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MCAS EL TORO  
SSIC #5090.3

**Comprehensive Long-Term Environmental Action Navy (CLEAN) II**  
Contract No. N62742-94-D-0048  
Contract Task Order No. 0072



Work Plan

# **Phase II Evaluation of Radionuclides in Groundwater at Former Landfill Sites and the EOD Range**

**Marine Corps Air Station, El Toro, California**

Prepared for:



Department of the Navy  
Commander, Southwest Division  
Naval Facilities Engineering Command  
San Diego, California 92132-5190

Prepared by:



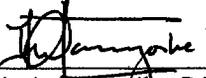
Earth Tech, Inc.  
700 Bishop Street, Suite 900  
Honolulu, Hawaii 96813

January 2001

Work Plan  
Phase II Evaluation of Radionuclides in Groundwater  
at Former Landfill Sites and the EOD Range  
MCAS El Toro, California

Contract No. N62742-94-D-0048  
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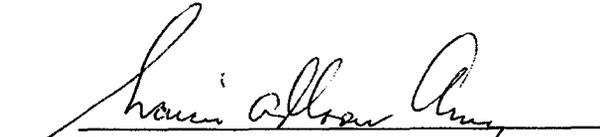
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DEPARTMENT OF THE NAVY  
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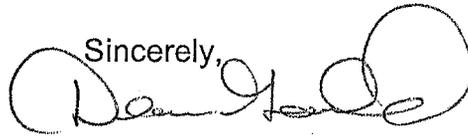
5090  
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05 February 2001

Mr. John Broderick  
Remedial Project Manager  
California Regional Water Quality Control Board  
Santa Ana Region  
3737 Main Street, Suite 500  
Riverside, CA 92501-3339

Dear Mr. Broderick:

Provided for your records is the Final Work Plan, Phase II Evaluation of Radionuclides in Groundwater at Former Landfill Sites and the EOD Range, MCAS El Toro. In addition, a complete set of the response to comments is also provided. Thank you for your timely review and productive feedback, in support of this significant effort.

Should you have any questions regarding the enclosure, please call Ms. Content Arnold, at (619) 532-0790, or myself at (619) 532-0784.

Sincerely,  


DEAN GOULD  
Base Realignment and Closure  
Environmental Coordinator  
By direction of the Commander

Enclosure: 1. Final Work Plan, Phase II Evaluation of Radionuclides in Groundwater at Former Landfill Sites and the EOD Range, MCAS El Toro

Copy to:  
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Department of Toxic Substances Control  
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Cypress, CA 90630-4700

5090  
Ser 06CC.DG/0140  
05 February 2001

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Hazardous Waste Management Division (SFD 8-2)  
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A handwritten signature in black ink, appearing to read "Dean Gould", written over a circular stamp or mark.

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# CONTENTS

SIGNATURE PAGE	i
ACRONYMS AND ABBREVIATIONS	viii ✓
1. INTRODUCTION	1-1
1.1 Site Description	1-1
1.2 Background	1-1
1.3 Previous Investigations	1-2
1.4 Identification of Data Needs	1-7
1.5 Project Approach	1-7
1.6 Tasks	1-7
1.6.1 Data Review and Project Planning	1-8
1.6.2 Field Activities	1-8
1.6.3 Data Evaluation and Report Preparation	1-8
1.6.4 Meetings	1-8
1.6.5 Purchasing Support	1-8
1.6.6 Project Management	1-8
1.7 Project Organization	1-8
1.8 Schedule	1-9
2. WORK PLAN	2-1
2.1 Data Quality Objectives	2-1
2.1.1 Problem Statement	2-1
2.1.2 Project Decisions	2-2
2.1.3 Decision Inputs	2-2
2.1.4 Study Boundaries	2-2
2.1.5 Decision Rules	2-2
2.1.6 Error Analysis	2-3
3. SAMPLING AND ANALYSIS PLAN	3-1
3.1 Sampling Design	3-1
3.2 Sampling Locations	3-1
3.3 Sample Collection	3-2
3.4 Sample Handling	3-4
3.5 Sample Designation	3-4
3.6 Sample Custody	3-6
3.7 Equipment Decontamination	3-7
3.8 Investigation-Derived Waste	3-7
3.9 Quality Control and Corrective Action	3-8
3.10 Inspection/Acceptance Requirements for Supplies and Consumables	3-9
3.11 Laboratory Analysis	3-9
3.12 Laboratory Quality Control	3-11
3.13 Project Quality Assurance Criteria	3-14
3.14 Data Calculation and Reporting Units	3-14
3.15 Documentation and Deliverables	3-14
3.16 Data Quality Assessment	3-15
3.16.1 Precision	3-15
3.16.2 Accuracy	3-15
3.16.3 Representativeness	3-15

3.16.4	Comparability	3-15
3.16.5	Completeness	3-16
3.17	Data Management	3-16
3.17.1	Receipt of Deliverables	3-16
3.17.2	Data Validation	3-17
3.17.3	Data Reduction	3-17
3.17.4	Data Reporting	3-17
3.18	Audits and Corrective Actions	3-18
3.18.1	Field Audits	3-18
3.18.2	Laboratory Performance Review	3-18
3.18.3	Corrective Actions	3-18
3.18.4	Reports to Management	3-18
4.	DATA EVALUATION	4-1
5.	REFERENCES	5-1

**APPENDIX**

Response to Comments from EPA, DTSC and the RAB Members on the Draft Technical Memorandum, Evaluation of Radionuclides in Groundwater at Former Landfill Sites and the EOD Range.

**FIGURES**

1-1	Project Location Map	1-3
1-2	Phase II Radionuclide Sampling Locations	1-5
1-3	Project Organization Chart	1-11
1-4	Phase II Radionuclide Evaluation Project Schedule	1-13

**TABLES**

1-1	CTO-0072 Task Summary	1-7
2-1	Summary of Decision Error Probability	2-4
3-1	Candidate Wells for the Phase II Radionuclide Evaluation	3-1
3-2	Well Development Monitoring Parameters	3-3
3-3	Summary of Target Analytes, Holding Times, Preservation, Analytical Laboratories, and Sample Volumes	3-5
3-4	Character Identifiers	3-6
3-5	QC Identifiers	3-6
3-6	Planned Analyses and Method References	3-9
3-7	Project Quality Control Criteria	3-11

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## ACRONYMS AND ABBREVIATIONS

$\sigma$	one standard deviation from the mean in a normal distribution
°C	degrees Celsius
$\mu$ mho	micro-mhos
ASTM	American Society for Testing and Materials
BCT	BRAC Cleanup Team
bgs	below ground surface
BNI	Bechtel National, Inc.
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
COC	chain of custody
COPC	contaminant of potential concern
CTO	contract task order
DER	duplicate error ratio
DOT	Department of Transportation
DQO	data quality objective
Earth Tech	Earth Tech, Inc.
EDD	electronic data deliverable
EOD	Explosive Ordnance Disposal
EPA	United States Environmental Protection Agency
FAR	Federal Acquisition Requirements
HNO <sub>3</sub>	nitric acid
HSP	health and safety plan
ICPMS	inductively coupled plasma mass spectrometry
ID	identification
IDW	investigation-derived waste
IRP	Installation Restoration Program
LCS	laboratory control sample
LLNL	Lawrence Livermore National Laboratory
MCAS	Marine Corps Air Station
MCL	maximum contaminant level
mg/L	milligrams per liter
MIT	Massachusetts Institute of Technology
ml	milliliter
MQO	measurement quality objective
MS	matrix spike
MSD	matrix spike duplicate
MSL	mean sea level
mV	millivolt
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEDTS	Naval Environmental Data Transfer System
NIST	National Institute of Standards and Technology
NFESC	Naval Facilities Engineering Service Center
NPL	National Priorities List
OCWD	Orange County Water District
PACNAVFACENGCOM	Pacific Division, Naval Facilities Engineering Command

PARCC	precision, accuracy, representativeness, comparability, and completeness
pCi/L	picoCuries per liter
pH	negative log of the hydrogen ion concentration
PPE	personal protective equipment
ppm	parts per million
QA	quality assurance
QAO	quality assurance officer
QC	quality control
%R	percent recovery
RAB	Restoration Advisory Board
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RPD	relative percentage of difference
RPM	remedial project manager
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act
SOP	standard operating procedure
SOW	statement of work
Sr	strontium
TCE	trichloroethene
TDS	total dissolved solids
TIMS	thermal ionization mass spectrometry
TU	tritium unit (1 TU = 3.2 pCi/L)
U	uranium
U.S.	United States

## 1. INTRODUCTION

Previous investigations have identified radionuclides in groundwater at concentrations exceeding decision thresholds at Marine Corps Air Station (MCAS) El Toro, California. This work plan details objectives and procedures to evaluate the origin of radionuclides detected in groundwater at the former landfill sites and the Explosive Ordnance Disposal (EOD) range. Groundwater samples will be collected from 23 wells, including 6 wells within the on-station portion of the trichloroethene (TCE) plume. An aliquot of each sample will be transferred to the Orange County Water District (OCWD) for analysis at Lawrence Livermore National Laboratory (LLNL) for uranium and other relevant isotopes. The Navy will analyze aliquots of each sample for the target analytes presented in this work plan.

This project was authorized by the U.S. Navy, Pacific Division, Naval Facilities Engineering Command (PACNAVFACENGCOM) under contract task order (CTO) no. 0072 of the Comprehensive Long-Term Environmental Action Navy (CLEAN) II program, contract number N62742-94-D-0048. It complies with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) in Title 40 of the Code of Federal Regulations (CFR), Part 300.

This work plan presents the elements of the quality assurance project plan as recommended in U.S. Environmental Protection Agency (EPA) *Requirements for Quality Assurance Project Plans for Environmental Data Operations, QA/R-5* (EPA 1997a).

### 1.1 SITE DESCRIPTION

MCAS El Toro is located in a semi-urban, agricultural area of southern California, approximately 8 miles south of Santa Ana and 12 miles northeast of Laguna Beach (Figure 1-1). MCAS El Toro covers approximately 4,740 acres (Figure 1-2). Land use around the MCAS includes commercial, light industrial, and residential. MCAS El Toro closed on 2 July 1999 as part of Base Realignment and Closure (BRAC).

### 1.2 BACKGROUND

Alpha and beta emissions and uranium isotopes have been detected in groundwater. In some samples, alpha and uranium concentrations exceeded regulated levels for drinking water, a preliminary decision threshold selected for the project. There are two potential sources of the alpha and beta emissions detected in groundwater at the site:

1. Naturally occurring radioactive isotopes. Many geological formations have measurable concentrations of radioactive elements. These elements are also present in the groundwater flowing through the formations.
2. Use of specific areas as landfills for military wastes, including household trash, office wastes, industrial wastes, and expended or decommissioned military equipment. If radionuclides are present due to wastes disposed at the landfills, likely materials which could account for them are self-illuminating instrument dials or faces with radium-containing paint, depleted uranium from munitions, or isotopes associated with smoke detectors or measuring instruments.

There are no documented sources or use of enriched uranium (used in nuclear weapons) at MCAS El Toro. However, due to the low concentrations and the relative error inherent in the measurement technique, previous investigation results did not provide conclusive data to ascertain the origin of the

radioisotopes detected in the groundwater. Therefore, additional analysis will be performed using a more definitive analytical technique.

### 1.3 PREVIOUS INVESTIGATIONS

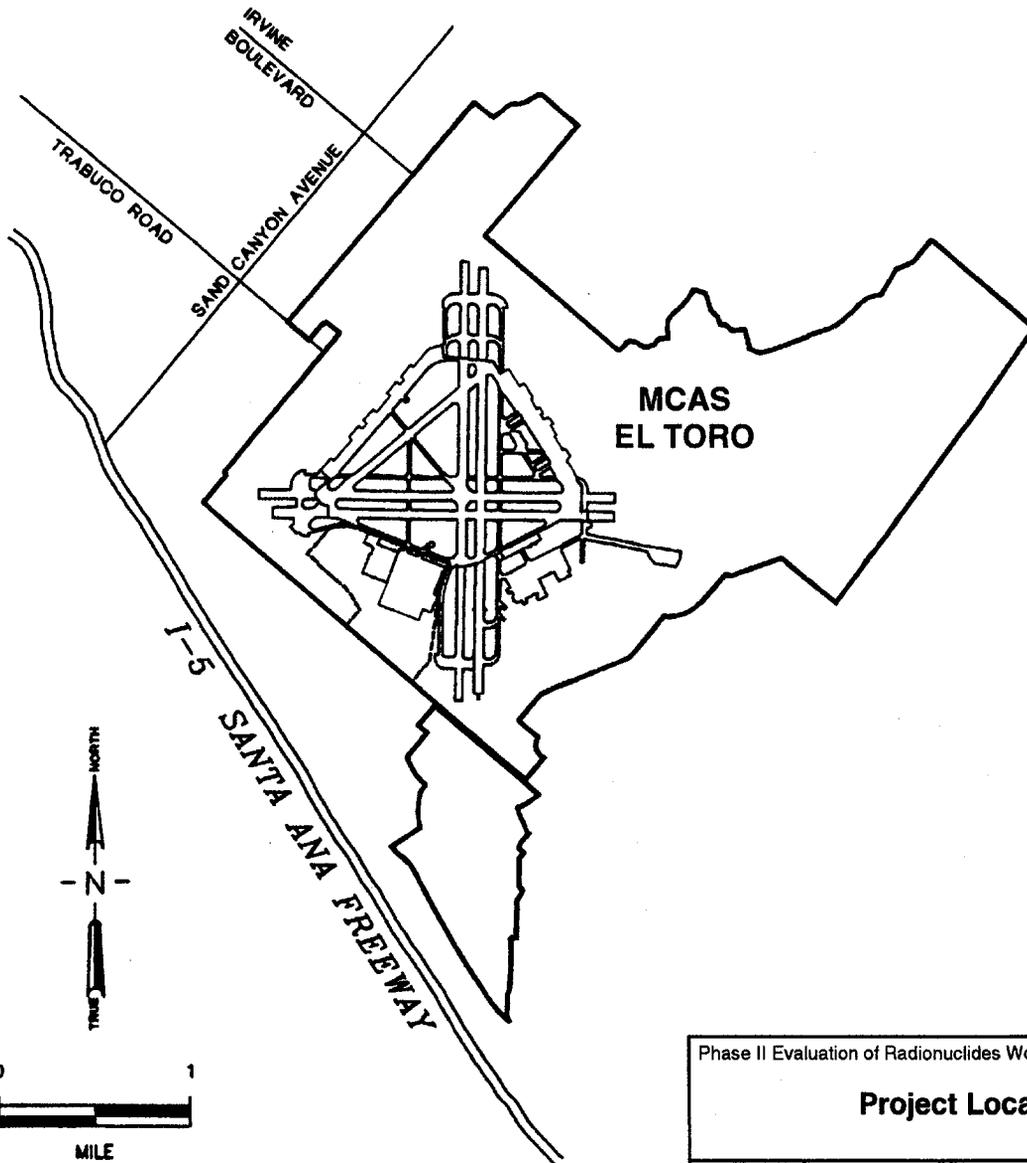
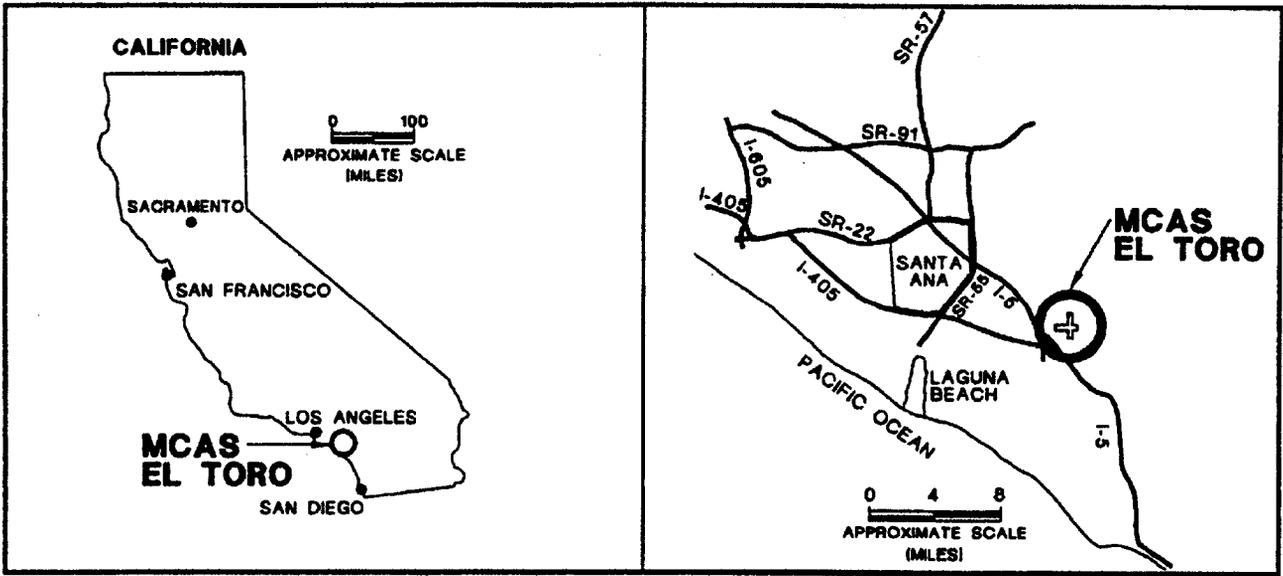
Groundwater samples collected from 1992 through 1996 during the phase II remedial investigation (RI) were analyzed for gross alpha, gross beta, radon, cesium<sup>134</sup>, radium<sup>226</sup>, radium<sup>228</sup>, strontium<sup>89</sup>, strontium<sup>90</sup>, and total uranium (BNI 1996).

