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Final

Munitions Response Program Master Project Plan

Marine Corps Base Camp Lejeune Jacksonville, North Carolina

NAVFAC
Naval Facilities Engineering Command
NAVFAC ATLANTIC

Prepared for

Department of the Navy

Naval Facilities Engineering Command Atlantic

Contract No. N62470-02-D-3052
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Prepared by

CH2MHILL

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Chantilly, Virginia

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Acronyms and Abbreviations

AHA	Activity Hazard Analyses
AM	Activity Manager
amsl	above mean sea level
APP	Accident Prevention Plan
ARAR	Applicable or relevant and appropriate requirement
ATF	Bureau of Alcohol, Tobacco, Firearms, and Explosives
bgs	below ground surface
BIP	blow-in-place
BRAC	Base Realignment and Closure Act
CAD	computer-aided design
CAP	Corrective Action Plan
CAR	corrective action request
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COC	chain of custody
CPR	cardiopulmonary resuscitation
CTO	contract task order
CWM	chemical warfare materiel
DDESB	Department of Defense Explosives Safety Board
DFOW	definable feature of work
DGM	digital geophysical mapping
DGPS	differential global positioning system
DID	data item description
DMM	discarded military munitions
DO	dissolved oxygen
DoD	Department of Defense
DOJ	Department of Justice
DOT	Department of Transportation
DPT	direct-push technology
DQO	data quality objective
DRMO	Defense Reutilization and Marketing Office
EOD	explosive ordnance disposal
EP	Engineering Pamphlet
ESQD	Explosives Safety Quantity-Distance
ESRI	Environmental Systems Research Institute, Inc.
ESS	Explosives Safety Submission
EZ	Exclusion Zone
°F	degrees Fahrenheit
FAR	Federal Acquisition Regulation

ft	foot/feet
FTL	Field Team Leader
FUDS	Formerly Used Defense Sites
GIP	Geophysical Investigation Plan
GIS	geographic information system
GPO	geophysical prove-out
GPS	global positioning system
H&S	health and safety
HSA	hollow stem auger
HSM	Health and Safety Manager
HSP	Health and Safety Plan
HTRW	hazardous, toxic, and radioactive wastes
HTW	hazardous and toxic waste
IBD	inhabited building distance
IDW	investigation-derived waste
IRP	Installation Restoration Program
LCS	laboratory control sample
MC	munitions constituent
MCB	Marine Corps Base
MD	munitions debris
MDL	method detection limit
MEC	munitions and explosives of concern
MGFD	munitions with the greatest fragmentation distance
MLI	Munitions List Items
MMRP	Military Munitions Response Program
MPP	Master Project Plan
MPPEH	Material Potentially Presenting an Explosive Hazard
MR	Munitions Response
MRP	Munitions Response Program
MRSIMS	Munitions Response Site Information Management System
MS/MSD	matrix spike/matrix spike duplicate
NAD83	North American Datum of 1983
NAV88	North American Vertical Datum of 1988
NAVFAC	Naval Facilities Engineering Command
NAVSEA	Naval Sea Systems Command
NC	North Carolina
NCDENR	North Carolina Department of Environment and Natural Resources
NOSSA	Naval Ordnance Safety and Security Activity
NTU	nephelometric turbidity unit
ORP	oxidation reduction potential
OSHA	Occupational Safety and Health Administration

PARCC	precision, accuracy, representativeness, comparability, and completeness
PC	Project Chemist
PDF	portable document format
PM	Project Manager
POC	point of contact
PPE	personal protective equipment
PQL	practical quantitation limit
PTR	public transportation route
PVC	polyvinyl chloride
QA	quality assurance
QACM	Quality Assurance Control Manager
QAPP	Quality Assurance Project Plan
QC	quality control
QCP	Quality Control Plan
RA	Removal Action
RCRS	Resource Conservation Recovery Section
RPD	relative percent difference
RRD	range related debris
RTK	real-time kinematics
SOP	standard operating procedure
SSWP	Site-specific Work Plan
SU	standard unit
SUXOS	Senior UXO Supervisor
TMP	Technical Management Plan
TP	Technical Paper
TSD	temporary storage and disposal
U.S.	United States
USACE	United States Army Corps of Engineers
USAESCH	United States Army Engineering Support Center, Huntsville
USEPA	United States Environmental Protection Agency
UXO	unexploded ordnance
UXOQCS	Unexploded Ordnance Quality Control Specialist
UXOSO	UXO Safety Officer
VOC	volatile organic compound
WP	Work Plan

SECTION 1

Introduction

1.1 Preface

This document presents the Master Project Plan (MPP) for the activities to be performed for Munitions Response (MR) investigations at the Marine Corps Base (MCB) Camp Lejeune. The MPP will provide the approach to be used for MR investigations and general types of activities to be completed.

This MPP will be updated by CH2M HILL as necessary, and reviewed at least once a year to ensure that the information contained herein is accurate and reflects current procedures and guidance. Any updates or necessary changes will be incorporated as necessary.

Site-specific details, such as sampling locations, numbers of samples, and analytical parameters will be provided in separate Site-specific Work Plans (SSWPs). The SSWPs will supplement the MPP and will present information specific to each new area of investigation. Details, such as results of previous site investigations and site-specific maps, will be provided in the SSWPs.

1.2 Organization

The MPP is organized as follows:

- **Section 1, Introduction**—Description of the document
- **Section 2, Technical Management Plan (TMP)**—The technical approach, methods, and operational procedures that will be used at all MR sites
- **Section 3, Explosives Management Plan**—Management of explosives in accordance with applicable regulations
- **Section 4, Explosives Siting Plan**—Explosives safety criteria for planning and siting explosives operations
- **Section 5, Geophysical Prove-out (GPO) Plan**
- **Section 6, Geophysical Investigation Plan**
- **Section 7, Field Investigation Plan**—The technical approach, methods, and operational procedures that will be used to execute the field investigation activities.
- **Section 8, Quality Control Plan (QCP)**—The approach, methods, and operational procedures to be employed for quality control (QC) at the MR sites.
- **Section 9, Environmental Protection Plan**—The approach, methods, and operational procedures to be employed to protect the natural environment during the performance of tasks at the MR sites.

- **Section 10, Investigation-derived Waste (IDW) Plan**—The approach, methods, and operational procedures to be employed to manage wastes generated during the investigation in order to protect the public and the environment, as well as to meet legal requirements.
- **Section 11, References**—List of references cited in the preceding sections.
- **Appendix A, GPO Plan**—GPO activities to be performed as part of the process for validating the digital geophysical mapping (DGM) systems to be utilized in the geophysical investigation.
- **Appendix B, Geophysical Investigation Plan (GIP)**—The approach, methods, and operational procedures that will be used in performing geophysical investigations.

1.3 Base Description and History

1.3.1 Location

MCB Camp Lejeune is located within the Atlantic Coastal Plain Physiographic Province in Onslow County, North Carolina, approximately 45 miles south of New Bern and 47 miles north of Wilmington. The Base covers approximately 236 square miles. The Base is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean (Figure 1-1).

The Base is bordered by the City of Jacksonville, North Carolina (NC) and State Route 24 to the north; the Atlantic shoreline to the south and east; and United States (U.S.) Route 17 to the west (not including the Greater Sandy Run Area of the Base west of U.S. Route 17).

1.3.2 History

Construction of MCB Camp Lejeune began in 1941 with the objective of developing the "World's Most Complete Amphibious Training Base." Construction of the Base centered on Hadnot Point, where the major functions of the Base are located. During World War II, MCB Camp Lejeune was used as a training area to prepare Marines for combat. MCB Camp Lejeune was again used for training during the Korean and Vietnam conflicts, as well as the Gulf War.

MCB Camp Lejeune currently hosts several Marine Corps commands and one Navy command. Tenant commands include MCB Camp Lejeune, II Marine Expeditionary Force, 2nd Marine Division, and 2nd Marine Logistics Group. All real estate and infrastructure is owned, operated, and maintained by MCB Camp Lejeune. The mission of MCB Camp Lejeune is to maintain combat-ready units for expeditionary deployment.

1.4 Climate

The climate in the MCB Camp Lejeune area is characterized by short, mild winters with occasional short-duration cold periods and long, hot humid summers. Average annual net precipitation is approximately 50 inches. Ambient air temperatures generally range from 33 to 53°degrees Fahrenheit (°F) in the winter months, and from 71°F to 88°F during the summer months. Winds are generally south-southwesterly in the summer and north-northwesterly in the winter (WAR, 1983). The hurricane season begins on June 1 and continues through November 30. Storms of non-tropical origin, such as frontal passages, local thunderstorms, and tornadoes, are more frequent and can occur year-round.

1.5 Topography

The topography of the Base is generally flat and typical of the NC Coastal Plain. Elevations on the Base range from sea level to approximately 72 feet (ft) above mean sea level (amsl). However, elevations on the majority of the base range from approximately 20 to 40 ft amsl.

Drainage at the Base generally is toward the New River, except in areas near the coast, which drain through the Intracoastal Waterway. In developed areas, the natural drainage has been altered by asphalt cover, storm sewers, and drainage ditches. Approximately 70 percent of the Base is situated in broad, flat interstream areas. Drainage is poor in these areas and the soils are often wet. The U.S. Army Corps of Engineers (USACE) has mapped the limits of the 100-year floodplain at the Base at 7 ft amsl in the upper reaches of the New River increasing downstream to 11 ft amsl near the coastal area (WAR, 1983).

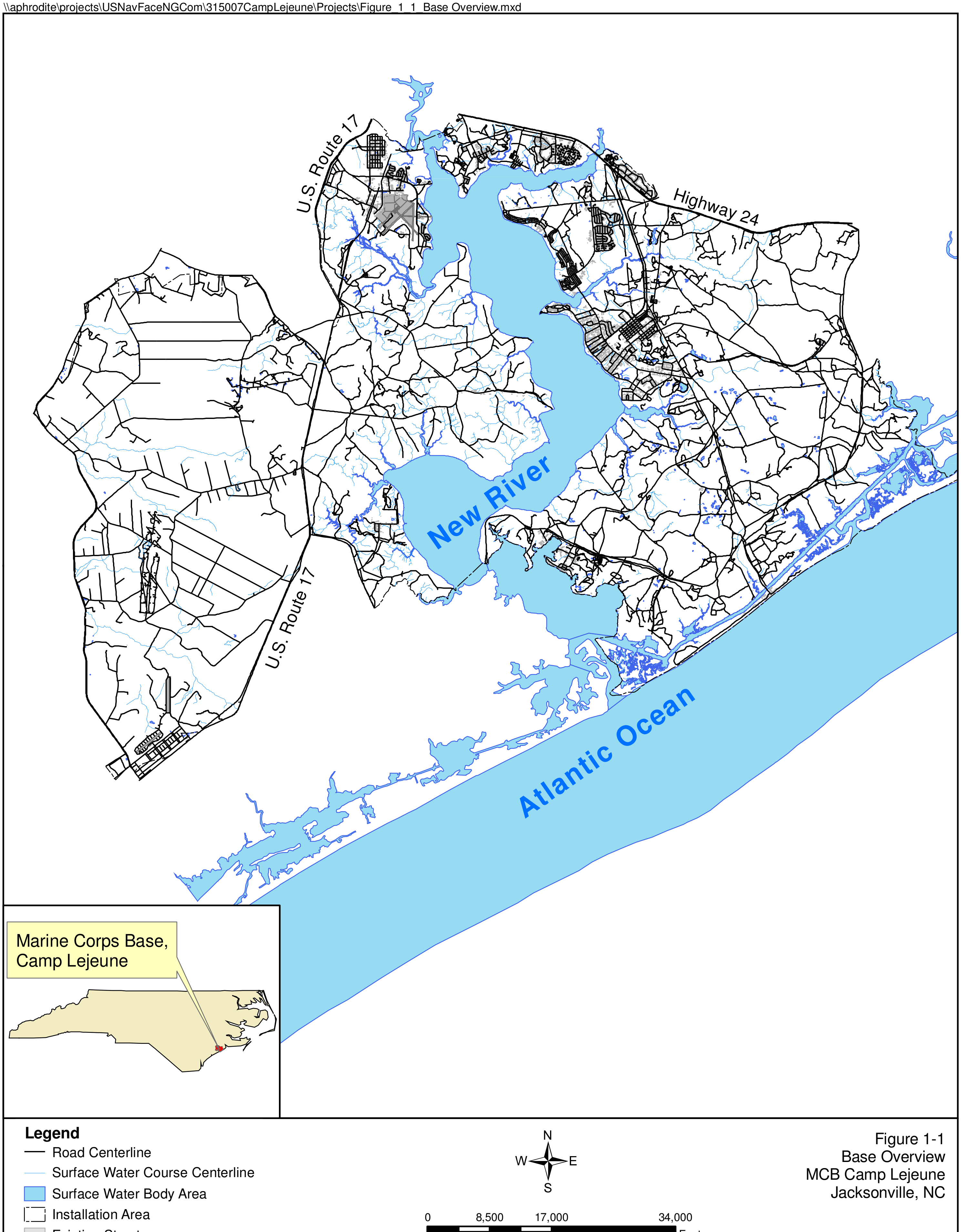
1.6 Geology

According to Cardinell, Berg, and Lloyd (1993), the uppermost undifferentiated formation of Holocene and Pleistocene age sediments consist of mostly fine, loose to medium dense sands, with a lesser amount of silt and clay and is present from land surface to depths of 20 to 30 ft below ground surface (bgs). Thin, discontinuous lenses of silt and clay may be regionally associated with the Belgrade formation. The Belgrade formation generally consists of mostly fine sands, silts and clays, with lesser amounts of shell fragments.

The upper portion of the River Bend Formation, which underlies the Quaternary age sediments is composed of sands, silts, shell and fossil fragments, and trace amounts of clay. The River Bend Formation overlies the Eocene Castle Hayne Formation. The Castle Hayne formation consists of both poorly indurated and well indurated biomicrite and biomicrudite limestone (Harris and Zullo, 1991). Thickness of the Castle Hayne Formation ranges between 150 ft and over 450 ft locally at MCB Camp Lejeune (Cardinell, Berg, and Lloyd, 1993). Site-specific geologic information will be discussed in the SSWPs.

1.7 Hydrogeology

The surficial aquifer lies in a series of sediments, primarily sand and clay, which commonly extend to depths of 50 to 100 ft. This aquifer is not used for water supply at MCB Camp Lejeune. The principal water supply aquifer for MCB Camp Lejeune lies in a series of sand and limestone beds located between 50 and 300 ft below land surface. This series of sediments is generally known as the Castle Hayne Formation. The Castle Hayne Formation is approximately 150 to 350 ft thick in this vicinity and contains the most productive aquifer in North Carolina. Onslow County and MCB Camp Lejeune lie in an area where the Castle Hayne Formation contains freshwater, although the proximity of saltwater in deeper layers just below this aquifer formation and in the New River estuary is of concern in managing water withdrawals from the aquifer. Site-specific hydrogeologic information will be discussed in the SSWPs.



Legend

- Road Centerline
- Surface Water Course Centerline
- Surface Water Body Area
- Installation Area
- Existing Structures
- Airfield Surface Area

Figure 1-1
Base Overview
MCB Camp Lejeune
Jacksonville, NC

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SECTION 2

Technical Management Plan

The purpose of the TMP is to identify the approach, methods, and operational procedures to be employed during MR investigations at MCB Camp Lejeune.

2.1 MR Guidance, Regulations, and Policy

The MR investigations at MCB Camp Lejeune will be conducted under the following guidance documents, regulations, and policies:

- **DDESB TP 16, *Methodologies for Calculating Primary Fragment Characteristics*.** Technical Paper (TP) 16 provides Department of Defense Explosives Safety Board (DDESB) approved methodologies for calculating the characteristics of primary fragments. It includes methodologies for calculating primary fragment mass and velocity, maximum fragment range, hazardous fragment distance, effects of detonating stacks of items, effects of detonating buried items, and penetration information.
- **DDESB TP 18, *Minimum Qualifications for Unexploded Ordnance (UXO) Technicians and Personnel*.** This document provides minimum qualification standards for personnel performing unexploded ordnance (UXO)-related operations in support of the Department of Defense (DoD) with the exception of DDESB personnel.
- **Naval Ordnance Safety and Security Activity (NOSSA) Instruction 8020.15A, *Military Munitions Response Program Oversight*.** This document assigns responsibility and establishes procedures and reporting requirements for oversight, review, and verification of the explosives safety aspects of the Navy MR Program (MRP). This instruction applies to response actions involving military munitions, including UXO, at other than operational ranges.
- **Naval Sea Systems Command (NAVSEA) OP 5, Volume 1, Seventh Revision, *Ammunition and Explosives Safety Ashore*.** This document provides NAVSEA's safety regulations for handling, storing, production, renovation, and shipping of explosives ashore.
- **DoD, 2004, 6055.9-STD, *DoD Ammunition and Explosives Safety Standards*, October 5, 2004**. This is the primary DoD regulation that establishes uniform safety standards for ammunition and explosives, associated personnel and property, and unrelated personnel and property exposed to the potential damaging effects of an accident involving ammunition and explosives. It applies for determining minimum safety distances, explosives storage requirements, facility construction and siting (e.g., work sites, magazines), and Explosives Safety Quantity-Distance (ESQD) requirements.
- **DoD, 1991, 4160.21-M, *Defense Material Disposition Manual*, and 4160.21-M-1, *Defense Demilitarization and Trade Security Control Manual***. DoD 4160.21-M implements the Federal Property Management Regulation and other laws and regulations applying to

the disposition of excess, surplus, and foreign excess personal property. DoD 4160.21-M-1 contains specific guidance for property identified as Munitions List Items (MLI) and Commerce Control List Items. The guidance is applicable for the demilitarization and disposal of Material Potentially Presenting an Explosive Hazard (MPPEH) and Munitions Debris (MD).

- **USACE, 2004, Engineering Pamphlet (EP) 75-1-2,** ***Munitions and Explosives of Concern (MEC) Support for HTRW and Construction Support Activities***. This policy provides USACE personnel with procedural guidance, technical specifications, personnel and training requirements, and health and safety (H&S) criteria for MEC support during hazardous, toxic, and radioactive wastes (HTRW) and construction support activities. It applies to all projects for which anomaly avoidance or construction support is necessary because of the potential presence of MEC onsite.
- **USACE, 2000b, EP 1110-1-18,** ***Ordnance and Explosives Response***. This guidance provides the procedures and process to be used to manage and execute all aspects of MEC Removal Actions (RAs). It applies to all phases of MEC-related projects.
- **USACE, 2003c, ER 385-1-92,** ***Safety and Occupational Health Requirements for HTRW Waste Activities***. These requirements identify the safety and occupational health documents and procedures that USACE and their contractors are required to develop and implement when they are responsible for executing HTRW- and MEC-related activities.
- **U.S. Army Engineering Support Center, Huntsville (USAESCH), 2004, EP 385-1-95a,** ***Basic Safety Concepts and Considerations for Munitions and Explosives of Concern (MEC) Operations***. This guidance document establishes the safe operating procedures for dealing with MEC items on Formerly Used Defense Sites (FUDS), Base Realignment and Closure Act (BRAC) installations, and Installation Restoration Program (IRP) projects. This guidance is applicable for all MEC-related projects.

  In addition, this WP was developed in accordance with the following USACE Data Item Descriptions (DID) for MR activities:

  - DID MR-005-01, ***Type II Work Plan***
  - DID MR-005-02, ***Technical Management Plan***
  - DID MR-005-03, ***Explosives Management Plan***
  - DID MR-005-04, ***Explosives Siting Plan***
  - DID MR-005-11, ***Quality Control Plan***
  - DID MR-005-12, ***Environmental Protection Plan***
  - DID MR-005-13, ***Investigative Derived Waste Plan***

2.2 MEC Contingency Procedures

The discovery of unidentified MEC is not anticipated. If any MEC items are discovered that cannot be identified by onsite personnel, the Senior UXO Supervisor (SUXOS) will contact the MCB Camp Lejeune Explosive Ordnance Disposal (EOD) team for additional support. Digital photos of the unidentified item(s) and information concerning size, depth, and markings will be provided to the EOD for identification purposes.

2.3 Chemical Warfare Materiel Contingency Procedures

If unexpected chemical warfare materiel (CWM) is encountered, all work will immediately cease. Project personnel will withdraw upwind from the discovery. A team, consisting of a minimum of two personnel, will secure the area to prevent unauthorized access. Personnel will position themselves as far upwind as possible while still maintaining visual security of the area. The SUXOS will immediately notify MCB Camp Lejeune EOD, who will be responsible for control of the site and for further notifications.

2.4 Project Organization and Personnel

2.4.1 Organization

The key organizations involved in the MR program are Naval Facilities Engineering Command (NAVFAC), the U.S. Environmental Protection Agency (USEPA), the NC Department of Environment and Natural Resources (NCDENR), and CH2M HILL. Project execution will be conducted by CH2M HILL and its subcontractors. CH2M HILL will issue subcontracts for services that cannot be conducted in-house. Subcontractors typically procured for MR Investigations are described below.

Prime Contractor

As the prime contractor, CH2M HILL is the primary point of contact with NAVFAC. CH2M HILL will manage the overall project, providing day-to-day oversight and related program management support to execute the project successfully. Project duties controlled by CH2M HILL include the following:

- Project planning, implementation, and reporting
- Subcontractor selection, management, and control
- Program- and project-level QC
- Program- and project-level H&S
- Site management
- Work Plan (WP) and Explosives Safety Submission (ESS) Preparation (if required)
- Technical direction for geophysical operations, geographical information system (GIS), and database management
- Performance of field sampling activities
- Analysis of data and preparation of report
- Project closeout

MEC Subcontractor

If CH2M HILL-employed UXO Technicians are unavailable, a subcontractor will provide qualified UXO technicians to provide MEC avoidance services during field operations at MR sites. Specific project duties will include the following:

- Train field personnel in appropriate MEC safety procedures prior to initiation of field activities
- Escort field personnel while conducting onsite activities in areas of potential MEC contamination
- Provide subsurface MEC avoidance for intrusive environmental investigation activities (e.g., soil sampling, soil boring, direct push sampling, monitoring well installation)
- Coordinate with Marine Corps EOD personnel in the event MEC is discovered during the investigation

A subcontractor will also provide qualified UXO technicians to conduct MEC intrusive investigations, or to support CH2M HILL UXO technicians during MEC intrusive investigations. Specific roles and responsibilities of UXO personnel for MEC intrusive investigations will be defined in the SSWPs.

The MEC subcontractor will provide the labor, equipment, and supplies required for the work described above.

Geophysical Services Subcontractor

The geophysical services subcontractor will provide trained personnel for geophysical investigation services. Specific project duties assigned to the geophysical services subcontractor include the following:

- Implementing the GPO according to the GPO plan (Appendix A)
- Perform DGM services according to the GIP (Appendix B), including the DGM survey, data processing and interpretation, and preparation of geophysical anomaly maps

The geophysical services subcontractor will provide the labor, equipment, and materials required for the work described above.

Brush Clearing Subcontractor

A brush clearing subcontractor will provide trained personnel for brush clearing services. Specific project duties will be included in the SSWPs.

The brush clearing subcontractor will provide the labor, equipment, and materials required for the work described above.

Geoprobe® and Drilling Subcontractor

Monitoring well installation and subsurface soil sampling will be accomplished utilizing a Geoprobe or drilling subcontractor. Specific project duties assigned to the subcontractor include the following:

- Perform direct push technology (DPT) or drilling services according to the SSWPs and under the direction of the Field Team Leader (FTL). The drilling method and rationale for selection will be specified in the SSWPs.
- Perform monitoring well installations under the direction of the FTL in accordance with the SSWPs.
- Prepare collected samples for shipment to the selected analytical laboratory in accordance with the SSWPs and under the direction of the FTL.
- Perform all intrusive activities under the supervision and direction of the UXO Technician.

The Geoprobe or drilling services subcontractor will provide the labor, equipment, and tools required for the work described above.

Investigation-derived Waste Subcontractor

A transportation and disposal subcontractor will transport and dispose of IDW generated during the environmental investigations in accordance with the MCB Camp Lejeune MPPs (CH2M HILL, 2005). MD and other scrap recovered during MEC intrusive investigations will not be disposed of through the IDW subcontractor, but will be handled in accordance with Section 2.6 of this WP.

The IDW subcontractor will provide the labor, equipment, and materials required for the work described above.

Analytical Laboratory Subcontractor

A NC-certified laboratory will be used for all chemical analyses. Environmental samples will be collected in accordance with this WP and the MCB Camp Lejeune MPPs (CH2M HILL, 2005). The Analytical Laboratory subcontractor is responsible for providing facilities and testing equipment that complies with testing standards and implementing an approved laboratory quality assurance/quality control (QA/QC) program.

Data Validation Subcontractor

Data validation will be conducted by a subcontracted data validation service which will validate the complete laboratory data packages using the latest versions of the USEPA National Functional Guidelines.

2.4.2 Project Personnel

The reporting relationships between key project personnel are illustrated in the organization chart provided as Figure 2-1. The roles and responsibilities of the key personnel are discussed below.

- **Program Manager—**will provide program management support and will ensure that all contract requirements are met during execution of this project.
- **Senior Technical Consultants—** will provide overall direction and oversight of project implementation, and will ensure that appropriate reviews are conducted on all submittals in their areas of technical expertise (e.g., MR, hydrogeology).

- **Activity Manager—**will coordinate the implementation of all Contract Task Orders (CTO) at MCB Camp Lejeune. The Activity Manager (AM) will ensure that information is shared between CTO project teams and will communicate with the NAVFAC Project Manager (PM) concerning the overall MCB Camp Lejeune activity.
- **PM—**will have overall CH2M HILL responsibility for technical support and oversight, budget and schedule review and tracking, invoice review, personnel resources planning and allocation, and project coordination. The PM will also coordinate field activities with project field personnel and act as CH2M HILL's primary point of contact with NAVFAC and MCB Camp Lejeune personnel during implementation of a CTO.
- **Corporate MR Safety and QC Officer—**will oversee the FTL's implementation of the Health and Safety Plan (HSP) and QCP (refer to Section 8) to ensure that they meet the specific needs of the project and that appropriate H&S and QC requirements are defined and properly executed.
- **Program H&S Manager—**will support the implementation of the HSP to ensure that it meets all specific needs of the project and that appropriate H&S requirements are defined.
- **FTL—**The FTL will be CH2M HILL's onsite representative to coordinate and oversee the activities of field support personnel and subcontractor personnel. The FTL is also responsible for implementation of and compliance with HSP and QC requirements during the field effort.
- **Program Geophysicist**—will be responsible for ensuring that the QC procedures and objectives for the GPO and geophysical investigations are implemented and met. The Program Geophysicist will work closely with the geophysical services subcontractor during the execution of the CTOs, will provide oversight of the geophysical services subcontractor, and will be responsible for the acceptance of the geophysical data.

2.5 Procedures for Reporting and Disposition of MEC and MPPEH Items

This section discusses the procedures for reporting and disposing of MEC and MPPEH encountered during MEC intrusive investigations, including the responsibilities of personnel, overall safety precautions, data reporting, transportation, safe holding areas, operations in populated/sensitive areas, demolition operations, and required engineering controls and Exclusion Zones (EZs) for intrusive operations and intentional detonations.

> If suspected MEC is discovered on a site where MEC avoidance is being practiced, Base EOD personnel will be notified in accordance with the HSP that is contained in the SSWP and will be responsible for MEC handling and disposal.

2.5.1 Overall Safety Precautions

General work practices outlined in USACE EP 385-1-95a, *Basic Safety Concepts and Considerations for Ordnance and Explosives Operations* (USACE, 2004), will be followed. Other basic precautions are as follows:

- The work periods for UXO technicians are limited to maximums of 10 hours per day and 40 hours per week.
- The field team will consist of a UXO Technician III and six or fewer team members.
- The SUXOS will oversee no more than 10 UXO Technician IIIs.

Qualified UXO personnel will dispose of all MEC items using demolition procedures that will be provided in the SSWP. During detonation, unnecessary personnel will be restricted from the area to limit unnecessary exposure. At all times the UXO Safety Officer (UXOSO) will be present to confirm that all demolition materials are handled and prepared correctly and that WP procedures are followed. Each demolition team member has the authority to stop operations if he/she observes an unsafe condition. Demolition operations will not commence until the unsafe condition has been made safe to the satisfaction of the SUXOS, UXOSO, and the demolition team members performing the operation.

Prior to demolition operations, the SUXOS will notify and coordinate with local emergency services to reduce public exposure, maintain safety, and keep the public informed. The emergency contacts and phone numbers are provided in the HSP attached to each SSWP.

2.5.2 Data Reporting

The collection of accurate and detailed data is essential to documenting the MEC-related activities for future reference. Data for each metallic anomaly will be recorded in the field as intrusive actions are performed. The data will be recorded electronically in the field on mobile data collection devices.

A grid data packet will be created for each new grid to be investigated. The UXO Technician III will retain the packet in the grid during clearance activities. Each packet will contain a map showing the location of the grid.

Anomaly tracking sheets will be used to list data for each item encountered and removed. The anomaly tracking sheet will contain the following information:

- **Easting coordinate**
- **Northing coordinate**
- **Depth to item** (depth to the center of the mass of the item in inches)
- **Orientation** (geographical direction [N, S, E, W] the item is pointing, unless vertical)
- **Source of anomaly** (UXO, discarded military munitions [DMM], MC, MD, MPPEH, range-related debris [RRD], cultural debris)

- If ordnance:
  - **Type of ordnance** (as specific as possible)
  - **Type of filler** (e.g., none, inert, HE, White Phosphorus, illumination, incendiary, chemical, smoke)
  - **Type of fuze** (e.g., none, inert, point detonating, powder train, base detonating)
- **Date found**
- **Disposal status** (e.g., blow-in-place [BIP], picked up and carried away for demolition, EOD response)
- **Disposal date**
- **Comments**

2.5.3 Operations in Populated and Sensitive Areas

Each SSWP will provide site-specific information regarding populated and sensitive areas at each site.

2.5.4 EZs and Separation Distances

The munitions with the greatest fragmentation distance (MGFD) will be determined for each site where intrusive MEC operations are planned. Selection of the MGFD will be documented in the SSWP.

ESQD arcs will be determined for the MGFD and will be documented in the SSWP. ESQD arcs include the team separation distance for intentional and unintentional detonations, inhabited building distance (IBD), and public transportation route (PTR) distance.

2.6 Scrap and Munitions Debris Disposition

2.6.1 Inspection and Segregation

A systematic approach will be used for collecting, inspecting, and segregating site debris. The approach is designed so that materials undergo a continual evaluation/inspection process from the time they are acquired until the time they are removed from the site. Site debris will be classified and segregated into one of three categories: (1) MEC, (2) MPPEH, or (3) cultural debris.

Segregation procedures begin at the time the metal item is discovered by the UXO Technician. At this point, the UXO Technician makes a preliminary determination as to the classification of the item. If the item is identified as non-MPPEH debris, it is placed at a temporary non-MPPEH debris accumulation point located within the current operating grid. If the item is identified as MPPEH, it is placed in a temporary MPPEH accumulation point located within the current operating grid. If the item is identified as MEC, it is handled as described in Section 4.2.

2.6.2 Inspection, Certification, and Verification

The MEC Team will collect the scrap piles deposited at the grid corner markers and will perform an inspection to confirm that segregation of the items according to proper classification has occurred. The MPPEH items will be inspected and divided into three groups: (1) MPPEH items that require treatment/demilitarization, (2) MPPEH-safe items that require further demilitarization, and (3) MPPEH-safe items that do not require further demilitarization. Figure 2-2 is a logic diagram for the collection and disposition of MPPEH-related scrap.

Two scrap metal containers will be positioned at the site. One container will be marked "Non-MPPEH Scrap Metal Debris" and will be used to collect general metal debris. The other container will be marked "MPPEH-Safe Scrap Metal" and will be used to collect munitions-related scrap metal that has been inspected and is awaiting certification and verification that the material is free of explosives (i.e., metal components that do not contain any explosives that would present an explosives safety hazard) as described below. The two collection containers will be located a minimum of 50 ft apart. MPPEH that cannot be certified and verified as "Safe" will remain at the grid collection point and will be treated in the same manner as MEC (see Section 4.2).

MPPEH will be inspected, certified, and verified in accordance with the requirements of DoD 4160.21-M (Chapter 4, Paragraph B) and OP 5 Volume 1 (Chapter 13-15) and demilitarized, if necessary, in accordance with DoD 4160.21-M-1. Disposal of MPPEH-safe material will occur in coordination with the nearest Defense Reutilization and Marketing Office (DRMO).

CH2M HILL will confirm that MPPEH is properly inspected in accordance with the procedures in the project WPs. Only UXO-qualified personnel will perform these inspections. The Tech III will certify that the scrap metal is free of explosive hazards. The SUXOS (per OP 5, Section 13-15.7.2) will verify that the scrap metal is free of explosive hazards. DD Form 1348-1A will be used as certification/verification documentation. All DD Form 1348-A1 forms will clearly show the following information in typed or printed letters:

1. Name of CH2M HILL's SUXOS and the Government representative
2. Organization
3. Signatures
4. CH2M HILL's home office
5. Field office phone number(s) of the persons certifying and verifying the scrap metal

For scrap metal, the DD Form 1348-A1 will clearly indicate the following:

1. Basic material content (type of metal, for example, steel or mixed)
2. Estimated weight
3. Unique identification of each sealed container
4. Location where MPPEH was obtained
5. Seal identification, if different from the unique identification of the sealed container

As part of the transfer of MPPEH-Safe material for final disposition, the following certification/verification will be entered on each DD Form 1348-A1 and will be signed by the SUXOS and the qualified Government representative.

> "This certifies and verifies that the AEDA residue, Range Residue and/or Explosive Contaminated property listed has been 100 percent properly inspected and to the best of our knowledge and belief, is inert and/or free of explosives or related materials."

CH2M HILL will arrange for maintaining the chain of custody (COC) and final disposition of the certified and verified materials. The certified and verified material will be released only to an organization that will:

1. Provide signed documentation stating that the organization has received the containers, that each container has an unbroken seal and unique identification, and that after reviewing the documentation accompanying the containers, agrees that the sealed containers contained no explosive hazards when received. This documentation will be signed on company letterhead and state that the contents of these sealed containers will not be sold, traded, or otherwise given to another party until the contents have been smelted and are identifiable only by their basic content.
2. Send notification and supporting documentation to the generating contractor (CH2M HILL) documenting that the sealed containers have been smelted and are now identifiable only by their basic content. These documents will be incorporated into the final report.

Once all intrusive activity is finished and all required certifications verifications are complete, the local DRMO will be contacted to dispose of scrap metal.

2.7 Recording, Reporting, and Implementation of Lessons Learned

Documenting and implementing lessons learned are an integral part of every project. During the weekly QC meeting, lessons learned from the preceding week will be shared. This is also an important aspect of CH2M HILL's Behavior-Based Loss Prevention Program. Lessons learned will also be shared at the daily tailgate meetings with the site personnel. Site personnel will be encouraged to share information of near misses as well as lessons learned.

