FINAL

PHASE II REMEDIAL INVESTIGATION REPORT

FOR THE

WINKLEPECK BURNING GROUNDS AT THE RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO

VOLUME 1—MAIN TEXT

Prepared for

US Army Corps of Engineers®

U.S. Army Corps of Engineers - Louisville District
Contract No. DACA-62-94-D-0029

Delivery Order No. 0060

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CONTENTS

FIGURES

TABLES

ABBREVIATIONS

ADD	average daily dose
amsl	above mean sea level
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
AUF	area use factor
BAF	bioaccumulation factor
BCF	bioconcentration factor
BEIAS	Biomedical and Environmental Information Analysis System (of the Oak Ridge National Laboratory)
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
BTF	biotransfer factor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COEC	constituent of ecological concern
COC	chemical of concern
COPC	chemical of potential concern
COPEC	constituent of potential ecological concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CRREL	Cold Regions Research and Engineering Laboratory (USACE)
CSM	Conceptual Site Model
CX	Center of Excellence
DAD	dermally absorbed dose
DNB	dinitrobenzene
DNT	dinitrotoluene
DOD	U.S. Department of Defense
DQO	Data Quality Objective
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ESA	Endangered Species Act
FS	Feasibility Study
GOCO	government-owned, contractor-operated
HEAST	Health Effects Assessment Summary Table
HI	hazard index
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HQ	hazard quotient
ILCR	incremental lifetime cancer risk
IOC	Industrial Operations Command
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
LOAEL	lowest observed adverse effect level
MCL	maximum contaminant limit
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NCP	National Oil and Hazardous Substances Pollution Contingency Plan

NOAEL	no observed adverse effect level
OBG	Open Burning Ground
ODOW	Ohio Department of Wildlife
OE	Ordnance and Explosive (survey)
OEPA	Ohio Environmental Protection Agency
OHARNG	Ohio Army National Guard
ONG	Ohio National Guard
PAH	polynuclear aromatic hydrocarbon
PETN	pentaerythritol tetranitrate
PRG	Preliminary Remediation Goal
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
QCSR	Quality Control Summary Report
RAGS	Risk-Assessment Guidance for Superfund
RBSC	risk-based screening concentration
RCRA	Resource Conservation and Recovery Act
RDX	cyclotrimethylenetrinitramine
RfC	reference air concentration
RfD	reference dose
RGO	remedial goal option
RI	Remedial Investigation
RME	reasonable maximum exposure
RPD	relative percent difference
RRSE	Relative Risk Site Evaluation
RTLS	Ravenna Training and Logistics Site
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SRC	site-related chemical
SVOC	semivolatile organic compound
SWMM	Storm Water Management Model
T&E	threatened and endangered
TAL	Target Analyte List
TEF	Toxicity Equivalency Factor
TNB	1,3,5-trinitrobenzene
TNT	2,4,6-trinitrotoluene
TRV	toxicity reference value
TUF	temporal use factor
UCL_{95}	upper 95% confidence limit
USACE	U.S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USAEHA	U.S. Army Environmental Health Administration
USCS	Unified Soil Classification System
UTL	upper tolerance limit
UXO	unexploded ordnance
VOC	volatile organic compound
WBG	Winklepeck Burning Grounds

EXECUTIVE SUMMARY

This Phase II Remedial Investigation (RI) Report characterizes the nature and extent of contamination, evaluates the fate and transport of contaminants, and assesses risk to human health and the environment resulting from operations at the Winklepeck Burning Grounds (WBG) at the Ravenna Army Ammunition Plant (RVAAP), Ravenna, Ohio. WBG has been in operation since 1941 and consists of approximately 80.9 ha (200 acres). Recent activities have been limited, however, to a Resource Conservation and Recovery Act area at Burning Pad #37, an area of approximately 0.4 ha (1 acre). Before 1980, the burning was carried out primarily in several pits and at numerous pads, and occasionally on the roads. Although the exact number of pads contained within the 80.9-ha (200-acre) unit over its operational history is unknown, 70 burning pads have been identified from historical drawings and aerial photographs. Primary sources of contamination at WBG are residues from the open burning and detonation of explosives such as 2,4,6-trinitrotoluene (TNT), dinitrotoluene (DNT), hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX), and associated metals (e.g., chromium, lead, and mercury).

The overall purpose of this RI Report is to describe the investigations conducted at WBG at RVAAP and to define the vertical and horizontal extent of contamination. The specific objectives of the Phase II RI include the following:

- Characterize the physical environment of WBG and its surroundings to the extent necessary to define potential transport pathways and receptor populations and to provide sufficient engineering data for preliminary screening of remedial action alternatives. This includes the collection of additional facility-wide background soils and groundwater data to augment the Phase I RI background characterization.

- Characterize the nature and extent of contamination at WBG such that a baseline risk assessment can be conducted to evaluate the potential threats to human health and the environment and to develop remedial goal options, if needed.

- Characterize the sources of contamination at WBG sufficient to evaluate remedial actions. Information on source locations, types and amounts, potential releases, physical and chemical properties of wastes present, and engineering characteristics will be evaluated.

