**Range Sustainability Environmental Program Assessment (RSEPA)**
**Range Condition Assessment (RCA) Phase III**

# On-Site Visit
# Information Collection and Review Synopsis

**Fallon Ranges (Bravo 16, 17, 19, and 20)**
**NAS Fallon, Nevada**

**June 2004**

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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| 2,4-DNT | 2,4-Dinitrotoluene |
| 2,6-DNT | 2,6-Dinitrotoluene |
| 2-A-4,6-DNT | 2-Amino-4,6-Dinitrotoluene |
| 4-A-2,6-DNT | 4-Amino-2,6-Dinitrotoluene |
| 1,3,5-TNB | 1,3,5-Trinitrobenzene |
| AB | Assembly Bill |
| ACHP | Advisory Council on Historic Preservation |
| ACM | Asbestos-Containing Materials |
| AHERA | Asbestos Hazard Emergency Response Act |
| APM | Asbestos Program Manager |
| ASN | Assistant Secretary of the Navy |
| AST | Aboveground Storage Tank |
| ATC | Air Traffic Control |
| AUL | Authorized Users List |
| BAPC | Bureau of Air Pollution Control |
| BLM | Bureau of Land Management |
| BLS | Below Land Surface |
| BOR | Bureau of Reclamation |
| BOS | Base Operating Services |
| BUREC | Bureau of Reclamation |
| BWPC | Bureau of Water Pollution Control |
| CAAA90 | Clean Air Act Amendments 1990 |
| CAGs | Carrier Air Groups |
| CFR | Code of Federal Regulations |
| CNO | Chief of Naval Operations |
| CO | Carbon Monoxide |
| $CO_2$ | Carbon Dioxide |
| CRE | Comprehensive Range Evaluation |
| CRMP | Cultural Resources Management Plan |
| CWA | Clean Water Act |
| CY | Calendar Year |
| DOD | U.S. Department of Defense |
| DODIC | Department of Defense Identification Code |
| DOE | Department of Energy |
| DQO | Data Quality Objective |
| EA | Environmental Assessment |
| ECE | Environmental Compliance Evaluation |
| EFA | Engineering Field Activity |
| EIR | Environmental Impact Review |
| EIS | Environmental Impact Statement |
| EOD | Explosive Ordnance Disposal |
| EPCRA | Emergency Planning and Community Right-to-Know Act |
| EPR | Environmental Program Requirements |
| EQA | Environmental Quality Assessment |
| EQAR | Environmental Quality Assessment Report |
| ERAP | Emergency Response Action Plan |
| ERDC | Engineer Research and Development Center |
| FEHM | Finite Element Heat and Mass Transfer Model |
| FEWR | Fallon Electronic Warfare Range |

## LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

| | |
|---|---|
| FOTW | Federally Owned Treatment Works |
| FRP | Facility Response Plan |
| FRTC | Fallon Range Training Complex |
| FY | Fiscal Year |
| GPS | Global Positioning System |
| $H_2O$ | Dihydrogen Oxide (Water) |
| HAZCOM | Hazardous Communication |
| HE | High Explosive |
| HMCRM | Hazardous Material Control and Management |
| HMTA | Hazardous Materials Transportation Act |
| HMX | Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine |
| HWMP | Hazardous Waste Management Plan |
| I&E | Installations and Environment |
| I/I | Inflow and Infiltration |
| IADS | Integrated Air Defense System |
| ICP | Integrated Contingency Plan |
| ICRMP | Integrated Cultural Resources Management Plan |
| INRMP | Integrated Natural Resources Management Plan |
| $LD_{50}$ | Lethal Dose-50 Percent |
| MACT | Maximum Achievable Control Technology |
| MAGs | Marine Aircraft Groups |
| MC | Munitions Constituent |
| MCL | Maximum Contaminant Level |
| MIDAS | Munitions Items Disposition Action System |
| MMR | Military Munitions Rule |
| MOA | Military Operating Area |
| MOU | Memorandum of Understanding |
| MSL | Mean Sea Level |
| $N_2$ | Nitrogen |
| NAAS | Naval Auxiliary Air Station |
| NAGPRA | Native American Graves Protection and Repatriation Act |
| NAS | Naval Air Station |
| NAVFAC | Naval Facilities Engineering Command |
| NDEP | Nevada Department of Environmental Protection |
| NDI | Northern Digital Inc. |
| NDWS | No-Drop-Weapons-Scoring |
| NEPA | National Environmental Policy Act |
| NESHAP | National Emissions Standards for Hazardous Air Pollutants |
| NOAV | Notice of Alleged Violation |
| NOTAM | Notice to Airman and Mariners |
| NOV | Notice of Violation |
| $NO_X$ | Nitrogen Oxides |
| NPDES | National Pollution Discharge Elimination System |
| NRHP | National Register of Historic Places |
| NSAWC | Naval Strike and Air Warfare Center |
| NVG | Night Vision Goggles |
| OB/OD | Open Burn/Open Detonation |
| OMB | Office of Management and Budget |
| OPA | Oil Pollution Act of 1990 |

## LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

| | |
|---|---|
| OPP | Oil Pollution Prevention Regulation of 1973 |
| ORSM | Operational Range Site Model |
| OSHA | Occupational Safety and Heath Administration |
| P2 | Pollution Prevention |
| PA | Programmatic Agreement |
| PAO | Public Affairs Office |
| PCB | Polychlorinated Biphenyl |
| PM10 | Particulate Matter with aerodynamic size less than or equal to 10 micrometers |
| PM25 | Particulate Matter with aerodynamic size less than or equal to 2.5 micrometers |
| POL | Petroleum, Oils, and Lubricants |
| QAPP | Quality Assurance Project Plan |
| RCA | Range Condition Assessment |
| RCRA | Resource Conservation and Recovery Act |
| RDF | Range Data Folder |
| RDX | Hexahydro-1,3,5-trinitro-1,3,5-triazine |
| RfD | Reference Dose |
| RSEPA | Range Sustainability Environmental Program Assessment |
| SAIC | Science Applications International Corporation |
| SARA | Superfund Amendments and Reauthorization Act |
| SCP | Spill Contingency Plan |
| SDWA | Safe Drinking Water Act |
| SEAL | Sea, Air, Land |
| SERDP | Strategic Environmental Research and Development Program |
| SHPO | State Historic Preservation Office |
| $SO_X$ | Sulfur Oxides |
| SPCC | Spill Prevention Control and Countermeasures |
| SUA | Special Use Airspace |
| T&E | Threatened and Endangered |
| TACTS | Tactical Aircrew Combat Training Systems |
| TDS | Total Dissolved Solids |
| TERA | Toxicology Excellence for Risk Assessment |
| Tetryl | Tetryl Methyl-2,4,6-Trinitrophenylnitramine |
| TNT | 2,4,6-Trinitrotoluene |
| TRI | Toxics Release Inventory |
| TRIMS | Target and Range Information Management System |
| TSCA | Toxic Substances Control Act |
| TSS | Time Strike Sensitive |
| USACE | U.S. Army Cops of Engineers |
| USACHPPM | U.S. Army Center for Health Promotion and Preventive Medicine |
| USAEC | U.S. Army Environmental Center |
| USEPA | U.S. Environmental Protection Agency |
| USFS | U.S. Forestry Service |
| USFWS | U.S. Fish and Wildlife Service |
| UST | Underground Storage Tank |
| UXO | Unexploded Ordnance |
| VSP-RSM | Visual Sample Plan-Range Sustainment Module |
| WSA | Wilderness Study Area |

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# 1. INTRODUCTION

This document assesses the environmental compliance, develops operational range site models (ORSMs), and conducts predictive modeling for munitions-related military testing and training operations conducted by the Navy at Naval Air Station (NAS) Fallon in the Fallon Range Training Complex (FRTC). The environmental compliance section summarizes the compliance status and major issues found for all possible environmental areas with the FRTC. The ORSM summarizes operational and environmental conditions and is used to support range planning and management. The predictive modeling section discusses the possibility of an off-range release of munitions constituents (MCs) potentially posing an imminent and substantial threat to human health or the environment. In addition, this document provides information needed to address the following questions from Decision Point 1 of the Range Sustainability Environmental Program Assessment (RSEPA) Policy Implementation Manual (U.S. Navy 2004a): "Are further steps required to maintain compliance?" and "Is further analysis required to assess risk of off-range release?"

This document has been prepared to meet an emerging requirement for conducting RSEPAs at Navy land-based operational ranges found in the RSEPA Policy Implementation Manual (U.S. Navy 2004a). This manual was developed by a team of representatives from various organizations within the Navy who were led by representatives of the Chief of Naval Operations (CNO) and Naval Facilities Engineering Command (NAVFAC) Headquarters.

In addition to guiding the development of the RSEPA Implementation Manual, the Navy will use information collected during Phases II and III of a RSEPA Range Condition Assessment (RCA) at the FRTC to determine the environmental compliance, develop the ORSM, and conduct predictive modeling. Results from these three tasks will be used to address Decision Point 1.

This document assesses the environmental compliance, develops the operational range site model (ORSM), and conducts predictive modeling for munitions-related military testing and training operations conducted by Navy at the FRTC. The FRTC encompasses an extensive area. It includes NAS Fallon and four operational ranges: Bravo 16, Bravo 17, Bravo 19, and Bravo 20.

The environmental compliance section summarizes the compliance status and major issues found for all possible environmental areas at the ranges. The ORSM summarizes the operational and environmental conditions at the FRTC ranges and is used to support range planning and management. Predictive modeling is typically conducted in order to forecast the possibility of a release of munitions constituents (MCs) posing an imminent and substantial threat to human health or the environment. MCs are defined in the RSEPA Policy Implementation Manual (U.S. Navy 2004a) as materials originating from military munitions, including explosive and non-explosive materials, and the emissions, degradation, or breakdown products of such munitions, including the following:

- 1,3-Dinitrobenzene
- 2,4-Dinitrotoluene (2,4-DNT)
- 2,6-Dinitrotoluene (2,6-DNT)
- Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
- Nitrobenzene
- Nitroglycerin
- 2-Nitrotoluene
- 3-Nitrotoluene
- 4-Nitrotoluene
- 1,3,5-Trinitrobenzene (1,3,3-TNB)
- Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
- Perchlorate

- 2,4,6-Trinitrotoluene (TNT)
- Methyl-2,4,6-trinitrophenylnitramine (Tetryl)
- 2-Amino-4,6-dinitrotoluene (2-A-4,6-DNT)
- 4-Amino-2,6-dinitrotoluene (4-A-2,6-DNT).

Because the Bravo 16 and a portion of Bravo 17 do not use live munitions, predictive modeling was only conducted for part of Bravo 17 and all of Bravo 19, and Bravo 20. This document, however, is still able to provide information needed to address both Decision Point 1 questions.

A team of Navy civilians and personnel from Science Applications International Corporation (SAIC) conducted the RCA Pre-Site Visit Information Collection (Phase II) in San Diego from 5 to 7 November 2002. During this time, the team was able to brief the Commanding Officer, Captain Goetsch, about the upcoming Fallon RCA. The team gathered as much pertinent information as possible to plan the onsite visit. The team also contacted Larry Jones, Program Manager for Navy Region Southwest Ranges, to discuss logistical and administrative needs for the upcoming Fallon RCA.

Another team of Navy civilians and personnel from SAIC conducted additional RCA Pre-Site Visit Information Collection (Phase II) and the RCA Onsite Visit Information Collection and Review (Phase III) for NAS Fallon from 25 to 28 February 2003. During Phase II and III activities, the teams interviewed key Navy personnel responsible for range and environmental operations and collected range, operational, and environmental information where exercises with munitions are conducted. In addition, this team conducted a tour of NAS Fallon and the FRTC. The information obtained during RCA Phases II and III is used to complete an environmental compliance assessment, develop the ORSM, and conduct predictive modeling. The following sections present information needed to complete this evaluation.

## 1.1 OVERVIEW OF ENVIRONMENTAL COMPLIANCE

Environmental compliance serves as a basis for addressing one of the two major questions posed during Decision Point 1 of the RSEPA process. During Phase III, information is collected about the possible impacts of range operations on the environment. Efforts during Phase III are focused on munitions usage on land-based operational ranges. The collected information is reviewed and analyzed for environmental regulatory applicability and compliance deficiencies.

Phase III information collection efforts are not carried out to the same degree of detail as a Navy Environmental Quality Assessment (EQA), which is a Navy internal environmental compliance assessment program. Rather, range personnel and environmental managers are interviewed to determine what environmental and range management programs are in place and to what extent these programs addressed environmental regulatory requirements and current and potential environmental and human health risks due to range operations. The environmental compliance and explosives safety management areas addressed during interviews and in the environmental compliance section of this report include:

- Air Quality
- Water Quality
- Hazardous Materials
- Hazardous Waste
- Emergency Planning and Community Right-to-Know Act (EPCRA)
- Pollution Prevention
- Storage Tank Management
- Petroleum, Oils, and Lubricants (POL)
- Natural Resources
- Cultural Resources
- National Environmental Policy Act (NEPA)

- Pesticides Management
- Lead-based Paint Management
- Asbestos Management
- Polychlorinated Biphenyl (PCB) Management
- Environmental and Explosives Safety Management.

The assessment areas listed above were chosen based upon those environmental compliance and explosives safety management areas found in the Navy's Environmental Compliance Evaluation Program, the U.S. Army Corps of Engineers (USACE) Environmental Assessment and Management (TEAM) Guide (Revised March 2003), and OPNAVINST 5090.1B. Information obtained and conclusions made during this portion of Phase III also aided in ORSM development and predictive modeling efforts.

## 1.2 OVERVIEW OF ORSMs

ORSMs use existing knowledge to describe land-based operational ranges and their environments in both graphical and tabular formats. ORSMs summarize operational and potential release information, migration and exposure pathways, and expected levels and locations of releases. They summarize the links between potential sources of munitions constituents, release mechanisms, exposure pathways, exposure routes, and receptors. ORSMs include range boundaries, topography, vegetation, and hydrology to the extent that is known through historical information and a range visit.

ORSMs assist in planning studies, interpreting data, and communicating conclusions. They are developed initially during RCA Phase III and, if conducted, they are refined during the Comprehensive Range Evaluation (CRE) – Preliminary Screening (Phase I) and further refined during the CRE – Verification Analysis (Phase II).

If a CRE is conducted, ORSMs then are used in the systematic planning process, particularly in the development of data quality objectives (DQOs) and to support the use of tools such as Visual Sample Plan-Range Sustainment Module (VSP-RSM). In other words, ORSMs are tools to assist decisionmakers in determining the types, locations, and degrees of field analysis that might be needed in the CRE.

## 1.3 OVERVIEW OF PREDICTIVE MODELING

Predictive modeling is conducted to determine the potential for off-range releases of MCs. The release of particular concern in RSEPA is a release of explosive compounds, specifically as demonstrated by the release of one or more of the following modeling compounds (U.S. Navy 2004a): Her Majesty's Explosive (HMX or octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine), Royal Dutch Explosive (RDX or hexahydro-1,3,5-trinitro-1,3,5-triazine), 2,4,6-trinitrotoluene (TNT), 2,4-dinitrotoluene (2,4-DNT), and perchlorate. In order to determine the potential for off-range release, predictive modeling is conducted in two stages. The first stage of the modeling, known as mass loading modeling, predicts potential concentrations of modeling compounds in soil using munitions usage data, information about the compounds in munitions, low-order detonation rates, and information about sizes of targets. The second stage uses the mass loading information and transport models to predict the potential vertical and horizontal migration of marker compounds off-range through environmental media, since the ORSM identified groundwater at Bravo 17 East, Bravo 19, and Bravo 20 as potential off-range migration pathways for modeling compounds.

Because of the limited information available to determine if an off-range release of MCs is possible, screening-level models were used. Screening models typically are relatively simple and are used to make more extensive modeling or sampling unnecessary. Screening models generally produce conservative estimates in order to reasonably ensure that maximum concentrations will not be underestimated. If the resulting estimates from screening models indicate a potential threat of a release, a refined model could be used to re-estimate concentrations, protective measures could be implemented, or a CRE could be conducted. Refined models may provide more accurate estimates, but they require substantially more effort in developing detailed and precise input data than do screening models.

## 1.4 REPORT FORMAT

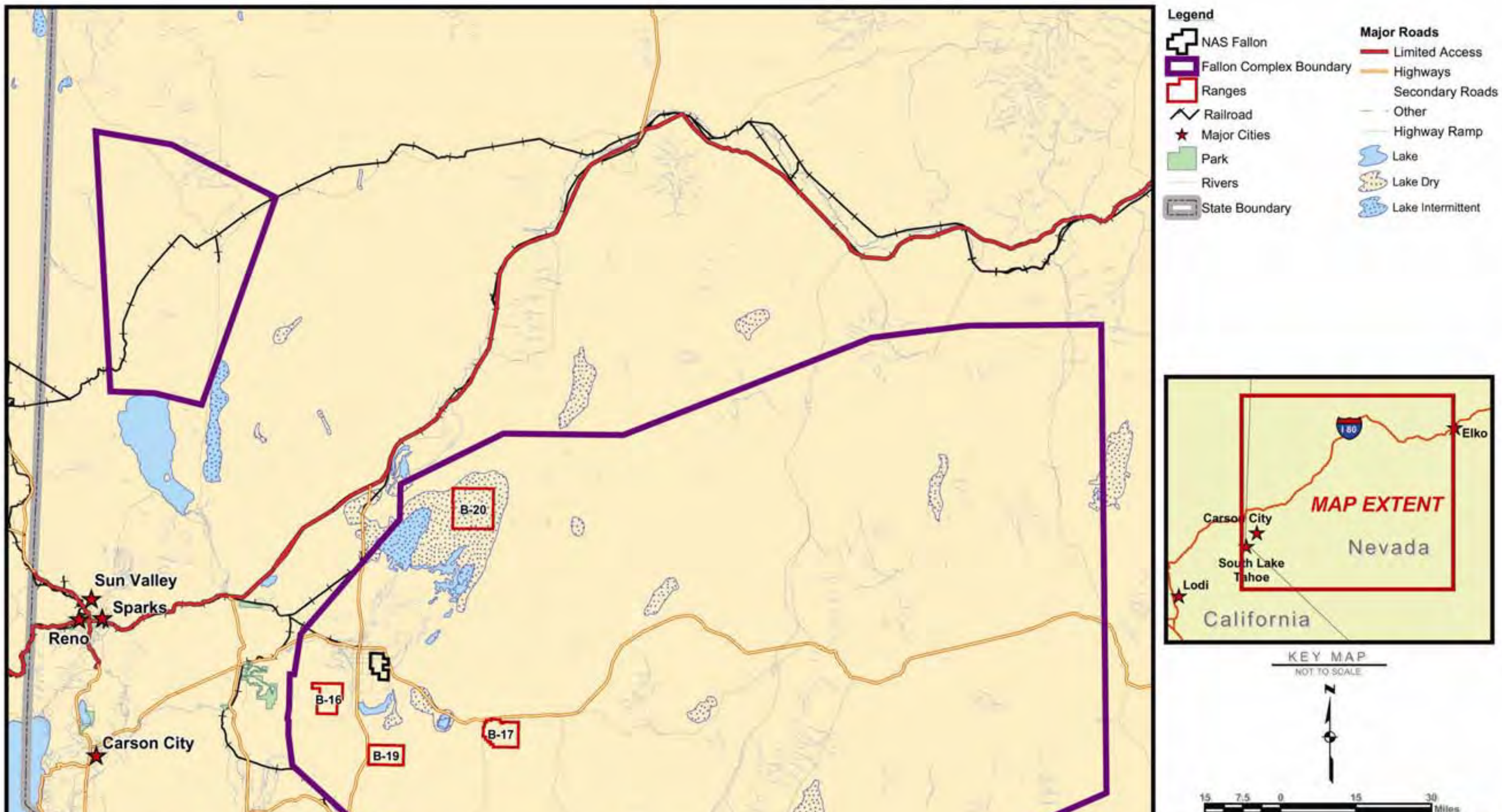
Section 2 presents a brief description of the NAS Fallon location and mission. Section 3 presents each of the environmental compliance areas assessed and any deficiencies noted as a result of the Phase III information collection process. Section 4 presents the ORSM. It includes information about historical, current, and future military operations at the FRTC and describes where military testing and training operations occur. Section 4 also details the physical environment of the FRTC and describes factors that may affect munitions constituent release, fate and transport, and potential receptors. Cultural resources also are presented in Section 4, along with land use and information that could identify and evaluate the applicable scenarios and locations of human and ecological exposure to potential releases of munitions constituents. Predictive modeling is presented in Section 5. The conclusions recommendations for this report are provided in Section 6.

# 2. BACKGROUND FOR NAS FALLON

In 1942 NAS Fallon was constructed when the Civil Aviation Administration and the Army Air Corps built four airfields in the Nevada desert as a part of the Western Defense Program's plan to repel the expected Japanese attack on the West Coast. One year later, in an effort to improve the training and combat competence of aviation pilots, the Navy assumed control over the runways and built barracks, air traffic control towers, hangers, and target ranges. The following year, NAS Fallon was commissioned and fully operational.

The base, over many years, expanded its facilities to improve training capabilities with increasing technological advances. The current mission of NAS Fallon is to provide services and materiel to tenants and transient units stations at or deploying to NAS Fallon for CNO approved aviation training. The major tenant command is the Naval Strike and Air Warfare Center (NSAWC) and it develops realistic combat training scenarios for military aircrews. NSAWC also is responsible for operating, maintaining, scheduling, developing, and configuring the FRTC. The FRTC encompasses an extensive area. It includes NAS Fallon and four operational ranges: Bravo 16, Bravo 17, Bravo 19, and Bravo 20. This area encompasses 105,451 acres. The FRTC and the location of NAS Fallon and the four ranges within the FRTC are shown in Figure 2-1.

NAS Fallon is currently the training facility for the Navy's most elite pilots from around the nation. Pilots can enroll in one of two programs: Navy's Fighter Weapons School (TOPGUN) or Carrier Airborne Early Warning Weapons School (Top Dome). On average, NAS Fallon receives and trains 55,000 military personnel every year, each staying an average of 14 days.




LOCATION OF NAS FALLON
& FALLON RANGE
TRAINING COMPLEX
NAS FALLON
FALLON, NEVADA

PROJECT: \GIS_Projects\RSEPA\FALLON\Projects\Fallon Ranges.mxd

FIGURE: 2-1 DATE: 02/26/2004

# 3. ENVIRONMENTAL COMPLIANCE

## 3.1 INTRODUCTION

Environmental compliance serves as a basis for addressing one of the two major questions posed during Decision Point 1 of the RSEPA process. During Phase III, information is collected about the possible impacts of range operations on the environment. Efforts during Phase III are focused on munitions usage on land-based operational ranges. The collected information is reviewed and analyzed for environmental regulatory applicability and compliance deficiencies.

Initially, pertinent information was gathered and reviewed in order to plan the onsite visit. These documents are compiled and organized in the Fallon "Range Data Folder" (RDF). Appendix A contains a spreadsheet outlining all documents obtained thus far in the Fallon RDF. The Technical Team conducted RSEPA RCA, Phase II for the FRTC by using this information to make an initial assessment of applicability of environmental regulations to the range and its operations. This initial assessment prior to the onsite visit identified data gaps, increased the efficiency of the onsite visit, and minimized disruptions to installation personnel and operations during the onsite visit.

The RSEPA Technical Team commenced the RSEPA RCA, Phase III for the FRTC by meeting with Commanding Officer, range personnel, the Public Affairs Officer, and environmental managers from 27 through 25 February 2003 at NAS Fallon. The RSEPA Technical Team assessed operational range areas (Bravo 16, Bravo 17, Bravo 19, and Bravo 20), along with range support operations and facilities. The RCA conducted at the Fallon ranges was not carried out to the degree of detail as a Navy Environmental Compliance Evaluation, which is a Navy environmental programs audit. Rather, range personnel and environmental managers were interviewed to determine what environmental and range management programs are in place and to what extent these programs address environmental regulatory requirements and current and potential environmental and human health risks due to range operations. The environmental compliance and explosives safety management areas addressed during interviews and in this report include:

- Air Quality
- Water Quality
- Hazardous Materials
- Hazardous Waste
- EPCRA
- Pollution Prevention
- Storage Tank Management
- POL
- Natural Resources
- Cultural Resources
- NEPA
- Pesticides Management
- Lead-Based Paint Management
- Asbestos Management
- PCB Management
- Environmental and Explosives Safety Management.

The assessment areas listed above were chosen based upon those environmental compliance and explosives safety management areas found in the Navy's Environmental Compliance Evaluation Program, The USACE Environmental Assessment and Management (TEAM) Guide (Revised March 2003), and OPNAVINST 5090.1B. To supplement information gained from interviews, copies of additional documents pertaining to range operations and environmental programs were obtained during the onsite visit and also are compiled and organized in the Fallon RDF. A summary of the documents contained in the RDF is provided in Appendix A.

Technical Team members analyzed the information gained from the FRTC visit, interviews, and documents received. The Team documented their findings as individual reports for their assigned environmental media. These individual reports are contained in Appendix B as “Onsite Visit Information Collection Review Summary Reports.”

## 3.2 ENVIRONMENTAL REGULATORY APPLICABILITY AND COMPLIANCE ASSESSMENT

This section summarizes the Technical Team members' individual reports that are presented in detail in Appendix B. The summaries entail the Team's environmental regulatory applicability and compliance assessment of the FRTC.

### *3.2.1 Air Quality*

The Clean Air Act and its amendments apply to the ranges, their operations, and support facilities. The majority of air quality regulations apply to stationary emission sources, which in Nevada, are regulated by the Nevada Department of Environmental Protection, Bureau of Air Pollution Control (BAPC). The authority of the BAPC has jurisdiction of air quality programs over all counties in the state except for Washoe and Clark Counties, who have local jurisdiction. All counties in the state are in attainment with Federal ambient air quality standards for criteria pollutants (Nitrogen Oxides [$NO_x$], Sulfur Oxides [$SO_x$], Ozone, Particulate Matter with aerodynamic size less than or equal to 10 micrometers [PM10], Particulate Matter with aerodynamic size less than or equal to 2.5 micrometers [PM2.5], Carbon Monoxide [CO], and lead), except for Washoe (Reno) and Clark Counties (Las Vegas).

#### 3.2.1.1 Air Quality at Fallon Ranges

The operational ranges within the FRTC that are the focus of this RCA are Bravo 16, Bravo 17, Bravo 19, and Bravo 20 and are all located within Churchill County, an attainment county. Therefore, due to the county’s attainment status, the ranges and NAS Fallon are not subject to as many regulations as they would be if they were located in a non-attainment air basin.

The primary air emission sources found in operational range areas are mobile sources. The following two regulations apply to mobile emission sources and potentially could affect Fallon range operations. The first regulation is the Federal General Conformity Act; however, since NAS Fallon and the ranges are located within an attainment air basin, the Federal General Conformity Rule does not apply and a threshold conformity determination is not required. The second mobile emission regulation is the proposed Nevada legislation, state Assembly Bill (AB) 36, which may indirectly affect range operations by regulating “smoke and other emissions by inspection of certain heavy-duty motor vehicles.” Range operators use heavy-duty vehicles out on the range and they are concerned that restrictions may be placed on these vehicles. The Navy is seeking a military tactical heavy-duty vehicle exemption similar to one that exists in California.

Most regulations that apply to stationary sources apply to NAS Fallon; however, the ranges have backup generators. According to the NAS Fallon Environmental Department, the internal combustion engines on these range generators are not large enough to require a state air permit. In addition, these generators are not included under NAS Fallon’s state facility air permit.

The state’s Open Burning Rule may apply to open burning/open detonation (OB/OD) range operations with regard to ensuring that OB/OD activities are attended at all times to prevent a fire hazard. OB/OD may be exempted from permitting under the rule as “personnel training” or “elimination of hazards.”

The BAPC recently has raised the issue of whether a particular explosive ordnance disposal (EOD) training exercise (the "FBI post blast training exercise") may possibly be subject to the state's Fugitive Dust Rule for "surface area disturbance." The intent of this rule is for the control of airborne particulate emissions for the following types of activities: 1) the handling, transporting, and storing of materials that could be airborne; 2) construction/earth moving operations; and 3) agriculture (exempted). Currently, NAS Fallon is researching the BAPC's allegations that the proposed training exercise is subject to air pollution control regulations. It is recommended that the Regional Environmental Coordinator be consulted and that a legal review by Navy environmental attorneys be conducted.

#### 3.2.1.2 Air Quality at Off-Range Support Facilities

Nevada air quality regulations apply to NAS Fallon, since Fallon has both stationary and mobile emission sources that are subject to Nevada air quality regulations. NAS Fallon does not have a Title V permit, since annual actual and potential emissions do not exceed Title V permitting thresholds. NAS Fallon has a Class II (Minor Source) facility permit that encompasses all stationary sources whose emissions exceed Nevada permitting thresholds. Other regulations that apply to NAS Fallon are Clean Air Act Amendments 1990 (CAAA90), Title III maximum achievable control technology (MACT) standards for area sources; Title III, Section 112r, Risk Management Plan (if stored chemicals exceed established thresholds), and Federal Asbestos National Emission Standards for Hazardous Air Pollutants (NESHAP).

The ranges appear to be in compliance with all applicable air quality regulations. However, it is recommended that NAS Fallon address compliance under CAAA90, Title III Sections 112 (a – r) and the Federal Asbestos NESHAP. NAS Fallon has received a Notice of Alleged Violation (NOAV) for violating a boiler permit emission limit during a stack test. A "Compliance Order" from the BAPC will require a boiler stack retest that will determine final compliance.

### *3.2.2 Water Quality*

#### 3.2.2.1 Water Quality at Fallon Ranges

There is no significant groundwater source or perennial water bodies on operational ranges Bravo 16, Bravo 17, Bravo 19, and Bravo 20. During wet years, seasonal ponding of water may occur within topographic depressions. Seasonal water accumulation does not constitute jurisdictional waters of the United States that are subject to protection under the Clean Water Act (CWA); therefore, CWA does not apply. There are no sources of drinking water on Bravo 16, Bravo 17, Bravo 19, and Bravo 20 and no sole source aquifers on any of the ranges that require protection under the Safe Drinking Water Act. In addition, according to NAS Fallon Environmental Department staff, the general direction of groundwater flow is in a southeasterly direction, which is away from populated areas.

#### 3.2.2.2 Water Quality at Off-Range Support Facilities

NAS Fallon has a Stormwater Pollution Prevention Plan that requires stormwater monitoring for primarily paved areas, such as the station's tarmac. As of yet, no requirements have been made of NAS Fallon to monitor stormwater runoff from operational range areas, which are not paved.

NAS Fallon has a Federally Owned Treatment Works (FOTW) that has a National Pollution Discharge Elimination System (NPDES) permit. According to NAS Fallon Environmental Department staff, FOTW effluent must meet drinking water standards, which is probably due to the fact that the FOTW discharges to a ditch and effluent receives no dilution. Currently, NAS Fallon, with the help of Engineering Field Activity (EFA) Northwest, is addressing an inflow and infiltration (I/I) problem of groundwater seeping into sanitary sewer lines on station. The state Bureau of Water Pollution Control (BWPC) wants to reduce I/I to reduce the concentration of arsenic and total dissolved solids (TDS) in effluent from groundwater infiltration.

