional grid established in accordance with systematic sampling protocol. The EPA DEFT software program was used to calculate the number of samples required to meet user-specified DQO constraints such as limits on decision errors, assuming a population mean is being compared to a fixed action level (i.e., the cleanup level). The software predicted 10 soil samples, consistent with WDOE Toxics Cleanup Program *Guidance on Sampling and Data Analysis Methods* (WDOE 1995), which states that a minimum of 10 sample locations for each contaminant be analyzed to reduce the chances of failing to demonstrate compliance with a cleanup level for an area that is actually clean.

If post-excavation sampling is required, samples will be collected from the 0–6 in. depth interval from the bottom and four sides of the excavation. The sample locations will be selected as the approximate center point of the bottom and side walls.

3.2.5 Sampling Analysis Options

The primary drawback of on-site data is the low accuracy and precision of the method. To demonstrate compliance with risk-based clean closure standards, analytical levels synonymous with risk assessment data uses are recommended (i.e., data for risk assessment purposes should be a minimum of Level III). On-site data provide only Level II quality due to lower accuracy and precision of the field methods. Therefore, Level III is preferred and analytical Method 8332 will be used to analyze the samples.

3.3 Measurement Quality Objectives

To ensure that quality data are continuously produced during analysis and allow the eventual compliance review, systematic QC checks are incorporated into the sampling and analysis to show that procedures and test results remain reproducible and that the analytical method is actually measuring the quantity of target analytes without unacceptable bias. Systematic QC checks include field and laboratory replicates, standards, surrogates, spiked samples, and blanks. Measurement quality objectives for these systematic QC checks are established to verify that the DQIs support data usability and contract compliance. This program of systematic QC checks involves two areas: batch QC and matrix-specific QC.

3.3.1 QC Checks of Known Composition Samples

General batch QC are those QC procedures applied to an interference-free matrix or a matrix of known composition [blanks, laboratory control samples (LCSs), standard reference materials, calibration verification standards, etc]. These procedures ensure that the sampling procedures are appropriate and the analytical method is being performed in an in-control mode of operation; however, these QC checks provide no information on how well the method is

performing with respect to the project sample matrix. Table 3-1 provides a summary of the measurement quality objectives for batch QC procedures for Method 8332.

Table 3-1
Summary of Measurement Quality Objectives for Method 8332

Applicable QC Procedures	Use	Criteria	Corrective Actions
General Batch QC			
Method Blank	Interference-free blank matrix to which all reagents are added in the same proportions used in sample preparation and carried through the complete sample preparation, cleanup, and determinative procedures	Concentration of nitroglycerin below one-half the method reporting limit	Find/reduce/eliminate the source of contamination
	Used to assess background interference or contamination that exists in the analytical system	If nitroglycerin is found in both the method blank and in some or all of the other batch samples	Reanalyze the method blank and any samples containing the contaminant
	Determine acceptability of the data generated for that batch of samples	If contamination remains	Re-prepare the contaminated samples of the batch and reanalyze with a new method blank and batch-specific QC samples
Laboratory Control Samples	A purified solid matrix (sand, sodium sulfate, etc.) that is spiked with all single-component target analytes before it is carried through the preparation, cleanup, and determinative procedures	Water: Percent recovery = 60%–120%	Reanalyze LCS for failed analytes only
	Used to assess general method performance based on the ability of the lab to successfully recover the target analytes from a control matrix	Solids: Percent recovery = 60%–120%	If second analysis fails, LCS, Method Blank, and all associated samples of the batch will be re-prepared and reanalyzed for the failed analytes only
	Determine acceptability of the data generated for that batch of samples		Flag sample results within the batch and discuss the impact on the data within the case narrative
Matrix-Specific QC			
MSs	An environmental sample to which known concentrations of certain target analytes have been added before sample manipulation from the preparation, cleanup, and determinative procedures have been implemented	Percent recovery = 50% - 140%	Re-spike the sample at a higher level then re-analyze

Table 3-1
(Continued)