In 1998, Bechtel National, Inc. (BNI) evaluated radionuclides in groundwater at landfill sites 2, 3, and 5. A technical memorandum summarizing the results of this evaluation (BNI 1998) concluded the following:

- Gross alpha activity exceeding the 15 picoCuries per liter (pCi/L) drinking water MCL occur in groundwater samples from Sites 2, 3, and 5;
- Gross alpha activity above the MCL is found in wells upgradient, cross-gradient, and downgradient from the site;
- Comparison of upgradient and downgradient gross alpha activities does not show an apparent effect from the landfills;
- Gross alpha activity has significant correlation to total dissolved solids (TDS) concentrations;
- The distribution of gross alpha activity appears to be representative of a natural background in groundwater;
- The distribution of gross beta activity appears to be representative of a natural background in groundwater.

A subsequent radionuclide evaluation was conducted in October and November 1999 at landfill Sites, 2, 3, 5, and 17, and Site 1, the former EOD range (Earth Tech 2000a). The analytical laboratory reported gross alpha and total uranium concentrations exceeding regulatory levels for drinking water in several samples. The laboratory reported no man-made radionuclides at concentrations indicative of a release, although americium<sup>241</sup> was detected at a concentration equivalent to the minimum detectable activity. After evaluation of the uranium isotopes, Earth Tech concluded that, within measurement error, the uranium is naturally occurring and serves as the primary source of the alpha emissions. In addition, the comparison of uranium isotopes indicated that their ratios were consistent with naturally occurring uranium. However, the isotope evaluation conclusions were not definitive due to the low radionuclide concentrations and analytical uncertainty associated with the methods used.

Comments on the Draft *Technical Memorandum, Evaluation of Radionuclides in Groundwater at Former Landfill Sites and the EOD Range* (Earth Tech 2000a) were received from the EPA, California Department of Health Services, and the Restoration Advisory Board (RAB) members. These comments were considered during the development of this work plan. A copy of the comments and responses are provided in the Appendix.

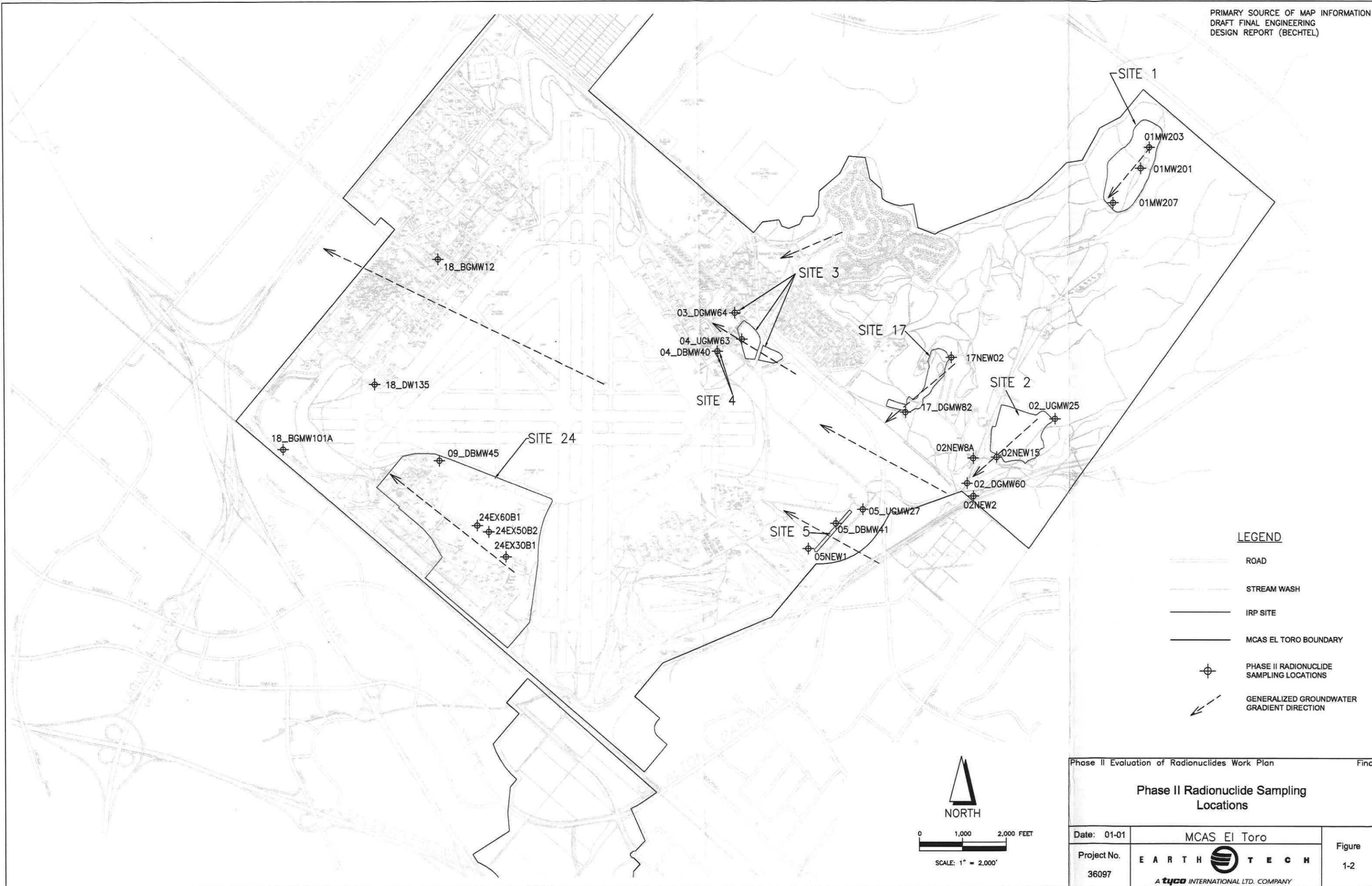


Phase II Evaluation of Radionuclides Work Plan		Final
<b>Project Location Map</b>		
Date 01-01	 <b>EARTH TECH</b> <small>A STUDEBAKER INTERNATIONAL LTD. COMPANY</small>	Figure
Project No. 36097		<b>1-1</b>

36097.00.22.02

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**LEGEND**

- ROAD
- STREAM WASH
- IRP SITE
- MCAS EL TORO BOUNDARY
- PHASE II RADIONUCLIDE SAMPLING LOCATIONS
- GENERALIZED GROUNDWATER GRADIENT DIRECTION

Phase II Evaluation of Radionuclides Work Plan Final

**Phase II Radionuclide Sampling Locations**

Date: 01-01	MCAS El Toro	Figure 1-2
Project No. 36097	EARTH  TECH A tyco INTERNATIONAL LTD. COMPANY	

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## 1.4 IDENTIFICATION OF DATA NEEDS

To evaluate the origin of radionuclides in groundwater at MCAS El Toro, data representing the current conditions of the site are required. These data will consist of the following:

- Mass ratios of uranium isotopes  $U^{238}:U^{235}$  in groundwater,
- Concentrations of anthropogenic  $U^{236}$  in groundwater,
- Concentrations of anthropogenic  $Sr^{90}$  in groundwater, and
- Concentration of Americium<sup>241</sup> in monitoring well 17NEW02.

Uses of the results that fulfill these data needs are presented in Section 2.1 of this plan.

## 1.5 PROJECT APPROACH

Groundwater samples will be collected throughout the station from wells located near potential contaminant sources.

Prior sampling and analysis used published standard methods for assessment of radioisotopes. The methods were not sensitive or precise enough to determine if the detected uranium was naturally occurring. The low concentrations of the target analytes in the groundwater samples, coupled with uncertainty inherent in the analytical method, rendered the data inconclusive (i.e., neither affirming nor denying the presence of anthropogenic material). Analytical methods used in academic research have been identified that may be sensitive enough to provide conclusive data regarding the radionuclide origin. The sampling and analysis approach presented in this document will focus on achieving the following objective: determine whether radionuclides detected in groundwater at MCAS are due to anthropogenic or naturally occurring sources.

## 1.6 TASKS

Tasks associated with CTO-0072 are summarized on Table 1-1 and described in the following subsections.

**Table 1-1: CTO-0072 Task Summary**

Data Review and Project Planning (SOW Task 1)	Field Activities (SOW Task 2)	Data Evaluation and Report Preparation (SOW Task 3)
Task 20 Project Planning	Task 30 Field Activities	Task 50 Data Validation
Task 22 Work Plan	Task 46 Laboratory Analysis and Oversight	Task 51 Data Evaluation
Task 23 Sampling and Analysis Plan		Task 67 Report Preparation
Task 24 Health and Safety Plan		
Meetings (SOW Task 4)	Purchasing Support (SOW Task 5)	Project Management (SOW Task 6)
Task 11 Meetings	Task 12 Purchasing and Subcontract Administration	Task 10 Project Management
Task 42 BCT/RAB Support		

**Notes:**

SOW = Statement of Work

BCT = BRAC Cleanup Team

RAB = Restoration Advisory Board

### **1.6.1 Data Review and Project Planning**

Existing data will be compiled and reviewed, and technical statements of work (SOWs) will be prepared. Planning documents, including a combined work plan and sampling and analysis plan (SAP), and a health and safety plan (HSP) will be prepared. Coordination and scheduling with subcontractors will be completed. Site access will be secured, and pre-work meetings will be conducted.

### **1.6.2 Field Activities**

Groundwater monitoring wells will be purged and sampled. Field parameters such as temperature and pH will be measured at the wellhead during purging. Groundwater samples will be collected and submitted to analytical laboratories for analysis.

### **1.6.3 Data Evaluation and Report Preparation**

Project staff will review all laboratory reports for contract and method compliance and data usability. Laboratory data packages will be subject to independent, third party validation.

Data will be loaded into a relational database using the conventions and structure of the Naval Environmental Data Transfer System (NEDTS). Electronic data will be verified for consistency with hard copy laboratory data reports.

Data collected during this investigation and pertinent historical data will be evaluated as described in Section 4 and presented in a technical memorandum. The technical memorandum will provide the results of evaluation, including interpretation of results of laboratory analysis, assessment of data quality, evaluation of compliance with measurement quality objectives, adherence to this plan, and uncertainty associated with the conclusions.

### **1.6.4 Meetings**

Earth Tech personnel will participate in periodic BRAC Cleanup Team/Restoration Advisory Board (BCT/RAB) meetings and provide technical support when applicable, including briefing packages and fact sheets documenting project progress.

### **1.6.5 Purchasing Support**

Materials, supplies, and subcontractor services will be procured, and subcontracts will be administered in accordance with requirements of the Earth Tech Navy CLEAN project and applicable Federal Acquisition Requirements (FAR).

### **1.6.6 Project Management**

The CTO manager will coordinate with the Navy Remedial Project Manager (RPM) to ensure that project objectives are accomplished in a timely and effective manner. Monthly progress reports summarizing project status will be prepared.

## **1.7 PROJECT ORGANIZATION**

The project organization chart (Figure 1-3) identifies project team members.

**RPM.** Provides governmental oversight of technical issues for the project. Interfaces with the BRAC Closure Team (BCT), community representatives, and the contractor to meet project objectives.

**Quality Assurance Officer (QAO).** Provides governmental oversight of contractor's quality assurance (QA) program. Provides quality-related directives through the RPM. Has authority to suspend project execution if QA requirements are not adequately met.

**BRAC Cleanup Team (BCT).** Representatives from local, state, and federal regulatory agencies who provide input to the Navy. The OCWD is performing parallel and supporting analysis through their own laboratory subcontractor, Lawrence Livermore National Laboratory (LLNL). The data developed by this work will be incorporated into the findings and conclusions of the report.

**CTO Manager.** Responsible for day-to-day management of project budgets, staffing, deliverables, and schedule. Ensures compliance with applicable project health and safety requirements. Communicates with the RPM on technical issues.

**CLEAN II Program Manager/Program Quality Manager.** Provides management oversight of execution of the task order in compliance with the program contract. Responsible for executing the contractor's QA program. Responsible for ensuring that technical standards and specifications are met for each deliverable to the client. Coordinates the peer and technical review of project deliverables and ensures that standards and QA requirements are met. Directs corporate health and safety manager to support project execution as necessary.

**Pacific Division Contracting Officer.** Represents the government in all contractual, cost, and scheduling issues. Interfaces with RPM on performance and execution of the task order.