NAS Fallon also has a Federally designated "public water system" consisting of three potable wells northwest of the station. The well water is chlorinated prior to distribution for public consumption and is used only by NAS Fallon employees and base housing. Arsenic is naturally occurring in well water in Fallon and is higher than Federal and state drinking water concentrations for arsenic. NAS Fallon was issued a Notice of Violation (NOV) in 2002 for exceeding the arsenic maximum contaminant level (MCL) in NAS Fallon's drinking water. The NOV is being addressed with the building of a treatment plant that will reduce the concentration of arsenic in both NAS Fallon and the city of Fallon's drinking water. The city of Fallon is building the plant, which is funded by both the city and NAS Fallon.

### *3.2.3 Hazardous Materials*

NAS Fallon's Environmental Department manages Occupational Safety and Health Administration (OSHA) hazardous material regulatory requirements on Fallon operational ranges and NAS Fallon. NAS Fallon participates in a Hazardous Communication (HAZCOM) program under the Hazardous Material Control and Management (HMC&M) program. NAS Fallon meets OSHA hazardous material regulatory requirements for the ranges by having an Authorized Users List (AUL). The Technical Team did not receive a copy of the AUL, but did receive and review a copy of a spreadsheet showing what hazardous materials are located on the ranges and NAS Fallon.

Based upon the information gained from the NAS Fallon Environmental Department, there have been "reportable spills" of hazardous materials (such as POL) at the ranges and NAS Fallon; however, these spills were contained, cleaned up, and did not go off-range. Based on the HMC&M program that is in place and past spill response practices, it is expected that future spills will be limited and will not go off-range.

NAS Fallon and Fallon ranges have not received any hazardous material management NOVs as of the date of this report and currently appear to be in compliance with hazardous material management regulations.

### *3.2.4 Solid and Hazardous Waste*

The Resource Conservation and Recovery Act (RCRA) of 1976 is applicable to the Fallon ranges, since hazardous wastes are present on the operational range areas, such as at range satellite accumulation points. The Military Munitions Rule (MMR), under RCRA, defines when conventional and chemical military munitions become solid wastes that are then potentially subject to hazardous waste regulations and establishes procedures and management standards for waste military munitions. The MMR applies to Fallon operational ranges where military munitions are used, such as Bravo 16, Bravo 17, Bravo 19, and Bravo 20. All munitions are destroyed in place, on range, by approved OB/OD practices by EOD and there are no known areas where military munitions were discarded historically (i.e., abandoned without following proper disposal procedures). From review of information and interviews with Navy personnel, it appears that the Fallon ranges are in compliance with the MMR.

The Navy recently released the *Operational Range Clearance Policy for Navy Ranges* (U.S. Navy 2004b), which includes new requirements for activities such as the removal, disposal, and recycling of UXO, range scrap, and debris. Generally, existing FRTC procedures appear to comply with the operational range clearance policy, but the FRTC Range Manager should ensure that range-specific scrap management policies and procedures comply with the operational range clearance policy.

NAS Fallon's Environmental Department manages solid waste, hazardous waste, and MMR requirements at NAS Fallon and the ranges. NAS Fallon meets RCRA hazardous waste regulatory requirements by having a Hazardous Waste Management Plan (HWMP), which applies to the ranges and NAS Fallon.

NAS Fallon and the Fallon ranges have not received any hazardous waste management NOVs as of the date of this report and currently appear to be in compliance with hazardous waste management regulations.

### *3.2.5 Emergency Planning and Community Right-to-Know Act*

The primary purpose of the EPCRA or the Superfund Amendments and Reauthorization Act (SARA) Title III is to inform communities and citizens of chemical hazards in their areas in order to help communities prepare to respond to chemical spills and similar emergencies. In addition, EPCRA requires the U.S. Environmental Protection Agency (USEPA) and the states to collect annually data on releases and transfers of certain toxic chemicals from industrial facilities, and make the data available to the public in the Toxics Release Inventory (TRI).

#### 3.2.5.1 EPCRA at Fallon Ranges

Sections 311, 312, and 313 of EPCRA are applicable to the Fallon ranges, since hazardous and toxic chemicals such as petroleum products, metallic compounds, paints, and specialty gases are sometimes stored on-range. Examples include diesel stored in aboveground storage tanks (ASTs) at the ranges and used oil and latex paint at Bravo 17 flammable lockers. However, it was in 1998 that munitions activities were required to be included in EPCRA reporting, according to a U.S. Department of Defense (DOD) Deputy Under Secretary of Defense for Environmental Security policy. Reporting under Section 313 of EPCRA was extended to the use of military munitions on operational ranges with the first reports due 1 July 2000. Facilities must meet two initial criteria before they are required to do a toxic release threshold determination for their range. The criteria are that military munitions had to have been used on the range in the past year and that the facility must have 10 or more full-time employees (or meet the full-time equivalent hours of 20,000 hours per year). NAS Fallon determined, in an internal Navy document for CY 2001, that the “total range man hours for EPCRA reporting was 16,952.3 hours” which was for Bravo 16, Bravo 17, Bravo 19, and Bravo 20 employee hours combined. NAS Fallon included only the work hours that range employees spent physically on the ranges in their full-time equivalent hours threshold calculations. However, according to a 20 March 2002 memorandum from the CNO entitled Supplemental Guidance for EPCRA Compliance and Mandate to Use Data Delivery System to Apply the Toxic Release Inventory Requirements to Munitions Activities, “the employee threshold calculation shall also account for time spent by personnel on base not physically located on the range, but in direct support of range operations. This includes time spent by schedulers and controllers in direct support of range operations.” Because the CNO guidance memorandum is dated 2002, the ranges at NAS Fallon are not considered to have deficiencies for previous EPCRA reporting years. The Technical Team concludes that NAS Fallon should re-evaluate their calculation of range full-time employee equivalent hours and considers this need for additional calculations to be a significant deficiency. NAS Fallon will exceed established compliance deadlines, if immediate action is not taken.

#### 3.2.5.2 EPCRA at Off-Range Support Facilities

Sections 311, 312, and 313 of EPCRA are also applicable to NAS Fallon facilities that store, handle, and may potentially release hazardous and toxic chemicals. A few examples are the jet fuel stored at the Fuel Farm, gasoline at the NEX Gas Station, and the use of PD-680 at the hangars. “Tier II Emergency and Hazardous Chemical Inventory” reporting forms, as required by Sections 311 and 312 of EPCRA, were submitted to the Nevada Department of Environmental Protection (NDEP). NAS Fallon appears to be in compliance with regard to Section 313 requirements for chemicals stored and used on station. According to dated calculations, NAS Fallon did not exceed threshold toxic release quantities for non-munitions activities and, therefore, did not have to submit a Form R for TRI reporting. However, the Environmental Department plans to recalculate the quantities for CY 2002 to ensure that NAS Fallon does not exceed the threshold quantities for non-munitions activities.

### 3.2.6 Pollution Prevention

NAS Fallon has a Pollution Prevention (P2) Plan, which does not specifically address any P2 practices at the ranges. Pollution prevention opportunities at the ranges are few, since few waste streams are produced. Any spent fuels are burned in place, since they are a hazard. Most P2 opportunities are related to the recycling of scrap metal from range targets and the recycling of POL drained from targets prior to placement on the ranges.

NAS Fallon and Fallon ranges have not received any P2 noncompliance NOVs as of the date of this report and currently appears to be in compliance with pollution prevention regulations.

### 3.2.7 Storage Tank Management

#### 3.2.7.1 Storage Tank Management at Fallon Ranges

NAS Fallon replaced all underground storage tanks (USTs) that were associated with on-range generators with ASTs; therefore, no Federal or state UST regulations apply to the ranges. The USTs that were replaced by ASTs on the ranges either were slurry-filled in place or removed. Some of these USTs were leaking and soil removals were performed and the NDEP declared them as requiring "No Further Action." Storage tank laws that apply to ASTs apply to range ASTs. Range and NAS Fallon ASTs have secondary containment, 5- to 7-gallon overfill boxes, tank gauges, and high-level overfill alarms. NAS Fallon has both USTs and ASTs on station; therefore, Federal and state storage tank laws apply to station tanks.

#### 3.2.7.2 Storage Tank Management at Off-Range Support Facilities

NAS Fallon's Environmental Department manages storage tank regulatory requirements for NAS Fallon and range storage tanks. They have oversight on the Spill Prevention Control and Countermeasures (SPCC) Plan, the Spill Contingency Plan (SCP), the Emergency Response Action Plan (ERAP), and the Facility Response Plan (FRP), which are the four major reports submitted to the NDEP to satisfy Federal and state storage tank regulation requirements. The SPCC and SCP have been combined into an SPCC-SCP and the ERAP and FRP have been combined into the ERAP-FRP. The ERAP-FRP is out of date; however, no NOVs have been issued. The SPCC-SCP and ERAP-FRP will be combined into one Integrated Contingency Plan (ICP). NAS Fallon does not have a current Tank Management Plan, as required under OPNAVINST 5090.1B, but has put in a funding request for one through Environmental Program Requirements (EPR) and Command Navy Region Southwest.

### 3.2.8 Petroleum, Oils, and Lubricants (POL)

The Oil Pollution Prevention Regulation of 1973 (OPP) and Oil Pollution Act of 1990 (OPA90) apply to NAS Fallon and Fallon range areas where both oil and petroleum-based materials and wastes are stored. No perennial water bodies are on the ranges. During wet years, seasonal ponding of water may occur within topographic depressions. Seasonal water accumulation does not constitute jurisdictional waters of the United States that OPA90 would protect; therefore, CWA does not apply. Regardless, NAS Fallon has measures in place for storage, handling, and disposal of oils that are compliant with OPA90 and protect any waters located on or near NAS Fallon and the ranges.

NAS Fallon's Environmental Department manages POL regulatory requirements at NAS Fallon and the ranges and is responsible for overseeing the SPCC Plan, SCP, ERAP, and FRP, which satisfy regulatory requirements under CWA, OPP, OPA90, and OSHA. The SPCC and SCP are combined into an SPCC-SCP and meet OPP regulatory requirements, while the ERAP and the FRP are combined into the ERAP-FRP and meet OPP, OPA90, and OSHA regulatory requirements. The SPCC-SCP and ERAP-FRP will be combined into one ICP.

NAS Fallon's Tank Management Plan is not current, but the Environmental Department has put in a funding request for a Tank Management Plan through EPR and Command Navy Region Southwest.

To date, no NOVs have been issued for NAS Fallon with regard to POL management regulations. However, NAS Fallon and the ranges would receive an overall compliance grade of "few deficiencies" due to the out of date Tank Management Plan.

### 3.2.9 Natural Resources

The NAS Fallon Natural Resources Specialist and Environmental Department are responsible for the day-to-day management of natural resources and compliance issues at NAS Fallon and the ranges. There are few natural resource-related issues at the active ranges and, therefore, there are no programs designed specifically for the ranges.

The Navy prepared an Integrated Natural Resources Management Plan (INRMP) for NAS Fallon in September 2001 (U.S. Navy 2001), with the cooperation and concurrence of the U.S. Fish and Wildlife Service (USFWS) and the Nevada Division of Wildlife. The INRMP describes the management protocols developed by NAS Fallon to meet applicable natural resource regulations. Ecological surveys were conducted in 1996 and 1997 to characterize the plant, bird, and mammal communities, as described in the Ecological Inventory Survey Report (TetraTech 1997); surveys were conducted on all four ranges. ESA Section 7 compliance/USFWS consultation for proposed actions have been reported in corresponding NEPA documents (e.g., environmental impact statement [EIS] and environmental assessment [EA]); compliance for the operational use of the ranges is reported in the Proposed Fallon Range Training Complex Requirements EIS (U.S. Navy 2000c). No federally listed threatened or endangered plant or wildlife species are known to be residents or seasonal visitors to Fallon's training ranges (although other species of concern can be found near and possibly on the training ranges). Regulations associated with outleasing for grazing and farming, wild horses, outdoor recreation (including hunting), urban forestry, off-road vehicle use, national trails, water rights (i.e., Fallon Paiute-Shoshone Indian Tribes Water Rights Settlement Act of 1990), and landscaping apply to some areas of NAS Fallon, but are not applicable to the active training ranges.

NAS Fallon and the ranges appear to be currently in compliance with natural resource regulations. No NOVs have been issued for noncompliance with natural resources regulations and no deficiencies are noted in this report.

### 3.2.10 Cultural Resources

The NAS Fallon Archaeology and Environmental Department are responsible for the day-to-day management of cultural resources and compliance issues at NAS Fallon. The Cultural Resources Management Plan (CRMP) describes the management protocols developed by NAS Fallon to meet the applicable cultural resource regulations.

More than 200 cultural resource studies have been conducted at NAS Fallon, and numerous reports have been written about previous surveys, excavations, and eligibility testing of archaeological resources. There is a CRMP (May 1993) and a draft Integrated Cultural Resources Management Plan (ICRMP) (July 2000). All buildings at the main station have been inventoried and evaluated for World War II and Cold War significance. Documents related to the Native American Graves Protection and Repatriation Act (NAGPRA), such as mandatory Inventory and Summary, have been compiled for NAS Fallon. Section 106 compliance and State Historic Preservation Office (SHPO) consultation for proposed actions have been reported in corresponding NEPA documents (e.g., EIS and EA); compliance for the operational use of the ranges is reported in the Proposed Fallon Range Training Complex Requirements EIS (U.S. Navy 2000c).

A Memorandum of Understanding (MOU) has been negotiated with the Fallon Paiute-Shoshone Tribe with regard to Native American burials, skeletal material, and grave goods found on NAS Fallon land. There is a 1996 Programmatic Agreement (PA) among NAS Fallon, Nevada SHPO, and the Advisory Council on Historic Preservation (ACHP) regarding evaluation and treatment of historic properties on lands managed by NAS Fallon. A new PA is being negotiated between the Bureau of Land Management (BLM) and the three parties involved in the 1996 PA. Activities associated with the operational use of the ranges currently are covered in the 1996 PA and should be covered under the new PA.

NAS Fallon and the ranges appear to be currently in compliance with cultural resource regulations. No NOVs have been issued for noncompliance with cultural resources regulations and no deficiencies are noted in this report.

### *3.2.11 National Environmental Policy Act*

EAs have been prepared over the years for individual Fallon range activities and comprehensive EISs that address the environmental impacts of Fallon range operations and land withdrawal related to ranges Bravo 16, Bravo 17, Bravo 19, and Bravo 20. Examples of two Fallon EISs are the Final EIS for the Withdrawal of Public Lands for Range Safety and Training Purposes at NAS Fallon, and the Final EIS for the Proposed Fallon Range Training Complex Requirements. All EAs and EISs have been submitted to and reviewed by the appropriate Federal, state, and local agencies and finalized under the NEPA process.

According to Fallon range management, NAS Fallon has an informal Environmental Impact Review (EIR) process in place to evaluate new or modified range operations for compliance with current NEPA documentation.

NAS Fallon and range operations appear to be in compliance with the requirements of the statutes, regulations, and instructions that govern NEPA actions and have not received any NEPA noncompliance NOVs as of the date of this report.

### *3.2.12 Pesticide Management*

#### 3.2.12.1 Pesticide Management at Fallon Ranges

The Federal and state regulations governing application; experimental use; storage, mixing, and preparation; labeling; and worker protection do not apply to ranges Bravo 16, Bravo 17, Bravo 19, and Bravo 20, since pesticides are not used at these ranges.

#### 3.2.12.2 Pesticide Management at Off-Range Support Facilities

Pesticide use practices on station and at the Dixie Valley Centroid Facility are reviewed and managed by the NAS Fallon Environmental Department, Natural Resources Branch. “Navy policy is to employ an integrated pest management program that minimizes pesticide use” (OPNAVINST 5090.1B CH-1, 2 February 1998, Section 13-5.1). NAS Fallon has a Pest Management Plan, including a Pesticides Use Plan. In addition, a Pest Control Management Program exists that is conducted by Pestmaster Services, a subcontractor to the Base Operating Services (BOS) contractor.

NAS Fallon and the ranges have not received any NOVs for pesticide management noncompliance as of the date of this report and appears to be in compliance with pesticide management regulations. No deficiencies were noted in this report.

### *3.2.13 Lead-based Paint Management*

The Environmental Department at NAS Fallon has assessed buildings located at NAS Fallon for lead-based paint; however, no information was available regarding the presence of lead-based paint on structures at the ranges. The Toxic Substances Control Act (TSCA), with respect to the regulation of lead-based paint, could apply during the renovation of the few buildings that are located on the range, such as the buildings that appear to be located on Bravo 17 West in the Army Compound, if they contained lead-based paint. However, it is not possible to make an applicability assessment with respect to the range buildings without knowing if the buildings contain lead-based paint.

The lead-based paint management program is lacking a written lead-based plan. This lack of a written plan was noted in NAS Fallon Environmental Department's Environmental Quality Assessment Report (EQAR), December 2002 (U.S. Navy 2002a). NAS Fallon is advised to develop a written lead-based paint management plan and it is understood that the Environmental Department is working to resolve this issue. Lead-based paint compliance assessment for NAS Fallon normally is addressed in detail during Navy Environmental Compliance Evaluations.

Due to the focus of the RSEPA RCA on the Fallon ranges and since lead-based paint is not a major compliance issue for the ranges, which have very few structures, no deficiencies were noted for NAS Fallon or the ranges.

### *3.2.14 Asbestos Management*

Asbestos is well recognized as a health hazard and is highly regulated. OSHA regulates the construction, repair, containment, and removal of asbestos-containing materials (ACM) to protect workers from exposure of asbestos in the workplace. The CAA's Asbestos NESHAP applies to asbestos abatement practices. The Hazardous Materials Transportation Act (HMTA) (49 Code of Federal Regulations [CFR] 172-177, amended in 1978, to regulate the transport of asbestos materials) requires that asbestos must be loaded, handled, and unloaded in a manner that will minimize occupational exposure to airborne asbestos. Asbestos-containing wastes, which are transported for disposal at a landfill or other disposal facility, must meet all applicable RCRA hazardous waste disposal requirements. Asbestos NESHAP and OSHA would apply to the abatement of ACM in any buildings at NAS Fallon and the few buildings located on operational range areas. HMTA would apply to the transport of ACM abated from buildings and RCRA would apply to hazardous waste manifesting of ACM to a landfill licensed to receive ACM. With regard to applicability of asbestos management regulations and the ranges, the Federal TSCA and the Asbestos Hazard Emergency Response Act (AHERA) do not apply, since there are no schools on the Fallon ranges. There are some buildings located on Bravo 17 West in the Army Compound, but the range buildings were surveyed and ACM was removed, so HMTA and Asbestos NESHAP no longer apply to the ranges.

The NAS Fallon Environmental Department oversees compliance with the Asbestos NESHAP, including the time-critical notifications to USEPA Region IX. According to NAS Fallon's Environmental Department, when asbestos-related projects are identified, the Public Works Maintenance Division is responsible for notifying the Environmental Department so that they can make the appropriate notifications. The last known asbestos demolition/renovation project was in July 2002. The notification to USEPA Region IX was accomplished in June 2002.

In addition, the Environmental Department informed the Technical Team that NAS Fallon has an asbestos survey that is maintained between the Safety Office, Public Works Maintenance and the BOS contractor. The NAS Fallon Safety Office used to have the Asbestos Program Manager (APM) responsibility, but their certification expired because there was a difference of opinion between Public works (PW) Maintenance, Environmental, and Safety as to who was responsible for the program. The Environmental Department has identified this deficiency to Command Navy Region Southwest as a critical compliance issue that needs to be addressed.

### *3.2.15 PCB Management*

Toxic Substances Control Act (TSCA) (40 CFR 761) currently regulates PCBs. TSCA generally bans the use, manufacture, processing, and distribution in commerce of PCBs. Regulations issued under TSCA regulate the marking, storage, and disposal of PCB-containing items and require generator identification numbers and the manifesting of PCB wastes. RCRA (40 CFR 260-270) applies to the disposal of PCB-containing items in certain instances. According to the NAS Fallon Environmental Department, PCB sampling results of range equipment suspected of using PCB-containing fluids indicated that there is no PCB-containing equipment on Bravo 16, Bravo 17, Bravo 19, or Bravo 20. Therefore, the ranges are currently not subject to the PCB regulating statutes listed above. However, both statutes do apply to range support operations/facilities at NAS Fallon because there is electrical equipment on station that contains PCBs. The Environmental Department is responsible for overseeing the proper storing, handling, and disposal of PCB-containing items.

This lack of a written PCB management plan was mentioned in the NAS Fallon Environmental Department's EQAR (U.S. Navy 2002a). It is understood that the Environmental Department is working to resolve this issue. The PCB compliance assessment for NAS Fallon normally is addressed in detail during Navy Environmental Compliance Evaluations.

Due to the focus of the RSEPA RCA on the Fallon ranges and the lack of PCB-containing equipment on the Fallon ranges, no deficiencies were noted for NAS Fallon or the ranges, although it is advised that a written PCB management plan be developed under the PCB management program.

### *3.2.16 Environmental and Explosives Safety Management*

DOD Directive 4715.11, Environmental and Explosives Safety Management on Department of Defense Active and Inactive Ranges within the United States, 17 August 1999 applies to the FRTC since it includes four active ranges: Bravo 16 (R-4803), Bravo 17 (R-4804), Bravo 19 (R-4810), and Bravo 20 (R-4802/ R-4813). Existing range documents reviewed do not mention the existence of inactive ranges at the FRTC, but this Directive also would apply to those. In general, the Directive makes requirements of range managers to ensure the future sustainability of military ranges. Some requirements of the Directive to ensure range sustainability relate to explosives safety measures, unexploded ordnance (UXO) hazard notifications and education, assessment of environmental impacts of range operations, and working with the community to promote compatible land use around ranges.

Many requirements of the Directive are being met, including NAS Fallon working with civilian land use planners to promote the compatible use of land surrounding military ranges. NAS Fallon senior military and the Public Affairs Office (PAO) work with city and county planning departments to promote compatible land use around NAS Fallon ranges and NAS Fallon air operations. Current education programs consist of mandatory access briefs and cards (renewable every six months, U.S. Navy 2002b) for all personnel who enter the bombing ranges, vehicle passes for bombing ranges per visit, and explosives briefs to non-governmental personnel. For personnel conducting studies on range or hunters entering the range are provided with mandatory access briefs and vehicle passes per visit. In addition, presentations are given during the Nevada Land Use Committee meetings and presentations are provided to and discussions are held with State Offices and Military of Nevada at Joint Military Affairs Committee meetings. Furthermore, NSAWC employs a full time employee as a liaison with BLM and prepares a decontamination report submitted yearly to Congress.

One of the more important requirements of DOD Directive 4715.11 is found in Section 5.5.9, which describes ensuring that procedures are in place to notify installation personnel and the public of operations that may present an explosive hazard off the DOD range and respond promptly to protect personnel from such hazards. NAS Fallon and the BLM executed a MOU regarding the recovery of off-range ordnance in October 2003.

There is a requirement under Section 5.4.3 in DOD Directive 4715.11 to "establish and implement procedures to assess the environmental impacts of munitions use on DOD ranges." The RSEPA process and EISs prepared for FRTC ranges satisfies this requirement; however, a significant deficiency related to the past use of submunitions on range was noted in this report with regard to compliance with DOD Directive 4715.11. Use of submunitions generally is prohibited at FRTC, but records show the potential use of the following submunitions: Mk 20 and Mk 99 submunitions (1997), Mk 20's, CBU-99's and CBU-100's (1998), CBU-20's (1999), CBU-100's (2000). Interviews with EOD personnel indicated that they have found submunitions on and around FRTC ranges and submunition remnants found on NAS Fallon ranges are maintained in the EOD building at NAS Fallon for recognition training purposes.

Encroachment due to urban or residential development has not been a major issue for NAS Fallon and the ranges compared to other Navy facilities in more populated areas of the country, but it is something that must be managed nonetheless. A recent example of encroachment at the Fallon ranges is that the flight approach path to Bravo 16 was altered due to noise complaints from residents living north of Bravo 16.

## 3.3 RSEPA COMPLIANCE STATUS SUMMARY

Section 3.2 outlines the compliance assessment performed at NAS Fallon. All significant deficiencies found by team members during the RCA, which are items not in compliance with Federal, state, or local environmental laws or regulations or DOD/Navy requirements, are outlined in Table 3-1. The environmental compliance deficiencies are classified according to compliance categories found in OPNAVINST 5090.1B, Chapter 1. OPNAVINST 5090.1B compliance categories are defined as follows:

- ***Minor Deficiency***—Mostly administrative in nature. May involve temporary or occasional instances of noncompliance with environmental statutes.
- ***Major Deficiency***—Requires action, but not necessarily immediately. This category identifies conditions that usually represent violations of environmental statutes and may result in an NOV. Major findings may pose a future threat to human health, safety, the environment, or the ability to accomplish the mission.
- ***Significant Deficiency*****—**Requires immediate action. These deficiencies pose, or have a high likelihood of posing, a direct and immediate threat to human, health, safety, the environment, or the mission of the range.

In addition, each deficiency in Tables 3-1 and 3-2 is classified according to Office of Management and Budget (OMB) compliance categories. These compliance categories are defined as follows:

- ***Class I*****—**Class I projects are those in which ranges are currently out of compliance with established regulatory deadlines.
- ***Class II***—Class II projects are those in which ranges will be out of compliance at a specific, impending published deadline, if action is not taken. If not accomplished by the deadline, projects become Class I.
- ***Class III***—Class III projects are those needed to meet DOD, Assistant Secretary of the Navy (Installations and Environment) (ASN, I&E), CNO, and/or claimant goals related to environmental protection, pollution prevention, cost effectiveness, environmental quality, or enhancement initiatives. These requirements are not mandated by law, but demonstrate Federal leadership and goodwill.

## Table 3-1. Summary of RSEPA Compliance Status for FRTC

| Area of Compliance | Statute/Regulation or Defense Requirement | Describe Potential Compliance Deficiency (Specify Location) | Categorize Each Deficiency | | | OMB Compliance Category |
|---|---|---|---|---|---|---|
| | | | Significant | Major | Minor | |
| Solid and Hazardous Waste | Navy Operational Range Clearance Policy | Existing procedures may not fully comply with requirements specified in new policy. | X | | | Class III |
| Environmental and Explosives Safety Management | DOD Directive 4715.11 | Submunition usage is not restricted to particular targets or impact areas range (DOD Directive 4715.11, Section 5.5.4). Use of submunitions generally is prohibited at FRTC, but records show the potential use of the following submunitions: Mk 20 and Mk 99 submunitions (1997), Mk 20's, CBU-99's and CBU-100's (1998), CBU-20's (1999), CBU-100's (2000). Interviews with EOD personnel indicated that they have found submunitions on and around FRTC ranges and submunition remnants found on NAS Fallon ranges are maintained in the EOD building at NAS Fallon for recognition training purposes. | X | | | Class III |
| EPCRA | SARA Title III, Section 313 reporting & OPNAVINST 5090.1B | Employee threshold determination method for Fallon Ranges does not adhere to guidance from Chief of Naval Operations dated 20 March 2002, stating that the employee threshold calculation for a range also should take into account the time spent by personnel on base such as offsite personnel in direct support of range operations (i.e., schedulers and controllers of range operations). Because reporting under Section 313 of EPCRA is due the first day of July of each year, NAS Fallon still has the opportunity to correctly determine their employee threshold calculations for CY 2003. | X | | | Class II |

## Table 3-2. Summary of RSEPA Compliance Status for Off-Range Support Facilities

| Area of Compliance | Statute/Regulation or Defense Requirement | Describe Potential Compliance Deficiency (Specify Location) | Categorize Each Deficiency | | | OMB Compliance Category |
|---|---|---|---|---|---|---|
| | | | Significant | Major | Minor | |
| Air Quality | CAAA90 | NOAV for exceeding permit emission limits during boiler stack testing. Retest will determine compliance. | | X | | Class II |
| Asbestos Management | OPNAV 5100.23E | No Asbestos Program Manager. | | X | | Class II |
| POL Management | Clean Water Act, Oil Pollution Act of 1990 | No current Tank Management Plan. No NOVs have been issued. NAS Fallon is currently working on an Integrated Contingency Plan and has put in a request for a Tank Management Plan. | | X | | Class II |
| Storage Tank Management | | | | | | |
| Water Quality | Safe Drinking Water Act | NOV issued for exceeding arsenic MCL. | X | | | Class I |

## 3.4 CONCLUSIONS

The conclusions for the assessment of environmental compliance are presented below for the operational range areas and support facilities.

### *3.4.1 Operational Range Areas*

There are few environmental regulations that have specific reporting and compliance requirements of military ranges. Two exceptions are the MMR and EPCRA. Based upon information gained during interviews with NAS Fallon Environmental Department program managers and review of environmental documents received in the RDF, Fallon appears to be in compliance with the requirements of the MMR, but there is some question of compliance under EPCRA. Under the recently required SARA Title III, Section 313 (EPCRA TRI) reporting for military munitions use that exceeds toxic release thresholds, the RSEPA Technical Team advises the NAS Fallon Environmental Department to recalculate the number of full-time equivalent employee hours worked in support of range operations. In light of new CNO guidance, it appears that NAS Fallon needs to take into account hours worked by employees not just physically on the range, but those spent off-range in support of range operations. This is a significant compliance issue as the results of this range full-time employee calculation determines whether NAS Fallon is required to do a toxic release threshold determination under EPCRA for munitions use at the Fallon ranges.

An additional requirement that pertains specifically to operational range areas is DOD Directive 4715.11, Environmental and Explosives Safety Management on DOD Active and Inactive Ranges within the United States, which requires DOD ranges to implement procedures to ensure range sustainability through range explosives safety measures and the assessment of environmental impacts due to range munitions use. Many requirements under DOD Directive 4715.11 are being met through range management plans; however, a number of deficiencies were noted. Deficiencies relate to addressing environmental impacts from range operations, educating on- and off-base personnel regarding explosives hazards, past use of submunitions on range and the expiration of an MOU between NAS Fallon and the BLM regarding the recovery of off-range ordnance.

### *3.4.2 NAS Fallon Operations and Facilities*

Additional environmental regulations were reviewed that apply to clean air; clean water; hazardous materials and waste management; storage tank and POL management, environmental planning; PCB, lead-based paint, and asbestos management; and natural and cultural resources management. Regulations in these environmental areas apply most directly to NAS Fallon operations and facilities; however, they also can apply to operational range areas.

Based upon information gained thus far, both NAS Fallon operations/facilities and operational range areas appear to be in compliance with most requirements, with the exception of deficiencies noted in Table 3-1. NAS Fallon is already aware of these deficiencies, as they also are mentioned in NAS Fallon's internal required EQAR (U.S. Navy 2002a). Noted environmental regulatory and Navy requirement deficiencies are: an outdated Tank Management Plan, NOAV for noncompliant boiler air emissions stack test, lack of an Asbestos Program Manager, and an NOV for exceeding drinking water arsenic concentration standards. The RSEPA Technical Team highlights these deficiencies since they have yet to be resolved since December 2002, when they were noted in NAS Fallon's EQAR. The Technical Team advises NAS Fallon to ensure that these items are brought into compliance as soon as possible.

It is important to reiterate that the primary focus of the RSEPA RCA is to evaluate the compliance of ranges, as the Navy already has an Environmental Compliance Evaluation (ECE) Program in place to manage compliance deficiencies at Navy installations. The Navy ECE Program is required to audit Navy shore station environmental programs on a routine basis for compliance with applicable environmental regulations and Navy requirements. The RSEPA Technical Team expects that the status of the deficiencies noted in this report will be evaluated during NAS Fallon's next scheduled ECE.