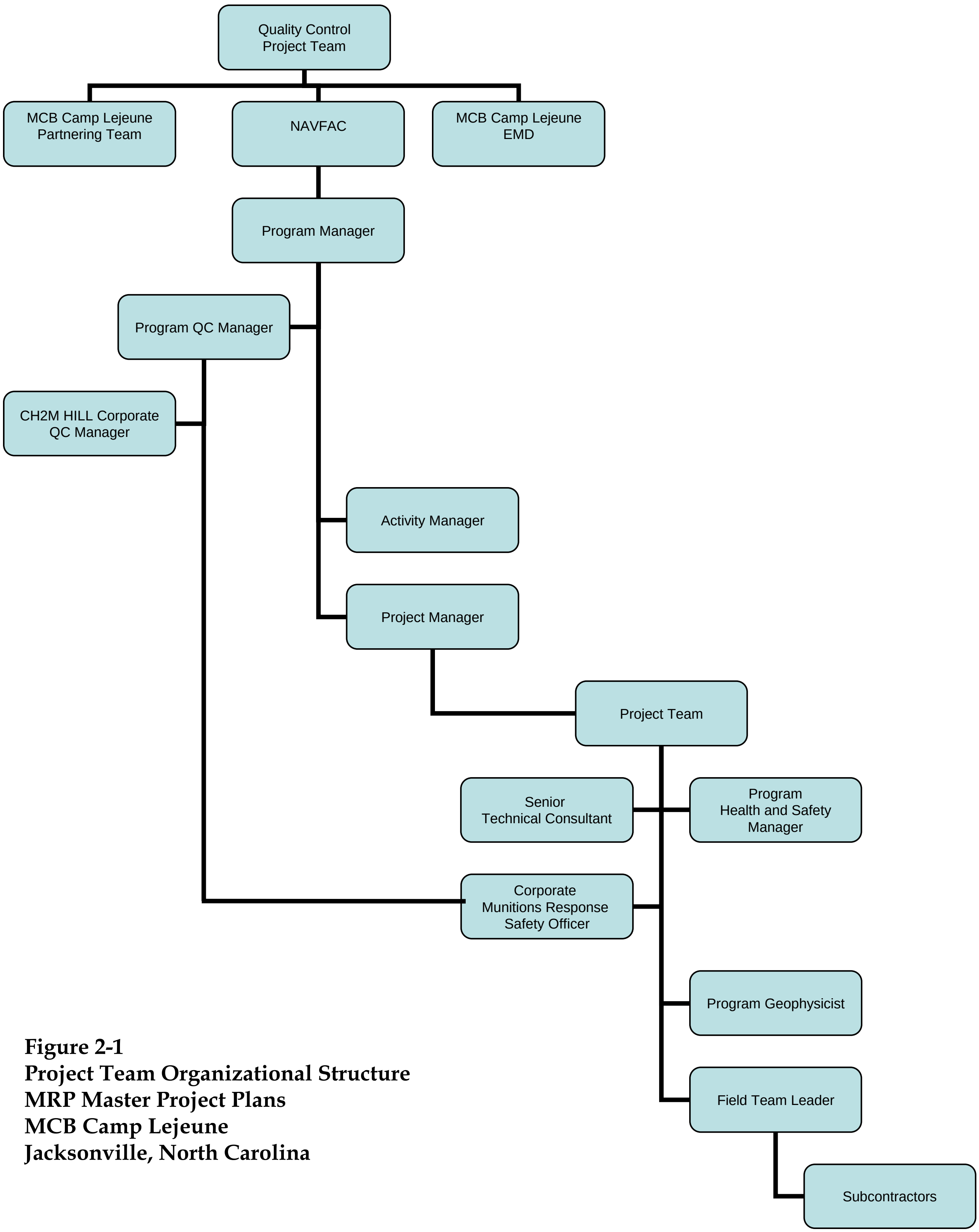
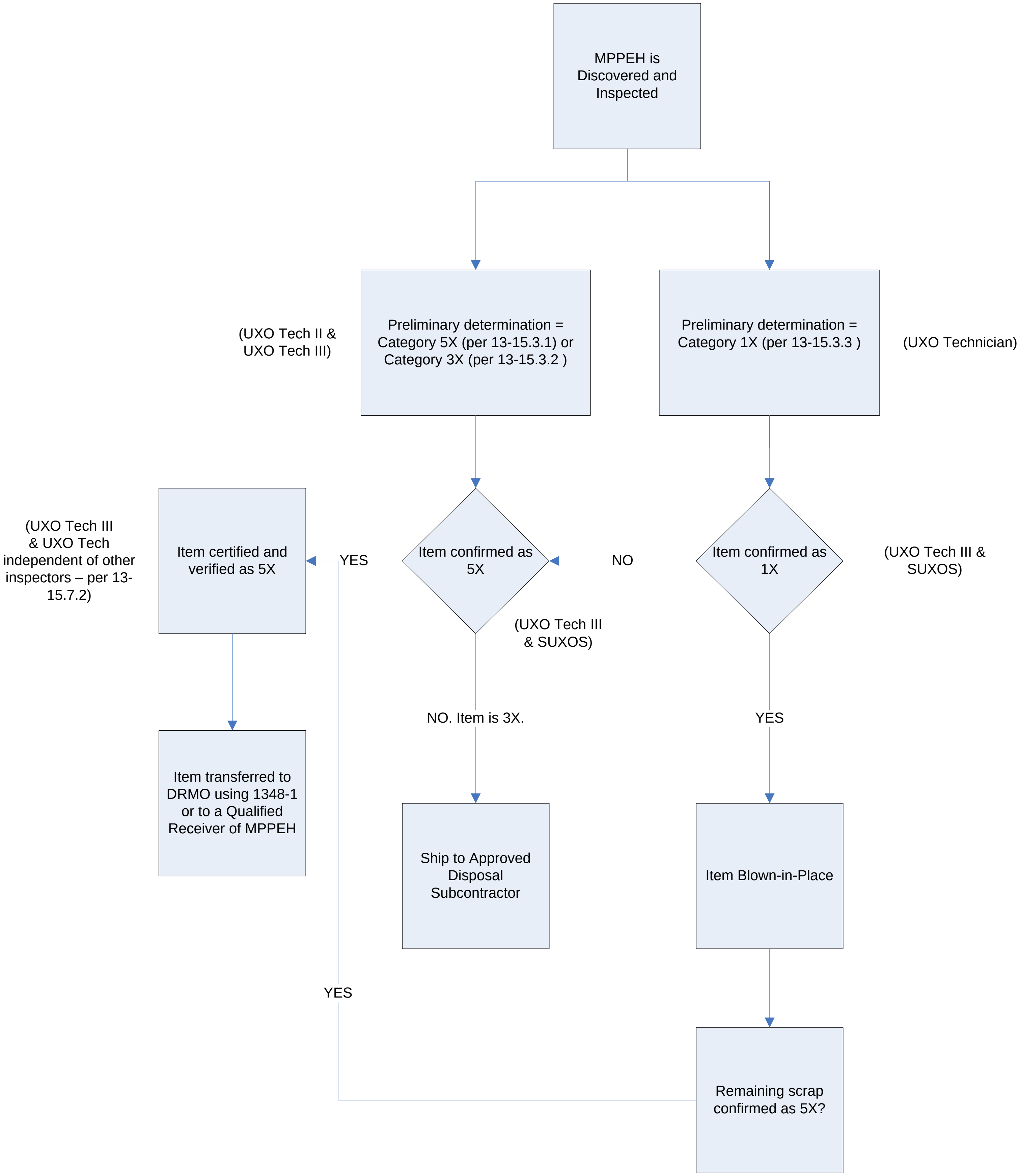


Figure 2-1
Project Team Organizational Structure
MRP Master Project Plans
MCB Camp Lejeune
Jacksonville, North Carolina



NOTES:
1. Individual(s) responsible for action are shown in parentheses next to activitivy (e.g. UXO Tech III)
2. All Section references (e.g. 13-15.3.3) are from NAVSEA OP 5, Volume 1, 2006
3. 1348.1 = Disposal Turn-in Document DD Form 1348-1 (series)

Figure 2-2
MPPEH Logic Diagram
MRP Master Project Plans
MCB Camp Lejeune
Jacksonville, North Carolina

SECTION 3

Explosives Management Plan

This Explosives Management Plan details the management of explosives to support the removal and disposal of MEC and MPPEH items that could possibly be discovered during the MR investigations at MCB Camp Lejeune. In the event that MEC and MPPEH are discovered the MEC subcontractor will comply with this explosives management plan and follow BIP procedures. This plan was developed in accordance with DID FPRI-005-03, Federal Acquisition Regulations (FAR) Subpart 45.5, *Management of Government Property in the Possession of Subcontractors*; Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF), 1990, P 5400.7, *ATF Explosives Laws and Regulations*; DoD, 2004, *6055.9-STD, DoD Ammunition and Explosives Safety Standards*, October 2004; U.S. Department of Transportation (DOT) regulations; and local and state laws and regulations.

3.1 Acquisition

CH2M HILL and the MR subcontractor maintain valid ATF&E permits for the purchase and use of explosives. The MR subcontractor will be the primary point of contact (POC) for all acquisition and use of the explosives used during this intrusive investigation. Copies of these licenses will be maintained at the project site and, upon request, will be made available to any local, state, or federal authority.

3.1.1 Description and Estimated Quantities

The types and quantities of explosives used during this intrusive investigation will be determined by a UXO Technician III upon verifying that the discovered anomaly is MEC. All explosives will be used in a just in time for delivery manor and will be used for BIP demolition immediately. Explosives will not be stored onsite.

3.1.2 Acquisition Source

The MR subcontractor will acquire explosives from commercial explosives vendors who will deliver the materials directly to the project site. Explosives will be purchased through a local vendor, delivered to the project site, and used immediately for BIP operations.

3.2 Initial Receipt

3.2.1 Procedures for Receipt of Explosives

Commercial explosives will be transported by a licensed and permitted commercial explosives carrier to the Site. The MR subcontractor will be responsible for verifying that the type, quantity, and lot number of each explosive item has been checked against the manifest and properly recorded.

The original receipt and shipping documents will be maintained onsite with other project records by the SUXOS.

3.2.2 Reconciling Discrepancies

Any discrepancies between the actual type and quantity of explosives received and the shipping documentation will be noted on the shipping documentation with the signatures of both the delivery driver and the individual authorized to receive the explosives. A legible copy will be filed onsite. The authorized individual receiving the explosives will immediately inform the UXO Quality Control Specialist (UXOQCS) and SUXOS of the discrepancy. The SUXOS will coordinate notification of the commercial explosives vendor.

3.3 Transportation

Explosives will be delivered directly to the project site by a licensed commercial vendor under subcontract to the MR subcontractor. Explosives will not be transported onsite by CH2M HILL or the MR subcontractor.

3.4 Receipt Procedures

This section describes the procedures for maintaining records of explosives inventories.

3.4.1 Records Management

At the time of an explosives delivery and explosives issuance, the SUXOS will ensure that all additions and subtractions from the shipment inventory are properly recorded. Explosives will be ordered on a just in time for delivery basis, and are expected to be used immediately once onsite.

CH2M HILL will archive all explosives inventory records generated for at least 5 years in accordance with ATF&E regulations.

3.4.2 Authorized Individuals

The MR subcontractor shall have an ATF Permit to purchase, use, handle, transport, and store explosives. The Blaster in Charge will be responsible for the proper receipt of explosives from the explosives vendor. The Blaster in Charge may specifically authorize other individuals to perform the receipt and initial inventory of the explosives, but the Blaster in Charge cannot delegate the responsibility for ensuring that the inventory, receipt, and handling of the explosives are performed in accordance with the requirements of this plan. The SUXOS will retain authority to approve detonation.

Any individual authorized to receive explosives will be at least a UXO Technician III and will be either a Department of Justice (DOJ) Employee Possessor or Responsible Person with the MR subcontractor. Written authorization designating the personnel who can receive or use explosives will be provided by the MR subcontractor. As the end user of explosives, the Blaster in Charge will certify in writing that the explosives were used for their intended purpose. A copy of this certification, along with all inventory records, will be provided to the CH2M HILL MR Operations Director and the ATF License Holder.

Prior to the receipt of explosives, approval to bring commercial explosives onto the Base must be received from the MCB Camp Lejeune Commander. The MCB Camp Lejeune Fire

Chief and Base EOD will also be notified prior to receipt of explosives. Notifications will be conducted and approvals received by CH2M HILL prior to the start of field operations.

3.5 Lost, Stolen, or Unauthorized Use of Explosives

If explosives are discovered to be lost, stolen, or used without authorization, the incident will be reported immediately to the SUXOS, who in turn will inform CH2M HILL's PM, MR Operations Director, and the MR Market Segment Director.

As the federal licensee, the MR subcontractor is required by law to report the theft or loss of explosives to the ATF within 24 hours (27 CFR 55.30). In the event of such an occurrence, the following procedures will be followed:

- The area will be sealed until the appropriate authorities complete their investigation.
- The MR subcontractor will make the appropriate notifications per 27 CFR 55.30, which include calling the **ATF (1-800-424-9555)** and the local law enforcement authorities.
- The MR subcontractor is responsible for completing and forwarding ATF Form 5400.5, *Report of Theft or Loss – Explosive Materials.* This form will be completed by the SUXOS and provided to the MR Operations Director, MR Market Segment Director, PM, and the UXOQCS. Final disposition of the form will be the responsibility of the MR Operations Director.

SECTION 4

Explosives Siting Plan

This Explosives Siting Plan provides explosives safety criteria for planning and siting explosives operations for MEC intrusive investigations at MCB Camp Lejeune MRP sites. This plan was prepared in accordance with DID FPRI-005-04.

4.1 Demolition Areas

If MEC detonation areas are established, the locations will be specified in the SSWP. If MEC is not safe to move, it will be blown in place where it is found. With the concurrence of the UXOSO, items that are acceptable to move may be consolidated at one location to reduce the number of demolition shots and the fragmentation contamination.

The SUXOS and a UXO Technician III will evaluate the recovered MEC and existing ESQD arcs to confirm that disposal by detonation can be performed safely (see Section 2.5.5).

4.2 BIP

Prior to the initiation of demolition operations, all non-essential personnel within the EZ will be evacuated from the detonation site. The appropriate local authorities will be notified of the time and place of the demolition operation. Prior to priming the demolition charges, all avenues of ingress will be physically blocked by guard personnel. Radio communications will be maintained between the involved parties at all times. Upon completion of disposal operations, the Disposal Team's UXO Technician III and the UXOSO will inspect each disposal shot; the UXOSO will visually inspect the disposal site(s) and the UXO Technician III will stand by at a safe distance, ready to render assistance in the event of an emergency. Upon completion of this inspection and if no residual hazards have been identified, the SUXOS will authorize the resumption of site operations.

4.3 Collection Points

BIP will be the preferred method of MEC demolition. However, if UXO collection points are used, their locations will be specified in the SSWP. Suspect items that are acceptable to move and items requiring demilitarization may be relocated within the grid in order to be added to other planned demolition shots. All items will be disposed of on a daily basis or guarded; therefore, no items will be stored.

4.4 In-grid Consolidated Shots

MEC items that are safe to move may be consolidated at one location to reduce the number of demolition shots and fragmentation contamination. Consolidated shots will be conducted only with the approval of the UXOSO.

4.5 Safe Holding Areas

MEC and MPPEH items encountered will be left in place pending response by the SUXOS. The location of the item will be marked with caution tape. At least one UXO technician will be assigned as a guard to ensure that no one disturbs the item.

A designated secure area will be established for collection of MD. This area will be locked and will have controlled access.

SECTION 5

Geophysical Prove-out Plan

Prior to commencing the DGM survey, the selected geophysical equipment and survey methodologies will be tested, evaluated, and demonstrated as meeting the data quality objectives (DQOs) in the GPO plan (Appendix A). The information collected during the GPO will be analyzed and used to select or confirm that the selected geophysical system will meet the DQOs established for the geophysical survey. The GPO will be conducted in the location specified in the SSWPs.

SECTION 6

Geophysical Investigation Plan

Where DGM is to be conducted, it will be accomplished according to procedures provided in each SSWP. The GIP provided in Appendix B provides details of the equipment, approach, methods, operational procedures and QC to be used in performing the geophysical investigations.

SECTION 7

Field Investigation Plan

7.1 Field Operations

In order to evaluate the presence or absence of environmental contamination by hazardous and toxic waste (HTW) or munitions constituents (MC), groundwater, surface water, soil, and sediment samples may be collected for laboratory analyses.

Environmental samples will be collected as described below and in accordance with the MPPs (CH2M HILL, 2005). MEC anomaly avoidance procedures, which will be described in the site-specific HSPs, will be used during intrusive activities.

7.1.1 Surface Soil Sampling

Surface soil samples will be collected following CH2M HILL Standard Operating Procedure (SOP) C.1, *Systematic Random Multi-Increment (MI) Sampling* (Appendix C). The number of decision units, their locations, and the analytical parameters for samples collected from those decision units will be described in each SSWP.

7.1.2 Subsurface Soil Sampling

A DPT rig will be used to collect subsurface soil samples in accordance with CH2M HILL SOP C.2, *Direct Push Soil Sample Collection* (Appendix C), and the MPPs (CH2M HILL, 2005). MEC anomaly avoidance procedures will be described in the site-specific HSP. The locations, sample intervals, and the analytical parameters for subsurface soil sampling will be described in each SSWP.

7.1.3 Monitoring Well Installation and Development

Temporary and/or permanent groundwater monitoring wells may be installed for the collection of groundwater samples. The number of wells to be installed and well locations will be discussed in each SSWP. General installation procedures are described below.

Temporary monitoring wells will be installed in the shallow and intermediate aquifers using DPT rigs or hollow stem auger (HSA) drilling techniques. The temporary monitoring wells will be installed in accordance with Navy CLEAN SOPs, CH2M HILL SOP C.3, *Temporary Monitoring Well Installation* (Appendix C), and the MPPs (CH2M HILL, 2005).

Following sampling of temporary monitoring wells, all the soil boreholes will be abandoned by the drilling subcontractor following NCDENR guidelines by grouting from the bottom of the boring to the ground surface. Boreholes within asphalt or concrete slab will be patched at the surface. All temporary wells will be properly abandoned within 5 days of installation.

Type II permanent monitoring wells will be installed in the shallow aquifer using HSA drilling techniques, while the Type III cased well will be installed in an intermediate aquifer zone using both HSA and mud rotary drilling techniques. The monitoring wells will be installed in accordance with Navy CLEAN SOPs, CH2M HILL SOPs C.4, *Installation of*

Shallow Monitoring Wells and *Installation of Surface-Cased Monitoring Wells* (Appendix C), and the MPPs (CH2M HILL, 2005). Standard split-spoon soil samples will be collected from each well boring for lithological descriptions and volatile organic compound (VOC) screening. MEC anomaly avoidance procedures will be described in the site-specific HSP. The location for any monitoring wells as well as the type of monitoring well to be installed will be described in the SSWPs.

In order to limit potential cross-contamination during construction, the Type III intermediate well will be constructed utilizing a permanent casing to isolate the surficial aquifer unit. The boring for the surface casing will be advanced using rotary hollow-stem augers. Once the target depth for the surface casing is reached, a 6-inch diameter Schedule 80 polyvinyl chloride (PVC) casing will be positioned in the boring and grouted in place. After the grout has cured for a minimum of 24-hours, the well boring will be advanced through the surface casing down to the intermediate aquifer zone using mud rotary drilling techniques.

The screened interval for wells will be placed on the basis of the lithology data collected during the borehole installations. In general, layers having assumed higher permeability than adjacent layers will be selected for screening. This is consistent with well installations at other MCB Camp Lejeune IRP sites and with the MPPs (CH2M HILL, 2005). Precise well construction depths will be determined in the SSWPs or in the field following review of the boring logs. Boring logs and well completion diagrams will be provided in the report.

The monitoring wells will be constructed using 2-inch diameter Schedule 40 PVC riser and either 10-ft (shallow wells) or 5-ft (intermediate wells) of 10-slot (0.010-inch) PVC screen. Each monitoring well will be completed at the surface with either an 8-inch diameter steel, manhole type, protective cover with concrete pad or a steel, stick-up protective cover with concrete pad (depending on the location of the well). The drilling and well installation activities will be conducted by a NC-licensed well driller under the supervision of a CH2M HILL engineer or hydrogeologist in accordance with the Well Construction Standards provided in the NC Administrative Code (NCAC) 15A Subchapter 2C Section 0100.

Each new monitoring well will be developed within 48 hours after installation depending on scheduled field activities. Wells will be developed in accordance with Navy CLEAN SOPs, CH2M HILL SOPs, and the MPPs (CH2M HILL, 2005). Well development will include surging and over pumping with a submersible pump across the length of the well screen. With respect to the volume of groundwater removed, adequate well development is normally achieved when the column of water in the well is free of visible sediment. With respect to groundwater geochemical parameters, adequate development is achieved when the pH, specific conductance, and temperature of the groundwater have stabilized and the turbidity has either stabilized or is below 10 nephelometric turbidity units (NTUs). Stabilization occurs when pH measurements remain constant within 0.1 standard unit (SU), specific conductance varies no more than 10 percent, and the temperature is constant for three consecutive readings. Readings will be taken following purging of a minimum of one sampling system volume after the preceding reading. Sampling system volume consists of the volume in the pump, discharge tubing, and flow through cell (if used).

7.1.4 Monitoring Well Sampling

Groundwater Elevation Measurements

Groundwater elevations will be measured in each well to be sampled immediately prior to sampling activities using a decontaminated portable electric water level indicator. Depth will be measured from a reference point at the top of the PVC casing. Upon recording groundwater elevation data, the water level indicator will be lowered to the bottom of each well to record the well's total depth and determine the presence of sediment within each well. All measurements will be made consecutively within a 1-hour time frame and immediately recorded in a dedicated field logbook. These data will also be used to estimate general groundwater flow direction.

Well Purging and Water Quality Measurements

Prior to sampling, each monitoring well will be low-flow purged. During the monitoring well low-flow purging, field parameters of groundwater pH, specific conductance, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity will be measured using portable meters calibrated in the field. Groundwater samples will be collected after (1) field parameters have become stable over three consecutive readings and at least one well volume has been purged, or (2) at least three well volumes have been purged from the well.

Purge waters will be collected and containerized and managed in accordance with the IDW management procedures described in Section 10.

Groundwater Sample Collection and Analysis

Groundwater samples will be collected in accordance with Navy CLEAN SOPs, CH2M HILL SOP C.5, *Low-Flow Groundwater Sampling from Monitoring Wells* (Appendix C), and the MPPs (CH2M HILL, 2005). The locations and the analysis for any groundwater samples to be collected will be described in the SSWPs.

7.1.5 Surface Water and Sediment Sampling

Surface water and sediment samples will be collected in accordance with CH2M HILL SOPs C.6, *Surface Water Sampling* and C.7, *Sediment Sampling* (Appendix C) and the MPPs (CH2M HILL, 2005).

7.2 Data Documentation and Processing Procedures

During the investigation, three types of data will be generated: field, laboratory, and investigation interpretive. This subsection presents documentation and processing procedures for the data.

7.2.1 Field Data

The field team will document all field activities, including any visits to the site by regulatory personnel or their contractors, in a bound field logbook. The logbook will also be used to document, explain, and justify all deviations from the approved WP and MPPs (CH2M HILL, 2005). Its pages will be water-resistant and will be consecutively numbered.

Indelible ink, preferably black, will be used to record entries in the field logbook. Each page will be dated and signed by the individual making the entry. The field logbook should provide a summary of the field activities.

The sampling team will record in the field logbook sampling information, physical and geological information, and any field measurements (e.g., pH, temperature) taken during sampling. The sample identification system in the SSWPs will be used to identify each sample, in accordance with Camp Lejeune protocol. An identification label will be affixed on each sample container sent to the laboratory.

A copy of all field logbook entries and COC records will be made available to NAVFAC upon request.

7.2.2 Laboratory Data

Upon their arrival at the laboratory, the samples will be cross-referenced against the COC records. All sample labels will be checked against the COC, and any mislabeling will be identified, investigated, and corrected prior to the sample login at the laboratory when possible. The samples will be logged in at every storage area and work station required by the designated analyses. Individual analysts will verify the completeness and accuracy of the data recorded on the forms.

Raw data will be entered by the analysts in bound laboratory notebooks. A separate book will be maintained for each analytical procedure. All calculations will be entered into designated laboratory notebooks with a sufficient amount of data to compute without reference to other documents. A tracking form will be used to show that at least 10 percent of all calculations have been checked by the analyst and the laboratory QA supervisor from the raw data to the final value stages prior to reporting the results of a group of samples. This tracking form, as well as all logs and calculations, will be made available for any QA audit conducted during the investigation.

Instrument calibration logs and internal quality control procedures will be documented in accordance with the analytical method in use. Documentation of these activities will be made available during QA audits.

The reporting requirements will be in accordance with the Contract Laboratory Program (CLP) Statement of Work OLM04.3 for organics analysis and ILM05.2 for inorganics analysis, or other specified analytical method.

Copies of all the analytical data reports, including the QC data, will be maintained by CH2M HILL in the project files.

7.2.3 Investigation Results

The results of the investigation will be presented in tabular and graphical formats, as well as descriptive and interpretive text. The raw data will be included in a tabular format in appendices of the subsequent investigation report. The following data, as appropriate, will be presented in tables:

- Water level elevations
- Sampling location coordinates
- Comparative data between study areas and background areas

Graphs or figures will be used to depict the following, as appropriate:

- Layout and topography
- Sampling locations
- Boundaries of sampling locations
- Stratigraphy and water level elevations
- Horizontal extent of contamination
- Vertical distribution of contaminants

7.3 Project File Requirements

This project will require the administration of a central project file. The data and records management protocols will provide adequate controls and retention of all materials related to the project. Record control will include receipt from external sources, transmittals, transfer to storage and indication of record status. Record retention will include receipt at storage areas, indexing, filing, storage, maintenance, and retrieval.

7.3.1 Record Control

All incoming materials related to the project, including sketches, correspondence, authorizations, and logs, shall be forwarded to the PM or designated assistant. These documents will be placed in the project file. Project personnel will work from a copy of the necessary documents. All records shall be legible and easily identifiable.

Examples of the types of records that will be maintained in the project file are:

- Field documents
- Correspondences
- Photographs
- Laboratory data
- Reports
- Procurement agreements

Outgoing project correspondence and reports will be reviewed and signed by the PM.

7.3.2 Record Status

To prevent the inadvertent use of obsolete or superseded project-related procedures, the project team members will be responsible for reporting changes in protocol to the CH2M HILL PM. The PM will then inform other members of the Project Team and the Project Quality Assurance Officer of these changes.

Revisions to procedures shall be subject to the same level of review and approval as the original document. The revised document will be distributed to all holders of the original document and discussed with project personnel. Outdated procedures will be marked "void." One copy of a document marked "void," along with the reason(s) for marking the document "void" will be maintained in the project file. In addition, the date a document is marked "void" will be recorded.

7.3.3 Record Storage

All project related information will be maintained by CH2M HILL for the duration specified by contract N62470-02-D-3052. Designated personnel will assure that incoming records are legible and in suitable condition for storage. Record storage will be performed in two stages: storage during and immediately following the project, and permanent storage of records directly related to the project.

CH2M HILL will use storage facilities providing a suitable environment, one that will minimize deterioration or damage and prevent loss. Records will be secured in steel file cabinets labeled with the appropriate project identification. CH2M HILL will use Microsoft Excel for data storage. Data will be maintained on CD-ROM and backed up each time a file is edited. Upon presentation of data to MCB Camp Lejeune, a backup of that version will be permanently stored in the central filing location.

At the completion of the project, the PM or his appointed document custodian will be responsible for the project file inventory. All material from the project file, including drawings, project related QA documents, and electronic project documentation and verification records will be maintained by CH2M HILL for the duration specified by contract N62470-02-D-3052.

At the termination of the CLEAN III program, all project files, laboratory data, and reports will be archived and returned to the Navy according to Navy guidance.

7.4 Geospatial Information and Electronic Submittals

7.4.1 General Information

This subsection describes the methods, equipment, and accuracy requirements for conducting location surveys and mapping. This plan also identifies the requirements for the electronic submittal of documents, mapping, and GIS data.

All geospatial data will conform to the computer-aided drafting (CAD)/GIS Technology Center Spatial Data Standards for Facilities Infrastructure and Environment and will be provided in metric units.

7.4.2 Surveying

Horizontal and vertical control of Class I, Third Order or better will be established for the network of monuments. Horizontal control will be based on the metric system and referenced to the North American Datum of 1983 (NAD83) and the Universal Transverse Mercator Grid System. Vertical control will also be based on the metric system and referenced to the North American Vertical Datum of 1988 (NAVD88).

If new control points are established, they will be of a permanent nature to allow for future recoverability. All control points will be established using iron or steel pins, concrete monuments, or other permanent construction method.

A professional land surveyor licensed in the State of North Carolina will certify all survey data. The professional land surveyor will use either real-time kinematic (RTK) differential global positioning system (DGPS) or conventional geodetic survey instruments to collect or emplace points. Upon completion of the field work, the eastings and northings (x,y) for all control points and sampling locations will be presented in a certified letter or drawing, along with an electronic submittal of the same.

Geophysical surveying will be conducted by the geophysical subcontractor using RTK DGPS connected to their DGM systems.

Portable global positioning satellite (GPS) systems may also be used to determine horizontal coordinates for points, such as sampling locations.

7.4.3 Geographic Information System Incorporation

Environmental Systems Research Institute, Inc. (ESRI)–compliant formats (shapefiles, coverages, or geodatabases) will be used to present GIS data during the project, with supporting tabular data provided in Microsoft Excel format, Microsoft Access format, or both, as needed.

7.4.4 Plotting

All of the control points recovered and/or established at the site will be plotted at the appropriate coordinate points on reproducible electronic media for production of planimetric or topographic maps at scales appropriate for the parcel size being described.

7.4.5 Mapping

The location, identification, coordinates, and elevations of all control points that are recovered and/or established at the site will be plotted on one or more site maps. Each control point will be identified on the map by its name and number and the final adjusted coordinates.

Each map will include a legend showing the standard symbols used for the mapping, a north arrow, and a title block.

7.4.6 Digital Data

Location information will be collected as part of the DGM survey and will be sufficient to accurately relocate the position of geophysical anomalies in the field and accurately plot the position of each anomaly in the GIS.

7.4.7 Computer Files and Digital Data Sets

All final document files, including reports, figures, and tables, will be submitted in electronic format. These files will be compatible with Microsoft Office 97 or later formats or in portable document format (PDF) on CD-ROM.

SECTION 8

Quality Control Plan

This QCP describes the QC approach and procedures for the MRP sites and references the MCB Camp Lejeune Master Quality Assurance Project Plan (QAPP) (CH2M HILL, 2005). The QCP is divided into two parts: Section 8.1 addresses environmental investigation activities and Section 8.2 addresses MEC avoidance, surveying, and DGM activities.

The requirements and systems established in this QCP are relevant and applicable to project work performed by CH2M HILL and its subcontractors.

8.1 Environmental Investigation Quality Assurance Objectives

DQOs are qualitative and quantitative statements that specify the quality of data required from field and laboratory data collection activities to support decisions concerning risk and remediation. DQOs are established prior to data collection and describe what data are needed, why the data are needed, and how the data will be used to address the problems being investigated. DQOs help to ensure that all data collected are legally and scientifically defensible.

The environmental QC forms referenced in this section are provided at the end of the section.

8.1.1 Levels of Data Quality

Three categories of data will be collected as part of the field effort under this Master WP, and each category has a different level of supporting QA/QC documentation. Level 1 includes field monitoring activities, such as pH, conductivity, temperature, and turbidity. Level 2 includes the analyses associated with the characterization of the IDW samples. All other samples will be submitted to the laboratory for Level 3 or 4 analyses. For each QC level, the measures and methods to be used, as well as the applicable data package deliverables, are outlined below.

Level 1—Field Surveys

Level 1 encompasses field monitoring or screening activities and does not require formal data package deliverables. Level 1 activities are focused on easily-measured characteristics of a sample such as pH, conductivity, and temperature as well as characteristics with short holding times. The data generated from field surveys are used to make decisions about the execution of the investigation or to provide general sample screening before laboratory analysis.

Monitoring results, as well as pertinent data concerning the sampling event, will be documented in the field logbook. Level 1 documentation will consist of the following:

- Instrument identification
- Calibration information (standards used and results)
- Date and time of calibration and field measurements
- Field measurement results

The logbooks will be reviewed daily by the FTL for completeness and correctness. No additional documentation or data quality evaluation is required.

Level 2—IDW Analyses

Level 2 includes the samples submitted to the laboratories for IDW characterization. Samples submitted for analysis under Level 2 will require the delivery of an analytical data package. Level 2 documentation will consist of the following:

- Case narrative
- Sample results
- Selected QC information such as surrogate recovery
- Associated blank results
- Completed COC form and sample receipt information

Levels 3 and 4—Laboratory Analyses

The purposes of Levels 3 and 4 data include determining the nature, extent, and potential fate and transport of HTW contamination at the MRP sites.

Samples will be analyzed for the constituents presented in the SSWPs. USEPA-approved methods from *Superfund Analytical Services/Contract Laboratory Program Multi-Media, Multi-Concentration Organics Analysis, OLM04.3*[1] and from the current edition of publication SW-846, *Test Methods for Evaluating Solid Waste,*[2] will be used to analyze samples where appropriate. In addition, the DOD Perchlorate Handbook (DOD, 2007) should be referenced for requirements related to perchlorate analysis. Data package deliverables are summarized below in Table 8-1.

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[1] Available at http://www.epa.gov/superfund/programs/clp/olm4.htm

[2] Available at http://www.epa.gov/epaoswer/hazwaste/test/main.htm#table.

TABLE 8-1
Levels 3 and 4 Data Package Deliverables (Standard Deliverable Package)

All Analytical Fractions
Case Narrative
Sample ID Cross Reference Sheet (Lab IDs and Client IDs)
Completed COC form and any sample receipt information
Any analytical/procedural changes (copies of “Confirmation of Communication”)
Copies of non-conformance memos and corrective actions
Gas Chromatograph/Mass Spectrometer Organic Analyses
Form 1—Sample Results
Form 2—Surrogate Recovery Summary
Form 3—MS/MSD Accuracy and Precision Summary
Form 4—Method Blank Summary
Form 5—Instrument Tuning Summary
Form 6—Initial Calibration Summary
Form 7—Continuing Calibration Summary
Form 8—Internal Standard Summary
General Chemistry
Includes potentiometric, gravimetric, colorimetric, and titrimetric analytical techniques. The following forms must be included (where applicable)
Form 1—Sample Results
Form 2A—Initial and Continuing Calibration Summary
Form 3—Initial and Continuing Calibration Blanks and Method Blanks Summary
Form 5A –MS/MSD Recoveries Summary
Form 6—Native Duplicate and MS/MSD Precision Summary
Form 7—Laboratory Control Sample Recovery Summary
Form 10—Instrument or Method Detection Limit Summary
Form 13—Preparation Log Summary
Level 4 only
Note: In addition to all the forms above, Level 4 data packages include all instrument printouts, chromatograms and spectra, bench logs, and any other raw data sufficient for the validator to follow the path of each sample in the analysis process, to examine the chemist’s interpretations, and to allow re-calculation of concentrations.

8.1.2 Quality Assurance Objectives for Chemical Data Management

Analytical performance requirements are expressed in terms of precision, accuracy, representativeness, comparability, and completeness (PARCC). Brief definitions for each parameter are presented below.

Precision

Precision is a measure of the agreement or repeatability of a set of replicate results obtained from duplicate analyses made under identical conditions. Precision is estimated from analytical data and cannot be measured directly. The precision of a duplicate determination can be expressed as the relative percent difference (RPD).

Accuracy

Accuracy is a measure of the agreement between an experimental determination and the true value of the parameter being measured. Accuracy is estimated through the use of known reference materials or matrix spikes. It is calculated from analytical data and is not measured directly. Spiking of reference materials into a sample matrix is the preferred technique because it provides a measure of the matrix effects on analytical accuracy. Accuracy is defined as percent recovery.

Representativeness

Representativeness is a qualitative measure of the degree to which sample data accurately and precisely represent a characteristic environmental condition. Representativeness will be assessed by reviewing the presence/absence of contaminants in method blanks, trip blanks, and equipment blanks; sample condition/integrity upon receipt and storage at the laboratory; and laboratory adherence to sample holding times. In addition, the effects of sample matrix interferences, if any, will be evaluated to determine possible data impact.

Comparability

Comparability is another qualitative measure designed to express the confidence with which one data set may be compared to another. Sample collection and handling techniques, sample matrix type, and analytical method all affect comparability. Comparability is limited by the other PARCC parameters because data sets can be compared with confidence only when precision and accuracy are known.

Completeness

Completeness is defined as the percentage of valid measurements compared to the total number of measurements made for a specific sample matrix and analysis. The completeness goal for analytical data is 90 percent. All validated data, with the exception of data rejected by the validator, will be used. During the data validation process, an assessment will be made of whether the valid data are sufficient to meet project objectives. If sufficient valid data are not obtained, corrective action will be initiated by the PM.

8.1.3 Sampling Procedures

Sampling locations and procedures are discussed in each site-specific WP.