**Health and Safety Manager.** Ensures that all field operations are conducted in accordance with safe operating practices and in compliance with federal and state requirements.

**Project Chemist.** Manages analytical laboratory services for the project. Prepares planning documents, technical specifications, and quality assurance plans for collection of data. Oversees technical performance of laboratory subcontractors. Coordinates with OCWD and LLNL to ensure comparability of data. Trains and provides technical guidance to the sampling team.

**Project Hydrogeologist.** Responsible for overseeing field operations and evaluating technical data. Prepares planning documents and technical specifications for collection of data. Oversees technical performance of subcontractors.

**Special Training Requirements.** Training requirements applicable to this project are as follows:

All field personnel will have current health and safety training in accordance with the *Health and Safety Plan (HSP)* (Earth Tech 2000b). This includes the initial 40-hour training and annual 8-hour refresher training. The onsite health and safety manager will also have an additional 8 hours of supervisor training.

The project chemist will train the sample collection team in the special requirements of the sampling techniques required to meet the measurement quality objectives, as presented in the sampling plan. The project chemist will directly supervise sample collection until the sampling team demonstrates competence in the sampling procedures.

## 1.8 SCHEDULE

The investigation will span approximately 6 months. The schedule shown on Figure 1-4 is for planning purposes only and will be revised as needed.

PAGE NO. 1-10

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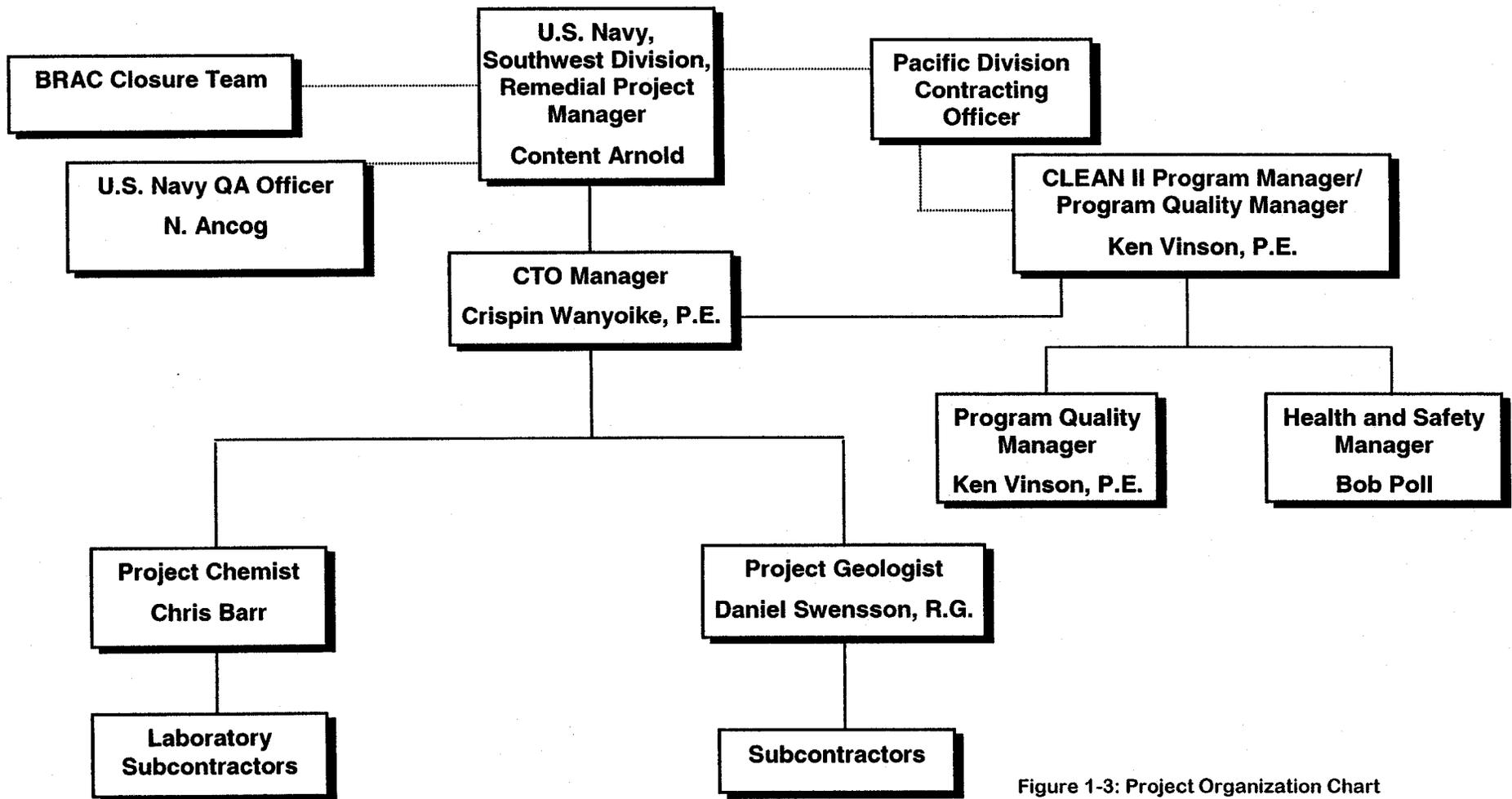
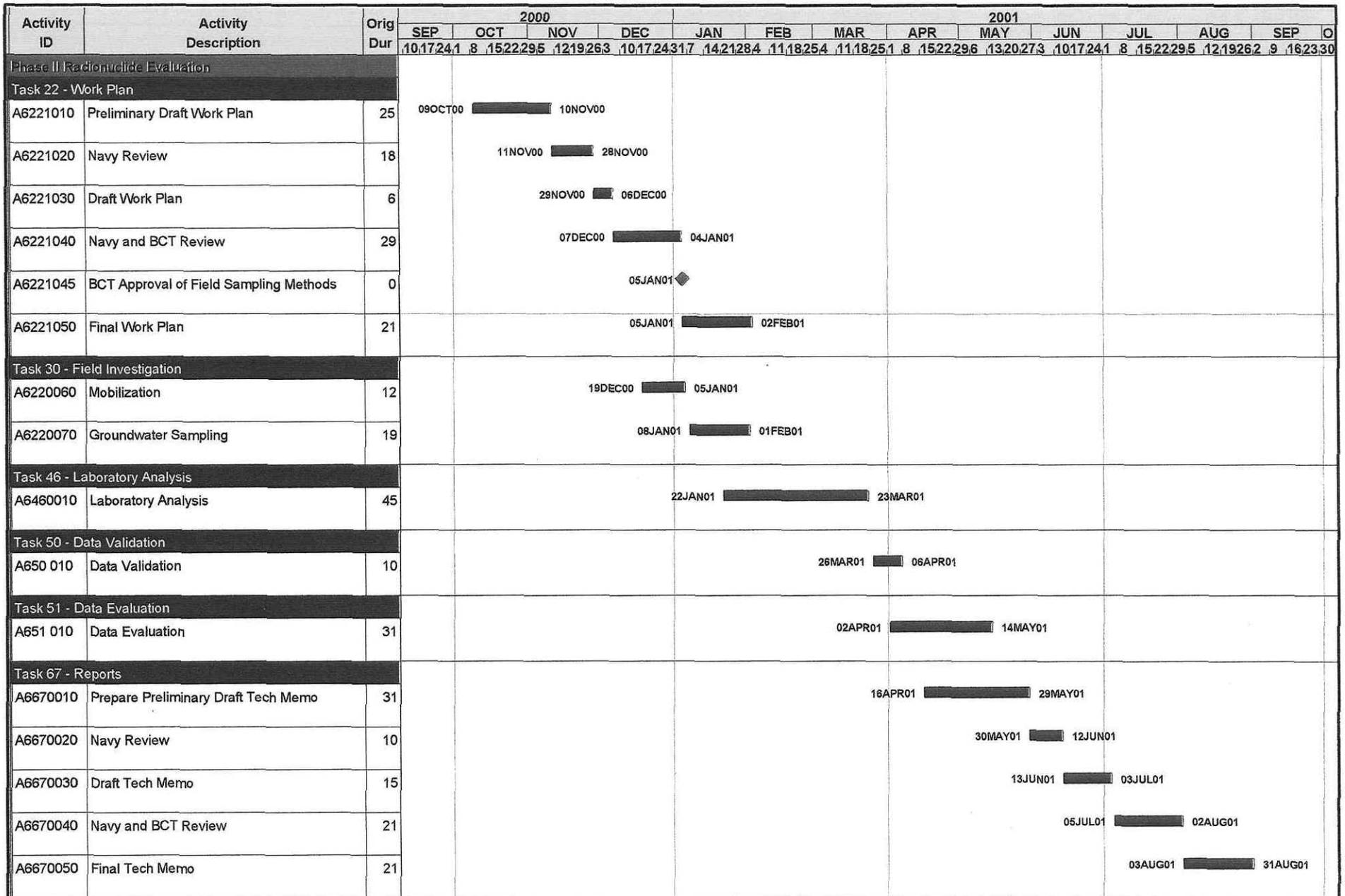


Figure 1-3: Project Organization Chart

PAGE NO. 1-12

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1-13



Start Date 13SEP00  
 Finish Date 31AUG01  
 Data Date 09OCT00  
 Run Date 01FEB01 12:43

██████████ Early Bar  
 ██████████ Progress Bar  
 ██████████ Critical Activity

MS72 - 72P5

Sheet 1 of 1

**Figure 1-4**  
**Phase II Radionuclide Evaluation**  
**MCAS El Toro**  
**Project Schedule**

Date	Revision	Checked	Approved
19JAN01	Final Work Plan	DS	CW

## 2. WORK PLAN

The sampling and analysis will be performed in concert with a parallel effort by the OCWD, as presented in *Sampling and Analysis Plan for Phase 2 Sampling of Radionuclides in Groundwater at Former MCAS El Toro* (OCWD 2000). The Navy will use the data collected to confirm radiochemistry conclusions raised in the course of previous investigations. The results of both the OCWD and Navy sampling and analysis will be applied to resolving the decision question.

### 2.1 DATA QUALITY OBJECTIVES

The project work plan has been developed using the seven-step data quality objectives (DQO) process of the U.S. Environmental Protection Agency (EPA 1994a). DQOs create a framework for the key decisions regarding contaminant releases and the threats they pose to human health and the environment. This section presents steps 1 through 6, and Section 3.1 presents Step 7, the sampling design.

#### 2.1.1 Problem Statement

Alpha and beta emissions and radionuclides have been detected in the groundwater. Alpha emissions and uranium concentrations in some samples exceeded the drinking water decision criteria. The origin of the radioactivity has not been determined and may be from an upgradient source, naturally occurring, or the result of materials placed in landfills.

Groundwater generally flows toward the south-southwest from the foothills (Installation Restoration Program [IRP] Sites 1, 2, and 17), toward the northwest in the main area of MCAS El Toro (IRP Sites 3, 4, and 5), and toward the west-northwest off-station. Depth to groundwater at the study sites ranges from approximately 26 feet below ground surface (bgs) in monitoring well 02NEW15 to approximately 219 feet bgs in monitoring well 03\_DGMW64. The regional flow direction in the principal aquifer is generally analogous to the flow direction in the shallow aquifer (although localized gradients have developed as a result of groundwater extraction).

It is speculated that materials placed in landfills could include depleted uranium (a component of some munitions), strontium sources (used in ice-detection equipment in some aircraft), and/or radium dials from aircraft instruments. If the materials leached those analytes to groundwater, this could account for the concentrations of radioisotopes detected in previous groundwater samples. However, the alpha, beta, and uranium previously reported could also be naturally occurring in the formations underlying the facility.

There are no documented sources or use of enriched uranium at MCAS El Toro, but some interpretations of previous laboratory data suggest that it might be present. However, due to the low concentrations and the relative error inherent in the measurement technique, previous investigation results did not provide conclusive data regarding the source (natural or anthropogenic) of the radioisotopes detected in the groundwater. Therefore, additional analysis will be performed using a more definitive analytical technique. In addition, to better assess the origin of the radionuclides, this radionuclide evaluation will focus on the dissolved radioisotopes. Therefore the data collected may not be comparable with previous investigation results.

Groundwater within the on-station portion of the TCE plume will be collected to assess concentrations of radioisotopes as well as their origin. The water districts will use this data as part of the planning process for groundwater TCE plume remediation. Radionuclide concentrations within this portion of the plume have historically been below drinking water decision criteria.

### 2.1.2 Project Decisions

The investigation will attempt to resolve the problem statement and identify alternative actions that may be taken based on the outcome of the investigation. The principal study question is: *Did U.S. Navy activity result in the release of radioactive isotopes to the groundwater?*

If there are detectable concentrations of isotopes that can be associated with anthropogenic sources, further investigation into the source of those isotopes will be conducted, and appropriate assessment and responses will be developed. If this investigation does not identify anthropogenic radioisotopes, no further investigation will be required.

### 2.1.3 Decision Inputs

Samples will be collected from existing groundwater monitoring wells and analyzed for radionuclides. The assessment will be based upon the following assumptions:

1. Natural uranium has a mass ratio of isotopes  $U^{238}$  to  $U^{235}$  of 137.88 (CRC Press 2000).
2.  $U^{236}$  is a product of nuclear fission (OCWD 2000) and is not naturally occurring, except in a unique environment in West Africa. There is no evidence that a similar environment is found in the El Toro region and, therefore, for the purposes of this investigation, it is assumed not to be present.
3. Strontium-90 ( $Sr^{90}$ ), a beta-emitter, is not naturally occurring (CRC Press 2000).
4. Americium-241 ( $Am^{241}$ ), an alpha particle emitting isotope, used in commercial and residential smoke detectors, is not naturally occurring (CRC Press 2000).
5. The characteristics of groundwater can be described by measuring the concentration of select analytes (stable isotopes and groundwater geochemistry). The characteristics of water from specific locations can be compared to literature values and other locations to describe source and determine the relative age of the sampled waters.

In addition to the laboratory results, the interpretation will include reasonable sources of detected contaminants, potential error in the laboratory measurements, and consistency of data with other indicators of contamination.

### 2.1.4 Study Boundaries

The decisions have physical and temporal boundaries. Physical boundaries are expressed as the lateral and vertical extent of the investigation. The lateral extent is defined by the hydrogeological influence of the wells selected for the evaluation. The vertical extent for groundwater sampling will be up to 285 feet bgs, the greatest screened depth of the selected wells.

Radionuclide concentrations are dynamic due to the continuous movement of groundwater. Therefore, the sample results are temporally applicable to the period during which the samples are collected. It is assumed that these samples are sufficient to demonstrate whether there is an anthropogenic source of the radionuclides detected in groundwater.

### 2.1.5 Decision Rules

Decision rules are if...then statements that define the outcomes of the expected results. By determining exactly what the conclusion of findings will be, the investigation is focused on specific objectives.

The following decision rules have been developed from the project decisions, and critical input data and measurements have been defined. The decision rules for radiochemical analysis are based on the radioisotopic decay series that would reasonably be expected to be present.