# 4. OPERATIONAL RANGE SITE MODEL

This section presents the ORSM for the FRTC. Section 4.1 describes the areas where munitions are handled, stored, used for testing and training, and disposed of at the FRTC. Section 4.2 describes the operational component of the ORSM. The environmental and land use components are described in Sections 4.3 and 4.4. The completed ORSMs for each investigation area within the FRTC are described in Section 4.5.

## 4.1 DEFINITION OF INVESTIGATION AREAS

Military testing and training operations occur within the FRTC. The following bullets define the areas that will or will not be evaluated for the potential releases of MCs in this report and Table 4-1 summarizes munitions-related activities occurring within the FRTC ranges.

- ***Munitions Handling and Storage***—Munitions are specifically designed for safe handling, storage, and transportation by containerizing energetic materials in components that are detached until needed for testing, training, or fighting. In addition, stringent safety standards for munitions handling and storage are designed to prevent and monitor releases of energetic materials through periodic inspections and routine testing. Furthermore, any releases would be accidental, and would be difficult to predict. However, munitions are not stored nor prepared for use on FRTC ranges. For these reasons, areas where munitions are handled and stored have been omitted from further analysis, unless included due to other munitions-related activities.
- ***Weapons Testing and Training – Firing Points***—Ground-based firing points are located at Bravo 17, 19, and 20.
- ***Weapons Testing and Training – Impact/Target Areas***—The principal focus of the ORSM is on releases of MCs from impact/target areas, since they are the most likely potential source of MCs in the environment at the FRTC. Bravo 16, Bravo 17 East, Bravo 19, and Bravo 20 are ranges that are evaluated in this report.
- ***Weapons Testing and Training – Demolition Ranges***—The release of MCs from demolition ranges is possible; however, demolition ranges do not exist at the FRTC, so they are omitted from this report.
- ***Weapons Testing and Training – Buffer Zones***—The ranges have been delineated to include all land area within the weapons safety footprints for all munitions used at the FRTC ranges. However, the buffer zones have not been specifically defined. Therefore, buffer zones are evaluated as a component of weapons testing and training, but the results are not reported separately for buffer zones.
- ***Troop Training***—Troop training as defined above does not occur at the FRTC ranges; therefore, troop training areas are not evaluated in this report.
- ***Defensive Positions***—Surface-to-surface testing or training does not occur at the FRTC ranges; therefore, this type of defensive position is not evaluated in this report.
- ***Sanctioned Ordnance Disposal***—Except for ordnance disposal related to removal of debris near targets, no sanctioned ordnance disposal areas exist at the FRTC ranges. For this reason, sanctioned ordnance disposal areas are omitted from further analysis in this report.

## 4.2 OPERATIONAL COMPONENT

This section summarizes information about land-based military operations, particularly where operations utilizing munitions are conducted, since RSEPA Decision Point 1 is concerned with releases of munitions constituents to off-range areas. Sections 4.2.1, 4.2.2, and 4.2.3 describe past, current, and future uses of the FRTC ranges, respectively.

**Table 4-1. Summary of Munitions-related Activities Occurring at the FRTC**

| Munition-Related Activity * | Primary Source | Location |
|---|---|---|
| Munitions Handling and Storage | *Transfer Points* – Areas where munitions shipments occur | None |
| | *Storage Magazines/Ammunition Supply Points* – Areas where munitions storage and/or issuance occurs | None |
| Weapons Testing and Training | *Firing Points* – Areas where weapons systems are placed for testing and training, including mobile systems (e.g., truck-mounted systems) | Bravo 17<br>Bravo 19<br>Bravo 20 |
| | *Impact/Target Areas* – Areas targeted by weapons systems | Bravo 16<br>Bravo 17 East<br>Bravo 19<br>Bravo 20 |
| | *Demolition Ranges* – Areas where explosives are used during training, testing, or munitions disposal | None |
| | *Buffer Zones* – The area on ranges extending beyond impact areas to provide safety zones to contain ricochets, blasts, and fragmentation from exploding munitions | Bravo 16<br>Bravo 17 East<br>Bravo 19<br>Bravo 20 |
| Troop Training | *Combat Range* – Areas used for combat maneuvers | None |
| | *Bivouac and Encampment Areas* – Troop living areas (bivouacs are short-term areas, encampments are long-term, more permanent installations) | None |
| Defensive Positions | *Minefields* – Areas containing buried or surface placed anti-personnel or anti-tank mines | None |
| | *Gun Emplacements* – Areas where defensive weapons (e.g., anti-aircraft guns) are located | None |
| Sanctioned Ordnance Disposal | *Mass Burial/Landfills with Munitions* – Areas where large quantities of ordnance were disposed of by burial | None |
| | *Open Burn/Open Detonation* **–** Areas where ordnance was consolidated and disposed of by either burning or detonation | None |
| | *Bomb Jettison Area* **–** Areas where bombers jettison bombs prior to landing | None |

* Excluding small-arms testing and training

The majority of the information that is presented in this report reflects current range use within the FRTC. Current and future uses of the FRTC ranges are more relevant to the primary purpose of RSEPA than are past uses, which is sustainment of operational ranges. In addition, limited information about past and future range use is available.

### *4.2.1 Historical Military Operations*

In 1942, NAS Fallon was constructed when Civil Aviation Administration and the Army Air Corps built four airfields in the Nevada desert as a part of the Western Defense Program’s plan to repel the expected Japanese attack on the West coast. The airfield construction consisted of runways and lighting systems built in Winnemucca, Minden, Lovelock, and Fallon.

In 1943, as an effort to properly train pilots in realistic combat situations using current tactics and weapons, the Navy assumed control over Fallon’s two 5,200-foot runways. Barracks, air traffic control towers, and hangars were constructed, as were a torpedo bombing range at Sutcliffe, two free gunnery ranges, a rocket bombing range, ground strafing targets, and the Lone Rock range (Bravo 20). On 10 June 1944, Naval Auxiliary Air Station (NAAS) Fallon was commissioned and its mission was to provide training, service, and support to air groups deploying there for combat training.

The additional ranges that were built in 1943 proved well-used and, in 1945, NAAS Fallon was at peak operation. An average of 21,000 take-offs and landings were recorded and more than 12,000 flight hours were logged at the station. However, once operations were at full tilt, the Japanese surrendered, bringing an end to utilization of NAAS Fallon. Because the military no longer needed to use NAAS Fallon with the same frequency, the air station was given reduced status several times. On 1 June 1945, NAAS Fallon was given "caretaker status" and the designation of NAAS was removed.

The Bureau of Indian Service used the air station during its 5-year hiatus. The Korean conflict brought new life to the installation and the Navy once again found the need for a location in which it could properly train pilots with the new and sophisticated equipment. In 1951, Fallon became an Auxiliary Landing Field for NAS Alameda, California and on 1 October 1953, NAAS Fallon was re-established by order of the Secretary of the Navy. Bombing ranges Bravo 16, Bravo 17, and Bravo 19 also were created that year. Over the next 30 years, Fallon would grow to become one of the premier training sites for the Navy and Marine Corps pilots and ground crew.

In 1956, the Air Force established the 858$^{th}$ Air Defense Group at Fallon to assist in the country's early warning radar system. For the following 19 years the Air Force command at Fallon assisted in America's national security. In an effort to enhance range capabilities and training efforts, the electronic warfare range was established in 1967.

On 1 January 1972, the Navy recognized Fallon's importance to naval aviation and upgraded the base to major command and NAS Fallon was commissioned. The 1980s brought a new and state-of-the-art air traffic control facility and a new hangar. The NSAWC was established as the primary authority for integrated strike warfare tactical development and training. In 1985, Fallon's aircrew training program was given the Tactical Aircrew Combat Training System (TACTS). This system provides visual, graphic displays of missions, eliminating any uncertainty for squadrons, carrier air wings, and students from the NSWC (NAS Fallon 2003a and 2003b).

The training acquired by aircrews at their respective home bases and at NAS Fallon provided the necessary skills to successfully complete missions against Libyan jets in the Gulf of Sidra, the invasion of Grenada, the interception of an Egyptian airliner carrying terrorists in the Mediterranean, the Persian Gulf conflict, and the ongoing war on terrorism being fought abroad.

### *4.2.2 Current Military Operations*

The current mission of NAS Fallon is to provide services and material to tenants and transient units stations at or deploying to NAS Fallon for CNO-approved aviation training. The major tenant command is the NSAWC and it develops realistic combat training scenarios for military aircrews. NSAWC also is responsible for operating, maintaining, scheduling, developing, and configuring the FRTC (U.S. Navy 2000a).

NAS Fallon currently operates and maintains a complete airfield facility, providing visiting squadrons and air wings with ordnance, fuel, air traffic control, berthing and messing, and all other aspects necessary for successfully conducting vital training on the range. Since 1995 and 1996, respectively, NAS Fallon has been home to the Navy's Fighter Weapons School (TOPGUN) and Carrier Airborne Early Warning Weapons School (Top Dome).

Currently, more than 3,000 people on the installation, including Active duty military, contractors, and personnel who work in Morale, Welfare and Recreation, Navy Exchange, Civil Service, and Commissary. Approximately five or six air wings visit NAS Fallon each year to train for a month at one time at the FRTC. Each visit brings approximately 1,500 personnel. On average, NAS Fallon receives and trains 55,000 military personnel every year, each staying an average of 14 days (NAS Fallon 2003a and 2003b).

NAS Fallon's weapons training and targeting facilities are located on the FRTC and are divided among five ranges: Bravo 16, Bravo 17, Bravo 19, Bravo 20, and the Fallon Electronic Warfare Range (FEWR) (U.S. Navy 2000a and 2002b). Table 4-2 summarizes the military operations at each range.

## Table 4-2. Summary of the FRTC

| Range | Description | Status of ORSM and Predictive Modeling |
|---|---|---|
| Bravo 16 | 27,680 acres of land primarily used for basic and intermediate training with air-to-ground conventional bombing and for rockets using only inert ordnance. | Include in ORSM, but excluded from predictive modeling because only inert munitions are used. |
| Bravo 17 | 54,800 acres of land that is divided into two complexes: Bravo 17 East and Bravo 17 West. Bravo 17 East consists of light inert, heavy inert, and impact areas, with multiple targets for air-to-ground bombing, rocket, and strafing exercises with live and inert ordnance. Bravo 17 West is a No-Drop-Weapons-Scoring (NDWS) area and ordnance is not allowed. | An ORSM was developed for Bravo 17 East and Bravo 17 West; however, predictive modeling only was conducted for Bravo 17 East because of the live munitions usage at this portion of the range. Predictive modeling was not conducted at Bravo 17 West because no munitions are used at this range. |
| Bravo 19 | 29,532 acres of land used for strafing, laser ranging and targeting, close air support, mortar, small arms, artillery spotting, and inert and live air-to-ground ordnance delivery training using bombs and rockets. The range also has facilities for simulated surface-to-air missile firing. | An ORSM was developed and predictive modeling was conducted because live and inert munitions are used. |
| Bravo 20 | Located in Carson Sink, this range consists of 41,282 acres of land used for air-to-ground bombing, strafing, and laser targeting. The targets allow for inert ordnance; however, one target, the Lone Rock area, allows live ordnance drops. | An ORSM was developed and predictive modeling was conducted because live and inert munitions are used. |
| Fallon Electronic Warfare Range | Located adjacent to Bravo 17, this range consists of one main complex (Centroid) and 20 to 35 remote sites. No targets are present due to the need for portable EW equipment in order to change EW scenarios when required. | No ORSM was developed nor was predictive modeling conducted because no munitions are used at this range. |

The use of these ranges has fluctuated over the years and the Navy has attempted to document use of range complexes by using the Navy Pacific Air Command's Target and Range Information Management System (TRIMS). Reports from TRIMS identified operations conducted by all branches of the U.S. military and forces from Japan, Australia, and Canada. The variability in operation tempo is related to U.S. military training goals, the geopolitical climate, and the status of active U.S. and international military activities. Appendix D presents the Navy's TRIMS reports for the FRTC investigation areas (TRIMS 2003). The numbers of sorties, which are defined as "a single training event by one aircraft, one ship, or one submarine which utilizes a range" (U.S. Navy 2000b), were recorded for each range between 1994 and 2003. Munitions usage (live and inert) was recorded for each range between 1994 and 2003. The total number of sorties and munitions used at each range within the FRTC are depicted in Figures 4-1 and 4-2, respectively.

NAS Fallon's Operations Department is responsible for the critical missions of airfield operations, air traffic control, emergency crash operations, organizational level maintenance of three HH-1N "Huey" helicopters and one C-12 aircraft, and search and rescue missions. The Longhorn Search and Rescue provides emergency rescue service for the FRTC. It also works closely with civilian law enforcement agencies and hospitals to assist in local rescue efforts. The Air Traffic Control (ATC) division provides air traffic control services for military and civilian aircraft. The primary responsibility is the safe conduct

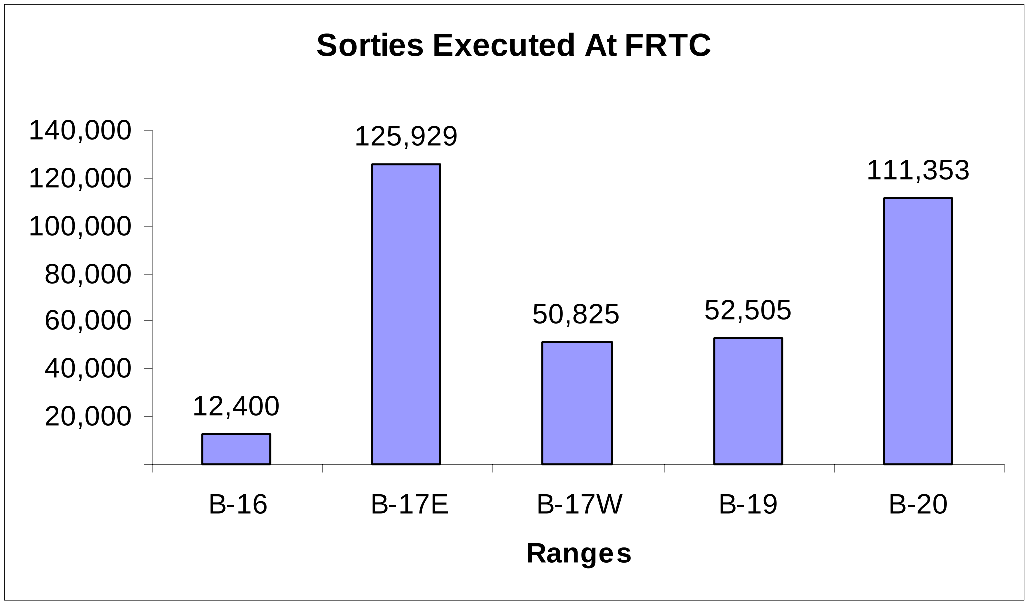



**Figure 4-1. Sorties Executed at the FRTC from 1994 to 2003**

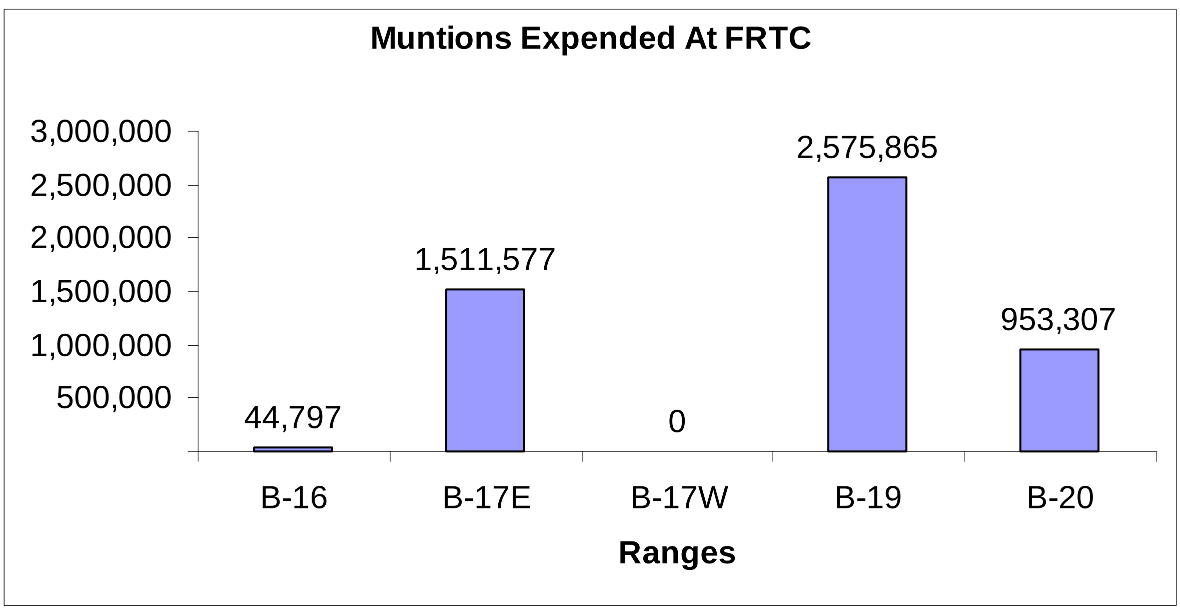



**Figure 4-2. Munitions Expended at the FRTC from 1994 to 2003**

of local and special-use airspace operations of embarked squadrons, carrier air wings, and Marine air groups. ATC's jurisdiction consists of more that 10,200 square miles and includes 8 restricted areas and 11 military operations areas. Fleet Liaison provides office, maintenance, and hangar spaces for deploying Carrier Air Groups (CAGs), Marine Aircraft Groups (MAGs), and squadrons.

### *4.2.3 Future Military Operations*

Several improvements for future military operations at the FRTC ranges are proposed. The amount of live munitions and the locations of where live munitions can be used will not change; however, increased operations may cause the amount of sorties to increase, where a sortie is defined as "a single training event by one aircraft which utilizes a range" (U.S. Navy 2000b). The 2002 NSAWC FRTC Requirements Document (U.S. Navy 2002c) identifies proposed requirements that will enable enhanced tactical combat training at the FRTC ranges. These requirements will allow the FRTC ranges to meet the goals and capabilities model of a transforming naval force. The improvements are discussed below:

- ***Electronic Warfare***—Fixed and/or manned electronic warfare sites are proposed in the Carson Sink area around and on Bravo 20.
- ***Bravo 17 Development***—33,400 acres of additional land were withdrawn by Congress in the 1999 Military Land Withdrawal Act primarily to ensure public safety from off-range ordnance and increased ground training operations areas. This acreage will be fenced and properly posted with signs as Time Sensitive Strike operations will take place within the newly withdrawn lands on a frequent basis.
- ***Bravo 20 Development***—A second major tactical target complex is proposed to meet the fleet Integrated Air Defense System (IADS) training requirements and provide multiple locations and realistic tactical targets within the FRTC. Live ordnance targets will be developed within the High Explosive (HE) area of Bravo 20, consisting of an airfield, surface-to-air missile complex, and a simulated underground/bunker facility. Inert ordnance targets proposed for development include an urban complex (e.g., town), classified facility, transformer station, radio relay facility, broadcast station, tropospheric facility, railroad bridge, submarine underground facilities, and a missile support area. Fiber optic connectivity within and from Bravo 20 to debrief facilities at NAS Fallon also is proposed.
- ***Airspace Requirements***—Altering the current vertical limitations of the Reno Military Operating Area (MOA) will allow required flexibility for realistic air-to-air engagement combat training. It is proposed that the "Floor" 13,000 feet above mean sea level (msl), be lowered to 9,000 feet msl. Furthermore, because realistic combat training for units using the FRTC during summer months is required and because summer daylight hours do not leave adequate night time training for combat operations that use Night Vision Goggles (NVG), it is proposed that the FRTC Special Use Airspace (SUA) be available after published hours by Notice to Airmen and Mariners (NOTAM).
- ***Tracking Requirements***—A number of tracking enhancements for realistic training must be accomplished. These include Near Term/Interim global positioning system (GPS) based/Northern Digital Inc. (NDI) Tracking Capability. Examples of these types of tracking enhancements include GPS tracking for higher positional fidelity and providing current weapons and electronic warfare threat systems simulations, and Long Term Tracking Capability, such as virtual/constructive weapon, weapon platform, and threat system capability.
- ***Time Sensitive Strike (TSS) Requirements***—It is proposed the area of operation for TSS expand to other roads and static display sites on public land beneath the FRTC airspace. Vehicles would be able to provide varying and changing visual cueing for TSS training for air units. Static targets simulating multiple threats and/or troop positions would need access to and use of public lands.

- ***Range Sustainability Support Requirements***—Periodic sweeps and removals of range residue are proposed on the FRTC bombing ranges. Sweeps would occur every 3 years on heavily used bombing ranges (e.g., Bravo 17) and every 5 to 10 years on lesser used ranges (e.g., Bravo 16). Renovations and upgrades also are proposed to facilities located on the FRTC bombing ranges.
- ***Track Vehicle Operations***—A Track Vehicle Operating Area (e.g., run and fire/no drop) for tanks and personnel carriers is proposed for operations on Bravo 17.

## 4.3 ENVIRONMENTAL AND CULTURAL COMPONENTS

The following sections present an evaluation of the environmental components of the ORSMs for Bravo 16, Bravo 17, Bravo 19, and Bravo 20. In order to ensure the long-term sustainability of the FRTC, the Navy must define what environmental conditions are at the range complex and determine if the resources are being managed in an environmentally sound manner. Information was collected for each site regarding predominant soil types; topography; vegetation; aquifer characteristics; and potential or known sensitive, threatened, or endangered flora or fauna from existing environmental restoration and NEPA documentation.

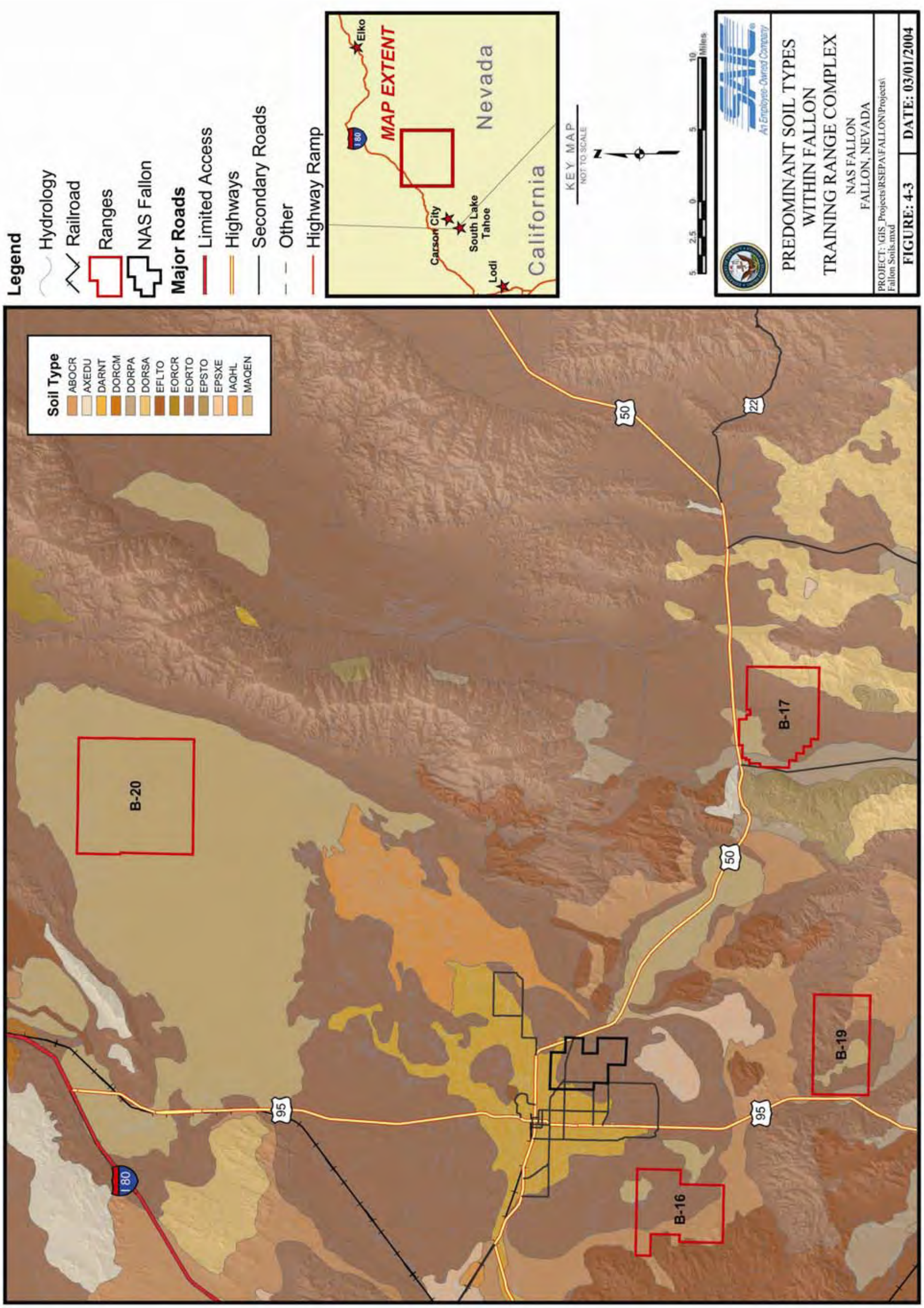
### *4.3.1 Predominant Soil Types*

Fallon is located in the Carson Desert Basin. Sedimentary deposits in the Carson Desert may be as much as 8,000 feet thick and found in multiple layers of alluvium, alluvial fan deposits, and lacustrine deposits (beach and eolian deposits). These sedimentary deposits were formed from massive expansions and contractions of glacial lakes over extended periods of time. As the glacial lakes and ice sheets changed, diverting water to many areas of the continent, rivers cut numerous channels through these deposits. Large sand dunes and sand sheet complexes also were formed as a result of these geological and climatic evolutions. The sedimentary deposits are composed of an indiscriminate mixture of sands, silts, and clays. These multiple-layered deposits have been separated into three differing formations based on geologic and physical properties. The soils at each investigation area are described below in order of closest proximity to the ground and are shown in Figure 4-3:

- ***Fallon Formation***—This vertical portion of the range's sedimentary deposits are predominantly alluvial deltaic sands, silt, and shallow lake deposits. Alluvial sands are found from 0 to 15 feet thick and channel deposits cut through older deposits.
- ***Turupah Formation***—This vertical portion of the range's sedimentary deposits are predominantly eolian sands ranging from 0 to 30 feet thick.
- ***Sehoo Formation***—Three deep lakes formed this vertical portion of the range's sedimentary deposits, which are predominantly sand from 1 to 5 feet thick west to northwest, clay and silt on the lowland areas from 5 to 30 feet thick, and clay as much as 30 feet thick in the northeast.

### *4.3.2 Predominant Topography*

NAS Fallon and the FRTC are located on the western portion of the Great Basin geomorphic province of Nevada. This location's geophysical activity, which is mostly seismic faulting, has resulted in the formation of several down-dropped valleys and small mountain ranges with a trend to the north (U.S. Navy 2000c). The elevations within all four ranges contained in the FRTC range from flat, low-lying land to areas of higher topography. The predominant topography at all four ranges is discussed below and is shown in Figure 4-4.


Legend
Hydrology
Railroad
Ranges
NAS Fallon
Major Roads
Limited Access
Highways
Secondary Roads
Other
Highway Ramp
Soil Type
ABOCR
AXEDU
DARNT
DORCM
DORPA
DORSA
EFLTO
EORCR
EORTO
EPSTO
EPSXE
IAQHL
MAQEN
B-20
B-17
B-19
B-16
50
95
22
80
MAP EXTENT
Elko
Nevada
California
Carson City
South Lake Tahoe
Lodi
KEY MAP
NOT TO SCALE
Miles
SAIC
An Employee-Owned Company
PREDOMINANT SOIL TYPES
WITHIN FALLON
TRAINING RANGE COMPLEX
NAS FALLON
FALLON, NEVADA
FIGURE: 4-3
DATE: 03/01/2004

- ***Bravo 16***—Bravo 16 is approximately 9 miles southwest of NAS Fallon at an elevation of 3,942 feet above msl. The range is composed of extensive alkali flats and patches of desert. Bravo 16 is surrounded by several elevated landmasses, including Red Mountain to the west, Dead Camel Mountains to the west/southwest, and Desert Mountains to the south (Global Security 2003). The two inert conventional weapons bull targets at Bravo 16 are located in the center of the range. This is a flat, low-lying area. An access road starts near the top northern edge of the range and runs south to southeast. The road lies west of the two targets.
- ***Bravo 17***—Bravo 17 is approximately 23 miles east/southeast of NAS Fallon at an elevation of 4,153 feet above msl. The northern portion of the range is made of alkali flats with patches of desert and foothills and the southern portion of Bravo 17 also contains foothills. The western region of the range is dominated by the Sand Spring Mountains, while Fairview Peak is in the eastern region (Global Security 2003). The elevation at Fairview Peak is 8,243 feet above msl, which is the highest elevation in the area (U.S. Navy 2000c). The live ordnance impact area at Bravo 17 is in the eastern region; however, it is in the lower-lying foothills of the mountains and is approximately 2.7 miles from the range boundary. Moving farther west across the site, the topography becomes flatter. An inert conventional weapons bull target and a strafe target lie west of the impact area. A zigzag, paved access road runs north and south and divides the eastern region from the western region. The western region is a no drop area and ordnance expenditure is prohibited.
- ***Bravo 19***—Bravo 19 is approximately 16 miles south/southeast of NAS Fallon at an elevation of 3,882 feet above msl. The range is composed of alkali flats with patches of desert. It is surrounded by the Sand Spring Mountains to the east and the Desert Mountains to the west (Global Security 2003). The live ordnance impact area at Bravo 19 is located in the lower-lying foothills of the Sand Spring Mountains and is approximately 1.5 miles from the range boundary. Moving farther south across the site, the topography becomes flatter. South of the impact area lie an inert conventional weapons bull target and a strafe target. An access road lies south of the targets. This road runs east and west and joins U.S. Highway 95 at the western boundary of Bravo 19.
- ***Bravo 20***—Bravo 20 is approximately 31 miles north/northeast of NAS Fallon at an elevation of 3,890 feet above msl. Bravo 20 is surrounded by the Sand Spring Mountains to the east and the Desert Mountains to the west (Global Security 2003). The range is composed of alkali flats and the elevation changes across the entire range are minimal. The live ordnance impact area lies in the southern portion of the range. Although the live target, Lone Rock, is elevated, this area of the range still remains relatively flat. Lone Rock is approximately 3.7 miles from the range boundary. Two inert conventional weapons bull targets and two strafe targets lie north west of the live ordnance impact area.

### *4.3.3 Predominant Vegetation*

During ecological surveys conducted to census and characterize the plant communities in the FRTC, 458 plant species were identified and collected. Cluster analysis of the upland plant communities resulted in the identification of 30 distinct upland habitats that were assigned to 20 upland plant communities related to plant communities identified in the *Major Land Resource Area 27, Fallon-Lovelock Area, Nevada, Site Descriptions,* and one wetland group (TetraTech 1997).