This RI Report was conducted as part of the approach to implement the Comprehensive Environmental Response, Compensation, and Liability Act process at RVAAP, which prioritizes environmental restoration at installation areas of concern (AOCs) on the basis of their relative potential threat to human health. The RVAAP Phase I RI, conducted in 1996, investigated 11 high-priority AOCs and resulted in the lowering of the Relative Risk Site Evaluation ranking score for four of the sites. Despite the revised ranking, all AOCs involved in the study will require further investigation. The purpose of the Phase II RI is to determine the nature and extent of contamination in environmental media so that quantitative human health and ecological risk assessments can be performed. Results of the risk assessments will be used to determine whether an AOC requires no further action or will be the subject of a Feasibility Study (FS).

PAST AND CURRENT INVESTIGATIONS

The Phase II RI at WBG was designed to collect data to supplement information obtained from five previous investigations at the site. Such investigations include

(1) Hazardous Waste Management Study No. 37-26-0442-84, *Phase 2 of AMC Open-Burning/Open-Detonation Grounds Evaluation, Ravenna Army Ammunition Plant* (USAEHA 1983);

(2) *Soils, Ground Water, and Surface Water Characterization for the Open Burning and Open Detonation Areas, Ravenna Army Ammunition Plant* (USAEHA 1992);

(3) *Phase I Remedial Investigation for 11 High-Priority Areas of Concern at the Ravenna Army Ammunition Plant* (USACE 1997a);

(4) *Soil Sample Analysis, Winklepeck Burning Grounds* (USACE 1997b); and

(5) *RCRA Field Investigation for Five Sites at Ravenna Army Ammunition Plant* (USACE 1998b).

These five studies, except for the Phase I RI, were limited to subsets of the 70 burning pads at WBG. All of the investigations, however, indicate elevated concentrations of the explosives TNT, RDX, HMX, and DNT in surface soils, as well as elevated concentrations of metals such as cadmium, chromium, lead, and mercury at some of the pads.

The findings and data gaps identified for these previous investigations guided the objectives and sampling design of the Phase II RI at WBG. As detailed in *the Sampling and Analysis Plan Addendum for the Phase II RI at Winklepeck Burning Grounds and Facility-Wide Background Investigation at RVAAP* (USACE 1998a), the Phase II RI objectives, by medium, included the following.

Surface Soil

(1) To determine the nature and horizontal extent of contamination at the ground surface at 14 former burning pads identified in the Phase I RI as having explosives in excess of 1 ppm or lead in excess of 100 ppm (Pads #5, 6, 37, 38, 40, 58, 59, 60, 61, 62, 66, 67, 68, and 70).

(2) To further characterize the extent of contamination in surface soils surrounding the Deactivation Furnace Area (Pad #45).

(3) To develop a background data set that characterizes natural facility-wide variability in the 23 Target Analyte List (TAL) metals by collecting additional background surface soil samples from 14 locations across RVAAP.

Subsurface Soil

(4) To define the vertical extent of contamination resulting from disposal of explosives and to study transport pathways of any such materials.

(5) To determine naturally occurring concentrations of several constituents, including TAL metals, in 15 subsurface soil samples.

Sediment/Surface Water

(6) To determine whether runoff from contaminated burning pads may contribute contaminants in dissolved and suspended form to the surface water system at WBG, which is unlined and untreated.

(7) To determine whether drainages at WBG allow contaminants to migrate eastward beyond the AOC boundary.

(8) To define background surface water and sediment conditions to support an evaluation of risk in these environmental media.

Groundwater

(9) To augment existing information on the WBG flow system and chemical groundwater quality, with emphasis on the shallow-water-bearing zone upgradient and downgradient of the most concentrated areas of soil contamination identified in the Phase I RI and other studies.

(10) To further characterize the installation-wide variability in 23 TAL metals in groundwater.

These objectives were met through the field activities conducted in April and May of 1998. Field investigation activities at WBG included surface and subsurface soil sampling; surface water and sediment sampling in streams and Mack's Pond; installation, sampling, and testing of five new monitoring wells; and sampling of four existing monitoring wells. To further characterize site-wide background conditions at RVAAP, the field program also included soil sampling and monitoring well installation, sampling and testing at 14 locations, and surface water and sediment sampling at 7 locations. The methodology for determining facility-wide background criteria was intended to establish values representative of conditions unaffected by human activity or processes at RVAAP.

A biased sampling strategy was used to focus on areas having the highest concentrations of contamination, which were originally suggested by earlier investigation results and confirmed by field screening. All surface soil and sediment samples were analyzed by colorimetric methods in the field to define the extent of surface soil contamination by TNT and RDX. Field colorimetry was also used as a screening method to reduce the number of samples that required fixed-base laboratory analysis for explosives. The strategy can be summarized as follows:

- If the field method indicated TNT was present ≥1 ppm, the sample was sent to the off-site laboratory for analysis of explosives and propellants.

- If the concentration of TNT was <1 ppm, the analysis for RDX was performed.

- If RDX was present at a concentration ≥1 ppm, the sample was sent to the off-site laboratory for analysis of explosives and propellants.

- In addition, 15% of the samples showing nondetects of TNT or RDX were sent to the off-site laboratory for analysis of explosives.