Applicable QC Procedures	Use	Criteria	Corrective Actions
MSs	Used to assess the performance of the method as applied to a particular project matrix Determine the effect of the matrix on the bias of the analysis		If matrix effect cannot be resolved, discuss the impact on the data within the case narrative
MSD	A duplicate of the MS carried through the complete sample preparation, cleanup, and determinative procedures	Relative Percent Difference (RPD) = 50%–60%	Same as MS
	Used to assess the performance of the method as applied to a particular project matrix and to provide information on the homogeneity of the matrix		
	Determine the effect of the matrix on the precision of the analysis		
Surrogates	Organic compounds that are similar to the analytes of interest in chemical behavior but are not normally found in environmental samples	Water: Percent recovery = 60%–140%	Implement additional cleanup procedures and re-analyze
	Used to assess the ability of the method to successfully recover these specific non-target analytes from an actual matrix	Solids: Percent recovery = 50%–150%	
	Determine the effect of the matrix on the bias of the individual sample	Project Sample Matrix: Percent recovery = 50%–150%	If interference not reduced, discuss the impact on the data within the case narrative
Target Analyte Confirmation	Use of a second analytical technique (e.g., gas chromatograph/mass spectrometry) to confirm the presence of an analyte	RPD = 40%	

3.3.2 QC Checks of Matrix-Specific Samples

Matrix-specific QC procedures provide information on the precision and bias of the analyses on project samples. These procedures include the analyses of field samples in association with surrogate compounds, MSs, MSDs, and/or matrix duplicates. Matrix-specific procedures must be performed on project field samples in order to provide information on the matrix under observation. An additional sample has been included in the sample matrix to ensure

adequate sample volume to perform the matrix-specific analyses. Table 3-1 provides a summary of the measurement quality objectives for matrix-specific QC procedures for Method 8332.

3.4 Data Quality Indicators

DQOs define data quality requirements in order to obtain sufficient data of known defensible quality. These objectives are established based on the intended use of the data being generated and are represented by a set of parameters consisting of PARCC and sensitivity requirements, which establish the standard criteria for reviewing project data results.

QC procedures are employed during chemical analysis to support and document the attainment of established measurement quality objectives. Whether these QC procedures support an assessment of general batch control or matrix-specific application, documentation must include calculating DQIs to verify data usability and contract compliance.

3.4.1 Precision

Precision refers to the distribution of a set of reported values about the mean, or the closeness of agreement between individual test results obtained under prescribed conditions. Precision reflects the random error and may be affected by systematic error. Precision also characterizes the natural variation of the matrix and how the contamination exists or varies within that matrix. Field precision is commonly determined from field duplicate samples or QA split samples. Laboratory precision is commonly determined from laboratory duplicate samples (MS/MSD samples).

For chemical analysis of environmental samples for this project, precision will be determined from duplicate laboratory sample analyses; therefore, precision will be expressed as RPD. Every batch of samples analyzed will include MSs and/or MSDs to evaluate precision. Precision determined by RPD will be calculated as follows:

$$\text{RPD} = \{[\text{absolute value of } (X_1 - X_2)] / [(X_1 + X_2) / 2]\} \times 100\%$$

Where:

- X₁ = primary sample result,
- X₂ = duplicate sample result.

QC samples will be analyzed to determine the precision achieved. The measurement quality objective for precision is 50 to 60% RPD.

3.4.2 Accuracy

Accuracy is the measure of the closeness of an observed value to the “true” value (e.g., theoretical or reference value, or population mean). Accuracy includes a combination of random error and systematic error (bias) components that result from sampling and analytical operations. Sources of error include the sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analysis techniques. Strict adherence to the FSP will eliminate process and handling errors, prevent cross-contamination of samples and equipment, and ensure that all samples are properly preserved.

Accuracy will be determined from spiked samples (laboratory control and MS samples) for this project and will be expressed as percent recovery (%R). Accuracy determined by percent recovery is calculated as follows:

$$\%R = [(X_s - X_u)/K] \times 100\%$$

Where:

- X_s = measured value of the spiked sample,
- X_u = measured value of the unspiked sample,
- K = known amount of the spike in the sample.

The measurement quality objective for accuracy is 50% to 140%.

3.4.3 Representativeness

Representativeness refers to the degree to which sample data accurately and precisely describe the characteristics of a population of samples, parameter variations at a

sampling point, or an environmental condition. Samples that are not properly collected (in accordance with the approved FSP) or preserved or are analyzed beyond acceptable holding times will not be considered to provide representative data.