8.1.4 Sample Custody

A sample is physical evidence collected from a hazardous waste site, the immediate environment, or another source. Because of the potential evidentiary nature of samples, the possession of samples must be traceable from the time the samples are collected until they are introduced as evidence in enforcement proceedings.

COC procedures are used to maintain and document sample possession for enforcement purposes. The principal documents used to identify samples and to document possession are the following:

- Packing lists
- COC records
- Air bills (such as FedEx, UPS)
- Field logbooks
- Color photographs of the field activities

Sample custody and COC records will be maintained by the field team until delivered to the laboratory. Sample shipping information from each day will be maintained by the FTL and relayed to the laboratory as soon as possible after sample pickup. These documents could be introduced as evidence should a site investigation result in legal action. To document sample possession, COC procedures are followed.

Definition of Custody

A sample is under the field team's custody if one or more of the following criteria are met:

- It is in the field team's possession
- It is in the field team's view after being in the field team's possession
- It was in the field team's possession and then the field team locked it up to prevent tampering
- It is in a designated secure area

Field Custody

In collecting samples, the amount collected should be only enough to provide a good representation of the media being sampled. To the extent possible, the quantity and types of samples and sample locations are determined before the actual field work begins.

The following procedures will be used to document, establish, and maintain custody of field samples:

- Labels will be completed for each sample with indelible ink, making sure that the labels are legible and affixed firmly on the sample container. Labels will be taped-over with clear packing tape to ensure they do not separate from the bottles.
- Samples will be placed on ice immediately upon collection.
- All sample-related information will be recorded in the site logbook.
- The field sampler will retain custody of the samples until they are transferred or properly dispatched.
- To simplify the COC record and minimize potential problems, as few people as possible will handle the samples or physical evidence. One individual from the field sampling team will be designated as the responsible individual for all sample transfer activities.

This field investigator will be responsible for the care and custody of the samples until they are properly transferred to another person or facility.

- All samples will be accompanied by a COC record, which documents the transfer of custody of samples from the field investigator to another person, the laboratory, or other organizational elements. Each change of possession must be accompanied by a signature for relinquishment and receipt of the samples.
- Completed COC forms will be placed in a plastic cover, which is then placed inside the shipping container used for sample transport from the field to the laboratory.
- When samples are relinquished to a shipping company for transport, the tracking number from the shipping bill or receipt will be recorded on the COC form or in the site logbook.
- Custody seals will be used on the shipping containers when samples are shipped to the laboratory to inhibit sample tampering during transportation.

Sample Labels

The sampling location identification and sample labeling, handling, and shipping must be performed using standardized and well-documented procedures so that a sample can be tracked to its point of origination. Tracking will be performed from the time of sampling until the analytical data are released from the laboratory. The effectiveness of the tracking process will determine the integrity of the samples. Therefore, a sample-numbering system with a tracking mechanism that allows the retrieval of sample information including sampling locations, date, time, and analytical parameters must be used. Procedures for this system are provided in the SSWPs. The method of sample identification to be used depends on the type of sample collected and container used, as follows:

- Samples collected for *in situ* field analysis are those collected for specific field analyses or measurements for which the data are recorded directly in the field logbooks or recorded on field data sheets, along with sample identity information, while in the custody of the sampling team. Examples are samples for measurement of field pH, specific conductance, and temperature.
- Samples other than those collected for *in situ* field measurements or analyses are to be identified on a sample label affixed to the sample container by the sampling personnel. The following information must be included on the label:
  - Laboratory
  - Project name (and number where appropriate)
  - Sample ID
  - Station ID
  - Date (for key to sampling round)
  - Preservation
  - Analysis
  - Sampler’s initials, date, and military time

COC Record

Samples are accompanied by a COC record, which will contain the information described in the next section.

Transfer-of-Custody and Shipment

When transferring samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the COC record. This record documents custody transfer from the sampler to the analyst at the laboratory.

Samples will be packaged properly for shipment and dispatched to the appropriate laboratory for analysis, with a separate COC record accompanying each shipping container. Shipping containers will be sealed with custody seals for shipment to the laboratory. Courier name(s) and other pertinent information will be entered in the '"Received By" section of the COC record.

When samples are split with a facility owner or agency, this information will be noted in the "Sample Remarks" section of the COC record and will be signed by both the sampler and the recipient. If the split is refused, the refusal will be noted and signed by both parties. The "Sample Remarks" section will also indicate if a representative is unavailable or refuses to sign. When appropriate, as in the case of the representative being unavailable, the COC record should contain a statement that the samples were delivered to the designated location at the designated time.

All shipments will be accompanied by the COC record identifying their contents. The original record and yellow copy will accompany the shipment to the laboratory, and the pink copy will be retained by the FTL.

If sent by mail, the package will be registered with return requested. If sent by common carrier, a bill of lading will be used. Freight bills, postal service receipts, and bills of lading will be retained as part of the permanent documentation.

Laboratory COC Procedures

When samples are shipped to the laboratory, they will be placed in containers that are sealed on each side with at least one custody seal. A designated sample custodian will accept custody of the shipped samples following the procedure outlined below.

When sample analyses and necessary QA checks have been completed in the laboratory, the unused portion of the sample will be disposed of properly. All identifying stickers, data sheets, and laboratory records will be retained as part of the documentation. Sample containers and remaining samples will be disposed in compliance with all federal, state, and local regulatory requirements.

Sample Receipt A designated sample custodian will accept custody of the shipped samples and verify that the packing list sample numbers match those on the COC record. The custodian will enter pertinent information as to shipment, pickup, and courier in the "Sample Remarks" section of the COC record and enter the sample numbers into a field logbook, which is arranged by project code and station number. Upon receipt of the samples, the custodian will check the original COC and request-for-analysis documents and compare them with the labeled contents of each sample container for corrections and traceability. The sample custodian will sign the COC and record the date and time received. The sample custodian also will assign a unique laboratory sample number to each sample. Cooler temperature (temperature vial) will be checked and recorded.

Care will be exercised to annotate any labeling or descriptive errors. If discrepancies occur in the documentation, the laboratory will immediately contact the FTL as part of the corrective action process (refer to Section 8.2.5). A qualitative assessment of each sample container will be performed to note anomalies, such as broken or leaking bottles. This assessment will be recorded as part of the incoming COC procedure.

Sample Storage The laboratory custodian will use the sample identification number and assign a unique laboratory number to each sample, and is responsible for seeing that all samples are transferred to the proper analyst or stored in the appropriate secure area. The laboratory will send a sample acknowledgement letter to the PM or FTL as a record of the shipment's arrival and the condition of the containers. Any discrepancy will be identified by the laboratory custodian, and corrective actions taken. The Project Chemist (PC) may need to provide guidance concerning additional actions. A copy of the sample acknowledgement letter will be retained with the COC by the PM.

Data Recording The custodian will distribute samples to the appropriate analysts. Laboratory personnel are responsible for the care and custody of samples from the time they are received until the sample is exhausted or returned to the custodian. The data from sample analyses are recorded on the laboratory report form.

Documentation Procedures

Field documentation for activities at MCB Camp Lejeune will consist of one or more site-specific field logbooks and any necessary field forms as described in Section 7.2. Each logbook will be identified uniquely by project task and consecutively numbered. For extended field activities, logbooks will be maintained onsite until complete, then stored in the project files.

Photographs will be taken during key field activities.

Sample Identification Sample identification procedures are identified in the SSWPs. The sample designation format will be followed throughout the project. Required deviations from this format in response to field conditions will be documented.

Field Logs Field logs will consist of all associated field logbooks and any necessary field forms.

Site Logbook The site logbook chronicles field investigation activities, but does not have the same level of detail as the field logbook. The site logbook delineates conditions and activities that occur on a given day and references the appropriate field logbooks and forms for specific information. The site logbook also is used to record field changes, along with supporting rationale (refer to Form 8-1a, at the end of this section).

The person responsible for the field effort will complete the site logbook. Pages will not be removed from the document. Partially used pages will be lined out, dated, and initialed to prevent data entry at a later date.

The front cover or first page of the site logbook must list the project name, the project number, and dates of use. The following items are to be included, as appropriate to the work scope, in the site logbook:

- Date
- Weather conditions
- List of CH2M HILL personnel, subcontractor personnel, and site visitors by name, title, organization, and purpose, who entered the project area during the day
- Brief descriptions of activities conducted
- Field changes or variances with references to the appropriate documentation of these changes
- Specific comments related to peculiar problems that occurred during the day, if any, and their resolution

Field Logbook

Information required on the cover of the site logbook also must be provided on the cover of each field logbook. Entries in the field logbook must be continuous through the day. Pages, as well as the logbooks themselves, are numbered consecutively. The following information should be included in the field logbook:

- Date, time of specific activities, and physical location
- Weather conditions
- Names, titles, and organization of personnel onsite, names and titles of visitors, and times of visits
- Field observations, including specific details on sampling activities (including type of sampling, time of sampling, and sample numbers), a description of any field tests and their results, and references to any field forms used and type of document generated
- A detailed description of samples collected and any splits, duplicates, matrix spikes, or blanks that were prepared. A list of sample identification numbers, packaging numbers, and COC record numbers pertinent to each sample or referenced to the appropriate documentation should be noted
- Specific problems, including equipment malfunctions and their resolutions
- A list of times, equipment types, and variations of decontamination procedures followed or a reference to the appropriate documentation
- Photograph records

Additional information may be recorded at the discretion of the logbook user. Information to be recorded may include the following:

- Identification of well
- Static water level, depth, and measurement technique

- Presence of immiscible layers and detection methods
- Collection method for immiscible layers and sample identification numbers
- Total depth of well
- Well yield
- Purge volume and pumping rate
- Well purging times and volumes
- Sample withdrawal procedure
- Date and time of collection
- Well sampling sequence
- Types of sample containers and sample identification numbers
- Preservatives used
- Laboratory analyses requested
- Field analysis data and methods
- Sample distribution and transporter

Corrections to Documentation All original handwritten data recorded in field logbooks, sample identification tags, COC records, and receipts-for-sample forms will be written in black, indelible ink. Corrections must be marked with a single line, dated, and initialed. No accountable control documents (such as site, field, and calibration logbooks) are to be destroyed or discarded, even if they are illegible or contain inaccuracies that require a replacement document.

If an error is made on an accountable document assigned to one team member, the FTL may make corrections simply by drawing a single line through the error and entering the correct information. The erroneous information should not be obliterated. Any subsequent error discovered on an accountable document should be corrected by the person who made the entry. All subsequent corrections must be initialed and dated.

Final Evidence File Documentation Documentation, including voided entries, must be maintained within project files.

8.1.5 Calibration Procedures

Field and laboratory equipment must operate satisfactorily within specified operating limits before it can be expected to produce reliable and usable data for a project. Documentation concerning the calibration laboratory equipment should include instrument type, calibration frequency, reference standards used, calibration acceptance criteria, and calibration documentation procedures. Calibration applies to field and laboratory instruments, including balances, refrigerators, and ovens.

Instrument testing is primarily achieved by following the manufacturer’s instructions with regard to proper voltages, carrier gas flow rates, temperatures, mass or retention time windows, and certified calibration standards. Practically all instruments come with manufacturer’s instructions for initial setup, routine checks, corrective actions, and preventive maintenance.

Field Instruments

Field instruments will be calibrated at the beginning of each day using the method described by the manufacturer’s instructions and then checked periodically during the day and at the end of the measurement period. Standards used to calibrate the field survey instruments will be traceable to National Institute of Standards and Testing standards. All instrument calibration activities are documented in the field logbooks.

The water quality indicators will be decontaminated before each sample is measured. The probes will be rinsed three times with American Society of Testing and Materials (ASTM) Type II water before storage each day. The meters will be checked for battery charge and physical damage each day. The meters and standard solutions will be stored in a cool, dry environment. Standard solutions will be discarded before they expire.

All field instruments will be set up and operated in strict accordance with the manufacturer's instructions. When the operation of these instruments needs modification because of specific site or sample conditions, such modification will be documented in the instrument logs and field logbooks.

Laboratory Equipment

Laboratory instruments will be calibrated in accordance with the manufacturer's directions and applicable method specifications. Laboratory instrument calibration procedures will be summarized in the laboratory's quality assurance plan, which will be reviewed and approved by the PC or designee before samples are submitted for analysis.

8.1.6 Analytical Procedures

Field Testing and Screening

All field parameters will be analyzed in accordance with SOPs for the individual equipment. Field parameters are discussed in the SSWPs.

Laboratory Methods

The parameters to be analyzed and the specific analytical methods to be used will be specified in each SSWP. Analytical methods commonly employed at MR sites are shown on **Table 8-2**, which also identifies requirements for container types, preservation and storage, and holding times.

8.1.7 Data Reduction, Validation, and Reporting

The data quality evaluation process is used to assess the effect of the overall analytical process on the usability of the data.

Level 1—Field Survey Data

Field instruments used to collect field survey data (or bulk measurements, such as pH or conductivity) are direct readings, thus making field calculations and subsequent data reduction unnecessary. Field data will be recorded in the site logbooks by appropriately trained field personnel. Field data will include the following:

- Instrument identification
- Calibration information (standards used and results)
- Date and time of calibration and sample measurement

- Sample results
- Supporting information if appropriate
- Data will be reviewed by the FTL, who is responsible for the collection and verification of all field data while in the field. Data initially will be accepted or rejected by the FTL before leaving the sampling site. Extreme readings (readings that appear significantly different from other readings at the same site) will be accepted only after the instrument has been checked for malfunction and the readings verified by re-testing.

Field documentation, sample data, instrument calibrations, and QC data will be reviewed by the PM (or a designee) before being included in the project files.

Laboratory Quality Control Assessments

The data quality assessment process is used to assess the effect of the overall analytical process on the usability of the data. The two major categories of data evaluation are laboratory performance and matrix interferences. Evaluation of laboratory performance is a check for compliance with the method requirements and identifies whether the laboratory did, or did not, analyze the samples within the limits of the analytical method. Evaluation of the matrix interferences is more subtle and involves analysis of several results including surrogate spike recoveries, matrix spike recoveries, and duplicate sample results.

Before the analytical results are released by the laboratory, both the sample and QC data will be reviewed carefully to verify sample identity, instrument calibration, detection limits, dilution factors, numerical computations, accuracy of transcriptions, and chemical interpretations. Additionally, the QC data will be reduced and spike recoveries will be included in control charts, and the resulting data will be reviewed to ascertain whether they are within the laboratory-defined limits for accuracy and precision. Any non-conforming data will be discussed in the data package cover letter and case narrative. The laboratory will retain all of the analytical and QC documentation associated with each data package.

Level 2—Screening Analyses

Level 2 data includes the samples submitted to the laboratories for physical parameter testing and IDW characterization. Samples submitted for Level 2 analysis will require the delivery of a limited data package, which includes:

- Case narrative
- Sample results
- Selected QC information, such as surrogate recovery
- Associated blank results
- Completed COC forms and sample receipt information

The PC or designee will review the supporting information and will provide a summary report to the PM at the end of the field effort.

Level 3—Data Quality Review

An internal data quality review will consist of the following will not include recalculation of analytical result concentrations:

- A review of the laboratory QC result forms which include laboratory control samples (LCS), matrix spike and spike duplicate (MS/MSD), laboratory method blanks, initial calibration forms, continuing calibration forms, surrogate result forms, internal standard result forms, instrument recalibrations if applicable, and instrument run logs when needed to determine whether the data results are useable
- Comparison of the field duplicates and parent samples in order to assess field reproducibility.
- Determining the most reliable result from dilutions, re-extractions, or reanalysis based on data quality.

Level 4—Data Validation

The data validation process is independent of the laboratory's checks and is performed by a third party. The validation process focuses on the usability of the data to support the project decision-making process. Areas of review include data package completeness, holding time compliance, initial and continuing calibration, spiked sample results, method blank results, and duplicate sample results. Acceptance criteria for each area of review are specified in the analytical method. The data package will be reviewed by the validator using the process outlined by the USEPA's National Functional Guidelines for organic and inorganic validation (1999, 2004).

For non-CLP methods, the validation will be performed in a process analogous to the National Function Guidelines, but will use QC criteria established by the method.

Sample results that do not meet the acceptance limit criteria will be indicated with a qualifying flag, which is a one- or two-letter abbreviation that indicates a possible problem with the data. Flags used in the text may include the following:

- **U—Undetected.** Samples were analyzed for this analyte, but it was not detected above the method detection limit (MDL) or instrument detection limit
- **UJ—Detection limit estimated.** Samples were analyzed for this analyte, but the results were qualified as not detected. The results are estimated
- **J—Estimated.** The analyte was present, but the reported value may not be accurate or precise
- **R—Rejected.** The data are unusable (analyte/compound may or may not be present)

It is important to note that laboratory qualifying flags are included on the data summary forms that are submitted by the laboratory. However, during the data review and validation process, the laboratory qualifying flags are evaluated and replaced with the project-specific validation flags.

Field and Laboratory Blank Contamination The appearance and concentration of target compounds in field and laboratory blanks as well as environmental samples will be reviewed. Common field sampling and laboratory contaminants detected in blanks include acetone, methylene chloride, 2-butanone, cyclohexane, and phthalates. Acetone, methylene chloride, 2-butanone, and cyclohexane are used to extract samples in the laboratory, and hence, are common laboratory contaminants. Phthalates (such as bis[2-ethylhexyl]phthalate) are used as plasticizers and are often introduced during sample handling.

If these compounds are encountered in a method blank at a concentration greater than the practical quantification limit (PQL), corrective actions will be taken in an attempt to eliminate these compounds. These compounds may also be detected in field blanks above the PQL. In either case, all analytical data above the PQL associated with these compounds will be flagged to indicate possible cross-contamination.

Surrogate Spike Recoveries Surrogate spike compounds are added to each sample for the organic analytical methods. Surrogate spike compounds are structurally similar (but not identical) to target compounds and should behave in a similar manner during analysis. Surrogate spike recoveries are used to monitor both laboratory performance and matrix interferences. Surrogate spike recoveries from field and laboratory blanks are used to evaluate laboratory performance because these blanks represent an ideal sample matrix. Surrogate spike recoveries for field samples are used to evaluate the potential for matrix interferences.

When surrogate spike recoveries for field samples fall outside the method target acceptance windows, the samples are re-extracted if appropriate, then re-analyzed. If the surrogate spike recovery is still outside the acceptance window for the re-analyzed sample, then the sample results are qualified as affected by matrix interferences.

Matrix Spike Recoveries For this QC measure, three aliquots of a single sample are analyzed—one normal and two spiked with the same concentration of matrix spike compounds. Unlike the surrogate spike compounds, matrix spike compounds are found on the method target compound list. Spike recovery is used to evaluate potential matrix interferences, as well as accuracy. The duplicate spike results are compared to evaluate precision.

Laboratory Control Samples An aliquot of ASTM Type II water or "Ottawa sand" for organic analyses is spiked with target analytes or compounds at concentrations in the middle of the linear calibration range, and then prepared and analyzed with a batch of samples. The laboratory control sample is used to ensure quality control for each preparation batch.

Duplicate Sample Results Duplicate samples will be collected and submitted for laboratory analysis. Both the native and duplicate samples will be analyzed for the same parameters. Target compounds that are detected in both the native and duplicate samples will be compared and the precision estimated for the sample results calculated.

8.1.8 Internal QC

Field Measures

Field sampling QC procedures will include collecting trip blanks, field blanks, equipment blanks, field duplicates, and MS/MSD samples. These QC samples, with the exception of MS/MSD samples, will be submitted blind to the laboratory. Field measurement QC procedures will include the calibration requirements discussed in Section 8.1.5.

Samples will be collected by personnel wearing modified Level D personal protection equipment.

Routine Analytical Services

Laboratory QC procedures will include the following:

- Analytical methodology according to the specific methods identified
- Instrument calibrations and standards as defined in the specific methods
- Laboratory blank measurements at a minimum frequency of 5 percent or one-per-batch
- Accuracy and precision measurements at a minimum frequency of 5 percent or one-per-set
- Data reduction and reporting according to the specific methods and the specifications outlined in Section 8.1.7
- Laboratory documentation according to the specifications outlined in Section 8.1.4

8.1.9 Performance and System Audits

Performance and systems will be audited to verify documentation and implementation of the project-specific QCP, to identify nonconformance, and to verify correction of identified deficiencies.

Assessment activities may include surveillance, inspections, peer review, management system review, readiness review, technical systems audit, performance evaluation, and data quality assessment. The Quality Assurance Control Manager (QACM) will be responsible for initiating audits, selecting the audit team, and overseeing audit implementation.

The QACM, or designee, in consultation with the PM, will evaluate the need for an independent audit. The client may also perform independent project audits. Performance audits are used to quantitatively assess the accuracy of analytical data through the use of performance evaluation and blind check samples. Laboratory performance will be audited by the QACM or designee

Project Systems Audit

A systems surveillance of operations may be required by the project-specific WP and would be used to review the total data generation process. This will include onsite review of the field operational system, physical facilities for sampling, and equipment calibrations. Informal document control surveillance will consist of checking each document for completeness, including such items as signatures, dates, and project numbers.

An audit report summarizing the results and corrections will be prepared and entered in the project files.

Technical Performance Audits

The FTL or a designated representative will conduct an informal surveillance of the field activities. Surveillance for completeness will include the following items:

- Sample labels
- COC records
- Field logbooks
- Sampling operations

The first three items above will be checked for completeness. Sampling operations will be reviewed to determine if they are being performed as stated in SSWPs or as directed by the FTL. A performance surveillance may be conducted by the PM and the FTL during the first week of sampling if it is deemed necessary by the PM, FTL, or client. The surveillance may focus on verifying that proper procedures are followed so that subsequent sample data will be valid. Before the surveillance, a checklist will be prepared by the PM and the FTL to serve as a guide for the performance surveillance. The surveillance may verify the following:

- Collection of samples follows the available written procedures
- COC procedures are followed for traceability of sample origin
- Appropriate QC checks are being made in the field and documented in the field logbook
- Specified equipment is available, calibrated, and in proper working order
- Sampling crews are adequately trained
- Record-keeping procedures are being followed and appropriate documentation is maintained
- Corrective action procedures are followed

An audit report summarizing the results and corrections will be prepared and entered in the project files.

Field Audits

Field audits are not currently anticipated during this investigation, but will be performed if necessary.

Laboratory Audits

The analytical laboratory is chosen from among the laboratories in the NAVFAC Atlantic CLEAN Basic Ordering Agreement, and is one who holds a current Naval Facilities Engineering Service Center approval letter for the analyses requested. The Center conducts audits to ensure laboratories meet the requirements of the DoD Quality Systems Manual for Environmental Laboratories. The manual is based on the National Environmental Laboratory Accreditation Conference's Chapter 5 Quality Systems standard with augmentation to cover Department of Defense environmental programs.

8.1.10 Preventive Maintenance

Field Equipment

The field personnel operating the field equipment and appropriate offsite laboratory chemists are responsible for the maintenance of their respective instruments. Preventive maintenance will be provided on a scheduled basis to minimize down time and the potential interruption of analytical work. All instruments will be maintained in accordance with the manufacturer's recommendations and normal approved laboratory practice.

Scheduled periodic calibration of testing equipment does not relieve field personnel of the responsibility of using properly functioning equipment. If a project team member suspects an equipment malfunction, the device will be removed from service, tagged so that it is not inadvertently used, and the appropriate personnel notified so that a recalibration can be performed or a substitute piece of equipment can be obtained.

Laboratory Equipment

Designated laboratory personnel will be trained in routine maintenance procedures for all major instrumentation. When repairs become necessary, they will be made by either trained staff or trained service engineers/technicians employed by the instrument manufacturer. The laboratory will have multiple instruments that will serve as backup to minimize the potential for downtime.

Preventive maintenance will be performed according to the procedures delineated in the manufacturer’s instrument manuals, including lubrication, source cleaning, detector cleaning, and the frequency of such maintenance. Procedures should be listed in greater detail in the laboratory’s quality assurance plan.

Chromatographic carrier gas purification traps, injector liners, and injector septa will be cleaned or replaced on a regular basis. Precision and accuracy data will be examined for trends and excursions beyond control limits to identify evidence of instrument malfunction. Maintenance will be performed when an instrument begins to degrade, as evidenced by the degradation of peak resolution, shift in calibration curves, decrease in sensitivity, or failure to meet one or more of the QC criteria.

Instrument downtime will be minimized by keeping adequate supplies of all expendable items (i.e., an expected lifetime of less than 1 year). Selected items include gas tanks, gasoline filters, syringes, septa, gas chromatograph columns and packing, ferrules, printer paper and ribbons, pump oil, jet separators, open-split interfaces, and mass spectrometer filaments.

Instrument Maintenance Logbooks

All maintenance will be documented in permanent logs that will be available for review by auditing personnel. Both scheduled and unscheduled maintenance required by operational failures will be recorded. The designated laboratory operations coordinator will review maintenance records regularly to ensure that required maintenance is occurring.

Instrument maintenance logbooks are maintained in laboratories at all times. The logbooks, in general, contain a schedule of maintenance, as well as a complete history of past routine and non-routine maintenance. Laboratories will be audited by the PC prior to the start of analyses.

8.1.11 Specific Procedures Used to Assess Data

The final activity of the data quality evaluation is an assessment of whether the data meet the DQOs. The goal of this assessment is to demonstrate that a sufficient number of representative samples were collected and that the resulting analytical data can be used to support the project decision making process.

Data assessment will follow the data review and validation described in Section 8.1.7. The PC or designee will perform data quality evaluation. Once each of the data packages has been reviewed, and the data review worksheets completed, then the entire data set will be evaluated for overall trends in data quality and usability. Information summarized as part of the data quality evaluation may include chemical compound frequencies of detection, dilution factors that might affect data usability, and patterns of target compound distribution. The data set will also be evaluated to identify potential data limitations or uncertainties in the laboratory. An assessment report will be prepared at the end of the project. The report will summarize the findings of the data review/validation as relevant to project usage. Data accuracy, precision, and completeness values will be summarized in the assessment report. The following subsections describe the quantitative definition of accuracy, precision, and completeness.

Precision

Precision is a measure of the agreement or repeatability of a set of replicate results obtained from duplicate analyses made under identical conditions. Precision is estimated from analytical data and cannot be measured directly. The precision of a duplicate determination can be expressed as the RPD and is calculated as follows:

$$RPD = \{(|X_1 - X_2|)/(X_1 + X_2)/2\} \text{ x } 100 = \left\{ \frac{|X_1 - X_2|}{\frac{(X_1 + X_2)}{2}} \right\} \text{x } 100$$

where

X_1	=	native sample
X_2	=	duplicate sample

Accuracy

Accuracy is a measure of the agreement between an experimental determination and the true value of the parameter being measured. Accuracy is estimated through the use of known reference materials or matrix spikes. It is calculated from analytical data and is not measured directly. Spiking of reference materials into a sample matrix is the preferred technique because it provides a measure of the matrix effects on analytical accuracy. Accuracy, defined as percent recovery (P), is calculated as follows:

$$P = \left[\frac{(SSR - SR)}{SA} \right] \text{x } 100$$

where

SSR	=	spiked sample result
SR	=	sample result (native)
SA	=	the spike concentration added to the spiked sample

Completeness

Completeness is defined as the percentage of measurements judged to be valid compared to the total number of measurements made for a specific sample matrix and analysis. Completeness is calculated using the following formula:

$$\text{Completeness} = \frac{\text{Valid Measurements}}{\text{Total Measurements}} \times 100$$

Experience on similar projects has shown that laboratories typically achieve about 90 percent completeness. All validated data will be used. During the data validation process, an assessment will be made of whether the valid data are sufficient to meet project objectives. If sufficient valid data are not obtained, corrective action will be initiated by the PM.

8.1.12 Corrective Actions

Field Activities

The PM is responsible for initiating corrective actions, which include problem identification, investigation responsibility assignment, investigation, action to eliminate the problem, increased monitoring of the effectiveness of the corrective action, and verification that the problem has been eliminated.

Documentation of the problem is important to the overall management of the study. A corrective action request form for problems associated with sample collection is completed by the person discovering the QA problem (refer to Form 8-2 at the end of this section). This form identifies the problem, establishes possible causes, and designates the person responsible for action. The responsible person will be either the PM or the FTL.

The corrective action request form includes a description of the corrective action planned and has space for follow-up. The PM verifies that the initial action has been taken and appears to be effective, and at an appropriate later date, checks to see if the problem has been resolved fully. The PM receives a copy of all corrective action request forms and enters them into the corrective action log. This permanent record aids the PM in follow-up and assists in resolving the QA problems.

Examples of corrective action include, but are not limited to, correcting COC forms, analysis reruns (if holding time criteria permit), recalibration with fresh standards, replacement of sources of blank contamination, or additional training in sampling and analysis. Additional approaches may include the following:

- Resampling and reanalyzing
- Evaluating and amending sampling and analytical procedures
- Accepting the data and acknowledging the level of uncertainty or inaccuracy by flagging the validated data and providing an explanation for the qualification

Laboratory Activities

The laboratory department supervisors review the data generated to verify that all QC samples have been run as specified in the protocol. Laboratory personnel will be alerted that corrective actions may be necessary if the following should occur:

- QC data are outside the warning or acceptable windows for precision and accuracy established for laboratory samples.
- Blanks contain contaminants at concentrations above the levels specified in the laboratory's quality assurance plan for any target compound.
- Undesirable trends are detected in matrix spike recoveries or RPD between matrix spike duplicates.
- There are unusual changes in detection limits.
- Deficiencies are detected by the laboratory QA Director during internal or external audits, or from the results of performance evaluation samples.

If nonconformances including but not limited to analytical methodologies or QC sample results are identified by the bench analyst, corrective actions will be implemented immediately. Corrective action procedures will be handled initially at the bench level by the analyst, who will review the preparation or extraction procedure for possible errors and check the instrument calibration, spike and calibration mixes, instrument sensitivity, etc. The analyst will immediately notify his/her supervisor of the problem and the investigation being made. If the problem persists or cannot be identified, the matter will be referred to the laboratory supervisor and QA/QC Officer for further investigation. Once resolved, full documentation of the corrective action procedure will be filed with the laboratory supervisor, and the QA/QC Officer will be provided a corrective action memorandum for inclusion in the project file if data are affected. Corrective actions may include, but are not limited to, the following:

- Re-analyzing suspect samples
- Re-sampling and analyzing new samples
- Evaluating and amending sampling and/or analytical procedures
- Accepting data with an acknowledged level of uncertainty
- Recalibrating analytical instruments
- Qualifying or rejecting the data

Following the implementation of the required corrective action measures, data that are deemed unacceptable may not be accepted by the PM, and follow-up corrective actions may be explored. Details of laboratory corrective actions are provided in the laboratory's quality assurance plan. Corrective action requests will be documented with Form 8-2 (refer to the end of this section).

8.2 MEC-Related Quality Assurance Objectives

The MEC-related QC forms (Forms 8-1b through 8-9b) referenced throughout this section are included at the end of the section. In addition to HTW-related objectives, the purpose of the investigations at the MRP sites is to evaluate the number and density of anomalies that could potentially represent subsurface MEC and provide geophysical data for future MEC intrusive investigations.

8.2.1 Introduction

This section of the QCP describes the QC approach and procedures for MEC intrusive investigation activities. The requirements and systems established in this QCP are relevant and applicable to project work performed by CH2M HILL and its subcontractors.

8.2.2 Project Organization and Responsibilities

This section identifies key project team members and lists the QA/QC responsibilities associated with each position and describes communication procedures that will be followed throughout the project.

Project Team Members The organizational structure and responsibilities of the project team (Figure 2-1) are designed to provide project QA/QC for MEC intrusive investigation activities. Selected positions are described in the following paragraphs. Specific individuals filling these roles will be identified in each SSWP.

PM The PM is responsible for overall project activities, including cost control, schedule control, and technical quality. In addition, the PM develops the WP and monitors task order activities to ensure compliance with project objectives and scope. The PM also communicates with MCB Camp Lejeune and other designated parties regarding project progress.

The PM has ultimate responsibility within the project team for producing deliverables that are technically adequate, satisfactory to the client, and cost-effective. To accomplish this, the PM develops an internal project review schedule, provides written instructions and frequent guidance to the project team, and monitors budgets and schedules. The PM will work with the project team to select an internal QA/QC review team, to coordinate review efforts, to address review comments, and to adjudicate technical issues.

AM The primary objectives of the AM are to build and maintain the relationship with the client and to provide continuity across all projects at MCB Camp Lejeune. The AM will provide overall guidance with regards to NAVFAC and MCB Camp Lejeune and will serve as the alternate CH2M HILL contact. The AM has overall responsibility for client satisfaction.

Senior Consultants The senior technical consultants are company-wide resources with significant experience in the various technical aspects involved in a complex project. The senior technical consultants are responsible for evaluating the technical merit of the work planning documents before field activities begin, and reviewing all deliverables before submittal to MCB Camp Lejeune. The senior technical consultants assist the PM in coordinating review efforts, addressing review comments, and resolving technical issues.

Corporate MR Safety and QC Officer The Corporate MR Safety and QC Officer's responsibilities include, but are not limited to, the following:

- Review and approve the qualifications of proposed UXO staff and UXO subcontractors
- Ensure that the requisite MEC safety records are generated and retained as prescribed in this QCP
- Perform MEC QC audits and surveillance as needed

- Ensure that the responsibilities specific to MR operations are performed by the UXO Technicians.

The Corporate MR Safety and QC Officer will coordinate with the PM and the Site Manager and has authority to enforce the MEC procedures defined in this QCP. The Corporate MR Safety and QC Officer (along with all UXO technicians onsite) has the authority to stop work to ensure project activities comply with MEC-related specifications of this QCP, the Contract, and the project. This authority applies equally to all project activities, whether performed by CH2M HILL or its subcontractors. The Corporate MR Safety and QC Officer also has authority to restart work following a stop-work incident.

SUXOS The SUXOS will have responsibility for the execution of all onsite activities in the EZ. The SUXOS will be responsible for overseeing scheduling of UXO personnel and ensuring that intrusive activities are performed in accordance with the specified plans. The SUXOS will be familiar with all aspects of H&S as related to MEC and will coordinate with the UXOSO to ensure H&S of site personnel.

UXOSO The UXOSO will be responsible for implementing the HASP, inclusive of the MEC-related and general safety components. He will verify compliance with applicable H&S requirements. He will report independently of project management to the CH2M HILL Corporate MR Safety and QC Officer. The UXOSO will implement the approved safety programs in compliance with all DoD, federal, state, and local statutes and codes; analyze operational risks, hazards, and safety requirements; enforce personnel limits and safety EZs for MEC intrusive operations; and conduct safety inspections to ensure compliance with safety codes.

UXOQCS The UXOQCS is responsible for implementing the MEC-related provisions of the project QC program; will conduct QC inspections of all MEC-related operations for compliance with established procedures; and will direct and approve all corrective actions to ensure that all MEC-related work complies with contractual requirements. The UXOQCS will have a direct line of communication with the CH2M HILL PM, Senior Technical Consultant, and Corporate MR Safety and QC Officer.

HSM The H&S Manager (HSM) reviews and approves the project-specific HSP as well as subcontractor HSPs. The HSM serves as the POC for the Site Safety Coordinator (SSC) for any health- or safety-related issues, and may conduct project audits. The HSM is also responsible for investigating accidents should any occur during the course of the project.

FTL The FTL reports to the PM and is responsible for efficiently applying the resources of the project team to execute the field phase of this project. In addition, the FTL is responsible for local client interface regarding details of the project and the project team while assigned to the site. The FTL will assist the PM in maintaining sufficient resource allocations to meet the project schedule and budget and will provide daily feedback to the PM on project progress, issues requiring resolution, and other project-specific issues, as required.

The quality-related responsibilities of the FTL include, but are not limited to, the following:

- Notifying the PM if problems arise with the schedule.
- Providing scheduling and integration of subcontractor services in support of the SUXOS.

- Serving as liaison for communications with project staff and subcontractors, as well as with the onsite client and regulatory agency representatives.
- Providing logistical support for field operations.
- Continuously monitoring work progress and adherence to authorized work scopes, budgets, and schedules.
- Aiding in the preparation of submittals.
- Reviewing the project WPs regularly.