1. *If* the ratio of the mass of  $U^{238}$  to  $U^{235}$  is equal to  $137.88 \pm 0.34$ , *then* the conclusion will be that the uranium is naturally occurring.
2. *If*  $U^{236}$  is present, *then* anthropogenic uranium is present.
3. *If* americium<sup>241</sup> is detected, *then* an anthropogenic source of alpha activity is present.
4. *If* strontium<sup>90</sup> is detected, *then* an anthropogenic source of beta activity is present.
5. *If* strontium<sup>90</sup> is detected above the California MCL of 8 pCi/L, *then* further evaluation of the extent will be performed and a response action will be developed.
6. *If* gross alpha exceeds the California MCL of 15 pCi/L, *then* additional evaluation of the radioisotopes contributing to this activity will be performed.
7. *If* gross beta exceeds the California MCL of 50 pCi/L, *then* additional evaluation of the radioisotopes contributing to this activity will be performed.
8. *If* the tritium activity is less than 1 tritium unit (TU; 1 TU = 3.2 pCi/L), *then* the water is more than 30 years old.
9. *If* the oxygen and hydrogen isotope values diverge from the local meteoric water line and are consistent with the isotope signature of the regional deep groundwater, *then* the groundwater in the samples did not originate from the ground surface onsite through infiltration/percolation, and it is probably from a deep groundwater source.
10. *If* the water shows little equilibration with minerals from the site geologic strata, *then* the water will be interpreted as being out of equilibrium with the system and very recently recharged.

#### 2.1.6 Error Analysis

The probability of a decision error is a function of the total sum of the measurement errors and the errors in the assumptions used in the sampling design.

The investigation is based on a judgmental sample collection design (as opposed to a statistically based design) and, therefore, an estimate of the overall probability of a decision error is not meaningful. However, because each measurement is a statistically quantifiable value with a known error, each can be evaluated independently. The probability of a decision error is simply the confidence interval around the measurement (i.e. isotopic ratio), based on the measurement technique and historical measurements.

Table 2-1 presents the anticipated measurement errors, based on historical method performance and analysis of known standards. These limits establish the standards by which measurement quality objectives (MQOs) are developed. MQOs for the individual analyses are presented in Section 3.10. All decisions are to be made at the 95 percent ( $2\sigma$ ) confidence level.

Table 2-1: Summary of Decision Error Probability

Measurement	Decision	Expected Probability of Incorrect Decision
<b>Mass ratio of uranium isotopes</b>		
<137.54	Presence of enriched uranium	5%
mean 137.88 (137.54 to 138.22)	Natural uranium	5%
>138.22	Presence of depleted uranium	5%
<b>Concentration of U<sup>236</sup></b>		
<0.1 pCi/L*	No evidence of anthropogenic uranium	5%
>0.1 pCi/L*	Evidence of anthropogenic uranium	5%
<b>Concentration of Sr<sup>90</sup></b>		
<1 pCi/L*	No evidence of anthropogenic strontium	5%
>1 pCi/L*	Evidence of anthropogenic strontium	5%
<b>Characterization of hydrological regime</b>		
Isotopic hydrogen, oxygen	No hydrological connection; evidence of anthropogenic influence	
Minerals	No hydrological connection; evidence of anthropogenic influence	

*Note:*

\* Laboratory reporting limit for the analyte

Qualitative decision errors are errors introduced by failure to recognize, account for, or control factors that influence the results. An example of a qualitative error would be cross contamination. A finding of contamination in a "clean" well would be a decision error resulting in the transfer of a contaminant from another source. Adherence to established data collection processes and careful evaluation of data and the data quality indicators will prevent qualitative decision errors.

The control of decision errors is based on the execution of the sampling and analysis plan presented in Section 3 of this document.

### 3. SAMPLING AND ANALYSIS PLAN

Methodologies and procedures for sample collection will conform to the standard operating procedures (SOPs) for the project (BNI 1999). Methods for sample collection will be modified to accommodate the special requirements of the planned analyses. Descriptions of the modifications are presented in this section.

In addition to work discussed in this document, the OCWD will authorize collection and analysis of samples by the LLNL. Lawrence Livermore National Laboratory has extensive experience in assessment of uranium through work at a National Priorities List (NPL) site at their facility. Lawrence Livermore National Laboratory has developed and implemented analytical protocols to measure uranium isotope ratios and concentrations with detection limits much lower than conventional, commercial laboratories. The sampling design and approach are presented in *Sampling and Analysis Plan for Phase 2 Sampling of Radionuclides in Groundwater at Former MCAS El Toro* (OCWD 2000).

#### 3.1 SAMPLING DESIGN

A summary of the key elements of the sampling design and the logic for selection of specific features is presented here. This section discusses Step 7 of the DQO process, "Optimization of the Design for Obtaining Data."

The sampling design has been developed using a judgmental approach. Wells were selected based upon previously characterized hydrogeology with the expectation that the wells would represent the worst-case contamination if there had been a release.

Data for the selected analytes are intended to resolve the decision rules presented in Section 2. The designated analytical methods will have sufficient resolution to address the decision question within the error bounds planned for this project.

Additional elements of the sampling design, including bottle cleaning, sample handling, and sample management, were specified to achieve the project MQOs.

#### 3.2 SAMPLING LOCATIONS

Candidate wells for the evaluation to be performed by the Navy and OCWD are presented in Table 3-1 and shown on Figure 1-2.

**Table 3-1: Candidate Wells for the Phase II Radionuclide Evaluation**

Monitoring Well	Date Previously Sampled <sup>a</sup>	Depth to Water <sup>b</sup> (feet bgs)	Screened Interval (feet bgs)
01MW201	10/25/99	36.03	27-57
01MW203	11/18/99	27.75 <sup>c</sup>	33-58
01MW207	11/19/99	42.17 <sup>c</sup>	19.5-54.5
02NEW02	10/22/99	64.03	75-95
02NEW08A	10/15/99	43.03	84-104
02NEW15	10/22/99	26.21	25-65
02_UGMW25	10/19/99	31.42	55-75
02_DGMW60	10/19/99	62.59	80-100

**Table 3-1: Candidate Wells for the Phase II Radionuclide Evaluation**

Monitoring Well	Date Previously Sampled <sup>a</sup>	Depth to Water <sup>b</sup> (feet bgs)	Screened Interval (feet bgs)
03_DGMW64	10/15/99	218.71	245–285
04_DBMW40	10/14/99	199.54	220–260
04_DGMW63	10/13/99	198.21	235–275
05NEW01	10/12/99	156.15	163–203
05_UGMW27	10/13/99	161.11	198–238
05_DBMW41	10/12/99	153.21	182–222
17NEW02	10/18/99	85.79	83–123
17_DGMW82	10/21/99	175.09	235–255
18_BGMW12	10/20/99	146.33 <sup>c</sup>	165–205
<i>24-EX3OB1</i>	-----	104.41	105–150
<i>24-EX5OB2</i>	-----	102.53	105–150
<i>24-EX6OB1</i>	-----	104.31	106–151
09_DBMW45	12/10/92	112.68	117–157
18_BGMW101A	-----	75 <sup>d</sup>	68.5–98.5
18_DW135	-----	110.80	115–135

**Notes:**

<sup>a</sup> Date previously sampled for radionuclides.

<sup>b</sup> Unless otherwise noted, all depths to groundwater were measured in July 1999.

<sup>c</sup> Depth to groundwater measured in November 1999.

<sup>d</sup> Depth to groundwater measured during drilling/well installation on August 15, 2000.

bgs = below ground surface

----- = Samples from this well have not been analyzed for radionuclides

Wells shown in italicized text are within the on-station portion of the trichloroethene (TCE) groundwater plume.

**3.3 SAMPLE COLLECTION**

Samples will be collected in the following order: tritium and stable isotopes, uranium, radioisotopes, and general chemistry. Samples for tritium, isotopic hydrogen, and isotopic oxygen will be collected in clean, unpreserved 1-liter plastic bottles. The first aliquot will be not be filtered and will be collected to minimize contact with air. After the unfiltered aliquot is collected, aliquots for uranium, radioisotopes, and general chemistry will be collected by placing a disposable filter on the discharge outlet of the pump and collecting the sample directly into the sample bottle.

The analysis procedures for uranium are low-level measurement techniques. In order to control for interference from the introduction of extraneous contaminants, ultra-trace metals sampling techniques will be used. The following techniques are derived from EPA Guidance *Method 1669 – Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels* (EPA 1996 [Draft]):

1. Sample bottles will be pre-cleaned by soaking for 1 week in a 1 percent solution of ultra-trace nitric acid. (Ultra-trace is a descriptive name and not a performance standard.) Earth Tech will use the services of Seastar Chemicals to prepare the bottles. After soaking, the bottles will be refilled and shipped with ultra-pure water to prevent contamination. Bottles will be double-bagged and sealed for shipping.

2. All bottles will be prepared in a clean-room environment.
3. Two technicians will collect the field samples. The first technician will handle only the outer packaging of the containers. The second technician will wear powderless latex gloves and handle clean materials only.
4. The samples will be collected from the pump outlet directly into the clean sample bottles, minimizing the opportunity to include dust and external materials. The samples will be filtered through 0.45-micron disposable filter cartridges attached to the outlet of the discharge hose.
5. The sample bottle will be pre-rinsed at least twice with approximately 100 milliliters (ml) of sample. The rinse will be discarded.
6. The bottle will be completely filled and capped. An adhesive label with applicable sampling information will be attached to the bottle, and the bottle will be resealed in the plastic bag. Refrigeration will not be required.
7. A field/bottle blank will be prepared and submitted by opening and closing one of the clean, filled sample bottles as a sample.
8. Samples will *not* be preserved in the field. For the uranium isotope analysis samples, the laboratory will add approximately 2 ml of concentrated ultra-trace nitric acid to ensure that the analyte remains in solution during storage. The acid shall be added in a clean-room environment.

Samples will be collected from wells with dedicated sampling pumps, using low-flow sampling procedures. Monitoring wells will be purged prior to groundwater sampling, using a submersible pump, Teflon™ bladder pump, or positive displacement pump, depending on the volume of fluid to be removed. Before purging each well, static water level will be measured to an accuracy of 0.01 feet, with a tape measure equipped with an electronic interface detector. Measurements will be recorded in each well development/purge log. The sampling pump will be set at a rate of 100–300 milliliters per minute and water quality parameters, shown in Table 3–2, will be periodically measured and assessed in accordance with CLEAN SOP 8, Groundwater Sampling (BNI 1999). These data will also be recorded in each well development/purge log. Field measurement equipment (e.g., pH meter, conductivity meter) will be calibrated prior to use each workday and promptly serviced, if required, in accordance with manufacturers' instructions. Samples will be collected from the outlet of a 0.45-micron disposable filter attached to the discharge line of the sampling pumps.

**Table 3-2: Well Development Monitoring Parameters**

Type of Data	Units	Resolution
Conductivity	Micro-mhos ( $\mu\text{mho}$ )	$\pm 5$ percent full scale
Dissolved oxygen	parts per million (ppm)	$\pm 0.5$ ppm
Oxidation-reduction potential	millivolts (mV)	$\pm 10$ mV
pH	standard pH units	$\pm 0.2$
Static groundwater level	feet above mean sea level (MSL)	$\pm 0.01$ foot
Temperature	degrees Celsius ( $^{\circ}\text{C}$ )	$\pm 1^{\circ}\text{C}$

### 3.4 SAMPLE HANDLING

Table 3-3 summarizes the chemical parameters to be tested and the types of containers and preservation methods to be used. These may be modified to accommodate selected laboratory preferences, but will meet the essential requirements of the method.

### 3.5 SAMPLE DESIGNATION

Sample containers will be labeled as follows.

1. Labels will be written in indelible ink with the following information:

- Project name
- EPA sample ID number
- Date and time of collection
- Initials of the person collecting the sample
- Method number or name of analysis to be performed

2. A label with adhesive backing will be affixed to each sample container.

The label will be covered with clear tape to further secure it to the container and to keep the ink from smearing.

**EPA Sample Identification (ID) Number.** To facilitate data tracking and storage, all samples will be labeled with a five-character sample ID number, referred to as an EPA ID, in accordance with recordkeeping, sample labeling, and chain-of-custody procedures. The ID number for CTO 0072 is determined as follows:

**LDzzz**

Where,

<b>L</b>	The Long Beach Office
<b>D</b>	CTO72, Groundwater Investigations
<b>zzz</b>	Chronological number, starting with 201

For example, the EPA number "LD220" would represent the 20th sample collected for the Phase II radionuclide evaluation, a project managed by Earth Tech's Long Beach office. Quality control (QC) samples will be included in the chronological sequence. If a sample is lost during shipping, a replacement sample will be assigned a new EPA number. If different containers for the *same* sample are shipped to the laboratory on different days, a new EPA number must be assigned. All sample identification numbers will be recorded in field logs, records, and a database to ensure traceability of the sample to the designated location or site.

Table 3-3: Summary of Target Analytes, Holding Times, Preservation, Analytical Laboratories, and Sample Volumes

		U <sup>238</sup> :U <sup>235</sup> Ratio		Isotopic H, O tritium		U <sup>235</sup> , U <sup>236</sup> , U <sup>238</sup>		Ca, Mg, Na, SiO <sub>2</sub> , K		Cl <sup>-</sup> , SO <sub>4</sub> , Alkalinity		Gross α and β, Ra <sup>226</sup> , Ra <sup>228</sup>		Sr <sup>90</sup>		Am <sup>241</sup>			
Holding time		6 months		6 months		6 months		6 months		14 days		6 months		6 months		6 months			
Preservative		HNO <sub>3</sub> to pH<2 <sup>1</sup>		none		HNO <sub>3</sub> to pH<2 <sup>1</sup>		HNO <sub>3</sub> to pH<2		none		HNO <sub>3</sub> to pH<2		HNO <sub>3</sub> to pH<2		HNO <sub>3</sub> to pH<2			
EPA ID	Well ID	Vol	Lab	Vol	Lab	Vol	Lab	Vol	Lab	Vol	Lab	Vol	Lab	Vol	Lab	Vol	Lab	Extra Vol <sup>2</sup>	Total Vol
LD201	05 UGMW27	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD202	05 DBMW41	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD203	05NEW01	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD204	05NEW01 (Dup)	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD205	02 UGMW25	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD206	02NEW15	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD207	02NEW08A	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD208	02NEW02	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD209	02 DGMW60	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----	1	Par		----		5
LD210	03 DGMW64	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----	1	Par		----	1	6
LD211	03 DGMW64 (Dup)	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----	1	Par		----		5
LD212	04 UGMW63	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD213	04 DBMW40	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD214	17NEW02	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----	1	Par		5
LD215	17 DGMW82	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD216	24EX3OB1	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par	4	Par		----		----	4	12
LD217	24EX5OB2	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par	4	Par		----		----		8
LD218	24EX6OB1	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par	4	Par		----		----		8
LD219	09 DBMW45	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par	4	Par		----		----		8
LD220	09 DBMW45 (Dup)	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par	4	Par		----		----		8
LD221	18 DW135	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par	4	Par		----		----		8
LD222	18 BGMW12	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD223	01MW203	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD224	01MW201	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD225	01MW207	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par		----		----		----		4
LD226	18 BGMW101A	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par	4	Par		----		----		8
LD227	Field Blank	1	Geo	1	Geo	1	LLNL	0.5	Par	0.5	Par	4	Par	1	Par	1	Par		10
LD228	Field Blank					1	LLNL												1

Notes:

All volumes are in liters.