The representativeness criterion is best satisfied in the laboratory by making certain that all subsamples taken from a given sample are representative of the sample as a whole. This will include sample premixing/homogenizing prior to and during aliquotting procedures. In addition, the use of a systematic sampling grid will help to ensure representativeness of the soil samples.

3.4.4 Completeness

Completeness is the percentage of measurements made that are judged to be valid measurements compared to the total number of measurements planned. Any critical samples will be identified to ensure that valid data are obtained in order to obtain the requisite type, quantity, and quality of data necessary to complete the project. The number of samples needed to meet project DQOs has been determined as discussed in Section 3.1. The Routine Analytical Services (RAS) Contract Laboratory Program (CLP) historical completeness is approximately 80–85%. If valid analytical results are not obtained for the clean samples, a new sample aliquot will be analyzed.

Completeness, expressed as percent complete (%C), will be calculated for the project as a whole as follows:

$$\%C = (V/N) \times 100\%$$

Where:

- V = number of measurements judged valid,
- N = number of valid measurements needed to achieve DQOs.

3.4.5 Comparability

Comparability is a qualitative objective of the data, expressing the confidence with which one data set can be compared to another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal will be achieved by using standard methods to collect representative samples, consistent application of analytical method protocols, and reporting analytical results with appropriate units. Comparability is unknown unless precision and bias (percent recovery – 100) are provided. Using this information, the data sets can be compared with confidence. The use of standard soil sampling procedures and recognized field and laboratory techniques should make the resulting data comparable with other similar measurements on similar samples.

3.4.6 Sensitivity

The term sensitivity is used broadly here to describe the method detection/quantitation/reporting limits established to meet the project-specific DQOs. The MDL is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. To determine a valid MDL, the laboratory can analyze an MDL check sample by spiking an interference-free matrix with target analytes at approximately two times the calculated MDL. The true MDL is determined as the lowest detected concentration for samples taken through appropriate method procedures. Low-level detection in the project matrix is not critical; therefore, quarterly analysis of the MDL check sample is sufficient for this project. Per USACE standards, the method quantitation limit (MQL) will be set at a minimum of three times the MDL and target analyte values detected and reported below the MQL must be flagged as an estimated quantity.

3.5 Data Quality Assessment

Similar to sampling plan designs, planning an approach to analysis and the actual analysis must begin before the first sample is collected. The first task of the analysis plan is to

determine how the cleanup standard should function (i.e., is the cleanup standard a value that should rarely be exceeded, an average value, or a level that defines the presence of a hot spot). This must be decided because it determines what analysis method will be used to determine attainment. The analysis plan must also be developed in conjunction with the sampling plan. The analysis plan describes the evaluation of the resulting data.

Once the DQOs are established and samples have been collected and measured, the Data Quality Assessment (DQA) process is used to assess whether the DQOs have actually been attained. DQA is the scientific and statistical evaluation of data to determine whether the data are of the right type, quality, and quantity to support their intended use.

As stated in WAC 173-340-740, data analysis procedures for evaluating compliance with soil cleanup levels should be based on a confidence interval approach to demonstrate that the upper one-sided 95% confidence limit on the true mean soil concentration is less than the cleanup soil level. Therefore, the proposed data analysis plan is to evaluate the data using a test of the means for systematic sampling.

3.5.1 Review DQOs and the Sampling Design

The key outputs from the DQO process will be reviewed as well as the methods used to collect and measure the sample concentrations and report the results. This retrospective look at the sampling plan will help to ensure that the decisions are supported by data of adequate quality. Since the DQOs have already been established (as discussed above), this step will most likely be limited to a review of the sampling design and noting any problems that occurred while implementing the sampling design. Any significant deviations from the sampling plan will be flagged so that their potential effect can be considered throughout the entire DQA process.

3.5.2 Conduct a Preliminary Review of the Data

A preliminary evaluation of the data will involve calculating basic statistical quantities and examining the data using graphical representations. The first task will be a review

of any relevant QA reports that describe the data collection and reporting process as it actually was implemented. The reports that will be reviewed include data validation reports (sample collection, handling, analysis, data reduction, and reporting procedures) and QC reports from the laboratories. Any apparent anomalies in recorded data, missing values, deviations from SOPs, and the use of nonstandard data collection methodologies will be noted.