Project Communication

During the field investigation phase of projects, the field teams will meet daily to review the status of the project and to discuss technical and safety issues. When necessary, other meetings will be scheduled or the FTL will meet individually with field personnel or the subcontractors to resolve problems. During the field effort, the FTL will prepare a weekly report detailing project progress.

During the field effort, the FTL will be in regular telephone or face-to-face contact with the project team. When significant problems or decisions requiring additional authority occur, the FTL can immediately contact the PM for assistance.

8.2.3 Definable Features of Work and the Three-phase Control Process

MEC-related QC will be monitored through the definable features of work (DFOW) using a three-phase control process.

DFOWs

The DFOWs for this project are divided into activities related to planning, field operations, and final project reports and closeout:

1. **Planning**
   - Pre-Mobilization Activities: System setup for GIS, document management and control, data management, and subcontracting
   - Preparing WP
2. **Field Operations**
   - Site Preparation: mobilization
   - DGM survey
   - Demobilization
3. **Final Project Reports and Closeout**
   - Preparing GIS maps
   - Draft and Final Reports: preparing and obtaining approval
   - Data archiving and project closeout

Three Phases of Control

The Corporate MR Safety and QC Officer is responsible for ensuring that the three-phase control process, including the Preparatory Phase, Initial Phase, and Follow-up Phase, is implemented for each DFOW listed in this QCP, regardless of whether it is performed by CH2M HILL or its subcontractors. Each control phase is important for obtaining a quality product and meeting the project objectives; however, the preparatory and initial audits are particularly valuable in preventing problems. Production work is not to be performed on a DFOW until successful Preparatory and Initial Phases have been completed.

Preparatory Phase

The Preparatory Phase culminates with the planning and design process leading up to actual field activities. Successful completion of the Preparatory Phase verifies that the project delivery, QC, and safety plans have been completed. The following actions will be performed as applicable for each DFOW:

1. Confirm that the appropriate technical procedures are incorporated into the project WP and review procedures.
2. Confirm that adequate testing is called for to ensure quality delivery.
3. Confirm definition of preliminary work required at the work site and examine the work area to confirm required preliminary work has been properly completed.
4. Confirm availability of required materials and equipment. Examine materials and equipment to confirm compliance with approved submittals and procedures. Ensure equipment testing procedures are in place, with control limits and frequency, for each piece of equipment.
5. Confirm qualifications/training of personnel and verify roles/responsibilities are well-defined and communicated.
6. Confirm with the HSM that the site HSP adequately address the work operations and that applicable safety requirements have been incorporated into the plan.
7. Discuss methods to be employed during the field activities.
8. Confirm any required permits and other regulatory requirements are met.
9. Verify that lessons learned during previous similar work have been incorporated as appropriate into the project procedures to prevent recurrence of past problems.

Project staff must correct or resolve discrepancies between existing conditions and the approved plans/procedures identified by the PM, Corporate MR Safety and QC Officer, and the team during the Preparatory Phase. The PM or designee must verify that unsatisfactory and nonconforming conditions have been corrected prior to granting approval to begin work.

Results of the activity are to be documented in the Preparatory Inspection Checklist (Form 8-1b) specific for the DFOW and summarized in the Weekly QC Report.

Initial Phase

The Initial Phase occurs at the startup of field activities associated with a specific DFOW. The Initial Phase confirms that this QCP, other applicable WP sections, and procedures are being effectively implemented and the desired results are being achieved.

During the Initial Phase, the initial segment of the DFOW is observed and inspected to ensure that the work complies with contract and WP requirements. The Initial Phase should be repeated if acceptable levels of specified quality are not met. The following shall be performed for each DFOW:

1. Establish the quality of work required to properly deliver the project in accordance with contractual requirements. The FTL will ensure that the field teams are aware of expectations associated with the field methods established under the Preparatory Phase by observing the initial work activities and interacting with the PM, AM, and responsible subcontractors' supervisors.

2. Resolve conflicts. The Senior Technical Consultant will guide the PM and responsible supervisor(s) in resolving conflicts. Should conflicts arise in establishing the baseline quality for the DFOW, the responsibility to resolve the conflict falls to the PM. Should the conflict not be resolved in a manner that satisfies the project requirements, the Senior Technical Consultant must elevate the conflict to the program level (i.e., the Program QC Manager) and issue a non-conformance report. The Senior Technical Consultant may direct a cessation of work activity with the concurrence of the Program QC Manager should the issue jeopardize the results of the DFOW or put the project at risk of non-conformance.

3. Verify with the HSM that the site HSP was developed to ensure that the identified hazards adequately address field conditions. Confirm that applicable safety requirements are being implemented during field activities.

Upon completion of Initial Phase activities, the results are to be documented in the Initial Phase Inspection Checklist (Form 8-2b) and the QC logbook and summarized in the Weekly QC Report. Should results be unsatisfactory, the Initial Phase will be rescheduled and performed again.

Follow-up Phase

Completion of the Initial Phase of QC activity leads directly into the Follow-up Phase, which covers the routine day-to-day activities at the site. Inspection and audit activities associated with each DFOW are discussed in Section 8.2.4. Specific concerns associated with the Follow-up Phase include:

1. Inspection of the work activity to ensure work complies with the Contract and WPs.

2. Evaluation and confirmation that the quality of work is being maintained at least at the level established during the Initial Phase.

3. Evaluation and confirmation that required testing is being performed in accordance with procedures established during the Preparatory Phase and confirmed during the Initial Phase.

4. Confirmation that nonconforming work is being corrected promptly and in accordance with the direction provided by the PM, FTL, Senior Technical Consultant, or Corporate MR Safety and QC Officer.

To conduct and document these inspections, the FTL is to generate the Follow-up Phase Inspection Checklist (Form 8-3b). The Follow-up Phase inspections will be performed daily or as otherwise identified in this QCP until the completion of each DFOW.

The FTL is responsible for onsite monitoring of the practices and operations taking place and verifying continued compliance with the specifications and requirements of the Contract, project, and approved project plans and procedures. The FTL is also responsible for verifying that a daily H&S inspection is performed and documented as prescribed in site specific HSP. Discrepancies between site practices and approved plans and procedures are to be resolved and corrective actions for unsatisfactory and nonconforming conditions or practices are to be verified by the UXOQCS or a designee prior to granting approval to continue work. Follow-up Phase inspection results are to be documented in the QC logbook and summarized in the Weekly QC Report.

Additional Audits

Additional audits performed on the same DFOW may be required at the discretion of the Program QC Officer, Senior Technical Consultant, Corporate MR Safety and QC Officer, HSM, or the PM. Additional preparatory and initial audits are generally warranted under any of the following conditions: unsatisfactory work, changes in key personnel, resumption of work after a substantial period of inactivity (i.e., 2 weeks or more), or changes to the project scope of work/specifications.

Final Acceptance Audit

Upon conclusion of the DFOW and prior to closeout, the Final Acceptance Inspection must be performed to verify that project requirements relevant to the work are satisfied. Outstanding and nonconforming items are to be documented on the Final Inspection Checklist (Form 4-4b). Resolution of each item must be noted on the checklist. Contractor acceptance and closeout of each definable work feature is a prerequisite to project closeout.

8.2.4 Audit Procedures

The Corporate MR Safety and QC Officer is responsible for verifying compliance with this QCP through audits and surveillance. The PM or a designee is to inspect/audit the quality of work being performed for the DFOW. The PM or a designee is to verify that procedures conform to applicable specifications stated in this WP or other applicable guidance. Identified deficiencies are to be communicated to the responsible individual and documented in the QC logbook and Weekly QC Report. Corrective actions are to be verified by the Corporate MR Safety and QC Officer and recorded in the Weekly QC Report.

The specific QC audit procedures for the DFOWs most commonly employed at MR sites, including the phase during which it is performed, the frequency of performance, the pass/fail criteria, and actions to take if failure occurs, are presented in Table 8-3. This DFOW table will be modified in each SSWP for the DFOWs employed at each MR site.

Detailed QC procedures for DGM activities are outlined in the GIP in Appendix B. The QC performed for the DGM activities will be tracked in the Munitions Response Site Information Management System (MRSIMS) (refer to Section 8.2.6) and will be audited by the Project Geophysicist or his designee on a daily basis.

The Inspection Schedule and Tracking Form (Form 8-5b) is to be used by the Corporate MR Safety and QC Officer for planning, scheduling and tracking the progress of audits for this project. The information on the form is to be kept up to date and reviewed by the Corporate MR Safety and QC Officer for planning purposes. Audit activities and corrective actions are to be documented by the Corporate MR Safety and QC Officer in accordance with this chapter. Audit records are to be maintained as part of the project QC file.

8.2.5 Corrective/Preventive Action Procedures

The corrective and preventive action procedures are designed to prevent quality problems and to facilitate process improvements, as well as identify, document, and track deficiencies until corrective action has been verified.

Preventive Measures

While the entire QC program is directed toward problem prevention, certain elements of the program have greater potential to be proactive. The primary tools for problem prevention on this project are discussed in Section 8.2.3, *Three Phases of Control,* Section 8.2.7, *Submittal Management,* and Section 8.2.8, *Personnel Qualification and Training.* Should these preventive measures fail, tracking and communicating deficiencies provide a mechanism for preventing their recurrence.

Continual Improvement

Project staff at all levels are encouraged to provide recommendations for improvements in established work processes and techniques. The intent is to identify activities that are compliant but can be performed in a more efficient or cost-effective manner. Typical quality improvement recommendations include identifying an existing practice that should be improved and/or recommending an alternate practice that provides a benefit without compromising prescribed standards of quality. Project staff members are to bring their recommendations to the attention of project management or the QC staff through verbal or written means. However, deviations from established protocols are not to be implemented without prior written approval by the PM and concurrence of the Senior UXO Consultant. Where a staff-initiated recommendation results in a tangible benefit to the project, public acknowledgment is to be given by the PM.

Deficiency Identification and Resolution

While deficiency identification and resolution occurs primarily at the operational level, QC audits provide a backup mechanism to address problems that either are not identified or cannot be resolved at the operational level. Through implementation of the audit program prescribed in this QCP, the QC staff is responsible for verifying that deficiencies are identified, documented as prescribed herein, and corrected in a timely manner. Deficiencies identified by the QC staff are to be corrected by the operational staff and documented by the QC staff.

Corrective Action Request

A Corrective Action Request (CAR) (Form 8-6b) can be issued by any member of the project staff, including CH2M HILL and subcontractor employees. If the individual issuing the CAR is also responsible for correcting the problem, then that individual should do so and document the results on Part B of the CAR (Form 8-6b). Otherwise, the CAR should be forwarded to the PM, who is then responsible for evaluating the validity of the request, formulating a resolution and prevention strategy, assigning personnel and resources, and specifying and enforcing a schedule for corrective actions. Once a corrective action has been completed, the CAR and supporting information are to be forwarded to the Corporate MR Safety and QC Officer for closure. Sufficient information is to be provided to allow the QC reviewer to verify the effectiveness of the corrective actions.

In addition to observing actual work operations, CARs are to be reviewed during follow-up QC audits. The purposes of this review are as follows: to ensure that established protocols are implemented properly; to verify that corrective action commitments are met; to ensure that corrective actions are effective in resolving problems; to identify trends within and among similar work units; and to facilitate system root cause analysis of larger problems. Particular attention is to be given by the QC staff to work units that generate either an unusually large or unusually small number of CARs.

The PM will determine whether a written Corrective Action Plan (CAP) (Form 8-7b) is necessary, based on whether or not any of the following are met: the CAR priority is high; deficiency requires a rigorous corrective action planning process to identify similar work product or activities affected by the deficiency; or deficiency requires extensive resources and planning to correct the deficiency and to prevent recurrence. The CAP is developed by a PM designee and approved and signed by the PM. The CAP is to indicate whether it is submitted for informational purposes or for review and approval. In either event, the operational staff members are encouraged to discuss the corrective action strategy with the QC staff throughout the process. The CAP form is included at the end of this chapter.

Deficiency and Corrective Action Tracking

Each CAR must be given a unique identification number and tracked until corrective actions have been taken and documented in Part B of the form and the CAR is submitted to the PM or a designee for verification and closure.

Lessons Learned and Other Documentation

The lessons learned through the deficiency management process are documented on CARs and CAPs. To share the lessons learned, these documents can be submitted to the Client through a Weekly QC Report summarizing the week's QC activities and including a grouping of the Daily QC Reports (Form 8-8b) and all other pertinent reports created during the week.

CARs should be cited in the Weekly QC Report. Minor deficiencies identified during a QC audit that are readily correctable and can be verified in the field are to be documented in the QC logbook and Weekly QC Report without initiating a CAR. Deficiencies that cannot be readily corrected are to be documented by the QC staff on a CAR and in the Weekly QC Report. Copies of CARs are to be referenced in and attached to the Weekly QC Report. CAPs will also be attached to Weekly QC Reports to document the final outcome of the deficiency. Similar or related deficiencies may be addressed on a single CAP.

8.2.6 Records Generated

Onsite Project File

The FTL will establish and maintain an onsite project file in accordance with the CH2M HILL corporate quality manual for document control. The onsite files will be maintained in the project field office or designated field vehicle. The purpose of these files is to maintain a complete set of all documents, reports, certifications, and other records that provide information on project plans, contractual agreements, and project activities.

The CH2M HILL MRSIMS, which consists of a mobile field data collection device used to collect form-based information of DGM operations and a centralized desktop interface and database, will be the repository for most of the information collected by the field team (e.g., daily reports). This database will contain information that can be easily presented and delivered through automated report production, which reduces the amount of actual paper in the files. The database will be backed-up daily and stored in an offsite location as well as in the project trailer. The files (in either paper or digital format) will include copies of the following:

- Qualifications and training records of all site personnel
- Submittals
- Schedule and progress reports
- Survey records
- Conversation logs
- Meeting minutes and agenda
- Audit logs and schedules
- Photo documentation
- Site maps
- Equipment check records
- Nonconformance and corrective action reports
- Daily work activity summary reports, which may include:
  - Weekly QC Report
  - Daily H&S Report
  - Daily Report (including activity log)
  - Daily DGM Team Logs (Field Data Sheets)
  - Reports on any emergency response actions (EOD will handle emergencies on this project)
  - Equipment check records
  - COC records
  - Incident reports
  - Truck load tickets and shipping papers (if applicable)

As the project activities progress, the FTL will monitor the usefulness of the project filing system for information retrieval. If additional file sections are needed, the FTL will expand the initial filing structure to include additional sections.

Weekly QC Report

The FTL is responsible for preparing and submitting the Weekly QC Report to the Corporate MR Safety and QC Officer for the project file and providing concurrent courtesy copies to the PM. The Weekly QC Report with attachments is to be submitted to the Program QC Officer on the first workday following the dates covered by the report.

The Weekly QC Report is to provide an overview of QC activities performed each day, including those performed by subcontractors. The QC reports must present an accurate and complete picture of QC activities by reporting both conforming and deficient conditions, and the reports should be precise, factual, legible, and objective. Copies of supporting documentation, such as checklists and surveillance reports, are to be attached.

A field QC log is to be maintained by the FTL to document details of field activities during QC monitoring activities. At the end of each day, copies of the log entries are to be attached to the Weekly QC Report. The information in the field QC log provides backup information and is intended to serve as a phone log and memory aid in the preparation of the Weekly QC Report and for addressing follow-up questions.

QC and H&S staff input for the Weekly QC Report is to be provided in writing to the FTL at a previously agreed upon time and place, generally no later than 1 hour before normal close of business. For the sake of simplicity and completeness, the format for QC staff input should follow the same format as the Weekly QC Report with only the relevant sections completed.

Copies of Weekly QC Reports with attachments and field QC logs no longer in use are to be maintained in the project QC file. Upon project closeout, all QC logs are to be included in the project QC file.

8.2.7 Submittal Management

The PM is responsible for overall management and control of project submittals. The PM is also responsible for submittal scheduling and tracking.

The PM is responsible for ensuring, through detailed review, that submittals as well as the materials and the work they represent, are in full compliance with applicable contractual specifications and the project plans. The PM is also responsible for ensuring that a project file is established and maintained and that accountable project documents are retained and controlled appropriately.

Review of Plans and Specifications

During the Preparatory Phase of a DFOW, the PM is responsible for reviewing the plans and, when necessary, requesting clarification from the project team. The primary purpose of this review is to identify and resolve potential conflicts prior to initiating work operations.

Review and Approval of Submittals

The CH2M HILL Corporate MR Safety and QC Officer, the Senior Technical Consultant, and the PM must review submittals prepared by CH2M HILL and subcontractors for completeness and compliance with the specifications of the project and Contract. Non-compliant submittals are to be returned to the originator for corrective action and re-submittal to the PM or his designee.

Prior to submittal to the CH2M HILL Corporate MR Safety and QC Officer for certification, technical documents (e.g., reports, plans) are to be reviewed by the Senior Technical Consultant. Although part of the QC process, technical reviewers may include, but are not limited to, the QC staff.

For each project document that is submitted for technical review, a Document Review and Release Form (Form 8-9b) is to be initiated by the author, submitted with the document to be reviewed, and used to document and track the review process. A copy of the completed Document Review and Release Form is to be submitted to the PM together with the corrected document for his review and certification. Each document is to provide a signature block for PM and Senior Technical Consultant certification. Original Document Review and Release Forms, reviewer comments, and annotated versions are to be retained with the deliverable in the project file and reviewed by the QC staff during project audits.

8.2.8 Personnel Qualifications and Training

All project staff members will be qualified to perform their assigned jobs in accordance with the terms outlined in the Contract and by the project plans. Specific qualifications and training required for UXO-qualified personnel are stated in the following subsections. Qualifications for DGM operations-related personnel are covered in the GIP.

Documentation of Qualification and Training for UXO-qualified Personnel

The FTL will maintain records documenting the required qualifications, training, and certifications for each site worker. The FTL will monitor expiration dates to provide advance warning to the PM of when employees will require refresher training or other renewals. The FTL will maintain records of site-specific and routine training for personnel and visitors, as required by these project plans. These records will be maintained onsite for audit purposes.

All UXO Personnel

UXO personnel assigned to positions UXO Technician I, UXO Technician II, UXO Technician III, UXO Safety Officer, UXOQCS, or Senior UXO Supervisor, will be qualified and certified in accordance with NAVSEAINST 8020.9B, Ammunition and Explosives Personnel Qualification and Certification Program; terms outlined by U.S. Department of Labor Employment Standards Administration Wage Hour Division for UXO Personnel; and DDESB TP-18, *Minimum Qualifications for Unexploded Ordnance (UXO) Technicians and Personnel*.

UXO Sweep Personnel

UXO sweep personnel assist UXO technicians and UXO-qualified personnel in the performance of UXO-related operations. UXO sweep personnel do not have to be UXO technicians; however, they must be provided job and site-specific training. At a minimum, training will include: explosives safety, recognition of MEC (particularly UXO), and the proper use of personal protective equipment. UXO sweep personnel are not involved in the execution of explosives operations and will not have intentional physical contact with MEC. With direction and supervision of UXO-qualified personnel, UXO sweep personnel may:

- Conduct visual and/or detector-aided MEC field search activities
- Locate subsurface MEC by operating geophysical detection instruments and related equipment
- Perform field maintenance and tests on geophysical detection instruments and related equipment
- Remove non-hazardous munitions debris and range-related debris, only after such items have been inspected by a UXO technician or UXO-qualified personnel and determined to be safe for handling
- Perform site and area security functions

UXO Technician I

In addition to being able to perform all functions of the UXO sweep personnel listed in this section, for this project, UXO Technician I personnel may, with the direction and supervision from UXO-qualified personnel:

- Reconnoiter and classify MEC
- Identify all types of military munitions, including possible fuzes and their condition, armed or unarmed; examples are the following:
  - Bombs
  - Guided missiles
  - Projectiles
  - Rockets
  - Land mines and associated components
  - Pyrotechnic items
  - Military explosives and demolition materials
  - Grenades
  - Submunitions
- Operate personnel decontamination stations

UXO Technician II

In addition to being able to perform all functions of the UXO sweep personnel and UXO Technician I listed in this chapter, for this project, UXO Technician II personnel may:

- Determine precise location in field environment using a variety of techniques such as global positioning equipment or basic land navigation using topographical map and compass
- Perform field-expedient identification procedures to identify contaminated soil
- Perform limited technical supervision of UXO sweep personnel
- Escort personnel who are not directly involved in UXO-related operations (e.g., personnel performing environmental monitoring), but who have activities to perform within EZs
- Inspect MPPEH for the presence of explosive safety hazards

UXO Technician III

In addition to being able to perform all functions of the UXO Sweep Personnel and for UXO Technicians I and II listed in this chapter, UXO Technician III personnel may:

- Supervise and perform the onsite demolition of MEC and handle demolition materials.
- Prepare an explosives storage plan per all applicable guidance.
- Prepare required UXO munitions response actions and/or range maintenance administrative reports.
- Prepare SOPs for onsite munitions responses and/or range clearance activities.
- Conduct daily site safety briefings.
- Supervise the conduct of all onsite UXO-related operations.
- Inspect and certify and/or verify MPPEH as safe or as to the explosive hazard it may present for transfer within DoD or release from DoD control per current policies and standards.

UXO Quality Control Specialist

In addition to being able to perform all functions of the UXO Sweep Personnel, UXO Technicians I, II, and III listed in this chapter, a UXOQCS may:

- Develop and implement the MEC-specific sections of the QCP Plan (QCPP) for all explosives-related operations.
- Conduct daily audits of the procedures used by UXO teams and individuals for processing MPPEH.
- Perform and document random sampling (by pieces, volume, or area) of all MPPEH collected from the various teams to ensure no items with explosive hazards, engine fluids, illuminating dials and other visible liquid HTRW materials are identified as MD or range-related debris as required for completion of the Requisition and Turn-in Document, DD Form 1348-1A.
- Conduct QC audits of all explosives operations for compliance with established procedures.
- Identify and verify completion of all corrective actions to ensure all explosives operations comply with requirements.

UXO Safety Officer

In addition to being able to perform all functions of the UXO Sweep Personnel, UXO Technicians I, II, and III listed in this chapter, UXOSOs may:

- Develop and implement approved explosives and MEC H&S program in compliance with applicable DoD policy and federal, state, and local H&S statutes, regulations and codes.
- Analyze operational risks, explosive hazards, and safety requirements.

- Establish and ensure compliance with all site-specific explosives operations safety requirements.
- Enforce personnel limits and safety EZs for explosives-related operations.
- Conduct, document, and report the results of safety inspections to ensure compliance with all applicable explosives safety policies, standards, regulations and codes.
- Ensure all protective works and equipment used within the EZ are operated in compliance with applicable DoD policy, DDESB approvals, and federal, state, and local H&S statutes, regulations and codes.

Senior UXO Supervisor

In addition to being able to perform all functions of the UXO Sweep Personnel, UXO Technicians I, II, and III listed in this chapter, the SUXOS will:

- Plan, coordinate, and supervise all explosives operations
- Assist in the development of munitions response plans
- Supervise multiple teams

UXO Team Composition and Roles

MEC avoidance support will be provided by a two-man UXO team consisting of one UXO Technician II and one team member of UXO Technician I or above.

H&S Training

H&S training requirements for onsite project personnel have been established in accordance with Occupational Safety and Health Act/Occupational Safety and Health Administration (OSHA) requirements for hazardous site workers (29 Code of Federal Regulations [CFR] 1910.120) and are specified in the HSP which will be an Appendix to the SSWPs. These training requirements must be met before project personnel can begin site work.

8.2.9 Testing and Maintenance

Testing and maintenance of equipment such as geophysical instruments, radios, cell phones, vehicles and machinery will be performed per the manufacturer's specifications, this WP, and all applicable SOPs. Geophysical detection equipment will be tested daily, as specified in the GIP.

Test results must be documented by the individual performing the test. Testing and maintenance records associated with the measuring and testing of equipment must be generated by the individual performing the activity. Documentation for testing and maintenance of equipment is to be made available to the client upon request.

The FTL is responsible for ensuring that the tests are performed and that the results are summarized and provided with the weekly QC report. To track each failing test for future retesting, the failing test must be noted on the deficiency log. Resolution of the failing test is complete when retesting is performed and the corrective action is verified on the deficiency log.

8.2.10 DGM Systems QC

An extensive QC program will be applied to the DGM operations at the site. Program elements include DGM instruments quality control, QC seed items, QC of DGM data and deliverables, and analog geophysical systems QC. QC program details are provided in the GIP included as Appendix B.

TABLE 8-2
Analyses, Bottleware, Preservation, and Holding Time Requirements
MRP Master Project Plans
MCB Camp Lejeune
Jacksonville, North Carolina

Media	Analysis	Method	Container	Preservation / Storage	Holding Times
Soil and Sediment	TCL VOCs	OLM04	2x5-gram + 1x25-gram Encore™ Sampling receptacle	4ºC	48 hours
	Total Organic Halogens	SW-846 9020B	1x4-oz bottle, Teflon cap	4ºC	48 hours
	TCL SVOCs	OLM04	1x8-oz bottle, Teflon cap	4ºC	7 days to extraction, 40 days from extraction to analysis
	Explosives Residues	SW-846 8330/8330B	1x8-oz bottle, Teflon cap(8330) 2x16 oz wide mouth glass jars (8330B)	4ºC	7 days to extraction, 40 days from extraction to analysis
	Perchlorate	EPA 6850	1x8-oz bottle, Teflon cap	4ºC	14 days to extraction, 40 days from extraction to analysys
	TCL Pesticides/PCBs	OLM04	1x8-oz bottle, Teflon cap	4ºC	7 days to extraction, 40 days from extraction to analysis
	TAL Metals/Cyanide	ILM04	1x4-oz bottle, Teflon cap	4ºC	6 months, Cyanide: 14 days, Mercury: 28 days
	Total Petroleum Hydrocarbons (full range)	EPA 8015/5030 EPA 8015/3550 EPA 9071 (Oil & Grease)	1x4-oz bottle, Teflon cap 1x8-oz bottle, Teflon cap	4ºC	48 hours
	Total Organic Carbon	SW-846 9060	1x4-oz bottle, Teflon cap	4ºC	28 days
	Grain Size	sieve and hydrometer (ASTM D422)	1x16-oz bottle, Teflon cap	4ºC	28 days
Groundwater and Surface Water	TCL VOCs	OLC03	3x40-mL vials	HCl to pH <2; cool to 4ºC	14 days
	Total Organic Halogens	SW-846 9020B	2x50-mL amber jar	H_2SO_4 to pH <2, no head space, and cool to 4ºC	28 days
	TCL SVOCs	OLC03	2x1-L amber jar	4ºC	28 days to analysis, nitrate 48 hours
	Explosives Residues	OLC03	2x1-L amber jar	4ºC	7 days to extraction, 40 days from extraction to analysis
	Perchlorate	EPA 6850	1x1-L Poly bottle	4ºC	7 days to extraction, 40 days from extraction to analysis
	TCL Pesticides/PCBs	OLC03	3x1-L amber jar	4ºC	7 days to extraction, 40 days from extraction to analysis
	Total and Filtered TAL Metals	ILM04	1x1-L Poly bottle	HNO_3 to pH <2 and cool to 4ºC	6 months, Mercury: 28 days
	Cyanide	ILM04	1x1-L Poly bottle	NaOH to pH >12 and cool to 4ºC	14 days
	Total Petroleum Hydrocarbons (full range)	EPA 8015/5030 EPA 8015/3550 EPA 9071 (Oil & Grease)	2x40-mL vials 2x1-L amber jar	HCl to pH <2; cool to 4ºC 4ºC	14 days 48 hours
	Total Dissolved Solids	MCAWW 160.1	1x250-mL Poly bottle	4ºC	7 days
	Filtered Total Organic Carbon	SW-846 9060	2x40-mL vials	H_2SO_4 to pH <2, and cool to 4ºC	28 days

Notes
mL = milliliter   HCL = hydrochloric acid   NaOH = Sodium Hydroxide
oz = ounce HNO_3 = nitric acid
g = gram H_2SO_4 = sulfuric acid
TAL = Target Analyte List (TAL) metals   BTEX = Benzene, toluene, ethylbenzene, and total xylenes
TCL = Target Compound List   MTBE = Methyl tertiary butyl ether
VOCs = Volatile Organic Compounds   PCBs = polychlorinated biphenyls
SVOCs = semivolatile organic compoundss

Definable Feature of Work with Auditable Function	Responsible Person(s)[1]	Audit Procedure[2]	QC Phase[3]	Freq. of Audit	Pass/Fail Criteria	Action if Failure Occurs
Planning						
Geographical Information System (GIS) Setup (Pre-mobilization Activities)	Project GIS Manager	Verify GIS system has been set up and is ready for site data.	PP	O	GIS system has been set up and is ready for site data.	Do not proceed with field activities until criterion is passed.
Document management and control (Pre-mobilization Activities)	Project Manager	Verify appropriate measures are in place to manage and control project documents.	PP	O	Appropriate measures are in place to manage and control project documents.	Do not proceed with field activities until criterion is passed.
Data Management (Pre-mobilization Activities)	Project Manager, Project Geophysicist	Verify appropriate measures are in place to manage and control project data.	PP	O	Appropriate measures are in place to manage and control project data.	Do not proceed with field activities until criterion is passed.
Subcontracting (Pre-mobilization Activities)	Project Manager, Site Manager	Verify subcontractor qualifications, training, and licenses.	PP/IP	O	Subcontractors' qualifications, training, and licenses are up to date and acceptable.	Ensure subcontractor provides the qualifications, training, and licenses or change subcontractor.
Technical and Operational approach (Technical Project Planning)	Project Manager	Verify technical and operational approaches have been agreed on by the project team.	PP/IP	O	Technical and operational approaches have been agreed on by project team and incorporated into the Work Plans.	Do not proceed with field activities until criterion is passed
Geophysical Prove-out (GPO) Plan preparation and approval	Project Manager	Verify GPO Plan has been prepared and approved.	PP/IP	O	GPO Plan has been approved	Do not proceed with field activities until criterion is passed.
GPO Execution	Project Manager, Project Geophysicist	Verify data quality objectives (DQOs) established in GPO Plan have been accomplished.	PP/IP	O	DQOs identified in GPO Plan have been achieved	Continue with GPO until DQOs are achieved.
GPO Report	Project Manager, Project Geophysicist	Verify recommendations in GPO Report for Digital Geophysical Mapping (DGM) system and associated DQOs have been approved.	PP/IP	O	Recommendations for DGM equipment and associated DQOs are approved by USACE.	Do not proceed with DGM field activities until recommendations of GPO Report are approved.
Work Plan preparation and approval	Project Manager	Verify Work Plan prepared and approved.	PP/IP	O	Work Plan has been approved	Do not proceed with field activities (excluding site mobilization) until criterion is passed.
Field Operations						
Site preparation (Mobilization)	Project Manager	Verify local agencies are coordinated.	PP/IP	O	Local agencies are coordinated.	Do not proceed with field activities until criterion is passed.
Site preparation (Mobilization)	Project Manager	Verify equipment has been inspected and tested.	PP/IP	E	Equipment passes inspection and testing.	Proceed only with activities for which equipment has passed inspection and testing.
Site preparation (Mobilization)	Project Manager	Verify communications and other logistical support are coordinated.	PP/IP	O	Communications and other logistical support are coordinated.	Do not proceed with field activities until criterion is passed.
Site preparation (Mobilization)	Project Manager	Verify emergency services have been coordinated.	PP/IP	O	Emergency services are coordinated.	Do not proceed with field activities until criterion is passed.
Site preparation (Mobilization)	MEC QCS, Project Manager	Verify site-specific training is performed and acknowledged.	PP/IP	O	Site-specific training is performed and acknowledged	Do not proceed with field activities until criterion is passed.
Site preparation (Mobilization)	MEC QCS, Project Manager	Hold pre-mobilization meeting and Operations Readiness Review (ORR) with the project team.	PP/IP	O	Project plans are reviewed and acknowledged by team members.	Do not proceed with field activities until criterion is passed.
Site preparation (Site Survey)	Project Manager	Verify surveyor qualifications.	PP/IP	O	Surveyor's qualifications are up to date and acceptable.	Ensure surveyor provides the qualifications prior to starting work or change surveyor.
Site preparation (Site Survey)	Project Manager	Verify surveyor licenses.	PP/IP	O	Surveyor's licenses are up to date and acceptable.	Ensure surveyor provides the licenses prior to starting work or change surveyor.
Site Preparation (Site Survey)	Project Manager	Verify benchmarks for survey have been established and documented.	PP/IP	O	Benchmarks for survey have been established and documented.	Ensure benchmarks for survey are established and documented prior to performing survey.

Definable Feature of Work with Auditable Function	Responsible Person(s)[1]	Audit Procedure[2]	QC Phase[3]	Freq. of Audit	Pass/Fail Criteria	Action if Failure Occurs
Site Preparation (Site Survey)	Project Manager	Verify site boundaries and grids have been established.	PP/IP	O	Site boundaries and grids have been established.	Do not proceed with dependent field activities until criterion is passed.
Site Preparation (Site Survey)	Project Manager	Verify surveyor notes are legible, accurate, and complete.	IP	O	Surveyor notes are legible, accurate and complete.	Ensure surveyor replaces deficient notes with legible, accurate and complete notes.
DGM Survey	Project Geophysicist	Verify DGM Survey conducted IAW Geophysical Investigation Plan (Appendix B) and DGM SOPs: EM61-MK2 Metal Detection Munition Response Surveys Geophysical Surveying with EM61-MK2 Configuration and Operation of the GPS Base-Station System Configuration and Operation of the GPS Rover System Field Methodology and Survey Setup	IP/FP	O/D	DGM Survey conducted IAW Geophysical Investigation Plan (Appendix B) and DGM SOPs.	Stop activity until full compliance can be assured and any activities not performed within compliance are re-evaluated and re-performed if necessary.
DGM Survey	Project Geophysicist	Check results of QC tests performed as specified in QCP and DGM SOPs	FP	E	QC tests must pass IAW standards determined during the GPO and referenced SOPs.	If a QC test does not pass, a root-cause analysis must be performed and the project team must meet to discuss and determine appropriate action.
DGM Survey	Project Geophysicist	Confirm that DGM survey DQOs established during GPO are being met.	FP	E	DGM survey DQOs are being met.	If the DQOs are not being met, a root-cause analysis must be performed and the project team must meet to discuss and determine appropriate action.
DGM Data Processing	Project Geophysicist	Verify data checks specified in QCP and SOPs: EM61-MK2 Data Processing and Database Management Uploading and Downloading Data to the FTP Site	FP	E	Data checks must pass in accordance with standards determined during the GPO and referenced SOPs.	If a QC test does not pass, a root-cause analysis must be performed and the project team must meet to discuss and determine appropriate action.
Demobilization	Project Manager	Verify facilities-support infrastructures are dismantled and shipped to appropriate location and area is returned to original condition.	FP	O	Facilities-support infrastructures are dismantled and shipped to appropriate location and site is returned to original condition.	Ensure that all support facilities are removed and that the site is returned to original condition
Final Project Reports and Closeout						
Site Specific Final Report preparation and approval	Project Manager, Project Geophysicist	Verify all dig sheets where geophysical mapping and investigation performed are accurate and complete.	FP	O	All dig sheets where geophysical mapping and investigation performed are accurate and complete.	Ensure all dig sheets where geophysical mapping and investigation performed are accurate and complete
MEC Response Completion Acceptance	Project Manager	Verify Final Report has been approved.	IP	O	Final Report has been approved.	Take appropriate actions to ensure Report gets approved
Archiving	GIS Manager	Verify data back-up systems are in place.	IP	O	Data back-up systems are in place	Ensure data back-up systems are in place
Project Closeout	Project Manager	Verify purchase orders have been closed out.	IP	O	Purchase orders have been closed out	Ensure purchase orders are closed out
Project Closeout	Project Manager	Verify invoices completed and approved.	IP	O	Invoices completed and approved	Ensure invoices are completed and approved

Notes:
IAW = in accordance with

QC Phase	Frequency
PP = Preparatory Phase	O = Once
IP = Initial Phase	D = Daily
FP = Follow-up Phase	W = Weekly
	E = Each occurrence

[1] The responsible person (if other than the MEC QCS) is the individual with whom the MEC QCS will coordinate with to ensure compliance with requirements and to verify that any necessary follow-up actions are taken.
[2] Where appropriate, a reference has been included referring the reader to a more detailed description of the procedures being audited.
[3] Documentation to be in accordance with the three-phase control process as outlined in the Quality Control Plan.