(Dup) field duplicate sample.

<sup>1</sup>preserved in clean-room conditions at the laboratory

<sup>2</sup>for laboratory quality control

Geo - GeoChron

LLNL - Lawrence Livermore National Laboratory

Par - Paragon Analytical

Samples will also be assigned an Earth Tech sample ID, which will be recorded in field logs and databases. A descriptive sample ID number will specify the location, sequence, matrix, and depth, as follows:

**#bb-ccdde-ffff**

Where,

**#** IRP Site number  
**bb** Well identification  
**cc** Sample type and matrix (see Table 3-4)  
**dd** Chronological sample number from a particular sampling location (e.g., 01, 02, 03)  
**e** Sample or QC identifier (see Table 3-5)  
**ffff** month and date of collection (for field blanks and equipment rinsates only)

**Table 3-4: Character Identifiers**

Identifier	Sample Type	Matrix
GW	Groundwater Well	Water
QW	Field QC	Water

**Table 3-5: QC Identifiers**

Identifier	QC Sample Type	Description
S	Normal Sample	All non-field QC Samples
D	Duplicate	Collocate (adjacent liners or locations)
E	Equipment Rinsate	Water
F	Field Blank	Water
X	Blind Spike	Performance evaluation sample

### 3.6 SAMPLE CUSTODY

Sample lids and caps will be covered with custody seals. All samples will be recorded on the chain of custody (COC) forms in accordance with CLEAN SOP 10, Sample Custody, Transfer and Shipment (BNI 1999). Samples to be analyzed by LLNL will be transferred to a representative from OCWD at the end of each day of fieldwork. Samples to be analyzed by GeoChron and Paragon laboratories will be shipped once per week on Thursday afternoons for Friday delivery.

Two copies of the COC forms will be placed in an adhesive plastic pouch and taped on the inside of each sample cooler. The coolers will then be sealed with waterproof tape and labeled. Coolers will also have custody seals placed on them to detect tampering.

Upon receipt, the laboratory will sign and retain copies of the COC. A list of analyses to be performed and a space to record sample condition upon receipt are located on the COC record. The laboratory representative will sign the COC form and record the temperature of the samples or cooler on the COC form and on the Sample Condition Upon Receipt form. All samples requiring preservative will be checked for proper preservation by measuring pH upon receipt. In the event of breakage or discrepancies between the COC form, sample labels, or requested analysis, the sample custodian will notify the laboratory project manager. A nonconformance report will be completed,

and the project chemist will be notified within 24 hours. At the time of notification, corrective action will be chosen. The sample custodian will enter the information into the laboratory system, and a log-in confirmation sheet will be sent to the project chemist within 48 hours. The laboratory will send the project chemist a written declaration of the samples in each sample delivery group.

**Hazardous Materials Shipment.** Hazardous materials, as defined by the Department of Transportation (DOT), are not expected in the course of this project. Although samples are being analyzed for radionuclides, there is no evidence that the samples will qualify as radioactive for the purposes of shipping and handling. The field team leader has been trained to recognize hazardous or dangerous goods and will notify the CTO manager of such issues prior to shipping.

### 3.7 EQUIPMENT DECONTAMINATION

All non-consumable equipment that comes into contact with potentially contaminated groundwater will be decontaminated in accordance with CLEAN SOP 11, Decontamination of Equipment (BNI 1999). Equipment will be decontaminated by steam cleaning or by a non-phosphate detergent scrub, followed by fresh water and distilled or deionized water rinses. Decontamination will take place on pallets or on plastic sheeting. Clean equipment will be stored on plastic sheeting in an uncontaminated area. Equipment stored for an extended period will also be covered by plastic sheeting.

All consumable equipment (e.g., gloves, disposable bailers) and liquid and solid wastes (e.g., purged groundwater, decontamination water, and soil cuttings) will be treated in accordance with the procedures prescribed in Section 3.8.

### 3.8 INVESTIGATION-DERIVED WASTE

Investigation Derived Waste (IDW) consists of all materials generated during this evaluation that may be contaminated with constituents of concern. It is anticipated that this field investigation will generate nonhazardous wastes, including but not limited to the following:

- Well development and purged groundwater
- Decontamination water
- Disposable personnel protection and sampling equipment

IDW will be properly classified, labeled, managed, and disposed in accordance with EPA guidance and CLEAN SOP 22, IDW Management (BNI 1999). If the IDW generated during sampling is determined to be regulated by the Resource Conservation and Recovery Act (RCRA), then RCRA storage, transportation, and disposal requirements may apply. In general, proper implementation of IDW procedures requires CTO managers, field managers, and their designees to perform the following tasks:

- Minimize IDW as it is generated
- Segregate IDW by matrix and source location
- Follow proper procedures for IDW drum handling and labeling
- Prepare an IDW drum inventory
- Update and report changes to the IDW drum inventory

**Decontamination Water and Purged Groundwater.** Non-disposable sampling equipment, and personal protective equipment (PPE) will be cleaned and decontaminated between each sample or activity location as appropriate in accordance with the procedures described in Section 3.7. Decontamination water will be collected in troughs, buckets, or a decontamination pit constructed on site. Collected decontamination water will be transferred daily to DOT-approved 55-gallon drums. Drums containing liquid IDW will be left with a headspace of 5 percent by volume to allow for expansion of the liquid and volatile contaminants. The drums will be labeled with the date and the well ID in accordance with CLEAN SOP 22, Investigation Derived Waste Management (BNI 1999). Drums containing IDW will be inventoried daily, stored on pallets at a designated staging area, and covered with tarps. Upon completion of field activities, a final inventory of the drums will be conducted to ensure that they are labeled correctly and that all drums are present.

**Disposable Sampling Equipment and PPE.** If, based on the professional judgment of the field manager, the PPE and disposable sampling equipment can be rendered nonhazardous after decontamination procedures, then this equipment will be collected in double plastic bags and disposed off site as municipal waste. Equipment that is potentially contaminated will be stored in drums, labeled, inventoried, and disposed of as hazardous waste. All waste materials generated in the support zone are considered non-IDW trash and will be properly disposed as municipal waste.

**IDW Disposal.** A disposal contractor will dispose all IDW within 90 calendar days of the completion of field work in accordance with the Station-wide IDW Management Plan (*Final Investigation Derived Waste Management Plan for Groundwater Monitoring*, CDM 1995). Should hazardous waste disposal be required, an activity-specific IDW disposal report documenting the screening sampling, chemical analysis, and disposal of the waste will be prepared.

### 3.9 QUALITY CONTROL AND CORRECTIVE ACTION

Project data quality will be assured through internal (field and laboratory) and external (second-party review and validation) processes designed to meet the DQOs. To ensure sample quality, only personnel trained in sampling techniques will collect samples. Standardized sample collection procedures will be followed. Field logs and notes will be reviewed by a second party in accordance with CLEAN SOP 17, Logbook Protocols (BNI 1999). Quality control samples such as field duplicates, field blanks, and equipment rinsate samples (if required) will be collected to ensure that field samples are representative.

**Field Duplicates.** Groundwater replicates will be collected at a frequency of one per ten field samples. Field duplicates or replicates will be evaluated qualitatively to assess the reproducibility of the sample collection procedures. The results of the analyses will be compared to laboratory criteria (Section 3.12) to assess whether the results reflect that the error inherent in the sampling procedures is within the expected analytical error.

If field duplicate data exceed the laboratory analytical error criteria, then further evaluation of sample collection procedures, laboratory sub-sampling procedures, analysis results, and other sample results will be conducted. The findings of the additional review will be included in the data quality assessment section of the report; these will include a discussion of the effect of the discrepancy on the ability to make decisions based on the data.

**Field Blanks.** A field blank will be submitted to measure potential contamination inherent in the measurement system, including the contribution of the sample containers. For the samples collected using ultra-trace techniques, a bottle blank containing clean water provided by the bottle vendor will be submitted as a sample. Analytes detected in field blanks will be compared to analytes found in

samples. The findings, along with a discussion of the effect of the discrepancy on the ability to make decisions based on the data, will be included in the data quality assessment section of the report.

**Equipment Rinsates.** It is anticipated that no reusable equipment will be exposed to the samples, and equipment rinsates will not be required.

### 3.10 INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES AND CONSUMABLES

Supplies and consumables are items necessary to support the sampling activities. Non-reusable items will be purchased or obtained new from vendors specializing in the particular requirements.

### 3.11 LABORATORY ANALYSIS

The primary purpose of this investigation is to resolve the issue of the isotopic ratio of uranium and to assess the presence of isotopic strontium. Data will also be collected to support the overall radiological analyte evaluation at the facility, and select wells will include standard screening measurements. Samples will also be collected for analytes that will support groundwater fingerprinting. The planned analyses are presented in Table 3-.

**Table 3-6: Planned Analyses and Method References**

Measurement	Method	Reference	Laboratory
Uranium <sup>235</sup> :Uranium <sup>238</sup> ratio	Thermal ionization mass spectrometry		GeoChron in partnership with the Massachusetts Institute of Technology
Uranium isotopes: U <sup>235</sup> , U <sup>236</sup> , and U <sup>238</sup>	ICPMS with isotope dilution		Lawrence Livermore National Laboratory
Strontium <sup>90</sup>	Gas flow proportional counting	ASTM D5811-95	Paragon Analytics
Gross Alpha	Gas flow proportional counting	EPA 900.0	Paragon Analytics
Gross Beta	Gas flow proportional counting	EPA 900.0	Paragon Analytics
Radium <sup>226</sup>	Co-precipitation/gas flow proportional counting	EPA 903.0	Paragon Analytics
Radium <sup>228</sup>	Co-precipitation/gas flow proportional counting	EPA 904.0	Paragon Analytics
Total uranium	Alpha spectroscopy	ASTM D3972-90M	Paragon Analytics
Americium <sup>241</sup>	Alpha spectroscopy	ASTM D3972-90M	Paragon Analytics
Hydrogen isotopes	Flow proportional counting		GeoChron
Tritium	Enrichment-gas proportional counting		GeoChron
Oxygen isotopes	Flow proportional counting		GeoChron
<b>General chemistry</b>			
Calcium, magnesium, sodium, potassium, silica	Inductively coupled plasma emission spectroscopy	SW6010	Paragon Analytics
Chloride, sulfate	Ion chromatography	WW300.0	Paragon Analytics
Alkalinity	Titration	WW310	Paragon Analytics

**Notes:**

U = uranium

EPA = Environmental Protection Agency

ICPMS = inductively coupled plasma mass spectrometry

ASTM = American Society for Testing and Materials

**Uranium by ICPMS.** The OCWD will contract with LLNL to analyze the samples for uranium, using isotope dilution inductively coupled plasma mass spectrometry (ICPMS). A known quantity of a non-target isotope will be added to the sample. The concentration of that isotope is used to determine the concentrations of the target isotopes. This method will allow for the simultaneous evaluation of isotope ratios based on the concentration of the individual isotopes ( $U^{238}$ ,  $U^{236}$ , and  $U^{235}$ ). The technology is similar to that used for high-resolution organics analysis (EPA 8290 for dioxins, EPA 1624 or 1625).

**Uranium Isotope Ratio by TIMS.** Earth Tech will submit the samples for uranium isotope ratios to a laboratory operated by the Massachusetts Institute of Technology for analysis by thermal ionization mass spectrometry (TIMS). This method evaluates the relative concentrations of the isotopes ( $U^{238}:U^{235}$ ) and does not quantify individual isotope concentrations. The uranium will be extracted by chemical separation and plated onto an electrode. The electrode will be placed in an evacuated chamber, and a filament will be heated to emit the masses that are then detected by the collectors.

Neither of these methods have a federal agency-approved reference. The technology is expensive and is only needed for sites where uranium at trace concentrations is of concern. Most sites where uranium is a contaminant of potential concern (COPC) have much greater concentrations (personal communication, John Griggs, EPA Air and Radiation Laboratory), and the drinking water analytical methods used in the previous investigation typically provide adequate precision and accuracy. Data quality evaluation will be achieved through the use of certified standards and detailed reporting of analytical methods and results.

**Stable Isotopes and Tritium.** In addition to evaluation of uranium and strontium, additional information about the groundwater will be obtained through the use of hydrogeological fingerprinting techniques. Stable isotopes of hydrogen and oxygen and tritium are found in various concentrations depending on the age and source of the water. Water recently introduced into the subsurface from rainfall has measurably different concentrations of these isotopes. The samples collected for uranium can also be measured for stable isotopes. Unfiltered aliquots of each sample will be submitted for stable isotopes and tritium.

Finally, common ions can also be used to support analysis of groundwater sources. The target analytes are presented in Table 3-7 as general chemistry parameters.

**Laboratory Handling.** All sample preparation and handling for analysis of the isotopic uranium will be performed in a clean-room environment. Reagents will include ultra-pure and triple-distilled chemicals. Each batch will include reagent blanks and the appropriate calibration standards. Conventional chemistry and radiochemistry parameters will be handled in accordance with the established field and laboratory procedures.

**Laboratory Qualifications.** Lawrence Livermore National Laboratory performs analysis for uranium isotopes in support of environmental restoration and CERCLA investigations at the Livermore NPL Site and Site 300. The quality of the measurements will be assessed against the quality control measurements incorporated into the analysis program presented in the OCWD planning document (OCWD 2000). Uranium<sup>236</sup> results presented by LLNL will be used by Earth Tech to support the results of the isotopic ratio measurements.

Geochron is a commercial laboratory specializing in isotopic measurements for carbon dating and geochronology. The laboratory is operated in association with the Massachusetts Institute of Technology, Department of Earth, Atmospheric and Planetary Sciences. As an academic research facility, the work done is "stand-alone" and the facility does not operate under a quality management system of a commercial laboratory. Each analysis will be supported by the quality control/assurance

measurements appropriate for the determinations to be performed. Earth Tech has developed a scope of work for Geochron to ensure that sufficient quality control and quality assurance measurements will be collected to adequately support the conclusions derived from the data. The planned quality control activities are detailed in Section 3.10 below.

Paragon Analytics, a Naval Facilities Engineering Service Center (NFESC)-evaluated laboratory, will perform strontium<sup>90</sup>, gross alpha and beta, radium, uranium by alpha spectroscopy, americium<sup>241</sup>, and general chemistry analyses. All work performed will be in accordance with the current *Navy Installation Restoration Chemical Data Quality Assurance Manual* (NFESC 1999).

### 3.12 LABORATORY QUALITY CONTROL

The laboratory performing the strontium, radium, gross alpha, gross beta, and general chemistry analyses is required to have an approved QA program, with current SOPs for each method performed. The laboratory quality assurance program must meet the requirements of the *Navy Installation Restoration Laboratory Quality Assurance Guide* (NFESC 1996).