Since compliance with the cleanup levels is based on the test of the means, the following statistical quantities will be summarized: number of observations, measures of central tendency (mean), measures of dispersion (range, variance, standard deviation, coefficient of variation), and measures of distribution shape.

Trends and patterns in the data that could go unnoticed using the purely numerical methods (statistical quantities) will be identified by graphing the data. At a minimum, a graphical presentation of the individual data points and a graphical representation of the statistical quantities will be prepared. A normal probability plot will be used to roughly determine how well the data set is modeled by a normal distribution. In addition, a posting plot (a map of data locations along with corresponding data values) will be prepared in order to reveal any obvious errors in data location and identify data values that may be in error.

3.5.3 Select the Statistical Test

The results of the preliminary data review will be used to determine whether the statistical test specified in WAC 173-340-740(7)(d)(i)(A) (upper 95% confidence level) is a legitimate test for the data collected. D'Agostino's test and/or censored probability plots will be used to determine whether the data are normally or lognormally distributed. The upper one-sided 95% confidence limit on the true mean soil concentration will be calculated using Land's method if the data are lognormally distributed.

3.5.4 Verify the Assumptions of the Statistical Test

Calculating the 95% UCL requires knowledge of whether the data are normally or lognormally distributed. In order to determine the distribution of the data, the Shapiro-Wilk test for normality (the W test) will be used as provided in *MTCASat*. If the data are lognormally distributed, the UCL will be calculated using Land's method. If the data are normally distributed, the UCL will be calculated using the t-statistic. Both of these calculations will be completed using *MTCASat* program provided by WDOE.

Reliable statistical methods do not exist for estimating a UCL for the mean from unknown distributions where only a small number of samples are available. However, as discussed in *Statistical Guidance for Ecology Site Managers* (WDOE 1992), the UCL (based on a Z-statistic) may be used even though the sample size is small. If the Z-statistic cannot be determined (using *MTCASat*), the largest value in the data set will be compared directly with the cleanup level.

3.5.5 Draw Conclusions from the Data

In accordance with WAC 173-340-740(7)(e), compliance with clean closure standards will be demonstrated if the analytical results of the samples collected during closure indicate that:

- The upper 95% confidence limit on the true population mean does not exceed the cleanup level,
- No single sample concentration is greater than two times the soil cleanup level, and
- Less than 10% of the sample concentrations exceed the soil cleanup level.

If the data are lognormally or normally distributed, *MTCASat* will be used to calculate a 95% UCL. If the data do not meet the normal distribution requirement, the Z-statistic will be calculated, if possible. If the Z-statistic cannot be determined, the maximum concentration detected in the sample set will be compared directly with the cleanup level.

4.0

SAMPLING LOCATIONS AND PROCEDURES

The rationale for sampling locations and procedures are discussed in detail in Section 4.0 of the FSP.

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5.0**SAMPLE CUSTODY AND HOLDING TIMES**

Requirements for sample custody and documentation during the field work are discussed in Section 5.0 of the FSP. Custody requirements also apply to the receiving laboratory. Laboratory personnel shall indicate transfer of custody by signing the COC record upon receiving the shipment of samples. This COC record shall be maintained (or an internal COC record) and returned to URS in a timely manner.

The holding time for nitroglycerin by Method 8332 is 7 days prior to extraction and 40 days prior to analysis. However, due to the rapid turnaround of the data required, no exceedances of holding times are anticipated.

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6.0

ANALYTICAL PROCEDURES

The analytical procedures for this project are discussed in Section 3.0. Chemical analyses will be performed according to the following guidelines:

- SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, EPA Office of Solid Waste and Emergency Response, November 1986, Third Edition.
- EPA, *Method for Chemical Analysis of Water and Wastes*, EPA/600/4-79-020, March 1993.

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7.0 CALIBRATION PROCEDURES AND FREQUENCY

7.1 Analytical Support Areas

Preparation and maintenance of standards and reagents will be performed per the specified methods. Primary reference standards and standard solutions used by the laboratory will be obtained from the National Institute of Standards and Technology, an EPA supplier, or other reliable commercial sources to ensure the highest purity possible. Standards and standard solutions will be catalogued to identify the supplier, lot number, purity/concentration, receipt/preparation date, preparer's name, method of preparation, expiration date, and all other pertinent information. Both stock and working standard solutions will be validated before use. Stock and working standards will be checked regularly for signs of deterioration, such as discoloration, formation of precipitates, or change in concentration.