Form 8-1a: Field Change Documentation

Date: ____________

Page _______ **of** ________

Project:

Project No.:

Applicable Document:

Change Description:

Reason for change:

Recommended disposition:

Impact on present and completed work:

Final disposition (MCB Camp Lejeune only)

Request by:

CH2M HILL Project Manager: ____ Date:______________

Approvals:

MCB Camp Lejeune Project Manager: ______________________________________ Date:______________

Form 8-2a: Corrective Action Request Form

Originator: ____ Date: _______

Person responsible for replying: ____

Description of problem and when identified: ____________________________________

____

Sequence of Corrective Action (CA): (Note, if no responsible person is identified, submit this form directly to the PM)

State date, person, and action planned:

____

____

____

____

____

CA initially approved by: __________________________________ Date: _____________

Follow-up date: ____

Final CA approval by: _____________________________________ Date: _____________

Information copies to:

Responsible person:____

Field Team Leader:____

Project Manager: ____

FORM 8-1b

Preparatory Inspection Checklist (Part I)

Contract No.:

Date: ___________

TITLE AND NO. OF TECHNICAL SECTION: ______________________________

____

____

____

A. Planned Attendees:

	Name	Position	Company
1)			
2)			
3)			
4)			
5)			
6)			
7)			
8)			
9)			
10)			
11)			

B. Submittals required to begin work:

	Item	Submittal No.	Action Code
1)			
2)			
3)			
4)			
5)			
6)			
7)			
8)			

I hereby certify, that to the best of my knowledge and belief, that the above required materials delivered to the job site are the same as those submitted and approved.

____

Contractor Quality Control Systems Manager

FORM 8-1b (Continued)

Preparatory Inspection Checklist
(Part I)

Contract No.:

Date: __________

C. Equipment to be used in executing work:

1) ____________________
2) ____________________
3) ____________________
4) ____________________
5) ____________________

D. Work areas examined to ascertain that all preliminary work has been completed:

____
____

E. Methods and procedures for performing Quality Control, including specific testing requirements:

____
____

The above methods and procedures have been identified from the project plans and will be performed as specified for the Definable Feature of Work.

____
Contractor Quality Control Systems Manager

FORM 8-1b (Continued)

Preparatory Inspection Checklist
(Part II)

A. Persons in attendance: See Meeting Attendance Sheet (attached)

B. Because of mutual understanding developed during review of preparatory outline and Contract Requirements: (Contract items not specifically covered during the preparatory inspection conference are assumed to be in strict conformance with the contract requirements.)

____

The items noted above constitute a memorandum of mutual understanding and will be performed as planned and specified.

____________________ ____________________

MEC QCS Technical Representative

FORM 8-2b

Initial Phase Check List

Contract No.:

Date: ___________

Title and No. of Technical Section: ____

____

____

Description and Location of Work Inspected: ____

A. Key Personnel Present:

Name	Position	Company

B. Materials being used are in strict compliance with the contract plans and specifications: Yes ___ No ____

If not, explain: ____

____

____

____

C. Procedures and/or work methods witnessed are in strict compliance with the contract specifications: Yes No ___

If not, explain: ____

____

____

____

D. Workmanship is acceptable: Yes ____ No ____

State where improvement is needed: ____

____

____

____

E. Workmanship is free of safety violations: Yes ____ No ____

If no, corrective action taken:

____

____

____

____

____

MEC QCS

FORM 8-3b

FOLLOW-UP CHECKLIST

Date:
Contractor:
Contract No:

Y=YES; N=NO; SEE REMARKS BLANK=NOT APPLICABLE	
WORK COMPLIES WITH CONTRACT AS APPROVED IN INITIAL PHASE	

IDENTIFY DEFINABLE FEATURE OF WORK, LOCATION, AND LIST PERSONNEL PRESENT

TESTING PERFORMED & WHO PERFORMED TEST (Include number of samples and/or tests taken)

QA Representative________________________ **Date** _________________

MEC QCS________________________________ **Date** _________________

FORM 8-4b

Final Inspection Checklist
(Part I)

DATE: ____________

CONTRACT NO.:____

Project / Area of Inspection: ____

A. DEFINABLE FEATURES OF WORK: Status of Inspection:

I hereby certify, that to the best of my knowledge and belief, that the work inspected is complete and all materials and equipment used and work performed were completed in accordance with plans submitted and approved.

____

CONTRACTOR QUALITY CONTROL SYSTEMS MANAGER

B. Final Acceptance is Approved, Subject to the Correction of the Punchlist Items Below:

FORM 8-4b (Continued)

Final Inspection Checklist
(Part I)

DATE:______________________

CONTRACT NO.:

A. Persons in Attendance: See Meeting Attendance Sheet (attached)

B. Resolution of Punchlist Items:

The items noted above constitute a memorandum of mutual understanding and work has been performed as planned and specified.

MEC QCS

TECHNICAL REPRESENTATIVE

FORM 8-4b (Continued)

Final Inspection Checklist
(Part II)

MEETING ATTENDANCE LIST

Meeting:		Date:
Name	**Organization**	**Phone Number**

FORM 8-5b

INSPECTION SCHEDULE AND TRACKING FORM

Project:	**Project Manager:**	**MEC QCS:**

Reference Number	Definable Feature of Work	**Preparatory**		**Initial**		**Follow-Up**		**Completion**		
		Date Planned	Actual Date	Date Planned	Actual Date	Planned Begin/End	Actual Dates	Planned Begin/End	Actual Dates	Status

FORM 8-6b

CORRECTIVE ACTION REQUEST

(2)CAR #:	(3)PRIORITY: □HIGH □NORMAL	(4)DATE PREPARED:

PART A: NOTICE OF DEFICIENCY

(5)PROJECT:	
(6)PROJECT MANAGER:	(7)MEC QCS:
(8)WORK UNIT:	(9)WORK UNIT MANAGER:
(10)ISSUED TO (INDIVIDUAL & ORGANIZATION):	
(11)REQUIREMENT & REFERENCE:	
(12)PROBLEM DESCRIPTION & LOCATION: (4)CAP REQUIRED? □YES □NO (14)RESPONSE DUE:	
(15)ISSUED BY (PRINTED NAME & TITLE): SIGNATURE: DATE:	(16)MANAGEMENT CONCURRENCE:

Form 8-6B (continued)
CORRECTIVE ACTION REQUEST

PART B: CORRECTIVE ACTION

(17) PROPOSED CORRECTIVE ACTION/ACTION TAKEN:

NOTE: SUPPORTING DOCUMENTATION MUST BE LISTED ON THE BACK OF THIS FORM AND ATTACHED.

(18) PART B COMPLETED BY (NAME & TITLE): SIGNATURE: DATE:	(19) QC CONCURRENCE:

PART C: CORRECTIVE ACTION VERIFICATION

(20) CAR VERIFICATION AND CLOSE-OUT: (CHECK ONLY ONE & EXPLAIN STIPULATIONS, IF ANY)

☐ APPROVED FOR CLOSURE WITHOUT STIPULATIONS
☐ APPROVED FOR CLOSURE WITH FOLLOWING STIPULATIONS

COMMENTS/STIPULATIONS:

(21) CLOSED BY (PRINTED NAME & TITLE):

SIGNATURE: DATE:

Form 8-6B (continued)
CORRECTIVE ACTION REQUEST

CORRECTIVE ACTION REQUEST (CAR) INSTRUCTION SHEET

(1) **MEC QCS**: Verify that the total number of pages includes all attachments.

(2) **MEC QCS**: Fill in CAR number from CAR log.

(3) **MEC QCS**: Fill in appropriate priority category. **High** priority indicates resolution of deficiency requires expediting corrective action plan and correction of deficient conditions noted in the CAR and extraordinary resources may be required due to the deficiency's impact on continuing operations. **Normal** priority indicates that the deficiency resolution process may be accomplished without further impacting continuing operations.

(4) **CAR Requestor**: Fill in date CAR is initiated.

(5) **CAR Requestor**: Identify project name, number, CTO, and WAD.

(6) **CAR Requestor**: Identify Project Manager

(7) **CAR Requestor**: Identify CQC System Manager.

(8) **CAR Requestor**: Identify project organization, group, or discrete work environment where deficiency was first discovered.

(9) **CAR Requestor**: Identify line manager responsible for work unit where deficiency was discovered.

(10) **MEC QCS**: Identify responsible manager designated to resolve deficiency (this may not be work unit manager).

(11) **CAR Requestor**: Identify source of requirement violated in contract, work planning document, procedure, instruction, etc; use exact reference to page and, when applicable, paragraph.

(12) **CAR Requestor**: Identify problem as it relates to requirement previously stated. Identify location of work activities impacted by deficiency.

(4) **MEC QCS**: Identify if Corrective Action Plan (CAP) is required. CAP is typically required where one or more of the following conditions apply: CAR priority is **High**; deficiency requires a rigorous corrective action planning process to identify similar work product or activities affected by the deficiency; or deficiency requires extensive resources and planning to correct the deficiency and to prevent future recurrence.

(14) **MEC QCS**: Identify date by which proposed corrective action is due to QC for concurrence.

(15) **MEC QCS**: Sign and date CAR and forward to responsible manager identified in (10) above.

(16) **Responsible Manager**: Initial to acknowledge receipt of CAR.

(17) **Responsible Manager**: Complete corrective action plan and identify date of correction. Typical corrective action response will include statement regarding how the condition occurred, what the extent of the problem is (if not readily apparent by the problem description statement in [12]), methods to be used to correct the condition, and actions to be taken to prevent the condition from recurring. If a CAP is required, refer to CAP only in this section.

(18) **Responsible Manager**: Sign and date corrective action response.

(19) **MEC QCS**: Initial to identify concurrence with corrective action response from responsible manager.

(20) **MEC QCS**: Check appropriate block to identify if corrective action process is complete so that CAR may be closed. Add close-out comments relevant to block checked.

(21) **MEC QCS**: Indicate document closeout by signing and dating.

FORM 8-7b

CORRECTIVE ACTION PLAN

Attach clarifications and additional information as needed. Identify attached material in appropriate section of this form.

PART A: TO BE COMPLETED BY PROJECT MANAGER OR DESIGNEE

(1)PROJECT:		
(2)PROJECT MANAGER:	(3)MEC QCS:	
(4)CAR NO(S) AND DATE(S) ISSUED:		
(5)DEFICIENCY DESCRIPTION AND LOCATION:		
(6)PLANNED ACTIONS	(7)ASSIGNED RESPONSIBILITY	(8) COMPLETION DUE DATE
(9)PROJECT MANAGER SIGNATURE:		DATE:

PART B: TO BE COMPLETED BY MEC QCS OR DESIGNEE

(10)CAP REVIEWED BY:	DATE:
(11)REVIEWER COMMENTS:	
(12)CAP DISPOSITION: (CHECK ONLY ONE AND EXPLAIN STIPULATIONS, IF ANY) ☐ APPROVED WITHOUT STIPULATIONS ☐ APPROVED WITH STIPULATIONS ☐ APPROVAL DELAYED, FURTHER PLANNING REQUIRED COMMENTS:	
(4)MEC QCS SIGNATURE:	DATE:

FORM 8-8b

DAILY QUALITY CONTROL REPORT

Contract No.: __________

Date: ________________Task Order No.:________Report No:_______

LOCATION OF WORK: ____
DESCRIPTION: _____________ ____
WEATHER: (CLEAR) (FOG) (P.CLOUDY) (RAIN) (WINDY)
TEMPERATURE: MIN °F MAX °F

1. Work performed today:

____

____

2. Work performed today by CH2MHILL subcontractor(s):

____

____

3. Preparatory Phase Inspections performed today (include personnel present, specification section, drawings, plans, and submittals required for definable feature of work):

____

____

4. Initial phase Inspections performed today (include personnel present, workmanship standard established, material certifications/test are completed, plans and drawings are reviewed):

____

____

5. Follow-up Phase Inspections performed today (include locations, feature of work and level of compliance with plans and procedures):

____

____

____

6. List tests performed, samples collected, and results received:

____

____

____

7. Verbal instructions received (instructions given by Government representative and actions taken):

____

____

____

8. Non-conformances/deficiencies reported:

____

____

____

9. Site safety monitoring activities performed today:

____

____

10. Remarks:

____

____

____

____

CERTIFICATION: *I certify that the above report is complete and correct and that I, or my representative, have inspected all work identified on this report performed by CH2M HILL and our subcontractor(s) and have determined to the best of my knowledge and belief that noted work activities are in compliance with the plans and specifications, except as may be noted above.*

MEC QCS (or designee) Signature: ____

Form 8-9b

Document Release and Review

Client:	Author:	Submittal Register Item No.:	Date:
Document Title:	Revision:	D.O.#	WAD#

Reviewer (*print*)	Reviewer initial & date	Technical	Project Manager	CQC System Mgr.	Health & Safety	Editorial	Chemistry	Construction	Reviewer Comments Resolved (*Signature & Date*)
Same as Technical Reviewer Above		X	Topic outline with objectives for each section submitted prior to Rev. A						

Program Reviewer's Acceptance for Document Submittal	Signature	Yes	No
1) A 4025 (as applicable) prepared and submitted with document?			
2) Technical Conclusions adequately supported by text and data?			
3) Tables and Figures are in the proper format and checked and approved?			
4) The Table of Contents consistent with text information?			
5) Technical Reviewers are qualified and accepted by Technical Manager?			
6) A document Distribution List been prepared and submitted with document?			

Approval: ______________________________
Project Manager

Approval: ______________________________
MEC QCS

Recommended
4025 Code _______________

SECTION 9

Environmental Protection Plan

9.1 Regional Ecological Summary

MCB Camp Lejeune is located within the headwaters of the New River Watershed. The New River is a slow moving and placid river that was dedicated as a National Scenic River in 1976. The topography along this coastal region is generally flat to gently rolling, which slopes from an altitude of 63 ft amsl to sea level. Approximately 59 percent of the New River Watershed is forested, with croplands and pastures making up 35 percent and the remaining area being considered urban.

This portion of the NC coast is a diverse region containing over 30 miles of sandy beaches which make up a continuously altering coastline. Many areas of the NC coastline are highly erodable due to the sandy substrate and violent currents. These sandy coastlines transition into a region of pines (*Pinus sp*.), scrub oaks (*Quercus sp*.), sweetgum (*Liquidambar styraciflua*), and dogwood (*Cornus sp*.). Bermuda grass (*Cynodon dactylon*) is the primary undergrowth species of the area. These areas are interspersed with bottomland hardwood forests that were once more prevalent in this region. These forest types are dominated by bald cypress (*Taxodium distichum*), and swamp tupelo (*Nyssa sylvatica var. biflora*), with Atlantic white cedar (*Chamaecyparis thyoides*) being common on organic substrates underlain by sand. Croplands are also common in this area and are predominantly corn, cotton, peanuts, and tobacco.

The climate in Jacksonville, NC, is characterized by short, mild winters and long, hot, humid summers. Average annual net precipitation is approximately 50 inches Ambient air temperatures generally range from 33°F to 53°F in the winter months, and 71°F to 88°F during the summer months.

9.2 Site-specific Ecological Summary

Each SSWP will include a site-specific ecological summary for the site being investigated.

9.3 Compliance with Applicable or Relevant and Appropriate Requirements

CH2M HILL will follow all applicable regulations concerning environmental protection, pollution control, and abatement for the proposed project work. No environmental permits are anticipated to be required for investigative work. However, if such permits are required, they will be identified in the SSWP. Table 9-1 lists the applicable or relevant and appropriate requirements (ARARs) for environmental protection.

9.4 Detailed Procedures and Methods to Protect and/or Mitigate the Resources/Sites Identified

Prior to initiation of the proposed work, an evaluation of the project area will be conducted by a qualified ecologist to identify any obvious environmental concerns. The ecologist, in conjunction with the PM, will provide instructions to field personnel regarding the protection of onsite environmental resources. Such protective measures may include, but may not be limited to, the following:

- Should any federally protected plant be identified within the project area, the specimens will be flagged for easy relocation and verification.
- Should any cultural or archaeological material or resource be discovered within the project area, a qualified archaeologist will be notified to provide guidance on performing further work in the area.
- The PM will seek the guidance of the qualified ecologist to determine appropriate mitigation measures in the event that the performed work activities impact any environmental resource.

TABLE 9-1
Applicable or Relevant and Appropriate Requirements for Environmental Protection
Munitions Response Program, Master Project Plans

Reference	Title
Federal Requirements	
33 USC 1251, et seq.	Clean Water Act
33 USC 403	Rivers and Harbors Act of 1899
16 USC 1531 et seq., per 50 CFR 402	Endangered Species Act
16 USC 703, et seq.	Migratory Bird Treaty Act
16 USC 470	National Historic Preservation Act of 1966
16 USC 469, et seq., and 36 CFR 65	National Archaeological and Historic Preservation Act
State Requirements	
15A NCAC 7H	Guidelines for areas of environmental concern.
GS 113-331 to 133-337	North Carolina Endangered Species Act

USC = U.S. Code; NCAC = North Carolina Administrative Code

SECTION 10

Investigation-derived Waste Plan

This section addresses wastes generated during the environmental investigation of potentially HTW-contaminated sites, which are classified as IDW and will be managed to protect the public and the environment, as well as to meet legal requirements. Management of debris generated during intrusive MEC investigations is addressed in Section 2.6.

The FTL will be responsible for the documentation, generation, containerization, and on-site staging of IDW. The containers may be drums, roll-off boxes, poly tanks, or other. Prior to commencing fieldwork, the FTL will contact the IDW subcontractor and complete an IDW Management Form (Form 10-1). During fieldwork, IDW will be placed in the containers specified on the IDW Management Form and a copy of the same form will be placed in a sealed plastic sleeve and secured to the container. The containers will then be labeled (visible marker) corresponding to the appropriate IDW Classification (e.g., media, container type, waste source). All IDW will be staged at the location specified on the IDW Management Form. The on-site staging area will be identified in the SSWPs.

At completion of the field effort, the FTL will perform appropriate sampling/analysis of the IDW if site-specific data cannot be used to characterize the IDW for disposal. The FTL will also contact the IDW subcontractor to have the IDW containers removed from the Site.

The IDW subcontractor will be responsible for the documentation, secondary staging, and disposal of IDW. The SSWPs may detail the secondary staging area and disposal facility, although that information may not be available during SSWP preparation. The IDW subcontractor will provide the FTL an IDW Management Form and assist in its completion prior to the field effort and maintain a copy at all times.

Following completion of the field effort, the IDW subcontractor will meet the FTL at the specified on-site staging area, check to see that all IDW Management Forms are complete and correct, and transport the IDW containers to the secondary staging area.

The IDW subcontractor will coordinate with the Base’s Resource Conservation Recovery Section (RCRS) and provide the required analytical results for any IDW requiring disposal at the Base landfill or at a licensed Temporary Storage and Disposal (TSD) Facility. Once RCRS has concurred on the disposal plan and properly manifested the IDW, the IDW subcontractor will carry out disposal at the appropriate facility. All IDW management actions should be documented in field logbook by the FTL.

Form 10-1: IDW Management
(One Form Per Site or Location)

Form must be submitted to the following within 10 business days prior to start of work

Robert Lowder / EMD: lowderra@lejeune.usmc.mil /910-451-9607
Contact in field ____________________ Mobile ______________ Office __________________

Investigative Contractor: ____

Point of Contact (Field):

Name	Office Phone No.	E-Mail Address
____________	____________	____________
Cell Phone No.	Pager No.	
____________	____________	

Field Effort: Estimated Start Date ____________________

Estimated Completion Date ____________________

Wells Type ____

Quantity ____

Anticipated Waste: (Quantity Needed)

	Quantity	On-Site Staging Location
Drums	________	____________________
Rolloffs	________	____________________
Tanks	________	____________________

Form Completed by
Name ____________________
Phone No. ____________________
E-mail ____________________
Date ____________________

SECTION 11

Accident Prevention Plan

11.1 Background Information

This Accident Prevention Plan (APP) has been prepared in support of future MEC RAs to be performed at MCB Camp Lejeune. USACE DID FPRT-005-06 was used in the development of this APP. Along with the site-specific HSP, the APP comprises the H&S policy and procedures for work performed by CH2M HILL and its subcontractors at MCB Camp Lejeune. The APP and HSP identify the responsibilities of all safety personnel and provide the specific procedures and protocols to be followed by field personnel to ensure the H&S of all onsite workers.

11.1.1 Identifying Information

Contractor:	CH2M HILL 9191 S. Jamaica Street Englewood, CO 80112
Contract Number:	Refer to SSWP
Task Order No.	Refer to SSWP
Project Name	Refer to SSWP

11.1.2 Project Description

A detailed project description is provided in the SSWP Section 1.1.

11.1.3 Description of Work

A description of work to be performed is provided in Section 1.2 of the SSWP.

11.1.4 Tasks Requiring Activity Hazard Analysis

Activity Hazard Analyses (AHAs) will be prepared for each DFOW identified as a field operation activity in the SSWP. The following is a list of tasks that are known to require AHAs based on Hazard/Risk analysis:

- Mobilization and setup
- Site layout surveys with MEC avoidance
- Vegetation removal with MEC avoidance
- Surface MEC clearance operations
- DGM surveys
- Intrusive anomaly investigations/mag and dig operations (MEC investigations)
- Excavation operations, sifting, and separation of MEC from excavated soil
- MEC demolition and disposal (blasting operations)

- MPPEH/MD management
- Site restoration and demobilization

If other tasks are identified prior to or during project execution, the UXOSO will coordinate with the Program HSM to develop and publish the appropriate AHAs for the newly identified tasks.

11.2 Corporate Health and Safety Policy

CH2M HILL's Health, Safety, Environment, and Quality Policy, which has been signed by senior corporate executives, is provided as Figure 11-1.

11.2.1 Safe Work Policy

It is the policy of CH2M HILL to perform work in the safest manner possible. Safety must never be compromised. To fulfill the requirements of this policy, an organized and effective safety program must be carried out at each location where work is performed.

CH2M HILL believes that all injuries are preventable, and we are dedicated to the goal of a safe work environment. To achieve this goal, every employee on the project must assume responsibility for safety.

Every employee is empowered to:

- Conduct their work in a safe manner
- Stop work immediately to correct any unsafe condition that is encountered
- Take corrective actions so that work may proceed in a safe manner.

Safety, occupational health, and environmental protection will not be sacrificed for production. These elements are integrated into QC, cost reduction, and job performance, and are crucial to our success.

11.2.2 Health and Safety Commitment

CH2M HILL has embraced a philosophy for H&S excellence. The driving force of this commitment to the belief that employees are CH2M HILL's most significant asset and CH2M HILL values their safety, health, and welfare. We also believe that all injuries are preventable. CH2M HILL's safety culture empowers employees at all levels to accept ownership for safety and take whatever actions are necessary to eliminate injury. Our company is committed to world-class performance in H&S and understands that world-class performance in H&S is a critical element in overall business success.

CH2M HILL is committed to the prevention of personal injuries, occupational illnesses, and damage to equipment and property in all of its operations; the protection of the general public whenever it comes in contact with the company's work; and the prevention of pollution and environmental degradation.

Company management, field supervisors, and employees plan safety into each work task in order to prevent occupational injuries and illnesses. The ultimate success of our safety program depends on the full cooperation and participation of each employee.

CH2M HILL will exceed recognized MR industry standards as we work to be a model in the Military Munitions Response Program (MMRP) industry. CH2M HILL management extends its full commitment to H&S excellence.

11.3 Responsibilities and Lines of Authority

11.3.1 Identification and Accountability of Personnel Responsible for Safety

The Program and project personnel responsible for safety are identified in Section 2.4 and in SSWP Section 2.

11.4 Subcontractors and Suppliers

11.4.1 Subcontractor Information

CH2M HILL will subcontract various services to support site-specific project activities, which may include: MEC support, geophysical services, vegetation clearing, and land surveying. These subcontractors will be identified prior to mobilization and will be required to follow all applicable H&S requirements identified in this APP and the site specific HSP.

11.4.2 Subcontractor/Supplier Coordination and Control

CH2M HILL subcontractors will be screened for safety performance and compliance with Federal Alcohol and Drug testing requirements prior to being issued any contract for site work. CH2M HILL subcontractors will comply with the requirements for site safety as outlined in the HSP.

11.4.3 Subcontractor/Supplier Safety Responsibilities

All subcontractor employees are subject to the same training and medical surveillance requirements as project team personnel, depending on job activity. All activities involving the potential for exposure to hazardous waste materials will require medical and training certification as mandated by OSHA (29 CFR 1910.120). All subcontractor personnel will be required to sign-in daily and will be required to attend a daily meeting to discuss operations and safety issues. Subcontractors will submit AHAs specific to their work activities to the UXOSO. The subcontractor reports directly to the SUXOS for operational direction and to the FTL for logistics. All incidents involving subcontractor employees shall be reported orally to the UXOSO and a copy of the subcontractor's injury/illness report shall be submitted to the UXOSO within 24 hours.

Subcontractors are required to sign and comply with all requirements of the HSP. Plans to address specific hazards may be added to the APP by during the course of work. Subcontractors will be required to sign and comply with any supplemental plans. Subcontractors not in compliance will be immediately dismissed from the site. Subcontractors must comply with the following activities and are responsible for:

- Complying with applicable federal, state and local safety standards
- Actively participating in the project safety program and attending all required safety meetings

- Providing a site supervisor who is qualified as a competent person for the subcontractor's work activities and who also serves as the subcontractor's safety representative to coordinate their compliance with the HSP with the UXOSO
- Maintaining a first aid kit for the subcontractor's work crews onsite
- Maintaining and replacing safety protection systems damaged or removed by the subcontractor's operations
- Notifying the UXOSO of any accident, injury, and/or incident immediately and submitting reports to CH2M HILL within 24 hours
- Installing contractually required general conditions for safety for lower tier subcontractors (e.g., engineering controls)
- Conducting and documenting weekly safety inspections of their specific tasks and associated work areas

Suppliers delivering materials to the project site or providing equipment or equipment maintenance will comply with the H&S procedures in the HSP. Non-UXO-qualified personnel will not be permitted into areas potentially containing MEC or MPPEH without a qualified UXO escort, and only essential UXO qualified personnel will be allowed within the EZs during MEC operations. The DGM operation is an exception to this requirement and will be limited to the non-intrusive geophysical mapping that will occur only after the surface clearing activity has been accomplished.

Subcontractors will not ride on tractors, forklifts, or similar vehicles unless specific seats are provided. Trucks will be loaded and unloaded in a safe and effective manner and materials will be stored safely in designated locations only. Associated packaging will be properly disposed of and litter will not be permitted to be scattered or blown from truck beds. Operators of mobile equipment on site must observe all traffic rules, such as speed limits and right-of-ways of pedestrians.

11.5 Training Mandatory

Training and certification requirements are discussed in Section 8.2.8.

11.6 Health and Safety Inspections

11.6.1 Internal Safety Inspections

The UXOSO will perform daily site inspections to ensure that project activities are being performed in accordance with the HSP. Any serious H&S deficiencies observed during the UXOSO's daily site inspection will be corrected immediately or that specific work operation will be suspended until it is in compliance with the HSP requirements. Results of these inspections will be documented daily in the UXOSO's logbook. Any H&S deficiency or non-compliant observation will be discussed during the next day's safety meeting.

The UXOSO will also perform weekly H&S inspections, using the activity-specific H&S self-assessment checklist provided in Attachment 6 of the HSP, to confirm specific project activities are performed in compliance with the hazard control procedures of the HSP. All deficiencies and corrective actions, along with the date they were taken or required to be taken, will be verified by the UXOSO and documented in the self-assessment checklists at the time of the inspection. The UXOSO will confirm that all deficiencies are closed out with appropriate corrective actions taken. Copies of these inspection checklists will be maintained on file at the project location.

The UXOSO and UXOQCS are responsible for conducting and preparing reports of daily safety inspections of UXO work processes, site conditions, equipment conditions and submitting them to the PM.

The Program HSM will periodically conduct site visits and perform site H&S audits. These reports will be kept on file, tracked as to the number of action items noted during the visit with written confirmation of the corrective actions for each item. These responses are compiled and provided to program management for review.

11.6.2 External Inspections/Certifications

There are currently no scheduled or required External Inspections or certifications. The Project management team will make every effort to accommodate requests for external inspections, reviews and surveys.

11.7 Health and Safety Expectations, Incentive Programs, and Compliance

11.7.1 Company Safety Program Goals

CH2M HILL considers safety the highest priority during work at all project sites and its business offices and has established a goal of **zero incidents.** All projects will be conducted in a manner that minimizes the probability of near misses, equipment and/or property damage, or injury. CH2M HILL will establish programs to recognize people and projects that demonstrate excellence in safety performance. CH2M HILL will use safety observation programs to identify and correct unsafe acts and conditions. Safety awareness programs will be used to provide continuous training and development of good safety practices.
CH2M HILL site supervision will investigate all incidents to determine root causes and institute corrective actions to prevent recurrence. CH2M HILL will provide and enforce safety rules to protect employees, subcontractors, clients and the public. Project supervisory personnel that demonstrate superior safety performance will be rewarded.

11.7.2 Employee Safety Responsibilities

Each employee is responsible for personal safety as well as the safety of others in the area and is expected to participate fully in the H&S Program. The employee will use all equipment in a safe and responsible manner as directed by the project's H&S officer. All CH2M HILL personnel will follow the policies set forth in the CH2M HILL HSP. Site personnel concerned with any aspect of H&S shall bring the issue to the attention of the PM or the project's H&S officer. All project personnel have the authority to stop work if, in their judgment, serious injury could result from continued activity. The project's H&S officer shall be notified immediately if this becomes necessary. To protect the H&S of all personnel, employees that knowingly disregard safety policies and procedures may be subject to disciplinary actions up to, and including, termination.

11.7.3 Managers and Supervisors Safety Accountability

It is the duty of the first line supervisor to motivate employees to adhere to CH2M HILL's safety policy in each work situation. For these purposes, a first line supervisor is defined as that person designated to give immediate onsite supervision to personnel involved in a task.

All supervisors shall have complete knowledge of the safe procedures for all jobs and tasks under their supervision. When in doubt, they shall seek assistance prior to initiating a task. This is the only acceptable manner in which to perform the task. If the task cannot be accomplished safely, it will not be attempted.

Supervisors will:

- Explain the safety procedure involved with a task to each employee and check frequently to see that the employee understands and works as instructed
- Allocate sufficient time for the training and coaching of all employees to ensure that everyone knows the correct procedure for safely accomplishing required tasks
- Prevent new employees from performing any tasks until required training is completed
- Immediately correct unsafe conditions that involve CH2M HILL employees or subcontractors
- Ensure that the employees are outfitted with and wear personal protective equipment PPE as specified by this APP, HSP, other CH2M HILL procedures or as directed by the PM, project H&S officer, or Program HSM
- Set a good safety example
- Obtain the cooperation of employees and subcontractors
- Provide a safe work environment for employees and subcontractors
- Confirm subcontractor safety performance records have been verified prior to contract award and monitor contractor performance during operations
- Report all accidents, near misses and property damage in accordance with CH2M HILL and USACE Incident Reporting Procedures
- Establish a safety culture, using the elements of the CH2M HILL Safety Improvement process, which promotes awareness, encourages participation, and recognizes excellence

11.7.4 Incentive Program

CH2M HILL will implement a safety incentive program for the project that rewards workers for exhibiting exemplary safety behaviors. Actions that qualify are those that go above and beyond what is expected (i.e., wearing your own safety equipment, seatbelt, etc). Actions that will be rewarded include spotting and correcting a hazard, bringing a hazard to the attention of your supervisor, telling your supervisor about an incident, determining a safer way to get the work done, and stopping a crew member from doing something unsafe. The program will operate throughout the project, covering all workers. The incentive program will be communicated to all employees during the project employee orientation and project safety meetings.

11.7.5 Stop Work Authority

Each employee on the project has the obligation and authority to shut down any perceived unsafe work. During employee orientation, each employee will be informed of their authority to stop work.

Once stop work is declared by an employee, the UXOSO shall investigate the cause of the cessation, rendering appropriate mitigation and controls after consulting with offsite personnel (if required) and documenting the event in the UXOSO project log book. Appropriate entries will also be made in the QC Logbook and daily reports.

11.7.6 Standards of Conduct Violations

All individuals associated with this project are expected to act in a professional manner. Violations of the standards of conduct include, but are not limited to, the following:

- Failure to perform work
- Inefficient performance, incompetence, or neglect of work
- Willful refusal to perform work as directed (insubordination)
- Negligence in observing safety regulations, poor housekeeping, or failure to report on-the-job injuries or unsafe conditions
- Unexcused or excessive absence or tardiness
- Unwillingness or inability to work in harmony with others
- Discourtesy, irritation, friction, or other conduct that creates disharmony
- Harassment or discrimination against another individual
- Failure to be prepared for work by wearing the appropriate clothing, PPE, or bringing the necessary tools
- Violation of any other commonly accepted reasonable rule of responsible personal conduct

11.7.7 Intolerable Offenses

Certain employee conduct may be so intolerable as to justify removal from the project. Intolerable offenses and actions include, but are not limited to, the following:

- Any manager, supervisor, or other person in charge of the work being performed who requires, requests, asks, threatens with their job, allows, or condones employees to work in or around unsafe acts or conditions

- Any employee, supervisor, or manager who knowingly falsifies any investigative documents or testimony involving an investigation
- Any employee, supervisor, or manager who openly exhibits disregard, defiance, or disrespect for the safety program
- Any employee who violates established safety rules, regulations, or codes and endangers themselves or other employees
- Any and all parties involved in workplace violence, including physical encounters (fighting) or threats of violence, theft, or destruction of property
- Any employee, supervisor, or manager failing to comply with procedures contained in the subcontract, HSP, USACE EM 385-1-1 Manual, or any applicable federal, state, local safety laws and regulations that create the potential for serious or costly consequences
- Any employee who commits repeated minor offenses and shows a lack of responsible effort to correct these offenses

11.7.8 Enforcement and Discipline

CH2M HILL's Enforcement and Discipline procedures, the Standards of Conduct, the Intolerable Offenses, and the Drug Free Workplace policy will be thoroughly reviewed with each employee during the employee project orientation.

Intolerable Offenses

CH2M HILL practices zero tolerance for intolerable offenses. Those individuals found participating in such offenses will be:

- Suspended from work for 3 days without pay, or
- Immediately discharged and not allowed to return.

Other Violations

Other violations, as outlined in the Standards of Conduct, will be handled accordingly:

- **First Offense**—Employee will receive a written warning
- **Second Offense**—Employee will receive a 2-day suspension without pay
- **Third Offense**—Employee will be discharged

11.7.9 Incident Notification and Reporting

The appropriate guidelines and procedures for incident notification and reporting are listed in Section 9.7 of the HSP.

11.8 Medical Support

11.8.1 Medical and First Aid Requirements

Prior to starting site work, the UXOSO will arrange with the local medical facility and emergency response personnel to provide prompt medical attention in the event of an accident. Emergency phone numbers are listed in Section 9.8 of the HSP.

11.8.2 First Aid and CPR Training

A minimum of two fully qualified First Aid and cardiopulmonary resuscitation (CPR)-trained individuals will be on the project site at all times. These individuals will hold certifications in First Aid and CPR from the American Heart Association or from an organization with equivalent training. The certificates shall state the date of issue and the length of validity. The qualified individuals will be identified to all personnel on site during the morning safety briefing.

11.8.3 First Aid Kits

At a minimum, first aid kits will be provided in the ratio of one for every 25 people onsite. Preferably there will be one first aid kit for each individual team conducting operations within the EZ. The first aid kits will be Type III, 16-unit first aid kits that meet ANSI Z308.1-1998. First aid kits will be easily accessible to all workers, protected from the weather, and each item maintained sterile. The locations of the kits will be clearly marked and distributed as appropriate throughout the site.