- All samples collected, regardless of field colorimetry results, were submitted for TAL metals and cyanide analyses.

AVAILABLE DATA

The environmental database for the WBG Phase II RI includes recent data obtained from the field activities conducted in 1998, as well as those from the Phase I investigation conducted in 1996. As a result, the database includes the following data for use in evaluation of the nature and extent of contamination, contaminant fate and transport analysis, and the human health and ecological risk assessments:

- 171 surface soil samples,
- 41 subsurface soil samples,
- 19 sediment samples,
- 2 slag samples,
- 1 surface water sample, and
- 10 groundwater samples.

CONCEPTUAL SITE MODEL

Information gathered during the Phase I RI and the Phase II RI of WBG has been used to develop a conceptual model for WBG. The elements of the conceptual site model are

- The topography of WBG consists of gently undulating slopes and level areas that decrease in elevation from west to east. Elevations range from 1084.9 to 993.2 ft above mean sea level.

- Low-permeability soils and glacial sediments cover much of the ground surface of WBG, except where the natural materials have been either eroded, removed, reworked, or covered during RVAAP operations. The glacial material present at WBG is presumed to be tens of feet thick.

- Groundwater is present in the sandy interbeds found in glacial materials that occur within about 7.6 m (25 ft) of the ground surface at WBG. The more permeable sand units may be laterally discontinuous. Whether the monitoring wells installed during the Phase II RI are in hydraulic communication with one another is unknown. Groundwater is presumed to flow from the western side of WBG to the east, based on the topography of the site and potentiometric surface data for the four existing and five newly installed monitoring wells at the site. The water-bearing units behave as unconfined systems.

- Most surface water flows from west to east across WBG in three small streams that are all tributaries that form Sand Creek to the south of WBG. Mack's Pond is located in the southwest quadrant of WBG. It is fed by the southernmost surface water channel, which drains most of the western end of the WBG. The pond drains eastward to an unnamed creek that eventually joins Sand Creek east of George Road. The stream north of Pallet Road B runs behind Pads #29 through 39, in the center of WBG. The northernmost stream runs from Pad #63 eastward beyond the AOC boundary. The extreme northwest corner of WBG (Pads 58-61) drains northeastward toward the pistol range. Beaver ponds are also present in low areas in the southeast quadrant of WBG.

- Contaminant sources at WBG are the individual burning pads and roadside ditches that were used periodically to destroy explosives and other materials by burning. Some pads were used regularly, while others were rarely, or perhaps never, used. Burning of waste munitions may have caused detonations that disturbed the native soils below the burning pads and introduced contaminants into the subsurface soils. The crushed slag that was used throughout WBG for roads, pads, and driveways may also be a source of aluminum, arsenic, barium, beryllium, calcium, copper, magnesium, sodium, and zinc. Contaminants released at WBG through these non-localized, non-permanent sources include heavy metals, explosives, and propellants.

NATURE AND EXTENT OF CONTAMINATION

The RI evaluated the nature and extent of contamination in four media, divided into five aggregates as follows: surface soils [0 to 0.6 m (0 to 2 ft) below ground surface (bgs)], subsurface soils [0.6 to 1.2 m and 1.2 to 1.9 m (2 to 4 ft and 4 to 6 ft bgs)], sediment, surface water, and groundwater. The results of this evaluation are summarized by aggregate here.

Surface Soils

- Explosives were present at concentrations ≥1 ppm at Pads #5, 6, 37, 38, 59, 62, 66, 67, and 68, with the greatest concentrations occurring at Pads #66 and 67. Based on negative results in both the Phase I study and Phase II field screening, surface soil samples from Pad #70 were not analyzed by the laboratory for explosives. Explosives contamination in surface soils was generally found on the pads.

- Propellants (nitroglycerin and/or nitrocellulose) were present at Pads #5, 37, 60, 61, 66, 67, and 68 with the highest concentration occurring at Pad 66. Concentrations of propellants are generally below 20 mg/kg, making them a minor contaminant constituent in surface soils.

- Lead was present at concentrations >100 ppm at every pad except Pads #5, 6, and 70. Although high concentrations of metals were often found with explosives contamination in soil, metal contamination appeared to be distributed around the burning pads as well as on the pads. Cadmium was present above background in the highest concentrations (>20 ppm) at Pads #37, 38, 45, 58, 60, and 61. It was detected at concentrations below 10 ppm or never detected at Pads #5, 6, 40, 59, 62, 66, 67, 68, and 70.

- Volatile organic compounds and semivolatile organic compounds (SVOCs), evaluated at Pads #37, 60, 66, 68, and 70, were detected in several surface soil samples. Detected polynuclear aromatic hydrocarbons (PAHs) may reflect the burning of materials at the pads.

Subsurface Soils

- Explosives concentrations >1 ppm were present in the 0.6- to 1.2-m (2- to 4-ft) interval at Pads #62, 66, and 67, and in the 1.2- to 1.9-m (4- to 6-ft) interval at Pads #37, 67, and 68. Pads #60, 66, and 67 had the greatest concentrations of explosives in the subsurface soils. Generally, explosives concentrations are lower in subsurface soils than in surface soils.