The majority of FRTC land consists of habitats dominated by black greasewood or Bailey greasewood, with shadscale, which is the most widespread associate species. Among the habitats found at Fallon are three dune-associated habitats and three distinct sagebrush habitats. These habitats exist in the valley lands, where there is either flat to slightly sloping topography. Within the wetland groups classified at Fallon, eight wetlands were individually identified: saltgrass meadow, sedge-spikerush meadow, bulrush meadow, iodinebush habitat, forested riparian wetlands, alkali riparian wetlands, man-made ponds dominated by cattails, and man-made ditches also dominated by cattails and a variety of grasses (TetraTech 1997).

The FRTC also contains, to a lesser extent, many other types of vegetation categorized into two relevant categories, valley bottoms and benches and fans. Plants found in the valley bottoms include rabbitbrush, witherfat, giant wild rye, bottlebrush, squirreltail, cheatgrass, pepperweed, halogeton, Russian thistle, and wild mustard (U.S. Navy 2000c). Plants belonging to the benches and fans include rabbitbrush, hopsage, squirreltail, Indian ricegrass, galleta grass, cheatgrass, wild mustard, halogeton, and primrose (U.S. Navy 2000c).

### 4.3.4 Surface Water and Groundwater

The primary sources of public drinking water for all residents of the Carson Desert area are natural basalt and basin-fill (alluvial and lacustrine) aquifers. Of these aquifers, three classifications have been created based on depth: shallow, intermediate, and deep. Most residents in the Carson Desert rural areas obtain their water from wells completed in the shallow and intermediate aquifers (Lico and Seiler 1994). Very little information exists on the deep aquifers in this area. Sedimentary deposits in the Carson Desert may be as much as 8,000 feet thick, although rural water supplies are limited to the upper 500 feet.

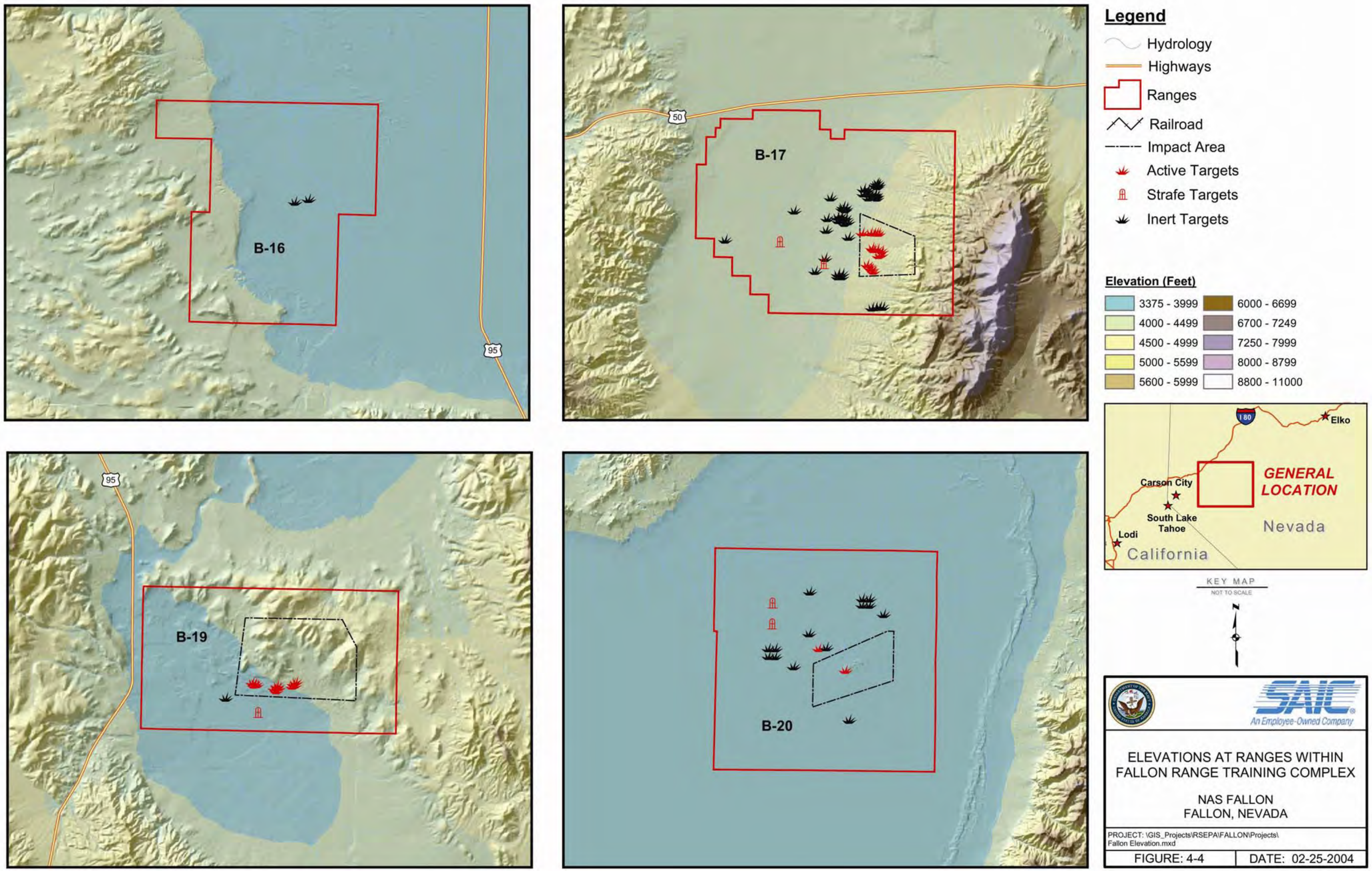
Shallow aquifers in Fallon and the surrounding areas exist at depths ranging from 0 to 50 feet. The hydraulic properties of the deposits are variable over short distances. Highly transmissive zones of gravel are thought to facilitate most of the flow in these aquifers, vertically and hydraulically connecting other sand layers or zones. Intermediate aquifers are 50 to as much as 1,000 feet below land surface (BLS), while deep aquifers are found to underlie the intermediate aquifers at depths ranging from 500 to 100 feet BLS (Herrera, Seiler, and Prudic 2000).

The mineral components of water in the aquifer of the Carson Desert are highly variable. For the groundwater in shallow aquifers, minerals vary from dilute calcium bicarbonate to a sodium saline chloride type. Beneath areas of irrigation, water is found to be generally more dilute (Lico and Seiler 1994).

The principal source of recharge to the shallow basin-fill aquifers is infiltration of surface waters from irrigation and the numerous river channels, canals, and ditches that crisscross the southern Carson Desert. Widespread irrigation has resulted in the rise of the water table, as much as 60 feet in the Soda Lakes area, but usually much less in other areas of the Carson Desert (Lico and Seiler 1994). Discharge of groundwater generally flows through the Carson River Basin in the northeast, south, and southeast.

The groundwater flow at Fallon is controlled by the location of canals and drains, and the application of water to fields. Due to the irrigation cycles, the groundwater levels fluctuate from 2 to 6 feet from the typical water levels. Using a variety of information, the water levels and directions at each of the four investigation areas are described below:

- ***Bravo 16***—Available information estimated groundwater levels to range from 10 to 90 feet BLS, and in general, the depth was found to range from 40-90 feet BLS with the exception of the northeast corner of the site. Because the exact depth of groundwater is unknown, groundwater depths were estimated at 65 feet BLS (i.e., halfway the distance between 40 and 90 feet BLS). Using available information, groundwater at Bravo 16 flows in a south/southeast direction.
- ***Bravo 17***—Site-specific information is not available for Bravo 17; however, water levels in wells located 3 to 6 miles east of Bravo 17 are 35 to 52 feet BLS. Because the exact depth to groundwater is unknown, groundwater depths were estimated at 43 feet BLS (i.e., halfway the distance between 35 and 52 feet BLS). Using available information, groundwater at Bravo 17 would most likely flow in a south/southeast direction.


B-16
95
B-17
50
B-19
95
B-20
Legend
Hydrology
Highways
Ranges
Railroad
Impact Area
Active Targets
Strafe Targets
Inert Targets
Elevation (Feet)
3375 - 3999
4000 - 4499
4500 - 4999
5000 - 5599
5600 - 5999
6000 - 6699
6700 - 7249
7250 - 7999
8000 - 8799
8800 - 11000
I 80
Elko
Carson City
GENERAL LOCATION
South Lake Tahoe
Lodi
Nevada
California
KEY MAP
NOT TO SCALE
N
SAIC
An Employee-Owned Company
ELEVATIONS AT RANGES WITHIN FALLON RANGE TRAINING COMPLEX
NAS FALLON
FALLON, NEVADA
PROJECT: \GIS_Projects\RSEPA\FALLON\Projects\ Fallon Elevation.mxd
FIGURE: 4-4
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- ***Bravo 19***—Site-specific information is not available for Bravo 19; however, based on the area and the topographic changes within Bravo 19, groundwater depth is estimated to be 25 to 50 feet BLS. Because the exact depth of groundwater is unknown, groundwater depths were estimated at 38 feet BLS (i.e., halfway the distance between 25 and 50 feet BLS). Using available information, groundwater at Bravo 19 flows in a south/southeast direction.
- ***Bravo 20***—Bravo 20 is in an area known as "Carson Sink." This area contains a series of alkali flats. Groundwater depth has not been measured at Bravo 20, but is found at approximately 10 feet BLS in nearby irrigated areas and at approximately 25 feet in nearby non-irrigated areas. Ponding of water also has been noted at Bravo 20, leading to the conclusion that the depth to groundwater may be more shallow than reference documents have noted. In addition, reference documents have shown that surface water in the area may flow toward the middle of the site as a "sink" effect, while groundwater at Bravo 20 has been estimated to flow in a southwest direction.

Fallon is found to have an annual precipitation of 5.3 inches and the annual evaporation rate is 60 inches. The temperatures in Fallon range from 17 to 90°F (average minimum).

### *4.3.5 Sensitive Ecosystems*

This section summarizes the sensitive ecosystems found within the FRTC. This includes any threatened and endangered species along with special status species. Findings of ecological surveys are identified in Section 4.3.5.1 and human impacts to species found within the FRTC are identified in Section 4.3.5.2.

#### 4.3.5.1 Known Threatened and Endangered Species

Ecological surveys have been conducted outside the impact areas on the FRTC ranges. These surveys identified 458 individual plant species (growing without cultivation), 126 bird species, 11 small mammal species (trapped), 9 bat species (positively identified and another 7 may be present based on their known occurrence in the central Great Basin), 23 reptile species, and 4 amphibian species (TetraTech 1997). Of all the organisms found during the survey, there was no evidence of any threatened or endangered species inhabiting, foraging, or using the sites in any manner (U.S. Navy 2000c). The facilities also were examined for any signs of breeding or nursing grounds and none was found.

There are, however, six special status species that are known to exist on the range areas. These include one plant and five insect species (with the potential of another insect species being present in riparian areas). Several bat species, which are listed as "species of concern," also are known to exist on the range areas. The special status species found to exist within the land area are the Sand Cholla (*Opuntia pulchella*) (plant), Hardy's aegialian scarab beetle (*Aegialia hardyi*), Sand Mountain serican scarab (*Serica psammobunus*), Sand Mountain aphodius scarab (*Aphodius sp.*), Sand Mountain blue butterfly (*Euphilotes rita pallescens*), and Nevada viceroy (*Limenitus archippus lahontani*) (insects). The bats found to inhabit the FRTC, several of which are listed as species of concern, are: Mexican free-tailed bat (*Tadarida brasiliensis*), Pallid bat (*Antrozous pallidus*), Townsend's big-eared bat (Corynorhinus townsendii), Big brown bat (*Eptesicus fuscus*), California myotis (*Myotis californicus*), Small-footed myotis (*Myotis ciliolabrum*), Long-eared myotis (*Myotis evotis*), Hairy-winged myotis (*Myotis volans*), and Western pipistrelle (*Pipistrellus hesperus*) (TetraTech 1997). These species, along with the vegetative habit in which they live, are shown in Figure 4-5.

In addition to these findings, there are federally listed, proposed, and candidate species thought to potentially occur within the area. These species include the bald eagle, mountain plover, a fish known as the Cui-ui, Lohontan cutthroat trout, and spotted frog. It is believed that bald eagles and mountain plovers, two species on the bird threatened and endangered (T&E) list, do not reside in the area but rather transit the FRTC (U.S Navy 2000c).

#### 4.3.5.2 Human Impacts

As noted in the preceding section, no known threatened or endangered species have been found to inhabit the FRTC ranges; therefore, there are no expected human impacts from conducting military operations on threatened or endangered species. Bald eagles and mountain plovers, however, are suspected of periodically entering the ranges during times of transit. Because they are flying through range areas and are likely to avoid military operations, particularly those involving munitions, military operations and construction activities do not appear to impact these species or their habitat. To avoid any accidental dangers posed to birds by powerlines, the width separating adjacent lines should be greater than 60 inches. The presence of powerlines also provides perching opportunities for birds of prey, possibly resulting in the increased risk of predation of T&E animals. However, studies of the area have confirmed that no T&E animals that would be preyed upon by raptors and eagles inhabit the area of these powerlines; therefore, there is no increased risk (U.S. Navy 2000c).

One sensitive species of plant, the sand cholla, was discovered to inhabit portions of Bravo 16 and Bravo 19. This organism is not protected under Federal or state listings; however, it is listed as a species of concern. As a result, the damage that these species must incur will be minimized to the greatest extent practical (U.S. Navy 2000c).

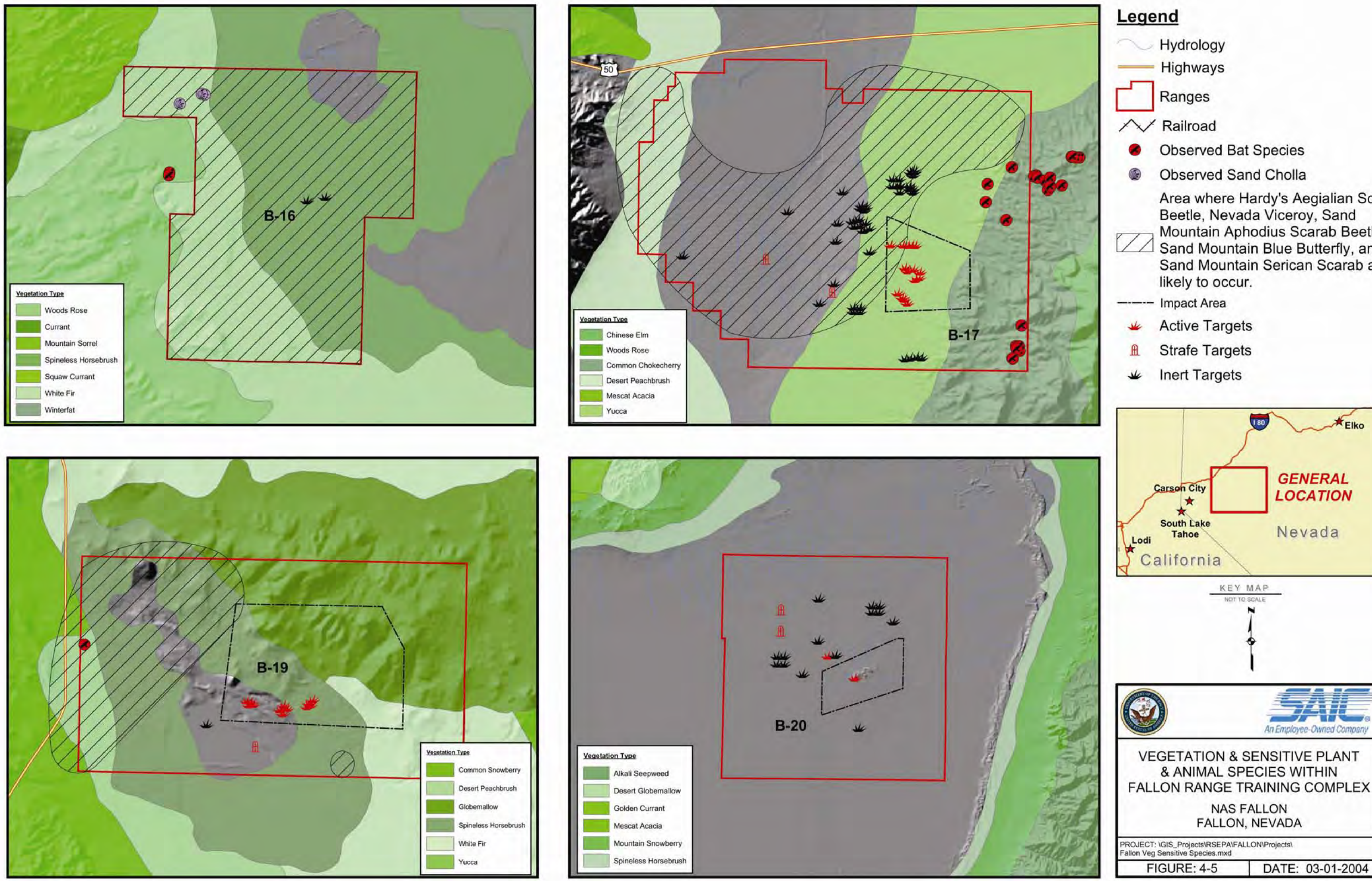
There are no known sensitive aquatic habitats in the area of the FRTC ranges, and all weapons testing will be conducted so as to not affect any adjacent waterways. All proposed activities to occur on FRTC sites are not expected to affect any local wetlands, which include perennial streams, freshwater lakes, and reservoirs, as well as irrigation canals and saltwater marshes (U.S. Navy 1998). As a protective measure, all sites will be surveyed prior to any construction on ranges. Any activities requiring permits under the Federal CWA policy will not commence until such permits are acquired (U.S. Navy 2000c).

### *4.3.6 Cultural Resources*

Archaeological resources at the FRTC include prehistoric and historic locations and sites where human actions have resulted in detectable changes to the area. The FRTC contains at least 223 archaeological sites, including prehistoric and historic resources (U.S. Navy 1998). Prehistoric sites within the FRTC contain such elements as petroglyphs, pictographs, rock alignments, rock shelters, caves, quarry sites, camp and task sites, and Stillwater March District. Historic sites within the FRTC (those dating after European contact) include roads with associated transportation features, mining related objects, towns, ranges, agriculture, woodcutting, irrigation, water networks, Boyer-Gilbert Ranch, Pony Express Trail, and the Overland Wagon Route (U.S. Navy 2000c).

Many of the 223 archaeological sites exist within the boundaries of the Bravo ranges. Fifty-six archaeological sites are found on the NAS itself, 37 sites within Bravo 16, 77 sites within Bravo 17, and 53 sites within Bravo 19. The types of prehistoric objects found in these locations are villages, sites with residential features, lithic quarries, rock art, shelters/caves, lithic scatters with and without groundstone, and groundstone scatters. These sites also have a historic military significance dating back to World War II and the Cold War. These sites are primarily buildings that over time have had to be rebuilt, disqualifying them from eligibility to the National Register of Historic Places (NRHP), with the exception of one (U.S. Navy 1998).

The Bravo 20 training range also has some objects of cultural interest. These interests include archaeological isolates, or items that have been found alone, and the Lone Rock, a spiritually significant geologic formation for the Native American Tribes. Lone Rock was not given eligibility for the NRHP. After numerous discussions with the existing tribes as to its cultural value, it was determined that Lone Rock and the isolates are not considered cultural resources that may be impacted by range activities (U.S. Navy 1998).



B-16
Vegetation Type
Woods Rose
Currant
Mountain Sorrel
Spineless Horsebrush
Squaw Currant
White Fir
Winterfat
50
B-17
Vegetation Type
Chinese Elm
Woods Rose
Common Chokecherry
Desert Peachbrush
Mescat Acacia
Yucca
B-19
Vegetation Type
Common Snowberry
Desert Peachbrush
Globemallow
Spineless Horsebrush
White Fir
Yucca
B-20
Vegetation Type
Alkali Seepweed
Desert Globemallow
Golden Currant
Mescat Acacia
Mountain Snowberry
Spineless Horsebrush
Legend
Hydrology
Highways
Ranges
Railroad
Observed Bat Species
Observed Sand Cholla
Area where Hardy's Aegialian Scarab Beetle, Nevada Viceroy, Sand Mountain Aphodius Scarab Beetle, Sand Mountain Blue Butterfly, and/or Sand Mountain Serican Scarab are likely to occur.
Impact Area
Active Targets
Strafe Targets
Inert Targets
I 80
Elko
Carson City
South Lake Tahoe
Lodi
GENERAL LOCATION
Nevada
California
KEY MAP
NOT TO SCALE
N
SAIC
An Employee-Owned Company
VEGETATION & SENSITIVE PLANT & ANIMAL SPECIES WITHIN FALLON RANGE TRAINING COMPLEX
NAS FALLON
FALLON, NEVADA
PROJECT: \GIS_Projects\RSEPA\FALLON\Projects\ Fallon Veg Sensitive Species.mxd
FIGURE: 4-5
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The surveys that were conducted for the Bravo ranges were incomplete and a large portion of these training facilities have not been analyzed; thus, more cultural resources may exist in these areas.

## 4.4 LAND USE COMPONENT

The FRTC airspace covers approximately 13,000 square acres. The land beneath the FRTC airspace has multiple ownerships including Federal, state, and local agencies; Native American groups; and private entities. The majority of the land within Fallon is publicly owned and administered by the BLM. Most of the proposed land changes that occur on these lands are on Navy or BLM administered lands. Navy lands are managed for military training and support activities solely. BLM lands, however, have multiple uses including wilderness, recreation, livestock grazing/wild horse management, and mining (U.S. Navy 1998).

### *4.4.1 Military Land Use*

All four of the Bravo training ranges are used as target areas for air-to-ground ordnance delivery training and live weapons firing. These ranges also provide limited area in support of integrated air and ground training (U.S. Navy 1998). Often, the Navy proposes to withdraw federally administered land around the training ranges in order to facilitate and improve the realistic operational and strategic combat training conducted there and to provide public safety buffers. The BLM, Bureau of Reclamation (BUREC), or U.S. Department of Energy (DOE) administers all lands proposed for withdrawal. The land within the proposed action is expected to fulfill the majority of the training requirement. Military use that becomes necessary outside the proposed withdrawal footprint would continue to be coordinated with the BLM or other appropriate agency. Withdrawn land does not cause an increase in air operations or increase the size of the impact areas within the ranges, but is designed to improve the realistic operational and strategic combat training at the FRTC. It also increases control and management of safety buffers and areas where off-range ordnance has been found in the past (U.S. Navy 1998). The operation uses at each of the training ranges along with the location of any withdrawn land at the ranges is described below.

- ***Bravo 16***—This range is used for air-to-ground conventional bombing with only practice/inert ordnance. It contains two bull’s-eyes and three spotting towers. Bravo 16 is the only training area that is independent of the restricted and military operations airspace over Bravos 17, 19, and 20 used during air wing training, allowing for other military uses to be scheduled during such time. This site is used for basic and intermediate training (U.S. Navy 1998). Withdrawn land lies to the north and east of Bravo 16.
- ***Bravo 17***—This is the most used of the four ranges. It is equipped with numerous scored, realistic looking tactical targets, a standard bull’s-eye, and a strafing target for live ordnance training. The site also contains simulated aircraft shelters, POL site and tank farm, power plant area, missile assembly area, industrial park targets, runways, airfield control tower, and an obsolete helicopter and aircraft. All are used for close air support training (U.S. Navy 1998). The Dixie Valley Training Range lies north of Bravo 17. Withdrawn land lies to the south of Bravo 17.
- ***Bravo 19***—Bravo 19 has remote tower scoring capabilities, a conventional bull’s-eye, strafing target, close air support and laser designating areas, and tank targets in the high impact area. This site also contains live ordnance bombing for close air support and Sea, Air, Land (SEAL) training (U.S. Navy 1998). Withdrawn land lies to the east of Bravo 19.
- ***Bravo 20***—This range is the most remote, largest, and least developed of all of the training ranges at Fallon. Bravo 20 is used for air-to-ground training, strafing, and laser targeting. There is a mock submarine, two strafing banners, two bull’s-eyes, one lighted helicopter pad, run-in lighting, two spotting towers, and electronic scoring. This site is able to test live

ordnance up to 2,000 pounds (U.S. Navy 1998). No land surrounding Bravo 20 has been withdrawn.

### *4.4.2 Public Land Use*

Given that much of the land in Fallon, Nevada is publicly owned, there are multiple land uses administered by many parties. The BLM administers the majority of the land within the area. Within the BLM administered lands are several wilderness study areas (WSAs). The Stillwater National Wildlife Refuge, Fallon National Wildlife Refuge, and Stillwater Wildlife Management Area lie approximately 10 miles south to southeast of Bravo 20. The goal of the WSAs is to preserve wilderness characteristics regardless of suitable or non-suitable recommendations by BLM field offices (U.S. Navy 1998).

Other land uses are administered by USFWS, U.S. Forestry Service (USFS), Bureau of Reclamation (BOR), Indian Tribes, and private land owners. Lone Rock, located at Bravo 20, is a spiritually significant geologic formation for the Native American Tribes. However, due to the extremely dangerous use of the Bravo ranges, all of these ranges remain restricted for all unauthorized personnel.

Residents are not in close proximity to any of the ranges. The closest residents are at the Walker River Indian Reservation. This reservation lies along the southern boundary of Bravo 19; however, the land immediately beyond the boundary is used for grazing and a mountain range divides the range from where the residents live. Approximately 800 people live on this reservation.

## 4.5 OPERATIONAL RANGE SITE MODELS

Prior sections presented the three components of ORSMs: operational, environmental, and land use. This section integrates the operational and release information, migration and exposure pathways, and expected locations of MCs as the ORSMs for Bravos 16, 17, 19, and 20.

### *4.5.1 ORSM for Bravo 16*

Basic and intermediate air-to-ground training is the predominant military operation conducted at Bravo 16. Figure 4-6 illustrates the ORSM for Bravo 16. The following sections summarize and depict the source areas, receptors, and potential transport pathways in terms of the operational, environmental, cultural, and land use components:

- ***Operational***—The activities related to Naval training include conventional and special-weapon deliveries. Two targets are used for inert ordnance, including inert rockets, and paraflares.
- ***Environmental***—Soils in Bravo 16 are sandy. The range is composed of extensive alkali flats and patches of desert and is surrounded by the several elevated landmasses, including Red Mountain to the west, Dead Camel Mountains to the west/southwest, and Desert Mountains to the south.

  Groundwater levels in the vicinity of Bravo 16 range from 10 to 90 feet BLS, however, in general, the depth ranges from 40 to 90 feet BLS with the exception of the northeast corner of the site. Because the exact depth of groundwater is unknown, groundwater depths were estimated at 65 feet BLS (i.e., halfway the distance between 40 and 90 feet BLS). The water table deepens as it flows in the south/southeast direction. The city of Fallon is found to have an annual precipitation of 5.3 inches, which limits any vertical migration.

  There are no federally or state listed T&E plant and animal species at the FRTC; however, several special status insect and plant species and several bat “species of concern” possibly exist within the FRTC. These species may be impacted from military operations at Bravo 16.

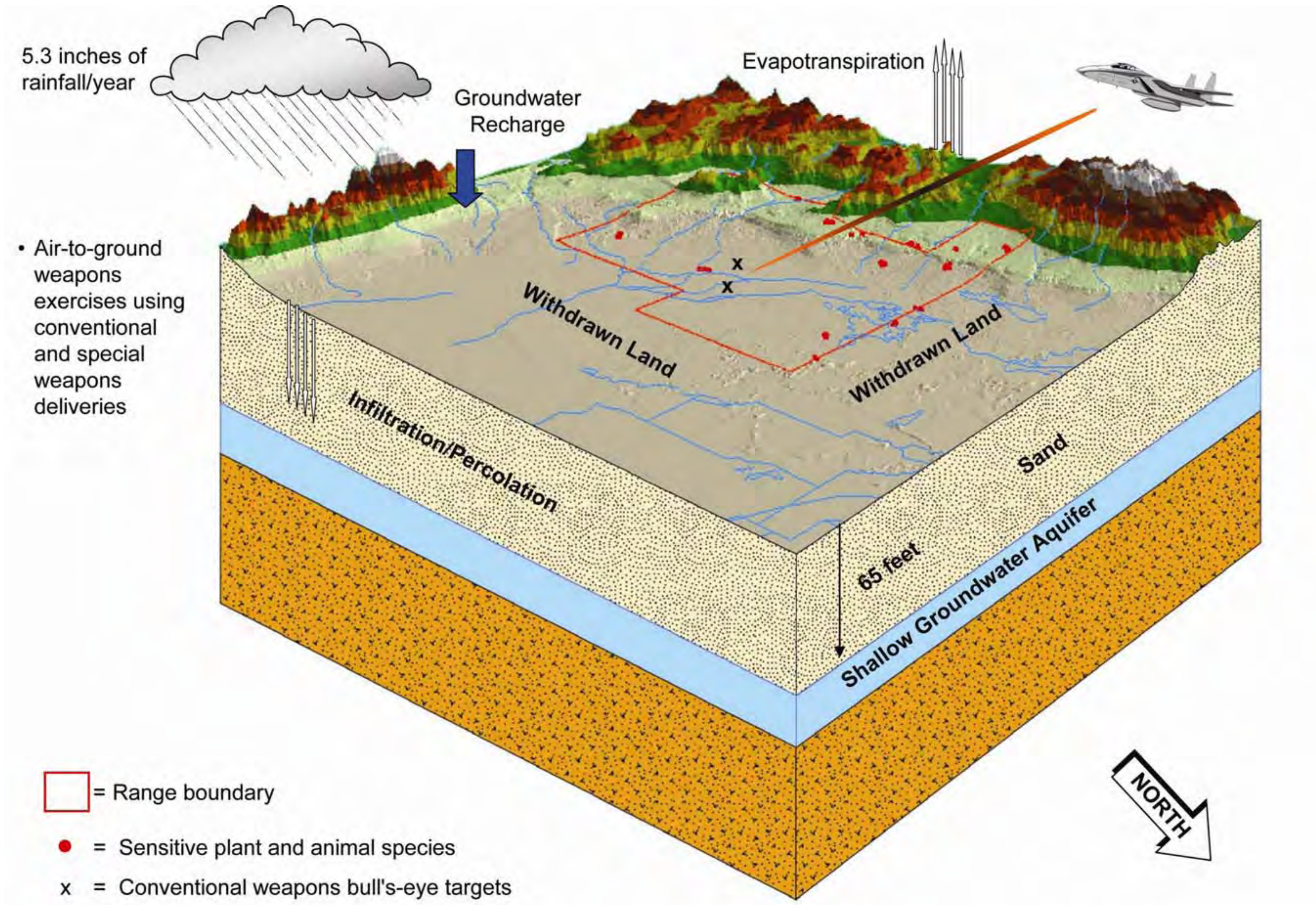



**Figure 4-6. Operational Range Site Model for Bravo 16**

Thirty-seven archaeological sites exist within Bravo 16. The types of prehistoric objects found in these locations include villages, sites with residential features, lithic quarries, rock art, shelters/caves, lithic scatters with and without groundstone, and groundstone scatters.

- ***Land Use***—Withdrawn land lies to the north and east of the range boundaries. Bravo 16 remains restricted for all unauthorized personnel.