11.9 Personal Protective Equipment

PPE requirements and selection criteria are outlined in Section 4 of the HSP. Protection levels provided in the HSP have been established for the anticipated scope of work. Once on site, visual inspection of the work activities may indicate the need for changes in the PPE level(s). Any significant change in the PPE level(s) will be approved by the UXOSO in consultation with the PM, Program HSM, and/or CENWO OE Safety Specialist. Currently there are no identified hazards or areas that would require a respiratory protection program on the project site.

11.10 Plans Required by the Safety Manual

11.10.1 Layout Plans

All plans for the layout of temporary buildings, facilities, fencing, access routes, and anchoring systems for temporary structures will be submitted for approval in accordance with Section 4 of USACE EM 385-1-1 Manual. If temporary power distribution is required on site, that plan will be submitted for approval in compliance with Section 11 of USACE EM 385-1-1 Manual.

11.10.2 Emergency Response Plan

An Emergency Response Plan is included as Section 9 of the HSP.

11.10.3 Hazard Communication

The site-specific Hazard Communication Program is included as Section 2.1.2 of the HSP. The CH2M HILL Hazard Communication Program complies with 29 CFR 1926.59/ 1910.1200.

11.10.4 Respiratory Protection Program

If conditions or work processes on a MR site warrant the need for respiratory protection, the UXOSO will consult with the PM and obtain the approval of the Program HSM and CENWO OE Safety Specialist before implementing a respiratory protection program on the project. The respiratory protection program will be included as an amendment to the HSP. The program will require all respirator wearers to be cleared by a physician for respirator use, be fit-tested to ensure an acceptable fit, and complete a site-specific respirator training program.

11.10.5 Health Hazard Control Program

The potential chemical hazards posed by project activities and relevant controls are provided in Section 2.4 of the HSP.

11.10.6 Hazardous Energy Control (Lockout/Tagout)

Hazardous Energy Control (Electrical Lockout/Tagout) procedures are provided in Section 2.1.12 of the HSP.

11.11 Blasting Program

The Explosive Storage and Accountability and the Ammunition and Explosives Transportation SOPs are provided in Attachment 9 of the HSP.

11.12 Drug Free Workplace

CH2M HILL does not tolerate illegal drugs or any use of drugs, controlled substances, or alcohol that impairs an employee’s work performance or behavior. CH2M HILL has established a policy that its employees and subcontractors shall not be involved in any manner with the unlawful manufacture, distribution, dispensation, possession, sale, or use of illegal drugs in the workplace. The use or possession of alcohol in the workplace is also prohibited. Any violation of these prohibitions may result in discipline or immediate discharge. Please reference CH2M HILL SOP 105, *Drug-Free Workplace Standard of Practice*, for more information. The following subsections describe mandatory program requirements.

11.12.1 Policy Statement

The policy statement for the Drug Free Workplace Program details prohibited conduct and ramifications, along with the following:

- Prohibit drug, alcohol, and/or controlled substances use or abuse
- Prohibit involvement in the manufacture, distribution, dispensation, possession, sale, or use of illegal drugs in the workplace
- Describe disciplinary actions

11.12.2 Subcontractor Management

All subcontractors must comply with the provisions of the Drug Free Workplace Program. It is the responsibility of subcontractors to transfer this information to the lower-tiered subcontractors.

11.12.3 Prescription and Non-Prescription Drugs

Employees using prescription or non-prescription drugs that could impair their function on the project are required to notify the employer in advance of such drug use.

Failure to report prescription and non-prescription drugs as required above, illegally obtaining the substance, or use that is inconsistent with the prescription or label may be subject to disciplinary action.

11.12.4 Employee Education

Employees and supervisors must be provided with a Drug Free Workplace Program and an Alcohol Education Awareness Program.

11.13 Sanitation Plan

Adequate sanitation facilities will be provided at each work site to ensure proper personal hygiene.

11.14 Site-Specific Hazards and Controls

AHAs will be prepared for each DFOW identified as a field operation activity in the SSWP.

FIGURE 11-1
Corporate Health and Safety Policy
Munitions Response Program Master Project Plans
MCB Camp Lejeune
Jacksonville, North Carolina

CH2M HILL Health, Safety, Environment, and Quality Certification

Our commitment to H&S begins with our President and expands to individual employees in the field.

CH2M HILL Companies, Ltd.
Health, Safety, Environment & Quality Policy

It is CH2M HILL's vision to achieve excellence in and be a leader of Health, Safety, Environment and Quality (HSE&Q) performance throughout our global operations. We fulfill the expectations of our clients, staff and communities through safe, innovative and environmentally sound practices in all of our operations.

Our HSE&Q programs, plans, and procedures use OSHA regulations (29 CFR 1910 & 1926) as well as meet U.S. Army Corps of Engineers requirements (EM 385-1-1) as the minimum acceptable criteria for their development.

Ralph R. Peterson
President and CEO CH2M HILL Companies, Ltd.

CEHNC_QPPH-I_201_4

SECTION 12
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Appendix A
Geophysical Prove-Out Plan

Final

Munitions and Explosives of Concern Master Geophysical Prove-out Plan

Marine Corps Base Camp Lejeune Jacksonville, North Carolina

Contract Task Order 168

May 2008

Prepared for

Department of the Navy
Naval Facilities Engineering Command
Mid-Atlantic

Under the

LANTDIV CLEAN III Program
Contract N62470-02-D-3052

Prepared by

CH2MHILL

Chantilly, Virginia

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APPENDIX A

Master Geophysical Prove Out Plan

This Master Geophysical Prove-out (GPO) Plan documents the GPO activities to be performed as part of the process for validating digital geophysical mapping (DGM) systems to be utilized during DGM activities at Munitions Response Sites (MRSs) at Marine Corps Base (MCB) Camp Lejeune, Jacksonville, North Carolina. Site-specific Work Plans (SSWPs) will be developed prior to investigation of each MRS. Each SSWP will provide additional details or modifications as necessary for the specific sites.

A.1 Objective

The primary objective of the GPO is to document the site-specific capabilities of a DGM system to operate as an integrated system capable of meeting project data quality objectives (DQOs) and to validate that the specific system to be used is functional and operating within industry standards. For the purposes of this work, a system is considered to include the survey platform, sensors, navigation equipment, data analysis and management, and associated equipment and personnel. Additional objectives of the GPO include:

- Document[1] the consideration given to various geophysical detection instruments, the criteria used to identify geophysical instruments for consideration, and the causes for their respective selection or rejection.
- Document the capabilities and limitations of the geophysical detection instrument selected for consideration.
- Observe the geophysical detection instrument operating in the DGM subcontractor's configuration, using their personnel and methodologies.
- Evaluate the DGM subcontractor's data collection, data transfer quality and data QC method(s).
- Evaluate the DGM subcontractor's method(s) of data analysis and evaluation.
- Establish initial anomaly selection criteria based on observed signal to noise ratios (SNR).
- Document system reliability.

The GPO objectives will be attained through evaluation of the achievement of the DQOs (discussed below), observation of the GPO activities by the CH2M HILL Project Geophysicist and review of previous industry and CH2M HILL experience with the geophysical instruments considered. A full discussion of the evaluation will be provided in the site-specific Preliminary Assessment/ Site Investigation (PA/SI) (see Section A.9 for topics to be discussed).

[1] The documentation referred to in the objectives may be accomplished without additional fieldwork as the instruments considered for the production surveys have been extensively tested, used and documented at many UXO sites.

A.2 Project DQOs

DGM operations performed in the GPO area will demonstrate the ability of the tested system to achieve project DQOs. The project DQOs, measurement performance criteria, and test method to be used during the GPO are discussed in the following subsections and summarized in Table A-1. The specific DQOs for each site, if different, modified or additional to those presented in this document, will be discussed in the SSWPs.

A.2.1 General Geophysical Systems Functioning

DGM Systems Positioning

The DQO for DGM systems positioning is that the coordinates being obtained from the positioning systems are at a sufficient enough accuracy to allow for appropriate relocation of munitions and explosives of concern (MEC) items for intrusive investigation. The measurement performance criterion for this is that the positional error of the system at known locations will not exceed 1 meter (m). This will be evaluated during the GPO by ensuring that, on a daily basis, the geophysical system being used passes QC Test # 3, *Record Sensor Positions,* as outlined in Section A.6.

DGM Systems Data Repeatability

The DQO for DGM systems data repeatability is that the systems respond consistently from the beginning to the end of an operation. The measurement performance criterion for this is that the response to a standardized item will not vary more than ±20%. This will be evaluated during the GPO by ensuring that, on a daily basis, the geophysical system being used passes QC Test # 6, *Static Background and Static Spike,* as outlined in Section A.6.

A.2.2 DGM Surveys

Ordnance Detection (Inert Items)

The DQO for inert ordnance items detection within the GPO is to detect (with the system selected as the most appropriate[2] system for site surveys) the items comparably to what would be expected through either documented instrument tests or instrument response models for the instrument being validated. In general, industry accepted instruments can detect most MEC items of 60mm size and larger to a depth of at least 11 times their diameter[3] (the “11X” depth). Because of the intrinsic physics involved, the minimum peak amplitude response measured by a particular geophysical instrument over a particular item does not change from location to location. The amplitude response of that item is generally consistent regardless of the surrounding medium (e.g. sand, clay, gravel, weathered rock, etc.); however, the ability of the system to select the item as anomalous from the background is dependent on site-specific and munitions-specific parameters, such as: 1) item orientation, 2) site background/noise levels, 3) masking effects from adjacent metallic items, 4) item condition, 5) magnetic conductivity of item materials, and 6) weathering effects on the magnetic conductivity of the individual item. It is therefore not possible to state with

[2] The most appropriate system will be a system that is industry accepted for MEC detection, can perform surveys at a reasonable production rate (i.e. is cost effective) and has the least limitations with respect to site conditions.

[3] USACE DID MR-005-05

certainty the specific maximum depths to which a particular type of MEC item can be detected and selected from the geophysical data at a particular site. The focus of the GPO analysis for detection is therefore concentrated more on determining that the geophysical instrument and the system as a whole is functioning as designed and to evaluate the background noise (created by the geology or outside electromagnetic influences) at the particular location.

True measurement of how well the system performs over the project site is best measured as a process, with the initial step being demonstration that the system is performing comparably to it's expected performance (detection of subsurface items comparably to equipment tests, modeled data or empirical data), review of intrusive investigation results during the project as validation of system performance, and a quality control program designed to catch inconsistencies or issues in system performance.

Acceptance that the system is meeting the detection DQO will be determined by the CH2M HILL QC Geophysicist and documented through comparison of instrument response over a seeded item and the expected response over that item (through previous tests, empirical data or modeled data).

Downline Data Density

The DQO for downline (along the survey transect) data density is to have sufficient data collected along each transect to detect MEC items. The measurement performance criterion for this is that at least 98 percent of possible sensor readings are captured along each transect at 0.7 ft (0.213 m) or less. In addition, any transect (or portion thereof) containing a data gap of 2 feet or greater does not meet the DQO. This will be evaluated during the GPO by verifying that all of the DGM data collected and used for anomaly selection meets this standard.

Survey Coverage (Lane Spacing)

The DQO for lane spacing is to maintain appropriate lane spacing to provide 100 percent coverage of the survey area. The measurement performance criterion for this is that the lane spacing varies no more than ±20 percent of 0.75m. This will be evaluated during the GPO by verifying that all of the DGM data collected and used for anomaly selection meets this standard.

Positioning Accuracy

The DQO for horizontal positioning accuracy is that positioning of detected anomalies is accurate enough to allow for effective reacquisition of the anomaly. The measurement performance criterion for this is that 95 percent of all anomaly locations lie within a 1 m radius of a point on the ground surface directly above the source of the seeded item. Any anomaly that is selected outside of 1 m from a point directly above the item will not be considered to be a detection of that item. This will be evaluated during the GPO by verifying that all anomalies selected are within this standard or can be otherwise explained. For transect surveys, this DQO is only applicable if the seed item is within the footprint of the instrument as it is not possible to accurately predict the location of items in the transverse direction from the transect if the items lie outside of the instrument footprint.

A.2.3 Data Handling

The DQO for data handling is that all data must be delivered in a timely manner and in a useable format. Because of the need for rapid feedback during GPO operations to effectively test potential DGM systems, the measurement performance criterion for data handling during GPO activities will require that within 4 hours after data collection, the DGM Contractor shall furnish draft data associated with each GPO survey performed that day. (This data is intended for data review by the CH2M HILL Project Geophysicist.) Final data packages (see Section A.8) must be completed and delivered to the CH2M HILL Project Geophysicist **within 1 working day of data collection**. During production surveys, the measurement performance criterion for data handling will require that "draft" (raw) data packages be completed and delivered to the CH2M HILL Project Geophysicist within 3 working days of data collection and the final data packages within 5 working days of data collection. This will be evaluated based on the actual delivery of data.

A.3 Personnel and Qualifications

All personnel involved in performance of the GPO and the production geophysical surveys will meet the following qualifications:

The **Project Geophysicist** shall have a degree in geophysics, geology, geological engineering, or a closely related field, and shall have a minimum of 5 years of directly related geophysical experience. This individual will be capable of managing a geophysical data collection and processing project/program including several task orders/sites and will have at least 1 year of experience in managing geophysical operations for an MEC site.

The **Site Geophysicist** shall have a degree in geophysics, geology, geological engineering, or a closely related field, and shall have a minimum of 3 years of directly related geophysical experience. This individual will be capable of competently managing personnel, equipment, and data on projects requiring multiple (three or more) geophysical field teams and geophysical data processors and will have at least one year of experience in performing geophysical operations on an MEC site.

The **Geophysical Data Processor** shall have a degree in geophysics, geology, geological engineering, or a closely related field, and shall have at least 6 months of experience in processing geophysical data related to MEC projects.

The **Field Geophysicist** shall have a degree in geophysics, geology, geological engineering, or a closely related field, and shall have a minimum of 2 years of directly related geophysical experience.

The **Geophysical Technician** shall have at least 6 months of experience in geophysical data collection on MEC related projects.

The following CH2M HILL team individuals will be involved.

- CH2M HILL Project Geophysicist
- DGM subcontractor's Site Geophysicist
- DGM subcontractor's Data Processor(s)
- DGM subcontractor's Geophysical Technician(s)

A.4 Procedures

A qualified and experienced MEC DGM operations geophysical team (see Section A.3) will separately employ each system to be tested on the GPO plot. Figure A-1 illustrates the GPO process and the procedures to be employed (numbered in accordance with the steps shown in this section.)

1. A GPO area will be selected based on:
   - Terrain, geology, and vegetation similar to that of the project site.
   - Geophysical noise conditions similar to those expected across the survey area.
   - Large enough site to accommodate all necessary GPO tests and equipment and for adequate spacing of the seed items to avoid ambiguities in data evaluation.
   - Readily accessible to project personnel.
   - Close proximity to the actual survey site.
2. A "background" DGM survey will be performed by the DGM subcontractor with the instrument to be tested in the GPO. This step will allow background geophysical conditions to be recorded, will help determine the appropriateness of the location (i.e., few existing anomalies), and will verify that items are not seeded near existing anomalies. The data will be post-processed (i.e., filtered and positions attached to the geophysical data) but the DGM subcontractor will not view the results apart from this.
3. The data will be provided to the CH2M HILL Project Geophysicist for evaluation.
4. A sufficient number of seed items will be buried at a range of depths and orientations to document approximate detection limits within the GPO grid. The targets will include simulated items intended to represent MEC potentially present at the subject site.

   CH2M HILL personnel will construct the GPO using shovels and, if necessary, a mechanical auger or backhoe to dig the holes to the appropriate depths for burial of the seed items. The seed items will be painted blue and tagged with a non-biodegradable label identifying the items as inert and providing a contract reference, a point of contact address, phone number, and a target identifier. The background survey data and anomaly avoidance techniques will be used to ensure that corner stakes and seed items are not placed on top of or near existing anomalies. Personnel will emplace each seed item and record the emplacement data (depth, orientation, and azimuth). All seed items will be photographed prior to burial.
5. A Registered Land Surveyor (RLS) will use a Real-time Kinematic (RTK) Differential Global Positioning System (DGPS) or conventional Total Station survey equipment to record seed item locations to a horizontal accuracy of 3 centimeters (cm) and a vertical accuracy of 5 cm, providing an easting and northing (in North American Datum 83 [NAD83] universal transverse Mercator [UTM] meters) for the center and each end (where applicable) of the targets. The location of the four corners of the grid will also be recorded (in UTM meters). All target markings in the GPO grid will be removed and the

grid will be returned as near as possible to its natural condition. Information on the seeded target's location will not be released to the DGM subcontractor.

6. DGM surveys will be performed by the DGM subcontractor using the system(s) selected for evaluation or validation. The system configurations to be tested will be shown in the SSWPs. The data will be processed and interpreted by the DGM subcontractor and anomaly selections made. "Draft Final" data packages will be provided to the CH2M HILL Project Geophysicist for evaluation.

7. If the initial DQOs have not been met, the CH2M HILL Project Geophysicist will meet with the DGM subcontractor to discuss whether modifications (e.g., sensor spacing) or procedures (e.g., lane spacing) can be made to the DGM system in order to meet the DQOs.

8. If the DQOs cannot be met by the DGM subcontractor, the CH2M HILL Project Geophysicist will meet with the NAVFAC LANTDIV Project Manager to discuss a resolution (i.e., modification of a DQO) prior to completing the GPO.

9. Once the surveys have been performed and at least one of the configurations has been determined capable of meeting the initial (or modified) DQOs, the GPO will be complete.

A.5 Additional GPO Considerations

Additional topics to be taken into consideration for the design of the GPO should include plot location, size, and shape; quantities of seeded items; and geophysical and positioning instruments and technologies. These topics will be addressed in the SSWPs.

A.6 QC

Geophysical instruments will be field tested frequently by the DGM Contractor to ensure that they are operating properly. A description of each test, its acceptance criteria and frequency is provided below and summarized in Table A-2.

1. **Equipment Warm-up.** This is an instrument specific activity (although a standard warm- up time is 5 minutes). Some geophysical systems require more warm-up time than others do. For example, the Geometrics G-858 system has an on-screen display that indicates when the sensors have warmed up sufficiently and are ready to be used for survey activities. Equipment warm-up is performed each time the instrument is first turned on for the day or has been turned off for a sufficient amount of time for the specific instrument to "cool-down."

2. **Positioning System Accuracy**. Positioning accuracy of the final processed data will be demonstrated by testing the positioning equipment over one or more known points. This test will be performed in a static mode over a known coordinate point to ensure that the positioning system is with accuracy requirements. The positioning of the system in kinematic (moving) mode can be measured through comparison of anomaly selections over seed item locations. The sensor position test will be conducted at the beginning of the survey operations for each work day.

3. **Record Sensor Positions.** Positioning accuracy of the final processed data will be demonstrated by testing the positioning equipment over one or more known points. This test will be performed in a static mode over a known coordinate point to ensure that the positioning system is with accuracy requirements. The positioning of the system in kinematic (moving) mode can be measured through comparison of anomaly selections over seed item locations. The sensor position test will be conducted at the beginning of the survey operations for each work day.

4. **Personnel Test.** This test checks the response of instruments to the personnel and their clothing/proximity to the system. On a daily basis, instrument coils are checked for their response to the personnel operating the system, with response observed in the field for immediate corrective action and transmitted back to the processor and analyzed and checked for spikes in the data that can possibly create false anomalies. The personnel test is conducted at the beginning of the survey operations for each work day.

5. **Vibration Test (Cable Shake).** This test checks the response of instruments to vibration. On a daily basis, instrument coils are checked for their response to vibrations in the cables, with response observed in the field for immediate corrective action and transmitted back to the processor and analyzed and checked for spikes in the data that can possibly create false anomalies. The vibration test is conducted at the beginning of the survey operations for each work day.

6. **Static Background and Static Spike.** Static tests are performed by positioning the survey equipment within or close to the survey boundaries in an area free of metallic contacts and collecting data for a specific period, while holding the instrument in a fixed position without a "spike" (known standard) and then with a "spike." The purpose of the static test is to determine whether unusual levels of instrument or ambient noise exist. The static background and static spike test are conducted at the beginning and end of each survey operation. This is the test that essentially "opens" and "closes" out a survey area (grid, grid block, set of transects, etc.)

7. **Azimuthal Test (Magnetometer only).** This test is performed to ensure that a system's sensors are oriented in such a way that they minimize data drop-outs and maximize instrument response. This test is typically only performed for magnetometer systems and should be done the first time the system is used at the site.

8. **Height Optimization (Magnetometer only).** This test is performed to ensure that the sensors are at a height that optimizes the signal-to-noise ratio while still reliably detecting the smallest MEC item of interest at the site. This test should be done the first time the system is used at the site.

9. **Six Line Test.** The "Six Line Test" is a standard response test consisting of a predetermined route (survey line) established on or near the site in an area free of metallic contacts. The beginning, midpoint, and end of the line are marked, and data is collected along the line. The line is traversed a total of six times as follows: 1) *normal* data collection speed *without* a "spike" at the centerpoint; 2) *normal* data collection speed *without* a "spike" at the centerpoint; 3) *normal* data collection speed *with* a "spike" at the centerpoint; 4) *normal* data collection speed *with* a "spike" at the centerpoint; 5) *fast* data collection speed *with* a "spike" at the centerpoint; 6) *slow* data collection speed *with* a

"spike" at the centerpoint. This test is conducted the first time a system is used at the site.

10. **Octant Test (Heading Error Test) (Magnetometer only)**. This test is done to document "heading" error associated with magnetometer systems so that the error can be corrected during data processing. This test will only be performed for magnetometer systems and will be conducted the first time the system is used at the site.

11. **Repeat Data.** This test is performed to ensure repeatability of the data and will be performed after the initial survey over an area. Because of the intrinsic difficulty of following the exact same path for collecting repeat data, this test will be a qualitative comparison as opposed to quantitative. QC Test #5 (Static Background and Static Spike) serves as a quantitative check on data repeatability by the instrument from start to finish of a survey.

A.7 Records Management

All raw data files, final processed data files, hard copies, and field notes will be maintained by the DGM subcontractor for the duration of the GPO and then turned over to the CH2M HILL Project Geophysicist.

A.8 Data Delivery

The following are the DGM data delivery requirements:

- All sensor data shall be correlated with navigational data based upon a local "third order" (1:5,000) monument or survey marker. If a suitable point is not available, the Title 2 Services Contractor shall have a Professional Land Surveyor establish a point.
- All sensor data shall be preprocessed for anomalies (e.g., sensor offsets, diurnal magnetic variations, latency corrections, drift corrections) and correlated with navigation data.
- Diurnal magnetic variations measured at a base-station must be collected at a minimum of once per minute.
- The geophysical mapping technology shall digitally capture the instrument readings into a file coincident with the grid coordinates.
- All raw and final processed data shall be delivered corrected and processed in American Standard Code for Information Interchange (ASCII) files.
- Corrections such as for navigation, instrument bias, and diurnal magnetic shift shall be applied.
- All corrections shall be documented.
- Geophysical data files may be provided in grids of up to 400 ft × 400 ft.
- Data shall be presented in delineated fields (e.g., x, y, z, v1, v2), where x and y are UTM grid plane coordinates in easting (meters) and northing (meters) directions, z (elevation is an optional field in meters), and v1, v2, v3, are the instrument readings.
- The last data field should be a time stamp.

- Each data field shall be separated by a comma or tab.
- No individual file may be more than 100 megabytes in size and no more than 600,000 lines long.
- Each grid (or set) of data shall be logically and sequentially named so that the file name can be easily correlated with the grid name used by other project personnel.
- Within 4 hours after data collection, the DGM Contractor shall furnish draft data associated with each GPO survey performed that day. This data is intended for data review by the CH2M HILL Project Geophysicist.
- Within 2 working days after collection, the DGM Contractor shall furnish final data packages for each GPO survey. Final data packages must include the following:
  - Dig sheets in pdf and Microsoft Excel formats,
  - Adobe Acrobat Portable Document Format (PDF) file(s) of color contoured geophysical results with anomaly selections shown and labeled at a readable scale for dig team use
  - Final processed data files
  - All QC data files associated with the survey files, along with showing graphical presentation of the QC data
  - PDF file documenting the field activities associated with the data, and the processing performed (see Table A-3)
  - Digital planimetric map, in Geosoft format, and coincident with the location of the geophysical survey

A.9 Reporting

CH2M HILL will prepare a GPO Report that will include the following elements:

- As-built drawing of the GPO plot
- Pictures of the seed items
- Color maps of the geophysical data
- Summary of the GPO results
- Geophysical equipment, techniques, and methodologies selected for the production survey
- Sufficient supporting information to justify selection

TABLE A-1
Project Data Quality Objectives
MCB Camp Lejeune, Jacksonville, North Carolina

DQO	Measurement Performance Criteria	Test Method During GPO
General System Functioning		
Accurate positioning is being obtained from DGM positioning systems.	Position of known items will not exceed 1 m in geophysical data.	Results of QC Test #3 (Record Sensor Positions) will be evaluated to ensure compliance.
Repeatable data are being obtained from DGM system.	Response to standardized item will not vary more than ±20%.	Results of QC Test #5 (Static Background and Static Spike) and QC Test #7 (Repeat Data) (see Section A.6) will be evaluated to ensure compliance.
DGM Surveys		
Ordnance detection: DGM survey system response is comparable to expected response of geophysical instrument.	Sensor response over specific items to be compared to response of geophysical instrument over similar items under previous test or field production conditions.	Verify that: System response is comparable to response expected through previously documented instrument capabilities.
Downline data density is sufficient to detect MEC items.	Over 98% of possible sensor readings are captured along a transect with a spacing of no greater than 0.7 ft (0.213 m) between points. In addition, any transect containing a downline data gap of 2 ft or greater does not meet the DQO.	Results of DGM surveys will be evaluated to ensure compliance.
Coverage over survey area is sufficient to detect MEC items.	Search transect spacing to vary no more than ±20% of 0.75m.	Results of DGM surveys will be evaluated to ensure compliance.
Positioning of detected anomalies is accurate.	95 percent of all anomaly locations lie within a 1 m radius of a point on the ground surface directly above the seed items.	Anomalies selected will be compared with known seed item locations to ensure compliance.
Data Handling		
All data must be delivered in a timely manner and in a useable format.	Data packages (see Section A.8) are completed and delivered to the CH2M HILL Project Geophysicist within 1 working day of data collection.	Evaluated based on actual delivery of data

Notes:
DGM = digital geophysical mapping, DQO = data quality objective, ft = foot/feet, GPO = geophysical prove-out, m = meter, MEC = munitions and explosives of concern, mm = millimeter, QC = quality control

TABLE A-2
Geophysical Instrument Standardization Tests and Acceptance Criteria
MCB Camp Lejeune, Jacksonville, North Carolina

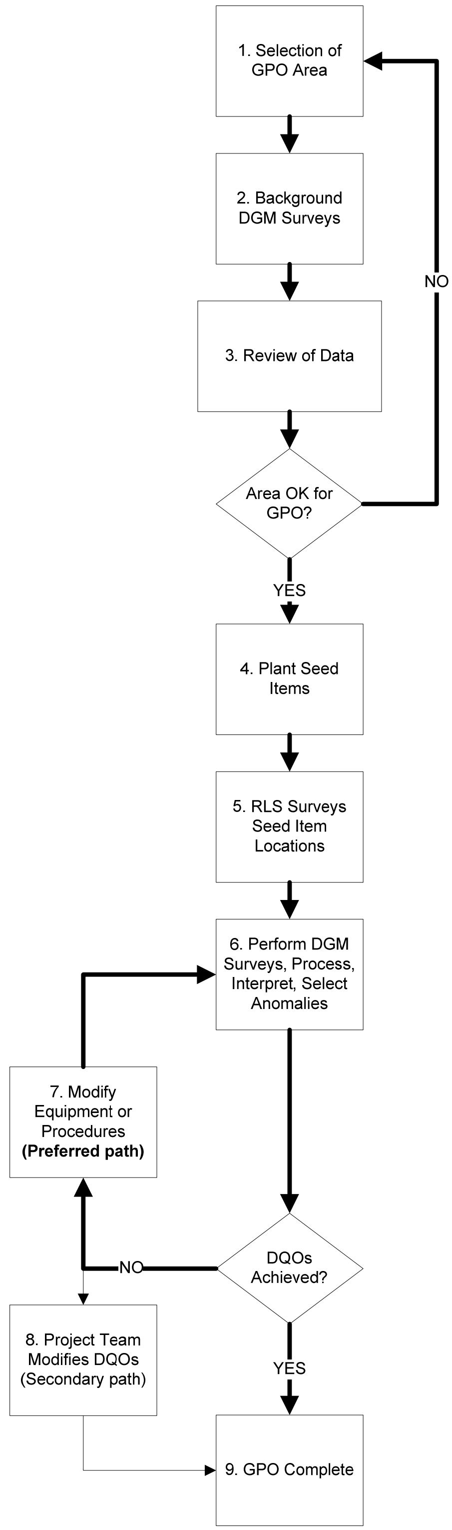
Test	Test Description	Acceptance Criteria	Power On	Beginning of Day	Beginning and End of Day	1st Time Instr. Used	2% of Total Area Surveyed
1	Equipment Warm-up	Equipment specific (typically 5 minutes)	X				
2	Positioning System Accuracy	10 cm		X			
3	Record Sensor Positions	1 m		X			
4	Personnel Test	Based on instrument used. Personnel, clothing, etc. should have <2 mV or 2 nT on instrument response.		X			
5	Vibration Test (Cable Shake)	Data profile does not exhibit data spikes (<2 mV or 2 nT)		X			
6	Static Background and Static Spike	±20 percent of standard item response, after background correction			X		
7	Azimuthal Test *	Sensor orientation that minimizes drop-outs				X	
8	Height Optimization *	Maximum S/N ratio that reliably detects smallest target objective				X	
9	Six Line Test	Repeatability of response amplitude ±20 percent, Positional Accuracy ±20 cm				X	
10	Octant Test (Heading Error Test) *	Document heading error for post-processing correction				X	
11	Repeat Data	Qualitative repeatability of response amplitude					X

Notes:
* Magnetometer Only
cm = centimeter, M = meter, mV = millivolt, nT = nano-Tesla, S/N = Signal to Noise

TABLE A-3
Processing Documentation Requirements
MCB Camp Lejeune, Jacksonville, North Carolina

Information Type	Final Data Delivery	Must be in File Headers
Site ID	X	X
Geophysical instrument type used	X	
Positioning method used	X	
Instrument serial numbers (geophysical and positioning)	X	
Coordinate system and unit of measure	X	
Grid ID (or other identifier of surveyed area)	X	X
Date of data collection	X	X
Raw data file names associated with delivery	X	
Processed data file names associated with delivery	X	
Name of Project Geophysicist	X	
Name of Site Geophysicist	X	
Name of data processor	X	
Data processing software used	X	
Despiking method and details	X	
Sensor drift removal and details	X	
Latency correction and details	X	
Heading correction and details	X	
Sensor bias, background leveling and/or standardization adjustment method and details	X	
Geophysical noise identification and removal (spatial, temporal, motional, terrain induced) and details	X	
Other filtering/processing performed and details	X	
Gridding method	X	
Anomaly selection and decision criteria details	X	
Other processing comments	X	
Date data processing is completed	X	
Data delivery date	X	
Scanned copy of field notes and field PDA notes (if applicable)	X	

FIGURE A-1
GPO Process
MCB Camp Lejeune, Jacksonville, North Carolina



Appendix B
Geophysical Investigation Plan

Final

Munitions and Explosives of Concern Master Geophysical Investigation Plan

Marine Corps Base Camp Lejeune Jacksonville, North Carolina

Contract Task Order 168

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Prepared for

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Chantilly, Virginia

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APPENDIX B

Master Geophysical Investigation Plan

The following sections present the Master Geophysical Investigation Plan (GIP) in support of the digital geophysical mapping (DGM) activities to be conducted during investigation of Munitions Response Sites (MRSs) at Marine Corps Base (MCB) Camp Lejeune, Jacksonville, North Carolina. Site-specific Work Plans (SSWPs) will be developed prior to investigation of each MRS. Each SSWP will further define the geophysical investigation approach to be implemented at that site.

B.1 Objective

The primary objective of the geophysical investigations at Camp Lejeune is to accurately locate geophysical anomalies that could represent munitions and explosives of concern (MEC) in the subsurface while developing a clear, defensible, and complete administrative record containing all recorded and developed data. Some of the resources used for development of this document and that should be consulted for development of the DGM related work plans in the SSWP include:

- United States Army Corps of Engineers (USACE), *Data Item Description (DID) MR-005-05* (December 2003)
- USACE, *DID MR-005-05A* (December 2003)
- USACE, *Engineer Manual (EM) 1110-1-4009 (Ordnance and Explosives Response)* (June 2000)
- *Ordnance and Explosives Digital Geophysical Mapping Guidance – Operational Procedures and Quality Control Manual* (December 2003)
- Interstate Technology Regulatory Council (ITRC), *Geophysical Prove-outs for Munitions Response Sites* (November 2004)
- Environmental Security Technology Certification Program (ESTCP), ITRC, *The Strategic Environmental Research and Development Program (SERDP): Survey of Munitions Response Technologies* (June 2006)

Tasks associated with this objective are listed here and specifics related to each of the tasks will be addressed in the SSWPs developed for individual sites:

- **Define Geophysical Investigation Area**. The area(s) of investigation will be defined and the boundaries marked in the field. Based on results from the geophysical investigation the investigation area may be refined.
- **Select Geophysical Survey Approach**. The geophysical survey approach will be determined based on the overall goals and data quality objectives (DQOs) of the investigation, types of munitions expected at the site, geology, terrain, and

vegetation. Included will be the types of equipment, methods, and personnel needed to carry out the geophysical investigation.

- **Select Potential DGM Equipment**. Potential DGM systems will be selected while developing the geophysical survey approach and a geophysical prove-out (GPO) may be used to facilitate final system selection. Multiple types of potential DGM systems may be identified and the GPO may be helpful in selecting the system that will most effectively meet the investigation and site needs. In other cases the appropriate system may not be known and the GPO will help to test the effectiveness of various DGM systems for the site and the conditions.
- **Equipment Tests**. The proposed geophysical systems will be tested under site-specific conditions. During the GPO the equipment will be deployed over an area representative of the investigation area seeded with inert MEC items or (if necessary) surrogates. The GPO will test the entire survey process from data collection to anomaly reacquisition (as appropriate).
- **Site Preparation**. The necessary site and safety preparations will be made, which will include a MEC surface clearance, removal of surface metallic items, vegetation clearance, establishing survey boundaries, and establishing control points.
- **Digital Geophysical Mapping**. The survey is conducted by deploying the geophysical equipment according to the methods and procedures defined in the GIP.
- **Data Processing and Interpretation**. For DGM surveys, geophysical data will be processed and subsurface geophysical anomaly maps will be created. The anomalies will be evaluated and dig sheets created. The dig sheets will indicate the anomalies to be reacquired and subsequently investigated by unexploded ordnance (UXO) personnel.
- **Anomaly Reacquisition and Intrusive Investigations**. Anomaly locations selected during the processing and interpretation phase will be located in the field (reacquired). The locations will be presented as coordinates on the dig sheets and then located in the field. UXO personnel will then investigate the anomalies intrusively within an established search radius. During the intrusive investigations appropriate geophysical instruments will be used to locate the metallic item(s).
- **Conduct Quality Control**. Quality control (QC) procedures will be performed to ensure that performed work meets contractual and quality standards. Daily functional checks will be conducted for the geophysical equipment.
- **Verify Results and Report.** The results of the survey will be compiled and compared to the DQOs. A summary report as outlined in the SSWP will be prepared.

B.2 Personnel Qualifications

DGM operations will be conducted by personnel experienced in MEC geophysical operations led by a qualified Munitions MEC-experienced geophysicist. All geophysical support personnel onsite will have documentation of 40-hour Occupational Safety and Health Administration (OSHA) certification, any necessary re-certification (8-hour refresher), and OSHA-compliant medical monitoring physical exams. Throughout DGM operations, geophysical support personnel will strictly adhere to the general practices given in this Master Work Plan (MWP) and applicable SSWPs. Personnel conducting DGM operations will practice avoidance in the event that MEC is encountered.