- Lead occurred at concentrations >100 ppm at Pad #60, in the 0.6- to 1.2-m (2- to 4-ft) interval only. Cadmium was detected in four Phase II samples, with the highest concentrations observed at Pads #60 and 61. Pads #5, 6, 37, and 70 exhibited no exceedances of background criteria for TAL metals in the subsurface. Pads #38, 40, 58, 59, 61, 66, 67, and 68 all had three or fewer metals above background in the 0.6- to 1.2-m (2- to 4-ft) interval. Pad #62 had six metals above background in the 0.6- to 1.2-m (2- to 4-ft) interval. Two or fewer metals exceeded background in the 1.2- to 1.9-m (4- to 6-ft) interval at Pads #59, 60, 62, 66, 67, and 68.

Sediment

- Explosives were not present in sediments at concentrations >1ppm.

- Two of the four samples collected had eight metals results above background criteria. Most of the exceedances occurred in the sample from the extreme eastern end of WBG.

- Eleven PAHs, all at concentrations <1 ppm, were identified in one sample from the upstream end of Mack's Pond.

Surface Water

- No explosives were detected in the surface water sample from Mack's Pond.

- The surface water sample had no metal results that exceeded the background criteria. One organic compound, acetone, was detected in the surface water sample. Acetone is a common laboratory contaminant, however, and no SVOCs were detected.

Groundwater

- Seven of the nine monitoring wells at WBG had minor detections of explosives. The only occurrences of explosives in groundwater >1 μg/L were in WBGmw-006, downgradient from Pad #67, and in WBGmw-009, located at Pad #7. Well WBGmw-006 exhibited the highest concentrations of explosives in WBG groundwater.

- Eight detections of inorganic analytes occurred above background in the filtered samples from nine wells. None of these values exceed primary maximum contaminant limits (MCLs), although some metals (e.g., manganese) have no primary MCL. However, concentrations of manganese exceeded the secondary MCL in all but one well.

FATE AND TRANSPORT ANALYSIS

Groundwater

- Organic compounds and explosives detected at the WBG subsurface soils are expected to degrade considerably before leaching to the groundwater. Potential off-AOC migration of these constituents via groundwater pathway may be limited due to natural attenuation processes in the groundwater. However, site-specific data have not been gathered to confirm this.

- Heavy metals detected at the WBG subsurface soil are not expected to significantly leach to the groundwater due to their high adsorption coefficients.

- Because of the high sorption coefficients of WBG soils and generally low contaminant concentrations in the groundwater, fate and transport modeling was not conducted for groundwater.

Surface Water

Computer-based contaminant fate and transport modeling analyses were performed using the U.S. Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) to support evaluation of potential future impacts to human health and the environment and to provide a basis for evaluating the effectiveness of the proposed remedial alternative in the FS. Fate and transport modeling for the Phase II RI was limited to surface water because it was the primary medium at WBG determined to have the potential for off-AOC contaminant migration. Sediment transport was not included in the modeling, although the SWMM modeling does account for soil loss from the site and transport to the stream.

The analysis of contaminant fate and transport in surface water at WBG included the following:

- fate and transport modeling to simulate contaminant distribution in the WBG surface water system comprising overland flow from drainage areas to the drainage ditches and tributaries;
- surface water transport modeling to predict future contaminant concentrations in the tributaries flowing west to east across WBG and entering Sand Creek; and
- simulation of surface water concentrations in Sand Creek resulting from contaminant loading from WBG.

The modeling focused on determining spatial variations of contaminants for a typical rainfall year. Several steps were taken to ensure that the model results reflect realistic and representative conditions at WBG. These include

- A typical rainfall year was selected based on the average rainfall for the site.
- Available contaminant loadings for the drainage areas were used for the contaminant concentration simulations.
- The hydrologic and contaminant transport variables were integrated into the EPA SWMM to simulate a typical rainfall condition.
- Emphasis was placed on delineating drainage areas and distinguishing drainage ditches/tributaries to realistically represent the site hydrologic and transport conditions.
- The topographic divides were identified from a 2-ft contour map to determine subcatchments that allow overland flow with contaminants to drainage ditches and tributaries.
- Physically meaningful data for surface roughness, depth of storage, washoff, and runoff parameters were used to increase the realism of the model.

The 14 primary SRCs in surface soil and sediments were selected for the simulation. They are considered representative of all SRCs. Six metals (arsenic, chromium, copper, lead, mercury, and zinc), five explosives [1,3,5-trinitrobenzene (TNB)], 2,4-DNT, TNT, HMX, and RDX], and three PAHs [benzo(*a*)pyrene, phenanthrene, and pyrene] were modeled. The simulated spread of these contaminants for a typical rainfall year, as depicted by the model, was not significant. All predicted concentrations of contaminants in the surface water system comprising overland flow from drainage areas to the drainage ditches and tributaries were substantially below the available Ohio statewide water quality criteria for the protection of aquatic life and human health. Only negligible amounts of explosives (yearly average concentrations of 0.013 µg/L for TNB and 0.000034 µg/L for TNT) from the WBG site were predicted to be discharging to the Sand Creek. Therefore, potential off-AOC contaminant migration via surface water and sediment pathways at WBG is not expected to be a problem.