### 4.5.2 ORSM for Bravo 17

Bravo 17 is divided into two independent operating areas. Figure 4-7 illustrates the ORSM for Bravo 17. The following sections summarize and depict the source areas, receptors, and potential transport pathways in terms of the operational, environmental, and land use components:

- ***Operational***—Bravo 17 East consists of light inert, heavy inert, and live impact areas, with multiple targets for air-to-ground bombing, rocket, and strafing exercises with live and inert ordnance. The live ordnance targets consist of three clusters of hard tank targets. Bravo 17 West is an NDWS area and ordnance is not allowed.
- ***Environmental***—Soils in Bravo 17 are sandy. The northern portion of the range is made of alkali flats with patches of desert and foothills and the southern portion also contains foothills. The eastern and western portions also are dominated by mountain ranges.

  Although site-specific data are not available, the depth to groundwater 3 to 6 miles east of Bravo 17 ranges from 35 to 52 feet BLS. Because the exact depth of groundwater is unknown, groundwater depths were estimated at 43 feet BLS (i.e., halfway the distance between 35 and 52 feet BLS). The city of Fallon is found to have an annual precipitation of 5.3 inches, which limits any vertical migration.

  There are no federally or state listed T&E plant and animal species at the FRTC; however, several special status insect and plant species and several bat "species of concern" possibly exist within the FRTC. However, only the bat "species of concern" are found within Bravo 17 and may be impacted from activities.

  Seventy-seven archaeological sites exist within Bravo 17. The types of prehistoric objects found in these locations include villages, sites with residential features, lithic quarries, rock art, shelters/caves, lithic scatters with and without groundstone, and groundstone scatters.
- ***Land Use***— Withdrawn land lies to the south of Bravo 17. Dixie Valley Training Area lies to the north of the range. Bravo 17 remains restricted for all unauthorized personnel.

### 4.5.3 ORSM for Bravo 19

Bravo 19 has multiple targets for air-to-ground bombing, rocket, strafing, and laser system exercises. Figure 4-8 illustrates the ORSM for Bravo 19. The following sections summarize and depict the source areas, receptors, and potential transport pathways in terms of the operational, environmental, and land use components:

- ***Operational***—Bravo 19 contains a conventional weapons bull for practice ordnance and an impact area for live ordnance. The live ordnance targets consist of three clusters of hard tank targets.
- ***Environmental***—Soils in Bravo 19 are sandy. The range is composed of alkali flats with patches of desert and is surrounded by mountain ranges to the east and west.

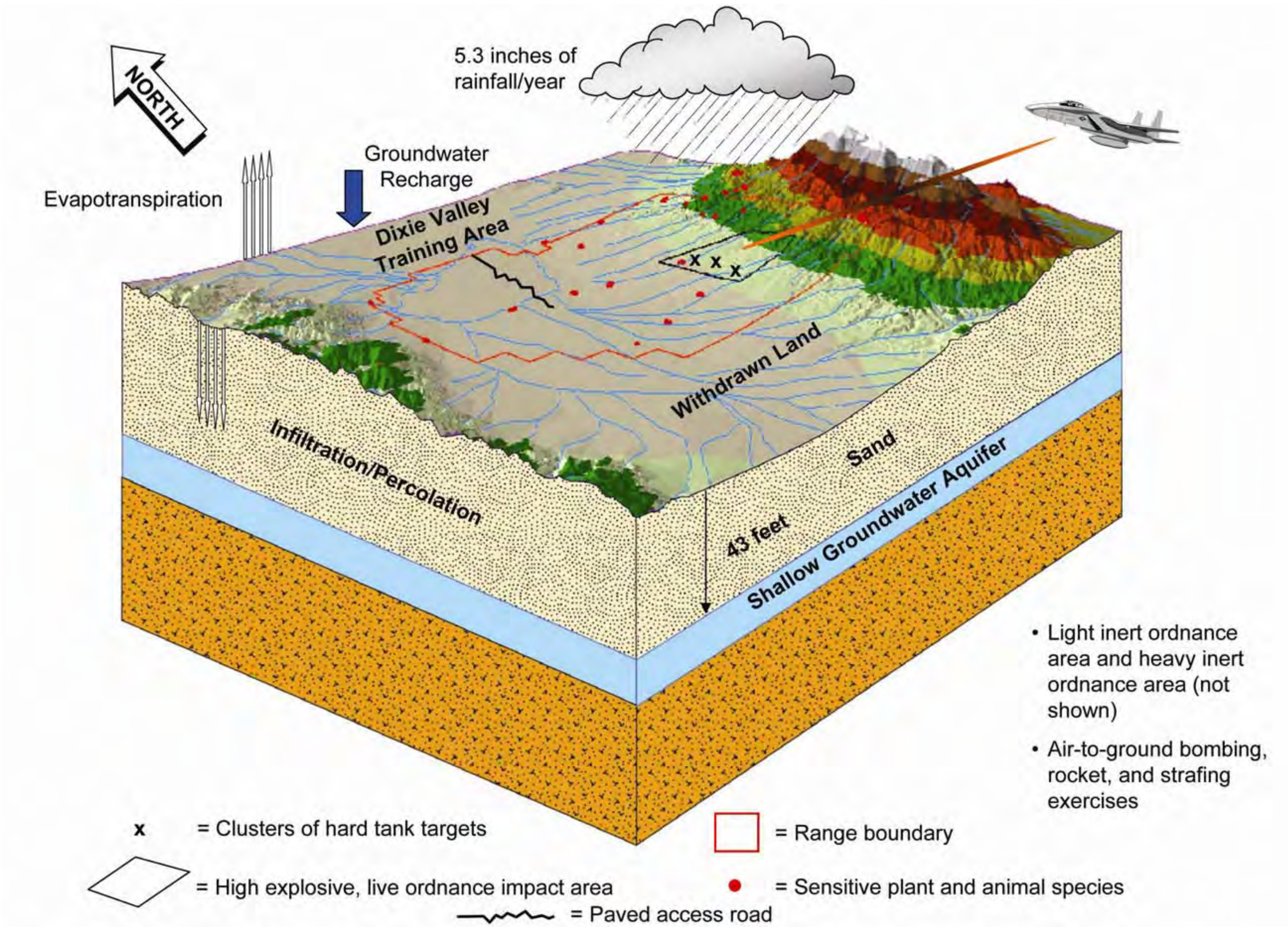



**Figure 4-7. Operational Range Site Model for Bravo 17**

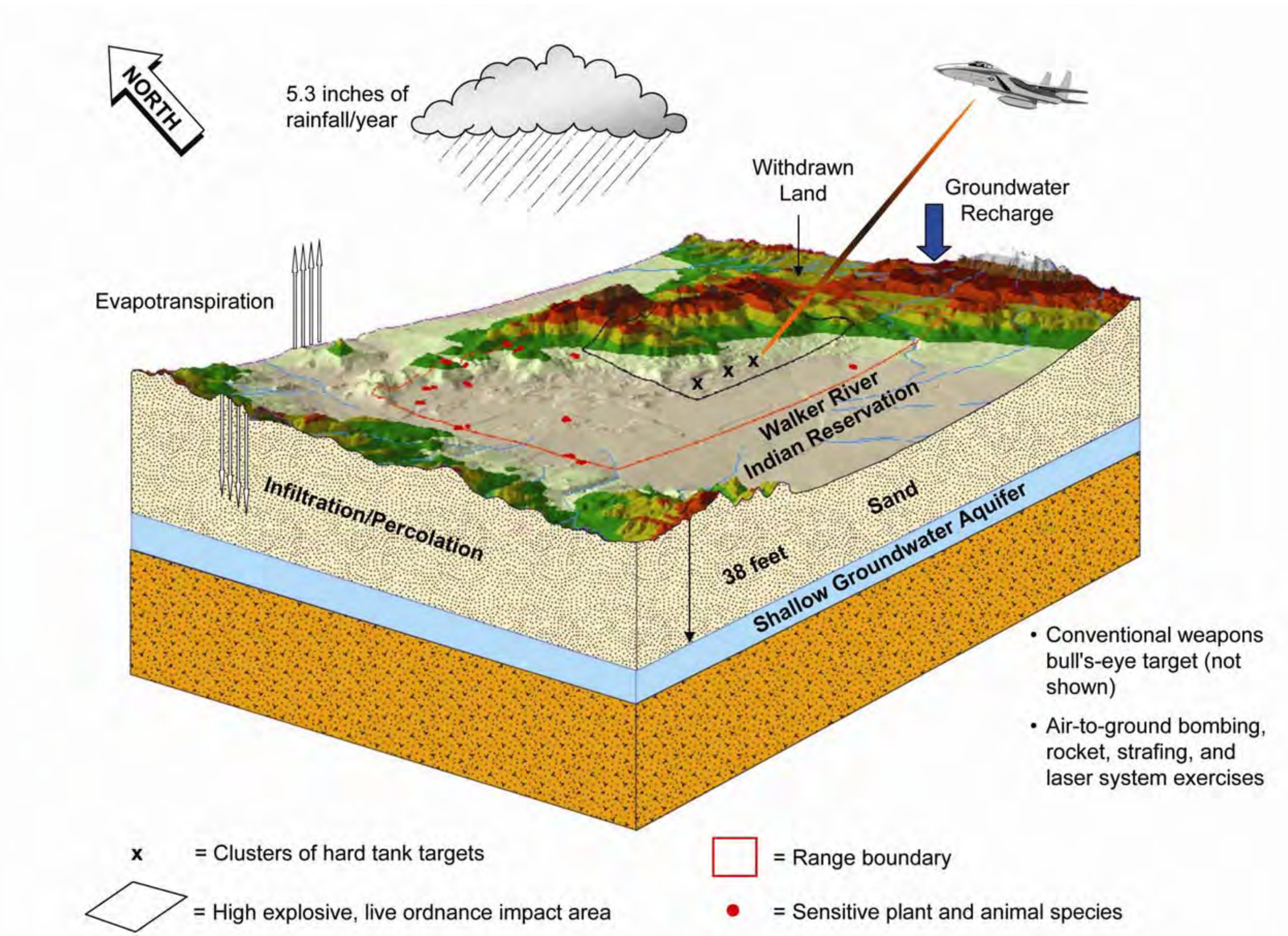



**Figure 4-8. Operational Range Site Model for Bravo 19**

Based on topography and the wells existing within the Fallon area, the depth to groundwater at Bravo 19 ranges from 25 to 50 feet BLS. Because the exact depth of groundwater is unknown, groundwater depths were estimated at 38 feet BLS (i.e., halfway the distance between 25 and 50 feet BLS). The city of Fallon is found to have an annual precipitation of 5.3 inches, which limits any vertical migration.

There are no federally or state listed T&E plant and animal species at the FRTC; however, several special status insect and plant species and several bat "species of concern" possibly exist within the FRTC. These species may be impacted from activities at Bravo 19.

Fifty-three archaeological sites exist within Bravo 19. The types of prehistoric objects found in these locations include villages, sites with residential features, lithic quarries, rock art, shelters/caves, lithic scatters with and without groundstone, and groundstone scatters.

- ***Land Use***—The Walker River Indian Reservation borders Bravo 19 along its southern edge and approximately 800 people live there. Withdrawn land lies to the east of Bravo 19. The range remains restricted for all unauthorized personnel.

### *4.5.4 ORSM for Bravo 20*

Bravo 20 has multiple targets for air-to-ground bombing, rocket, and strafing exercises. Figure 4-9 illustrates the ORSM for Bravo 20. The following sections summarize and depict the source areas, receptors, and potential transport pathways in terms of the operational, environmental, and land use components:

- ***Operational***—The targets at Bravo 20 use conventional ordnance except for missiles and cluster bomb units. However, the only live ordnance impact area within Bravo 20 is located at Lone Rock.
- ***Environmental***—Bravo 20 is located in an area known as "Carson Sink." Soils in this area are sandy and the area is composed of alkali flats. Mountain ranges surround Bravo 20 to the east and west.

  Groundwater at Bravo 20 is located at approximately 25 feet BLS. The city of Fallon is found to have an annual precipitation of 5.3 inches, which limits any vertical migration.

  There are no federally or state listed T&E plant and animal species at the FRTC; however, several special status insect and plant species and several bat "species of concern" possibly exist within NAS Fallon. However, none of these species has the possibility of occurring within Bravo 20.

  Bravo 20 contains numerous archaeological isolates and the Lone Rock. However, the rock, which is a spiritually significant geological formation for the Native American Tribes, along with the isolates, were determined to not be cultural resources that may be impacted by range activities.
- ***Land Use***—Although Bravo 20 contains a spiritually significant geologic formation, the range remains restricted for all unauthorized personnel. The Stillwater National Wildlife Refuge, Fallon National Wildlife Refuge, and Stillwater Wildlife Management Area are approximately 10 miles south to southeast of Bravo 20.

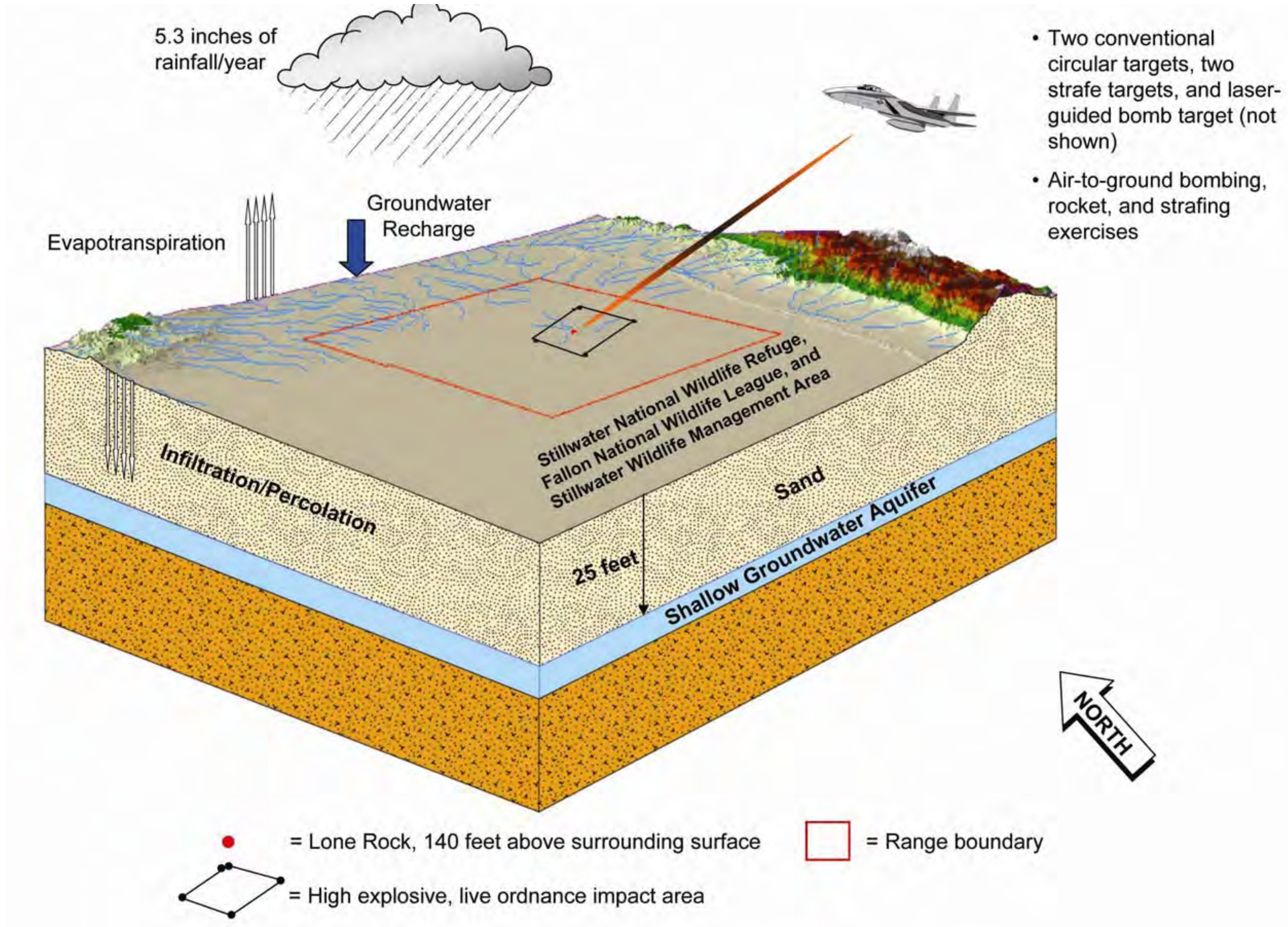



**Figure 4-9. Operational Range Site Model for Bravo 20**

# 5. PREDICTIVE MODELING

This section evaluates the potential for an off-range release of the modeling compounds HMX, RDX, TNT, 2,4-DNT, and perchlorate from munitions after they have been used for testing or training purposes. This requires information about the munitions (e.g., chemical and physical properties of various explosive fillers) and environmental data about the range. A process is presented below to help answer the question posed by RSEPA Decision Point 1, “Is further analysis required to assess the risk of off-range release?” This question is a direct corollary “to a release or substantial threat of a release of munitions constituents from an active or inactive range to off-range areas, when such release poses an imminent and substantial threat to human health or the environment,” as provided by DOD Directive 4715.11, Section 5.5.14. As described in the RSEPA Policy Implementation Manual (U.S. Navy 2004a), an appropriate response to such conditions could be to conduct a CRE or implementing protective measures.

Figure 5-1 illustrates the decision diagram from Decision Point 1 of the RSEPA Policy Implementation Manual (Navy 2004a) that is used to determine if further analysis is required to assess the risk of an off-range release. The following bullets provide the rationale for answers to questions in Figure 5-1.

- Section 4.2 provided the information needed to affirm the first question, “Was range ever used for munitions (live-fire or inert) training?” Section 4.2 indicated that Bravo 16, Bravo 17, Bravo 19, and Bravo 20 have been used for munitions training and testing since the 1940s.
- Neither laboratory testing data nor predictive modeling data are available from samples collected on- or off-range to ascertain the potential quantities, transport potential, or transformation products of MCs. As indicated by Figure 5-1, the conclusion under this scenario is that “Further analysis is required; continue to answer ‘release’ question.”
- The following sections build on the ORSMs for Bravo 16, Bravo 17, Bravo 19, and Bravo 20 that were presented in Section 4.5 and are intended to provide information needed to address the RSEPA Decision Point 1, “Is further analysis required to assess the risk of off-range release?”

A general process is used to evaluate the potential for releases of MCs through an evaluation of modeling compounds at Bravo 16, Bravo 17, Bravo 19, and Bravo 20. This process includes two parts: mass loading modeling (Section 5.1) and transport modeling (Section 5.2). Mass loading modeling is used to estimate the potential soil concentrations of modeling compound residues resulting from testing and training operations with munitions. The mass loading modeling is conducted through consideration of the predominant types and chemical compositions of fillers and propellants in munitions used at the ranges, the operational tempo and munitions usage rates, and the potential quantities of modeling compounds from duds and low-order detonations. Then, using the soil concentrations of modeling compound residues, screening-level environmental transport modeling is conducted to determine the potential for the off-range migration of modeling compounds. The transport modeling uses physical and environmental characteristics of the ranges, which are components of the ORSMs presented in Section 4.5.

## 5.1 MASS LOADING MODELING

Mass loading modeling is used to estimate the potential masses of modeling compound residues from munitions testing and training operations and then, using these masses, estimating potential concentrations of modeling compounds in soil. The historic and current operational tempos, nature of operations, and types of munitions used at each range, as well as munition failure rates, are factors that affect the potential existence and quantities of modeling compounds on-range and the potential for modeling compounds to be released off-range. The following sections describe these general characteristics as they relate to the FRTC ranges.

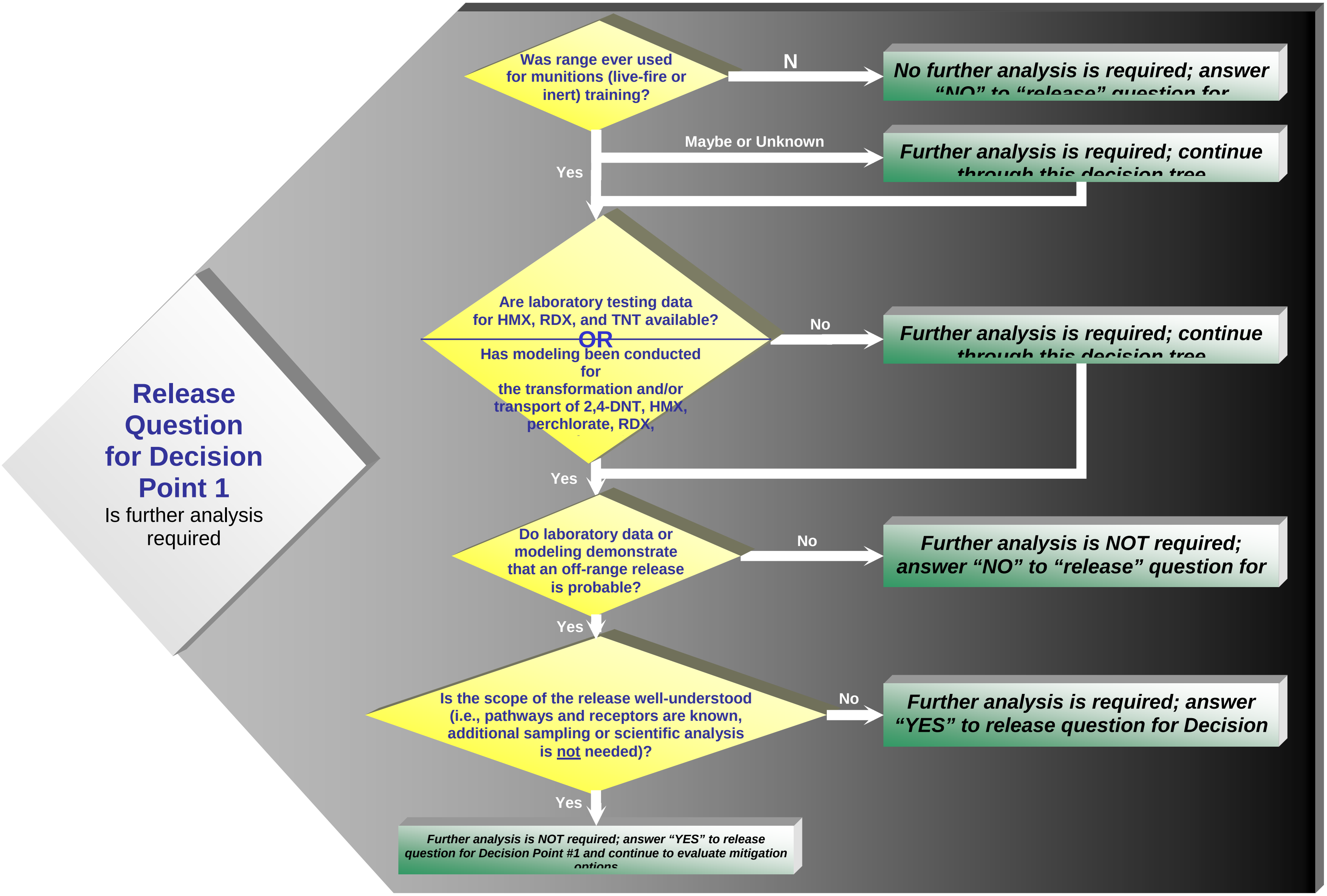



**Figure 5-1. Process Diagram for Decision Point 1**

### *5.1.1 Operational Tempo and Munition Usage*

The Navy has used the FRTC as an operational range complex since 1943 and, since that time, it has become the Navy's premier tactical combat aviation training facility. Limited ground operations currently are conducted at the FRTC. The operational tempo, therefore, is best represented by aviation training data.

The Navy has been and continues to be the primary user of the FRTC, although other military aircrews and groundcrews conduct operations on the FRTC. Bravo 16 consists of two bull's-eye targets, one for conventional deliveries and one for special-weapons (e.g., nuclear simulation weapons) deliveries. Munitions at Bravo 16 are limited to air-to-ground weapon exercises using light inert munitions and/or paraflares. No ordnance is allowed on Bravo 17 West, however, Bravo 17 East includes light inert, heavy inert, and live munition impact areas. Air-to-ground bombing, rocket firing, and strafing exercises with live and/or inert munitions are allowed on Bravo 17 East. Bravo 19 also has multiple targets where air-to-ground bombing, rocket firing, strafing, and laser system exercises can occur with live and/or inert munitions. Air-to-ground bombing, rocket firing, and strafing exercises with live and/or inert munitions are allowed at Bravo 20. The current assessment focuses on the operations at Bravo 17 East, Bravo 19, and Bravo 20 because these ranges currently are used to conduct operations with live munitions and the Navy plans to continue to use these ranges for operations for the foreseeable future.

NSAWC holds data for operations conducted back to and including 1984. For operations conducted prior to 1984, there is a lack of documentation on users of the range complex, how many munitions were expended, where they were targeted, and when the operations took place. However, since 1994, the Navy has documented the use of range complexes including the FRTC by using the Navy Pacific Air Command's TRIMS. Reports from TRIMS (TRIMS 2003) identified aviation operations conducted by all branches of the U.S. military and forces from Japan, Australia, and Canada. The variability in operational tempo is related to U.S. military training goals, the geopolitical climate, and the status of active U.S. and international military activities. Appendix D presents the Navy's reporting procedure for TRIMS data (U.S. Navy 2000b), as well as detailed TRIMS reports from 1994 to 2002 (TRIMS 2003). The total numbers of munitions (live and inert) used between FYs 1994 and 2003 are summarized in Table 5-1.

**Table 5-1. Total Numbers of Munitions Expended Per Year**

| Year | Bravo 16 | Bravo 17 East | Bravo 17 West | Bravo 19 | Bravo 20 | Total |
|---|---|---|---|---|---|---|
| 1994 | 9,209 | 122,821 | 0 | 136,977 | 167,854 | 427,652 |
| 1995 | 8,109 | 147,140 | 0 | 171,154 | 100,011 | 426,414 |
| 1996 | 7,958 | 178,450 | 0 | 195,766 | 141,058 | 523,232 |
| 1997 | 6,307 | 138,969 | 0 | 216,698 | 128,256 | 483,923 |
| 1998 | 3,966 | 119,252 | 0 | 87,099 | 51,520 | 257,871 |
| 1999 | 5,347 | 93,970 | 0 | 271,127 | 127,742 | 498,186 |
| 2000 | 4,522 | 183,790 | 0 | 343,236 | 59,758 | 591,306 |
| 2001 | 6,376 | 264,222 | 0 | 442,903 | 56,630 | 770,131 |
| 2002 | 7,693 | 145,571 | 0 | 369,784 | 84,076 | 607,124 |
| 2003 | 872 | 14,436 | 13,073 | 2,854 | 13,030 | 499,774 |
| **Total** | **4,792** | **117,392** | **67** | **341,121** | **36,402** | **5,085,546** |
| **% of Total Across All Ranges** | **0.9%** | **29.7%** | **0%** | **50.7%** | **18.7%** | **100%** |

In order to obtain accurate and representative information regarding the chemical composition of each munition, Department of Defense Identification Codes (DODICs) are needed for each munition. Unfortunately, DODICs are not available in TRIMS reports. However, the Navy provided separate reports with DODICs for munitions used during training and testing operations that occurred in FYs 1997, 1999, and 2000 (Appendix D). This list includes live munitions as well as inert or dummy munitions with live components. For example, practice rockets (i.e., dummies) could include inert fillers in the warheads, but the rocket motors are filled with live propellant and, therefore, are considered live for inclusion on this list. Table 5-2 summarizes the munitions that were expended by the Navy in FYs 1997, 1999, and 2000 by munition class and DODIC.

Unfortunately, while the reports that identified DODICs provided enough detailed information to ascertain chemical data for most munitions, the ranges where each munition was expended was not available. Instead, munitions usage data from TRIMS were used to apportion the quantities listed in Table 5-2 across the ranges where live munition expenditures are reported (i.e., Bravo 17 East, Bravo 19, and Bravo 20). Using the total numbers of munitions expended as reported by TRIMS, the quantities listed in Table 5-2 were apportioned at rates of 30, 50, and 20 percent for Bravo 17 East, Bravo 19, and Bravo 20, respectively.

### *5.1.2 Munitions Constituents and Modeling Compounds*

This section presents the chemical properties of the modeling compounds used at the FRTC and the rationale for selecting these five modeling compounds. It includes discussions of the background, fate and transport properties, toxicological information, and relative abundances of the modeling compounds. The chemical properties are needed to estimate the potential quantities and locations of MCs at Fallon and the potential for off-range transport.

As listed in Table 5-2, various types of munitions have been and continue to be used at Bravo 17 East, Bravo 19, and Bravo 20. Each different munition contains varying types and quantities of MCs. Of these, the following five compounds were selected for evaluation in assessing the risk of off-range releases and are referred to as “modeling compounds” since they are the focus of modeling described in this report: HMX, RDX, TNT, 2, 4-DNT, and perchlorate.

#### 5.1.2.1 Background

TNT, 2,4-DNT, RDX, and HMX are secondary explosives that are formulated to detonate after being initiated by another explosive charge (i.e., primary explosive). They are used both as main charges or for boosting other explosives. TNT and RDX constitute the largest quantities of explosives used in military applications because they are major ingredients in nearly every munitions formulation (Walsh et al. 1995) They are favored because they are extremely powerful and are much less shock-sensitive than primary explosives. 2,4-DNT is both a major impurity in production-grade TNT (USAEC 2002) and an environmental degradation byproduct of TNT. HMX is a byproduct of RDX manufacturing and a major impurity of production-grade RDX and can be present at concentrations as high as 12 percent (U.S. Army 1994).

Secondary explosives fall into two main categories: (1) melt-cast explosives, based primarily on TNT, and (2) plastic-bonded explosives, which consist of a polymer matrix filled with a crystalline explosive, such as RDX. In either case, these explosives are manufactured as formulations rather than the components that are the basis of the physical, chemical, and toxicological properties provided in the literature. The properties of these mixtures are expected to differ from those of the pure components. Unfortunately, because the physical and chemical properties of the manufactured forms of these explosives are extremely limited, the data properties of the pure forms primarily are used in this report.