Personnel must have the following qualifications:

The **Project Geophysicist** shall have a degree in geophysics, geology, geological engineering, or a closely related field, and shall have a minimum of 5 years of directly related geophysical experience. This individual will be capable of managing a geophysical data collection and processing project/program including several task orders/sites and will have at least one year of experience in managing geophysical operations for an MEC site.

The **Site Geophysicist** shall have a degree in geophysics, geology, geological engineering, or a closely related field, and shall have a minimum of 3 years of directly related geophysical experience. This individual will be capable of competently managing personnel, equipment and data on projects requiring multiple (three or more) geophysical field teams and geophysical data processors and will have at least one year of experience in performing geophysical operations on an MEC site.

The **Geophysical Data Processor** shall have a degree in geophysics, geology, geological engineering, or a closely related field, and shall have at least 6-months experience in processing geophysical data related to MEC projects.

The **Field Geophysicist** shall have a degree in geophysics, geology, geological engineering, or a closely related field, and shall have a minimum of 2 years of directly related geophysical experience.

The **Geophysical Technician** shall have at least 6 months experience in geophysical data collection on MEC related projects.

B.3 Safety Issues

Because MEC and materials potentially presenting an explosive hazard (MPPEH) may be present in some of the survey areas, DGM survey personnel are prohibited from touching, handling, moving, or investigating any item that resembles MEC or MPPEH. In the event that MEC or MPPEH is discovered and no UXO-qualified personnel are present, survey personnel will conspicuously mark and secure a perimeter around the item and evacuate the area while immediately contacting the CH2M HILL Site Manager. The CH2M HILL Site Manager will immediately notify the Base Explosive Ordnance Disposal (EOD) team and the CH2M HILL Project Manager (PM). DGM survey personnel should not remain within 200 feet of any suspected MEC or MPPEH item.

Personnel will be required to adhere to the project Health and Safety Plan (HSP) (refer to SSWPs).

B.4 Geophysical Prove-Out

The initial phase of each investigation to locate MEC in the subsurface will be an evaluation of the proposed geophysical system through a geophysical prove-out (GPO). A GPO may be performed for each site or the SSWP may refer to a GPO performed for a Camp Lejeune site with similar geology, terrain, vegetation and target MEC. (If the latter is the case, the system to be used will be operated over the GPO grid to demonstrate comparability of results to the prior GPO results.) The GPO Plan and procedures are given in Appendix A.

The purpose of the GPO is to demonstrate and document the site-specific capabilities of a DGM system to operate as an integrated system capable of meeting project DQOs. For the purposes of this work, a system is considered to include the survey platform, sensors, navigation equipment, data analysis and management, and associated equipment and personnel.

A GPO area consistent with the local site conditions (geologic, topographic, and vegetation), will be established and seeded with known items (similar to those suspected or discovered at the site) at various depths and orientations. The depths and orientations of the items will be varied to effectively evaluate the DGM systems. DGM systems will be evaluated across the entire GPO area using the same survey techniques determined to be suitable for the investigation. Specifics regarding each GPO will be given in the SSWP for each site.

Results of the GPO will be included in a GPO report prepared after the GPO has been performed. The report will include a summary of all of the GPO operations, seed item specifics (e.g., actual burial locations, depths), an as-built map of the GPO plot, and GPO results.

B.5 Boundary Survey

A surveyor will perform a boundary survey, to include placement of markers (e.g., colored flagging on stakes) along the perimeter of the site to establish work area limits for the vegetation removal crews. The survey team will consist of a surveyor party chief, a surveyor technician, and a UXO escort. The escort will be equipped with an appropriate geophysical instrument to perform anomaly avoidance.

B.6 Vegetation Removal

Many areas within Camp Lejeune have a dense shrub canopy that must be removed prior to performing DGM operations. Vegetation removal will consist of clearing sufficient subgrowth and small trees (less than a 3-inch diameter unless otherwise stated in the SSWP) where necessary to perform the DGM surveys. Personnel will use mechanical means where possible and manual means in other areas. Vegetation removal will be conducted by a vegetation removal subcontractor under the observation of UXO technicians, and activities will be conducted in conjunction with a visual UXO surface clearance by the technicians to protect personnel and equipment.

B.7 Grid/Transect Survey

In order to establish an operational grid system, a surveyor will emplace individual grids over the investigation area. The corners of the grids will be coincident with the North American Datum (NAD) 83, Universal Transverse Mercator (UTM) Grid Plane, Zone 18 coordinates in easting (meters [m]) and northing (m) and will be marked using labeled, non-metallic stakes.

Transects will be established by placing survey markers at the beginning and end of a transect. Periodic markers will be placed along the transect to provide accurate locations for use during DGM surveys. The number of markers will vary depending on site conditions and transect length. The markers will be coincident with UTM Grid Plane Coordinates in easting (m) and northing (m) and will be marked using labeled, non-metallic stakes.

B.8 Surface Clearance

Following the grid survey, surface clearance will be performed to facilitate the DGM Survey. Only UXO qualified personnel will be used to locate, remove, and/or dispose of MEC/MPPEH. The surface MEC clearance team composition will be specified in the SSWP. Each UXO technician will be equipped with an appropriate geophysical instrument (e.g., Schonstedt Model GA-52Cx magnetometer, Minelabs Explorer, White's Metal Detector) to assist in locating MEC items and metal debris that are obscured by brush cuttings. The team leader (UXO Technician III) will organize his/her UXO Team in a line-abreast formation, with each UXO Technician spaced at approximately 5-foot (ft) intervals. The team will move forward in unison and will visually search the ground for metallic debris and/or MEC items.

B.9 Digital Geophysical Mapping

B.9.1 Instrumentation

Based on site conditions and prior DGM surveys at the site, it is clear that there are several industry standard geophysical instruments that can successfully perform DGM surveys at Camp Lejeune. The actual DGM system for each specific site will be determined through the GPO process. General descriptions of typical instruments and positioning systems are described in the following subsections. Descriptions of the specific instruments if other than those described herein to be used for the DGM surveys and their SOPs will be provided in each SSWP.

Geophysical Instruments

Geonics EM31 Terrain Conductivity Meter. The Geonics EM31 is a non-intrusive frequency domain instrument used to map average variations of electrical conductivity at depths between 0 and 3–6 m. Frequency domain instruments work by transmitting a sinusoidally varying electro-magnetic signal at one or more frequencies through a transmitter coil. A separate receiver coil measures a signal that is a function of the primary signal and the induced currents in the subsurface. The EM31 operates at a single frequency of 10 kilohertz (kHz), has an intercoil spacing of 3.7 m (12 ft) and provides two measurements, quadrature (apparent conductivity) and in-phase (metallic response). One transmitter coil generates the EM energy and a second receiver coil detects EM fields caused by the transmitter as well as fields induced in subsurface conductive regions.

Geometrics G-858. The G-858 is an optically pumped cesium vapor instrument that measures the intensity of the earth's magnetic field in nanoTeslas (nT). During operation of the magnetometer, a direct current is used to generate a polarized monochromatic light. Absorption of the light occurs within the naturally precessing cesium atoms found in the instrument's two vapor cells. When absorption is complete, the precessing atoms become a transfer mechanism between light and a transverse radio-frequency (RF) field at a specific frequency of light known as the Larmor frequency. The light intensity is used to monitor the precession and adjusts the RF frequency allowing for the determination of the magnetic field intensity.

The earth's magnetic field, believed to originate in currents in the earth's liquid outer core, varies in intensity from approximately 25,000 nT near the equator, where it is parallel to the earth's surface, to approximately 70,000 nT near the poles, where it is perpendicular to the earth's surface. In the United States, the intensity of the earth's magnetic field varies from approximately 48,000 to 60,000 nT and has an associated inclination ranging from approximately 58 to 77 degrees.

Anomalies in the earth's magnetic field are caused by remnant or induced magnetism. Remnant magnetism is caused by naturally occurring magnetic materials. Induced magnetic anomalies result from the induction of a secondary magnetic field in a ferromagnetic material by Earth's magnetic field. The shape and amplitude of an induced magnetic anomaly over a ferromagnetic object depend on the geometry, size, depth, and magnetic susceptibility of the object and on the magnitude and inclination of the earth's magnetic field in the study area. Induced magnetic anomalies over buried objects such as drums, pipes, tanks, and buried metallic debris and UXO generally exhibit an asymmetrical, south high/north low signature (maximum amplitude on the south side and minimum on the north).

The earth's magnetic field undergoes low-frequency diurnal variations associated with the earth's rotation, generally referred to as magnetic drift. These variations have their source mainly in the ionosphere and they are of a magnitude large enough to introduce artificial trends in field data. A base station G-856 magnetometer is generally used to monitor and record this drift so that it can be removed from the field data during processing.

Geometrics G-856. The G-856 magnetometer is a proton-precession magnetometer that operates through the application of direct current is to a coil that is wrapped around a sensor bottle filled with a hydrogen-rich fluid. The current temporarily polarizes the protons in the fluid. When the current is turned off, the protons precess about the earth's magnetic field at a frequency proportional to the total magnetic field intensity. Measurement of the precession frequency, as a voltage induced in another coil, permits the calculation of the intensity of the earth's magnetic field.

Geonics EM61-MK2. Time-domain electromagnetic metal detectors are designed to detect shallow ferrous and non-ferrous metallic objects with very good spatial resolution and with minimal interference from adjacent metallic features. An EM transmitter generates a pulsed primary magnetic field in the earth, which induces eddy currents in nearby metallic objects. The eddy current decay produces a secondary magnetic field measured by the receiver coil of the instrument. By taking the measurement at a relatively long times after the start of the decay, the current induced in the ground has fully dissipated and only the current in the metal is still producing a secondary field.

The EM61-MK2 is a high-resolution time-domain electromagnetic instrument designed to detect, with high spatial resolution, shallow ferrous and non-ferrous metallic objects. In comparison with other metal detectors, especially magnetometers, it is much better suited for work in close proximity to man-made structures and in areas of dense subsurface metallic debris. The Standard EM61-MK2 system consists of two air-cored, 1-meter by 0.5 meter coils, a digital data recorder, batteries and processing electronics. The EM61-MK2's transmitter generates a pulsed primary magnetic field, which then induces eddy currents in nearby metallic objects. Each of the two spatially separated receiver coils measures these eddy currents. The EM61-MK2 offers the ability to measure the eddy currents at three distinct time intervals in the bottom coil or four intervals if no top coil measurements are recorded. Earlier time gates provide enhanced detection of smaller metallic objects. Secondary voltages induced in both coils are measured in millivolts (mV). The arrangement of coils is such that there is a vertical separation of 40 centimeters (cm). Assuming accurate data positioning, target resolution of approximately 0.5 m can be expected.

Positioning

Global Positioning Systems (GPS). Global positioning system (GPS) satellites orbit the earth transmitting a signal which can be detected with a GPS receiver. The GPS receiver uses the known locations of the satellites and the time of signal transmittal to calculate its position. Differential GPS (DGPS) increases the accuracy of GPS readings through the use of two receivers: a stationary receiver that acts as a base station and collects data at a known location and a second roving receiver that makes the position measurements. The base stations can be configured to either transmit the correction data to the rover system or to save the data to be used to correct positional data during post-processing. Real-time kinematic (RTK) DGPS instruments are ideal for field-mapping applications when satellite visibility conditions are adequate as they provide the highest GPS accuracy possible (sub-centimeter accuracy). Typical accuracies of geophysical data positioning after adding errors induced by the DGM system operation are in the range of 20–50 cm.

Laser Positioning Methods. Laser navigation methods, which measure a highly accurate position relative to a fixed base station location, represent an accurate alternative for precision sensor location under some conditions where GPS is not applicable. In particular, laser positioning methods using robotic total stations (RTS) can be used for geophysical mapping under tree canopy where continuous line-of-site to GPS satellites is obscured. The RTS system consists of a base station, positioned at a surveyed location that holds a transmit laser on a robotic mount. The roving sensor platform has a prism that reflects the laser from the transmitter. The distance between the base station and the prism is measured by the time of flight of the laser pulse and the azimuth and elevation angles are tracked by the robotic mount. The positioning information is processed by an on-board computer and the position of the prism is calculated in three dimensions. The base station laser system is also able to lock on to and track the position of the prism in real-time to allow on-the-fly data acquisition. Typical accuracies are similar to RTK GPS.

Odometer and Fiducial Methods. Odometer and fiducial methods are appropriate for use while collecting data in the following situations:

1. Low-accuracy requirement surveys (e.g., trench/pit, boundary delineation)
2. Surveys in areas where the use of GPS or RTS are either not possible or impractical and conventional survey methods are used to establish tight (typically 30 m or closer spacing) survey control.

Odometer methods utilize a procedure wherein a measuring device (e.g., wheel-based, thread-feeding) is used to determine the distance traveled along a linear transect. Using this approach, a series of survey lanes are established over a grid. Flags are placed at the beginning and end of each lane and an operator walks down the lane while sensor readings are collected when triggered by the odometer system at a pre-defined interval (e.g., every 20 cm). As the operator walks past the starting and ending points in the survey lane, he/she stops the data collection. By assuming the operator walked in a straight line, the total distance recorded by the odometer system is compared to the known distance travel and the down-line position for each of the data points is adjusted accordingly.

Fiducial methods use a time-marking procedure to determine the spatial location of the collected data. As in the odometer approach, a series of survey lanes are established over a grid. Flags are placed at the beginning and end of each lane, and at equal distances along the transect (e.g., every 30 m). An operator walks down the lane while the data logger collects sensor readings at a prescribed sampling. As the operator walks past the starting, fiducial and end lines in the survey lane, he/she hits a button on the data logger that places a fiducial time mark in the data stream. By assuming the operator walked in a straight line at a constant velocity, the location of each data point can be calculated.

B.9.2 Survey Modes

A variety of survey modes may be utilized to collect geophysical data for the detection, location, and characterization of MEC (or other targets) at Camp Lejeune. These modes include:

- Full Surveys
- Transects
- Meandering Paths

The most appropriate survey mode is dictated by several factors including topography, vegetation, and the number, type, and distribution of MEC. Additionally, the most effective survey mode is dependent on the objectives of the survey. For example, if a site is to be remediated, then it may be appropriate to conduct a full survey, whereas if a site characterization is being performed, transects or meandering paths may prove more effective.

Full Coverage Surveys

Full coverage is used when an entire site requires MEC detection, location, and characterization. Under this methodology, the site is evaluated prior to deployment to determine the most effective strategy of data collection. The project GIS will be employed to review site conditions including site topography, vegetation, proximity to structures (e.g., pipelines, fences), and other site conditions that may affect access or sensor performance. Full coverage can be achieved through deployment of the sensor system in a variety of techniques, including subdivision of the site into a grid mosaic or collection of parallel survey lines. All data traverses are brought into the GIS for verification of full coverage.

Transect Surveys

Transect surveys are utilized to evaluate the extent of contamination in a large area through systematic surveying along linear paths (or paths with linear segments). For example, to determine an estimate of the extent of contamination associated with a known impact area, transect survey lines can be collected radially outward from the known contamination area. Subsequent analysis can define the approximate limits of the contamination. Similarly, transects can be utilized in a rectilinear pattern to search large areas. These “pattern searches” can be employed to locate large features such as landfills, or to statistically evaluate the MEC contamination within a large site. Transect offset patterns and swath widths are dictated by the site-specific objectives of the survey.

Meandering Path Investigations

Meandering path surveys, like transects, are effective for the statistical evaluation of MEC contamination. Under this approach, semi-random traverses are executed within pre-defined bounds of an investigation site. The operator deploys sensors in a “random walk” mode to collect data from across the site. An advantage of the meandering path approach relative to grids or transect surveys is the flexibility afforded to the operator to make minor “real-time” adjustments in the path to avoid problematic survey area (e.g., trees, bushes, ravines) As such, this method sometimes allows for characterization without significant brush cutting.

B.9.3 Survey Information

Survey information to be recorded by the DGM teams will include the following:

- Site ID
- Grid ID (or other identifier of surveyed area)
- Field team leader name
- Field team members’ names
- Date of data collection
- Instrument used

- Positioning method used
- Instrument serial numbers
- File names in data recorders
- Data collection sampling rate
- Line numbers, survey direction, fiducial locations, start and end points
- Weather conditions
- Grid conditions (as applicable)
- Terrain conditions (as applicable)
- Cultural conditions (as applicable)
- Survey area sketch (as applicable)
- Associated base station data file names (magnetometer) (as applicable)
- Associated QC data file names
- Field notes (other)

B.10 Data Processing and Interpretation

The following subsections provide details on data processing, interpretation, anomaly selection, dig sheets and maps.

B.10.1 Data Processing

Instrument specific software (e.g. DAT61MK2, MagMap2000) will be used for initial data processing and the output imported into Geosoft Oasis Montaj™ (or comparable software if available) for additional processing, graphical display, anomaly selections and QC. Types of processing will be system specific and will be defined through standard operating procedures (SOPs) contained in SSWPs. The general processing steps that may be performed on the data include the following:

- Diurnal correction (magnetic data)
- Positional offset correction
- Sensor bias, background leveling and/or standardization adjustment
- Sensor drift removal
- Latency Correction
- Heading error removal (magnetic data)
- Geophysical noise identification and removal (spatial, temporal, motional, terrain induced)
- Contour level selection with background shading
- Analytic signal calculation (magnetic data)
- Digital filtering and enhancement (low pass, high pass, band pass, convolution, non-linear, etc.)

B.10.2 Interpretation/Anomaly Selection

MEC-experienced data processing geophysicists will use the following criteria (as applicable), supplemented by site- and system-specific criteria established during the GPO, for selecting and locating anomalies:

- The maximum amplitude of the response with respect to local background conditions
- The lateral extent (plan size) of the area of response
- The 3-dimensional shape of the response
- The location of the response with respect to the edge of the grid, unsurveyable areas, land features, cultural features, or utilities within or adjacent to the grid
- The shape and amplitude of the response with respect to the response of known targets buried in the GPO test plot
- The shape and amplitude of the response with respect to relevant anomalies encountered in previous MEC removal grids
- Potential distortions in the response due to interference from nearby cultural features
- Proven discrimination algorithms (if available)

B.10.3 Dig Sheets

The target analysis process culminates in the creation of "dig sheets," which contain target information location and amplitude. At a minimum, the following information will be provided on the dig sheets:

1. Project site
2. Grid identification
3. Unique anomaly identification numbers
4. Predicted location in UTM Grid Plane Coordinates in easting (m) and northing (m)
5. Instrument peak value (where applicable) at each anomaly location.

B.10.4 Grid Maps

The DGM Contractor will also provide with each dig sheet a grid map that contains the following information:

1. Client
2. Project
3. Contractor
4. Map creator
5. Map approver
6. Date map was created

7. Map file name (full path and file extension)
8. Scale
9. Grid identification
10. Grid corner locations
11. Contoured data
12. Anomaly locations with unique identification numbers
13. North arrow, legend, title block.

B.11 Anomaly Reacquisition

Two different reacquisition methodologies may be used when anomalies are to be intrusively investigated:

- The DGM Contractor who performed the initial DGM survey will reacquire target anomalies.
- The MEC Contractor responsible for the target investigation will reacquire target anomalies.

Wherever possible, coordinate locations of each targeted anomaly will be uploaded into a RTK DGPS, which will be used to navigate or re-occupy the point where a temporary mark will be placed. Reacquisition of target locations will be through an equivalent (or higher) accuracy system to the one used for the initial data collection. Each reacquired target location will be marked with a pin flag labeled with the anomaly's identifying number.

Depending on the goals of the project (removal or characterization), the reacquisition team will use the same type of geophysical equipment as was used for the DGM survey to accomplish one of the following:

- Refine the location of the anomaly prior to intrusive investigation.
- Check the location after intrusive investigation has been performed to ensure that the source of the anomaly was removed.
- A combination of these activities.

In any case, the DGM instrument response will be observed in a continuous mode while slowly maneuvering the instrument over and within a radius of 1 m of the anomaly location. The maximum amplitude response will be recorded for comparison to the initial response to ensure that the source of the anomaly was removed.

B.12 Data Quality Objectives

Data quality objectives particular to DGM surveys are discussed in the GPO Work Plan, Appendix A. For any particular site, the DQOs are validated during the GPO process and those DQOs are carried forward as designed or as modified for the DGM surveys.

B.13 Quality Control

An extensive QC program will be applied to all DGM operations. The QC activities to be performed for each site include those described in the following subsections unless otherwise modified in the SSWP. Figure B-1 shows an overall chart of the QC steps.

B.13.1 DGM System QC

Geophysical instruments will be field tested frequently by the DGM Contractor to ensure that they are operating properly. A description of each test, its acceptance criteria and frequency is provided below and summarized in Table B-1.

- **Equipment Warm-up**. This is an instrument specific activity (although a standard warm- up time is 5 minutes). Some geophysical systems require more warm-up time than others do. For example, the Geometrics G-858 system has an on-screen display that indicates when the sensors have warmed up sufficiently and are ready to be used for survey activities. Equipment warm-up is performed each time the instrument is first turned on for the day or has been turned off for a sufficient amount of time for the specific instrument to "cool-down."
- **Positioning System Accuracy.** Positioning accuracy of the final processed data will be demonstrated by testing the positioning equipment over one or more known points. This test will be performed in a static mode over a known coordinate point to ensure that the positioning system is with accuracy requirements. The positioning of the system in kinematic (moving) mode can be measured through comparison of anomaly selections over seed item locations. The sensor position test will be conducted at the beginning of the survey operations for each work day.
- **Record Sensor Positions.** Positioning accuracy of the final processed data will be demonstrated by testing the positioning equipment over one or more known points. This test will be performed in a static mode over a known coordinate point to ensure that the positioning system is with accuracy requirements. The positioning of the system in kinematic (moving) mode can be measured through comparison of anomaly selections over seed item locations. The sensor position test will be conducted at the beginning of the survey operations for each work day.
- **Personnel Test.** This test checks the response of instruments to the personnel and their clothing/proximity to the system. On a daily basis, instrument coils are checked for their response to the personnel operating the system, with response observed in the field for immediate corrective action and transmitted back to the processor and analyzed and checked for spikes in the data that can possibly create false anomalies. The personnel test is conducted at the beginning of the survey operations for each work day.
- **Vibration Test (Cable Shake)**. This test checks the response of instruments to vibration. On a daily basis, instrument coils are checked for their response to vibrations in the cables, with response observed in the field for immediate corrective action and transmitted back to the processor and analyzed and checked for spikes in

the data that can possibly create false anomalies. The vibration test is conducted at the beginning of the survey operations for each work day.

- **Static Background and Static Spike**. Static tests are performed by positioning the survey equipment within or close to the survey boundaries in an area free of metallic contacts and collecting data for a specific period, while holding the instrument in a fixed position without a "spike" (known standard) and then with a "spike." The purpose of the static test is to determine whether unusual levels of instrument or ambient noise exist. The static background and static spike test are conducted at the beginning and end of each survey operation. This is the test that essentially "opens" and "closes" out a survey area (grid, grid block, set of transects, etc.)

- **Azimuthal Test (Magnetometer only)**. This test is performed to ensure that a system's sensors are oriented in such a way that they minimize data drop-outs and maximize instrument response. This test is typically only performed for magnetometer systems and should be done the first time the system is used at the site.

- **Height Optimization (Magnetometer only)**. This test is performed to ensure that the sensors are at a height that optimizes the signal-to-noise ratio while still reliably detecting the smallest MEC item of interest at the site. This test should be done the first time the system is used at the site.

- **Six Line Test**. The "Six Line Test" is a standard response test consisting of a predetermined route (survey line) established on or near the site in an area free of metallic contacts. The beginning, midpoint, and end of the line are marked, and data is collected along the line. The line is traversed a total of six times as follows: 1) *normal* data collection speed *without* a "spike" at the centerpoint; 2) *normal* data collection speed *without* a "spike" at the centerpoint; 3) *normal* data collection speed *with* a "spike" at the centerpoint; 4) *normal* data collection speed *with* a "spike" at the centerpoint; 5) *fast* data collection speed *with* a "spike" at the centerpoint; 6) *slow* data collection speed *with* a "spike" at the centerpoint. This test is conducted the first time a system is used at the site.

- **Octant Test (Heading Error Test) (Magnetometer only)**. This test is done to document "heading" error associated with magnetometer systems so the error can be corrected during data processing. The test is conducted the first time a system is used at the site.

- **Repeat Data:** This test is performed to ensure repeatability of the data and will be performed after the initial survey over an area. Because of the intrinsic difficulty of following the exact same path for collecting repeat data, this test will be a qualitative comparison as opposed to quantitative. QC Test #5 (Static Background and Static Spike) serves as a quantitative check on data repeatability by the instrument from start to finish of a survey.

B.13.2 Quality Control of DGM Data and Deliverables

Both the DGM subcontractor and CH2M HILL will perform QC of geophysical data and data deliverables at each step of the processing path. Figure B-12 shows the processing path and the QC steps performed. Data will not move to the next stage until they have passed the QC check.

The following items are among the QC checks performed on the field forms:

- Appropriate fields have been completed
- Field entries are appropriate for work performed
- Data required for geophysical data processors have been entered
- General editorial review (spelling, dates, etc.)

The following items are among the QC checks performed (as applicable to the particular data set) on the "Pre-processed Data":

- Data have been translated from local coordinates into the UTM system
- Coordinates are correct (transects fall in correct locations when loaded into GIS)
- Line gaps have been accounted for
- Background geophysical noise is acceptable
- Crosstrack distances between lines are acceptable
- Downline data density is acceptable
- Appropriate file headers have been attached
- Files contain appropriate transects

The following items are among the QC checks performed (as applicable to the particular data set) on the "Processed Data":

- Latency/Lag correction is appropriate
- Despiking is appropriate
- Leveling is appropriate
- Filtering performed is appropriate
- Line breaking is appropriate
- Anomaly selections are appropriate

B.13.3 QC Seed Items

Prior to performance of the DGM of each area, representative inert MEC items (QC seeds) will be buried across the site. The QC seed items will be buried at depths not-to-exceed the maximum detection depths as determined from the GPO. These items will be used to validate both the DGM surveys and any intrusive operations at the site. Each SSWP will specify the approximate number of QC seed items to be buried across each investigation area.

B.13.4 Corrective Measures

Specific corrective measures are dependent on the type of geophysical equipment used; however, the following are the basic corrective measures to be followed in association with DGM surveying:

- Replacement of sensors if they fail to meet instrument check requirements.

- Resurvey of transects if seeded items are not identified (do not show in the DGM data). In a situation in which there is a failure to select a seed item from the data but the item is clearly present in the DGM data, a resurvey will not be performed, but instead a re-analysis of the DGM data.

All QC failures will be analyzed through a root-cause analysis by the DGM subcontractor and a corrective action plan will be submitted by the subcontractor for CH2M HILL approval.

B.14 Records Management

All files will be made available for QA verification during the project to verify that the field and data processing procedures are properly implemented. All raw data files, final processed data files, hard copies, and field notes will be maintained for the duration of the project.

B.15 Data Delivery

The following are the DGM data delivery requirements:

- All sensor data shall be correlated with navigational data based upon a local "third order" (1:5,000) monument or survey marker. If a suitable point is not available, the Title 2 Services Contractor shall have a Professional Land Surveyor establish a point.
- All sensor data shall be preprocessed for sensor offsets, diurnal magnetic variations, latency corrections, drift corrections, etc. and correlated with navigation data.
- Diurnal magnetic variations measured at a base-station must be collected at a minimum of once per minute.
- The geophysical mapping technology shall digitally capture the instrument readings into a file coincident with the grid coordinates.
- All raw and final processed data shall be delivered corrected and processed in American Standard Code for Information Interchange (ASCII) files.
- Corrections such as for navigation, instrument bias, and diurnal magnetic shift shall be applied.
- All corrections shall be documented.
- Geophysical data files may be provided in grids of up to 400 ft. x 400 ft. square.
- Data shall be presented in delineated fields as x, y, z, v1, v2, etc., where x and y are UTM Grid Plane Coordinates in Easting (meters) and Northing (meters) directions, z (elevation is an optional field in meters), and v1, v2, v3, etc., are the instrument readings.
- The last data field should be a time stamp.
- Each data field shall be separated by a comma or tab.

- No individual file may be more than 100 megabytes in size and no more than 600,000 lines long.
- Each grid (or set) of data shall be logically and sequentially named so that the file name can be easily correlated with the grid name used by other project personnel.
- Within 3 working days after collection, the DGM Contractor shall furnish a file documenting the field activities associated with the data, the pre-processing performed, and each day's data. Delivery should be via internet using file transfer protocol (FTP), E-mail attachment for small files under 5 Mb, digital compact disk (CD) or other approved method. Such data is considered to be in draft form. This data shall be corrected for sensor offsets, diurnal variations, latency, heading error, and drift.
- Within 5 working days after collection, the DGM Contractor shall furnish final data packages for each area (e.g. grid, grid block, set of transects, etc.) surveyed. Final data packages must include the following:
  - Dig sheets in pdf and Microsoft Excel formats
  - Adobe Acrobat Portable Document Format (PDF) file(s) of color contoured geophysical results with anomaly selections shown and labeled at a readable scale for dig team use
  - Final processed data files
  - All AC data files associated with the survey files, along with PDF showing graphical presentation of the QC data
  - File documenting the field activities associated with the data, and the processing performed (see TableB-2)
  - Digital planimetric map, in Geosoft format, and coincident with the location of the geophysical survey, so that each day's geophysical data set can be registered within the original mission plan survey map

TABLE B-1
Geophysical Instrument Standardization Tests and Acceptance Criteria
MCB Camp Lejeune, Jacksonville, North Carolina

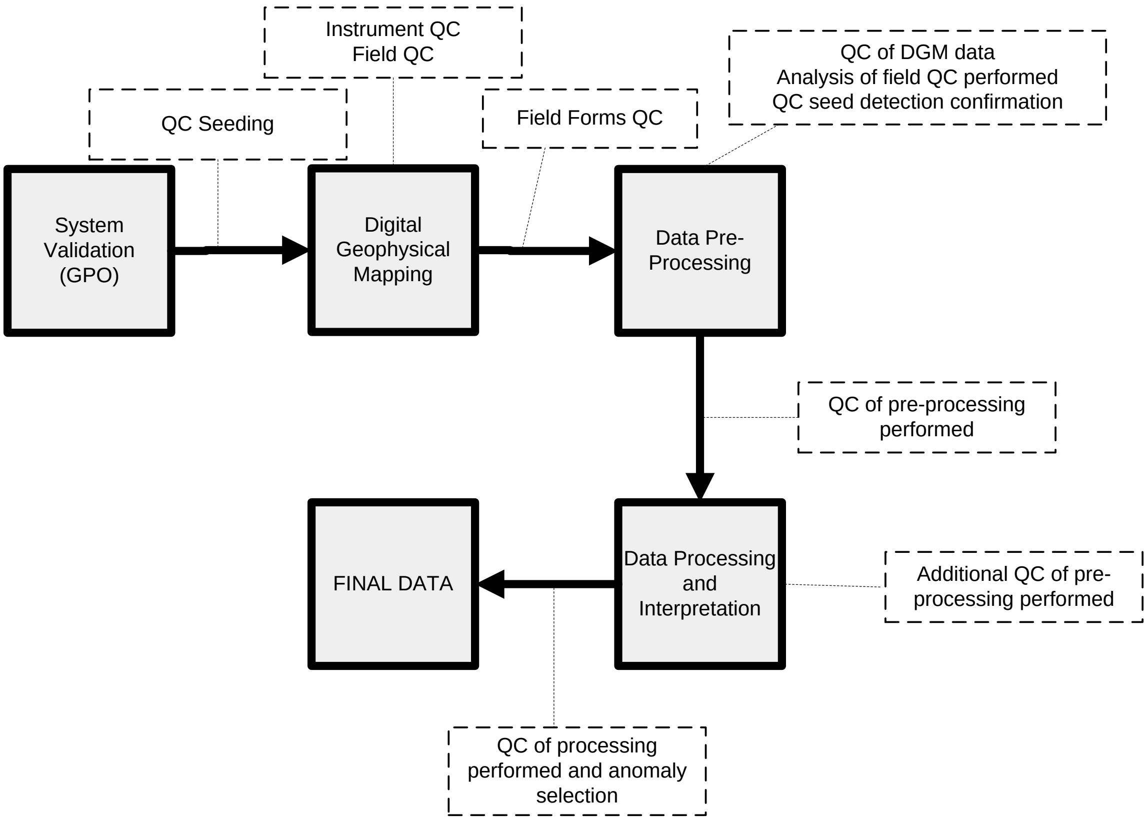
Test	Test Description	Acceptance Criteria	Power On	Beginning of Day	Beginning and End of Day	1st Time Instr. Used	2% of Total Area Surveyed
1	Equipment Warm-up	Equipment specific (typically 5 min)	X				
2	Positioning System Accuracy	10 cm		X			
3	Record Sensor Positions	1m		X			
4	Personnel Test	Based on instrument used. Personnel, clothing, etc. should have <2mv or 2nT on instrument response.		X			
5	Vibration Test (Cable Shake)	Data profile does not exhibit data spikes (<2mv or 2nT)		X			
6	Static Background & Static Spike	+/- 20% of standard item response, after background correction			X		
7	Azimuthal Test *	Sensor orientation that minimizes drop-outs				X	
8	Height Optimization *	Maximum S/N ratio that reliably detects smallest target objective				X	
9	Six Line Test	Repeatability of response amplitude +/-20%, Positional Accuracy +/- 20cm				X	
10	Octant Test (Heading Error Test) *	Document heading error for post-processing correction				X	
11	Repeat Data	Qualitative repeatability of response amplitude					X

Magnetometer Only
S/N = Signal to Noise

TABLE B-2
Processing Documentation Requirements
MCB Camp Lejeune, Jacksonville, North Carolina

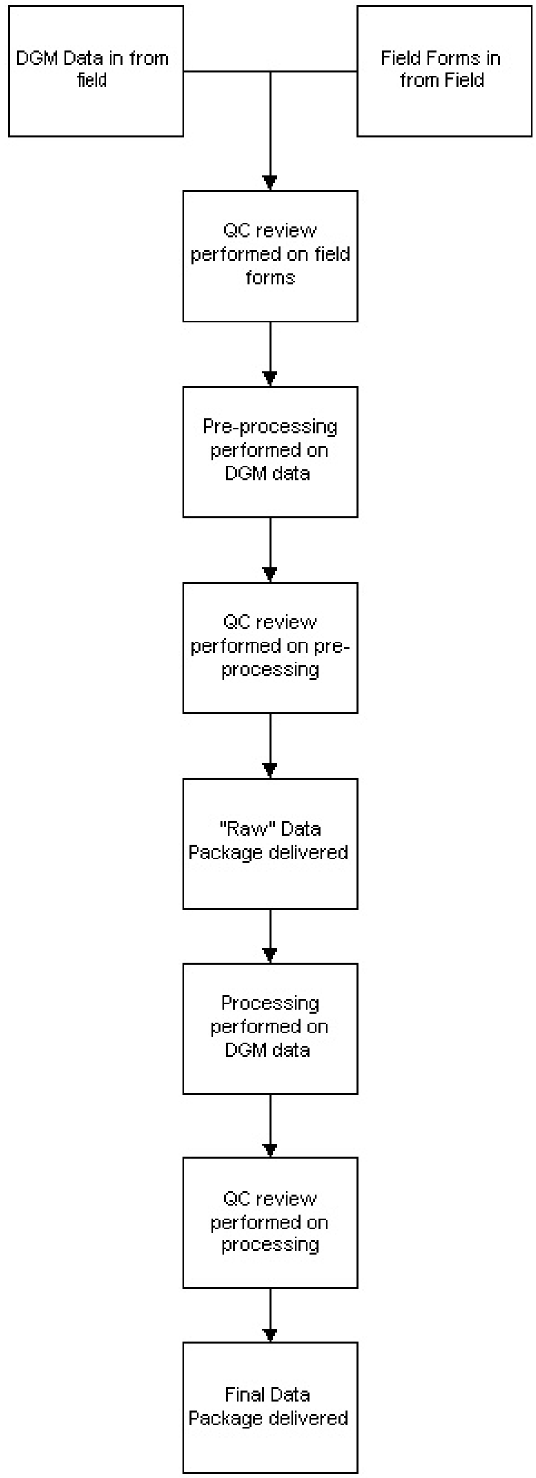
Information Type	Raw/Pre-processed Data Delivery	Final Data Delivery	Must be in File Headers
Site ID	X	X	X
Geophysical instrument type used	X	X	
Positioning method used	X	X	
Instrument serial numbers (geophysical and positioning)	X	X	
Coordinate system and unit of measure	X	X	X
Grid ID (or other identifier of surveyed area)	X	X	X
Date of data collection	X	X	X
Raw data file names associated with delivery	X	X	
Processed data file names associated with delivery		X	
Name of Project Geophysicist	X	X	
Name of Site Geophysicist	X	X	
Name of data processor	X	X	
Data processing software used	X	X	
Despiking method and details		X	
Sensor drift removal and details	X	X	
Latency correction and details	X	X	
Heading correction and details	X	X	
Sensor bias, background leveling and/or standardization adjustment method and details		X	
Diurnal correction (magnetic data)	X	X	
Geophysical noise identification and removal (spatial, temporal, motional, terrain induced) and details		X	
Other filtering/processing performed and details		X	
Gridding method		X	
Anomaly selection and decision criteria details		X	
Other processing comments		X	
Date data processing is completed		X	
Data delivery date	X	X	
Scanned copy of field notes and field PDA notes (if applicable)	X	X	

FIGURE B-1
Overview of DGM Operations QC Process
MCB Camp Lejeune, Jacksonville, North Carolina



Note: Steps may not apply to all sites and a revised figure will be provided in the SSWPs as appropriate.