7.2 Laboratory Instruments

Each instrument will be calibrated with standard solutions appropriate to the type of instrument and linear range established within the analytical methods. If the calibration checks do not meet the established criteria, corrective action will be taken. Corrective action is method-specific and may include recalibration and reanalysis of samples. All corrective action procedures implemented will be documented, summarized with the case narrative, and submitted with the analytical results.

Positive values reported below the method-specific low-level standard and above the PQL may be considered estimated. In this instance, the laboratory will be required to analyze an additional low standard at or near the PQL.

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8.0 INTERNAL QUALITY CONTROL CHECKS

Internal QC checks are used to determine whether analytical operations are in control, as well as determining the effect sample matrix may have on data being generated. These two aspects are described as batch QC and matrix-specific QC procedures, respectively. The type and frequency of specific QC samples performed by the laboratory will be according to the specified analytical methods. Acceptance criteria and target ranges for the laboratory QC samples are presented within the analytical methods and summarized in Section 3.0. Data that vary from these target ranges will result in the implementation of appropriate corrective measures. Full documentation of all actions taken will be recorded within a case narrative.

8.1 Batch Quality Control

Typical batch QC for analyses to be performed for this project are described below.

8.1.1 Method Blanks

Method blanks are analyzed to assess the level of background interference or contamination that exists in the analytical system and that might lead to the reporting of elevated concentration levels or false positive data. At least one method blank will be prepared and analyzed with every batch of samples processed. The concentration of target analytes in the blank shall be below the MDL or 5% of the measured concentration in the sample. If the blank does not meet acceptance criteria, the source of contamination will be investigated and appropriate corrective action will be taken and documented. Corrective actions may include reanalysis of the blank and/or reparation and reanalysis of the blank and associated samples at the laboratory's cost. Sample results will not be corrected for blank contamination.

8.1.2 Laboratory Control Samples

Laboratory performance QC will be based on the use of standard control matrices that are prepared independently from the standard solutions used in establishing the calibration

curve, to calculate precision and accuracy data. These QC data will be compared on a per-batch basis, to the control limits of the methods, to verify compliance. This data, along with method blank data, will be used to assess laboratory performance.

8.1.3 Other QC Samples

Additional appropriate QC requirements are detailed within the analytical methods and will be performed.

8.2 Matrix-Specific QC

Matrix-specific QC will be based on the use of an actual environmental sample for precision and accuracy determinations and will rely on the analysis of matrix duplicates, surrogate compounds, MSs, and MSDs. The required frequency of these sample types is established within each specific analytical method. Results of these samples will be used to assess the effect of sample matrix conditions on analytical data.

9.0 CORRECTIVE ACTIONS

When errors, deficiencies, or out-of-control situations exist, the laboratory's QA plan (procedures and corrective actions) shall be implemented to resolve problems and restore proper functioning to the analytical system. The laboratory shall implement corrective actions if the following conditions exist:

- Any QC data are outside the acceptable windows for precision and accuracy.
- Blanks, LCSs containing contaminants above acceptable levels, occur.
- Undesirable trends are detected in spike or surrogate recoveries or RPD between duplicates.
- Deficiencies are detected by the QA department during internal audits or external audits or from results of performance evaluation samples.
- Inquiries concerning data quality are received from URS or URS' client.

Corrective actions and/or procedures shall be required as described in the following subsections.

9.1 Incoming Samples

Problems noted during sample receipt shall be documented on the COC record or an appropriate form. URS shall be contacted immediately by the laboratory for problem resolution. All corrective actions taken shall be thoroughly documented.

9.2 Sample Holding Times

If samples cannot or were not extracted/digested and/or analyzed with the appropriate method required holding times (Section 5.0), URS shall be notified by the laboratory immediately for problem resolution. All corrective actions shall be thoroughly documented.

9.3 Instrument Calibration

Sample analysis shall not be allowed until all initial calibrations meet the appropriate requirements. All calibrations must meet method time requirements or recalibration must be performed. Continuing calibrations that do not meet method requirements shall result in a review of the calibration, rerun of the appropriate calibration standard(s), and if necessary, reanalysis of all samples affected back to the previous acceptable calibration check at the laboratory's cost.