## Table 5-2. Numbers of Munitions Expended by DODIC and Fiscal Year

| DODIC/Class | Nomenclature | 1997 | 1999 | 2000 | DODIC/Class | Nomenclature | 1997 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|
| **Projectiles/Mortars/Rockets** | | | | | **Cluster Bombs** | | | | |
| A665 | 20mm HEI | 4,912 | 0 | 0 | E173 | MK-20 (CBU) | 63 | 173 | 27 |
| A978 | 25mm | 1,292 | 0 | 0 | E835 | MK-20 (CBU) | 63 | 2 | 0 |
| B081 | 20mm | 0 | 0 | 10,589 | E892 | CBU (Dispenser and Bomb) | 0 | 0 | 47 |
| B535 | 40mm (Paraflare) | 39 | 0 | 0 | E895 | CBU 100/B | 31 | 20 | 0 |
| C256 | 81mm Mortar HE | 741 | 204 | 0 | E896 | CBU (Dispenser and Bomb) | 0 | 0 | 0 |
| C445 | 105mm Projectile HE | 2,507 | 574 | 180 | E898 | MK-20 (CBU) | 16 | 0 | 0 |
| H663 | 2.75-inch Rocket (Practice) | 0 | 0 | 0 | E916 | CBU-99/B | 34 | 0 | 0 |
| H842 | 2.75-inch Rocket HE | 136 | 0 | 0 | E918 | CBU (Dispenser and Bomb) | 0 | 0 | 0 |
| N945 | 5-inch Rocket (Practice) | 0 | 0 | 0 | EA59 | CBU-100 (T5 G) | | | |
| **General Purpose Bombs** | | | | | **Missiles** | | | | |
| E480 | MK-82 | 966 | 109 | 36 | E220 | Walleye MK-1 | 54 | 0 | 0 |
| E483 | MK-82 | 4 | 0 | 0 | E282 | Walleye MK-23 | 3 | 0 | 0 |
| E485 | MK-82 | 754 | 1,961 | 619 | E283 | Walleye MK-23 | 5 | 1 | 0 |
| E487 | MK-82 | 1,418 | 0 | 0 | E285 | Walleye MK-23 | 7 | 11 | 0 |
| F243 | MK-82 | 102 | 278 | 84 | E286 | Walleye MK-23 | 5 | 0 | 0 |
| E508 | MK-83 | 266 | 9 | 0 | E534 | Walleye MK-34 | 9 | 0 | 0 |
| E509 | MK-83 | 349 | 90 | 17 | E537 | Walleye MK-34 | 25 | 0 | 0 |
| E510 | MK-83 | 765 | 136 | 99 | E539 | Walleye MK-34 | 4 | 0 | 0 |
| E511 | MK-83 | 139 | 330 | 130 | E542 | Walleye MK-34 | 1 | 0 | 0 |
| E513 | MK-83 | 17 | 0 | 0 | E544 | Walleye MK-34 | 14 | 0 | 0 |
| F127 | MK-84 | 259 | 113 | 0 | E559 | Walleye MK-37 | 4 | 0 | 0 |
| F127 | MK-84 | 259 | 113 | 0 | E563 | Walleye MK-37 | 6 | 0 | 0 |
| F243 | MK-84 | 102 | 278 | 84 | E567 | Walleye MK-37 | 3 | 0 | 0 |
| F262 | MK-84 | 0 | 17 | 0 | PB69 | Maverick (LZ) | 23 | 10 | 3 |
| F272 | MK-84 | 85 | 0 | 0 | PC61 | Hellfire | 1 | 0 | 0 |
| F278 | MK-84 | 17 | 102 | 8 | PC91 | Hellfire | 10 | 9 | 1 |
| F278 | MK-84 | 17 | 102 | 8 | PD63 | Maverick (IR) | 25 | 6 | 1 |
| F763 | GBU-12 | 8 | 0 | 0 | PV07 | AGM-85G | 0 | 3 | 0 |
| **Miscellaneous Munitions** | | | | | PV07 | AGM-85G | 0 | 3 | PV66 |
| F372 | Adapter Booster | 125 | 0 | 0 | PV70 | Sparrow | 8 | 4 | 0 |
| F392 | Adapter Booster | 666 | 0 | 0 | | Sidewinder | 0 | 4 | 0 |

Secondary explosives also can be classified according to their chemical structure. For example, TNT and 2,4-DNT are classified as nitroaromatic (a composition wherein the organic component contains a direct nitrogen to oxygen nonionic bond) and RDX and HMX are nitramines (compounds that contain a nitro- or nitroso-group bonded directly to an amino nitrogen) (USACE 2002a and 2002b). Perchlorate is used in rockets and missiles as an energetics booster since it is a powerful oxidizing agent (ITRC 2002). Ammonium perchlorate is the most commonly used form of perchlorate as a solid rocket propellant. Figure 5-2 presents the chemical structures of the modeling compounds.

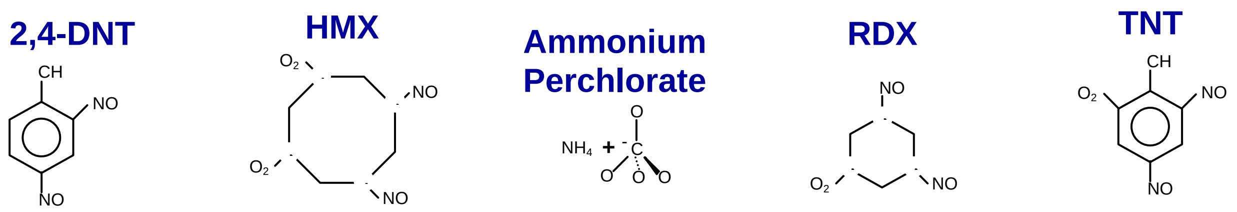



**Figure 5-2. Chemical Structure of Modeling Compounds**

### 5.1.2.2 Utility of Marker Compounds

The *Briefing Paper: Target Analytes for Explosives Contamination Assessment* (U.S. Navy 2004a) marker compounds are identified (i.e., HMX, RDX, and TNT), as are sampling methods for initial screening of sites with potential explosives contamination from munitions use. Conclusions are based on studies of the fate and transport of explosives on ranges in order to fill physical and chemical property data gaps. Walsh et al. (1993) are cited for concluding that most samples from arsenals, depots, and ammunition plants contained TNT and/or RDX. "Since almost all (94 percent) of the soils samples with explosives detectable with Method 8330 contained TNT and/or RDX, testing soils for these two compounds would be an efficient way to screen for explosives residue contamination. Of the contaminated soils that did not have TNT and/or RDX, all had tetryl, trinitrobenzene, dinitrobenzene, or 2,4-DNT, all of which are detectable by field screening procedures described in the Experimental section." Crockett et al. (1996 and 1998) concluded that it is feasible to screen "for one or two compounds or classes of compounds to identify the initial extent of contamination at munitions sites." TNT and RDX are widely recognized as the two most widespread explosives contaminants (Jenkins et al. 2000, Pennington et al. 1999, USAEC 2001, and NAVEODTECHDIV 1998). As discussed in Jenkins et al. 2001, Canadian Defence Research Establishment found only TNT, RDX, and HMX with extensive Method 8330 analysis at the following ranges: Valcartier, WATC, and Dundurn (Ampleman et al. 1998, Thiboutot et al. 1998), Tracadie (Thiboutot and Ampleman 2000), CFAD Rocky Point, and Chilliwack (Ampleman et al. 2000). They found either no residue or combinations of TNT, RDX, and/or HMX. After extensive sampling at Camp Edwards in Massachusetts, the U.S. National Guard found TNT and/or degradation products, and/or RDX and HMX in all samples with explosives detected (NGB 1998). The same can be said for an unpublished study (NAVEODTECHDIV 1998) by the U.S. Marine Corps at the Marine Corps Air Ground Combat Center 29 Palms in California.

### 5.1.2.3 Physical and Chemical Properties of Modeling Compounds

The physical and chemical properties of chemical compounds influence their behavior in the environment. The properties of the selected modeling compounds are more readily available than properties of other MCs. Ongoing research is working to fill these data gaps, but information currently is very limited for MCs other than the five modeling compounds.

Table 5-3 presents the predominant physical and chemical properties affecting the fate and transport of the modeling compounds in the environment. Significant properties include:

- Melting and boiling points indicate that all of the modeling compounds are solids at ambient pressure and temperature.
- Solubility indicates that ammonium perchlorate is most soluble out of the five compounds. 2,4-DNT, TNT, RDX, and HMX are far less soluble. Highly soluble compounds can be quickly distributed in the hydrologic cycle.
- The vapor pressures of the five modeling compounds are too low for volatilization (i.e., $<1 \times 10^{-6}$ torr) to occur at ambient temperature and pressure.
- Although not listed in Table 5-3, TNT is highly subject to photo and microbial degradation (Walsh et al. 1995). HMX and RDX also are subject to biological degradation, while ammonium perchlorate is extremely persistent and resistant to photo, microbial, or chemical degradation.

#### 5.1.2.4 Toxicity of Marker Compounds

Table 5-4 presents the toxicity information for evaluating human health risks from hypothetical exposures to the modeling compounds, which are summarized in the following bullets:

- USEPA classifies 2,4-DNT as a Class B2 carcinogen (i.e., probable human carcinogen, limited evidence in humans). USEPA classifies TNT and RDX as Class C carcinogens (i.e., they are considered possible human carcinogens with limited evidence in animals and inadequate evidence in humans) and HMX as a Class D carcinogen (i.e., its carcinogenicity has not been defined relative to humans). RDX is the most potent carcinogen of the modeling compounds and HMX is not evaluated for carcinogenic effects, since USEPA classifies it as a Class D carcinogen.
- USEPA-verified oral reference doses (RfDs) are available for 2,4-DNT, HMX, RDX, and TNT. A provisional RfD of 2 × 10-3 mg/kg-day was developed for perchlorate by Toxicology Excellence for Risk Assessment (TERA 2002). This value is currently under review by the National Research Council. The value for TNT is the lowest; therefore, it is considered the most potent modeling compound in terms of chronic health effects.
- The lethal dose-50 percent ($LD_{50}$) represents the dose that is lethal to 50 percent of the animals included in the toxicity testing; therefore, lower numbers indicate higher toxicity. Generally, $LD_{50}$ tests are conducted to assess acute toxicity because the endpoint is mortality. There is a great deal of variability in different species tested in laboratory studies, but the $LD_{50}$ values indicate that RDX is the most potent acute toxin among the modeling compounds.

#### 5.1.2.5 Relative Abundances of Modeling Compounds in FRTC Munitions

Table 5-5 summarizes the quantities of the most abundant chemical compounds and materials (e.g., waxes and resins) found in munitions expended at Fallon in FYs 1997, 1999, and 2000. The five modeling compounds, which are highlighted and bolded, comprise 65, 78, and 80 percent of the total masses of all chemicals and materials included in munitions expended during FYs 1997, 1999, and 2000, respectively. The remaining unlisted compounds and materials comprise less than 1 percent of the total mass for all munitions fired. Tables listing all the chemicals and materials, including their masses and percentages of the total masses, are included in Appendix D.

Some of the more environmentally persistent and toxic chemicals manufactured in munitions are metals and metallic compounds. Table 5-6 summarizes the metals that may be present in metallic form or as metallic compounds, in munitions expended at NAS Fallon in FYs 1997, 1999, and 2000.

## Table 5-3. Physical and Chemical Properties of Marker Compounds

| Analyte | Molecular Weight | Melting Point (°C) | Boiling Point (°C) | Water Solubility (mg/L at 20°C) | Vapor Pressure (torr at 20°C) |
|---|---|---|---|---|---|
| TNT [a] | 227.13 | 80.1-81.6 | 240 (explodes) | 130 | $1.1 \times 10^{-6}$ |
| 2,4-DNT [a] | 182.15 | 70 | 300 (decomposes) | 270 (at 22°C) | $2.2 \times 10^{-4}$ (at 22°C) |
| HMX [a] | 222.26 | 204.1 | Decomposes | 5 (at 25 °C ) | $4.2 \times 10^{-9}$ |
| RDX [a] | 296.16 | 276-280 | Decomposes | 60 (at 25 °C) | $3.3 \times 10^{-14}$ |
| Ammonium Perchlorate | 117.49 [b] | Decomposes at 439 °C [c] | | $2 \times 10^{5}$ (at 22°C) [c] | $2.07 \times 10^{-16}$ (at 25°C)[e] |

[a] USACE 2002a

[b] www.chemfinder.com

[c] California Environmental Protection Agency 2002

[d] SRC 2004

[e] SRC 2004 used the value for sodium perchlorate, which was the same as the value for potassium perchlorate, because the value for ammonium perchlorate could not be located.

Note: The numerical values for solubility represent the mass of chemical (in mg) that can dissolve in 1 L of water.

## Table 5-4. Toxicity Data of Modeling Compounds

| Modeling Compound | Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$ | RfD (mg/kg-day) | $LD_{50}$ |
|---|---|---|---|
| TNT | $3.0 \times 10^{-2}$ [a] | $5 \times 10^{-4}$ | 660 to 1,320 mg/kg [b] |
| 2,4-DNT | $6.8 \times 10^{-1}$ [f] | $2 \times 10^{-3}$ [f] | 270 to 650 mg/kg [f] |
| RDX | $1.1 \times 10^{-1}$ [d] | $3 \times 10^{-3}$ [e] | 50 to 200 mg/kg/day |
| HMX | NA | $5 \times 10^{-2}$ | 0.1 to 6.5 g/kg [c] |
| Ammonium Perchlorate | NA | $2 \times 10^{-3}$ | 2,000 mg/kg [g] |

[a] USACHPPM 2000a
[b] USACHPPM 2000b
[c] USACHPPM 2001
[d] DOD 1984
[e] DOD 1983
[f] ATSDR 1998
[g] California Environmental Protection Agency 2002

**Table 5-5. Annual Masses of Most Abundant Chemical/Material Components of Munitions by Fiscal Year**

| FY 1997 | | | FY 1999 | | | FY 2000 | | |
|---|---|---|---|---|---|---|---|---|
| Chemical/Material Name | Mass (pounds) | Percentage of Total Mass | Chemical/Material Name | Mass (pounds) | Percentage of Total Mass | Chemical/Material Name | Mass (pounds) | Percentage of Total Mass |
| **TNT** | **546,572** | **43%** | **RDX** | **125,055** | **42%** | **TNT** | **109,445** | **72%** |
| **RDX** | **418,923** | **33%** | **TNT** | **100,055** | **34%** | Aluminum Powder | 28,328 | 19% |
| Aluminum Powder | 254,131 | 20% | Aluminum Powder | 56,104 | 19% | **RDX** | **12,538** | **8%** |
| Wax | 42,309 | 3.3% | Wax | 11,819 | 4.0% | Wax | 785 | 0.52% |
| Nitrocellulose | 6,065 | 0.48% | Nitrocellulose | 1,393 | 0.47% | Nitrocellulose | 428 | 0.28% |
| **Dinitrotoluene** | **640** | **0.050%** | **Dinitrotoluene** | **146** | **0.050%** | **Dinitrotoluene** | **46** | **0.030%** |
| Dibutylphthaluminumate | 409 | 0.032% | Dibutylphthaluminumate | 81 | 0.028% | Dibutylphthaluminumate | 25 | 0.017% |
| Nitrocellulose (N 13.15%) | 200 | 0.016% | Nitroglycerin | 19 | 0.0065% | Potassium Nitrate | 5.7 | 0.0038% |
| Nitroglycerin | 143 | 0.011% | Potassium Nitrate | 19 | 0.0064% | Lead Azide | 5.6 | 0.0037% |
| Potassium Nitrate | 89 | 0.0070% | Diphenylamine | 16 | 0.0055% | Tetryl | 5.5 | 0.0036% |
| Diphenylamine | 79 | 0.0063% | Tetryl | 14 | 0.0049% | Diphenylamine | 5.1 | 0.0034% |
| Lead Carbonate | 55 | 0.0043% | Lead Azide | 13 | 0.0044% | Lead Carbonate | 4.0 | 0.0026% |
| Charcoaluminum | 17 | 0.0013% | Lead Carbonate | 13 | 0.0043% | Calcium Stearate | 2.8 | 0.0019% |
| Lead Azide | 16 | 0.0012% | Calcium Stearate | 7.4 | 0.0025% | PETN | 2.6 | 0.0017% |
| Tetryl | 15 | 0.0012% | PETN | 6.9 | 0.0023% | Charcoaluminum | 1.2 | 0.00079% |
| Sulfur | 11 | 0.00088% | Charcoaluminum | 3.9 | 0.0013% | Graphite | 0.94 | 0.00062% |
| Calcium Stearate | 8.6 | 0.00068% | Sulfur | 2.6 | 0.00087% | Polyisobutylene | 0.94 | 0.00062% |
| PETN | 7.4 | 0.00058% | Graphite | 2.5 | 0.00084% | Sulfur | 0.80 | 0.00053% |
| Graphite | 6.4 | 0.00051% | Polyisobutylene | 2.5 | 0.00084% | Lead Styphnate | 0.37 | 0.00024% |
| Tin Dioxide | 5.9 | 0.00047% | Lead Styphnate | 1.5 | 0.00049% | Barium Nitrate | 0.18 | 0.00012% |
| Calcium Carbonate | 5.7 | 0.00045% | Barium Nitrate | 0.73 | 0.00025% | Antimony Sulfide | 0.14 | 0.000094% |
| **HMX** | **5.7** | **0.00045%** | Antimony Sulfide | 0.56 | 0.00019% | Tetracene | 0.046 | 0.000030% |
| Sodium Sulfate | 3.8 | 0.00030% | Ethyl Centraluminumite | 0.36 | 0.00012% | Potassium Chlorate | 0.014 | 0.0000090% |
| Magnesium | 3.2 | 0.00025% | Tetracene | 0.18 | 0.000062% | Lead Thiocyanate | 0.0065 | 0.0000043% |
| Sodium Nitrate | 2.8 | 0.00022% | **Potassium Perchlorate** | **0.013** | **0.0000046%** | **HMX** | **0** | **0%** |
| **Potassium Perchlorate** | **0.074** | **0.0000059%** | **HMX** | **0** | **0%** | **Potassium Perchlorate** | **0** | **0%** |
| **Total** | **1,269,746** | **100%** | | **294,776** | **100%** | | **151,632** | **100%** |

## Table 5-6. Abundance of Metals/Metal Compounds in Munitions by Fiscal Year

| Chemical/Material Name | Total Mass Chemical/ Material | | |
|---|---|---|---|
| | 1997 | 1999 | 2000 |
| Aluminum Powder | 254,131 | 56,104 | 28,328 |
| Antimony Sulfide | 0.82 | 0.56 | 0.14 |
| Barium Chromate | 0.28 | 0.069 | 0 |
| Barium Nitrate | 1.9 | 0.73 | 0.18 |
| Boron Amorphous Powder | 0.10 | 0.0016 | 0 |
| Calcium Carbonate | 5.7 | 0 | 0 |
| Calcium Resinate | 0.87 | 0 | 0 |
| Calcium Silicide | 0.29 | 0 | 0 |
| Calcium Stearate | 8.6 | 7.4 | 2.8 |
| Cobalt Naphthenate | 7.0E-04 | 0 | 0 |
| Diatomaceous Earth | 0.019 | 0.0051 | 0 |
| Iron | 0.0014 | 0 | 0 |
| Iron Oxide | 0.075 | 0.021 | 0 |
| Lead Azide | 16 | 13 | 5.6 |
| Lead Carbonate | 55 | 13 | 4.0 |
| Lead Mono | 0.0019 | 0 | 0 |
| Lead Styphnate | 2.7 | 1.5 | 0.37 |
| Lead Thiocyanate | 0.12 | 0.028 | 0.0065 |
| Magnesium | 3.2 | 0 | 0 |
| Magnesium Powder | 0.96 | 0 | 0 |
| Nickel | 0.067 | 0.019 | 0 |
| Potassium Chlorate | 0.25 | 0.059 | 0.014 |
| Potassium Nitrate | 89 | 19 | 5.7 |
| Potassium Oxalate | 1.9 | 0 | 0 |
| Potassium Sulfate | 1.9 | 0 | 0 |
| Red Lead Oxide | 0.012 | 0.0033 | 0 |
| Silicon Powder | 0.0030 | 8.2E-04 | 0 |
| Sodium Nitrate | 2.8 | 0 | 0 |
| Sodium Sulfate | 3.8 | 0 | 0 |
| Strontium Nitrate | 1.5 | 0 | 0 |
| Strontium Peroxide | 1.00 | 0 | 0 |
| Sulfur | 11 | 2.6 | 0.80 |
| Tin Dioxide | 5.9 | 0 | 0 |
| Tungsten | 0.026 | 0 | 0 |
| Zinc | 0.016 | 0 | 0 |
| Zirconium | 0.13 | 0.035 | 0 |
| **Total** | **254,347** | **56,162** | **28,348** |

Aluminum powder comprises 99.9 percent of the total mass of metals listed in Table 5-6 for munitions expended at NAS Fallon in FYs 1997, 1999, and 2000. The total masses of metals are approximately 49,343; 5,195; and 5,001 pounds for FYs 1997, 1999, and 2000, respectively. The sharp decrease in metal masses from 1997 to 1999 and 2000 is the result of a significant decrease in the numbers of live MK-80 series bombs dropped in the latter years.

Cumulatively, the five modeling compounds plus aluminum powder comprise 79, 89, and 96 percent total mass of all chemicals and materials listed in Table 5-5 for munitions expended at NAS Fallon in FYs 1997, 1999, and 2000, respectively. The total masses of all chemicals and materials listed in Table 5-5 for munitions expended at NAS Fallon in FYs 1997, 1999, and 2000, respectively, roughly equal 311,000; 46,000; and 31,000. As noted above, the sharp decrease in total masses from 1997 to 1999 and 2000 is the result of a significant decrease in the numbers of live MK-80 series bombs dropped.

#### 5.1.2.6 Selection of Modeling Compounds in FRTC Munitions

The relative abundances, when considered in combination with the fate and transport characteristics and the potential risks to human health and the environment, substantiate the selection of 2,4-DNT, HMX, RDX, perchlorate, and TNT as modeling compounds. Although metals are potentially abundant, the modeling compounds are present in munitions in much larger quantities. Furthermore, distinguishing levels that are naturally occurring compared to those potentially introduced through operations with munitions could be inconclusive because of the high mineral resources characteristic of this region of the country. Therefore, it does not appear necessary to expand the list of MCs to include metals.

### *5.1.3 Quantifying Masses of Modeling Compounds in Munitions*

This section presents the chemical compositions of the munitions used at the FRTC in FYs 1997, 1999, and 2000. This information is needed to estimate the potential quantities of modeling compounds and where they may be located at NAS Fallon.

As stated in Section 5.1.1, TRIMS reports include numbers and types of munitions expended by year and by range, but they do not include the chemical composition of each munition. There could be many different types and masses of fillers for munitions. For example, the TRIMS report for munitions expended at Bravo 20 in FY 2002 lists 209 “MK-82 L” (the “L” presumably means “live” MK-82 bombs). However, there are six different MK-82 (500-pound) bombs listed in ORDATA Online (ORDATA 2004), and three different filler configurations: 48 (kg) of RDX/TNT, 87.1 kg of Composition H-6 (97.5% RDX), and 2.84 kg of Composition C-4 (91% RDX). Because of these ambiguities, DODICs are needed to identify the chemical composition of specific munitions. DODICs and the Munitions Items Disposition Action System (MIDAS) provide specific quantities of chemicals contained in most of the munitions used at the FRTC. MIDAS was developed by the U.S. Army Defense Ammunition Center in McAlester, Oklahoma, as an online database of most of the munitions in DOD’s inventory.

In cases where MIDAS does not have data for all military munitions and does not provide data needed for all munitions used at the FRTC in FYs 1997, 1999, and 2000, the information was taken from ORDATA Online. In cases where several different choices are available for munitions, a conservative approach was taken by adopting the maximum mass of each compound from all of the potentially applicable items. For example, using the ORDATA Online filler configurations for the three MK-82 bombs in the previous paragraph, the configuration with 87.1 kg of Composition H-6 would have been used in mass loading modeling because it had the highest total mass of modeling compounds. Appendix D includes reports for each munition found in the MIDAS database. Table 5-7 lists the sources of data used in this analysis for every munition type.

## Table 5-7. Sources of Munition Constituent Data

| DODIC | Source | Nomenclature | DODIC | Source | Nomenclature |
|---|---|---|---|---|---|
| A665 | M | 20mm HEI | E835 | M | MK-20 (CBU) |
| A978 | M | 25mm | E845 | M | MK-82 |
| B081 | O | 20mm | E892 | M | CBU (Dispenser and Bomb) |
| B535 | M | 40mm (Paraflare) | E895 | M | CBU 100/B |
| C256 | M | 81mm Mortar HE | E896 | M | CBU (Dispenser and Bomb) |
| C445 | M | 105mm Projectile HE | E898 | M | MK-20 (CBU) |
| E173 | M | MK-20 (CBU) | E916 | M | CBU-99/B |
| E220 | O | Walleye MK-1 | E918 | M | CBU (Dispenser and Bomb) |
| E282 | O | Walleye MK-23 | EA59 | O | CBU-100 (T5 G) |
| E283 | O | Walleye MK-23 | F127 | M | MK-84 |
| E285 | O | Walleye MK-23 | F243 | M | MK-82 |
| E286 | O | Walleye MK-23 | F262 | M | MK-84 |
| E480 | M | MK-82 | F272 | M | MK-84 |
| E483 | M | MK-82 | F278 | M | MK-84 |
| E485 | M | MK-82 | F372 | O | Adapter Booster |
| E487 | M | MK-82 | F392 | O | Adapter Booster |
| E508 | M | MK-83 | F763 | O | GBU-12 |
| E509 | M | MK-83 | H663 | O | 2.75-inch Rocket (Practice) |
| E510 | M | MK-83 | H842 | O | 2.75-inch Rocket HE |
| E511 | M | MK-83 | N945 | O | 5-inch Rocket (Practice) |
| E513 | M | MK-83 | PB69 | O | Maverick (LZ) |
| E534 | O | Walleye MK-34 | PC61 | O | Hellfire |
| E537 | O | Walleye MK-34 | PC91 | O | Hellfire |
| E539 | O | Walleye MK-34 | PD63 | O | Maverick (IR) |
| E542 | O | Walleye MK-34 | PV07 | O | AGM-85G |
| E544 | O | Walleye MK-34 | PV66 | O | Sidewinder |
| E559 | O | Walleye MK-37 | PV70 | O | Sparrow |
| E563 | O | Walleye MK-37 | PV76 | O | Sidewinder |
| E567 | O | Walleye MK-37 | | | |

M – MIDAS, O – Other data source (see Appendix D).

The munition compositions will vary for different munitions; thus, masses of potential modeling compounds also will vary for different munitions. Tables 5-8 through 5-10 present the potential masses of modeling compounds in munitions used at the FRTC ranges in FYs 1997, 1999, and 2000. In the case of missiles or adapter boosters, the masses of modeling compounds are not available in MIDAS (MIDAS 2004) or ORDATA Online (ORDATA 2004). However, as discussed in Section 5.3.1 the failure rates of missiles are expected to be extremely low, so excluding them from the assessment should not significantly alter the results. Because very limited quantities of adapter boosters were used (i.e., 791 adapter boosters in 1997 only), excluding them from the analysis also should not significantly alter the results.

The following bullets summarize information regarding the masses of modeling compounds that could be present at the FRTC based on the quantities manufactured in each munition:

- The largest mass of a single modeling compound in the munitions is RDX, which is related to the use of MK-80 series bombs with Composition H-6 filler (i.e., 97.5% RDX). The Navy uses MK-80 series bombs at Bravo 17 East, Bravo 19, and Bravo 20.
- The large mass of TNT also is related to the MK-80 series bombs, which are used at Bravo 17 East, Bravo 19, and Bravo 20.
- 2,4-DNT, HMX, and [potassium] perchlorate were present in some projectiles, mortars, and rockets in quantities substantially lower than RDX and TNT. The locations where these munitions are used is not known, but is assumed equally likely at Bravo 17 East, Bravo 19, and Bravo 20.
- The quantities of modeling compounds were not determined for missiles or adapter boosters. Excluding these items from the assessment should not significantly alter the results.

### *5.1.4 Munition Failure Rates*

This section describes the failure rates (i.e., low-order detonations and duds) of the munitions used at the FRTC. Although munitions function properly 96 to 97 percent of the time, failure rates are used to estimate potential quantities of modeling compounds on ranges because experimental data indicate that explosive compounds are entirely consumed during high-order detonations (Volk and Schedlbauer 2002). The major combustion products of complete detonations are carbon dioxide ($CO_2$), carbon monoxide (CO), dihydrogen oxide ($H_2O$), nitrogen ($N_2$), and soot (Pennington et al. 2003). Contrary information recently was reported by Pennington et al. (2003), suggesting that "0.24 percent of the total explosive present prior to detonation remains as residues following a detonation of standard military munitions." However, the authors also indicated that this estimate could be skewed high because the propellant charge and fuse both were removed from the round prior to testing for safety reasons. This could have artificially inflated the residual explosives for the following two reasons:

- Placing the Composition C-4 donor charge on the munition casing altered the fundamental physics required by the original design of the munition. In this case, the initiating detonation may not have fully propagated the detonation wave through the explosive filler and, rather than completely consuming the main explosive charge as designed, some of the explosive charge would have burned, some of it would have melted, and some of it would have been hurled from the detonation.
- Traces of munitions residue could have originated in the Composition C-4 booster charge that was used to conduct the in-place detonation. This was substantiated by the detection of RDX in samples following tests conducted with 60-mm mortars and land mines that have no RDX (i.e., 100 percent TNT explosive filler).

**Table 5-8. Total Masses of Modeling Compounds Per Projectile, Mortar, and Rocket**

| Nomenclature | Total Masses of Modeling Compounds (pounds)/Munition | | | | |
|---|---|---|---|---|---|
| | 2,4-DNT | HMX | Perchlorate | RDX | TNT |
| 20mm HEI | 0 | 0.0012 | 0 | 0.017 | 0 |
| 25mm | 0.0020 | 0 | 0 | 0 | 0 |
| 20mm | 0 | 0 | 0 | 0.021 | 0 |
| 40mm (Paraflare) | 0 | 0 | 6.5E-04 | 0 | 0 |
| 81mm Mortar HE | 0 | 0 | 6.6E-05 | 1.3 | 0.82 |
| 105mm Projectile HE | 0.25 | 0 | 0 | 0 | 4.6 |
| 2.75-inch Rocket (Practice) | 0 | 0 | 0 | 0 | 0 |
| 2.75-inch Rocket HE | 0 | 0 | 0 | 2.8 | 1.8 |
| 5-inch Rocket (Practice) | 0 | 0 | 0 | 0 | 0 |

**Table 5-9. Total Masses of Modeling Compounds Per Cluster Bomb**

| Nomenclature | Total Masses of Modeling Compounds (pounds)/Munition | | | | |
|---|---|---|---|---|---|
| | 2,4-DNT | HMX | Perchlorate | RDX | TNT |
| MK-20 (CBU) | 0 | 0 | 0 | 63 | 39 |
| MK-82 | 0 | 0 | 0 | 63 | 39 |
| CBU (Dispenser and Bomb) | 0 | 0 | 0 | 87 | 56 |
| CBU 100/B | 0 | 0 | 0 | 63 | 39 |
| CBU (Dispenser and Bomb) | 0 | 0 | 0 | 63 | 39 |
| CBU-99/B | 0 | 0 | 0 | 0.042 | 0 |
| CBU-100 (T5 G) | 0 | 0 | 0 | 63 | 39 |

**Table 5-10. Total Masses of Modeling Compounds Per General Purpose Bomb and Guided Bomb Unit**

| Nomenclature | Total Masses of Modeling Compounds (pounds)/Munition | | | | |
|---|---|---|---|---|---|
| | 2,4-DNT | HMX | Perchlorate | RDX | TNT |
| MK-82 | 0 | 0 | 0 | 0 | 154 |
| MK-82/GBU-12 | 0 | 0 | 0 | 87 | 56 |
| MK-83 | 0 | 0 | 0 | 201 | 130 |
| MK-84 | 0 | 0 | 0 | 426 | 276 |

Although information suggests that explosive residues are present on range scrap (USAEC 2000a, USAEC 2002b, U.S. Air Force 2000, DOD 2000, DOD 2003), data are not available to ascertain the potential quantities of residual MCs remaining on range scrap following high-order detonations. Therefore, residues from high-order detonations are not evaluated in this assessment.

Munitions generally are expected to fail 3 to 4 percent of the time (USAEC 2000b). In these cases, the entire mass of MCs manufactured in each munition is potentially available for release and subsequent transport through the environment. However, a study sponsored by the Strategic Environmental Research and Development Program (SERDP) evaluated the corrosion of UXO (Packer 2002). The objective was to develop a predictive model of corrosion rates for UXO as a function of soil properties and climatic conditions. To date, the study evaluated soils and metal fragments obtained from 70 UXO items collected at 6 inactive Army training facilities. The results of the study thus far have concluded that the corrosion rates to perforate ½-inch casings ranged from 320 to 4,200 years.