BASELINE HUMAN HEALTH RISK ASSESSMENT

Human health carcinogenic risks and noncarcinogenic hazards were calculated for potential exposures associated with five land uses at the RVAAP (1) modified caretaker, (2) Ohio Army National Guard (OHARNG) training, (3) open recreational, (4) open industrial, and (5) open residential. The most likely near-term (2 to 10 years) use of the WBG area is “modified caretaker.” The most plausible long-term land use is a combination of OHARNG training use and controlled recreational use. Despite the likelihood of these future land uses, the Baseline Human Health Risk Assessment (BHHRA) also evaluated additional potential future land uses that reflect more open use of the land, including open industrial, open recreational, and open residential. The land uses that will be evaluated as part of the BHHRA are described, along with potential receptors, in Table ES-1.

Table ES-1. Potential Receptors for the WBG, RVAAP
Baseline Human Health Risk Assessment

Land Use Designation	Description	Potential Receptors
Modified Caretaker – Managed Recreational	Activities that are currently taking place at the sites, including light maintenance and controlled land management (e.g., controlled hunting and recreational activities)	Government contractors (e.g., security guards or maintenance workers) Permitted hunters, trappers, and nature study participants Trespassers
National Guard – Managed Recreational	National Guard training activities and controlled recreational activities (e.g., controlled hunting)	National Guard personnel and trainees Permitted hunters, trappers, and nature study participants Trespassers
Open Recreational	Uncontrolled recreational activities	Hunters, trappers, and nature study participants
Open Industrial	Commercial industrial operations	Full-time industrial workers
Open Residential	Residential housing and farming	On-site resident farmer (child and adult)

RVAAP = Ravenna Army Ammunition Plant.
WBG = Winklepeck Burning Ground.

The potential receptors listed in Table ES-1 were used to designate seven receptors for evaluation for human health risks and hazards at WBG (1) security guard/maintenance worker, (2) OHARNG personnel, (3) open industrial worker, (4) child trespasser, (5) hunter/trapper, (6) recreational user, and (7) on-site resident farmer.

The risks for the WBG site were evaluated by (1) exposure unit (EU) aggregate (i.e., AOC-wide) and (2) sample location. The EU aggregate risks were performed to evaluate a reasonable risk exposure across the AOC. Results of this aggregate risk evaluation were used to select the chemicals of concern (COCs) for the BHHRA. The location-by-location risk estimates were used to support the aggregate risk results, by evaluating the spatial distribution of risks at individual sampling locations. Thus, the sample location risk estimates were used to spatially define source areas of elevated risks for the COCs that were identified in the aggregate risk analysis.

EPA (*National Oil and Hazardous Substances Pollution Contingency Plan*), Federal Register Vol. 55 No. 46: 8666-8865.1990) indicates that remediation goals should represent an incremental lifetime cancer risk to an individual between 10^{-6} to 10^{-4} with a cancer risk of 10^{-6} serving as the point of departure. The 10^{-6} point of departure expresses EPA's preference for setting cleanup levels at the more protective end of the risk range; however, it is not a presumption that the final cleanup will attain that risk level. Consideration of site-specific and remedy-specific factors (i.e., exposure factors, uncertainty factors, and technical factors) enter into the determination of where within the acceptable risk range of 10^{-6} to 10^{-4} final remediation decisions will fall.

A summary of receptors with estimated cancer risks between 10^{-6} to 10^{-4}, estimated cancer risks $\geq 10^{-4}$, and hazards > 1 are noted in Table ES-2. This distinction is made because risks below 10^{-6} are considered negligible, risks above 10^{-4} are unacceptable, and risks within the 10^{-6} to 10^{-4} range are indeterminant until final remediation decisions are made.

Table ES-2. Summary of Risks/Hazards for Exposure Media Aggregates

Receptor	Hazards (HQ)	Cancer Risk (ILCR)	
	> 1	**≥ 10^{-4}**	**10^{-6} to 10^{-4}**
Child Trespasser	s		s
Hunter/Trapper			s
National Guard			gw, s
Security Guard/Maintenance Worker			s
Recreational User			s
Open Industrial Worker	s, sb		s, sb
On-site Resident Farmer (adult or child)	gw, s, s_i, sb	s, s_i	gw, sd, sb

gw = groundwater.
sd = sediment.
s = surface soil (direct exposure).
s_i = surface soil (indirect exposure via ingestion of foodstuffs).
sb = subsurface soil.

The primary contributors to these risks are metals, explosive compounds, and some PAHs.

Risks and hazards estimated on a location-by-location basis are summarized below. Since the assumption that a receptor remains in one location is unreasonable, this location-by-location evaluation is useful for focusing on the highest risk locations within the AOC. For this reason, the location-by-location risk/hazard results are presented graphically in Appendix J and should be used primarily to help locate priority areas within the AOC, not as the determining factor in the decision to implement a remedial action.

A summary of receptors with estimated cancer risks between 10^{-6} to 10^{-4}, estimated cancer risks ≥ 10^{-4}, and hazards > 1 for samples located at or near noted pads is noted in Tables ES-3 (groundwater), ES-4 (sediment), ES-5 (subsurface soil), ES-6 (direct exposure to surface soil), and ES-7 (indirect exposure to surface soil).