9.4 Practical Quantitation Limits

Appropriate sample cleanup procedures shall be employed to attempt to achieve the PQLs. If difficulties arise in achieving these limits due to a particular sample matrix, the laboratory shall notify URS immediately for resolution. Any dilutions made shall be documented in a case narrative along with the revised PQLs for those analytes directly affected.

9.5 Method Quality Control

All method QC including blanks, matrix duplicates, MSs, MSDs, surrogate recoveries, LCSs, and other method-specified QC samples shall meet the requirements as specified within the analytical method (summarized in Section 3.0). Failure of method-required QC shall result in the review of all affected data. If no errors can be noted, the affected sample(s) shall be reanalyzed and/or re-extracted/redigested, then reanalyzed within method-required holding times to verify the presence or absence of matrix effects at the laboratory's cost. In order to confirm matrix effects, QC results must observe the same direction and magnitude (ten times) bias. If matrix effect is confirmed, the laboratory shall discuss the interference in the case narrative. If matrix effect is not confirmed, the entire batch of samples may have to be reanalyzed and/or re-extracted/redigested, then reanalyzed at the laboratory's cost. The laboratory shall notify URS as soon as possible to discuss possible corrective actions should unusually difficult sample matrices be encountered.

9.6

Calculation Errors

Reports shall be reissued if calculation and/or reporting errors are noted with any given package. The case narrative shall clearly state the reason(s) for reissuance of a report.

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10.0 DATA VERIFICATION, REVIEW, AND EVALUATION

Any time chemical data are generated, their quality must be assessed prior to use. The type and degree of assessment required depends on the project DQOs. Several different levels of data assessment exist; including data verification, data review, data evaluation, and data validation.

10.1 Data Verification

Data verification is the most basic assessment of data. Data verification is a process for evaluating the completeness, correctness, consistency, and compliance of a data package against a standard or contract. In this context, "completeness" means all required hardcopy and electronic deliverables are present.

10.2 Data Review

Data review is the next step in the data assessment hierarchy. Data review involves the assessment of summary QC data provided by the laboratory and includes examination of laboratory data and the internal QC and QA sample results to ascertain the effects on the data.

The initial inspection of the data screens for errors and inconsistencies. The chemist checks the COC forms, sample handling procedures, analyses requested, sample description and sample ID, and cooler receipt forms. The chemist then verifies that the data were checked by the laboratory manager and/or QA officer. Sample holding times and preservation are checked and noted.

The next phase of data quality review is an examination of the actual data. By examining data from laboratory matrix duplicates, blind duplicates, equipment blanks, laboratory method blanks, LCSs, LCS duplicates, MS and MSD samples, and surrogate recoveries, the chemist can determine whether the data are of acceptable quality.

The data review will be used to document possible effects on the data that result from various QC failures, as discussed below.

QC Element/Type of Failure	Possible Effect on Data	Worst Case Data Evaluation
COC chain broken	Incomplete data	Data not legally defensible
Sample labels missing, unreadable, samples mislabeled	Incomplete data; false positives or false negatives	Invalidates all sample results
Use of incorrect sample containers	False positives or false negatives, high or low bias	Invalidates all sample results
No preservative, wrong pH, or too warm/cold	Incomplete data; false positives or false negatives; low bias	Invalidates all sample results
Holding times exceeded	False negatives; low bias	Invalidates all sample results
Use of incorrect analytical method	False negatives; low or high bias; low or high sensitivity	Invalidates or qualifies some or all sample results
Detection limit too high	False negatives; low sensitivity	Invalidates all sample results less than detection limit
Method blank absent	False positives	Invalidates all sample results greater than detection limit; sample results less than detection limit are valid
Method blank contaminated	False positives; high bias	Invalidates all sample results where method blank contamination is greater than 5% of sample concentration
Equipment blank (rinsate blank) contaminated	False positives; high bias	Invalidates all sample results where equipment blank contamination is greater than 5% of sample concentration
LCS absent	False positives or false negatives; poor precision (high or low bias)	Invalidates all sample results
Low recoveries for LCS(s)/LCS duplicate(s)	False negatives; low bias	Invalidates all sample results
High recoveries for LCS(s)/LCS duplicate(s)	High bias; possible false positives	Invalidates all sample results
High RPD(s) for LCS(s)/LCS duplicate(s)	Poor precision; high variability	Invalidates all sample results
Low recoveries for surrogates in method blanks, LCS(s)/LCS duplicate(s)	False negatives; low bias	Invalidates all sample results
High recoveries for surrogates in method blanks, LCS(s)/LCS duplicate(s)	High bias; possible false positives	Invalidates all sample results
Low recoveries for surrogates in samples	False negatives; low bias	Qualifies all sample results (possible matrix effects); rejection of individual sample results
High recoveries for surrogates in samples	False positives; high bias	Qualifies all sample results (possible matrix effects); rejection of individual sample results
MS and/or MSD missing	False negatives; low bias; high bias	Qualifies all sample results (no measure of matrix effects)
Low recoveries for MS and/or MSD	False negatives; low bias	Qualifies all sample results (possible matrix effects)
High recoveries for MS and/or MSD	False positives; high bias	Qualifies all sample results greater than the detection limit (possible matrix effects)