Data are not available to quantify the numbers of dud rounds that may have ruptured or cracked upon impact or during the detonation of neighboring munitions, thus releasing their contents to the environment. Discussions with various EOD experts suggest that the phenomenon of mechanical break-up is extremely rare. Consequently, this report assumes that none of the duds has ruptured or cracked open and released its contents.

Low-order detonations from munitions that were fired or dropped result from malfunctions in the explosive train (e.g., fuze to booster to main charge). In addition, low-order detonations can result from high-order detonations, causing sympathetic detonations that impact near UXO or when EOD personnel conduct blow-in-place operations. In low-order detonations, the explosive filler is not completely consumed during blasts. Unreacted explosives either are thrown to the environment by the explosive forces of the blast, melted, or consumed during combustion (i.e., rapid burning). Some of the scattered explosives could be consumed by the fireball, but some material will be thrown outside the fireball. The amount of unreacted explosive is likely to be a function of the energy yield of the detonation, the overall size of the detonation, and the intensity and burn time of the fireball (Pennington et al. 2003).

The dud rates and low-order detonation rates of munitions combined with the numbers of munitions expended and masses of modeling compounds per munition are used to determine the masses of residual modeling compounds that could be present in the environment. As described above, residual modeling compounds could be present in the environment as a result of low-order detonations and duds associated with live munitions (Pennington et al. 1998). Figures 5-3 and 5-4 present examples of dud and low-order detonations, respectively.

Dud rates and low-order detonation rates were compiled by the U.S. Army Defense Ammunition Center, Technical Center for Explosives Safety, McAlester, Oklahoma (USAEC 2000b). This report includes data for several items specifically used at the FRTC. In addition, it provides averages for families of munitions, such as rockets and gun-fired projectiles, like those used at the FRTC. However, the report did not include dud and low-order detonation rates for the MK-80 series bombs. The dud rate calculated from 1,057 live MK-80 series bomb impacts at another range indicates an average of 3.7 percent.

Reliability tests were conducted for the MK-80 series bomb fuzes and were documented in the *M904 and M905 Fuze Reliability Report for Tests Up to 2003* (Gordon Guymon, Ogden Air Logistics Center, Utah). This report summarized the results of reliability tests conducted on M904 and M905 fuzes, which are located in the nose and tail, respectively, of MK-80 series bombs. Since this was a test scenario, each bomb was fitted with either a nose or tail fuze for the purposes of the test. In conventional training and combat scenarios, each bomb is fitted with both nose and tail fuzes. Since either fuze will detonate the bomb, the purpose of having both is redundant; in case one fails, the other can initiate the detonation. The test included a limited number (71 each) of M904 nose fuzes and a similar number (73 each) of M905 tail

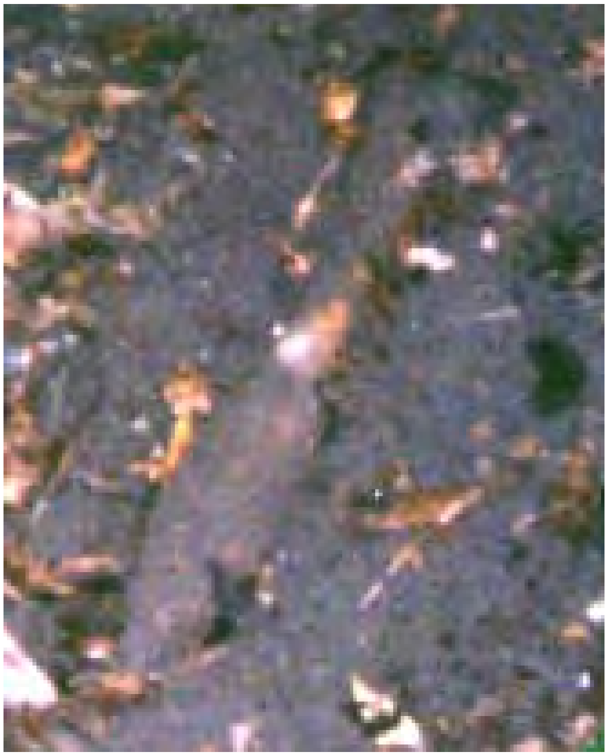


**Figure 5-3.  Example of a Dud 2.36-inch Rocket**

**Figure 5-4.  Example of Low-Order Detonations**

fuzes, both of which were fitted in MK-82 high explosive-filled bombs and dropped from both fighters and bombers in a variety of test environments. The reported reliability for the M904s was 94.63 percent, while the reliability for the M905s was 89.35 percent with 0 low order detonations reported. Because of the redundancy and because the tests were conducted on each fuze individually, the results do not directly correlate with dud rates (i.e., the dud rate would be more closely approximated by failure rate tests conducted when both fuzes fail on the same munition). However, the results show that the failure rate (100 percent minus the reliability rate) for MK-80 series bombs should be less than 10.65 percent (100 - 89.35) or less.

Low-order detonations are the focus of this assessment for reasons, but low-order detonation rates are not available for MK-80 series bombs, which include significant quantities of modeling compounds. To err on the side of protection, the default low-order detonation rate is set at 1 percent of the dud rate when rates are not available or when rates from similar munitions cannot be used as surrogates or proxies. Table 5-11 presents the dud and low-order detonation rates for the munitions used at the FRTC in FYs 1997, 1999, and 2000.

### *5.1.5 Quantifying Residual Masses of Modeling Compounds On-Range*

This section describes a three-step process for predicting concentrations of modeling compounds in soil that are needed to conduct the screening-level transport modeling (Section 5.2). The three-step process is described below:

- **Step 1:** Estimate the total masses (pounds) of modeling compounds remaining on range from low-order detonations.
- **Step 2:** Use the estimates from Step 1 to predict potential surface soil concentrations (mg chemical/kg soil).
- **Step 3:** Compare the predicted concentrations to sampling data from Army impact area studies.

The three-step process is described in greater detail in Sections 5.1.5.1 through 5.1.5.3.

#### 5.1.5.1 Estimating Total Residual Masses of Modeling Compounds

The total residual masses of each modeling compound are estimated for each munition for each year by multiplying the following factors:

- Numbers of munitions expended (annual maxima in FYs 1997, 1999, and 2000 – Table 5-2)
- Masses of each modeling compound per individual munition (pounds – Tables 5-8 through 5-10)
- Low-order detonation rate (percent – Table 5-11)
- Fifty percent (potential mass of modeling compound remaining after low-order detonation).

The following bullets use data for one type of MK-82 (i.e., DODIC is E480) that were dropped at the FRTC in FY 1997 to demonstrate how the masses of modeling compounds are estimated in this report:

- Munitions usage data indicate that 966 MK-82 bombs with an E480 DODIC were dropped at the FRTC in FY 1997.
- MIDAS data for DODIC E480 indicate that 153.6 pounds of TNT are present in each bomb. No other modeling compounds are present in the fuze, booster, or main charge.

**Table 5-11. Dud and Low-Order Detonation Rates**

| Ordnance Category | Dud Rate (%) [a] | Low-Order Detonation Rate (%) [b] | Basis |
|---|---|---|---|
| 105MM | 4.65% | 1.07% | Specifically listed in dud and low-order detonation rate study [c] |
| 2.75" RKT | 11.70% | 0% | Specifically listed in dud and low-order detonation rate study [c] |
| 20MM | 4.68% | 0.16% | "Gun" in detonation rate study [c] |
| 25MM | 4.68% | 0.16% | "Gun" in detonation rate study [c] |
| 40mm (Paraflare) | 0% | 0% | Not applicable |
| 5" RKT | 3.84% | 0.06% | Used family-based value for “rocket” listed in detonation rate study [c] |
| 81MM | 2.33% | 0.11% | Listed in detonation rate study [c] |
| Adapter Booster | 0% | 0% | Not applicable |
| AGM-85G | 0% | 0% | Guided missiles assume no duds/low-orders |
| CBU (Dispenser and Bomb) | 20% | 0.2% | Dud rate assumed = 20%; low-order rate = 1% of duds |
| CBU 100/B | 20% | 0.2% | Dud rate assumed = 20%; low-order rate = 1% of duds |
| MK-20 (CBU) | 20% | 0.2% | Dud rate assumed = 20%; low-order rate = 1% of duds |
| CBU-99/B | 20% | 0.2% | Dud rate assumed = 20%; low-order rate = 1% of duds |
| CBU-100 (T5 G) | 20% | 0.2% | Dud rate assumed = 20%; low-order rate = 1% of duds |
| GBU-12 | 3.7% | 0.037% | Dud rate from Pinecastle; low-order rate = 1% of duds |
| Hellfire | 0% | 0% | For guided missiles assume no duds or low-orders |
| MK-82, -83, -84 | 3.7% | 0.037% | Dud rate from another range; low-order rate = 1 % of duds |
| Maverick | 0% | 0% | Guided missiles assume no duds/low-orders |
| Sidewinder | 0% | 0% | Guided missiles assume no duds/low-orders |
| Sparrow | 0% | 0% | Guided missiles assume no duds/low-orders |
| Walleye | 0% | 0% | Guided missiles assume no duds/low-orders |
| 105MM | 4.65% | 1.07% | Specifically listed in dud and low-order detonation rate study [c] |
| 2.75" RKT | 11.70% | 0% | Specifically listed in dud and low-order detonation rate study [c] |
| 20MM | 4.68% | 0.16% | "Gun" in detonation rate study [c] |

[a] “A dud is a round that is fired, but completely fails to function at the target. Upon impact with the ground, a dud either penetrates or comes to rest on the surface.” (USAEC 2000a)

[b] “A low-order detonation occurs when a high explosive round is fired, but only partially functions at the target. Part of the high explosive filler detonates and part does not. The part that detonates scatters some or all of the part that does not. Any high explosives not scattered remain attached to the broken up pieces of the projectile body” (USAEC 2000b).

[c] Dud and low-order detonation rate data taken from USAEC 2000b.

- Applying the 3.7-percent dud rate and assuming 1 percent of duds are low-order detonations (i.e., low-order detonation rate = 0.037 percent), the low-order detonations frequency is 0.357.
- The product of the mass of TNT for each munition (153.6 pounds) times the low-order detonation frequency (0.357) equals 54.6 pounds of TNT.

Repeating the process described in the bullets above for all munitions, modeling compounds, and 3 years of munitions usage data, the total masses can be predicted for each modeling compound. Table 5-12 lists the total residual masses for each modeling compound based on the single-year maximum usage data from FYs 1997, 1999, and 2000. These total residual masses then have been summed across all munitions and placed within broad categories. Detailed tables for each year, munition, and compound are presented in Appendix D.

**Table 5-12. Total Residual Masses of Modeling Compounds Per Fiscal Year**

| Nomenclature | Masses (Pounds) | | | | |
|---|---|---|---|---|---|
| | 2,4-DNT | HMX | Perchlorate | RDX | TNT |
| Projectiles/Mortars/Rockets | 15 | 0.13 | 5.7E-04 | 41 | 290 |
| Cluster Bombs | 0 | 0 | 0 | 5,418 | 3,454 |
| General Purpose Bombs | 0 | 0 | 0 | 16,091 | 15,305 |
| **Total** | **15** | **0.13** | **5.7E-04** | **21,549** | **19,049** |

### 5.1.5.2 Estimating Soils Concentrations of Modeling Compounds

The previous sections described the approach for estimating the total residual masses of modeling compounds. This section describes how to distribute these residues on-range to estimate concentrations in soil. Ideally, the areas where modeling compounds are distributed could be measured (i.e., locations where munitions impact and how far modeling compounds are scattered following low-order detonations). Without information regarding how closely together munitions typically impact within targets or without liberally assuming that all munitions have equal probabilities of impacting anywhere on the range, the defined sizes of targets are used to represent the land surface areas where munition constituents potentially could be dispersed during operations with munitions at the FRTC.

NAVSTKAIRWARCENINST 3752.1C, the FRTC Users' Manual (U.S. Navy 2002b), specifies the types, locations, orientations, and sizes of FRTC targets. The live-munitions targets are 100, 250, or 300 feet in diameter, bull's-eye shaped targets. These diameters equate to 7,854; 49,087; and 70,686 $feet^2$ for the different target sizes, respectively. Using these surface areas in conjunction with an assumed 2-inch mixing depth (Pennington et al. 2003) and a density for sandy soil of 97 $pounds/foot^3$ (1.55 $g/cm^3$ = 96.76 $pound/foot^3$ – Hausenbuiller 1972), the masses of soil range from 126,663 to 1,139,969 pounds, depending on the size of the target.

Using the soil masses in combination with the masses of modeling compounds presented in Table 5-12 and apportioning the predictions at rates of 30, 50, and 20 percent for Bravo 17 East, Bravo 19, and Bravo 20, respectively, the resulting concentrations of modeling compounds in surface soil are presented in Table 5-13.

**Table 5-13. Summary of Predicted Surface Soil Concentrations for Modeling Compounds**

| Range | Modeling Compound | Mass (pounds) | Soil Mass (pounds) | | Predicted Surface Soil Concentration (mg/kg) | |
|---|---|---|---|---|---|---|
| | | | 300-foot target | 100-foot target | 300-foot target | 100-foot target |
| Bravo 17 East | 2,4-DNT | 4.5 | 1,139,969 | 126,663 | 0.81 | 7.3 |
| | HMX | 0.040 | 1,139,969 | 126,663 | 0.0072 | 0.064 |
| | Perchlorate | 1.7E-04 | 1,139,969 | 126,663 | 3.1E-05 | 2.8E-04 |
| | RDX | 6,465 | 1,139,969 | 126,663 | 1,167 | 10,501 |
| | TNT | 5,715 | 1,139,969 | 126,663 | 1,031 | 9,283 |
| Bravo 19 | 2,4-DNT | 7.4 | 1,139,969 | 126,663 | 1.3 | 12 |
| | HMX | 0.066 | 1,139,969 | 126,663 | 0.012 | 0.11 |
| | Perchlorate | 2.9E-04 | 1,139,969 | 126,663 | 5.1E-05 | 4.6E-04 |
| | RDX | 10,774 | 1,139,969 | 126,663 | 1,945 | 17,501 |
| | TNT | 9,524 | 1,139,969 | 126,663 | 1,719 | 15,471 |
| Bravo 20 | 2,4-DNT | 3.0 | 1,139,969 | 126,663 | 0.54 | 4.8 |
| | HMX | 0.026 | 1,139,969 | 126,663 | 0.0048 | 0.043 |
| | Perchlorate | 1.1E-04 | 1,139,969 | 126,663 | 2.1E-05 | 1.9E-04 |
| | RDX | 4,310 | 1,139,969 | 126,663 | 778 | 7,001 |
| | TNT | 3,810 | 1,139,969 | 126,663 | 688 | 6,188 |

[a] Mass of soil equals the product of the surface area of 300-foot diameter target, assumed soil depth of 2 inches, and soil density of sand (1.55 g/cm$^3$ = 96.76 pound/foot$^3$ - Hausenbuiller 1972)

[b] Mass of soil equals the product of the surface area of 100-foot diameter target, assumed soil depth of 2 inches, and soil density of sand (1.55 g/cm$^3$ = 96.76 pound/foot$^3$ - Hausenbuiller 1972)

### 5.1.5.3 Comparing Predicted Concentrations of Modeling Compounds to Army Studies

Sampling data are not available to validate the predicted concentrations listed in Table 5-13. In addition, sampling data collected in the vicinity of MK-80 series bomb impacts are not available to validate the predictions or use instead of the predictions. The best information available to substantiate the predictions made above is a series of studies conducted by USACE, Engineer Research and Development Center (ERDC). For the past several years, ERDC and two other Army organizations (i.e., U.S. Army Environmental Center [USAEC], U.S. Army Center for Health Promotion and Preventive Medicine [USACHPPM]) conducted sampling at impact areas at Fort Lewis, Washington; Yakima Training Center, Washington; and Camp Guernsey, Wyoming (Pennington et al. 2003).

During the studies at Fort Lewis, Yakima Training Center, and Camp Guernsey, Army personnel collected samples from the following locations:

- From areas where masses of explosives were visible at ground surface
- In the first 5 cm (2 inches) beneath masses of visible explosives
- Near low-order detonations
- Near craters caused by high-order detonations.

Samples were collected using various schemes (e.g., discrete, composite). Generally, the samples were collected from ground surface, but some were collected as deep as 5 cm (2 inches) BLS. Samples were analyzed for HMX, RDX, TNT, and several TNT degradation products, but were not analyzed for perchlorate. Table 5-14 summarizes the results of the sampling and testing (Pennington et al. 2003).

Because of the differences in munitions used by the Army at Fort Lewis, Yakima Training Center, and Camp Guernsey and the Navy at the FRTC, the results of Pennington et al. 2003 are not directly usable for this assessment. Furthermore, munition usage data for the ranges sampled by the Army at Fort Lewis are not available to ascertain the differences between the training regimes. However, the data are useful in establishing relative magnitudes of concentrations expected on ranges in impact areas. Table 5-15 compares the predicted results of the mass loading modeling presented in Table 5-13 to the sampling data summarized in Table 5-14. As identified in Table 5-15, all of the predicted concentrations listed in Table 5-13 (see three rows of modeling results) fall between the minimum and maximum detected concentrations (see two rows of measured results) listed in Table 5-14 except for RDX and TNT. The differences for these compounds can be explained by significant quantities of RDX and TNT in MK-80 series bombs compared to the munitions used by the Army.

**Table 5-14. Summary of Sampling Results**
**Fort Lewis, Yakima Training Center, and Camp Guernsey**

| Where Solid Masses of Explosives Were Visible | HMX | RDX | TNT | 2,4-DNT |
|---|---|---|---|---|
| Minimum (mg/kg) | <0.026 | <0.003 | <0.016 | 0.011 |
| Maximum Detect (mg/kg) | 0.198 | 1.4 | 2,100 | 5.31 |
| Numbers of Detects/Total Numbers of Samples | 5/46 | 4/46 | 42/46 | 21/46 |
| **Beneath Solid Masses of Explosives** | **HMX** | **RDX** | **TNT** | **2,4-DNT** |
| Minimum (mg/kg) | <0.026 | <0.034 | 1.12 | <0.016 |
| Maximum Detect (mg/kg) | 0.423 | 0.156 | 6,760 | 4.65 |
| Numbers of Detects/Total Numbers of Samples | 3/14 | 1/14 | 14/14 | 5/14 |
| **Near Low-Order Detonations** | **HMX** | **RDX** | **TNT** | **2,4-DNT** |
| Minimum (mg/kg) | <0.026 | <0.003 | <0.001 | <0.0008 |
| Maximum Detect (mg/kg) | 302 | 1,130 | 8,600 | 5.71 |
| Numbers of Detects/Total Numbers of Samples | 10/20 | 9/20 | 17/20 | 9/20 |
| **Near Craters** | **HMX** | **RDX** | **TNT** | **2,4-DNT** |
| Minimum (mg/kg) | <0.026 | <0.003 | <0.001 | <0.0008 |
| Maximum Detect (mg/kg) | 0.060 | 0.630 | 2.02 | <0.028 |
| Numbers of Detects/Total Numbers of Samples | 1/12 | 4/12 | 8/12 | 0/12 |
| **Overall** | **HMX** | **RDX** | **TNT** | **2,4-DNT** |
| Minimum (mg/kg) | <0.026 | <0.003 | <0.001 | <0.0008 |
| Maximum Detect (mg/kg) | 302 | 1,130 | 8,600 | 5.71 |

**Table 5-15. Comparison of Mass Loading Modeling to Sampling Data**

| Data Source | Target Sizes | HMX | | RDX | | TNT | | 2,4-DNT | |
|---|---|---|---|---|---|---|---|---|---|
| | | 300 | 100 | 300 | 100 | 300 | 100 | 300 | 100 |
| Modeled | Bravo 17 East | 0.0072 | 0.064 | 1,167 | 10,501 | 1,031 | 9,283 | 0.81 | 7.3 |
| | Bravo 19 | 0.012 | 0.11 | 1,945 | 17,501 | 1,719 | 15,471 | 1.3 | 12 |
| | Bravo 20 | 0.0048 | 0.043 | 778 | 7,001 | 688 | 6,188 | 0.54 | 4.8 |
| Measured* | Overall | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** |
| | | <0.026 | 302 | <0.003 | 1,130 | <0.001 | 8,600 | <0.0008 | 5.71 |

* Pennington et al. 1999

However, to allay any potential concerns regarding the limitations from the mass loading modeling described above and despite the limited correlation to FRTC operations, both sets of concentrations will be used within the transport modeling as initial concentrations.

## 5.2 TRANSPORT MODELING

Screening-level transport modeling was conducted to determine if a threat or substantial threat of a release of MCs pose an imminent and substantial threat to human health or the environment off-range. This section describes the screening-level modeling evaluating the potential vertical migration of modeling compounds (Section 5.2.1) and their subsequent horizontal migration in the subsurface (i.e., groundwater transport) of modeling compounds (Section 5.2.2). Because of the relatively flat terrain surrounding the live-impact targets, horizontal migration on the surface migration (i.e., overland flow) was not considered to be significant and, thus, the need to conduct horizontal transport modeling was ruled out in the ORSMs (Section 4.5).

The assessment began with an examination of potential vertical migration resulting from the release of pure modeling compounds at a hypothetical location on each FRTC range, using site-specific and assumed physical conditions. The screening-level modeling used conservative assumptions based on information that was obtained during the RCA Phase III and through the interpretation of site-specific data (e.g., GIS data), information presented in FRTC documents, available reference literature (e.g., DOD munitions studies), and residual masses of modeling compounds presented in Section 5.1. The transport modeling begins with an examination of potential vertical migration resulting from the release of pure modeling compounds at a hypothetical location on each FRTC range, using site-specific and assumed physical conditions.

### *5.2.1 Potential for Vertical Migration of Modeling Compounds*

Evaluation of the potential for residual modeling compounds to migrate to the groundwater table was conducted using a finite element mathematical model. The Finite Element Heat and Mass Transfer Model (FEHM version 2.11), developed and validated by Los Alamos National Laboratory, was selected to estimate the potential for chemical migration through variably saturated soil to a depth just above the groundwater table. FEHM is an extremely comprehensive flow and transport code, the capabilities used in this analysis consist of the unsaturated flow and reactive transport (partition and decay) attributes of soil at FRTC ranges. FEHM simulates non-isothermal, multi-phase, multi-component flow and solute transport in porous media.

This part of the modeling effort assesses the potential vertical migration of modeling compounds to reach groundwater in the absence of quantitative, site-specific chemical sampling and testing data. The modeling framework consists of a finite element model that includes a 24.6-foot soil horizon with the groundwater table at its base and considers chemical transport through variably saturated sandy soil under the impetus of an average of 0.53 inches per year of infiltrating precipitation. Table 5-16 lists the model input parameters. These parameters are included in the input files used by FEHM, which are included in Appendix D.

The vertical transport simulation was run first for 100 years then for 1,000 years for perchlorate only, assuming steady-state flow in both cases. Source concentrations at ground surface (source location) were maintained throughout the 100 and 1,000-year simulations (i.e., no depletion of the source over time was assumed).

## Table 5-16.  FEHM Modeling Input Parameters, FRTC Ranges

| FEHM Input Parameters | Value | Remarks |
|---|---|---|
| **Modeling Dimensions** | **Height:** 7.5 meters (m), 24.6 feet = depth to groundwater)<br>**Width:** 2m<br>**Length:** 2 m | Assumed cubical shape |
| **Finite Elements** | 0.5 m by 0.5 m by 0.5 m | Assumed cubic shape |
| **Reference Pressure and Temperature** | **Pressure:** 0.1 Megapascals (Mpa)<br>**Temperature:** 20° C | Standard references |
| **Saturation Limits** | **Lowest Saturation:** 0.15<br>**Maximum Saturation:** 1 | **Lowest Saturation:** Residual matrix saturation (15%)<br>**Maximum Saturation:** Fully saturated (100%) |
| **Recharge Boundary Conditions** | **Ground Surface:** 0.63 inches/year<br>**Water-Table Interface:** 1 | **Ground Surface:** Assumed 10% of the average annual precipitation<br>**Water Table Interface:** Full saturation (100%) |
| **Van Genuchten Model Parameters** | **Sand Matrix**<br>**Inverse air entry head:** 14.5 $m^{-1}$<br>**Power in formula:** 2.68 | Carsel and Parish 1988 |
| **Hydraulic Conductivity** | **Horizontal:** 7.128 m/day<br>**Vertical:** 0.7128 m/day | **Horizontal:** Carsel and Parish 1988<br>**Vertical:** Assumed 10 percent of the horizontal conductivity |
| **Porosity** | 0.42 | Carsel and Parish, 1988 |
| **Half-life (days)** | HMX – 13.32<br>RDX – 1.35<br>TNT – 365<br>DNT – 365<br>Perchlorate – persistent | Howard et al. 1991 |
| **Organic Carbon Partition Coefficient ($K_{oc}$)** | HMX – 1,853<br>RDX – 195.4<br>TNT – 1,834<br>DNT – 363.8<br>Perchlorate – 48.64 | Risk Assessment Information System (Oak Ridge National Laboratory 2004) |
| **Percent Organic Carbon** | 0.2 | Estimated based on soil type |
| **Total Simulation Time** | 100 years | After flow field reaches steady state |
| **Transport Modeling Options** | Advection<br>Decay (half-life)<br>Linear sorption (Kd)<br>Dispersion | Physical and chemical phenomena assessed during transport modeling |

FEHM was used to model concentrations over time at the following two depths: 1.64 feet (0.5 m) BLS and at the soil-groundwater interface at 24.6 feet (7.5 m) BLS. Concentrations could have been modeled at additional depths, but these depths were selected because the shallow depth is relatively close to ground surface and the other depth is needed to estimate the potential off-range migration via subsurface transport in groundwater. To facilitate the comparison of multiple initial concentrations resulting from the mass loading modeling, the mass transport results are presented in terms of percentages of starting concentrations (y-axis) as a function of time in years (x-axis).

The vertical transport modeling of perchlorate was conducted in two phases. The first phase was conducted assuming a 100-year timeframe. Results for the first phase of transport of perchlorate to 1.64 feet (0.5m) BLS are illustrated in Figure 5-5. The results illustrate that perchlorate migrates to this depth within an approximate one-year period. The residual concentration peaks, which is demonstrated by the flattening of the curve in Figure 5-5, after approximately 30 years at 100 percent of the initial concentration.

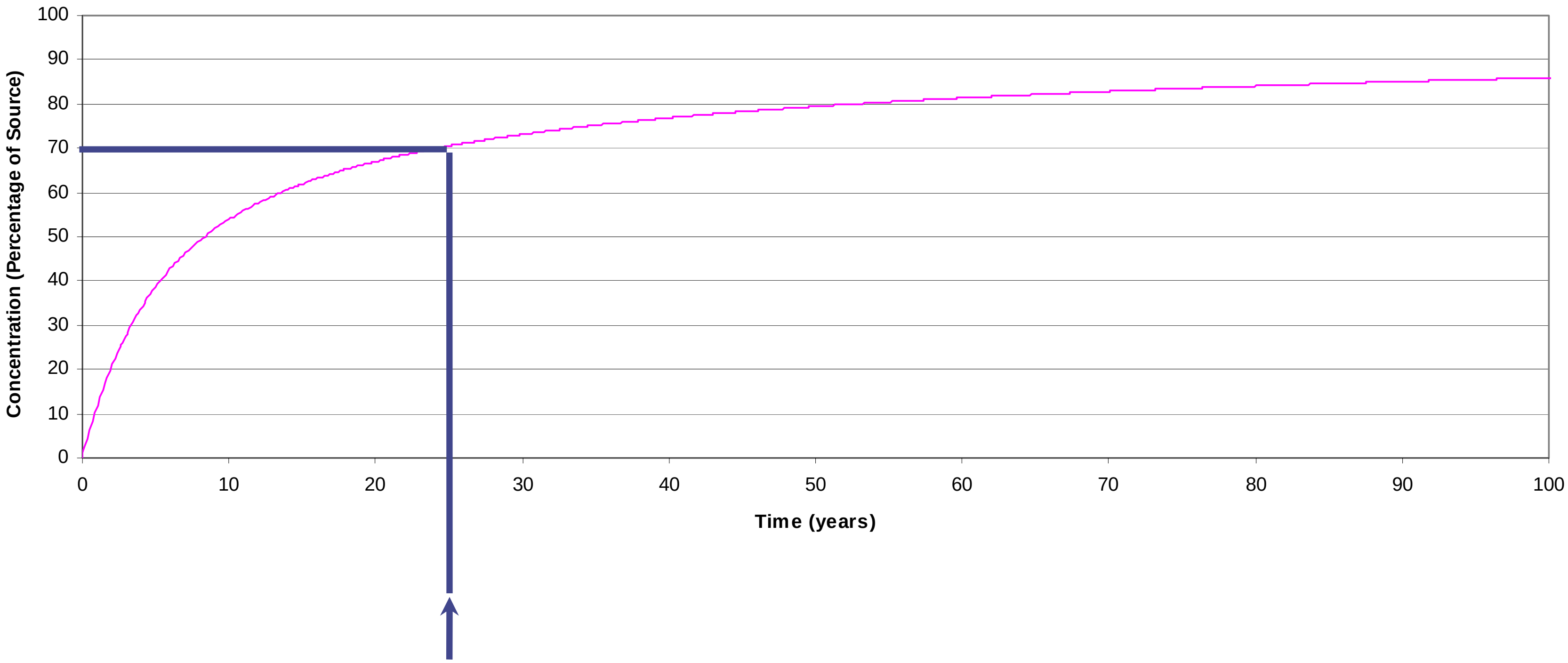
Results for the 100-year transport modeling simulation of perchlorate to the soil-groundwater interface at 24.6 feet (7.5m) BLS are illustrated in Figure 5-6. The figure illustrates that perchlorate first reaches the groundwater table after approximately 50 years from the beginning of the simulation. At the completion of the 100-year modeling simulation, the concentrations at the soil-groundwater interface appear to reach approximately 0.09 percent of the initial concentration. However, the concentrations appear to increase after the completion of the 100-year modeling simulation. For this reason, a second simulation was conducted for a 1,000-year period. The results of the 1,000-year transport modeling simulation of perchlorate to the soil-groundwater interface are illustrated in Figure 5-7. Most significantly, the modeling results indicate that only 0.6 percent of the initial perchlorate concentration travels to the soil-groundwater interface at 24.6 feet (7.5 m) BLS and does so between 300 and 400 years.

The results for HMX, RDX, TNT, and 2,4-DNT vary significantly from the results for perchlorate, since a very low proportion of the starting concentration travels to 1.64 feet (0.5 m) BLS and none appears to travel to the soil-groundwater interface at 24.6 feet (7.5m) BLS. The results are illustrated in Figures 5-8 through 5-11, respectively, for 2,4-DNT, HMX, RDX, and TNT. Since these compounds are far less soluble and are more likely to partition to soil particles than perchlorate, these results are understandable.

Table 5-17 summarizes the peak percentages of initial concentrations (i.e., the point on the curves in Figures 5-5 through 5-11 flatten) for each modeling compound that are predicted by FEHM at depths of 1.64 and 24.6 feet BLS. The peak percentages are presented and would have been used in initial modeling of off-range migration, but the predicted concentrations at the soil-groundwater interface are so low that horizontal migration through groundwater appears unnecessary.