Table ES-3. Summary of Pads with Location-by-Location Risk/Hazard Results Exceeding Various Thresholds for Groundwater

Pad	National Guard	Resident Subsistence Farmer
7	R	R
25	R	H, R
62	R	R
67	R	R

H = hazard index (total across all COPCs) > 1.
R = ILCR summed across all COPCs is between 10^{-6} and 10^{-4}.
R^+ = ILCR summed across all COPCs ≥ 10^{-4}.
This distinction between the two risk categories is made because risks below 10^{-6} are considered negligible, risks above 10^{-4} are unacceptable, and risks within the 10^{-6} to 10^{-4} range are indeterminant until final remediation decisions are made.
COPC = contaminant of potential concern.
ILCR = incremental lifetime cancer risk.

Table ES-4. Summary of Pads with Location-by-Location Risk/Hazard Results Exceeding Various Thresholds for Sediment

Pad	Hunter/Trapper	Resident Subsistence Farmer
70	R	R

H = hazard index (total across all COPCs) > 1.
R = ILCR summed across all COPCs is between 10^{-6} and 10^{-4}.
R^{+} = ILCR summed across all COPCs ≥ 10^{-4}.
This distinction between the two risk categories is made because risks below 10^{-6} are considered negligible, risks above 10^{-4} are unacceptable, and risks within the 10^{-6} to 10^{-4} range are indeterminant until final remediation decisions are made.
COPC = contaminant of potential concern.
ILCR = incremental lifetime cancer risk.

Table ES-5. Summary of Pads with Location-by-Location Risk/Hazard Results Exceeding Various Thresholds for Subsurface Soil

Pad	National Guard	Industrial Worker	Resident Subsistence Farmer
37			H, R
38	H	H	H
45		H	H
58		H	H, R
59			R
60		H	H, R
61		H	H
62		R	R
66	R	H, R	H, R^{+}
67	R	H, R^{+}	H, R^{+}
68			R
70		R	R

H = hazard index (total across all COPCs) > 1.
R = ILCR summed across all COPCs is between 10^{-6} and 10^{-4}.
R^{+} = ILCR summed across all COPCs ≥ $10^{-4.}$
This distinction between the two risk categories is made because risks below 10^{-6} are considered negligible, risks above 10^{-4} are unacceptable, and risks within the 10^{-6} to 10^{-4} range are indeterminant until final remediation decisions are made.
COPC = contaminant of potential concern.
ILCR = incremental lifetime cancer risk.

Table ES-6. Summary of Pads with Location-by-Location Risk/Hazard Results Exceeding Various Thresholds for Surface Soil

Pad	Security Guard	Hunter/ Trapper	Trespasser	National Guard	Recreator	Industrial Worker	Resident Subsistence Farmer
3	R			R		R	R
4	R	R		R		R	R
5	R			R		R	R
6	R			R		R	R
8	R			R		R	R
29				R			
30	R			R		R	R
30-32[a]	R			R		R	R
33	R			R		R	R
34				R			
37	R			R		R	H, R
38	H, R	H	H	H, R	H	H, R	H, R
40	R	R		R	R	R	R
41	R	R		R		R	R
45	H, R	H	H	H, R	H	H, R	H, R
45-60[b]	R			R		R	R
46	R			R		R	R
49	R			R		R	R
50	R			R		R	R
51				R		R	R
58	H, R	H, R	H	H, R	H	H, R	H, R
59				R			R
60	H		H	H, R		H	H, R
61	H		H	H, R		H	H
62	R	R	R	R	R	R	R
63				R			
65	R			R		R	R
66	H, R	H, R	H, R	H, R	H, R	H, R	H, R^+
67	H, R^+	H, R^+	H, R	H, R^+	H, R	H, R^+	H, R^+
68	R	R		H, R		R	R
70	R	R		R	R	R	R

[a] Sample collected between Pads 30 and 32.
[b] Sample collected between Pads 45 and 60.
H = hazard index (total across all COPCs) > 1.
R = ILCR summed across all COPCs is between 10^{-6} and 10^{-4}.
R^+ = ILCR summed across all COPCs ≥ 10^{-4}.
This distinction between the two risk categories is made because risks below 10^{-6} are considered negligible, risks above 10^{-4} are unacceptable, and risks within the 10^{-6} to 10^{-4} range are indeterminant until final remediation decisions are made.
COPC = contaminant of potential concern.
ILCR = incremental lifetime cancer risk.

Table ES-7. Summary of Pads with Location-by-Location Risk/Hazard Results Exceeding Various Thresholds for Surface Soil (Indirect Exposures)

Pad	Hunter/Trapper	Resident Subsistence Farmer
3		H, R^+
4		H, R^+
5		H, R^+
6		H, R^+
8		H, R^+
29		H
30		H, R^+
30-32[a]		H, R^+
32		H
33		H, R^+
34		H
37		H, R^+
38		H, R^+
40		H, R^+
41		H, R^+
45	H	H, R^+
45-60[b]		H, R^+
46		H, R^+
47		H
49		H, R^+
50		H, R^+
51		H, R^+
53		H
58		H, R^+
59		H, R^+
60		H, R^+
61		H
62		H, R^+
63		H
65		H, R^+
66		H, R^+
67		H, R^+
68		H, R^+
70		H, R^+

[a] Sample collected between Pads 30 and 32.
[b] Sample collected between Pads 45 and 60.
H = hazard index (total across all COPCs) > 1.
R = ILCR summed across all COPCs is between 10^{-6} and 10^{-4}.
R^+ = ILCR summed across all COPCs ≥ 10^{-4}.
This distinction between the two risk categories is made because risks below 10^{-6} are considered negligible, risks above 10^{-4} are unacceptable, and risks within the 10^{-6} to 10^{-4} range are indeterminant until final remediation decisions are made.
COPC = contaminant of potential concern.
ILCR = incremental lifetime cancer risk.