The laboratory will perform the following quality control analyses in accordance with the cited methods:

- Method or reagent blanks
- Matrix spikes
- Duplicates or matrix spike duplicates
- Surrogates or tracers
- Blank spikes or laboratory control samples

The values shown in Table 3-7 will be used to validate the data and assess the acceptability for the project goals. Actual, laboratory-derived acceptance criteria will be used if they are narrower than those presented in Table 3-7, or if they are developed in accordance with the published method and represent realistic operational criteria.

**Table 3-7: Project Quality Control Criteria**

Analyte	Project Decision Threshold	Reporting Limit Required	Precision (RPD)	Accuracy (%R) <sup>a</sup>	
				MS/MSD	LCS
Uranium <sup>235</sup> :Uranium <sup>238</sup> ratio	<137.54, >138.22	NA	±0.25%	NA	NA
Uranium <sup>235</sup>	20 pCi/L <sup>b</sup>	1 pCi/L	±1%	NA	NA
Uranium <sup>236</sup>	0.1 pCi/L	0.1 pCi/L	±1%	NA	NA
Uranium <sup>238</sup>	20 pCi/L <sup>b</sup>	1 pCi/L	±1%	NA	NA
Tritium	1 TU (3.2 pCi/L)	1 TU (3.2 pCi/L)	±1‰	NA	±1‰
Hydrogen isotopes	NA	NA	±1‰	NA	±1‰
Oxygen isotopes	NA	NA	±0.2‰	NA	±0.2‰
<b>Radionuclides in Water (pCi/L) (EPA 600/4-80-032)(EPA 1980)</b>					
Gross alpha (EPA 900.0)	5	1	DER <sup>c</sup> : 1.42	NA	see note d
Gross beta (EPA 900.0)	50	10	1.42	NA	see note d
Strontium <sup>90</sup> (ASTM D5811-95)	1.0	1.0	1.42	NA	see note d
Total Uranium (ASTM D-3972)	0.5	0.5	1.42	NA	see note d
Americium <sup>241</sup> (ASTM D-3972)	0.1	0.1	1.42	NA	see note d
Radium <sup>226</sup> (EPA 903.1)	5 <sup>e</sup>	1	1.42	NA	see note d
Radium <sup>228</sup> (EPA 904.0)	5 <sup>e</sup>	1	1.42	NA	see note d

Table 3-7: Project Quality Control Criteria

Analyte	Project Decision Threshold	Reporting Limit Required	Precision (RPD)	Accuracy (%R) <sup>a</sup>	
				MS/MSD	LCS
<b>General chemistry (mg/L)</b>					
Calcium	NA	1	20%	80-120	85-115
Magnesium	NA	1	20%	80-120	85-115
Sodium	NA	1	20%	80-120	85-115
Potassium	NA	1	20%	80-120	85-115
Chloride	NA	1	20%	75-115	90-110
Sulfate	NA	1	20%	85-115	90-110
Alkalinity	NA	10	20%	NA	NA
Silica (as silicon)	NA	1	20%	80-120	85-115

**Notes:**

- % R = percent recovery
- RPD = relative percentage of difference
- MS = matrix spike
- MSD = matrix spike duplicate
- LCS = laboratory control sample
- NA = not applicable
- pCi/L = picoCuries per liter
- TU = tritium units
- ‰ = parts per thousand or per mil
- EPA = Environmental Protection Agency
- DER = duplicate error ratio
- ASTM = American Society for Testing and Materials
- mg/L = milligrams per liter

<sup>a</sup> Method requires laboratory to establish criteria based on method performance. Actual project criteria will be modified with selection of laboratory subcontractor.

<sup>b</sup> MCL for total Uranium = 20 pCi/L

<sup>c</sup> DER: Duplicate Error Ratio is used in lieu of RPDs for radionuclides.

<sup>d</sup> Method performance criteria dependent upon interlaboratory sample analyzed.

<sup>e</sup> MCL for Radium<sup>226</sup> + Radium<sup>228</sup> = 5 pCi/L

**Method Blanks.** A method blank will be analyzed with every batch of 20 or fewer samples to measure laboratory contamination. The method blank will be an analyte-free matrix that will be carried through the entire preparation and analysis procedure. If any analytes are found above detection limits, the results of samples in the batch will be examined. Those with concentrations less than the reporting limit or greater than 10 times the value of the method blank will be accepted. Other samples will be reanalyzed in another batch. Consistent presence of contamination will require investigation and correction.

**Laboratory Control Samples.** A laboratory control sample (LCS) will be analyzed with every batch of 20 samples or less to measure accuracy. The LCS will consist of a method blank spiked with a known amount of analyte that will be carried through the entire preparation and analysis procedure. The LCS source will be different from that used to prepare calibration standards. Analytes used for the LCS will comply with the method requirements. Control charts may be used, and control limits will be calculated based upon historical data. When control limits are exceeded, the analysis will be stopped, and the problem corrected. Samples associated with the out-of-control LCS will be reanalyzed in another batch, unless documented evidence is presented to show that associated samples were not affected. Guidance limits for the LCS listed in Table 3-7 will be used unless more restrictive laboratory-specific limits are established.

**Matrix Spikes.** Conventional methods will utilize matrix spikes in accordance with the method. Matrix spike measurements are not performed for the isotopic uranium ratios, isotope dilution methods, other radioisotopes, or stable isotope procedures. A matrix spike (MS) will be analyzed for

at least one out of every 20 samples to measure matrix effects on accuracy. The MS will consist of additional aliquots of sample spiked with a known amount of analyte. Compounds to be spiked will be in accordance with the laboratory SOP or the published method. Guidance limits for the MS listed in Table 3-7 will be used unless more restrictive laboratory-specific limits are established. If the analyte concentration in the sample is greater than twice the amount of spike added, the spike will be considered invalid and the recovery will not be calculated. If a valid spike recovery exceeds acceptance limits but the LCS is in control, matrix interference is indicated.

**Matrix Spike Duplicates.** A duplicate or a matrix spike duplicate (MSD) will be analyzed at a frequency of at least one out of every 20 samples to measure precision. For any batch of samples that does not contain a duplicate or MSD (i.e., when insufficient sample is available), two LCSs may be used. However, every effort will be made to provide sufficient sample for laboratory QC. If the relative percentage of difference (RPD) does not meet the established acceptance limits, the problem will be investigated and corrected. Any affected samples will be reanalyzed in a separate batch. Acceptance limits for duplicates/MSDs listed in Table 3-7 will be used unless more restrictive laboratory-specific limits are established.

For radiochemical measurements, values less than 10 times the uncertainty ( $\sigma$ ) will be compared by evaluating the duplicate error ratio (DER). The DER is calculated as follows:

$$DER = \frac{|S - D|}{3 \times \sqrt{\sigma^2_s + \sigma^2_D}}$$

where:

$S$  = sample concentration

$D$  = duplicate concentration

$\sigma$  = counting uncertainty

The counting uncertainty in radiochemical measurements is a statistical calculation based on the time, background, and number of disintegrations counted during the sample analysis and is equivalent to two standard deviations above and below the count.

The DER is presented in Table 3-7. If values exceed 10 times the uncertainty, the RPD will be calculated, and if it exceeds 20 percent of the RPD, further evaluation of sampling or measurement error will be performed.

**Calibration and Preventive Maintenance.** The laboratory is required to document calibration procedures in accordance with NFESC guidance (NFESC 1996). Calibration procedures will be consistent with specified method requirements. The laboratory will perform preventive maintenance on instruments used to analyze project samples, and will keep records of all such maintenance. Preventive maintenance documentation is incorporated into laboratory certification requirements and is an element of the subcontractor laboratory quality assurance plan, which will be reviewed and approved prior to selection as a CLEAN II subcontractor laboratory.

### 3.13 PROJECT QUALITY ASSURANCE CRITERIA

Laboratory data quality strategies and criteria were developed in accordance with the project DQOs and the following references:

- *Navy Installation and Restoration Chemical Data Quality Manual (IR CDQM)* (NFESC 1999)
- *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods (SW846)* (EPA 1997b)
- *Laboratory Data Validation Functional Guidelines for Evaluating Organics Analysis* (EPA 1994b)
- *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analysis* (EPA 1994c)

### 3.14 DATA CALCULATION AND REPORTING UNITS

Calculation of results is documented in the laboratory SOPs and is required to be consistent with the referenced, published method. Reporting units will be consistent with and comparable to applicable regulatory and decision thresholds.

Tritium will be reported by the laboratory as tritium units (TU). Regulatory thresholds for tritium are expressed as pCi/L. The relationship between TU and pCi/L is: 1 TU = 3.2 pCi/L. Data reported will be in TU, and the data evaluation will note the concentration in pCi/L when comparing to regulatory thresholds.

### 3.15 DOCUMENTATION AND DELIVERABLES

**Field Documentation.** Records will be kept in accordance with CLEAN SOP 17, Logbook Protocols (BNI 1999). A bound field notebook with consecutively numbered, water-repellent pages will be maintained. The logbook will be clearly identified with the name of the activity, the person assigned responsibility for maintenance of the logbook, and the beginning and ending dates of the entries. Data forms, with predetermined formats for logging field data, will be incorporated into the logbook. This logbook will serve as the primary record of field activities. Logbooks will allow a reviewer to reconstruct applicable events by having entries made in chronological order and in sufficient detail. The logbook will be maintained in a clean area and used only when outer gloves have been removed. Entries on the data forms and in the logbook will meet the same requirements. Entries will be made in indelible ink. Information recorded in the logbook will include the following:

- The logbook will reference data maintained in other logs.
- Corrections to entry records will be made by drawing a single line through the incorrect entry, initialing, and dating the change. An explanation is to be included if more than a simple mistake is made.
- Entries will be signed or initialed at the end of each day by the individual making the entry.
- Page numbers will be entered on each logbook page.
- The preparer will photocopy completed pages weekly. The field manager will conduct a technical review of the logbook.

**Laboratory Documentation.** The laboratories providing isotopic uranium results will provide data packages that will enable a knowledgeable reviewer to replicate all calculations and results. Due to the research focus of the laboratory, the documentation will be custom-prepared for this project.

Earth Tech project staff will review the work product and, if necessary, recommend changes that will enable reviewers to evaluate the results in accordance with standards required for the project.

The laboratory providing conventional analysis will provide Level IV data packages for all results as required to perform validation in accordance with EPA guidance for data review (EPA 1994b, EPA 1994c). The packages will include a case summary, report forms, QC sample analysis results, acceptance criteria, calculations, chromatograms, and applicable bench logs and preparation notes. The laboratory will also provide data deliverables in a specified electronic format compatible with the project database, developed in compliance with the NEDTS. All laboratory deliverables will be submitted within 45 calendar days of receipt of samples.

### **3.16 DATA QUALITY ASSESSMENT**

The scope and requirements of the project include a comprehensive evaluation of field and laboratory data quality. This will be conducted in general accordance with *EPA Region IX RCRA Corrective Action Program Data Review Guidance Manual* (EPA 1997c). Evaluation of the analytical data will include an assessment of each of the precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters. This is achieved by reviewing particular types of QC sample results against preestablished acceptance limits.

#### **3.16.1 Precision**

Overall precision will be measured through analysis of field duplicates, collocates, and replicates. Laboratory analytical precision will be assessed through analysis of laboratory duplicates and MS/MSDs. Precision goals for the appropriate compounds are summarized in Table 3-7.

#### **3.16.2 Accuracy**

All field and analytical equipment and instrumentation will meet proper calibration and maintenance criteria. Accuracy will be monitored by the use of trip blank, field blank, laboratory blank spike, laboratory MS/MSD, certified reference materials, and performance evaluation samples. The accuracy goals for the appropriate compounds are summarized in Table 3-7.

#### **3.16.3 Representativeness**

Representativeness will be assured through appropriate sampling procedures, selection of analytical methods, sample identification, and COC documentation. The representativeness will be evaluated qualitatively by second-party review of field and laboratory procedures and documentation. Care will be taken to collect samples, which represent the conditions to be measured.

Laboratory contaminants will be evaluated in accordance with EPA data validation guidance (EPA 1994b, EPA 1994c) and qualified accordingly. Analytes characterized as probable laboratory contaminants will be removed from the data set and not evaluated further unless other evidence suggests that these analytes should be considered contaminants of concern.

#### **3.16.4 Comparability**

Lawrence Livermore National Laboratory has demonstrated the comparability of the two analytical methods in studies on samples from sites they investigate. The ICPMS method is more efficient; the TIMS method slightly more precise.

To help ensure comparability of results and correct for instrument and method bias, both laboratories will analyze certified National Institute of Standards and Technology (NIST) standard materials with the analytical batches. All quantitative analyses will include laboratory method blanks to assess

background or laboratory measurement contributions. Due to the nature of the materials and the regulatory restrictions on obtaining isotopes, field-supplied performance evaluation samples will not be practical.

Laboratory data packages will include all documentation of procedures, sample handling, preparation, analysis, and data calculations. The data packages will enable a knowledgeable reviewer to evaluate the results for accuracy and correctness.

### **3.16.5 Completeness**

Completeness will be assessed in terms of the percent of valid analytical results that are produced and will be based on the data validator's findings. The completeness objective goal for the project program is 100 percent. It should be noted that a "valid result" will not necessarily imply that 100 percent of the QC results are within an acceptable range. A result can be reported with qualifiers and still be considered valid. Rejected data (flagged with an "R" by data validators) are unusable, and the objective for this project is to have zero unusable results. Individual or single laboratory quality control measurements may fail due to matrix effects and statistical outliers, but these do not normally lead to rejected data. Holding times, field QC samples, and laboratory QC checks will all be taken into account when assessing completeness. If the completeness goal is not achieved, the effect on the recommendations and conclusions will be discussed in the report.

## **3.17 DATA MANAGEMENT**

The laboratories will verify, reduce, and report data as specified in their laboratory quality assurance plan and in accordance with the laboratory statement of work (SOW). Deliverables will be required within 45 calendar days of sample receipt. The format for both hard copies and electronic data deliverables (EDDs) is specified in the SOW. Hard copy data from conventional laboratory subcontractors will be delivered on Contract Laboratory Program (CLP)-like forms, along with a case narrative, table of contents, and raw data for Level D QC deliverables. Earth Tech personnel will manage, reduce, and report data as described below.

### **3.17.1 Receipt of Deliverables**

Hard copy laboratory reports will be received and reviewed for completeness and compliance with the laboratory SOW. The project chemist will immediately review the case narrative and report to project management any issues that may effect the project conclusions or schedule. The project chemist will also ensure that appropriate copies are provided to technical staff, data validation personnel, and project managers.

EDDs for conventional analyses will be received on 3.5-inch computer diskettes or through electronic mail in the format specified in the analytical laboratory SOW. Electronic Data Deliverables will be loaded into a database management system and checked for completeness and errors. Part of this check involves verifying that all requested analyses for each sample were performed and reported, which may be accomplished by comparing the delivered results to those recorded electronically. If errors are encountered or data are incomplete, the laboratory will be notified and data will be resubmitted. If only minor errors or omissions are encountered, data management personnel will manually correct the data, but the laboratory will be notified so that it will be aware of problems for future projects. Once in the database, the records will be made accessible to project personnel.