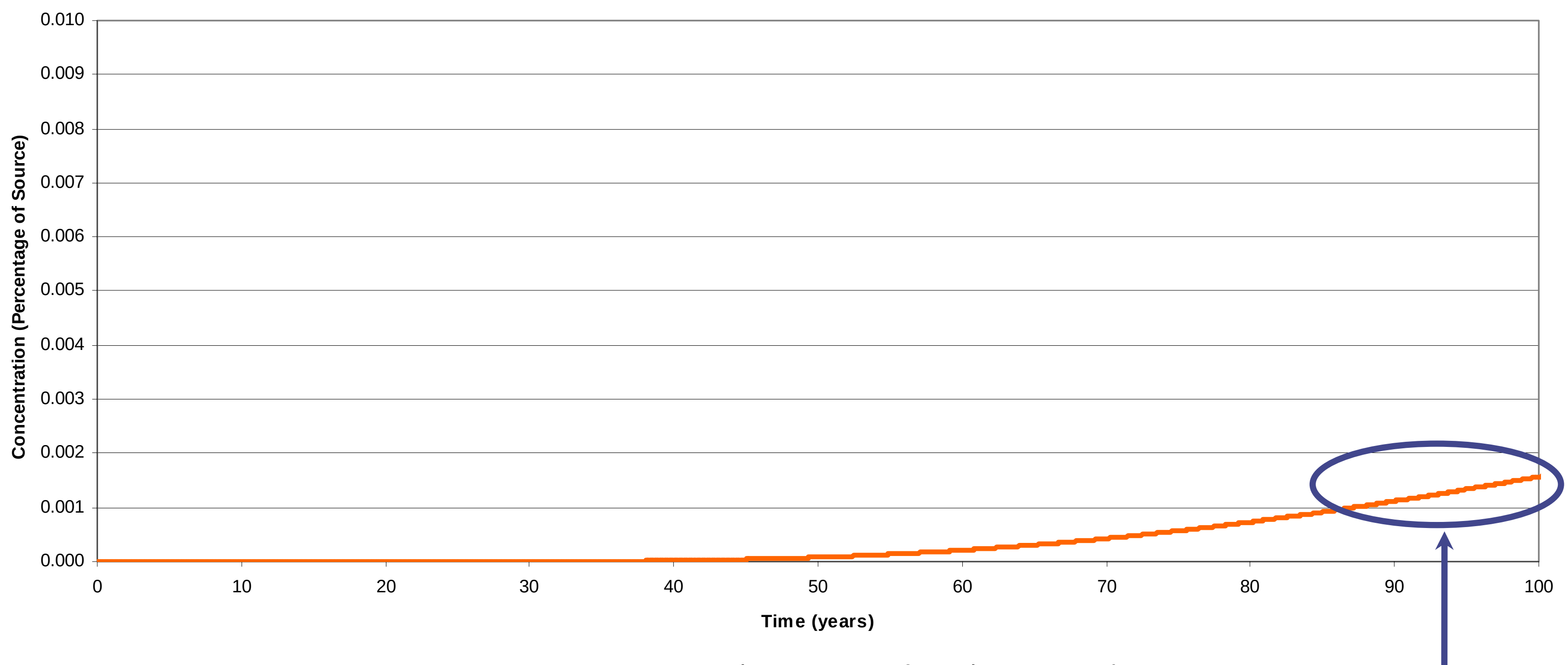
Using the concentrations predicted in Section 5.1.5 in combination with the percentages listed in Table 5-17, the residual concentrations in soil of all modeling compounds are predicted at depths of 1.64 and 24.6 feet BLS using mass loading modeling results and sampling results presented by Pennington et al. 2003 as the initial concentrations (see Table 5-15).

Concentrations of 2,4-DNT, HMX, RDX, and TNT predicted at 1.64 feet BLS exceed detection limits, but drop well below detection limits by many orders of magnitude at the soil-groundwater interface, as listed in Table 5-18. For soil analyses, the quantitation limits in the RSEPA Master QAPP are 0.01 for RDX and TNT, 0.02 for 2,4-DNT, and 0.05 for RDX. Currently, there is no USEPA-approved method for quantifying perchlorate in soil samples; however, efforts are underway in both USEPA and the private sector to develop alternative methods with improved sensitivity and specificity for perchlorate in environmental samples. Alternative analytical methods with improved sensitivity and specificity are commercially available on a limited basis; however, none has yet been published or approved for use by USEPA.




- Nearly 25 years after release to environment
- Approximately 70% of initial perchlorate concentration travels 0.5 m

**Figure 5-5. Transport Modeling Results of Perchlorate Vertical Transport to 1.64 Feet (0.5m) BLS Over Time**




- Nearly 100 years after release to environment
- Approximately 0.002% of initial perchlorate concentration travels 7.5 m

**Figure 5-6. Transport Modeling Results of Perchlorate Vertical Transport to 24.6 Feet (7.5 m) BLS Over 100-Year Period**

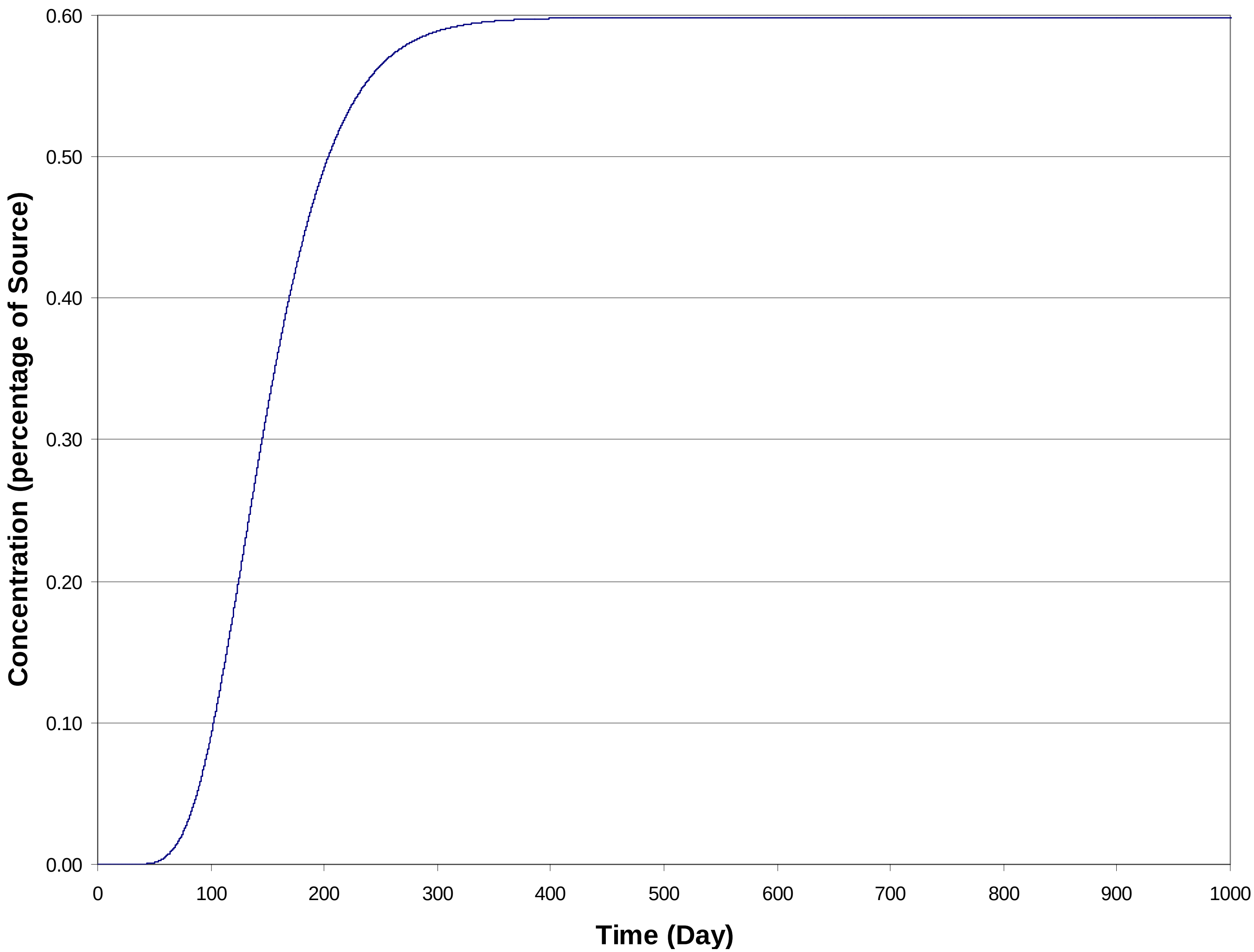
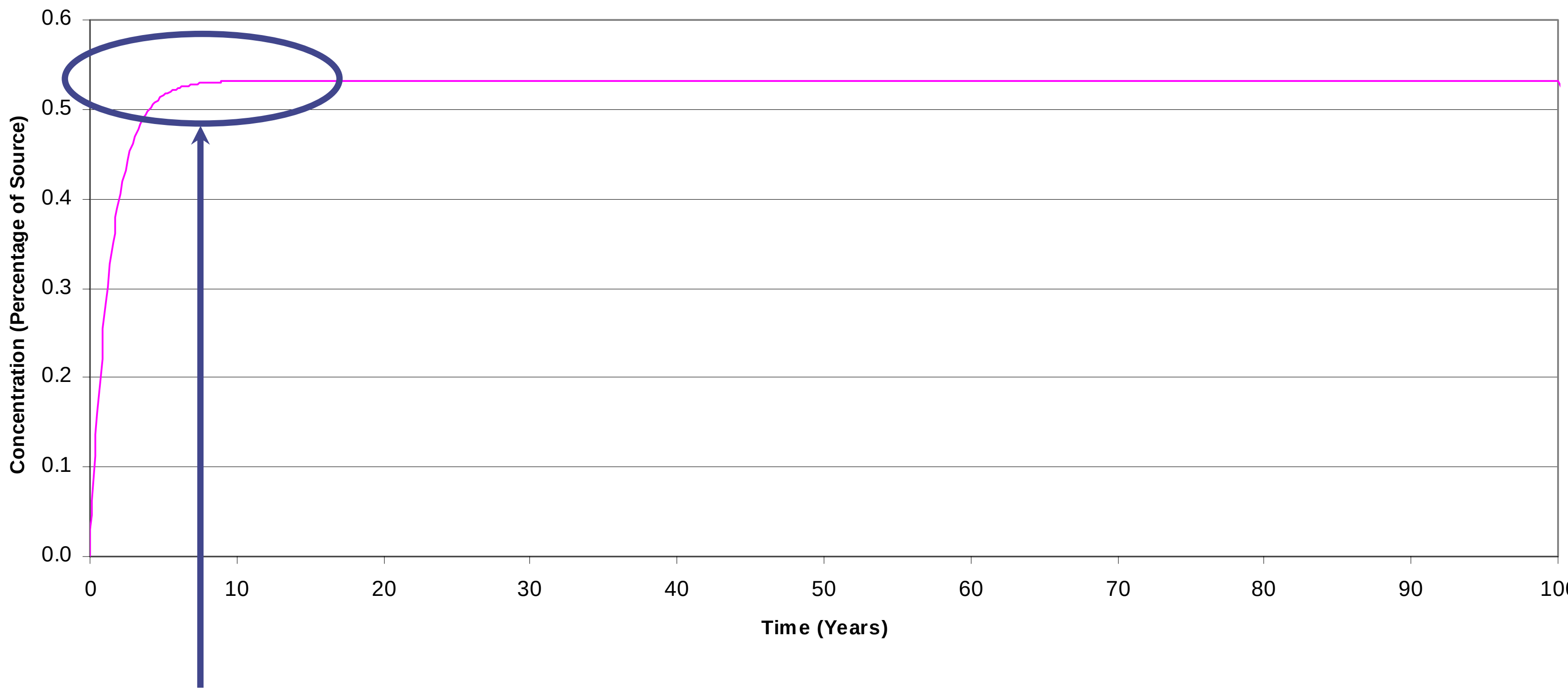
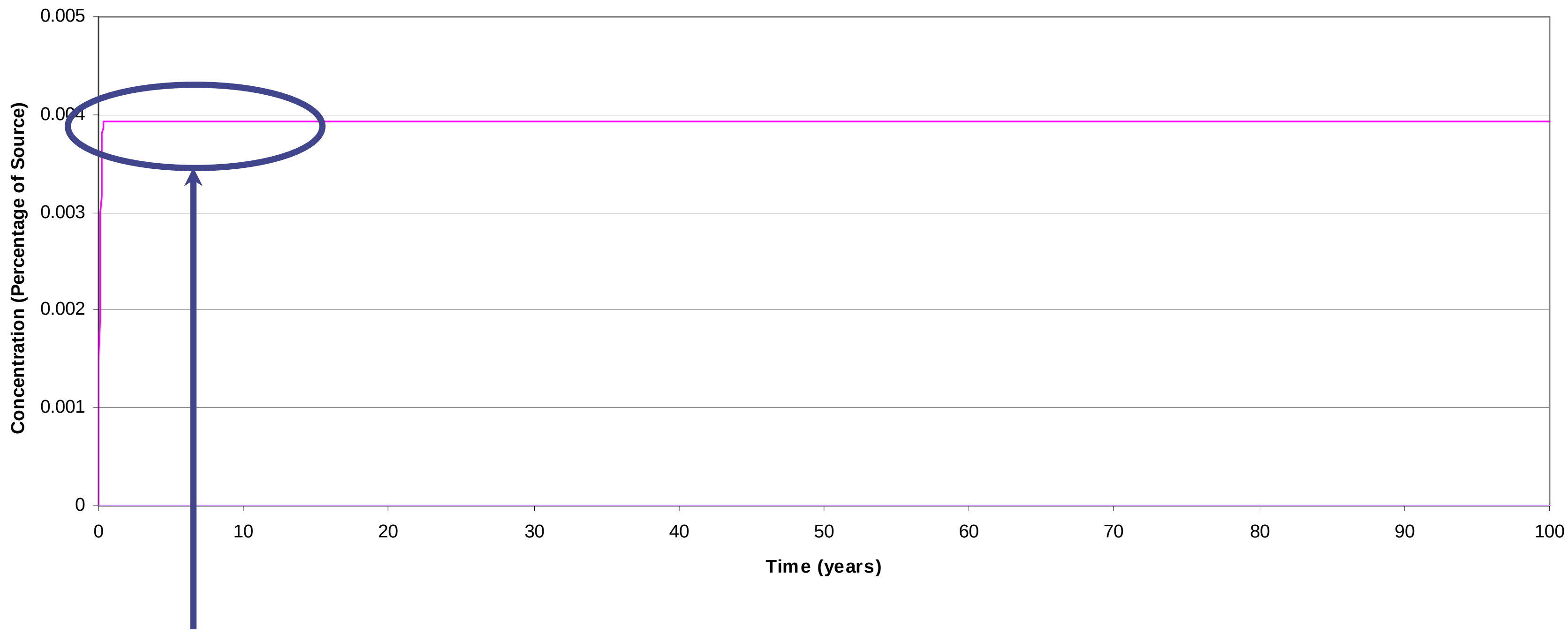



**Figure 5-7. Transport Modeling Results of Perchlorate Vertical Transport to 24.6 Feet (7.5 m) BLS Over 1,000-Year Period**



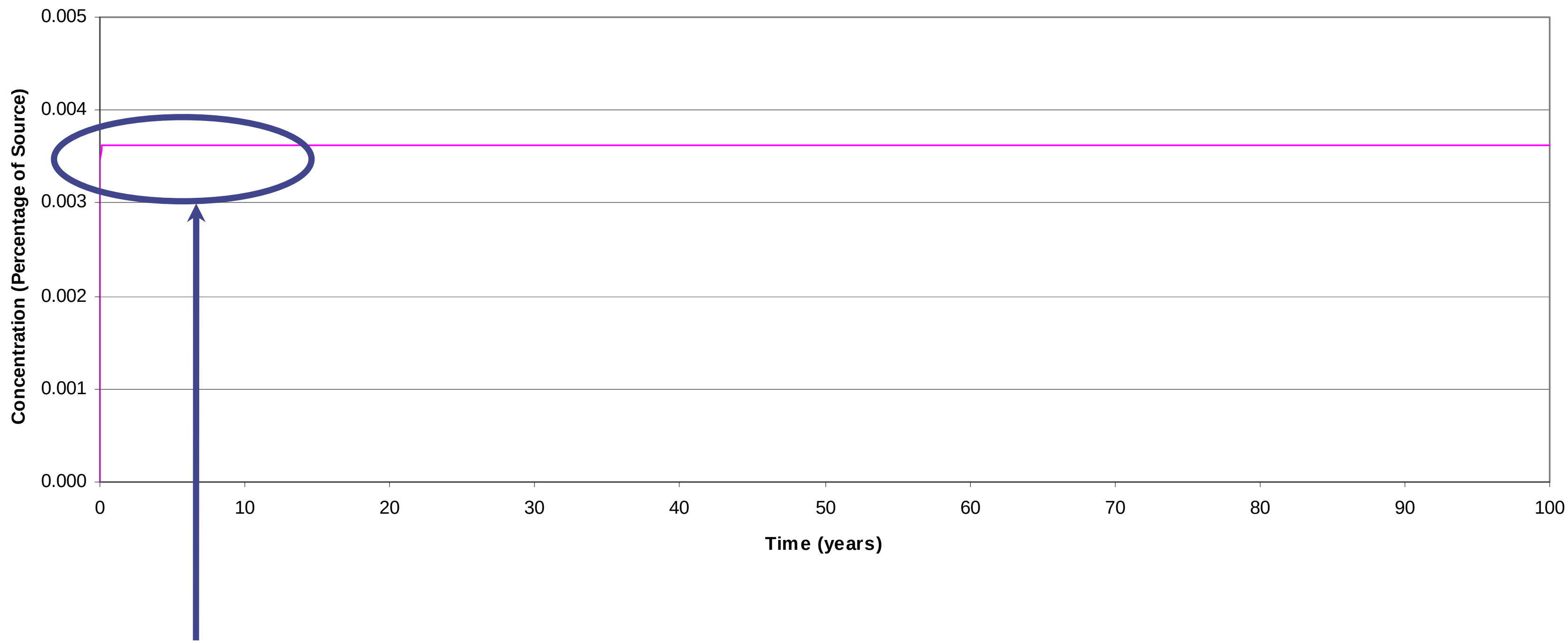

- Within 10 years of release to environment
- Approximately 0.5% of initial 2,4-DNT concentration travels 0.5 m (1.64 feet) BLS

**Figure 5-8. Transport Modeling Results of 2,4-DNT Vertical Transport to 1.64 Feet (0.5m) BLS Over Time**



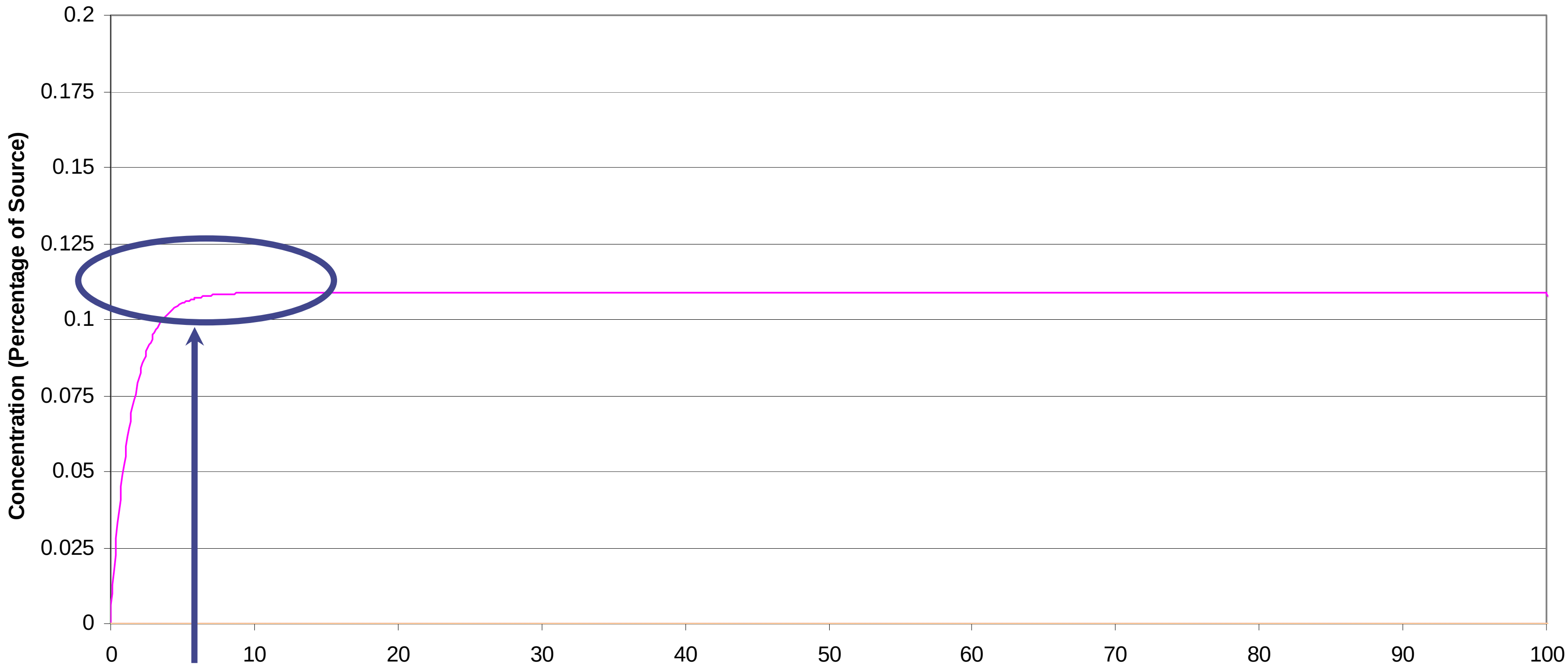

- Within 1 year of release to environment
- Approximately 0.004% of initial HMX concentration travels 0.5 m (1.64 feet) BLS

**Figure 5-9. Transport Modeling Results of HMX Vertical Transport to 1.64 Feet (0.5m) BLS Over Time**




- Within 1 year of release to environment
- Approximately 0.004% of initial RDX concentration travels 0.5 m (1.64 feet) BLS

**Figure 5-10. Transport Modeling Results of RDX Vertical Transport to 1.64 Feet (0.5m) BLS Over Time**




- Within 10 years of release to environment
- Approximately 0.1% of initial TNT concentration travels 0.5 m (1.64 feet) BLS

**Figure 5-11. Transport Modeling Results of TNT Vertical Transport to 1.64 Feet (0.5m) BLS Over Time**

**Table 5-17. Summary of Predicted Percentages of Initial Concentrations of Modeling Compounds Migrating 1.64 and 24.6 Feet BLS at FRTC**

| Modeling Compound | Peak Percentage of Initial Concentration (%) | |
|---|---|---|
| | 1.64 feet BLS | 24.6 feet BLS |
| 2,4-DNT | 2.6 | — |
| HMX | 0.020 | — |
| Perchlorate | 100 | 0.60 |
| RDX | 0.018 | — |
| TNT | 0.55 | — |

**Table 5-18. Comparison of Predicted and Measured Concentrations of Modeling Compounds Migrating from the Surface to 1.64 and 24.6 Feet BLS at FRTC**

| Range | Modeling Compounds | Maximum Concentrations (mg/kg) | | Peak Concentration at 1.64 Feet BLS (mg/kg) | | Peak Concentration at 24.6 Feet BLS (mg/kg) | |
|---|---|---|---|---|---|---|---|
| | | Modeling [a] | Sampling [b] | Modeling [a, c] | Sampling [b, c] | Modeling [a, c] | Sampling [b, c] |
| Bravo 17 East | 2,4-DNT | 35 | 5.7 | 0.93 | 0.15 | — | — |
| | HMX | 0.31 | 302 | 6.3E-05 | 0.061 | — | — |
| | Perchlorate | 0.0014 | NA | 0.0014 | — | 8.1E-06 | — |
| | RDX | 51,038 | 1,130 | 9.3 | 0.21 | — | — |
| | TNT | 45,117 | 8,600 | 250 | 48 | — | — |
| Bravo 19 | 2,4-DNT | 59 | 5.7 | 1.5 | 0.15 | — | — |
| | HMX | 0.52 | 302 | 1.1E-04 | 0.061 | — | — |
| | Perchlorate | 0.0023 | NA | 0.0023 | — | 1.3E-05 | — |
| | RDX | 85,063 | 1,130 | 15 | 0.21 | — | — |
| | TNT | 75,195 | 8,600 | 417 | 48 | — | — |
| Bravo 20 | 2,4-DNT | 23 | 5.7 | 0.62 | 0.15 | — | — |
| | HMX | 0.21 | 302 | 4.2E-05 | 0.061 | — | — |
| | Perchlorate | 9.0E-04 | NA | 9.0E-04 | — | 5.4E-06 | — |
| | RDX | 34,025 | 1,130 | 6.2 | 0.21 | — | — |
| | TNT | 30,078 | 8,600 | 167 | 48 | — | — |

[a] Results of mass loading modeling are listed in Table 5-15

[b] Results of Army studies used as points of comparison are presented in Table 5-15. Samples collected during Army studies (Pennington et al. 2003) were not tested for perchlorate and, therefore, the results are noted "- -."

[c] Concentrations were estimated by multiplying the appropriate concentration (i.e., mass loading modeling or sampling), the appropriate peak percentage of initial concentration (depth-specific, see Table 5-17), and 0.01 (factor to convert percentages to fractions).

### 5.2.2 Potential for Horizontal Migration Modeling Compounds

The evaluation of overland transport of residual modeling compounds previously was determined to be unnecessary in Section 5.2 because of the relatively flat terrain surrounding the live-impact targets. This section would have focused on horizontal migration of modeling compounds through the groundwater table after they have reached the groundwater table. However, as described in the previous section, evaluation of the potential for migrate horizontally migration through the groundwater table to locations off-range locations also appears to be unnecessary for the following reasons:

- Only perchlorate could reach the soil-groundwater interface. Even under extremely conservative modeling assumptions, the predicted concentrations are extremely low and only reach the groundwater after an extended time period. The potential concentrations in groundwater at the soil-water interface would not be detectable using technology available today (i.e., detection limit in drinking water is 4 µg/L).
- No hydrogeologic data are available for the FRTC ranges to ascertain the groundwater flow rates, but the terrain between the high-explosive impact targets and range boundaries suggests a flat water table, which means groundwater flow rates would be very slow and the transport of perchlorate would be even slower. In addition, the distance from high-explosives impact targets to the nearest respective range boundary are greater than 1 mile in all cases (see Table 5-19). These two factors suggest that groundwater from the high-explosive targets will not reach the range boundary in less than several hundred years. Furthermore, considering the information presented in the first bullet, the concentrations at that time would be virtually non-existent and certainly not detectable using technology available today.

**Table 5-19. Groundwater Migration Data**

| Range | Distance from High-Explosive Target to Nearest Range Boundary (miles) | Change in Elevation Between High-Explosives Impact Area and Boundary (feet) |
|---|---|---|
| Bravo 17 East | 2.7 | — |
| Bravo 19 | 1.5 | 20 |
| Bravo 20 | 3.7 | 56 |

Distances from high explosive targets to the nearest range boundary are greater than 1.5 miles. In addition, receptors who may hypothetically consume drinking water from the aquifer underlying the ranges are at far greater distances from the high explosive targets. Furthermore, the hydrogeologic conditions precludes the migration from the ranges to the nearest groundwater user.

## 5.3 SUMMARY OF PREDICTIVE MODELING

This section presented the mass loading and mass transport modeling conducted to evaluate the potential for an off-range release of the modeling compounds HMX, RDX, TNT, 2,4-DNT, and perchlorate from munitions after they have been used for testing or training purposes. This predictive modeling used information about the munitions (e.g., chemical and physical properties of various explosive fillers) used at FRTC in FYs 1997, 1999, and 2000 in addition to environmental data about the range.

This section presented the process and results needed to help answer the question posed by RSEPA Decision Point 1, "Is further analysis required to assess the risk of off-range release?" The answer to this question determines which of the following should be the next step in the RSEPA process:

- Conduct a CRE

- Implement protective measures to address the potential off-range release
- Take no immediate action, but conduct another RCA in 5 years.

Section 5.1 showed potential residual quantities of modeling compounds that could remain in surface soil at the FRTC. These residues were predicted using the quantities of modeling compounds in munitions used during FYs 1997, 1999, and 2000 in conjunction with low-order detonation rates and an assumption that 50 percent of the original mass of modeling compounds is consumed during the low-order detonation. Predicted concentrations in surface soil ranged from $2.1 \times 10^{-5}$ mg/kg for perchlorate to 10,501 mg/kg for RDX. These concentrations were compared with studies conducted by the U.S. Army at Fort Lewis, Washington; Yakima Training Center, Washington; and Camp Guernsey, Wyoming (Pennington et al. 2003). The Army analyzed surface soil samples for HMX, RDX, TNT, and several TNT degradation products, but did not analyze samples for perchlorate. When actually detected, sampling concentrations ranged from 5.71 mg/kg for 2,4-DNT to 8,600 mg/kg for TNT. The predicted results for residual modeling compounds in soil are thus in reasonable agreement with the observed results from a similar range.

Section 5.2 showed potential migration from surface soil to 1.64 feet (0.5 m) and 24.6 feet (7.5 m) BLS for each of the modeling compounds in soil at the FRTC. Vertical transport modeling in the soil predicted that all modeling compounds could migrate to 1.64 feet BLS. However, only perchlorate could migrate through the soil to the soil-groundwater interface (24.6 feet BLS), but the concentrations would be so low that they are not likely to be detectable using technology available today. Consequently, groundwater transport modeling in the groundwater is not necessary.

Horizontal migration on the surface (i.e., overland flow) was not considered to be significant and the need to conduct horizontal transport modeling was ruled out in the ORSMs (Section 4.5) because of the relatively flat terrain surrounding the live-impact targets.

# 6. CONCLUSIONS

The conclusions presented in this document complete the requirement for RCA Phase III and discuss information necessary to answer Decision Point 1 questions (U.S. Navy 2004a) for the FRTC: "Are further steps required to maintain compliance?" and "Is further analysis required to assess risk of off-range release?"

- To maintain compliance with environmental regulations, NAS Fallon needs to (1) determine the applicability of EPCRA Section 313 to the FRTC ranges and conduct the necessary calculations, if applicable; and (2) ensure that range-specific scrap management policies and procedures comply with the operational range clearance policy.
- Further analysis is not required to assess the risk of off-range releases. Predictive modeling was conducted at Bravo 17 East, Bravo 19, and Bravo 20 because the ORSM indicated the current and planned continued use of military munitions at these ranges. Mass transport modeling conducted in the soil predicted some modeling compounds could migrate to 1.64 feet BLS at detectable concentrations; however, none of the compounds could be expected to migrate at detectable concentrations through the soil to the soil-groundwater interface (24.6 feet BLS). Consequently, transport modeling through groundwater to off-range locations was not conducted. In addition, horizontal migration on the surface (i.e., overland flow) was not considered to be significant and the need to conduct horizontal transport modeling was eliminated in the ORSMs because of the relatively flat terrain surrounding the live-impact targets.

These conclusions will be incorporated into the Decision Point 1 Recommendations Report.

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