FIGURE B-2
Overview of DGM Data and Deliverables QC Process
MCB Camp Lejeune, Jacksonville, North Carolina



Appendix C
Standard Operating Procedures

STANDARD OPERATING PROCEDURE- C.1

Systematic Random Multi-Increment Sampling

I. Purpose

The Systematic Random Multi-Increment (MI) sampling of surface soil samples is performed to minimize any bias of sample representativeness introduced by compositional and distribution heterogeneity of constituents within the sample. This procedure should only be used when sampling surface soils for explosive residuals and metals.

II. Scope

Standard techniques for surface soil MI sampling for the analysis of explosives residuals and metals, and required equipment are provided in this SOP. These procedures do not apply to aliquots collected for VOCs, SVOCs, pesticides/herbicides, PCBs, or field GC screening (samples for these analyses should NOT be collected using MI sampling).

III. Equipment and Materials

MI sampling will be performed with clean hardened plastic or metal scoops, spoons, or coring tools depending on the cohesiveness of the soil. Sample containers will consist of two clean 16 ounce wide mouth glass jars for 1 kg samples and two clean 32 ounce wide mouth glass jars for 2 kg samples as required by the applicable analytical method. Soil will be homogenized in a clean stainless steel pan or bowl. Individual laboratory sample bottles will be required for Method 8330 and metals analysis, per analytical method requirements. Method 8330B samples will be shipped to the contract laboratory in a mass of not less than 3 kg per Decision Unit in sample containers supplied by the laboratory.

IV. Procedures and Guidelines

Surface soil composite samples will be collected from Decision Units for analysis for explosives residues and total metals. Each Decision Unit will be defined based on past range activities discovered during an archival records search. Decision units will have surveyed boundaries that may range in size from 10m x 10m to 100m x 100m. Each Decision Unit location and a summary of sampling activities will be recorded in a field book.

Multi-increment composite surface soil samples will be collected within the Decision Unit using a systematic sampling pattern with a random starting point. Number of increments should be between 30 and 100 depending on the size of the Decision Unit. Samples will be collected by walking from one corner of the grid systematically back and forth across the entire grid area, collecting an increment of soil every so many paces, depending on the grid size and number of increments to be collected. The sample increments will be approximately equal in the amount of soil, which will be collected from depths of 0-2 inches below ground surface. After the entire Decision Unit has been walked, the individual increment samples will be composited into a single sample following the *Homogenization of Soil and Sediment Samples* SOP, prior to being transferred to the appropriate sample containers. Two replicate samples should be collected from each Decision Unit. Each replicate sample will be collected using the same method as the original sample. The replicate samples should be started from a different corner of the decision unit to avoid sampling the same location as the original sample. Figure 1 shows an example of how to do MI sampling in a Decision Unit that is 50m x 50m.

A total of 3 composite surface soil samples (1 original sample and two replicate samples) will be collected at each Decision Unit. Samples will be stored on ice in clean plastic bags or clean large mouth glass bottles and submitted for laboratory analysis by one or more of the following analytical methods: EPA SW-846 Method 8330, Method 8330B, and the appropriate project specific analytical methods for metals. Method 8330B uses an air drying and mechanical grinding process. Mechanical grinding will not be conducted for samples submitted for metals analysis. A minimum of 1 kg of soil will be collected per MI sample.

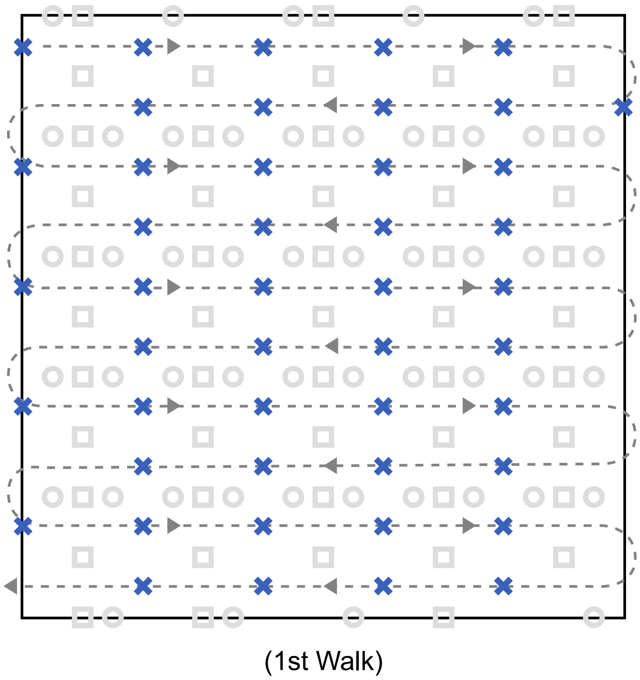
The sampling tools will not need to be cleaned between increments since each individual increment will be apart of the same sample, but tools will be cleaned between each MI sample. The decontamination process involves first removing all adhering soil, then rinsing the sampling head and pan/bowl with deionized water, concluding with an acetone rinse.

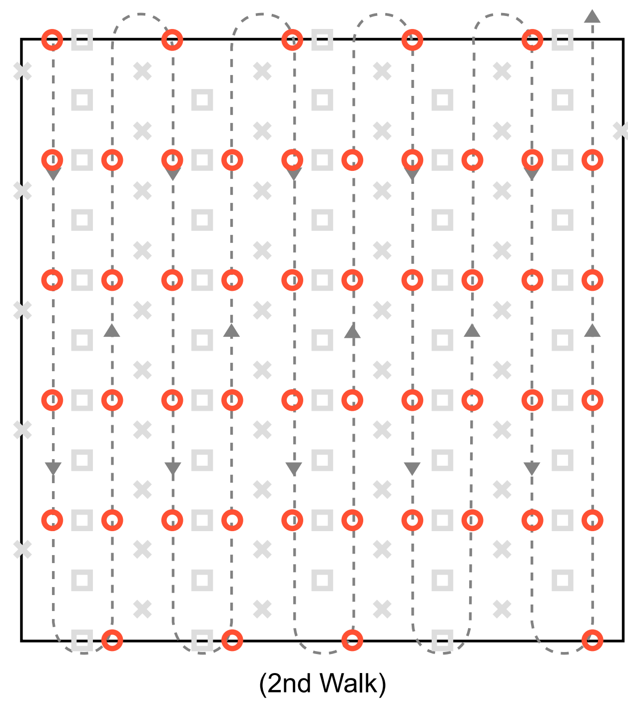
V. Attachments

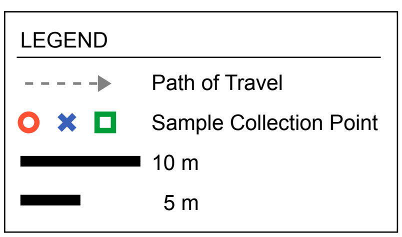
Figure 1- Systematic Random Multi-increment Sampling Pattern

VI. Key Checks and Items

- A total of 3 composite surface soil samples (1 original sample and two replicate samples) will be collected at each Decision Unit.
- Replicate samples should be started from a different corner of the decision unit to avoid sampling the same location as the original sample.
- Increment samples should be homogenized in the field in a clean, stainless steel pan/bowl. Sampling method is only applicable to explosives residues and metals.
- Number of increments should be between 30 and 100 depending on the size of the Decision Unit.
- Check that decontamination of equipment is thorough.







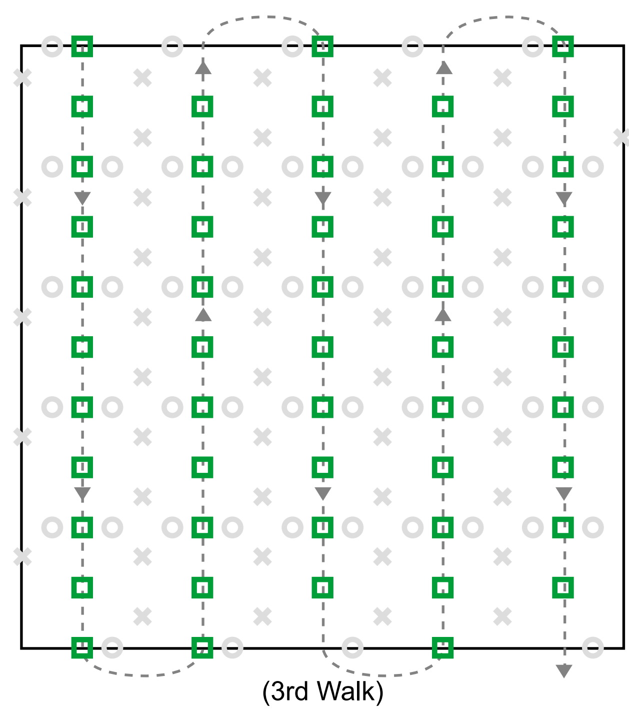


FIGURE 1
Systematic- Random Multi-Increment Sampling Pattern

Direct-Push Soil Sample Collection

I. Purpose

To provide a general guideline for the collection of soil samples using direct-push (e.g., Geoprobe®) sampling methods.

II. Scope

Standard direct-push (e.g., Geoprobe®) soil sampling methods.

III. Equipment and Materials

- Truck-mounted hydraulic percussion hammer.
- Sampling rods
- Sampling tubes and acetate liners (if desired)
- Pre-cleaned sample containers and stainless-steel sampling implements
- Clean latex or surgical gloves.

IV. Procedures and Guidelines

1. Decontaminate sampling tubes and other non-dedicated downhole equipment in accordance with SOP *Decontamination of Personnel and Equipment*.
2. Drive sampling tube to the desired sampling depth using the truck-mounted hydraulic percussion hammer. If soil above the desired depth is not to be sampled, first drive the lead rod, without a sampling tube, to the top of the desired depth.
3. Remove the rods and sampling tube from the borehole and remove the sample from the tube.
4. Fill all sample containers, beginning with the containers for VOC analysis, using a decontaminated or dedicated sampling implement.
5. Decontaminate all non-dedicated downhole equipment (rods, sampling tubes, etc.) in accordance with SOP *Decontamination of Personnel and Equipment*.
6. Backfill borehole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required.

V. Key Checks and Items

1. Verify that the hydraulic percussion hammer is clean and in proper working order.

2. Ensure that the direct-push operator thoroughly completes the decontamination process between sampling locations.

3. Verify that the borehole made during sampling activities has been properly backfilled.

STANDARD OPERATING PROCEDURE – C.3

Temporary Well Installation

Purpose

The purpose of this Standard Operating Procedure (SOP) is to give guidance on the installation of temporary wells that are intended for groundwater sampling.

Scope

Temporary well points will be used when sampling groundwater at stations that are not a groundwater well or direct-push groundwater sampling station. This procedure provides information on proper installation techniques for temporary well points. These wells are typically installed in direct-push locations, but may be installed in larger diameter boreholes, such as hollow stem auger locations. This information will facilitate planning of the field sampling effort by describing standard sampling techniques.

There are two primary situations when temporary well points would be installed:

- *Immediate Groundwater Sampling*: In this instance, the station produces enough water to collect the sample at the time of installation. The temporary well point provides protection of groundwater sampling equipment from soil contamination or fouling. It also protects the equipment and sample from partial or complete borehole collapse.
- *Delayed Groundwater Sampling*: In this instance, the borehole will not produce enough water within a 'reasonable' amount of time. The field team will install the well point and come back within 24 hours to complete the sampling. The ground surface at the well point must be sealed with sodium bentonite at the 24-hour groundwater sampling locations.

Equipment / Materials

The following pieces of equipment may be needed to install temporary well points.

- Decontaminated 1-or 2-inch diameter, threaded Schedule 40 PVC riser (supplied by the driller)
- Decontaminated 1- or 2-inch diameter, 2.5- or 5-foot long threaded Schedule 40 PVC screen (supplied by the driller)
- Decontaminated 1- or 2-inch diameter pointed screen base (supplied by the driller)
- Decontaminated 1- or 2-inch diameter PVC cap (supplied by the driller)
- Sodium bentonite pellets or chips (supplied by the driller)
- Inert, uncontaminated material, such as plastic sheeting or aluminum foil

Procedures / Guidelines

Temporary well points are to be installed in direct-push or hollow stem auger boreholes where groundwater samples could not be sampled using direct-push methods or at an installed monitoring well location.

Temporary wells points are sampled immediately after installation or within 24 hours of installation, so they do not have to be purged since there is no non-representative formation water to be purged.

Installation Procedure

- Ensure all well materials are decontaminated. Well point installers will wear clean gloves, as specified in the Health and Safety Plan.
- Attach the pointed well screen base to the base of the screen. Thread sections of riser onto the screen and lower the screen and riser through the direct-push rods or hollow-stem augers to the base of the boring
- Pull augers/rods out of the borehole, to a minimum of two feet above the top of the temporary piezometer screen, allowing direct contact with formation groundwater.
- Sample the wellpoint.
- If the sampling can not be completed immediately, then a temporary annular seal must be established.
  - If the formation does not collapse around the temporary well point screen, add filter pack to a depth of 2 feet above the top of the screen section. Complete the temporary annular seal by adding granular bentonite or bentonite pellets/chips to ground surface. Hydrate the granular bentonite or bentonite chips/pellets per manufacturers specifications. Attach the PVC cap prior to adding any materials to the borehole annulus.
  - Formation collapse to within 4 feet of ground surface is allowable as long as a single water-bearing unit is penetrated. If multiple water-bearing units are penetrated, then natural collapse to the top of the unit being sampled is allowable and granular bentonite or bentonite chips/pellets will be added from the top of the unit being sampled to ground-surface. Hydrate the granular bentonite or bentonite chips/pellets per manufacturers specifications. Attach the PVC cap prior to adding any materials to the borehole annulus.
- Return within 24 hours to complete well sampling. If the well is still not producing enough groundwater, consult with the FTL
- When complete, remove the temporary well point and either continue the boring and sampling or abandon the borehole.

Installation of Shallow Monitoring Wells

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of shallow monitoring wells and piezometers in unconsolidated or poorly consolidated materials using hollow stem augers or mud rotary. Installing monitoring wells in unconsolidated materials using sonic drilling is discussed in SOP *Installation of Monitoring Wells Using Sonic Drilling*. Methods for drilling and installing bedrock monitoring wells and deep, surface-cased wells in unconsolidated materials are presented in SOPs *Installation of Bedrock Monitoring Wells* and *Installation of Surface-Cased Monitoring Wells,* respectively.

II. Equipment and Materials

Drilling

- Drilling rig (hollow stem auger or mud rotary) and associated tools and equipment

Well Riser/Screen and Associated Materials

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainless-steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless-steel screen
- PVC bottom cap, threaded to match the well screen; alternatively, stainless steel
- PVC or stainless-steel centering guides (if used)
- Above-grade well completion: PVC well cap, threaded or push-on type, vented
- Flush-mount well completion: PVC well cap, locking, leak-proof seal
- Stainless steel to be used as appropriate

Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse) filter pack, and secondary (fine) filter pack. Grain size determined based on sediments observed during drilling.

Bentonite

- Pure, additive-free bentonite pellets or chips
- Pure, additive-free powdered bentonite
- Coated bentonite pellets; coating must biodegrade within 7 days
- Cement-Bentonite Grout: proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage

Protective Casing

- Above-grade well completion: 6-inch minimum ID steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: Morrison 9-inch or 12-inch 519 manhole cover, or equivalent; rubber seal to prevent leakage; locking cover inside of road box

Well Development

- Surge block
- Well-development pump and associated equipment
- Calibrated meters to ensure pH, temperature, specific conductance, ORP, and dissolved oxygen of development water
- Containers (e.g., DOT-approved 55-gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Typically, continuous-flight hollow-stem augers with a minimum 4-inch inside diameter (ID) will be used to drill shallow monitoring well boreholes. Alternatively, mud rotary may be used.

The bit of the auger is placed at the ground surface and then turned with the drilling rig. To collect split spoon samples, the auger is advanced to the top of the sampling depth, and the split-spoon sample is collected from below the auger head. The split spoon is advanced through repeated blows from a 140- or 300-pound hammer dropped from a height of 30 inches. Thin-walled tube samplers are advanced by pressing down on the rods with the weight of the drilling rig. Split-spoon samples will be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling procedures are detailed in SOPs *Soil Boring Sampling – Split Spoons* and *Soil Sampling*.

The use of water to assist in hollow-stem auger drilling for monitoring well installation will be avoided, unless required for such conditions as running sands.

Hollow-stem augers, drilling bits, rods, split-spoon samplers, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location. Split-spoon samplers and other downhole soil sampling equipment will also be properly decontaminated before and after each use. SOP *Decontamination of Drill Rigs and Equipment* details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan (IDWMP).

Mud rotary or other rotary drilling may be used instead of hollow-stem augers. The use of added mud should be kept to a minimum.

B. Monitoring-Well Installation

Shallow monitoring wells will be constructed inside the hollow-stem augers, once the borehole has been advanced to the desired depth, or in the mudded borehole once the drilling rods have been withdrawn. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or chips or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the augers to the bottom of the borehole. Centering guides, if used, will be placed at the bottom of the screen and above the interval in which the bentonite seal is placed.

Selection of the filter pack and well screen intervals for the shallow monitoring wells shall be made in the field.

A primary sand pack (nominally Morie #2) consisting of clean silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The augers will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the augers be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the well screen. A secondary, finer-grained (e.g., Morie #00), sand pack will be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for a shallow water table and a small saturated thickness of the surficial aquifer.

A bentonite seal at least 2 feet thick will be placed above the sand pack. The seal will be placed into the borehole in a manner that will prevent bridging.

The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table, clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be required following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This will allow the grout to diffuse laterally into the borehole and not disturb the bentonite pellet seal.

C. Well Completion

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 3 feet into the ground and 2 feet above ground but should not penetrate the bentonite seal. The concrete pad will be square, approximately 3 feet on a side, and poured into wooden forms. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing. Guard posts will be concrete-filled, at least 3 inches in diameter, and will extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover or equivalent, with a rubber-sealed cover and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 2 to 3 feet per side, will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade. The concrete pad will be 12 inches thick at the center and taper to 6-inch thick at the edge. The surface of the pad should slope away from the protective casing to prevent water from pooling around the casing. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

D. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include a surge block. Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes and until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP *Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring-well construction

STANDARD OPERATING PROCEDURE – C.5

Low-Flow Groundwater Sampling from Monitoring Wells

I. Purpose and Scope

This procedure presents general guidelines for the collection of groundwater samples from monitoring wells using low-flow purging and sampling procedures. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Flow-through cell with inlet/outlet ports for purged groundwater and watertight ports for each probe
- Meters to monitor pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature (e.g., Horiba® U-22 or similar)
- Water-level indicator
- In-line disposable 0.45µm filters (QED® FF8100 or equivalent)
- Adjustable-rate positive-displacement pump, submersible pump, or peristaltic pump
- Generator
- Disposable polyethylene tubing
- Plastic sheeting
- Well-construction information
- Calibrated bucket or other container and watch with second indicator to determine flow rate
- Sample containers
- Shipping supplies (labels, coolers, and ice)
- Field book

III. Procedures and Guidelines

A. Setup and Purging

1. For the well to be sampled, information is obtained on well location, diameter(s), depth, and screened interval(s), and the method for disposal of purged water.

2. Instruments are calibrated according to manufacturer's instructions.

3. The well number, site, date, and condition are recorded in the field logbook.

4. Plastic sheeting is placed on the ground, and the well is unlocked and opened. All decontaminated equipment to be used in sampling will be placed only on the plastic sheeting until after the sampling has been completed. To avoid cross-contamination, do not let any downhole equipment touch the ground.

5. All sampling equipment and any other equipment to be placed in the well is cleaned and decontaminated before sampling in accordance with SOP *Decontamination of Personnel and Equipment*.

6. Water level measurements are collected in accordance with SOP *Water Level Measurements*. **Do not measure the depth to the bottom of the well at this time**; this reduces the possibility that any accumulated sediment in the well will be disturbed. Obtain depth to bottom information from well installation log.

7. Attach and secure the polyethylene tubing to the low-flow pump. Lower the pump slowly into the well and set it at approximately the middle of the screen. Place the pump intake at least 2 feet above the bottom of the well to avoid mobilization of any sediment present in the bottom. Preferably, the pump should be in the middle of the screen.

8. Insert the measurement probes into the flow-through cell. The purged groundwater is directed through the cell, allowing measurements to be collected before the water contacts the atmosphere.

9. Start purging the well at 0.2 to 0.5 liters per minute. Avoid surging. Purging rates for more transmissive formations could be started at 0.5-liter to 1 liter per minute. The initial field parameters of pH, specific conductance, dissolved oxygen, ORP, turbidity, and temperature of water are measured and recorded in the field logbook.

10. The water level should be monitored during purging, and, ideally, the purge rate should equal the well recharge rate so that there is little or no drawdown in the well (i.e., less than 0.5-foot). The water level should stabilize for the specific purge rate. There should be at least 1 foot of water over the pump intake so there is no risk of the pump suction being broken, or entrainment of air in the sample. Record adjustments in the purge rate and changes in depth to water in the logbook. Purge rates should, if needed, be decreased to the minimum capabilities of the pump (0.1- to 0.2-liter per minute) to avoid affecting well drawdown.

11. During purging, the field parameters are measured frequently (every 3 to 5 minutes) until the parameters have stabilized. Field parameters are considered stabilized when measurements meet the following criteria:

    - pH: within 0.1 pH units
    - Specific conductance: within 3 percent

- Dissolved oxygen: within 10 percent
- Turbidity: within 10 percent or as low as practicable given sampling conditions
- ORP: within 10 mV

B. Sample Collection

Once purging has been completed, the well is ready to be sampled. The elapsed time between completion of purging and collection of the groundwater sample from the well should be minimized. Typically, the sample is collected immediately after the well has been purged, but this is also dependent on well recovery.

Samples will be placed in bottles that are appropriate to the respective analysis and that have been cleaned to laboratory standards. Each bottle typically will have been previously prepared with the appropriate preservative, if any.

The following information, at a minimum, will be recorded in the logbook:

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; whether the sample is filtered or not; time and date; sampler's identity)
2. Sample source and source description
3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements
4. Sample disposition (preservatives added; laboratory sent to, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.
2. The sample is slowly discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs.
3. Samples may be field filtered before transfer to the sample bottle. Filtration must occur in the field immediately upon collection. Inorganics, including metals, are to be collected and preserved in the filtered form as well as the unfiltered form. The recommended method is through the use of a disposable in-line filtration module (0.45-micron filter) using the pressure provided by the pumping device for its operation.

4. Samples for analysis for volatile organic compounds should be collected first, if such samples are required.

5. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to overflowing and capped.

6. The bottle is capped, then labeled clearly and carefully following the procedures in SOP *Packaging and Shipping Procedures*.

7. Samples are placed in appropriate containers and, if necessary, packed with ice in coolers as soon as practical.

C. Additional remarks

1. If the well goes dry during purging, wait until it recovers sufficiently to remove the required volumes to sample all parameters. It may be necessary to return periodically to the well but a particular sample (e.g., large amber bottles for semivolatile analysis) should be filled at one time rather than over the course of two or more visits to the well.

2. It may not be possible to prevent drawdown in the well if the water-bearing unit has sufficiently low permeability. If the water level was in the screen to start with, do not worry about it because there is no stagnant water in the riser above the screen to begin with.

   If the water level in the well is in the riser above the screen at the beginning of purging, then be sure you pump out sufficient volume from the well to remove the volume of water in the riser above the screen. For a 2-inch diameter well, each foot of riser contains 0.163 gallons; for a 4-inch riser, each foot of riser contains 0.653 gallons; for a 6-inch riser, each foot of riser contains 1.47 gallons.

   Alternatively, the water in the riser above the screen can be removed by lowering the pump into the well until the pump intake is just below the water level, starting the pump, running it at a low rate, and slowly lowering the pump as the water level in the riser declines. This approach can be terminated when the water level reaches the top of the screen, at which time the stagnant water in the riser has been removed. This may not be a practical approach for dedicated sampling equipment. As with typical low-flow sampling, the flow rate should be kept as low as practicable.

3. There may be circumstances where a positive-displacement or submersible pump cannot be used. An example is at isolated, hard-to-reach locations where the required power supply cannot be brought. In this case, a peristaltic pump may be used. Samples can be collected by the procedures described above for all but those for VOC analysis. The water to be placed in the vials for VOC analysis should not be run through the peristaltic pump but instead should be collected by the following:

   - Stop the pump when it is time to collect the VOC sample.

- Disconnect the tubing upstream from the pump (a connector must be installed in the line to do this).
- Pinching the tubing to keep the water in the tubing, remove the tubing from the well. Be sure that the tubing does not contact other than clean surfaces.
- Place the end of the tubing that was in the well into each VOC vial and fill the vial by removing the finger from the other end of the tube.
- Once the vials are filled, return the tubing to the well and collect any other samples required.

4. Nondedicated sampling equipment is removed from the well, cleaned, and decontaminated in accordance with SOP *Decontamination of Personnel and Equipment*. Disposable polyethylene tubing is disposed of with PPE and other site trash.

IV. Attachments

White paper on reasons and rationale for low-flow sampling.

V. Key Checks and Preventative Maintenance

- The drawdown in the well should be minimized as much as possible (preferably no more than 0.5-foot to 1 foot) so that natural groundwater-flow conditions are maintained as closely as possible.
- The highest purging rate should not exceed 1 liter per minute. This is to keep the drawdown minimized.
- Stirring up of sediment in the well should be avoided so that turbidity containing adsorbed chemicals is not suspended in the well and taken in by the pump.
- Overheating of the pump should be avoided to minimize the potential for losing VOCs through volatilization.
- Keep the working space clean with plastic sheeting and good housekeeping.
- Maintain field equipment in accordance with the manufacturer's recommendations. This will include, but is not limited to:
  - Inspect sampling pump regularly and replace as warranted
  - Inspect quick-connects regularly and replace as warranted
  - Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

Attachment to the SOP on Low-Flow Sampling Groundwater Sampling from Monitoring Wells

White Paper on Low-Flow Sampling

EPA recommends low-flow sampling as a means of collecting groundwater samples in a way that minimizes the disturbance to the natural groundwater flow system and minimizes the introduction of contamination into the samples from extraneous sources. The following are details about these issues.

When a pump removes groundwater from the well at the same rate that groundwater enters the well through the screen, the natural groundwater-flow system around the well experiences a minimum of disturbance. Some disturbance is bound to occur because you are causing groundwater to flow to the well in a radial fashion that otherwise would have flowed past it. However, the resulting low-flow sample provides the most-representative indication we can get of groundwater quality in the immediate vicinity of the well.

Normally, when a well is pumped at an excessive rate that drops the water level in the well below the water level in the aquifer, the water cascades down the inside of the well screen when it enters the well. The turbulence from this cascading causes gases such as oxygen and carbon dioxide to mix with the water in concentrations that are not representative of the native groundwater and are higher than expected. This causes geochemical changes in the nature of the water that can change the concentrations of some analytes, particularly metals, in the groundwater sample, not mention it's effect on the dissolved oxygen levels that then will be measured in the flow-through cell. Such turbulence also may cause lower-than-expected concentrations of volatile organic compounds due to volatilization.

For wells in which the water level is above the top of the screen, the water up in the riser is out of the natural circulation of the groundwater and, therefore, can become stagnant. This stagnant water is no longer representative of natural groundwater quality because its pH, dissolved-oxygen content, and other geochemical characteristics change as it contacts the air in the riser. If we minimize the drawdown in the well when we pump, then we minimize the amount of this stagnant water that is brought down into the well screen and potentially into the pump. As a result, a more-representative sample is obtained.

Typically, wells contain some sediment in the bottom of the well, either as a residue from development that has settled out of the water column or that has sifted through the sand pack and screen since the well was installed. This sediment commonly has adsorbed on it such analytes as metals, SVOCs, and dioxins that normally would not be dissolved in the groundwater. If these sediments are picked up in the groundwater when the well is disturbed by excessive pumping, they can:

- Make filtering the samples for metals analysis more difficult
- Add unreasonably to the measured concentration of SVOCs and other organic compounds

The SOP for low-flow sampling has been modified recently and should be consulted for additional information about low-flow sampling and ways of dealing with wells in which the water level cannot be maintained at a constant level.

STANDARD OPERATING PROCEDURE – C.6

Surface Water Sampling

I. Purpose and Scope

This procedure presents the techniques used in collecting surface water samples. Materials, equipment, and procedures may vary; refer to the Field Sampling Plan and operators manuals for specific details.

II. Materials and Equipment

Materials and equipment vary depending on type of sampling; the Field Sampling Plan should be consulted for project-specific details. Typical equipment required includes:

- Open tube sampler
- Dip sampler
- Weighted bottle sampler
- Hand pump
- Kemmerer or Van Dorn sampler
- Depth-integrating sampler
- Sample containers
- Meters for specific conductance, temperature, pH, and dissolved oxygen

III. Procedures and Guidelines

Before surface water samples are taken, all sampler assemblies and sample containers are cleaned and decontaminated as described in SOP *Decontamination of Personnel and Equipment*. Surface water samples collected from water bodies tidally influenced should be collected at low tide and under low flow conditions to minimize the dilution of potential contaminants. Methods for surface water sample collection are described below.

A. Manual Sampling

Surface water samples are collected manually by submerging a clean glass, stainless steel, or Teflon container into the water body. Samples may be collected at depth with a covered bottle that can be removed with a tripline. The most common sampler types are beakers, sealable bottles and jars, pond samplers, and weighted bottle samplers. Pond samplers have a fixed or telescoping pole attached to the sample container. Weighted bottle samplers are lowered below water surface, where the attached bottle is opened, allowed to fill, and pulled out of the water. When retrieved, the bottle is tightly capped and removed from the sampler assembly.

Specific types of weighted bottle samplers include dissolved oxygen, Kemmerer, or Van Dorn, and are acceptable in most instances.

A sample is taken with the following specific steps:

1. The location and desired depth for water sampling are selected.

2. The sample site is approached from downstream in a manner that avoids disturbance of bottom sediments as much as possible. The sample bottle is gently submerged with the mouth pointed upstream and the bottle tilted slightly downstream. Bubbles and floating materials should be prevented from entering the bottle.

3. For weighted bottle samplers, the assembly is slowly lowered to the desired depth. The bottle stopper is unseated with a sharp tug and the bottle is allowed to fill until bubbles stop rising to the surface.

4. When the bottle is full, it is gently removed from the water. If sample transfer is required, it should be performed at this time.

5. Measure dissolved oxygen, specific conductance, temperature, and pH at the sampling location.

IV. Attachments

None.

V. Key Checks and Items

- Start downstream, work upstream
- Log exact locations using permanent features
- Beware of hidden hazards

STANDARD OPERATING PROCEDURE – C.7

Sediment Sampling

I. Purpose

These general outlines describe the collection and handling of sediment samples during field operations.

II. Scope

The sediment sampling procedures generally describe the equipment and techniques needed to collect representative sediment samples. Operators manual , if available, should be consulted for specific details

III. Equipment and Materials

- Sample collection device (hand corer, scoop, dredge, grab sampler, or other suitable device)
- Stainless steel spoon or spatula for media transfer
- Measuring tape
- Log book
- Personal protection equipment (rubber or latex gloves, boots, hip waders, etc.)
- Materials for classifying soils, particularly the percentage of fines
- Sample jars, including jars for Total Organic Carbon and pH, as appropriate

IV. Procedures and Guidelines

1. Field personnel will start downstream and work upstream to prevent contamination of unsampled areas. In surface water bodies that are tidally influenced, sampling will be performed at low tide and under low flow conditions to minimize the dilution of possible contaminants. Sediment sampling activities will not occur immediately after periods of heavy rainfall.
2. Make a sketch of the sample area that shows important nearby river features and permanent structures that can be used to locate the sample points on a map. Whenever possible, include measured distances from such identifying features. Also include depth and width of waterway, rate of flow, type and consistency of sediment, and point and depth of sample removal (along shore, mid-channel, etc).

3. Transfer sample into appropriate sample jars with a stainless steel utensil. Be especially careful to avoid the loss of the very fine clay/silt particles when collecting the sample. The fine particles have a higher adsorption capacity than larger particles. Minimize the amount of water that is collected within the sample matrix. Decant the water off of the sample slowly and carefully to maximize retention of the very fine particles. The sampler's fingers should never touch the sediment since gloves may introduce organic interference into the sample. Classify the soil type of the sample using the Unified Soil Classification System, noting particularly the percentage of silt and clay.

4. Samples for volatile organics should immediately be placed in jars. Rocks and other debris should be removed before placement in jars.

5. For channel sampling, be on the alert for submerged hazards (rocks, tree roots, drop-offs, loss silt and muck) which can make wading difficult.

6. Sample sediment for TOC and pH also, to give context to organic and inorganic data during the risk assessment.

7. Follow the site safety plan designed for the specific nature of the site's sampling activities and locations.

8. Decontaminate all sampling implements and protective clothing according to prescribed procedures.

V. Attachments

None.

VI. Key Checks and Items

- Start downstream, work upstream.
- Log exact locations using permanent features.
- Beware of hidden hazards.

STANDARD OPERATING PROCEDURE – C.8

Homogenization of Soil and Sediment Samples

I. Purpose

The homogenization of soil and sediment samples is performed to minimize any bias of sample representativeness introduced by the natural stratification of constituents within the sample.

II. Scope

Standard techniques for soil and sediment homogenization and equipment are provided in this SOP. These procedures do not apply to aliquots collected for VOCs or field GC screening; samples for these analyses should NOT be homogenized.

III. Equipment and Materials

Sample containers, stainless steel spoons or spatulas, and stainless steel pans.

IV. Procedures and Guidelines

Soil and sediment samples to be analyzed for explosives residues, semivolatiles, pesticides, PCBs, metals, cyanide, or field XRF screening should be homogenized in the field. After a sample is taken, a stainless steel spatula should be used to remove the sample from the split spoon or other sampling device. The sampler should not use fingers to do this, as gloves may introduce organic interferences into the sample.

If samples for VOCs are collected, they should be taken immediately upon opening the spoon and should not be homogenized.

The sample should be placed in a decontaminated stainless steel pan and thoroughly mixed using a stainless steel spoon. The soil or sediment material in the pan should be scraped from the sides, corners, and bottom, rolled into the middle of the pan, and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually, and then rolled to the center of the pan and mixed with the entire sample again.

All stainless steel spoons, spatulas, and pans must be decontaminated following procedures specified in the appropriate SOP prior to homogenizing the sample. A composite equipment rinse blank of homogenization equipment should be taken each day it is used.

V. Attachments

None.

VI. Key Checks and Items

- Take VOC samples immediately and do not homogenize the soil.
- Homogenize soil for analyses other than VOCs in a clean, stainless steel bowl.