The electronic data versus hard copy data will be manually verified for the entire project. Final data tables will be compared to the database to verify the output.

Computer files will be backed up daily to avoid losing information. Hard copy data will be stored in secure areas, while electronic data will be stored in password-protected files, with read-only access to users who do not have authorization to edit the data. The data will be stored for 10 years after the close of the CLEAN contract.

### 3.17.2 Data Validation

Review (validation) of laboratory deliverables will be performed to assess method compliance, calibration frequency and acceptability, QC frequency and acceptability, and data usability. Validation will be performed by an independent third-party subcontractor on conventional analytical methods and will be in accordance with EPA guidance documents (EPA 1994b, EPA 1994c). Reports by the special analysis subcontractors will be evaluated by project staff for compliance with the scope of work. Copies will be made available to reviewers upon request. Qualifiers indicating usability of the data will be attached to each result.

Data may be assigned the following qualifiers:

- J = estimated concentration
- N = presumptive evidence of the identification of an analyte
- R = rejected data (unusable)
- U = not detected (e.g., not present because of blank contamination)

Combinations of qualifiers such as UJ and NJ are also possible.

Data validation will be summarized in the data evaluation section of the report, and the effect of the validation qualifiers on the conclusions of the report will be presented.

### 3.17.3 Data Reduction

Data reduction will consist of developing presentations of results and conclusions. Additional evaluation may be required, depending on the findings of the sampling events.

Data validation reports will be summarized as needed. This summary will focus on changes to the data, especially rejected data, violations of protocol, recurring problems, changes in values, and data qualified as not detected because of blank contamination. A summary of the reasons for any changes will be included.

### 3.17.4 Data Reporting

Laboratory sample data and QA/QC data will be included in both the hard copy and EDD packages as specified in the subcontractor's scope of work. Complete data tables will be included in the report for this project, typically as an appendix. Reduced data will be presented in the main portion of each report. Reduced data may include summary data tables, figures showing significant contaminant concentrations or detections only, and text to supplement the tables and figures. The text generally will not present information included in summary data tables or figures, except to emphasize important results, patterns, or trends. Report text will focus on temporal trends, spatial patterns, and the relation of detected analytes to waste sources.

In addition to data validation, a summary of the data relative to the DQOs will be provided. A photocopy of field logs may be included as an appendix in the report. Finally, a summary of the results of laboratory and field system and performance audits described in Section 3.18 will be included in the final project files and summarized in the project reports.

### **3.18 AUDITS AND CORRECTIVE ACTIONS**

System and performance audits are a fundamental element of the QA process and are the tools used to demonstrate compliance with data quality requirements.

Overall responsibility for implementation and monitoring of the Earth Tech QA Program resides with the CLEAN II program quality manager. The CLEAN II program quality manager and the CTO manager will be responsible for reviewing the technical contents of all submittals required under this project. All work will be subjected to peer review in accordance with CLEAN Program procedures.

#### **3.18.1 Field Audits**

The program quality manager or a designated substitute may perform field audits of sample and data collection activities to ensure that specifications and standards are implemented and being performed. Such audits will be documented in memorandum to the program quality manager and program manager. Any findings that affect the quality of the data collected will require immediate corrective action to ensure that the quality of the project is not compromised.

#### **3.18.2 Laboratory Performance Review**

Continual laboratory performance reviews will be performed for the project. These will consist of the following tasks:

- Internal laboratory oversight by laboratory QA manager
- Frequent progress reports and discussions between the project chemist and the laboratory project manager
- Project chemist oversight of deliverables and reports
- Desktop evaluation of reports and data packages
- Data validation

#### **3.18.3 Corrective Actions**

Corrective action requests will be issued and tracked by the analytical laboratory coordinator when deficiencies or noncompliance are noted. These findings will be resolved in a timely manner, typically less than 30 days. Findings that affect the collection or interpretation of project data will be noted in the technical report.

#### **3.18.4 Reports to Management**

The CLEAN II program quality manager may request that a specific quality assurance report be prepared, based on results of audits and potential corrective actions. If required, the quality assurance report will contain a discussion of the current status of the project, including the results of performance and system audits, results of data quality assessments, QA problems, and methods to resolve these problems.

#### 4. DATA EVALUATION

Results of the planned analyses will be evaluated to resolve the decision rules presented in Section 2.1.5. If the data collected are consistent with the current understanding of the site and the conditions expected to be found, the decision rules will be resolved based on the data.

**Decision Rule #1.** If the ratio of the mass of  $U^{238}$  to  $U^{235}$  is equal to  $137.88 \pm 0.34$ , **then** the uranium is naturally occurring. The variability expected in the measurements is based on laboratory experience with the methods. The actual variability (plus or minus values) will be calculated from laboratory replicates for the two analytical methods (TIMS & ICPMS).

If the isotopic ratio measured in the groundwater falls outside the expected range, the laboratory data will be reviewed to assess whether the *predicted* variability of  $\pm 0.34$  is consistent with the measurements collected. Laboratory and field duplicate measurements will be used to calculate the actual measurement variability that is applicable to this sampling event. If the results of these measurements exceed the actual range of the expected finding, an investigation into the apparent source of the anthropogenic uranium will be required.

**Decision Rule #2.** If  $U^{236}$  is present, **then** anthropogenic uranium is present. The absence of  $U^{236}$  will support the conclusion that the uranium present is naturally occurring. As presented in the LLNL/OCWD work plan, there is only one known source of naturally occurring  $U^{236}$ , a natural reactor in a region of Africa. Such conditions are not found at El Toro.

**Decision Rule #3.** If americium<sup>241</sup> is detected, **then** an anthropogenic source is present at monitoring well 17NEW02, and further investigation will be recommended.

**Decision Rule #4.** If strontium<sup>90</sup> is detected, **then** an anthropogenic source of beta activity is present. Strontium<sup>90</sup> is an artificial (non-natural) beta-emitting isotope. If the analyte is not detected, it would support the conclusion that gross beta emissions are naturally occurring.

**Decision Rule #5.** If strontium<sup>90</sup> is detected above the California MCL of 8 pCi/L, **then** further evaluation of the extent will be performed and a response action will be developed.

**Decision Rule #6.** If gross alpha exceeds 15 pCi/L, **then** additional evaluation of the source of the emissions will be presented. Gross alpha emissions may be accounted for by measurements for radium and uranium. If the radium and uranium account for the alpha activity, no further assessment will be required.

**Decision Rule #7.** If gross beta exceeds 50 pCi/L, **then** additional evaluation of the source of the emissions other than strontium<sup>90</sup> will be presented.

**Decision Rule #8.** If the tritium activity is less than 1TU (3.2 pCi/L), **then** the water is more than 30 years old.

**Decision Rule #9.** If the oxygen and hydrogen isotope values diverge from the local meteoric water line and are consistent with the isotope signature of the regional deep groundwater, **then** the groundwater in the samples did not originate from the groundsurface onsite through infiltration/percolation, and it is probably from a deep groundwater source.

**Decision Rule #10.** If the water shows little equilibration with minerals from the site geologic strata, **then** the water will be interpreted as being out of equilibrium with the system and very recently recharged.

## 5. REFERENCES

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**Response to Comments from  
EPA, DTSC and RAB Members on  
the Draft Technical Memorandum  
Evaluation of Radionuclides in Groundwater  
at Former Landfill Sites and The EOD Range**

Draft Technical Memorandum  
 Evaluation of Radionuclides in Groundwater  
 Reviewer: Ms. Deidre Dement, California Department of Health Services  
 20 April 2000

Comment No.	Section No.	Comment	Response
		<p>General Comments</p> <p>It appears from the analysis and use of uranium isotopic ratios that the groundwater is being analyzed for the presence of depleted and/or enriched uranium. Please clarify from the Jacobs 1993 report whether depleted or enriched uranium were named or suggested in the unsubstantiated reports that low-level radioactive material may have been used in training exercises. Also, please verify that the explosive ordnance disposal (EOD) range is the only area named or suggested where uranium materials may have been used or disposed.</p> <p>As with radium-226 (Ra-226), DHS thinks it unlikely that any unnatural variations of uranium would be found in groundwater at this time, even if it were embedded or buried in the ground, because of distance from the surface to the groundwater. If the Navy knows of a pathway to the groundwater other than by slow migration through the soil, please make this known. The data with the additions and changes noted in the Specific Comments below may be useful in the future to show if any migration of contamination occurs over time.</p>	<p>The specific use or disposal of uranium at the EOD range has never been reported or suggested, nor has the disposal of uranium in any of the landfills. Prior work has reported gross alpha measurements greater than the MCL for drinking water at the former landfill sites. The groundwater samples were analyzed for isotopic uranium in order to characterize the gross alpha measurements and confirm the presence and origin of the uranium as naturally occurring and the source of the alpha emissions. The Navy agrees with DHS's assertion that, even in the unlikely event that uranium was buried in the ground, it would not have migrated to groundwater. In addition, there is no pathway to groundwater other than transport through the soil.</p>
1	Section 2.2.1	<p>Specific Comments</p> <p>Page 2-1. It is unclear, as it was noted in earlier DHS' comments dated August 19, 1998, why gamma spectroscopy results are only being reported for one isotope (i.e., a pure beta emitter, strontium-90 (Sr-90)) and in this round of results for only one sample. There is no method shown for this one analysis. Please provide the method used. The method of analysis reported as used for the analysis of Cs-134 from the APCL Analytical Report dated 12/18/97, is EPA method 901.1 which is the Standard Method for analysis of gamma emitting radionuclides in drinking water. If this was the method used, DHS wonders why other gamma emitters were not reported. For example, potassium-40 (K-40)</p>	<p>The Sr-90 was erroneously reported as a gamma spectroscopy analyte. The gamma spectroscopy method (EPA Method 901.1) included the analysis of other gamma emitting radionuclides; however, none were detected. A complete set of analytes and detection limits will be provided in the Final Technical Memorandum.</p> <p>No elevated levels of beta emissions were detected. In fact, the highest gross beta result was 23.2 pCi/L at 02_DGMW60, a value less than half of the MCL of 50 pCi/L. Although beta emissions are not a concern for the</p>

Draft Technical Memorandum  
 Evaluation of Radionuclides in Groundwater  
 Reviewer: Ms. Deidre Dement, California Department of Health Services  
 20 April 2000

Comment No.	Section No.	Comment	Response
		is a naturally occurring beta/gamma emitter, is easy to detect with this method, and could account for elevated betas found during the gross beta analysis. This analytical method is applicable for analyzing water samples that contain radionuclides emitting gamma photons with energies ranging from 60 to 2000 kev (i.e., K-40, cesium-137, cobalt-60, radium-228, uranium and thorium daughters, etc.). This method detects a multitude of radioisotopes, and it requires no further processing or analysis to obtain a wide range of data relatively inexpensively. The only additional expense to the laboratory, which is most likely set up for these analyses, is to validate the results and report them and the lower limits of detection along with the analytical results you have already requested. Most radiological laboratories using this method are unable to detect pure beta emitters using gamma analysis.	groundwater at MCAS El Toro, the sample from 02_DGMW60 was analyzed by gamma spectroscopy in order to identify the beta emitting isotopes.
2	Section 3	Page 3-1, Analytical Results: Please verify that the reported uncertainty (+) values shown are 2 sigma uncertainties and specify whether or not they include only counting uncertainties or total uncertainty.	The uncertainties reported are the estimated total propagated uncertainties ( $2\sigma$ ), calculated from the uncertainty associated with both the sample counting and the background counting and represents the 95% confidence interval, as is standard with radiochemistry reporting.
3	Section 3.3	Page 3-1: See Specific Comment 5 regarding "adjusted gross values."	Please refer to the response to Specific Comment 5.
4	Section 3.4	Page 3-1: See Specific Comment 1 regarding gamma analysis. Please specify the methods used for the Sr-90 analysis.	Please refer to the response to Specific Comment 1.
5		Table 3-1 and Figure 3-1, Pages 3-3 and 3-4: DHS does not agree with the numbers assigned as "Adjusted Gross Alpha" values. The numbers derived from the "total uranium" results subtracted from the "gross alpha" results do not take into account the errors associated with each of the uranium results used to derive the total uranium or the errors associated with each of the gross alpha results. If the uranium results	The purpose of calculating adjusted gross alpha values is to indicate the contribution of uranium to total alpha emissions. The resultant adjusted gross alpha value for samples with gross alpha values within the range of total uranium values clearly illustrate the significant contribution of uranium to the gross alpha emissions.

Draft Technical Memorandum  
 Evaluation of Radionuclides in Groundwater  
 Reviewer: Ms. Deidre Dement, California Department of Health Services  
 20 April 2000

Comment No.	Section No.	Comment	Response
		<p>were to include the errors for each value, then the total uranium values would also include an associated error, showing the range of values this number represents. Please verify that the <math>\pm</math> values shown in the tables represent the 2 sigma errors (<math>2\sigma</math>), if not they should be changed to the <math>2\sigma</math> values and these numbers may then be used to calculate the errors to be reported with the total uranium values. For example at Well Number 02_DGMW60-GW01S, if the errors shown with the pCi/L results for analysis of U-234, U-235, and U-238 are <math>2\sigma</math> errors, then the respective values of <math>25 \pm 3.1</math>, <math>1.32 \pm 0.29</math>, and <math>19.5 \pm 2.5</math> would total <math>45.82 \pm 3.99</math>. This total uranium value compares well with the gross alpha value of <math>50 \pm 7.1</math> (i.e., the total uranium value ranges from 41.83 to 49.81 pCi/L which overlaps the gross alpha range of 42.9 to 57.1 pCi/L). Please recalculate the total uranium values and do not report an adjusted gross alpha for gross alpha values that fall within the range of the total uranium values. The data appear to indicate that gross alpha values are related to total uranium results. It might be useful to show a scatter plot of gross alpha results versus total uranium results.</p>	<p>Although in theory, total uranium values should not exceed gross alpha values, inherent detection errors sometimes result in negative adjusted gross alpha values in samples where all or the vast majority of the gross alpha emissions result from uranium. In addition, the calculation of adjusted gross alpha is a component of the DHS decision strategy discussed in Section 4.2.</p> <p>A scatter plot will be included in the Final Technical Memorandum.</p>
6	Section 4	<p>Pages 4-1 and 4-2, and Table 4-1: As in the case above, the <math>2\sigma</math> uncertainties for each analytical result should be included for each isotope and used to propagate the uncertainties for each of the ratios reported.</p>	<p>The uncertainties for each measurement are presented in the data table 3-1. The calculation of the uncertainty associated with the ratios would not necessarily add to the interpretation, as the uncertainty represents the 95% confidence interval of each measurement, an inherently wide range</p>
7	Section 4.2	<p>Page 4-3: It should be clarified that the "no further analysis" label was meant to apply to individual samples going through the screening process not to designate a sampling location as requiring no further sampling and/or analysis. Samples taken from the same well may have varying results, and contaminant levels change over time which is why many drinking water wells are routinely monitored within the State of California to ensure that they meet drinking water requirements.</p>	<p>The text in section 4.2 specifically references the DHS analysis strategy for radionuclides which is presented in Section 2.2. The term "no further analyses" is referenced directly and does not imply site or location status. However, the term "no further analyses" will be modified to "no further analyses required on sample".</p>

Draft Technical Memorandum  
 Evaluation of Radionuclides in Groundwater  
 Reviewer: Ms. Deidre Dement, California Department of Health Services  
 20 April 2000

Comment No.	Section No.	Comment	Response
8	Section 5	Page 5-1: See the Specific Comment 7 above regarding "no further analysis".	Please refer to the response to Specific Comment 7.
9		Appendix A, Pages 1-7: To make this data meaningful, as noted in the comments above and in DHS' comments dated April 30, 1998, all results for radioanalysis should specify how the error or uncertainty was determined. These are usually shown next to the value as $\pm 2\sigma$ pCi/L. Without this information, you cannot know what the quality of the data is, or whether the data ranges overlap.	Available error estimates for previous data will be included in Appendix A.