SCREENING ECOLOGICAL RISK ASSESSMENT

A screening or preliminary Ecological Risk Assessment (ERA), which depends on available site data and is conservative in all regards, was conducted at WBG. Results of the screening ERA will be used to determine whether a baseline ERA is required to make remedial decisions. The baseline ERA requires more site-specific and usually less conservative exposure and effects information, including such measurements as field-observed effects and even body burden measurements and bioassays.

Of the many observed plant and animal taxa at WBG, five terrestrial classes (vegetation, soil-dwelling invertebrates, worm-eating and/or insectivorous mammals, mammalian herbivores, and terrestrial top predators) were selected for terrestrial receptors. Specific terrestrial species evaluated were terrestrial plants, earthworms, short-tailed shrew, American robins, cottontail rabbit, white-tailed deer, red-tailed hawk, barn owl, and red fox. For aquatic classes, sediment-dwelling organisms and aquatic organisms were selected. Risks were quantitatively estimated for each receptor.

The screening ERA evaluated risks to these ecological receptors in five exposure groupings, which were defined on the basis of existing habitat and land use, observed and assumed patterns of behavior of the receptors, and the spatial area of the site and WBG habitats relative to the home range and foraging areas of the receptors. The five exposure groupings and the screening ERA results for each include the following:

- *All of WBG (terrestrial).* The screening ERA found significant ecological risk [hazard quotient (HQ) > 1] from surface soils for the entire WBG, as well as for each of the smaller pad areas. Ecological risk to one or more of the receptors came from a variety of ecological contaminants of potential concern (COPCs). Typical inorganic COPCs were aluminum, cadmium, chromium, lead, and zinc, and the primary organic COPCs were TNT, HMX, and RDX.

- *Each individual pad (terrestrial).* In the pad-by-pad evaluation, some pads had only a few COPCs while others showed many; and some COPCs at the pads had low HQs (e.g., 5) while others had high HQs (e.g., 2000). The HQs at each pad were grouped into three categories: HQs of 1 to 99, HQs of 100 to 999, and HQs of 1,000 and greater. Results of this categorization show that

    — One pad (Pad #4) has risk with HQs in the 1 to 99 range from the inorganic COPCs aluminum, arsenic, chromium, lead, selenium, and zinc.

    — A total of 46 pads have ecological risk in the 100 to 999 range from aluminum almost exclusively. Four slag samples were collected and all were high in aluminum. Thus, the slag at WBG may be the source of the widespread elevated concentrations of aluminum.

    — Seven pads have ecological risk in the 100 to 999 range from metals such as cadmium, lead, thallium, and zinc and explosives such as TNT, HMX, and RDX. These risks are found at Pads #8, 40, 45, 61, 62, 67, and 68.

    — Seven pads have ecological risk in the 1,000 and greater range from aluminum, cadmium, and lead. These risks are found at Pads #32, 37, 38, 58, 59, 60, and 66.

- *Sediment sites in ditches inside and adjacent to WBG*. Four COPCs were identified in dry sediment (ditches where water was absent when samples were taken): arsenic, copper, manganese, and nickel. All HQs were relatively low, ranging between 1 and 3.

- *Sediment sites in creeks inside and adjacent to WBG.* Twelve COPCs were identified in wet sediment (creeks where water was present when samples were taken): arsenic, copper, manganese, nickel, zinc, benzo(*a*)anthracene, benzo(*a*)pyrene, chrysene, fluoranthene, phenanthrene, pyrene, and acetone.

- *Surface water site in the pond nearby WBG*. For surface water, only one COPC, the common laboratory contaminant acetone, was identified. No toxicity reference value is noted for acetone; therefore, risk could not be calculated for the sample that came from Mack's Pond.

The most important finding of the screening ERA is that ecological risk exists at many locations at WBG. Some pads exhibit more ecological risk (i.e., more COPCs and higher HQs) than other pads. Pads #32, 37, 38, 58, 59, 60, and 66 have the most COPCs and highest HQs. Dominant COPCs are aluminum, cadmium, and lead for surface soils. These findings suggest that a baseline ERA may be needed for some locations to better assess risks and to aid in making decisions about the need for and extent of remediation.

CONCLUSIONS

The focus of the evaluation of the nature and extent of contamination at WBG is the Phase II RI data, which were collected for the specific objective of further defining the contaminant distribution identified during the Phase I RI. However, both the human health and ecological risk assessments combined the Phase I and Phase II data for statistical evaluation. The conclusions presented here by data aggregate combine the findings of the contamination nature and extent evaluation and both risk assessments with fate and transport modeling results (surface water only).