QC Element/Type of Failure	Possible Effect on Data	Worst Case Data Evaluation
High RPD for MS/MSD	Non-representative sample; poor precision; high variability	Qualifies all sample results greater than detection limit
Extremely high dilution factors	Low sensitivity; false negatives; poor accuracy	Invalidates samples with high detection limits; may qualify sample results as "estimated"
QA sample results do not agree with project sample results	Various	Invalidates all or part of data set

10.3 Data Evaluation

Data evaluation is performed to determine whether the data meet project-specific DQOs and contract requirements. A set of six criteria will be evaluated to determine whether performance is within the limits specified for the project. The project manager determines whether the data for each performance measure are satisfactory (data accepted), questionable (data qualified), or unsatisfactory (data rejected).

10.3.1 **Criterion I – Review of Reports**

Data and documentation supplied to the project manager will be evaluated for completeness and appropriateness and to determine whether any changes were made to the SAP during the course of the work. The project manager will review field notes to confirm the location of each sample, any deviations from the SAP, and a description of field conditions and physical parameter data. The project manager will also review the data package to confirm the analytical results for each sample, sample quantitation limits and MDLs, and the narrative explanation of the level of data review used and the resulting qualifiers.

10.3.2 **Criterion II – Documentation**

COC records must document the sample locations and the date of sampling so that sample results can be related to geographic location and specific sample containers. If a sample result cannot be related to a sampling date and the point of sample collection, the results will be considered unusable for site closure.

10.3.3 Criterion III – Data Sources

Data source assessment involves the evaluation and use of historical and current analytical data. Historical soil sampling data were evaluated according to DQIs and used to support the selection of nitroglycerin as the only COPC. These data were subject to the basic documentation and data review requirements discussed above (Criteria I and II).

The minimum analytical data requirement for closure and post-excavation sampling are that an approved analytical technique be used to obtain soil sample results. Therefore, for these closure activities, the soil samples will be analyzed for nitroglycerin using Standard EPA Method 8332 (high performance liquid chromatography).

10.3.4 Criterion IV – Analytical Method and Detection Limit

The project manager will compare soil quantitation limits (SQLs) and/or MDLs with the analytical results to determine their consequence given the concentration of concern (i.e., nitroglycerin). When a COPC is reported as not detected, the result can only be used with confidence if the quantitation limits reported are lower than the corresponding concentration of concern. The minimum recommended requirement is that the MDL be no more than 20% of the concentration of concern so that the SQL will also be below the concentration of concern. Chemicals identified above this ratio of detection limit to concentration of concern can be used with good confidence. Since the concentration of concern for nitroglycerin is 71 mg/kg, the detection limit of a suitable method for examination of the soil samples from the site should be no greater than 14 mg/kg. The MDL for Method 8332 is 0.5 mg/kg, well within the 20% requirement.

10.3.5 Criterion V – Data Review

The requirement for closure sampling is that only data that have been reviewed will be used to evaluate compliance with the clean closure performance standard. The analytical level specified for the closure and post-excavation sampling is Level III, which is commonly

used for risk assessment and site characterization. The data quality is comparable to Level IV data (data generated using CLP protocols); however, QA/QC is not quite as rigorous as the Level IV analyses. Level III analytical support is designed to provide laboratory analysis using standard EPA approved procedures other than current CLP RAS. Level III protocols all have built-in QA/QC, including calibration runs, surrogate standards, etc. External QA is employed in the form of blanks, replicate and duplicate samples, and blind spikes submitted with the samples. The data review requirements were presented in Section 10.2.