Draft Technical Memorandum  
 Evaluation of Radionuclides in Groundwater at Former Landfill Sites and the EOD Range  
 Reviewer: Steve Dean - USEPA Region IX

Comment No.	Comment	Response
	<p>General Comment</p> <p>The data provided in this memorandum demonstrates that the probability of radium-226 contamination or depleted uranium contamination in MCAS-ET groundwater is unlikely. However, some of the logic used to make the case for this conclusion is flawed and needs rethinking.</p>	<p>The objective of the study was to ascertain whether the elevated gross alpha and beta were due to anthropogenic sources. The isotopic ratio approach used to evaluate whether there are manmade sources is consistent with the current state of practice. Responses to specific comments will help clarify the investigation approach and address any flaws in the conclusions derived.</p>
1	<p>Page 2-1, Section 2.2.1: Using gamma spectroscopy for strontium-90 analysis is inappropriate. Neither strontium-90 nor its daughter, yttrium-90, emit gamma rays therefore gamma spectroscopy cannot detect the presence of strontium-90. The appropriate method is EPA 905.0 from ?Prescribed Procedures for Measurement of Radioactivity in Drinking Water? (EPA-600/40-80-032, August 1980</p>	<p>The conclusions regarding Sr<sup>90</sup> will be withdrawn. The purpose of the gamma spectroscopy was to attempt to characterize the emissions in the sample with the highest gross beta result, consistent with the procedures for assessment of drinking water. The conclusion was mistakenly applied to Sr<sup>90</sup> instead of Sr<sup>85</sup>, which is a gamma emitter and was reported</p>
2	<p>Page 2-3, Section 2.2.2, Criterion c): Lead-210 reaches secular equilibrium with radium-226 in less than 100 years. It does not take "millions of years" as this document states.</p>	<p>Lead-210, if derived from Ra-226, while not taking millions of years, would take several hundred years to achieve secular equilibrium and this time period would exceed the history of the base operations. However, since insufficient radium or lead were detected, no conclusion was drawn from these determinations.</p>
3	<p>Page 2-6: The back side of the CaDHS flow chart is blank. It this page 2-6 and was it intentionally left blank?</p>	<p>The referenced page represents page 2-6 and was intentionally left blank.</p>
4	<p>Page 2-7, Item d): There is a serious problem when using gross alpha to determine isotope specific alpha contaminants. Gross alpha is a screening tool for drinking water and is not an ideal method for use on groundwater where Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) can create interferences in gross alpha results. Since radium 226 is a potential contaminant of concern in the MCAS-ET landfills it should be characterized in all the samples regardless of the "adjusted gross alpha activity" or activities of other radionuclides present.</p>	<p>This discussion was only intended to reflect the California DHS procedure for assessing radioactivity in drinking water and provide a historical basis for the current efforts. Prior work identified gross alpha in excess of the State drinking water criteria and the presumption has been that the source is anthropogenic. The current efforts are to characterize the site with respect to the sources of the gross alpha results and attempt to differentiate between naturally occurring and anthropogenic radioisotopes.</p> <p>Consistent with previous comments and requests, all the samples in this study were analyzed for Ra-226</p>

Draft Technical Memorandum  
 Evaluation of Radionuclides in Groundwater at Former Landfill Sites and the EOD Range  
 Reviewer: Steve Dean - USEPA Region IX

Comment No.	Comment	Response
5	<p>Page 3-3, Table 3-1, Samples 2, 3, and 4: The proportions of U235 to total uranium for these three samples are just at twice the expected value. The reported values for U235 in three samples are well below Superfund's Preliminary Remediation Goal (PRG) of 1.0 picoCurie per liter for U235 in drinking water. However, several members of the public have expressed concern that this may be evidence of enriched uranium present in the EOD landfill. While that is unlikely, this document does not provide enough data to adequately discount this possibility. There are other possible explanations for the higher than expected U235 ratio. The mostly likely is that overlapping of U234 peaks which caused smearing of the U235 peaks in the alpha spectra resulting in overestimation of the U235. Dr. John Griggs of EPA's National Air and Radiation Environmental Laboratory (NAREL) recommends that these samples be reanalyzed using less mass carrier to yield sharper peak resolution if these samples are still available. If these samples are not still available then he recommends resampling and reanalyzing for U235. Dr. Griggs is willing to discuss this issue with the Navy and its contractor if they wish to do so. He can be reached at (334) 270-3450. Other sources of inference may be from radium 226 or bismuth 210m. Both emit alpha particles at energies very close to the two alphas of highest abundance emitted by U235. Either or both of these radionuclides may have been present in sufficient quantities to interfere with the U235 results</p>	<p>We concur, the relatively high ratios are an artifact of the analysis.</p> <p>The apparent discrepancy in the isotopic proportions was evaluated by inspecting the laboratory records for the analysis. The apparent enrichment is an artifact of the analytical method. The measurement technique relies on the separation of decay energies among the four uranium isotopes (three target analytes and a tracer) analyzed. There is only a small separation between decay energy range of the U235 and U234 isotopes, as shown in the accompanying plot. An affect, called alpha spectral tailing, matrix effects and probably in this case, instrument operating parameters, can attribute decay energy of U234 to U235. Since the relative quantity of U235 to U238 is small, even a slight overestimation of the U235 can appear to suggest the presence of enriched uranium. Support for this explanation is found in examining the apparent isotopic ratio of the Laboratory Control Standards (LCS) specific to each sample batch. (The LCS is prepared from certified material obtained from the National Institute of Standards and is made from natural uranium.). For the Site 1 (EOD Range) sample run, the LCSs exhibit isotopic ratios of 1.21% and 1.39% U235, very close to the ratios shown by the samples analyzed at the same time and with the same instrument. In addition, the performance evaluation sample analysis yielded a ratio of 1.52 % U235.</p> <p>In addition to the U238/U235 ratio, other isotopic relationships were also evaluated. The ratio U238/U234 is expected to be near 1 (when comparing the activity (pCi)) in natural uranium. This ratio was found consistently, even though the uranium concentrations are relatively low. These results do not contradict the assumption that the uranium present is naturally occurring.</p> <p>One of the reasons it appears this effect occurs solely at Site 1 is that the samples from Site 1 were collected in the same sampling event, submitted to the laboratory together, and analyzed together.</p> <p>An approach to resolving this particular question would be to perform isotopic uranium analysis using a different method. ICP/MS techniques</p>

Draft Technical Memorandum  
Evaluation of Radionuclides in Groundwater at Former Landfill Sites and the EOD Range  
Reviewer: Steve Dean - USEPA Region IX

Comment No.	Comment	Response
6	Page 4-1, Section 4.1.1, Item b), paragraph 3: This document does not Provide the calculations required to support the statement that isotopic ratio of uranium detected in groundwater is consistent (within measurement error) with the published isotopic ratio of naturally occurring uranium for the three samples results addressed in the previous comment.	could be performed in parallel with the standard method and help to address the issue. If required, additional analysis of groundwater from these wells can be performed and Dr. Griggs will be contacted to provide input on the analysis protocols for this reanalysis.  As presented above, the cause of the apparent discrepancy in the isotopic ratio is an artifact of the analysis.

Draft Technical Memorandum  
 Evaluation of Radionuclides in Groundwater at Former Landfill Sites and the EOD Range  
 Reviewer: Dr C. Bennett - RAB Subcommittee Chairman

Comment No.	Comment	Response
A	<p>General Comments</p> <p>This is a clear, thorough, complete, and well-prepared Report. It is one of the best El Toro reports that I have reviewed. Yet, it is not without certain problems.</p>	<p>Comment noted.</p>
B	<p>Table 4-1 is the linchpin of this entire report. Based upon Table 4-1, a conclusion is presented that the Uranium found is of "Natural" not "Anthropogenic" origin. This conclusion is stated in the paragraph above Table 4-1, but other data in Table 3-1 tend to lead to a contrary conclusion that there is some anthropogenic contribution. (In addition, some rather subjective statements about the value of uranium and how it is monitored are made. These types of unsubstantiated statements should be ignored in arriving at any conclusions without supporting documentation.</p>	<p>An evaluation of the isotopic ratios for uranium was used as the basis for arriving at the conclusions that uranium present is naturally occurring. The report states that these conclusions were based on the analytical data set and within the limits of accuracy of the analytical methods. The authors acknowledge that the isotopic ratios are not "spot on" the background levels. Results of analysis performed on performance evaluation samples and on laboratory control samples, which are certified to be from natural uranium sources, yielded isotopic ratios that are consistent with the results obtained during this study. (This data will be included in the Final Technical Memorandum). Therefore, the authors still contend that within the limits of accuracy of the analytical method used, the conclusion that the radionuclides are of natural origin is still valid</p>
C	<p>Page 3-1, In LD001 of Table 4-1, there are a series of NC's that can be calculated anyway (Table 3-1 does not have a "U" on the U235 result). If you do the calculation, the U235 proportion is 2.26% (cf. 0.7% for natural) and the ratio is 43.2. This is consistent with anthropogenic U</p>	<p>The result for U<sup>235</sup> should have been reported as 0.065U. The value reflected in the table is the calculated result, based on the counts from the instrument. However, when the natural background radiation (cosmic rays, etc.) is considered the U<sup>235</sup> is statistically indistinguishable from background instrument noise. The Minimum Detectable Concentration (MDC) is the threshold below which the measurement is not reliable (with a 95% probability). Values below the MDC exceed the specified certainty of the analysis; therefore, subsequent isotopic ratio calculations are invalid. A copy of the laboratory data sheet for that sample is provided.</p>

Draft Technical Memorandum  
 Evaluation of Radionuclides in Groundwater at Former Landfill Sites and the EOD Range  
 Reviewer: Dr C. Bennett - RAB Subcommittee Chairman

Comment No.	Comment	Response
D	<p>3. Page 3-1, Section 3.3: See Specific Comment 5 regarding "adjusted gross values LD089, LD090, LD094 are omitted in Table 4-1, but raw data is in Table 3-1. In calculating the U235 proportions they are 1.42%, 1.45%, and 1.46% respectively. The ratios are 69.6, 68.0, and 67.6 respectively. Along with LD001, all the Site 1 samples express the highest levels of U235. This is consistent with anthropogenic U in Site 1 groundwater samples."</p>	<p>The apparent discrepancy in the isotopic proportions was evaluated by inspecting the laboratory records for the analysis. The apparent enrichment is an artifact of the analytical method. The measurement technique relies on the separation of decay energies among the four uranium isotopes (three target analytes and a tracer) analyzed. There is only a small separation between decay energy range of the U235 and U234 isotopes, as shown in the accompanying plot. An affect, called alpha spectral tailing, matrix effects and probably in this case, instrument operating parameters, can attribute decay energy of U234 to U235. Since the relative quantity of U235 to U238 is small, even a slight overestimation of the U235 can appear to suggest the presence of enriched uranium. Support for this explanation is found in examining the apparent isotopic ratio of the Laboratory Control Standards (LCS) specific to the sample batch. (The LCS is prepared from certified material obtained from the National Institute of Standards and is made from natural uranium.) In this particular sample run, the LCSs exhibit isotopic ratios of 1.21% and 1.39% U235, very close to the ratios shown by the samples analyzed at the same time and with the same instrument. In addition, the performance evaluation sample analysis yielded a ratio of 1.52 % U235.</p> <p>In addition to the U238/U235 ratio, other isotopic relationships were also evaluated. The ratio U238/U234 is expected to be near 1 (when comparing the activity (pCi)) in natural uranium. This ratio was found consistently, even though the uranium concentrations are relatively low. These results do not contradict the assumption that the uranium present is naturally occurring.</p> <p>One of the reasons it appears this effect occurs solely at Site 1 is that the samples from Site 1 were collected in the same sampling event, submitted to the laboratory together, and analyzed together.</p> <p>An approach to resolving this particular question would be to perform isotopic uranium analysis using a different method. ICP/MS techniques could be performed in parallel with the standard method and help to address the issue.</p>
E	<p>The LD010 location in Table 4-1 disagrees with the location in Table 3-1. It appears that Table 3-1 has the correct location.</p>	<p>The LD010 location on Table 4-1 should reference 02NEW02-GW01D. Table 3-1 has the correct location referenced. Table 4-1 will be corrected in the final</p>

Draft Technical Memorandum  
 Evaluation of Radionuclides in Groundwater at Former Landfill Sites and the EOD Range  
 Reviewer: Dr C. Bennett - RAB Subcommittee Chairman

Comment No.	Comment	Response
		version of the document.
F	LD019 from location 18-BGMW12-GW01S has one of the highest uranium levels (in fact it slightly exceeds the MCL) and is the single most consistent with natural uranium isotopic ratios. This location has never been analyzed before for radionuclides, according to the June 1999 Proposed Groundwater Monitoring Program Report	Comment noted.
G	A propagation of error treatment of the LD094 data indicates that the U235 proportion is 1.46% +/- 0.7%; thus, the deviation from 0.7% for natural U235 appears to be statistically significant. This is consistent with anthropogenic U in Site 1 a groundwater sample.	The conclusion assumes that there are no other factors, such as systematic measurement error. As presented in the response to Comment D, there is a systematic error that accounts for the apparent ratio that is different from natural uranium.
	Appendix D contains Well Sampling log data. While this log data for is present for 1MW201 (LD001), it is absent for 1MW203 & 1MW207 (LD0089,LD090, LD094). These were the Site 1 locations with the highest proportions of U235.State of California to ensure that they meet drinking water requirements.	Well sampling logs for all wells will be provided in the final version of this document
	Of all 20 samples, all but four express U238/U235 ratios clearly below 137.88. Of the higher proportion four, two were both of the Site 17 results, one was the control at 18BGMW12, and one was a 2NEW15 sample that was on the southern edge of the Site 2 landfill (surprisingly). The other 16 results are consistent with anthropogenic U in groundwater samples.	Please see the response to comment B