Surface Soil

Explosives were present at concentrations greater than 1 ppm at Pads #37, 66, and 67. Cadmium and lead were detected at relatively high concentrations (>100 ppm for lead and >20 ppm for cadmium) at nearly all of the 14 pads sampled during the Phase II investigation. Seven COCs were identified for direct exposure to soil by one or more human receptors [arsenic, cadmium, chromium, TNT, benzo(a)pyrene, Dibenzo(a,h)anthracene, RDX]. Nearly every surface soil analyte had an HQ of 1 or greater for one or more ecological receptors.

Subsurface Soil

Explosives were present at concentrations >1 ppm at five of the pads sampled during the Phase II investigation, and metals occurred sporadically at concentrations above background criteria, with the highest concentrations at Pads #60 and 61. Pads #5, 6, 37, and 70 had no TAL metals above background in the subsurface. Five human health COCs were identified in subsurface soil: cadmium, TNT, benzo(a)pyrene, dibenzo(a,h)anthracene, and RDX. An ERA was not considered necessary for subsurface soil and was not included in the screening ERA.

Sediment

Explosives were not detected above 1 ppm in any sediment samples, metals were detected above background, and PAHs were present in several sediment samples upstream of Mack's Pond. Three human health COCs were identified in sediment: benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene. Twelve ecological COCs were identified in wet sediment in Mack's Pond: arsenic, copper, manganese, nickel, zinc, acetone, benzo(*a*)anthracene, benzo(*a*)pyrene, chrysene, fluoranthene, pyrene, and phenanthrene. Four ecological COCs were identified in dry sediment in the ditches: arsenic, copper, manganese, and nickel.

Surface Water

The one surface water sample analyzed from Mack's Pond showed no inorganic analytes exceeding background criteria and a single detection of the organic constituent acetone. The SWMM results show that potential off-site contaminant migration via surface water and sediment pathways at WBG is not expected to be a problem. Because no COPCs were identified for either human or ecological receptors, risk was not evaluated for surface water.

Groundwater

Explosives were detected at concentrations >1 ppb in two wells. Manganese, detected in one well at a concentration approximately three times greater than background, is a noncarcinogenic COC (hazard index >1) for the residential risk scenario. However, the background value for this element was more than six times greater than the human health risk-based criterion. Metals were detected in several wells at concentrations below MCLs for groundwater. Two organic COCs were also identified: chloroform and RDX. Organic compounds and explosives detected at the WBG subsurface soils are expected to degrade considerably before leaching to the groundwater. Potential off-AOC migration of these constituents via the groundwater pathway may be limited due to natural attenuation processes in the groundwater system. However, site-specific data have not been gathered to confirm this. Heavy metals detected in the WBG subsurface soil are not expected to significantly leach to the groundwater due to their high adsorption coefficients. Groundwater was not included in the screening ERA because ecological receptors are not exposed to groundwater.

RECOMMENDATIONS

Based on the results and conclusions of the Phase II RI at WBG, it is recommended that an FS be performed to evaluate potential remedial options. In addition to the conventional scope of an FS, the following components are recommended:

- An Ordnance and Explosive (OE) survey of the entire WBG is recommended prior to any remedial activity to locate and designate for removal all potentially remaining OE.

- Installation and sampling of six to eight additional groundwater monitoring wells, in addition to another round of sampling of existing groundwater wells at WBG, to further characterize the AOC and to augment the current groundwater chemical data set.

- If significant groundwater contamination is found, consider conducting soil leachate modeling and groundwater flow and contaminant transport modeling prior to completion of the FS.

- Re-characterization of groundwater risk following the additional groundwater characterization and modeling efforts.

- A statistical grid-sampling approach should be considered as a means of evaluating surface soils in areas of the WBG where burning activities were not known to occur.

- Due to the non-uniform, sporadic distribution of contaminants in soils at burning pads at WBG, it is recommended that the horizontal distribution of those pads with highest risk be evaluated during remedial action using field screening-level analyses for metals and explosives and confirmatory laboratory analysis.

- A ground-truthing approach to better defining ecological risk should be considered rather than continuing with conventional HQ computations. In lieu of traditional computations using less and less conservative exposure and effects data, the U.S. Army Center for Health Promotion and Preventive Medicine is developing a needed field-observed effects approach to facilitate faster and better recommendations and decisions about cleanup to protect ecological receptors.

Additional recommendations for the evolution of the Installation Restoration Program at RVAAP are as follows:

- A facility-wide risk assessment work plan and methodology is recommended as a means to establish agreed-upon exposure scenarios, technical assumptions, and methods and reporting of computations for evaluating both human health and ecological risk in this and other AOCs.

- In addition, an integrated environmental management system (an electronic, web-based data system) is recommended to provide RVAAP with a means to capitalize upon data collected across space and time at WBG and other AOCs.

Long-term land use and natural resource management at the facility, in conjunction with environmental restoration, will be determined, to a large extent, by OHARNG, as they are projected to assume responsibility for AOCs that are remediated. In light of this, it is recommended that the Army and OHARNG share all data gathered and communicate through existing channels.