10.3.6 Criterion VI – DQIs

Determining the usability of analytical results begins with the review of QC samples and qualifiers to assess analytical performance of the laboratory and the method. The data package will be reviewed as a whole for some criteria and at the sample level for other criteria. The following DQIs will be used to determine data useability.

Completeness. The measure of completeness is useful for data collection and analysis but misses the key closure issue, which is the total number of data points available and acceptable for demonstrating compliance with the nitroglycerin clean closure performance standard. Incompleteness will be assessed to determine whether an acceptable level of data usability can still be obtained or whether the level of completeness must be increased by further sampling. Since the statistical analysis requirements were used to determine the minimum number of samples required, any decrease in the number of samples from that specified in the SAP will affect the final results. Only the collection of additional samples will resolve the problem, unless extracts may be considered for reanalysis.

An analysis will be considered complete if all data generated are determined to be acceptable measurements as defined in the SAP. Results for each sample must be present as well as data from QC samples to necessary to determine precision and accuracy.

Comparability. Comparability is not compromised provided that the sampling design has not changed over time. However, the data from previous sampling events will not be

combined with the analytical results from the closure sampling. Likewise, the data set of post-excavation samples, if required, will be evaluated separately from the results of the closure samples.

Representativeness. The results of the compliance demonstration will be biased to the degree that the data do not reflect the concentration of nitroglycerin present at the site. Therefore, it is important to determine whether any changes have occurred in the actual sample collection. The project manager will review the FSP, field notes, and data packages to determine the degree to which the data meet the performance standards of the method and to which the analysis represents the sample submitted to the laboratory. Holding time, sample preservation, extraction procedures, and results from analysis of blanks affect the representativeness of analytical data.

Precision. Precision is a measure of the repeatability of a single measurement and is evaluated from the results of duplicate samples. Low precision can be caused by poor instrument performance, inconsistent application of method protocols, or a difficult, heterogeneous sample matrix. As stated in Section 3.4.1, the maximum performance objective for precision is 60%, determined using the analytical results for duplicate samples collected during closure and, if required, post-excavation samples.

Accuracy. Accuracy is a measure of overestimation or underestimation of reported concentrations and is evaluated using the results of spiked samples. Accuracy is controlled primarily by the analytical process and is reported as bias. Bias, which is estimated for the measurement process by computing the percent recovery for the spiked compound, will be compared to the performance objective of 50% to 140%, as calculated in Section 3.4.2.

Data Qualifiers. All data generated by the laboratory will be reviewed and qualified. Analytes qualified with a ND are considered "not detected." If precision and accuracy are acceptable (as determined by the QC samples and criteria presented above), data will be entered into a data summary table at the MDL and qualified with a "U" (for undetected). Data qualified with an "R" are rejected because performance requirements in the sample or associated

QC analysis were not met. Data qualified with a "J" are considered estimated because quantitation in the sample or associated QC samples did not meet specifications.

10.4 Data Reporting

A standard reporting format will be used to report all data along with the supporting QC information. The data report will include, at a minimum, a general discussion, analytical data for field samples and QC samples, calibration information, laboratory performance and matrix-specific information, and any other information that is pertinent to the project samples. Electronic format will be provided in Microsoft Excel.

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11.0**PREVENTATIVE MAINTENANCE**

To minimize downtime and interruption of analytical work, preventative maintenance shall be routinely performed on each analytical instrument. Designated laboratory personnel should be trained in routine maintenance procedures for all major instrumentation. When repairs are necessary, they shall be performed by either trained staff or trained service engineers employed by the instrument manufacturer. Backup instrumentation shall be provided in case of an extended breakdown for a piece of analytical instrumentation. It is the responsibility of the laboratory to have a backup plan in force such that all sample holding times can be met.

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12.0

QUALITY CONTROL REPORTS TO MANAGEMENT

General QC reports will not be required of the laboratory. However, all data packages shall include an assessment of accuracy, precision, and completeness and significant QA problems encountered.

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Attachment A-3
BIBLIOGRAPHY

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Attachment A-3
BIBLIOGRAPHY

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